

Flexible Learning Approach to Physics - Glossary

α -decay

is: the process in which a [nucleus](#) undergoes [radioactive decay](#) to form a less massive [nucleus](#) with the ejection of an [\$\alpha\$ -particle](#), e.g. ${}_{92}^{238}\text{U} \rightarrow {}_{90}^{234}\text{Th} + {}_2^4\text{He}$ (where ${}_2^4\text{He}$ denotes the [\$\alpha\$ -particle](#)). [P9.2]

is a type: of [radioactive decay](#). [P9.2]

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α -particle

is: a helium [nucleus](#) with positive [charge](#) $2e$ and [relative atomic mass](#) 4.0026. [[P8.1](#), [P9.1](#), [P9.2](#)]

is ejected: in [radioactive \$\alpha\$ -decay](#). [[P9.2](#)]

is denoted: α or ${}^4_2\text{He}$ (or He^{2+} since it is a helium [atom](#) stripped of its two [electrons](#)). [[P8.1](#), [P9.1](#), [P9.2](#)]

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aberration

is: distortion in an [optical image](#) produced by the [optical system](#) forming the [image](#) and composed of contributions arising from a number of well known causes that include [spherical aberration](#), [coma](#), and [chromatic aberration](#).
[[P6.2](#), [P6.4](#)]

is also: those features of a [lens](#) or [mirror](#) which cause such distortions. [[P6.4](#)]

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absolute error

is: the absolute value (i.e. [modulus](#)) of an [error](#) or [uncertainty](#) in a quantity. [\[P1.2\]](#)

has: the same [dimensions](#) as. the quantity itself. [\[P1.1\]](#)

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absolute maximum

See [global maximum](#).

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absolute minimum

See [global minimum](#).

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absolute temperature

is: a [temperature](#) expressed in [kelvin](#) (K) on a [temperature scale](#) that starts at [absolute zero](#). Such scales include the [ideal gas absolute scale](#), the [thermodynamic Kelvin temperature scale](#) and the [International Practical Temperature Scale 1990](#). [[P7.2](#)]

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absolute value

See [modulus](#).

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absolute zero

is: the lowest possible [temperature](#). [P7.2]

is defined: as 0 K (i.e. 0 [kelvin](#)). [P7.2]

corresponds: to $-273.15\text{ }^{\circ}\text{C}$ (i.e. -273.15 [degrees Celsius](#)). [P7.2]

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absorbed dose

is: the amount of [energy](#) from [ionizing radiation](#) absorbed per [unit mass](#) by a [body](#). [P9.3]

has as its SI unit: the [gray](#) (Gy), where $1 \text{ Gy} = 1 \text{ J kg}^{-1}$ (i.e. 1 [joule](#) per [kilogram](#)). [P9.3]

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absorption

of: [electromagnetic radiation](#)

is: the outcome of any process whereby the [energy](#) carried by [electromagnetic radiation](#) is transformed and added to the [internal energy](#) of the [medium](#) through which the [electromagnetic radiation](#) is travelling.

should be contrasted: with [emission](#), and [reflection](#).

more generally is: the outcome of any process in which an entity or agency is partly or wholly assimilated into another.

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absorption line spectrum

is: an [absorption spectrum](#) that exhibits [absorption lines](#). [P8.2]

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absorption lines

in: the [absorption spectrum](#) of a [medium](#) (especially a [gas](#), [vapour](#) or [plasma](#))

are: characteristic narrow ranges of [frequency](#) or [wavelength](#) (often treated as single [frequencies](#) or [wavelengths](#)) at which the [spectral brightness](#) is significantly less than the ([average](#)) [spectral brightness](#) in neighbouring parts of the relevant [spectrum](#). [P8.2]

correspond individually: to a [transition](#) between two [bound states](#) of a particular kind of [atom](#), [molecule](#) or [ion](#) (or to any other process) that causes the [absorption](#) of [electromagnetic radiation](#) at particular [frequencies](#) or [wavelengths](#). [P8.2]

absorption spectrum

of: [electromagnetic radiation](#), often produced from a [continuous emission spectrum](#) (e.g. a source of [white light](#)) which has been passed through a specified [absorbing medium](#).

is: the distribution of (relative) [spectral brightness](#) with respect to [frequency](#) or [wavelength](#). [P8.2]

may be displayed: as a [graph](#) of the (relative) [spectral brightness](#) plotted against [wavelength](#) or [frequency](#), or (photographically) as a band of varying levels of brightness and darkness. [P8.2]

may exhibit: (especially for a [gas](#), a [vapour](#) or a [plasma](#)) characteristic [absorption lines](#), in which case it is often referred to as an [absorption line spectrum](#), or (especially in the case of a [solid](#) or a [liquid](#)) smoothly varying [absorption](#) across a broad range of [frequencies](#) or [wavelengths](#). [P8.2]

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absorption transition

in: an [atom](#), [molecule](#) or [ion](#)

is: a [transition](#) in which the [atom](#), [molecule](#) or [ion](#) absorbs [energy](#) from incoming [electromagnetic radiation](#) and is thereby [excited](#) from one [bound state](#) to another [bound state](#) of higher [energy](#). Each absorption transition gives rise to an [absorption line](#) in an appropriate [absorption spectrum](#). [P8.2]

usually: involves the [ground state](#) as the lower [energy](#) state.

AC circuit, a.c. circuit

is: an [electrical circuit](#) in which an [alternating current](#) flows, or may be presumed to flow. [[P5.4](#)]

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AC, a.c.

See [alternating current](#).

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acceleration

is: a [vector quantity](#) \mathbf{a} which specifies the [rate of change](#) of [velocity](#) with [time](#). [M2.1, M2.4, P2.1]

in one dimension is: $a_x = \frac{v_x - u_x}{t}$ for a [particle](#) moving in a [straight line](#) with [uniform acceleration](#) a_x along the [x-axis](#), where u_x and v_x are the [initial](#) and [final velocities](#) respectively and t is the [time](#) taken for the change in [velocity](#). [P2.1]

is defined generally: as $\mathbf{a} = d\mathbf{v}/dt$, the [derivative](#) of [velocity](#) with respect to [time](#). [M4.1, M5.1]

is often specified: in terms of its [scalar components](#), a_x, a_y, a_z by $\mathbf{a} = (a_x, a_y, a_z) = (dv_x/dt, dv_y/dt, dv_z/dt)$. [M4.1, M5.1]

has as its SI unit: m s^{-2} (i.e. [metre](#) per [second squared](#)). [M4.1]

is given graphically: at any particular [time](#), by the [gradient](#) of the [tangent](#) to the [velocity-time graph](#) of the [motion](#) at that [time](#). [M4.1, P2.1]

See also [instantaneous acceleration](#).

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acceleration due to gravity

is: the [acceleration](#) with which an object falls near to the [surface](#) of the Earth, due to the [gravitational force](#) that acts upon it. The [magnitude](#) of this [acceleration](#) is given the symbol, g and has the approximate value 9.8 m s^{-2} . [[P2.1](#)]

is equal: to the [gravitational field](#) at the Earth's [surface](#). [[P3.2](#)]

may be regarded: as the [free fall](#) acceleration of an object at the Earth's [surface](#), or the [surface gravity](#). [[P3.2](#)]

See [magnitude of the acceleration due to gravity](#).

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accommodated (eye)

is: an eye in which the [ciliary muscles](#) (which control the [lens](#)) are not fully relaxed. [P6.4]

is focused: somewhere closer than at its [far point](#) (usually [infinity](#)). [P6.4]

Contrast with [unaccommodated \(eye\)](#). [P6.4]

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accuracy

of: a [measurement](#) or value

is: a [measure](#) of the extent to which the [measurement](#) (or value) differs from the true value. [[P1.1](#)]

is also: a [measure](#) of the extent to which the [measurement](#) (or value) is free of [systematic error](#). [[P1.1](#)]

linguistically is: perverse. The greater the accuracy, the smaller is its numerical value. A clearer way of expressing it is to say that a quantity is 'accurate to within plus-or-minus so-much'. [[P1.1](#)]

Compare with [precision](#).

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achromatic doublet

is: a combination of two [lenses](#) (glued together), designed to minimize [chromatic aberration](#) at two predetermined [wavelengths](#). [P6.4]

traditionally consists: of a [converging lens](#) of [crown glass](#) with low [dispersion](#) and a weaker [diverging lens](#) of [flint glass](#) with high [dispersion](#). [P6.4]

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acoustic energy

is: the [energy transported](#) by [sound](#). [P5.7]

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acoustic wave

See [sound wave](#).

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acoustics

is: the branch of [physics](#) concerned with the study of [sound](#).

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actinides

are: the fourteen [chemical elements](#) with [atomic numbers](#) in the range 89-102 inclusive (i.e. from actinium to nobelium). [[P8.4](#)]

are all: [radioactive](#). [[P9.3](#)]

include: uranium and plutonium. [[P8.4](#)]

occur: in a part of the [periodic table](#) where the 5f [subshell](#) of [atoms](#) in their [ground state](#) is being progressively filled. [[P8.4](#)]

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activity

is: the rate $R(t)$ at which the [nuclei](#) of a [radioactive](#) substance disintegrate due to [radioactive decay](#). [P9.2]

is also: a [measure](#) of the rate of emission of [\$\alpha\$ -particles](#), [\$\beta\$ -particles](#) or [\$\gamma\$ -radiation](#) from a [radioactive isotope](#). [P9.2]

is related: to the number $N(t)$ of [unstable nuclei](#) of [decay constant](#) λ in a pure sample (containing only a single type of [radionuclide](#)) by $R(t) = -dN/dt = \lambda N(t)$. [P9.2]

has as its SI unit: the [becquerel](#) (Bq). 1 Bq = 1 decay per [second](#). The non-[SI unit](#) of activity, the curie (Ci, 1 Ci = 3.70×10^{10} Bq) is also in common use. [P9.2]

See [activity law](#).

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activity law

is: the [law](#) which governs the [activity](#) $R(t)$ of a sample of a [radioactive isotope](#), which will remain after a given [time](#) t has elapsed. The [law](#) is [exponential](#): $R(t) = R_0 e^{-\lambda t}$, where R_0 is the initial [activity](#) and λ is the [decay constant](#).

[P9.2]

See [radioactive decay](#) and [radioactive decay law](#).

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acute angle

is: an [angle](#) of less than 90° . [[M2.1](#)]

Contrast with [obtuse angle](#) and [reflex angle](#).

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addition (of vectors)

See [vector addition](#).

addition formulae

are: a class of [trigonometric identities](#). [M1.6]

See trigonometric functions in the [Maths handbook](#).

addition identities

are: a class of [hyperbolic function identities](#). [M4.6]

See hyperbolic functions in the [Maths handbook](#).

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adiabat

is: a path representing a [quasistatic adiabatic process](#), usually on a [PVT-surface](#) (or some similar [surface](#)) or on one of its projections. [[P7.4](#)]

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adiabatic

describes: a situation in which no [heat](#) enters or leaves a [system](#), so that $\Delta Q = 0$. [[P7.3](#)]

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adiabatic condition

for: a fixed quantity of [ideal gas](#)

states: that $PV^\gamma = \text{constant}$, where the [constant](#) is characteristic of the process, and γ the [ratio of specific heats](#) of the [gas](#) (C_p/C_v), is approximately [constant](#) for the [gas](#). [P7.4]

characterizes: an [adiabatic process](#). [P7.4]

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adiabatic process

takes place: without [heat](#) entering or leaving the [system](#), so $\Delta Q = 0$. [P7.3]

See [adiabat](#) and [adiabatic condition](#).

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adjacent side

of: a [right-angled triangle](#)

is: the side (not the [hypotenuse](#)) that is adjacent to any specified one of the [acute angles](#). [[M1.6](#)]

See trigonometric functions in the [Maths handbook](#).

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air friction

is: [air resistance](#). [P5.2]

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air resistance

is: a [force](#) that opposes [motion](#) through air. [[P2.3](#)]

has magnitude: [proportional](#) to the [square](#) of the object's [speed](#), for objects of moderate size and [speed](#), moving through the Earth's atmosphere close to the Earth's [surface](#). [[P2.3](#), [P5.2](#)]

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Airy disc

is: the central [circular](#) region of an [Airy pattern](#), extending as far as the first minimum. [[P6.4](#)]

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Airy pattern

is: the ([angular](#)) distribution of [radiation diffracted](#) by a [circular aperture](#).
[\[P6.4\]](#)

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alcohol-in-glass thermometer

is: a glass [capillary](#) with a bulb containing alcohol. Changes in [temperature](#) cause the glass and alcohol to expand (or contract) by different amounts, and the result is that the [meniscus](#) moves to different [positions](#) in the [capillary](#). [[P7.2](#)]

can be calibrated: by marking [meniscus](#) positions corresponding to [fixed points](#) such as the [boiling](#) and [freezing points](#) of water, and then [interpolating](#) between them. [[P7.2](#)]

algebra

is: the branch of [mathematics](#) concerned with symbols and their manipulation according to defined rules.

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algebraic

pertains: to [algebra](#), the branch of mathematics concerned with symbols and their manipulation. [[M1.1](#)]

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algebraic division

is: the application of division to an [algebraic expression](#). [M1.4]

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algebraic expression

is: an [expression](#) that contains [algebraic](#) symbols as well as numbers.

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algebraic sum

is: a process of addition that respects a [sign convention](#). [P2.7]

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alkali metals

are: the [metallic elements](#) lithium, sodium, potassium, rubidium, caesium and francium. [P8.4]

are so named: because the [metals](#) dissolve in water to give solutions that contain significant concentrations of aqueous hydroxide (OH^-) [ions](#). Materials generating such solutions are said to be alkalis (essentially the opposite of acids). [P8.4]

occur: in Group I of the [periodic table](#). [P8.4]

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alloy

is: a material with characteristically metallic properties, formed from a combination of [elements](#), of which at least one major constituent is itself a [metal](#). Although specified by a [chemical formula](#), its constituents do not form [molecules](#) that correspond to the [chemical formula](#).

alpha-particle

See [α-particle](#).

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alternate angles

See [transversal](#).

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alternating current, a.c.

is: an [electric current](#) which changes [magnitude](#) and [direction](#) in a regular [periodic](#) way. [P5.4, P5.5]

often is: [sinusoidal](#), i.e. it may be described by the formula

$I(t) = I_0 \sin(\omega t + \phi)$, where I_0 is the [peak value](#) or [amplitude](#) of the current, ω is the [angular frequency](#), ϕ is the [phase constant](#) and $(\omega t + \phi)$ is called the [phase](#) of the current. [P5.4, P5.5]

may also be described: using [complex quantities](#), so in the [sinusoidal](#) case

$I(t) = \text{Re} [\mathcal{I}_0 \exp(\omega t + \phi)]$. [P5.5]

more generally refers: to other associated electrical quantities whose [direction](#) varies with [time](#), e.g. a.c. [voltage](#). [P5.4]

is abbreviated: AC at the beginning of a sentence, and a.c. elsewhere. [P5.4]

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alternator

is: a device that generates an [induced voltage](#) of changing [polarity](#) by [rotating](#) a [coil](#) within a [magnetic field](#). [P4.4]

is also known: as an [alternating current \(a.c.\) dynamo](#). [P4.4]

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ammeter

is: an instrument for [measuring electric current](#) that is placed in [series](#) with other [circuit components](#) through which the [current](#) to be [measured](#) flows. [\[P4.1\]](#)

ideally has: zero [resistance](#), so that it does not affect the [circuit](#) to which it is connected. [\[P4.1\]](#)

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amount of substance

is: a measure of the quantity of substance in a sample, expressed in terms of the number of basic entities ([atoms](#), [molecules](#), etc.) of the substance that are present in the sample.

has as its SI unit: the [mole](#) (mol).

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ampere, A

is: the [SI unit](#) of [electric current](#) (i.e. rate of flow of [electric charge](#)), one of the seven [base units](#). [P4.1]

is defined: as that [constant current](#) which, if maintained in each of two infinitely long, straight, [parallel](#) wires of negligible cross section, placed 1 [metre](#) apart, in a [vacuum](#), will cause each wire to experience a [force](#) of [magnitude](#) 2×10^{-7} [newton](#) per [metre](#) of its [length](#). [P4.3]

is equivalent: to the transfer of one [coulomb](#) per [second](#), so $1 \text{ A} = 1 \text{ C s}^{-1}$. [P4.1]

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amplitude

of: an [oscillation](#) or a [wave](#)

is: the maximum [magnitude](#) of [displacement](#) from an [equilibrium](#) value. [[P5.1](#), [P5.5](#), [P6.1](#)]

is represented: by the [constant](#) A that appears in the [general solution](#) of the [simple harmonic motion equation](#) when written in the form

$$y = A \sin(\omega t + \phi). \quad [\text{M5.1}, \text{P5.5}, \text{P5.6}]$$

also appears: in similar [equations](#) such as that describing [damped driven harmonic motion](#). [[M6.3](#), [M6.4](#)]

is exemplified: by the maximum value of the [pressure](#) change caused by the passage of a [sound wave](#). [[P5.7](#)]

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angle

is: the inclination of one [line](#) with respect to another or, equivalently, the amount by which one [line](#) must be rotated about a [point](#) in order to align it with another [line](#) passing through the same [point](#). [M1.6]

is commonly measured: in [degrees](#) or [radians](#). [M1.6]

is also called: [plane angle](#).

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angle of contact

in: [capillarity](#)

is: the [angle](#) between a [meniscus](#) and a [solid surface](#) at their point of contact.
[\[P7.6\]](#)

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angle of deviation

in: [geometrical optics](#) and [acoustics](#).

is: the [angle](#) through which a [ray](#) is turned, often by [refraction](#) on entering a different material or [medium](#). [[P6.3](#)]

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angle of dip

See [angle of inclination](#).

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angle of incidence

in: [geometrical optics](#) and [acoustics](#).

is: the [angle](#) between the [incident ray](#) and the [normal](#) to the [surface](#) or [interface](#) at the [point of incidence](#). [[P5.7](#), [P6.1](#), [P6.2](#)]

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angle of inclination

is: the [angle](#) between the (local) Earth's [magnetic field](#) and the horizontal.
[P4.2]

is also called: angle of dip. [P4.2]

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angle of reflection

in: [geometrical optics](#) and [acoustics](#).

is: the [angle](#) between the [reflected ray](#) and the [normal](#) to the [surface](#) or [interface](#) at the [point of incidence](#). [[P5.7](#), [P6.1](#), [P6.2](#)]

is equal: to the [angle of incidence](#), according to the [law of reflection](#). [[P5.7](#), [P6.1](#), [P6.2](#)]

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angle of refraction

in: [geometrical optics](#) and [acoustics](#).

is: the [angle](#) between the [refracted ray](#) and the [normal](#) to the [surface](#) or [interface](#) at the [point of incidence](#). [[P5.7](#), [P6.1](#), [P6.2](#)]

is related: to the [angle of incidence](#) via [Snell's law](#) (the [law of refraction](#)). [[P5.7](#), [P6.1](#), [P6.2](#)]

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angular acceleration

is: the [rate of change](#) of [angular velocity](#), either in [magnitude](#) or in [direction](#) or in both. [P2.7]

is defined: as $\boldsymbol{a}_\theta = d\boldsymbol{\omega}/dt$. [P2.7]

has as its SI unit: rad s^{-2} (i.e. [radian](#) per [second squared](#)). [P2.7]

can be represented: if the [direction](#) of the [angular velocity](#) does not change, by the [scalar quantity](#) $a_\theta = d\omega/dt$. [P2.7]

can be determined: if the angular acceleration a_θ is [uniform](#), by $a_\theta = (\omega_2 - \omega_1)/t$, where ω_2 and ω_1 are the [angular speeds](#) at the end and beginning respectively of the [time interval](#) t . [P2.7]

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angular frequency

of: [oscillatory motion](#)

is: a [measure](#) of the rate at which complete [oscillations](#) are executed. [[M5.1](#), [P5.5](#)]

is related: to the [frequency](#) f of the [oscillation](#) by $\omega = 2\pi f$. [[P5.1](#), [P5.4](#), [P5.5](#), [P5.6](#)]

is also related: to the [period](#) T of the [oscillation](#) by $T = 2\pi/\omega$. [[P5.1](#), [P5.5](#)]

has as its SI unit: the hertz (Hz), where $1 \text{ Hz} = 1 \text{ s}^{-1}$ (i.e. per [second](#)). [[P5.1](#), [P5.4](#), [P5.5](#)]

is represented: by the [parameter](#) ω in the formula $y = A \sin(\omega t + \phi)$ that describes [simple harmonic motion](#). [[M6.3](#), [M6.4](#), [P5.1](#)]

Compare with [angular speed](#).

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angular limit of resolution

See [angular resolving power](#).

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angular magnification

is: the [ratio](#) of the [angle](#) subtended at an [observer's](#) eye by an [optical image](#), to the [angle](#) subtended by the [object](#) from which it is derived. [[P6.4](#)]

Compare with [magnifying power](#).

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angular momentum

of: a [particle](#)

about: a chosen [origin](#) O, from which the position of the particle is specified by the [position vector](#) \mathbf{r} ,

is: $\mathbf{L} = \mathbf{r} \times \mathbf{p}$, where \mathbf{p} is the [momentum](#) of the particle. [P2.8]

is also known as: the [moment of momentum](#) of the particle about O. [M2.7]

of: a collection of [particles](#)

about: a given [point](#) P

is: the (vector) [sum](#) of all the [moments of momenta](#) of each of the [particles](#) about P. [P2.8, P11.3]

of: a [rigid body](#)

with: [angular velocity](#) $\boldsymbol{\omega}$ about a single fixed [axis of rotation](#), and [moment of inertia](#) I about that axis

is given by: $\mathbf{L} = I\boldsymbol{\omega}$. [P2.8]

has as its SI unit: $\text{kg m}^2 \text{s}^{-1}$ (i.e. [kilogram metre squared](#) per [second](#)).

See [conservation of angular momentum](#).

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angular position

of: a [particle](#) in a [plane](#), with respect to a [point](#) O, taken to be the [origin](#) of [Cartesian coordinates](#) in the [plane](#)

is: the [angle](#) θ between the particle's [position vector](#) and the positive [x-axis](#).
[P2.7]

equivalently is: the [polar angle](#) of the [point](#) at which the [particle](#) is located, measured in a [system](#) of [polar coordinates](#) with [origin](#) at O.

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angular probability density

in: [Schrödinger's model of the hydrogen atom](#)

is: the factor $|Y_{lm}(\theta, \phi)|^2$, that arises in calculating the [probability density](#) $|\Psi(r, \theta, \phi)|^2$, where $Y_{lm}(\theta, \phi)$ is the [angular](#) part of the [wavefunction](#) $\Psi(r, \theta, \phi)$. [\[P11.3\]](#)

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angular resolving power

of: an [optical system](#)

is: a measure of the [system's](#) ability to produce or distinguish two separate [images](#) of two point-like [objects](#) which are, or appear to be, very close together. [P6.4]

is defined: as the minimum [angular](#) separation that the [objects](#) must have if their [images](#) are to satisfy the [Rayleigh criterion](#). [P6.4]

is limited: by the 'diffraction limit' of the [aperture](#) of the [optical system](#), which for a [circular aperture](#) of [diameter](#) d admitting [light](#) of [wavelength](#) λ is $(1.22 \text{ radian})\lambda/d$. [P6.4]

is also known: as the angular limit of resolution. [P6.4]

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angular speed

of: a [particle](#) moving in a [plane](#) (taken to be the (x, y) plane) around a [point](#) O (taken to be the [origin](#) of the (x, y) [plane](#)) with an instantaneous [angular position](#) θ (measured between the particle's [position vector](#) \mathbf{r} and the positive [x-axis](#))

is: the [magnitude](#) of the [rate of change](#) of θ with respect to [time](#). That is, $\omega = |d\theta/dt|$, where θ is normally [measured](#) in [radians](#). [P2.6, P3.2]

has as its SI unit: rad s^{-1} (i.e. [radian](#) per [second](#)). [P2.7, P5.1]

is exemplified: in the case of [uniform circular motion](#) about O, at constant speed v , by the relation $\omega = v/r$. [P2.6]

of: a [rigid body](#) in [uni-axial rotation](#) about a single [axis of rotation](#) that is fixed in relation to the body

is: the (positive) [angle](#) swept out per [second](#) by a [line](#) drawn from the [axis of rotation](#) to any [point](#) in the [body](#) that is not on the axis. [P2.7]

See also [instantaneous angular speed](#).

Flexible Learning Approach to Physics - Glossary

angular velocity

of: a [particle](#) (or [rigid body](#)) in [uni-axial rotation](#) about a single fixed [axis of rotation](#)

is: a [vector](#), usually represented by the symbol $\boldsymbol{\omega}$, whose [magnitude](#) is the [angular speed](#) ω , about that axis, and whose [direction](#) is along the axis, in the [sense](#) given by the [right-hand grip rule](#) (i.e. if the fingers of the right hand are curled in the direction of [rotation](#) of the [body](#), then the extended thumb points in the [direction](#) of the angular velocity). [[P2.7](#), [P2.8](#)]

satisfies: the relation $\boldsymbol{v} = \boldsymbol{\omega} \times \boldsymbol{r}$, where \boldsymbol{v} is the [velocity](#) and \boldsymbol{r} the [position vector](#) of the [particle](#) (or of any point in the [rigid body](#)) measured from an [origin](#) O on the [axis of rotation](#). [[P2.7](#)]

has as its SI unit: rad s^{-1} (i.e. [radian](#) per [second](#)).

Flexible Learning Approach to Physics - Glossary

angular wavenumber

for: a [periodic wave](#) of [wavelength](#) λ

is defined: as $k = 2\pi/\lambda$. [[M6.4](#), [P5.6](#)]

has as its SI unit: m^{-1} (i.e. per [metre](#)). [[M6.4](#), [P5.6](#)]

is widely referred to: as the [wavenumber](#), though this latter term is more properly reserved for $\sigma = 1/\lambda$, i.e. $k/2\pi$. [[M6.4](#), [P5.6](#)]

See also [angular wave vector](#) and compare with [angular frequency](#). [[M6.4](#), [P5.6](#)]

Flexible Learning Approach to Physics - Glossary

angular wave vector

is: the generalization of the [scalar angular wavenumber](#) to a [vector quantity](#) which characterizes [waves propagating](#) in two or three [dimensions](#). [P5.6]

is equal: in [magnitude](#) to $2\pi/\lambda$. [P5.6]

has direction: [parallel](#) to the [direction of propagation](#) of the [wave](#). [P5.6]

usually is denoted: by the symbol \mathbf{k} . [P5.6]

more commonly is referred to: as the [wave vector](#), or the [propagation vector](#). [P5.6]

Flexible Learning Approach to Physics - Glossary

anharmonic oscillations

are: [oscillations](#) which are not [simple harmonic](#). [[P5.1](#), [P5.3](#)]

are characterized: by a [restoring force](#) which is not [proportional](#) to the [displacement](#), and a [period](#) which depends on [amplitude](#). [[P5.1](#), [P5.3](#)]

anharmonic oscillator

is: an [oscillator](#) which displays [anharmonic oscillations](#). [P5.3]

Flexible Learning Approach to Physics - Glossary

anion

is: a negatively [charged ion](#). [P8.4]

Flexible Learning Approach to Physics - Glossary

annulus

is: a region of a [plane](#) lying between two concentric [circles](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

anode

is: an [electrode](#) connected to the positive [terminal](#) of a supply of [electric current](#). (The term is used especially in the context of a [discharge tube](#) or a similar device.) [[P8.1](#)]

antidifferentiation

See [inverse differentiation](#).

Flexible Learning Approach to Physics - Glossary

antilog

See [antilogarithmic function](#).

antilogarithmic function

is: the [function](#) which undoes the effect of the [log function](#) $f(x) = \log_a(x)$, i.e. is the [inverse function](#) of $\log_a(x)$. [M1.5]

is given: by $g(x) = a^x$ (where $a > 0$), since $g(f(x)) = a^{\log_a(x)}$ which by definition is simply equal to x . [M1.5]

See also [exponential function](#).

Flexible Learning Approach to Physics - Glossary

antinode

in: a [standing \(stationary\) wave](#)

is: one of the [positions](#) where the maximum [displacement](#) from [equilibrium](#) occurs. [[P5.6](#)]

Flexible Learning Approach to Physics - Glossary

antiparallel (vectors)

are: two [vectors](#) which point in exactly opposite [directions](#). [[M2.4](#), [P2.2](#)]

See also [parallel \(vectors\)](#)

antiparticle

is: a [particle](#) having the same [rest mass](#) as its partner [particle](#) but with its other attributes having the opposite sign. For example, the [electron](#) (a [particle](#)) and the [positron](#) (its antiparticle) have equal [masses](#) and opposite [charges](#). [P9.2]

anti-phase

is: the condition in which two [oscillations](#) or [waves](#) of the same [frequency](#) have a [phase difference](#) of π (often referred to as π rad or 180°). The maxima of one disturbance then coincide with the minima of the other and vice versa, and the two [oscillations](#) or [waves](#) are totally out of step. [[P6.1](#)]

is equivalently: the condition of being totally [out of phase](#). [[P5.1](#)]

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anti-reflection coating

is: a thin [transparent](#) film applied to the [surface](#) of an [optical](#) component such as a [lens](#) in order to reduce (via [interference](#)) the amount of [light](#) which the [surface](#) [reflects](#). [[P6.1](#)]

antisymmetric function

See [odd function](#).

Flexible Learning Approach to Physics - Glossary

aperture

of: a [lens](#) or [mirror](#)

is: its effective size (usually expressed as a [circular diameter](#)).

more generally is: an opening or gap.

Flexible Learning Approach to Physics - Glossary

aperture stop

in: an [optical system](#)

is: the size of [aperture](#) which defines the amount of [light](#) entering the [system](#).
[\[P6.4\]](#)

Flexible Learning Approach to Physics - Glossary

apparatus

is: equipment used in a [scientific experiment](#) or investigation.

Flexible Learning Approach to Physics - Glossary

apparent depth

of: an object viewed by [refraction](#) at a [plane surface](#)

is: the depth below the [surface](#) at which the [image](#) appears to be. For near [normal](#) viewing the [ratio](#) of [real depth](#) to apparent depth is equal to the [refractive index](#). [P6.2]

approximation

of: a number or quantity y by another number or quantity x

is obtained: when x and y have 'similar' values. The term 'similar' is not precisely defined but generally means that $|x - y| / |x|$ is much less than 1. Such a relationship is shown by writing $x \approx y$. [M1.2]

also refers: to approximation of a real situation by a [model](#). [P1.1]

occurs: in 'orders', as in a crude 'first (order) approximation' or a more accurate 'second (order) approximation'. [P8.3, P8.4]

also occurs: in 'degrees', as in the approximation of a [function](#) by a [polynomial](#) (such as a [Taylor polynomial of degree \$n\$](#)). [M1.7, M4.5]

See also [numerical integration](#) and [numerical procedures](#) for information on the approximation of [definite integrals](#) and [roots of equations](#).

Flexible Learning Approach to Physics - Glossary

aqueous humour

is: the clear, watery fluid between the [cornea](#) and the [lens](#) of the eye. [[P6.4](#)]

arbitrary constants

are: [constants](#) that arise (as [constants of integration](#)) in the [solution](#) of [differential equations](#). The [general solution](#) of an n^{th} -[order linear, ordinary differential equation](#) contains n [independent](#) arbitrary constants (which are also known as [essential constants](#)). [[P5.5](#)]

Flexible Learning Approach to Physics - Glossary

arc

is: a part of a [curve](#).

often specifically means: a part of the [circumference](#) of a [circle](#), though this should more properly be called a circular arc. [[M1.6](#), [M2.1](#)]

Flexible Learning Approach to Physics - Glossary

arc length

is: a [length](#) measured along an [arc](#). [[M1.6](#)]

Flexible Learning Approach to Physics - Glossary

arccos, arcsin, arctan, arccosec, arcsec, arccot

See [inverse trigonometric functions](#), and the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

arccosh, arcsinh, arctanh, arccosech, arcsech, arccoth

See [inverse hyperbolic functions](#), and the [Maths handbook](#).

Archimedes' principle

states: that an object immersed in a [fluid](#) will experience a [force](#) due to the [fluid](#) which acts upward through the object's [centre of gravity](#), with a [magnitude](#) equal to the [weight](#) of the [fluid](#) which has been displaced by the object. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

area

is: a measure of the amount of [surface](#) within given closed boundaries.

See Table 11 in Section 2 of the [Maths handbook](#) for the areas of particular shapes.

Flexible Learning Approach to Physics - Glossary

area between two graphs

of: the [functions](#) $f(x)$ and $g(x)$ which [intersect](#) at the [points](#) $x = a$ and $x = b$ (where $a < b$), and for which any other [points](#) of intersection lie between $x = a$ and $x = b$

is given: by the [integral](#) $\int_a^b |f(x) - g(x)| dx$.

Flexible Learning Approach to Physics - Glossary

area under a graph

of: the function $f(x)$ between a and b

is: a synonym, used in *FLAP*, for the [definite integral](#) of $f(x)$ from a to b , namely $\int_a^b f(x) dx$ where $b > a$. [[M5.1](#), [M5.2](#)]

sometimes is referred to: as the signed [area](#) since, for $b > a$ it will be negative in any region where $f(x) < 0$. [[M5.2](#)]

can be identified: in [graphical](#) terms, with the physical [area](#) enclosed by the [curve](#) representing $f(x)$ the [x-axis](#), and the [lines](#) $x = a$ and $x = b$ provided that $a < x < b$ for all x satisfying $a < x < b$ and the [area](#) is [measured](#) in the scale [units](#) that are appropriate to the [graph](#) in question. [[M5.1](#), [M5.2](#)]

Argand diagram

is: a [plane](#) making use of [Cartesian coordinates](#) in which the [x-axis](#) represents the [real part](#) of a [complex number](#) and the [y-axis](#) represents the [imaginary part](#).
[[M3.1](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

argument (of a function)

of: a [function](#) (e.g. $f(x)$)

is: the [independent variable\(s\)](#) e.g. x whose value(s) determines the value of the [function](#). [[M1.3](#)]

Flexible Learning Approach to Physics - Glossary

argument (of a complex number)

of: a [complex number](#) in the [polar form](#) $z = r(\cos \theta + i \sin \theta)$, or the [exponential form](#) $z = r e^{i\theta}$

is: the value of θ . [[M3.2](#), [P5.5](#)]

of: a complex number in the [Cartesian form](#) $z = a + ib$

may be: any value of θ that satisfies the equations

$$\sin \theta = \frac{b}{\sqrt{a^2 + b^2}}$$

$$\cos \theta = \frac{a}{\sqrt{a^2 + b^2}} \quad [\text{M3.2, P5.5}]$$

usually is: the particular value of θ (the [principal value](#)) that also satisfies the additional requirement $-\pi < \theta \leq \pi$. [[M3.2](#)]

is denoted: by $\arg(z)$, though some authors use $\text{Arg}(z)$ to indicate the [principal value](#) of $\arg(z)$. [[M3.2](#)]

Flexible Learning Approach to Physics - Glossary

arithmetic

pertains: to the branch of [mathematics](#) concerned with numbers and their manipulation. [[M1.1](#)]

arithmetic progression

is: a [series](#) of the form:

$$\sum_{k=0}^{n-1} (a + kh) = a + (a + h) + (a + 2h) + \dots + [a + (n - 1)h]$$
$$= na + \frac{(n-1)}{2}h$$

where the [constant](#), h is known as the common difference. [\[M1.7\]](#)

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arithmetic series

See [arithmetic progression](#).

Flexible Learning Approach to Physics - Glossary

articulated body

is: a [body](#) of several defined, jointed parts, which otherwise can be treated as a [rigid body](#). [P2.8]

Flexible Learning Approach to Physics - Glossary

aspheric lens

is: a [lens](#) whose [surfaces](#) are non-[spherical](#). [[P6.4](#)]

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aspheric surface

is: a non-[spherical surface](#) of a [lens](#) or [mirror](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

astronomical telescope

is: a [telescope](#) which produces a final [image](#) that is [inverted](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

asymptote

is: a [straight line](#) which a [curve](#) approaches but does not meet. [M1.3]

more precisely is: a [straight line](#) related to a [curve](#) in such a way that there is at least one [direction](#) of travel along the [curve](#) in which the shortest [distance](#) between them decreases progressively as the [distance](#) from the [origin](#) to the [point](#) becomes very large. [M4.4]

more formally is: a [straight line](#) which is the limit of the [tangents](#) to a [curve](#) as the [point](#) at which those [tangents](#) touch the [curve](#) tends to [infinity](#). [M2.2, M2.3]

Flexible Learning Approach to Physics - Glossary

asymptotically

means: in the way that a [curve](#) approaches, but never meets, its [asymptote](#).
[M1.3]

Flexible Learning Approach to Physics - Glossary

atmosphere, atm

is: a non-[SI unit](#) of [pressure](#).

is defined: by $1 \text{ atm} = 1.013\,25 \times 10^5 \text{ N m}^{-2}$. [[P7.2](#)]

is more properly called: [standard atmosphere](#).

more generally is: the layer of air above the Earth's surface which exerts [atmospheric pressure](#).

Flexible Learning Approach to Physics - Glossary

atmospheric pressure

is: the [pressure](#) due to the [weight](#) of the atmosphere. [P7.2]

is not: a [constant](#), but varies with [time](#) and [position](#). [P7.2]

has a value: at the Earth's [surface](#) varying only by relatively small amounts. [P7.2]

has as a useful unit: the [standard atmosphere](#) (see [atmosphere, atm](#)) defined by $1 \text{ atm} = 1.013\,25 \times 10^5 \text{ N m}^{-2}$. [P7.2]

Flexible Learning Approach to Physics - Glossary

atom

is: the basic building block of all normal [solid](#), [liquid](#) or [gas](#) matter. [[P7.1](#)]

is: the smallest part of a [chemical element](#) that retains the fundamental chemical and physical properties of that [element](#). [[P8.1](#)]

extends: over a [diameter](#) of approximately 10^{-10} m. [[P7.1](#), [P8.1](#)]

has: a dense, positively [charged](#) central [nucleus](#) with a diameter of order 10^{-14} m composed of [neutrons](#) and positively [charged protons](#), surrounded by a cloud of negatively [charged electrons](#) equal in number to the number of [protons](#), according to [Rutherford's nuclear model](#) and all 'realistic' [models](#) ever since. [[P8.1](#)]

has: zero electrical [charge](#) overall. [[P8.1](#)]

Contrast with [ion](#).

Flexible Learning Approach to Physics - Glossary

atomic force microscope

is: an instrument that measures the vertical [displacement](#) of a probe tip, with a [diameter](#) of a few nanometers, as it is moved across the [surface](#) of a material in such a way that the [force](#) it experiences remains constant. [P7.1]

measures: the profile of the [surface](#) with an approximate [resolution](#) of 10^{-10} m. [P7.1]

can be used: to build a [three-dimensional](#) representation of the distribution of [atoms](#) on the [surface](#) of a material. [P7.1]

Flexible Learning Approach to Physics - Glossary

atomic mass unit, u

is: a non-[SI unit](#) of [mass](#). [[P8.1](#)]

is defined: as one twelfth of the [mass](#) of one [atom](#) of the commonest carbon [isotope](#) $^{12}_6\text{C}$, so the mass of one carbon-12 atom is exactly 12 u. According to current [measurements](#), $1 \text{ u} = 1.660\,54 \times 10^{-27} \text{ kg}$ (to six [significant figures](#)), or approximately $931 \text{ MeV}/c^2$. [[P8.1](#), [P9.1](#)]

Flexible Learning Approach to Physics - Glossary

atomic number

is: the number of [protons](#) within the [nucleus](#) of an [atom](#), usually denoted by the symbol Z [[P7.1](#), [P9.1](#)]

characterizes: each [chemical element](#) uniquely, since the [nuclear charge](#) of each [atom](#) of a [chemical element](#) with atomic number Z is simply Ze . [[P7.1](#), [P8.1](#)]

also represents: the number of [electrons](#) required to balance the [nuclear charge](#) in an [atom](#), and therefore determines the chemical behaviour of the [atom](#). [[P8.1](#)]

Flexible Learning Approach to Physics - Glossary

attenuation coefficient

is: a quantity μ that measures the rate of [exponential decrease](#) in [intensity](#), I , of [\$\gamma\$ -radiation](#) with [distance](#), x , travelled through a material. [P9.2]

is defined: by $I = I_0 e^{-\mu x}$. [P9.2]

depends for its value: on the material and on the [energy](#) of the [\$\gamma\$ -radiation photons](#). [P9.2]

auxiliary equation

of: the [differential equation](#)

$$a \frac{d^2y}{dt^2} + b \frac{dy}{dt} + cy = 0$$

is: the [quadratic equation](#) $ap^2 + bp + c = 0$. [[M5.5](#), [M6.3](#)]

has the significance: that its [roots](#), p_1 and p_2 appear in the [general solution](#) $B \exp(p_1 t) + C \exp(p_2 t)$ of the [differential equation](#). [[M5.5](#), [M6.3](#)]

may be generalized: (with changed significance) to other [differential equations](#) with [constant coefficients](#).

Flexible Learning Approach to Physics - Glossary

average

means: typical or representative, often describing a condition which, if it persisted, would have the same effect over a specified range as that of which it is an average.

is often used; as a synonym for [mean](#).

Flexible Learning Approach to Physics - Glossary

average a.c. power

of: an [a.c. circuit](#), or a part of such a circuit,

is: the total [energy](#) dissipated in one [period](#) of [oscillation](#) divided by the duration of that [period](#). [P5.4]

is given by: $\langle P \rangle = V_{\text{rms}} I_{\text{rms}} \cos \phi$, where V_{rms} and I_{rms} are the [root-mean-square values](#) of the [current](#) I and [potential difference](#) V and ϕ is the [phase difference](#) between I and V .

has as its SI unit: the [watt](#) (W). [P5.4]

Flexible Learning Approach to Physics - Glossary

average acceleration

over: a [time interval](#) Δt

of: a [body](#) moving in one [dimension](#), along the [x-axis](#)

is given most simply: by the change of [velocity](#) Δv_x divided by the [time interval](#) Δt . That is, $\langle a_x \rangle = \Delta v_x / \Delta t$. [P2.1]

is given more specifically: for a [body](#) moving with [velocity](#) v_{x1} at [time](#) t_1 and [velocity](#) v_{x2} at [time](#) t_2 , by

$$\langle a_x \rangle = \frac{v_{x2} - v_{x1}}{t_2 - t_1} \quad [\text{P2.1}]$$

Flexible Learning Approach to Physics - Glossary

average angular speed

over: a [time interval](#) Δt

of: a [particle](#) moving in a [circle](#) (whose [centre](#) is taken to be the [origin](#))

is: the (positive) [angle](#) $\Delta\theta$ swept out by the [position vector](#) of the [particle](#) divided by the [time interval](#) Δt , i.e. $\langle \omega \rangle = \Delta\theta/\Delta t$. [[P2.6](#)]

Flexible Learning Approach to Physics - Glossary

average speed

of: the [molecules](#) in a [gas](#) with [speed distribution](#) $f(v)$

is obtained: by dividing the [sum](#) of the [speeds](#) of all the [molecules](#) by the total number of [molecules](#). [[P7.5](#)]

is also obtained: by evaluating the [integral](#) $\langle v \rangle = \int_0^{\infty} v f(v) dv$. [[P7.5](#)]

See applications of integration in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

average value of a function

over: the [interval](#) from a to b

is defined: as $f_{\text{av}} = \frac{1}{(b-a)} \int_a^b f(x) dx$. [M5.4]

Flexible Learning Approach to Physics - Glossary

average velocity

over: a [time interval](#) Δt

of: a [body](#) moving in one [dimension](#), along the [x-axis](#)

is given most simply: by the change of [position](#) Δx divided by the [time interval](#) Δt , i.e. $\langle v_x \rangle = \Delta x / \Delta t$. [[M4.1](#), [P2.1](#)]

is given more specifically: for a [body](#) with [position](#) x_1 at [time](#) t_1 and [position](#) x_2 at [time](#) t_2 by

$$\langle v_x \rangle = \frac{x_2 - x_1}{t_2 - t_1} \quad [\text{M4.1}, \text{P2.1}]$$

may be similarly expressed: in terms of the [displacement](#) s_x from a fixed point, rather than the [position](#) x . [[P2.1](#)]

of: a [body](#) moving in three [dimensions](#)

is given most simply: by the change of [position](#) $\Delta \mathbf{r}$ divided by the [time interval](#) Δt , i.e. $\langle \mathbf{v} \rangle = \Delta \mathbf{r} / \Delta t$. [[P2.2](#)]

is given more specifically: if the [particle](#) has [position](#) \mathbf{r}_1 at [time](#) t_1 and [position](#) \mathbf{r}_2 at [time](#) t_2 , by

$$\langle \mathbf{v} \rangle = \frac{\mathbf{r}_2 - \mathbf{r}_1}{t_2 - t_1}$$

So, writing $\mathbf{r}_2 - \mathbf{r}_1 = \Delta \mathbf{r} = (\Delta x, \Delta y, \Delta z)$,

$$\langle \mathbf{v} \rangle = (\langle v_x \rangle, \langle v_y \rangle, \langle v_z \rangle) = \frac{\Delta \mathbf{r}}{\Delta t} = \left(\frac{\Delta x}{\Delta t}, \frac{\Delta y}{\Delta t}, \frac{\Delta z}{\Delta t} \right) \quad [\text{P2.2}]$$

Flexible Learning Approach to Physics - Glossary

Avogadro's constant

is: the [physical constant](#) N_A that represents the number of basic entities ([atoms](#), [molecules](#), [ions](#) etc.) per [mole](#) of any substance, [[P7.1](#), [P7.2](#)]

has: the value $N_A = 6.0223 \times 10^{23} \text{ mol}^{-1}$ (to five [significant figures](#)). [[P7.1](#), [P7.2](#)]

Compare with [Avogadro's number](#) (which has no [units](#)).

Avogadro's hypothesis

states: that equal [volumes](#) of all [gases](#) at the same [temperature](#) and [pressure](#) contain the same number of [atoms](#) or [molecules](#). [[P7.1](#)]

Avogadro's number

is: the number of basic entities ([atoms](#), [molecules](#), [ions](#), etc.) in one [mole](#) of any substance, namely 6.0223×10^{23} (to five [significant figures](#)). [[P7.1](#), [P7.2](#)]

Compare with [Avogadro's constant](#) (which is defined per [mole](#), and consequently has [units](#) mol⁻¹).

Flexible Learning Approach to Physics - Glossary

axes

are: [straight lines](#) at an [angle](#) to one another, along which and from which we can measure the [coordinates](#) of a [point](#). [P1.3]

usually are: [Cartesian coordinate](#) axes, which are at [right angles](#) to one another and which intersect at a common [point](#) called the [origin](#). [M1.3]

Flexible Learning Approach to Physics - Glossary

axis of rotation

of: a rotating [rigid body](#)

is: the [straight line](#) connecting all parts of the [body](#) which are at rest. [P2.8]

β -decay

is: the process in which a [nucleus](#) undergoes [radioactive decay](#) to form a less massive [nucleus](#) of a different [element](#) with the emission of a [\$\beta\$ -particle](#). [P9.2]

is classified: in two types: β^- -decay and β^+ -decay. [P9.2]

if β^- -decay, is: [radioactive decay](#) with the ejection of an [electron](#) (a β^- -particle) and an [electron antineutrino](#), e.g. ${}^{15}_6\text{C} \rightarrow {}^{15}_7\text{N} + {}^0_{-1}\text{e} + \bar{\nu}_e$. A [neutron](#) in the original [nucleus](#) is transformed into a [proton](#), an [electron](#) and an [electron antineutrino](#): $n \rightarrow p + e^- + \bar{\nu}_e$. [P9.2]

if β^+ -decay, is: [radioactive decay](#) with the ejection of a [positron](#) and an [electron neutrino](#), e.g. ${}^{11}_6\text{C} \rightarrow {}^{11}_5\text{B} + {}^0_{+1}\text{e} + \nu_e$. A [proton](#) in the original [nucleus](#) is transformed into a [neutron](#), a [positron](#) and an [electron neutrino](#): $p \rightarrow n + e^+ + \nu_e$. [P9.2]

Flexible Learning Approach to Physics - Glossary

β -particle

is: a [particle](#) that is [emitted](#) in [\$\beta\$ -decay](#). [P9.2]

is classified: in two types: the β^- -particle (an [electron](#)) which is [emitted](#) in [\$\beta^-\$ -decay](#), and the β^+ -particle (a [positron](#)) which is [emitted](#) in [\$\beta^+\$ -decay](#). [P9.2]

bac cab rule

is: a mnemonic reference to the [vector identity](#)
 $\mathbf{a} \times (\mathbf{b} \times \mathbf{c}) = \mathbf{b}(\mathbf{a} \cdot \mathbf{c}) - \mathbf{c}(\mathbf{a} \cdot \mathbf{b})$. [[M2.7](#)]

Flexible Learning Approach to Physics - Glossary

balanced bridge

is: a [bridge circuit](#) whose [electrical components](#) are arranged so that there is no [voltage](#) between its output [terminals](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

balanced forces

are: two or more [forces](#) whose [magnitudes](#) and [directions](#) are such that their [net force](#) or [resultant force](#) is zero. [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

ballistic galvanometer

is usually: a type of [moving-coil galvanometer](#). [P4.4]

is designed: with a weak [restoring force](#) and a weak [damping force](#), so that a [transient current](#) produces an initial swing whose [amplitude](#) is [proportional](#) to the total [charge](#) passed.

is used: to measure quantities of [electric charge](#), and (in conjunction with a [search coil](#)) [magnetic fields](#). [P4.4]

Balmer series

is: the [set](#) of visible [lines](#) in the [spectrum](#) of [atomic](#) hydrogen, whose [wavelengths](#) are given by [Balmer's formula](#). [[P8.2](#)]

Balmer's formula

is: the formula discovered by Johann Balmer (1825-1898) which gives, to a very high accuracy, the [wavelengths](#) of the visible [spectral lines](#) emitted by [atomic hydrogen](#):

$$\lambda = 364.56 \left\{ \frac{n^2}{n^2 - 4} \right\} \text{nanometres.} \quad [\text{P8.2}]$$

Flexible Learning Approach to Physics - Glossary

back e.m.f.

See [induced voltage](#).

Flexible Learning Approach to Physics - Glossary

band theory

is: the proposal that the [energy levels](#) of [electrons](#) in ([crystalline](#)) [solids](#) are distributed in [energy bands](#). [[P11.4](#)]

is also: the theoretical study of [energy bands](#) and their consequences. [[P11.4](#)]

Flexible Learning Approach to Physics - Glossary

bar

is: a non-[SI unit](#) of [pressure](#).

is defined: as $1 \text{ bar} = 10^5 \text{ Pa}$ (i.e. 10^5 N m^{-2}). [[P7.2](#)]

is slightly smaller: than another non-[SI unit](#) of [pressure](#), the [standard atmosphere](#); $1 \text{ atm} = 1.013 25 \text{ bar}$. [[P7.2](#)]

barrier penetration

See [quantum tunnelling](#).

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base (of a number system)

of: a system for specifying numbers

is: a number that takes on the role that 10 plays in the specification of [decimal numbers](#). A base n system uses n [digits](#) and is based on [powers](#) of n . [\[M1.2\]](#)

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base (of a logarithm)

is defined: as the value of a in the identity $a^{\log_a(x)} = x$. [[M1.5](#)]

must be: positive. [[M1.5](#)]

is most commonly: e (the base of [natural logarithms](#)) or 10 (the base of [common logarithms](#)). [[M1.5](#)]

basic differentiation

is: an informal term used to denote a range of mathematical skills in the area of [differentiation](#). [M4.2]

includes: the ability to [differentiate](#) 'standard' [functions](#) such as $\sin(kx)$, $\cos(kx)$, $\exp(kx)$ and $\log_e(kx)$, together with [constant multiples](#), [sums](#), [products](#) and [quotients](#) of such [functions](#). [M4.2]

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basic identities

are: a class of [trigonometric identities](#). [M1.6]

See trigonometric functions in the [Maths handbook](#) for further details.

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base units

are: seven [SI units](#). [[P1.1](#)]

comprise: the [metre](#), [kilogram](#), [second](#), [ampere](#), [kelvin](#), [mole](#) and [candela](#). [[P1.1](#)]

Flexible Learning Approach to Physics - Glossary

battery

consists: of two or more [electric cells](#) connected together to act as a single [current](#) source. (Colloquially, a single [cell](#) is also called a battery.) [[P4.5](#)]

Flexible Learning Approach to Physics - Glossary

beam

is: a collection of [waves](#) or [particles](#) travelling along closely parallel paths.

is also: a bundle of closely parallel [rays](#).

Flexible Learning Approach to Physics - Glossary

beat frequency

between: two [oscillations](#) or [waves](#) of similar [frequency](#) that are [superposed](#)

is: the [frequency](#) of the (modulated) [amplitude](#) of the [superposed waves](#). [[P5.1](#)]

is equal: to the difference between the [frequencies](#) of the two [oscillations](#) or [waves](#). [[P5.1](#), [P5.3](#), [P5.7](#)]

is also equal: to the [reciprocal](#) of the [beat period](#). [[P5.7](#)]

Flexible Learning Approach to Physics - Glossary

beat period

is: the [time interval](#) between successive [beats](#) in situations where two [waves](#) (e.g. [sound waves](#)) of slightly different [frequency](#) are [superposed](#). [[P5.7](#)]

is equal: to the [reciprocal](#) of the [beat frequency](#). [[P5.7](#)]

Flexible Learning Approach to Physics - Glossary

beating

between: two [oscillations](#) or [waves](#) of similar [frequency](#) that are [superposed](#)

is: the periodic variation of the total [amplitude](#) that gives rise to [beats](#). [P5.1]

occurs: at the [beat frequency](#). [P5.1]

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beats

are: [periodic](#) variations in [intensity](#) due to [beating](#). [[P5.1](#), [P5.7](#)]

are produced: when two [waves](#) of nearly equal [frequency](#) and similar [amplitude](#) are [superposed](#). [[P5.1](#), [P5.7](#)]

Flexible Learning Approach to Physics - Glossary

becquerel, Bq

is: the [SI unit](#) of [activity](#).

is defined: as an [activity](#) of 1 decay per [second](#).

is related: to a common non-[SI unit](#), the curie (Ci), by $1 \text{ Ci} = 3.70 \times 10^{10} \text{ Bq}$.
[\[P9.2\]](#)

Flexible Learning Approach to Physics - Glossary

biconcave lens

is: a [lens](#) having two [surfaces](#) which curve inwards into the material. The centre is thinner than the edges. [[P6.3](#)]

often is called simply: a [concave lens](#). [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

biconvex lens

is: a [lens](#) having two [surfaces](#) which curve outwards from the material. The centre is thicker than the edges. [[P6.3](#)]

often is called simply: a [convex lens](#). [[P6.3](#)]

bimetallic strip

is: a [thermally](#) sensitive device consisting of two thin strips of different metals soldered, or otherwise attached, face to face. [[P7.2](#)]

bends: with any change in [temperature](#), since the extent to which the two metals expand in response to a given change of [temperature](#) will generally differ. [[P7.2](#)]

can be used: to measure [temperature](#) or as a means of [temperature](#)-sensitive control. [[P7.2](#)]

Flexible Learning Approach to Physics - Glossary

binding energy (of a nucleus)

of: a [nucleus](#)

is: the minimum [energy](#) required to break a [nucleus](#) apart into its free constituent [nucleons](#). [P9.1]

more generally is: the minimum [energy](#) required to separate any [system](#) into appropriately specified components.

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binding energy (of an electron)

of: an [electron](#)

in: an [atom](#)

is: the minimum [energy](#) required to remove the [electron](#) from the [atom](#).
[P8.1]

binomial coefficient

is: any one of the coefficients, ${}^n C_r$, that arise in the [binomial expansion](#). [M1.7]

is defined: as

$$\begin{aligned} {}^n C_r &= \frac{n!}{r!(n-r)!} \\ &= \frac{n(n-1)(n-2)\dots(n-r+2)(n-r+1)}{r(r-1)(r-2)\dots 2 \times 1} \end{aligned}$$

where $n \geq r$.

(See [factorial](#) for the definition of $n!$) [M1.7]

See summations and series in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

binomial expansion

is: a [polynomial expression](#) for $(a + b)^n$, where n is a positive [integer](#):

$$(a + b)^n = \sum_{k=0}^n {}^n C_{n-k} a^{n-k} b^k$$

where ${}^n C_r$ is a [binomial coefficient](#) and \sum is the [summation symbol](#). [M1.7]

See [binomial series](#), [binomial theorem](#).

See also summations and series in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

binomial series

is: an [infinite series](#) for $(1 + x)^r$, where r is any real number and $-1 < x < 1$:

$$(1 + x)^r = 1 + \frac{rx}{1!} + \frac{r(r-1)x^2}{2!} + \frac{r(r-1)(r-2)x^3}{3!} + \dots \quad [\text{M1.7}]$$

is equivalent: to the corresponding [binomial expansion](#) when r is an [integer](#).

See summations and series in the [Maths handbook](#).

binomial theorem

is: an alternative expression for the [binomial expansion](#) or the [binomial series](#).
[\[M1.7\]](#)

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bisection method

for: locating a [root](#) of an [equation](#)

works: by constructing a sequence of [intervals](#) of decreasing [length](#), such that the associated [function](#) changes sign on each [interval](#). [[M1.4](#)]

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bisector

is: a [line](#) drawn in such a way that it cuts a specified [angle](#) into two equal parts. [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

black body

is: an idealized object that [absorbs](#) all the [electromagnetic radiation](#) that falls upon it. [[P8.2](#), [P10.1](#)]

reflects: absolutely no [radiation](#). [[P8.2](#), [P10.1](#)]

is also: an ideal [emitter](#) of [radiation](#). [[P8.2](#), [P10.1](#)]

emits: [black-body radiation](#) - which has a [spectrum](#) that depends only on the [temperature](#) of the black body. [[P8.2](#), [P10.1](#)]

has: [spectral brightness](#) which is given by [Planck's function](#). [[P7.3](#)]

is approximated roughly: by a matt black [surface](#). [[P7.3](#)]

is approximated well: by a cavity maintained at a well-defined [temperature](#) and connected to its environment by a small [aperture](#). The [spectrum](#) of [radiation](#) inside such a cavity is described quite accurately by [Planck's function](#), and the [radiation](#) emitted from the small hole closely approximates [black-body radiation](#) irrespective of the material of the container or the state of its inner [surface](#). [[P7.3](#), [P8.2](#), [P10.1](#)]

black-body radiation

is: [electromagnetic radiation](#) emitted by a [black-body](#). [P8.2, P10.1]

has: a characteristic [spectrum](#) whose [spectral brightness](#) at [wavelength](#) λ is given by [Planck's function](#):

$$R_{\lambda} = \frac{2hc^2}{\lambda^5 (\exp(hc / \lambda kT) - 1)}$$

with an overall shape, a [wavelength](#) for peak [emission](#), and a total [radiated power](#) per [unit surface area](#) all determined entirely by the [temperature](#) of the [black-body](#). [P7.3, P8.2, P10.1]

is also found: within a cavity in [thermodynamic equilibrium](#). [P8.2, P10.1]

therefore can be realized in practice: by using a cavity with a small [aperture](#). [P8.2, P10.1]

black-body spectrum

See [black-body radiation](#).

Flexible Learning Approach to Physics - Glossary

body

is: a collection of [interacting particles](#) which extends throughout a particular region of [space](#).

Bohr model

of: the hydrogen [atom](#)

is: now supplanted but remains historically important as the first theoretical account of atomic structure to make use of [quantum physics](#). [P8.2]

was formulated: by Niels Bohr (1885-1962) in 1913. [P8.2]

postulates: (1) that the negatively [charged electron](#) is held in a [circular orbit](#) around the positively [charged nucleus](#) by the [Coulomb force](#) between them;

(2) that the range of allowable [orbits](#) is restricted by the requirement that the [angular momentum](#) of the orbiting [electron](#) is [quantized](#) in [units](#) of $h/2\pi$, where h is [Planck's constant](#);

(3) that, contrary to [classical physics](#), the orbiting [electron](#) does not continuously lose [energy](#) through the [emission](#) of [electromagnetic radiation](#);

(4) that [electromagnetic radiation](#) is emitted when the [electron](#) makes a [transition](#) from an initial [orbit](#) of [energy](#) E_i to a final [orbit](#) of [energy](#) E_f and that the [frequency](#) of that radiation is given by the [Planck-Einstein formula](#) as $f = (E_i - E_f)/h$. [P8.2]

explains: many features of the [spectrum](#) of atomic hydrogen, including [Balmer's formula](#). [P8.2, P11.3]

may be: extended to atoms other than hydrogen, but only with limited success.

See [Bohr orbit](#), [Bohr radius](#), [Bohr's quantization](#), [Bohr's quantum number](#).

Flexible Learning Approach to Physics - Glossary

Bohr orbit

in: the [Bohr model](#) of the hydrogen [atom](#)

is: one of the allowed [orbits](#) for the [electron](#). An [electron](#) in such an [orbit](#) moves with a definite [speed](#) and has a [constant energy](#); contrary to [classical physics](#), it does not continuously [emit electromagnetic radiation](#). [P8.2]

corresponds: to a definite [energy level](#) of the [atom](#). [P8.2]

Flexible Learning Approach to Physics - Glossary

Bohr radius

in: the [Bohr model](#) of the hydrogen [atom](#)

is: the [radius](#) of the smallest [Bohr orbit](#) for the [electron](#). [[P8.2](#), [P11.3](#)]

is given: by $a_0 = \frac{\epsilon_0 h^2}{\pi m_e e^2}$ where ϵ_0 is the [permittivity of free space](#), m_e is the [mass](#) of the [electron](#), e the [charge](#) on the [proton](#), and h is [Planck's constant](#). [[P8.2](#)]

therefore is: [quantized](#) by [Bohr's quantum number](#) n . [[P8.2](#)]

Bohr's quantization condition

in: the [Bohr model](#) of the hydrogen [atom](#)

states: that the [magnitude](#) L of the [angular momentum](#) of the electron as it orbits the nucleus must be a positive integer multiple of [Planck's constant](#) h divided by 2π . Thus:

$$L = \frac{nh}{2\pi} \text{ for } n = 1, 2, 3, \dots$$

where n is called [Bohr's quantum number](#). [[P8.2](#)]

Bohr's quantum number

in: the [Bohr model](#) of the hydrogen [atom](#)

is: an [integer](#) n that may take any positive value starting from 1, and which determines the ([quantized](#)) [angular momentum magnitude](#) L of the [electron](#) in the n^{th} [Bohr orbit](#) around the [nucleus](#) (see [Bohr's quantization](#)). [P8.2]

also determines: the radius of the n^{th} [Bohr orbit](#) and the associated [energy level](#):

$$E_n = -(13.6 \text{ eV})/n^2 \text{ for } n = 1, 2, 3, \dots \text{ [P8.2]}$$

boiling point

of: a [liquid](#) subjected to a specified external [pressure](#) (usually [standard atmospheric pressure](#))

is: the [temperature](#) at which the [saturated vapour pressure](#) of the [liquid](#) is equal to the external [pressure](#).

Boltzmann's constant

is: the [physical constant](#) k that has the value $k = 1.380 \times 10^{-23} \text{ J K}^{-1}$ (to four [significant figures](#)). [P7.5]

is expressible: in terms of two other [physical constants](#), the [molar gas constant](#) R and [Avogadro's constant](#) N_A , by $k = R/N_A$. From this, Boltzmann's constant is seen to act as the [gas constant](#) per [molecule](#). [P7.5]

appears: in [equations](#) which relate [microscopic](#) properties to [macroscopic parameters](#) of [physical systems](#); e.g. in an [ideal gas](#) at [temperature](#) T , the [mean translational kinetic energy](#) of a [particle](#) is $3kT/2$. [P7.5]

Flexible Learning Approach to Physics - Glossary

bond

between: [atoms](#) in a [molecule](#) or [molecules](#) in a [solid](#) (more particularly between specified [states](#) of those [atoms](#) or [molecules](#))

is: a [quantum physical](#) phenomenon associated with a specific [bonding energy](#) that causes the [atoms](#) or [molecules](#) that have bonded to act as a single entity. [P11.4]

is fundamentally explained: by [electromagnetic forces](#) between the [atoms](#) or [molecules](#). [P11.4]

may be classified: according to the number of [electrons](#) involved in maintaining the bond.

bonding electron

is: an [electron](#) involved in forming or maintaining a [bond](#) between [atoms](#) or [molecules](#).

Flexible Learning Approach to Physics - Glossary

bonding energy

is: the minimum [energy](#) required to break a specific [bond](#).

Born probability interpretation (hypothesis)

is: the association between the [wavefunction](#) of a [particle](#) and the [probability](#) of finding that [particle](#) in a given region of [space](#) at a particular [time](#).

states: that if a [particle](#) moving in one [dimension](#) has the [wavefunction](#) $\Psi(x, t)$, then the [probability](#) of finding the [particle](#) in a small region Δx around x at [time](#) t is [proportional](#) to $|\Psi(x, t)|^2 \Delta x$. If the [wavefunction](#) is [normalized](#), then the [probability](#) is equal to $|\Psi(x, t)|^2 \Delta x$. [P10.4, P11.1]

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bound state

of: a [quantum system](#)

is: a [state](#) of a composite [system](#) in which a finite amount of [energy](#) is required to separate the components of the [system](#).

is: in [Schrödinger's model of the hydrogen atom](#), a [state](#) in which the [probability](#) that the [electron](#) will escape infinitely far from the [proton](#), is zero.

is: in the [Bohr model](#) of the hydrogen [atom](#), any one of an infinite number of possible [states](#), corresponding to the allowed [Bohr orbits](#) for the [electron](#), each with its own definite [energy](#) corresponding to one of the [energy levels](#). [[P8.2](#), [P11.3](#)]

boundary conditions

for: [differential equations](#)

are: conditions which specify the value of the [dependent variable](#) or its [derivatives](#), for specific values of the [independent variable](#). [[M6.1](#), [P11.1](#), [P11.2](#)]

can be used: to determine (or help to determine) any arbitrary [constants](#) that arise in the [general solution](#) of a [differential equation](#). [[P5.4](#), [P5.5](#), [P11.1](#), [P11.2](#)]

often arise as: conditions imposed on a [wave](#) at the boundary of a [medium](#), usually involving the value of either the [displacement](#) of the [medium](#) or the [derivative](#) of the [displacement](#) with respect to [position](#). [[P5.6](#), [P10.3](#)]

Boyle's law

states: that at [constant temperature](#), the [pressure](#) P and [volume](#) V of a fixed amount of [ideal gas](#) are related by $PV = \text{constant}$. [[P7.2](#)]

See [ideal gas equation of state](#).

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brackets

take the form: (), [], or { }. [M1.1]

have a hierarchy: {[()]}. [M1.1]

are used: to separate one part of an [expression](#) from the rest. In a [calculation](#), the part of an [expression](#) enclosed in brackets must be evaluated before being combined with other terms. [M1.1]

Flexible Learning Approach to Physics - Glossary

Bragg's law

for: [diffraction](#) of [monochromatic electromagnetic radiation](#) of [wavelength](#) λ

from: parallel planes of [atoms](#) separated by a [distance](#) d in an orderly array of [atoms](#) (such as a [crystal](#))

determines: the values of the angle θ , (measured between the incident ray and the plane of [atoms](#)) at which [local maxima](#) of [intensity](#) are formed in the [diffraction pattern](#) by [constructive interference](#) of the [reflected rays](#) from adjacent planes of [atoms](#). [P7.1]

is normally expressed: as $n\lambda = 2d \sin \theta$, where n is an [integer](#). [P7.1]

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branches

of: a [hyperbola](#)

refers: to the two separate parts of a [hyperbola](#) that are produced when a [plane intersects](#) a [double cone](#). [M2.3]

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breaking point

of: a given material

is: the [point](#) on the [loading curve](#) of the material at which the material breaks apart. [[P7.6](#)]

corresponds: to the maximum [tensile stress](#) that the material can sustain. [[P7.6](#)]

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breeder reactor

is: a [nuclear reactor](#) whose [reaction](#) products include material that can be used as fuel for further [reactions](#). [[P9.3](#)]

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bremsstrahlung

is: the [electromagnetic radiation](#) emitted when an [electrically charged particle](#) is [accelerated](#), in particular, when it is slowed down. For example, when high-energy [electrons](#) collide with a target, [X-rays](#) are produced with a [continuous spectrum](#). [[P8.3](#)]

linguistically is: German for 'braking radiation'. [[P8.3](#), [P10.1](#)]

bridge circuit

is: a [circuit](#) consisting of four [electrical components](#) (generally [resistors](#)) connecting four [points](#) (A, B, C, D, say) to form a closed loop. [[P4.1](#)]

produces: an output [voltage](#) between two non-adjacent points (A and C say) when a [voltage](#) source is connected across the other two [points](#) (B and D). [[P4.1](#)]

is used: to compare [resistances](#). [[P4.1](#)]

is balanced: when the [resistances](#) are such that the output [voltage](#) is zero.

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bridge circuit balance condition

is: the [equation](#) which relates the four [resistances](#) in a balanced [bridge circuit](#).
[\[P4.1\]](#)

Flexible Learning Approach to Physics - Glossary

brittleness

is: the property of a material which causes it to [fracture](#) without appreciable [plasticity](#), before or soon after the [elastic limit](#) is reached. [[P7.6](#)]

Brownian motion

is: the [microscopic](#) random [motion](#) of pollen grains and other small particles suspended in [gases](#) or [liquids](#). [[P7.1](#), [P8.1](#)]

was first observed: by the botanist Robert Brown (1773-1858). [[P7.1](#), [P8.1](#)]

was explained: as the result of numerous unseen [molecular](#) collisions, by Albert Einstein (1879-1955) in 1905. [[P7.1](#), [P8.1](#)]

Flexible Learning Approach to Physics - Glossary

bulk modulus

of: a material ([solid](#), [liquid](#) or [gas](#))

is: an [elastic modulus](#), conventionally denoted K . [[P5.7](#), [P7.6](#)]

is defined: as the [ratio](#) of the applied [volume stress](#) σ_{vol} to the resulting [volume strain](#) ϵ_{vol} :

$$K = \frac{\sigma_{\text{vol}}}{\epsilon_{\text{vol}}} = \frac{-\text{pressure change}}{\text{fractional volume change}} \quad (\text{note the } - \text{ sign}) \quad [\text{P5.7}]$$

has as its SI unit: N m^{-2} or Pa (i.e. [pascal](#)). [[P5.7](#), [P7.6](#)]

Flexible Learning Approach to Physics - Glossary

buoyancy

is: the phenomenon by which a [fluid](#) tends to reduce the apparent [weight](#) of a [body](#) through the [buoyancy force](#). [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

buoyancy force

is: the vertical upward [force](#) exerted on a [body](#) by a static [fluid](#) in which it is submerged or floating. [[P7.6](#)]

is quantified: by [Archimedes' principle](#). [[P7.6](#)]

is also called: the upthrust. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

caesium atomic clock

is: a device that uses an [atomic resonance](#) in caesium of very narrow [resonance absorption bandwidth](#) and very high [Q-factor](#), to provide a [time](#) or [frequency standard](#). [P5.3]

is used: to establish the [SI unit](#) of [time](#), the [second](#). [P5.3]

calculation

is: a sequence of [mathematical operations](#) performed with the objective of determining the answer to a question.

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calculus

is: a branch of [mathematics](#) which is concerned with the way in which (small) changes in one quantity determine or are determined by changes in related quantities. [[M4.1](#), [P2.1](#)]

is more properly called: [infinitesimal](#) calculus. [[M4.1](#), [P2.1](#)]

includes: [differentiation](#) and [integration](#). [[M4.1](#), [P2.1](#)]

Flexible Learning Approach to Physics - Glossary

calibration

is: the process of checking one [measuring](#) instrument against another, more [accurate](#) one. [[P1.1](#)]

Flexible Learning Approach to Physics - Glossary

calibration points

for: a [thermometer](#)

are: two or more fixed points which can be used to [calibrate](#) the scale of the [thermometer](#). [P7.2]

are usually: [triple points](#) or [boiling](#) or [freezing points](#). In the case of the [Kelvin temperature scale](#) one of the two points is the unattainable [absolute zero](#), the other is the [triple point](#) of H₂O. [P7.2]

permit between or beyond them: [interpolations](#) or [extrapolations](#), often using [polynomial thermometric relations](#). [P7.2]

Flexible Learning Approach to Physics - Glossary

calorimeter

is: a container of known [heat capacity](#) used in [calorimetry experiments](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

calorimetry

is: the branch of [physics](#) concerned with the measurement of [heat](#) and its effects. [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

camera

is: a device for producing a record of an [image](#), either on photographic film or via some other means (e.g. electronic). [\[P6.4\]](#)

See also [pinhole camera](#). [\[P6.4\]](#)

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cancelling

is: a term used to describe the [mathematical](#) process in which (a) a [factor](#) appearing on both sides of an [equation](#) is eliminated by dividing both sides of the [equation](#) by that [factor](#); or (b) a [factor](#) appearing in both the [numerator](#) and [denominator](#) of a [fraction](#) ([arithmetic](#) or [algebraic](#)) is eliminated by dividing both the [numerator](#) and the [denominator](#) by that [factor](#). [M1.1]

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candela, cd

is: the [SI unit](#) of luminous intensity, one of the seven [base units](#). (Not used in *FLAP*.)

Flexible Learning Approach to Physics - Glossary

capacitance

of: an isolated [electrical conductor](#)

is: the [ratio](#) of the [charge](#) q stored on the [conductor](#), to the [potential difference](#) V between it and some selected reference point. [P4.5]

is given: by $C = q/V$. [P4.5, P5.5]

more generally is: the [charge](#) stored between two points per [unit potential difference](#) between those points.

is exemplified: by the capacitance between the [terminals](#) of a [capacitor](#), which for [parallel](#) plates of [area](#) A separated by a [dielectric](#) with [permittivity](#) ϵ and thickness d is $C = \epsilon A/d$. [P4.5]

has as its SI unit: the [farad](#), (F), where $1 \text{ F} = 1 \text{ C V}^{-1}$. [P4.5, P5.5]

Flexible Learning Approach to Physics - Glossary

capacitive reactance

of: a [capacitor](#) with [capacitance](#) C , when passing [alternating current](#) of [angular frequency](#) ω

is: the [ratio](#) of the [peak voltage](#) to the [peak current](#) V_0/I_0 . [[P5.4](#), [P5.5](#)]

is given: by $X_C = 1/\omega C$. [[P5.4](#), [P5.5](#)]

has as its SI unit: the [ohm](#) (Ω). [[P5.4](#), [P5.5](#)]

See [complex capacitive reactance](#), [impedance](#), [reactance](#).

Flexible Learning Approach to Physics - Glossary

capacitive time constant

is: the [time](#) for the [current](#), [charge](#) or [voltage](#) across a [capacitor](#) to [decay exponentially](#) by a factor e . [[P4.5](#)]

is given: for a [circuit](#) in which a [capacitor](#) of [capacitance](#) C discharges through a [resistance](#) R , by $\tau = RC$. [[P4.5](#)]

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capacitor

is: a device for storing [electric charge](#). [[P4.5](#), [P5.5](#)]

usually consists: of two [parallel](#) metal [surfaces](#) (not necessarily flat) separated by a [dielectric](#). [[P4.5](#)]

generally has: in practical electronic [circuits](#), a [capacitance](#) very much less than 1 [farad](#) (1 F) so its [capacitance](#) might well be expressed in microfarad (μF) or picofarad (pF).

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capillarity

is: the elevation or depression of the [surface](#) of a [liquid](#) in contact with a [solid](#) due to the relative attraction of the [liquid molecules](#) for each other as compared to their attraction to those of the [solid](#). [P7.6]

See [meniscus](#).

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capillary

is: a tube of narrow internal [diameter](#). [P7.6]

See [capillarity](#).

Carnot cycle

in: [thermodynamics](#)

is: a [reversible closed cycle](#) consisting of four steps, two [isothermal processes](#) linked by two [adiabatic processes](#). [P7.4]

See [Carnot engine](#).

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Carnot engine

is: a [reversible heat engine](#) that utilizes the [Carnot cycle](#). [P7.4]

has: [efficiency](#) $\eta = 1 - T_{\text{cold}}/T_{\text{hot}}$ when operating between [temperatures](#) T_{hot} and T_{cold} . (Any [reversible heat engine](#) operating between those [temperatures](#) must have the same [efficiency](#).) [P7.4]

is: the most [efficient](#) possible [heat engine](#) operating between two fixed [temperatures](#). [P7.4]

Cartesian axes

See [Cartesian coordinate system](#).

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Cartesian component vectors

of: a [vector](#) \mathbf{v} , with respect to a given [Cartesian coordinate system](#)

are: the [vectors](#) \mathbf{v}_x , \mathbf{v}_y , \mathbf{v}_z directed along the [Cartesian axes](#) such that $\mathbf{v}_x + \mathbf{v}_y + \mathbf{v}_z = \mathbf{v}$. [M2.5]

are therefore: individually proportional to the corresponding [Cartesian unit vectors](#) \mathbf{i} , \mathbf{j} and \mathbf{k} . [M2.5]

should not be confused with: the [Cartesian scalar components](#) (v_x , v_y , v_z) of \mathbf{v} which are individually the scalars by which a [Cartesian unit vector](#) must be [scaled](#) to produce the corresponding component vector (e.g. $\mathbf{v}_x = v_x \mathbf{i}$). [M2.5]

Cartesian coordinate system

is: a [coordinate system](#) that uses [Cartesian coordinates](#), measured along mutually [perpendicular axes](#) from a [point](#) of common [intersection](#) called the [origin](#). In three [dimensions](#), the three [axes](#) are conventionally labelled as the [x-axis](#), [y-axis](#) and [z-axis](#), and it is conventional to perform the labelling so as to produce a [right-handed coordinate system](#) rather than a [left-handed coordinate system](#).

can be generalized: to any number of [dimensions](#).

Cartesian coordinates

are: [coordinates](#) measured from a common [origin](#) along [axes](#) that [intersect](#) (at the [origin](#)) at [right angles](#). The horizontal [axis](#) normally is used to represent values of x . In two [dimensions](#), the vertical [axis](#) is used to represent values of y . In three [dimensions](#), the second horizontal [axis](#) is used to represent values of y , and the vertical [axis](#) to represent values of z . The convention is to refer to these as the [x-axis](#), [y-axis](#) and [z-axis](#). [[M1.3](#), [M2.2](#)]

can be used: for any number of [dimensions](#). [[M1.3](#), [M2.2](#)]

Cartesian form (of a complex number)

represents: a [complex number](#) as $a + ib$ with a and b [real](#). [M3.2]

Compare and contrast with [exponential form](#) and [polar form](#), and see complex numbers in the [Maths handbook](#) for the relationship between these forms.

Cartesian form (of a vector)

is: the form in which a [vector](#) \mathbf{v} is represented as a [vector sum](#) of [Cartesian component vectors](#): $\mathbf{v} = v_x \mathbf{i} + v_y \mathbf{j} + v_z \mathbf{k}$ or of [scaled Cartesian unit vectors](#): $\mathbf{v} = v_x \mathbf{i} + v_y \mathbf{j} + v_z \mathbf{k}$ or, equivalently, as an [ordered triple](#) of [Cartesian scalar components](#): $\mathbf{v} = (v_x, v_y, v_z)$. [[M2.5](#)]

See scalars and vectors in the [Maths handbook](#).

Cartesian representation (of a complex number)

See [Cartesian form](#).

Cartesian scalar components

of: a [vector](#) \mathbf{v}

are: the [scalar](#) quantities v_x , v_y and v_z which appear in the [expression](#) for \mathbf{v} when given in the [Cartesian form](#) $v_x \mathbf{i} + v_y \mathbf{j} + v_z \mathbf{k}$. [M2.5]

are individually equal: to the [projection](#) of \mathbf{v} onto the corresponding [Cartesian unit vector](#), so $v_x = \mathbf{v} \cdot \mathbf{i}$, etc. [M2.6]

Cartesian sign convention

in: [optics](#)

is: a [sign convention](#) which takes the [pole](#) of a [surface](#) or the centre of a [lens](#) as the [origin](#) of a [Cartesian coordinate system](#), ascribing positive signs to [positions](#) measured to the right or upwards, and negative signs to [positions](#) measured to the left or downwards of this [origin](#). [[P6.3](#)]

Cartesian unit vectors

are: unit vectors in the mutually perpendicular directions of the Cartesian coordinate axes. Two such vectors are required in two dimensions, usually denoted by \mathbf{i} and \mathbf{j} in the directions of the x -axis and y -axis respectively. In three dimensions the three unit vectors are usually denoted \mathbf{i} , \mathbf{j} and \mathbf{k} . [M2.5]

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cathode

of: a [discharge tube](#) or a similar device

is: an [electrode](#) connected to the negative [terminal](#) of a supply of [electric current](#). [[P8.1](#)]

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cathode rays

are: the '[rays](#)' emanating from the [cathode](#) of a [discharge tube](#) containing [gas](#) at a sufficiently low [pressure](#). [[P8.1](#)]

are in fact: high-speed flows of [electrons](#), as shown by J. J. Thomson (1856-1940). [[P8.1](#)]

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cation

is: a positively [charged ion](#). [P8.4]

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caustic curve

is: the [curve](#) formed by the [superposition](#) of [rays](#) from a [lens](#) or [mirror](#) which suffers from [spherical aberration](#). [[P6.4](#)]

Cavendish's experiment

is: an [experiment](#) to determine [Newton's universal gravitational constant](#), G , first performed by Henry Cavendish (1731-1810) in 1798. [[P3.2](#)]

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cell

See [electric cell](#), and (in the context of [crystals](#)) [unit cell](#).

Celsius temperature scale

is: a nearly [centigrade temperature scale](#) which tracks the [Kelvin temperature scale](#) precisely. [P7.2]

is defined: in terms of the [Kelvin temperature scale](#) by $T_C/^{\circ}\text{C} = T/\text{K} - 273.15$, where T is an [absolute temperature](#) and T_C is the corresponding Celsius temperature. [P7.2]

is named: after Anders Celsius (1701-1744). [P7.2]

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centigrade

is: the description given to a [temperature](#) which is measured on a [centigrade temperature scale](#). [P7.2]

centigrade temperature scale

is: any [temperature scale](#) based on a [thermometric property](#) X that uses a [thermometric relation](#) of the form

$$T_{\text{cen}} = \frac{X - X_0}{X_{100} - X_0} \times 100^\circ \text{centigrade.} \quad [\text{P7.2}]$$

will agree: with another centigrade scale at any [fixed points](#) (normally the [freezing](#) and [boiling points](#) of water) that are common to both scales, but will not necessarily agree at any other points because different physical properties X may vary differently with [temperature](#). [P7.2]

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central force

is: a [force](#) that is always directed towards a fixed [point](#) (sometimes called the force centre) and which has the property that its [magnitude](#) depends only on the [distance](#) from that [point](#). [[P2.4](#), [P2.7](#), [P2.8](#)]

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centre

of: a [circle](#) (or [sphere](#))

is: the unique [point](#) that is at the same [distance](#) from every [point](#) on the [circumference](#) (or [surface](#)). [[M2.1](#), [M2.3](#)]

is also: the unique [point](#) at which any two different [diameters intersect](#). [[M2.1](#)]

is more generally: the mid-point of a [body](#) or [system](#).

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centre of gravity

of: a [rigid body](#) in a [gravitational field](#)

only exists: if the [gravitational field](#) is [uniform](#), or if the [body](#) has a sufficiently high degree of [symmetry](#).

is: the [point](#) (fixed with respect to the [body](#), but not necessarily within the [body](#)) at which the entire [mass](#) of the [body](#) can be considered to be concentrated for the purpose of determining the effect of [gravitational forces](#) on the [body](#). [[P2.3](#), [P2.7](#)]

is therefore: the [point](#) about which the [gravitational forces](#) produce no [resultant torque](#) irrespective of the orientation of the [body](#). [[P2.7](#)]

is determined: by the [gravitational forces](#) acting on the [body](#) as well as the distribution of [mass](#) within the [body](#), but will always coincide with the [centre of mass](#) for a [body](#) in a [uniform gravitational field](#).

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centre of mass

of: a [rigid body](#)

is: the [point](#) (not necessarily within the [body](#)) at which the entire [mass](#) of the [body](#) can be considered to be concentrated for the purpose of determining the [translational motion](#) of the [body](#) under an applied [force](#). If the [body](#) is entirely free to move and the [line of action](#) of the [force](#) passes through the centre of mass, that [force](#) will cause [translation](#) of the centre of mass but not [rotation](#) about the centre of mass. [[P2.3](#), [P2.7](#), [P2.8](#)]

is determined: by considering the body to consist of ([infinitesimal](#)) mass elements Δm_i at [positions](#) \mathbf{r}_i and then finding the point specified by \mathbf{r}_c , such that

$$\mathbf{r}_c = \frac{\sum_i \Delta m_i \mathbf{r}_i}{\sum_i \Delta m_i} \quad [\text{M5.4}]$$

should not be confused: with the [centre of gravity](#).

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centrifugal force

is: a fictitious [force](#) with no physical basis in fact, invented to allow [Newton's laws of motion](#) to be applied in a [rotating frame of reference](#), which is a non-inertial [frame of reference](#) where [Newton's laws](#) are otherwise invalid. [P2.3]

Flexible Learning Approach to Physics - Glossary

centripetal acceleration

of: a [particle](#) in [uniform circular motion](#)

is: an [acceleration](#) directed towards the centre of the [circle](#)

has magnitude: $r\omega^2$, where r is the [radius](#) of the [circle](#) and ω is the [particle's angular speed](#). [[P2.6](#), [P3.2](#)]

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centripetal force

on: a [particle](#) in [uniform circular motion](#)

is: the [force](#) which is necessary to maintain the [uniform circular motion](#).
[P2.3]

is directed: towards the centre of the [circle](#). [P2.3]

has magnitude: $m r \omega^2$, where r is the [radius](#) of the [circle](#), m is the [mass](#) of the [particle](#) and ω is its [angular speed](#). [P2.6, P3.2]

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chain rule

is: a rule used for [differentiating](#) a [function](#) of a [function](#), such as $f(g(x))$. The rule states that if $u = g(x)$ and $y = f(u)$ so that $y = f(g(x))$ then

$$\frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx} = f'(u) \times g'(x) \quad [\text{M4.3}]$$

See the chain rule and its uses in the [Maths handbook](#).

change of phase

is: a process in which a substance changes from the [solid phase](#), [liquid phase](#) or [gaseous phase](#) to one of the others. [[P7.3](#)]

changing the (dependent) variable

is: a technique used to transform a first-order [differential equation](#) into one that can be solved by a standard method such as [separation of variables](#) or use of an [integrating factor](#). A new [dependent variable](#) is defined as an appropriate [function](#) of the old [dependent variable](#) and the [independent variable](#). [M6.2]

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chaos

is: a property exhibited by [deterministic systems](#) which are described by certain [non-linear differential equations](#) (or [sets](#) of [non-linear equations](#)).

occurs: when two [systems](#) governed by the same [non-linear equation](#) but with slightly different [initial states](#) subsequently develop in completely dissimilar ways. [[M6.1](#)]

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characteristic emission spectrum

of: a [chemical element](#)

is: the [emission spectrum](#) from that [chemical element](#) and is unique to that [chemical element](#). [P8.2]

often contains: prominent [emission lines](#) and is then referred to as the [emission line spectrum](#) of the [chemical element](#). [P8.2]

characteristic X-ray spectrum

of: a heavy [atom](#)

is: the [characteristic emission spectrum](#) in the [X-ray wavelength](#) range from that [atom](#) and is unique to that kind of [atom](#). [P8.3]

is produced: when an ejected [inner shell](#) (comparatively low [energy](#)) [electron](#) is replaced by an [outer shell](#) (comparatively high [energy](#)) [electron](#), provided that the spacing between the [energy levels](#) is at least several thousand [electronvolts](#). [P8.3]

charge

See [electric charge](#).

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charge carriers

are: mobile [charged particles](#) (e.g. [electrons](#) and [ions](#)) that can move within a material. [[P4.1](#)]

See [hole](#).

Flexible Learning Approach to Physics - Glossary

charge sharing

is: the process by which a [body](#) can be [charged](#) by receiving some of the [charge](#) from another [charged](#) object with which it makes contact. [\[P3.3\]](#)

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charge-to-mass ratio

for: a [particle](#) of [charge](#) q and [mass](#) m

is equal: to q/m . In the case of the [electron](#) the quantity e/m . is often referred to as the charge-to-mass ratio, even though the [charge](#) of the [electron](#) is actually $q = -e$. [[P8.1](#)]

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Charles' law

states: that at [constant pressure](#), the [volume](#) V and [absolute temperature](#) T of a fixed quantity of [ideal gas](#) are related by $V/T = \text{constant}$. [[P7.2](#)]

chemical bonding

is: the binding together of [chemical elements](#) by [forces](#) that are fundamentally [electromagnetic](#). [P8.4]

See [covalent bonding](#), [ionic bonding](#), [metallic bonding](#).

chemical compound

is: a substance that consists of more than one [element](#), the [atoms](#) being bound together in a fixed [ratio](#) that is characteristic of the substance. [[P8.1](#)]

is also: a substance which can be broken down into more elementary substances by a process such as [heating](#) or the passing of an [electric current](#). [[P7.1](#)]

chemical element

traditionally is: a substance which cannot be divided or separated by chemical means, including [heating](#) and passing of [electrical current](#). [P8.1]

currently, is more appropriately defined: as [matter](#) consisting of [atoms](#) characterized by a single [atomic number](#) Z , which consequently contain a definite number of [protons](#). (The [atoms](#) may be bound together to form [molecules](#), as in the case of the diatomic oxygen [molecule](#) O_2 .) [P7.1, P8.1]

chemical formula

is: a formula such as H₂O which uses [chemical symbols](#) to indicate the [chemical elements](#) involved in a [chemical compound](#) and [subscripts](#) to show the relative numbers of [atoms](#) of those [chemical elements](#). [P8.1]

chemical reaction

is: a process in which [bonds](#) between [atoms](#) and [molecules](#) are made or broken with the result that materials are transformed.

chemical symbol

is: a symbol consisting of one or two letters that may be used to represent the name of a [chemical element](#). The first letter is always upper case while the second, if there is one, is lower case. [[P8.1](#)]

is exemplified: by H for hydrogen, He for helium and Na for sodium. (See a copy of the [periodic table](#) for a complete list.) [[P8.1](#)]

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chord

is: a [straight line](#) that cuts a [curve](#) at two [points](#). [[M2.1](#), [M4.1](#), [M4.2](#)]

chromatic aberration

is: [aberration](#) caused by the variation of the [focal length](#) of a [lens](#) with [wavelength](#), as a result of [dispersion](#). [P6.4]

appears as: coloured fringes seen on [images](#). [P6.4]

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ciliary muscles

make up: the ring of muscles surrounding the [lens](#) of the human eye. The [focal length](#) of the [lens](#) is changed as these muscles contract or relax. [[P6.4](#)]

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circle

of: [radius](#) R

centred: on a [point](#) P

is: the [locus](#) of all [points](#) in a [plane](#) that are located at a [distance](#) R from P .
[[M2.1](#), [M2.3](#), [P3.2](#)]

See [equation of a circle](#).

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circle of least confusion

is: the minimum but finite [image](#) size of a [point object](#), which results from [spherical aberration](#) – in which the [focal length](#) of the [lens](#) varies with the [radial distance](#) of [rays](#) from the [optical axis](#). [[P6.4](#)]

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circuit

is: a continuous closed pathway, or network of pathways, along which [electric charge](#) may flow. [[P4.1](#), [P5.5](#)]

circuit components

is: a general term for any of the many devices (e.g. [capacitors](#), [inductors](#), [resistors](#)) that might form part of a [circuit](#).

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circular

in: [geometry](#)

means: pertaining to a [circle](#). [M2.1]

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circumference (of a circle)

is (1): the [distance](#) $2\pi R$ around a [circle](#) of [radius](#) R . [[M2.1](#)]

is (2): the [circle](#) itself (as in 'a [point](#) on the circumference'). [[M2.1](#)]

See also [perimeter](#).

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classical mechanics

See [Newtonian mechanics](#).

Flexible Learning Approach to Physics - Glossary

classical physics

is: that part of [physics](#) which includes and builds on [Newtonian mechanics](#), [Maxwell's theory of electromagnetism](#), the [laws](#) of [thermodynamics](#) and (usually) [relativity](#), but which specifically excludes [quantum physics](#). [M6.4, P10.2]

Clausius-Clapeyron equation

is: an [equation](#) that relates the slope (dP/dT) of the boundary curve between two [phases](#) on a P - T diagram to the [latent heat](#) (ml) and change of [volume](#) (ΔV) involved in an [isothermal](#) crossing of that boundary at [temperature](#) T :

$$\frac{dP}{dT} = \frac{ml}{T \Delta V} \quad [\text{P7.4}]$$

Flexible Learning Approach to Physics - Glossary

closed cycle

is: any succession of processes (which may be [reversible](#) or [irreversible](#)) which restores a [system](#) to its [initial state](#). [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

codomain (of a function)

of: a [function](#)

is: that [set](#) within which can be found the range of values of the [dependent variable](#) which are generated by the [function](#) over its [domain](#). [[M1.3](#)]

Flexible Learning Approach to Physics - Glossary

coefficient

is: any one of the [constants](#), $a_0, a_1, a_2, \dots, a_{n-1}$ and a_n , that appear in a [polynomial expression](#) of the form $a_0 + a_1x + a_2x^2 + \dots + a_{n-1}x^{n-1} + a_nx^n$. [[M1.3](#), [M1.4](#)]

is exemplified: by the coefficient of x^3 in $x^4 - 5x^3 - x^2 + 4x + 2$, which is -5 .

coefficient of friction

See [coefficient of sliding friction](#), [coefficient of static friction](#).

Flexible Learning Approach to Physics - Glossary

coefficient of mutual inductance

of: a pair of [coils](#) (or [circuits](#)), or of a [transformer](#),

is: the quantity M that relates the [magnitude](#) of the [induced voltage](#) in one [coil](#) to the [rate of change](#) of [current](#), dI_2/dt , in the other [coil](#), through the equation

$$V_1 = M \left| \frac{dI_2}{dt} \right|. \quad [\text{P4.4}]$$

has as its SI unit: the [henry](#) (H), where $1 \text{ H} = 1 \text{ V s A}^{-1}$. [\[P4.4\]](#)

often is abbreviated: to mutual inductance. [\[P4.4\]](#)

See also '[mutual induction](#)'.

Flexible Learning Approach to Physics - Glossary

coefficient of self inductance

of: a [coil](#) (or [circuit](#))

is: the quantity L that relates the [magnitude](#) of the [self induced voltage](#) V_{ind} in the [coil](#) to the [rate of change](#) of [current](#) dI/dt in the [coil](#), through the equation

$$V_{\text{ind}} = L \left| \frac{dI}{dt} \right|. \quad [\text{P4.4}, \text{P4.5}]$$

has as its SI unit: the [henry](#) (H), where $1 \text{ H} = 1 \text{ V s A}^{-1}$. [\[P4.4, P4.5\]](#)

often is abbreviated: to self inductance or [inductance](#). [\[P4.4, P4.5\]](#)

See also [self-induction](#) and [inductance](#).

Flexible Learning Approach to Physics - Glossary

coefficient of sliding friction

for: an object sliding over a solid [surface](#)

is denoted: by μ_{slide} . [[P2.3](#)]

is: the [ratio](#) of the [magnitude](#) of the sliding [frictional force](#) on the object to the [magnitude](#) R of the [reaction force](#) on the object. [[P2.3](#)]

depends: on the [surfaces](#) involved and their [state](#) of lubrication. [[P2.3](#)]

is largely independent: of other factors, including the [area](#) of contact and the [speed](#) of the object. [[P2.3](#)]

usually is: smaller than the [coefficient of static friction](#) μ_{static} . [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

coefficient of static friction

for: an object on a solid [surface](#), being prevented by friction from moving

is denoted: by μ_{static} . [[P2.3](#), [P2.6](#)]

is: the [ratio](#) of the [magnitude](#) of the maximum [frictional force](#) on the object before it moves, to the [magnitude](#) R of the [reaction force](#) on the object. [[P2.3](#), [P2.6](#), [P7.6](#)]

depends: on the [surfaces](#) involved and their [state](#) of lubrication. [[P2.3](#), [P2.6](#)]

is largely independent: of other factors, including the [area](#) of contact. [[P2.3](#), [P2.6](#)]

usually is: larger than the [coefficient of sliding friction](#) μ_{slide} . [[P2.3](#), [P2.6](#)]

Flexible Learning Approach to Physics - Glossary

coefficient of thermal conductivity

of: a substance (under strictly specified conditions of [temperature](#) and [pressure](#))

is: the quantity κ that describes the relative ease with which [heat](#) is transferred through the material between points at different [temperatures](#). [P11.4]

is defined: as κ in the relation (a special case of [Fourier's law](#))

$$\frac{dQ}{dt} = -\kappa A \frac{T_2 - T_1}{l}$$

where, dQ/dt is the rate of flow of [heat](#) along a well insulated bar of [length](#) l and [uniform](#) cross-sectional area A from an end at [temperature](#) T_1 to an end at [temperature](#) T_2 . [P11.4]

has as its SI unit: $\text{W m}^{-1} \text{K}^{-1}$.

See [conduction \(of heat\)](#) and [Fourier's law](#).

coefficient of viscosity

is: the quantity η that describes the relative difficulty with which a [fluid](#) may flow. [P7.6]

is defined: by the relation (a special case of [Newton's law of viscosity](#))

$$\sigma_x = -\eta \frac{dv_x}{dy}$$

where σ_x is the [shear stress](#) applied in a given direction, dv_x/dy is the [velocity gradient](#) in a [perpendicular](#) direction, and the minus sign indicates that the [velocity](#) decreases with distance from the plane over which the shear stress is applied. [P7.6]

is sometimes called: the [viscosity](#) of the [fluid](#). [P7.6]

has as its SI unit: $\text{kg m}^{-1} \text{s}^{-1}$, or equivalently N s m^{-2} or Pa s.

Flexible Learning Approach to Physics - Glossary

coherence

between: [waves](#)

is: the property that enables [phase differences](#) known at one [position](#) or [time](#) to determine [phase differences](#) at other [positions](#) and [times](#). [[P5.3](#), [P6.1](#)]

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coherent

describes: two [waves](#) related in such a way that knowing the [phase](#) of one at some particular [time](#) and [position](#) enables the [phase](#) of the other to be predicted at some [position](#) (if [spatially coherent](#)) or [time](#) (if [temporally coherent](#)) [[P6.1](#)]

may also be applied: in its [temporal](#) sense, to two [oscillations](#). [[P5.3](#)]

Flexible Learning Approach to Physics - Glossary

coherent fibre bundle

is: an organized or stacked array of [optical fibres](#), such that the relative [position](#) of each [fibre](#) in the [fibre](#) bundle is the same at either end of the bundle. [[P6.2](#)]

can be used: to transfer [image](#) information. [[P6.2](#)]

Flexible Learning Approach to Physics - Glossary

coil

is: a structure consisting of several loops (called turns) of wire wound in a similar sense to form a simple geometric shape, most typically a [circular prism](#) (cylinder) or a [helix](#) ([solenoid](#)), but possibly some other shape such as a [rectangle](#).

Flexible Learning Approach to Physics - Glossary

coincident roots

of: an [equation](#)

are: [repeated roots](#). (As, for example, the [roots](#) of the [equation](#) $(x - 1)^2 = 0$ are [repeated](#) and are therefore coincident at $x = 1$.) [[M1.4](#)]

Flexible Learning Approach to Physics - Glossary

colinear

means: acting along the same [line](#). [[P5.1](#)]

collimator

is: a device used to produce a [parallel beam](#) of [radiation](#) from a lamp or other source. An [optical](#) collimator usually consists of a [converging lens](#) with an illuminated slit or [circular aperture](#) placed at its [focus](#). [P6.4]

forms: the first stage of a [spectrometer](#). [P8.2]

Flexible Learning Approach to Physics - Glossary

collision

is: a brief but strong [interaction](#) between two [particles](#) or [bodies](#) which come into close proximity. [[P2.4](#), [P2.5](#)]

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coma

in: an [image](#)

is: the [aberration](#) which appears as a comet-like flaring at the edge of an [extended image](#). It is the result of the [focal length](#) for non-axial [rays](#) varying with their [point of incidence](#) on a [lens](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

common denominator

of: two or more [fractions](#)

is: any number that is exactly divisible (without remainder) by the denominator of each of the fractions. [[M1.1](#)]

can be obtained: by multiplying together the [denominators](#) of each of the [fractions](#) (though the result will not necessarily be the lowest common denominator).

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common difference

See [arithmetic progression](#).

Flexible Learning Approach to Physics - Glossary

common factor

of: two or more numbers or [algebraic expressions](#)

is: any number or [algebraic expression](#) which is a [factor](#) of each. [M1.1]

Flexible Learning Approach to Physics - Glossary

common logarithm

is: a synonym for the [logarithm to the base 10](#), i.e. \log_{10} . [M1.5]

Flexible Learning Approach to Physics - Glossary

common ratio

See [geometric progression](#).

Flexible Learning Approach to Physics - Glossary

common tangent

is: a [straight line](#) that is a [tangent](#) to two (or more) given [curves](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

commutator

is: a device used to periodically reverse the [current](#) in a [rotating coil](#), in order to maintain the [direction](#) of a [magnetic torque](#) on the [coil](#). [[P4.3](#)]

Flexible Learning Approach to Physics - Glossary

complementary angles

are: two [angles](#) whose [sum](#) is 90° . [[M2.1](#)]

complementary function

forms: part of the [general solution](#) to a [second-order linear inhomogeneous differential equation](#) with [constant coefficients](#), of the form

$$a \frac{d^2 y}{dt^2} + b \frac{dy}{dt} + cy = f(x). \quad [\text{M6.3}]$$

is: the [general solution](#) to the corresponding [linear homogeneous differential equation](#)

$$a \frac{d^2 y}{dt^2} + b \frac{dy}{dt} + cy = 0. \quad [\text{M6.3}, \text{P5.5}]$$

completed square form

is: the form $y = a(x - p)^2 + q$ of a [quadratic function](#), $y = ax^2 + bx + c$ that makes clear the location of the [vertex](#) at $(p, q) = \left(-b/(2a), [c - b^2/(4a)]\right)$.

[M1.3]

completely inelastic collision

is: a [collision](#) in which the maximum amount of [kinetic energy](#) is converted into other forms of [energy](#), consistent with the principle of [conservation of momentum](#). [P2.5]

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completing the square

is: the procedure by which a [quadratic function](#) is expressed in [completed square form](#). [[M1.3](#), [M1.4](#)]

Flexible Learning Approach to Physics - Glossary

complex

means: pertaining to [complex numbers](#).

Flexible Learning Approach to Physics - Glossary

complex capacitive reactance

of: a [capacitor](#) with [capacitance](#) C when passing [alternating current](#) of [angular frequency](#) ω

is given: by $Z_C = -i/\omega C$. [[P5.5](#)]

See [complex impedance](#), [capacitive reactance](#).

Flexible Learning Approach to Physics - Glossary

complex conjugate

of: a [complex number](#), $z = x + iy$, (where x and y are [real numbers](#))

is: $x - iy$. [[M3.1](#), [P5.5](#)]

is denoted: by z^* . [[M3.1](#), [P5.5](#)]

complex impedance

of: an [electrical component](#) or a network of such components subject to an alternating [voltage](#) of [angular frequency](#) ω

is: a [complex](#) quantity Z that determines the [complex current](#) \mathcal{I} that flows in response to the [complex voltage](#) \mathcal{V} through the relation $\mathcal{V} = Z\mathcal{I}$. (It therefore determines the [peak value](#) and the [phase lag](#) of the [sinusoidally](#) varying [current](#) that flows in response to a [sinusoidally](#) varying [voltage](#). [P5.5])

is given: for n (complex) impedances connected in [series](#), by

$$Z = Z_1 + Z_2 + \dots + Z_n \quad [\text{P5.5}]$$

is given: for n (complex) impedances connected in [parallel](#), by

$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2} + \dots + \frac{1}{Z_n} \quad [\text{P5.5}]$$

is given: for a single [resistance](#) by $Z = R$; for a single [inductance](#) by $Z_L = i\omega L$ and for a single [capacitance](#) by $Z_C = -i/\omega C$. [P5.5]

See [complex capacitive reactance](#) and [complex inductive reactance](#)

Flexible Learning Approach to Physics - Glossary

complex inductive reactance

of: an [inductor](#) with [inductance](#) L when passing [alternating current](#) of [angular frequency](#) ω

is given: by $Z_L = i\omega L$. [[P5.5](#)]

See [complex impedance](#), [inductive reactance](#).

complex number

is: an [expression](#) that may be written in the form $x + iy$, where x and y are [real numbers](#) and i is a symbol satisfying the [algebraic](#) rule $i^2 = -1$, i.e. $i = \sqrt{-1}$.
[[M1.4](#), [M3.1](#), [P5.5](#), [P10.3](#), [P11.1](#)]

Flexible Learning Approach to Physics - Glossary

complex plane

is: the [set](#) of all [complex numbers](#) or the representation of them on an [Argand diagram](#). [[M3.1](#)]

Flexible Learning Approach to Physics - Glossary

complex variable

is: a [variable](#) that may take on [complex](#) values.

Flexible Learning Approach to Physics - Glossary

component vectors

of: a [vector](#)

are: a number of [vectors](#) (usually [orthogonal](#)) whose [vector sum](#) is the original [vector](#). [[M2.4](#), [M2.5](#)]

should not be confused with: ([scalar](#)) [components of a vector](#).

Flexible Learning Approach to Physics - Glossary

components of a vector

are: n [scalar](#) quantities (v_x, v_y, v_z) that can be used to specify an [n-dimensional vector](#) in [Cartesian form](#).

are sometimes referred to: as the [scalar components](#), in order to emphasize their distinction from [component vectors](#). [[M2.4](#), [P2.1](#), [P2.2](#)]

should not be confused with: [component vectors](#).

See [projection](#).

Flexible Learning Approach to Physics - Glossary

composite function

is: a [function](#) obtained through the combination of two or more [functions](#). Given two [functions](#) $f(x)$ and $g(x)$, the composite function $f(g(x))$ is obtained by replacing each occurrence of x in $f(x)$ by $g(x)$. [[M1.3](#), [M4.3](#)]

is also called: a function of a function. [[M1.3](#), [M4.3](#)]

compound

See [chemical compound](#).

compound microscope

is: a [microscope](#) which consists of an [objective lens](#) and an [eyepiece lens](#), although each of these may consist of several component [lenses](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

compression

is: the process of making something smaller in size.

is also: the [force](#) within the [body](#) of a compressed [elastic](#) spring, acting along the [axis](#) of the spring in order to restore the spring's natural [length](#). [P2.3]

also can mean: the externally applied [force](#) acting to compress such a spring. [P2.3]

also can mean: the difference in [length](#) between the uncompressed and the compressed spring. [P2.3]

also can mean: a region where [pressure](#) and hence [density](#) are higher than average. [P5.7]

Contrast with [expansion](#) and [rarefaction](#).

Compton effect

is: the phenomenon involving the scattering of [photons](#) by an [electron](#), which shows that each [quantum](#) of [electromagnetic radiation](#) has both [energy](#) and [momentum](#). [[P10.1](#)]

Compton wavelength

for: a [particle](#) of [mass](#) m

is defined: as h/mc , where h is [Planck's constant](#) and c is the [speed of light](#).
[P10.1]

appears: in the [theory](#) of the [Compton effect](#). [P10.1]

is of the same order of magnitude: as the change in [wavelength](#) of the scattered [photons](#). [P10.1]

Flexible Learning Approach to Physics - Glossary

concave downwards

describes: a [function](#) whose [second derivative](#) is less than zero throughout an [interval](#). [[M4.4](#)]

Flexible Learning Approach to Physics - Glossary

concave lens

is: a [lens](#), shaped so that at least one of its [surfaces](#) curves inwards into the material. The centre is thinner than the edges. Usually the [surfaces](#) are [spherical](#). [P6.3]

is also called: a [diverging lens](#) or a [negative lens](#). [P6.3]

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concave meniscus lens

is: a [lens](#) having two concave [surfaces](#) of different [radii](#) when viewed from one side and with the centre of the [lens](#) thinner than the edges. [[P6.3](#)]

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concave mirror

is: a [mirror](#) shaped so that its [reflecting surface](#) curves inwards, away from the incoming [light rays](#). [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

concave surface

is: a [surface](#) which bulges away from the [object position](#), when viewed from that position. [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

concave upwards

describes: a [function](#) whose [second derivative](#) is greater than zero throughout an [interval](#), i.e. a function where slope increases continually throughout the interval. [[M4.4](#)]

Flexible Learning Approach to Physics - Glossary

concentric

describes: any two objects which have the same centre, used especially of [circles](#) and [spheres](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

condensation

is: the process whereby a [gas](#) or [vapour](#) is converted into a [liquid](#).

Contrast with [evaporation](#).

Flexible Learning Approach to Physics - Glossary

conductance

of: a [body](#) of ([electrical](#)) [resistance](#) R

is: the [reciprocal](#) of the [resistance](#), i.e. $1/R$.

Flexible Learning Approach to Physics - Glossary

conduction (of electricity)

is: the process whereby [electric charge](#) flows from one part of a material to another

takes place: at the [atomic](#) level, mainly through the movement of [electrons](#) from [atom](#) to [atom](#).

therefore is: a [transport process](#).

Flexible Learning Approach to Physics - Glossary

conduction (of heat)

is: one of three processes (the other two being [convection](#) and [radiation](#)) in which [heat](#) can be transferred. [P7.3]

is operative: only in materials ([gases](#), [liquids](#) and [solids](#)), i.e. not in a [vacuum](#). [P7.3]

takes place: at the [atomic](#) level, through [energy](#) being passed from [atom](#) to [atom](#) by [vibration](#) and/or [collision](#). [P7.3]

is driven: at the [macroscopic](#) level, by a [temperature gradient](#), with [heat](#) being transferred from high [temperature](#) to low [temperature](#). [P7.3, P7.5]

therefore is: a [transport process](#). [P7.5]

sometimes is quantified: by [Fourier's law](#). [P7.3]

Flexible Learning Approach to Physics - Glossary

conduction band

in: the [band theory](#) of [solids](#)

is: the lowest [energy band](#) that would be completely unoccupied at [absolute zero](#). [[P11.4](#)]

Flexible Learning Approach to Physics - Glossary

conduction electrons

in: the [band theory](#) of [solids](#)

are: those [electrons](#) that are relatively free to move through the [solid](#) and may therefore give rise to [electrical conduction](#). [[P11.4](#)]

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conductivity

of: a material

is: the [reciprocal](#) of the [resistivity](#) ρ of that material. [[P4.1](#), [P7.3](#)]

has as its SI unit: $(\Omega \text{ m})^{-1}$, though S m^{-1} (i.e. [siemens](#) per [metre](#)) are also used. [[P4.1](#), [P7.3](#)]

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conductor (electrical)

See [electrical conductor](#).

conductor (thermal)

is: a substance with a moderate to high [coefficient of thermal conductivity](#), typically a [metal](#), and usually also an [electrical conductor](#).

Flexible Learning Approach to Physics - Glossary

cone

is: the shape formed by [rotating](#) a [triangle](#) about one of its sides. [[M2.3](#)]

Flexible Learning Approach to Physics - Glossary

cones

are: one of two types of [light](#) sensor present in the eye, the other type being [rods](#). [P6.4](#)]

provide: colour vision, being mainly sensitive to either red, green or blue [light](#) but being ineffective at low [light](#) levels. [\[P6.4\]](#)

confinement

See [plasma confinement](#).

Flexible Learning Approach to Physics - Glossary

congruent

describes: two [geometric figures](#) which are identical in shape and size.

[M2.1]

Flexible Learning Approach to Physics - Glossary

conic section

is: the intersection of a [cone](#) with a [plane](#). [M2.3, P3.2]

can be defined: as the [locus](#) of all [points](#) P, such that the [ratio](#) of the [distance](#) from P to a fixed [point](#) (the focus), to the distance from P to a fixed [line](#) (the directrix), is [constant](#). The value of this [constant](#) is known as the [eccentricity](#) e .

The conic section is:

an [ellipse](#) if $e < 1$,

a [parabola](#) if $e = 1$,

an [hyperbola](#) if $e > 1$. [M2.3]

also can be defined: as the shape described by any second [degree equation](#) of the form:

$$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$$

The conic section is:

an [ellipse](#) if $h^2 < ab$

a [parabola](#) if $h^2 = ab$

an [hyperbola](#) if $h^2 > ab$. [M2.3]

See conic sections in the [Maths handbook](#) for further information.

Flexible Learning Approach to Physics - Glossary

conical pendulum

is: a [mechanical system](#) consisting of a [mass](#), suspended from a point by a thread, undergoing [uniform circular motion](#) in a horizontal [plane](#). [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

conics

See [conic section](#).

conjugate equation

is: an [equation](#) which links [object](#) and [image points](#) for an [optical element](#).
[P6.3]

See [conjugate equation for a single spherical surface](#) and [conjugate equation for a thin lens](#).

conjugate equation for a single spherical surface

is: an [equation](#) which links together the [object distance](#) and [image distance](#) and the [radius of curvature](#) of the [spherical surface](#) at which [refraction](#) occurs.

[P6.3]

conjugate equation for a thin lens

is: an [equation](#) which links together the [object distance](#) and [image distance](#) and the [radii of curvature](#) of the [lens surfaces](#) at which [refraction](#) occurs. [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

conjugate planes

are: [planes perpendicular](#) to the [optical axis](#), containing [conjugate points](#).

[P6.3]

Flexible Learning Approach to Physics - Glossary

conjugate points

are: [object](#) and [image points](#) linked by a [conjugate equation](#). [[P6.3](#)]

conservation of angular momentum

is a principle which states: that when no unbalanced external [torque](#) acts on a [body](#) or a [system](#) of [bodies](#), the total [angular momentum](#) of that [body](#) or [system](#) stays [constant](#). [P2.8]

conservation of charge

is a principle which states: that the total net [charge](#) in the [Universe](#) is [constant](#). [Charges](#) can be created and destroyed but only if the amounts of positive and negative [charge](#) involved are identical so that the net change is zero. [[P3.3](#)]

Flexible Learning Approach to Physics - Glossary

conservation of energy

for: an isolated [system](#) (which is therefore not subjected to unbalanced [external forces](#))

is a principle which states: that the total amount of [energy](#) in the [system](#) is always [constant](#) (i.e. [energy](#) cannot be created or destroyed), although some or all of the [energy](#) may be converted from one form into another. [[P2.4](#), [P2.5](#)]

See [conservation of relativistic energy](#).

Flexible Learning Approach to Physics - Glossary

conservation of mass

for: a [system](#) that does not exchange any [matter](#) with its [environment](#)

is a principle which states: that the [mass](#) of the [system](#) is [constant](#) and is unaffected by [position](#), [velocity](#), [temperature](#) or any other factor. [[P2.3](#)]

is approximately true: when the [velocity](#) of the [system](#) is much less than the [velocity](#) of [light](#). [[P2.3](#)]

See [conservation of relativistic energy](#).

Flexible Learning Approach to Physics - Glossary

conservation of mechanical energy

for: an isolated [system](#) in which only [conservative forces](#) act

is a principle which states: that the total [mechanical energy](#) (i.e. the [sum](#) of the [kinetic](#) and [potential energies](#)) stays [constant](#). [[P2.4](#)]

Flexible Learning Approach to Physics - Glossary

conservation of momentum

for: an isolated [system](#) (which is therefore not subject to unbalanced [external forces](#))

is a principle which states: that the total [momentum](#) of the [system](#) is [constant](#). [P2.5]

implies: that the total [momentum](#) of the [system](#) of objects does not change due to mutual [interactions](#) between the objects within the [system](#). [P2.5]

Flexible Learning Approach to Physics - Glossary

conservation of relativistic energy

is: simply the [conservation of energy](#), but named in this way to emphasize that quantities such as [kinetic energy](#) should be specified in the form required by [Einstein's special theory of relativity](#), and that contributions arising from [mass energy](#) should be included. [P9.1]

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conservation principle (or law)

is: a [law](#) or principle which states that, at least under certain conditions, the value of a physical quantity remains fixed and does not vary in [time](#). [[P2.4](#), [P9.1](#)]

is exemplified: by [conservation of mass](#), [conservation of charge](#), [conservation of energy](#), [conservation of momentum](#) and [conservation of angular momentum](#). [[P2.4](#), [P9.1](#)]

Flexible Learning Approach to Physics - Glossary

conservative force

is: a [force](#) which may be associated with a unique value of [potential energy](#) at each [point](#) in [space](#) and for which the [work done](#) between any two [points](#) is independent of the path chosen. As a result, the [work done](#) by the [force](#) around any closed path is zero. [[P2.4](#), [P11.2](#)]

is exemplified by: [gravitational forces](#), and [electrostatic forces](#). [[P2.4](#), [P11.2](#)]

conserved quantity

describes: any quantity that has the same value at the beginning and end of a wide class of processes, so that it might be made the subject of a suitably formulated [conservation law](#). [P2.5]

Flexible Learning Approach to Physics - Glossary

constant

means: independent of [time](#).

is also: a quantity whose value does not change in the course of a calculation.
[[M1.1](#), [M1.3](#)]

may be: a physical constant, e.g. [Planck's constant](#) or the [speed of light in a vacuum](#).

may be: a mathematical constant, e.g. π or e .

Contrast with [variable](#).

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constant acceleration

See [uniform acceleration](#).

Flexible Learning Approach to Physics - Glossary

constant acceleration equations

See [uniform acceleration equations](#).

Flexible Learning Approach to Physics - Glossary

constant addition rule (for summation)

for: any [constant](#) a and any positive [integer](#) N

is:
$$\sum_{i=1}^N (x_i + a) = \sum_{i=1}^N x_i + Na \quad [\text{M1.7}]$$

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constant field

is: a [field](#) that does not change with [time](#). [[M2.6](#), [P3.3](#)]

Flexible Learning Approach to Physics - Glossary

constant multiple rule (for integration)

for: any [constant](#) a

is: $\int a f(x) dx = a \int f(x) dx$. [[M5.2](#)]

Flexible Learning Approach to Physics - Glossary

constant multiple rule (for summation)

for: any [constant](#) a and any positive [integer](#) N

is: $\sum_{i=1}^N ax_i = a \sum_{i=1}^N x_i$ [[M1.7](#)]

Flexible Learning Approach to Physics - Glossary

constant multiple rule (for differentiation)

for: any [constant](#) a

is: $\frac{d}{dx}(af(x)) = a\frac{d}{dx}(f(x))$ [M4.2]

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constant of integration

is: the arbitrary [constant](#) introduced by the process of [indefinite integration](#).
[[M5.1](#), [M5.2](#)]

is exemplified: by the constant C in the equation $\int x dx = \frac{x^2}{2} + C$

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constant of proportionality

between: two [variables](#) x and y which are [proportional](#) (i.e. $x \propto y$)

is: the [constant](#) k such that $x = ky$. [[M1.1](#), [P1.3](#)]

does not depend: on the values of x and y though it may depend on the values of other [variables](#) that are independent of x and y . [[M1.1](#), [P1.3](#)]

Flexible Learning Approach to Physics - Glossary

constant speed

See [uniform speed](#).

Flexible Learning Approach to Physics - Glossary

constant velocity

See [uniform velocity](#).

constant-volume gas thermometer

is: a thermally sensitive device in which the [pressure](#) of a [gas](#), constrained to a [constant volume](#), is used as a [thermometric property](#). [P7.2]

is: not particularly convenient to use, but occupies a central role in defining precise scales for the [measurement](#) of [temperature](#). [P7.2]

defines: a [gas](#) scale which is intimately related to the [thermodynamic Kelvin scale](#), which is the most fundamental of all [temperature scales](#) because it is totally independent of the material ([gas](#), [liquid](#), or [solid](#)) and the [thermometric property](#) chosen. [P7.2]

Flexible Learning Approach to Physics - Glossary

construction line

is: an imaginary [line](#) added to a diagram to help in explanation, proof or problem solving. [[P2.7](#)]

Flexible Learning Approach to Physics - Glossary

constructive interference

is: the condition in which the [superposition](#) of two [oscillations](#) or [waves](#) produces a [resultant](#) with larger [amplitude](#) than either of the original [oscillations](#) or [waves](#). When the two [oscillations](#) or [waves](#) are [in phase](#), the [amplitude](#) of their [resultant](#) is the [sum](#) of their [amplitudes](#). [[P5.1](#), [P5.6](#), [P5.7](#), [P6.1](#)]

constructive superposition

See [constructive interference](#).

Flexible Learning Approach to Physics - Glossary

continuous spectrum (emission or absorption)

of: [electromagnetic radiation](#) (usually from a specified source)

is: a [spectrum](#) that is (relatively) smooth and unbroken over a wide continuous range of wavelengths. [P8.2]

is typical: of the [emission spectrum](#) from a [solid](#) or [liquid](#) heated to a high [temperature](#). [P8.2]

is exemplified: by [white light](#), which can be dispersed by a [diffraction grating](#) or a [prism](#) into all the colours of the rainbow. [P8.2]

is also exemplified: by the [black-body spectrum](#). [P8.2]

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continuous flow method

is: a standard [calorimetry](#) procedure that can be used to measure specific heats of fluids. [[P7.4](#)]

involves: a [fluid](#) flowing at a constant known rate past a [heater](#) delivering a known [power](#) which produces a rise in [temperature](#) between the inlet and outlet. [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

continuous function

is: a [function](#) whose [graph](#) has no breaks. [[M4.4](#)]

Flexible Learning Approach to Physics - Glossary

continuous refraction

is: a phenomenon that can occur in a region of a [medium](#) where the [refractive index](#) varies smoothly with [position](#). [P6.2]

can cause: an appropriately directed [ray](#) to change its direction continuously. [P6.2]

Flexible Learning Approach to Physics - Glossary

continuous variable

is: a [variable](#) that changes only in a smooth fashion (with no sudden jumps in its value). [[M1.3](#)]

Flexible Learning Approach to Physics - Glossary

continuous X-ray spectrum

is: the [spectrum](#) of [X-rays](#) that results when [electrons](#) are [accelerated](#) through a [potential difference](#) of several thousand [volts](#) and then strike a target. [P8.3]

is created: as the [electrons](#) come to rest. Because the [energy](#) of the [electrons](#) in the target ranges from zero to a maximum value, the [energy](#) of the [X-rays emitted](#) will also vary continuously from zero up to a maximum. [P8.3]

also known as: [bremsstrahlung](#)

Contrast with [characteristic X-ray spectrum](#).

Flexible Learning Approach to Physics - Glossary

continuum

is: the continuous range of available [energies](#) for an [electron](#) moving under the influence of an [atom](#) or [ion](#) to which it is not [bound](#). The [electron](#) is sometimes said to be in an [unbound state](#) of the [atom](#) or [ion](#). [P8.2]

can be contrasted: with the [discrete energy levels](#) of the [bound states](#) of the [atom](#) which the [electron](#) might otherwise occupy. [P8.2]

is reached: by a bound [electron](#) which is given sufficient [energy](#) to exceed the [ionization level](#) of the [atom](#) or [ion](#) and therefore to escape from it. [P8.2]

Flexible Learning Approach to Physics - Glossary

continuum level

See [ionization level](#).

Flexible Learning Approach to Physics - Glossary

contraction

is: the process of making something smaller is size.

Flexible Learning Approach to Physics - Glossary

control rod

is: a rod of a material that readily absorbs [thermal neutrons](#). [P9.3]

is lowered: into a [nuclear fission reactor](#) to control or stop the [nuclear chain reaction](#). [P9.3]

Flexible Learning Approach to Physics - Glossary

convection

is: one of three processes (the other two being [conduction](#) and [radiation](#)) in which [heat](#) can be transferred. [P7.3]

operates: only in [fluids](#) (i.e. [gases](#) and [liquids](#)), where the relative movement of parts of the [fluid](#) at different [temperatures](#) is the means by which [heat](#) is carried from hot regions to cold regions. [P7.3]

is classified: in two broad categories: 'forced convection', in which the [fluid](#) is being moved by external means (a breeze blowing across your face, or a coolant being pumped past a hot object), and 'free convection', in which the flow is induced by [buoyancy](#) caused by [thermal expansion](#) of hotter regions of the fluid relative to cooler regions (around fins designed to cool the electronics in your hi-fi amplifier, in central heating by electric convectors or, despite their common name, by water-filled radiators). [P7.3]

involves: a generally very complicated relationship between [heat](#) flow and [temperature](#) difference, depending on [temperature](#) difference in a non-[linear](#) way and on other factors including many [thermal](#) properties of the [fluid](#) and the geometry and orientation of the object exchanging [heat](#) with the [fluid](#). There are many [empirical](#) formulae employed by engineers for situations commonly encountered, but when in doubt, or when information is lacking, the best one can do is to use [Newton's law of cooling](#) $\frac{dQ}{dt} = hA \Delta T$ where dQ/dt is the rate of heat flow between two [surfaces](#) of area A that differ in [temperature](#) by an amount ΔT , and h is an appropriately chosen convective heat transfer coefficient. [P7.3]

Flexible Learning Approach to Physics - Glossary

convective heat transfer coefficient

See [convection](#).

Flexible Learning Approach to Physics - Glossary

converge

See [convergent series](#) and [convergent sequence](#).

Flexible Learning Approach to Physics - Glossary

convergent integral

is: an [improper integral](#) with a finite value. [M5.2]

convergent sequence

is: a [sequence](#), $S_1, S_2, S_3, S_4, \dots$ all of whose members, beyond some particular member, are as close as we please to some particular number. This number is called the limit of the sequence. [[M1.7](#)]

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convergent series

is: a [series](#) whose [partial sums](#) form a [convergent sequence](#). The [limit of a sequence](#) of [partial sums](#) is known as the sum of the series. [[M1.7](#)]

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converging lens

is: a [lens](#) which increases the convergence or reduces the divergence of [light rays](#) passing through it. [[P6.3](#)]

is also called: a [convex lens](#) or a [positive lens](#). [[P6.3](#)]

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conversion factor

is: a [dimensionless](#) factor, such as (10^3 m/km) , which is actually equal to one, but which is expressed as a [ratio](#) of two quantities which have different [units](#).

[P1.1]

can be used: to convert a quantity expressed in terms of certain [units](#) into an equivalent quantity expressed in terms of other [units](#). [P1.1]

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convex lens

is: a [lens](#), shaped so that at least one of its [surfaces](#) curves outwards, away from the centre of the material. The centre is thicker than the edges. Usually the [surfaces](#) are [spherical](#). [P6.3]

is also called: a [converging lens](#) or a [positive lens](#). [P6.3]

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convex meniscus lens

is: a [lens](#) having two convex [surfaces](#) of different [radius of curvature](#) when viewed from one side, and with the centre of the [lens](#) thicker than the edges.
[P6.3]

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convex mirror

is: a [mirror](#) shaped so that its [reflecting surface](#) curves outwards, towards the incoming [light rays](#). [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

convex surface

is: a [surface](#) which bulges towards the [object position](#), when seen from that side. [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

coolant

in: a [nuclear reactor](#)

is: a [fluid](#) ([liquid](#) or [gas](#)) that keeps a [reactor](#) cool and transfers the [energy](#) released in the [reactor](#) so that it may be used to produce steam and hence drive [electricity generators](#). [P9.3]

Flexible Learning Approach to Physics - Glossary

coordinate axes

See [Cartesian coordinates](#).

Flexible Learning Approach to Physics - Glossary

coordinate system

is: a system for associating a [set](#) of values, called [coordinates](#), with [points](#) in [space](#) so that each [point](#) may be uniquely identified and distinguished from every other [point](#).

See [Cartesian coordinates](#), [polar coordinates](#) and [spherical polar coordinates](#).

Flexible Learning Approach to Physics - Glossary

coordinates

of: a [point](#)

are: the (unique) set of values associated with that [point](#) by a [coordinate system](#) that distinguish that [point](#) from other points.

are exemplified by: the x - and y -coordinates of a [point](#) on a [graph](#). [[P1.3](#)]

Copenhagen interpretation

is: the most commonly accepted view of [quantum physics](#). [P10.2]

holds that: the [Universe](#) operates according to [probabilistic laws](#) which tell us as much as can be known, even in principle, about future events. [P10.2]

was formulated: by a group of scientists (including Heisenberg) who worked in Copenhagen in the 1920s. [P10.2]

contrasts: with the [many universe theory](#).

Flexible Learning Approach to Physics - Glossary

coplanar

means: in the same [plane](#). [[P2.7](#)]

correspondence principle

states: that in the classical limit the predictions of [quantum mechanics](#) are in agreement with those of (non-[relativistic](#)) [classical physics](#). [[P11.2](#), [P11.3](#)]

Flexible Learning Approach to Physics - Glossary

corkscrew rule

is: a rule for working out the direction of a [vector product](#) such as $\mathbf{a} \times \mathbf{b}$.

states that: if the handle of a (right-handed) corkscrew is aligned with the vector \mathbf{a} and oriented in such a way that its handle may be twisted into alignment with \mathbf{b} by turning it through an angle less than 180° , then the direction of $\mathbf{a} \times \mathbf{b}$ is the direction in which the corkscrew would advance.

more briefly states: the direction of $\mathbf{a} \times \mathbf{b}$ is the direction of advance of a corkscrew as its handle is rotated from \mathbf{a} to \mathbf{b} . [[M2.7](#), [P4.3](#)]

Compare with the [right-hand screw rule](#) and the (preferred) [right-hand rule](#).

Flexible Learning Approach to Physics - Glossary

cornea

is: the [transparent](#) protective outer covering to the eye. [P6.4]

is: the first [surface](#) at which [refraction](#) takes place for [light](#) entering the eye.
[P6.4]

corresponding angles

See [transversal](#).

Flexible Learning Approach to Physics - Glossary

cosecant, cosec

See [trigonometric function](#).

Flexible Learning Approach to Physics - Glossary

cosech

See [hyperbolic function](#).

Flexible Learning Approach to Physics - Glossary

cosh

See [hyperbolic function](#).

Flexible Learning Approach to Physics - Glossary

cosine rule

states: that given a [triangle](#) with [angles](#) A , B and C opposite to sides a , b and c then $c^2 = a^2 + b^2 - 2ab \cos C$. Likewise $a^2 = b^2 + c^2 - 2bc \cos A$ and $b^2 = a^2 + c^2 - 2ac \cos B$. [[M1.6](#)]

reduces: to [Pythagoras's theorem](#) when the chosen angle is 90° .

See trigonometric functions in the [Maths handbook](#) for further details.

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cosine, cos

See [trigonometric function](#).

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cosmic rays

are: high [energy particles](#) (mainly [protons](#)) which enter the Earth's upper atmosphere from space. They may [collide](#) with [nuclei](#) in the atmosphere, producing [radioactive isotopes](#). [[P9.3](#)]

Flexible Learning Approach to Physics - Glossary

cotangent, cot

See [trigonometric function](#).

Flexible Learning Approach to Physics - Glossary

coth

See [hyperbolic function](#).

Coulomb force

See [electrostatic force](#) and [Coulomb's law](#). [P3.3]

Coulomb's law

is: the [law](#), first formulated by Charles Augustin de Coulomb (1736-1806), which describes the [electrostatic force](#) between [charged particles](#). [P3.1]

states that: for two [particles](#) of [charge](#) q_1 and q_2 separated by a [distance](#) r , the force on particle 2 due to particle 1 is

$$\mathbf{F}_{\text{el}} = \frac{q_1 q_2}{4\pi\epsilon_0 r^2} \hat{\mathbf{r}}$$

where ϵ_0 is the [permittivity](#) of [free space](#), q_1 and q_2 are signed quantities, and $\hat{\mathbf{r}}$ is a [unit vector](#) pointing from q_1 to q_2 . The [direction](#) of the [force](#) is therefore along the [line](#) joining the [charges](#), and like [charges](#) repel while unlike [charges](#) attract. [P3.3]

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coulomb, C

is: the [SI unit](#) of [charge](#).

is defined: as the amount of [charge](#) transferred when a [current](#) of 1 [ampere](#) flows for 1 [second](#), so $1 \text{ C} = 1 \text{ A s}$. [[P3.3](#)]

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couple

is: a pair of [forces](#) of equal [magnitude](#) acting in opposite [directions](#) along different [lines of action](#). [[P2.7](#), [P4.3](#)]

may be characterized: by a non-zero [torque](#) about any point, the [magnitude](#) of which is equal to the [magnitude](#) of either one of the [forces](#) multiplied by the [perpendicular distance](#) between their [lines of action](#). [[P2.7](#)]

causes: [rotation](#) but not [translation](#), when applied to [rigid body](#) that is entirely free to move [[P2.7](#)]

Flexible Learning Approach to Physics - Glossary

coupled oscillators

are: two [oscillators](#) connected in such a way that the [displacement](#) of one [oscillator](#) affects the [restoring force](#) acting on the other. [[P5.1](#), [P5.3](#)]

exhibit: [normal modes](#). [[P5.1](#), [P5.3](#)]

may be generalized: to a [system](#) of many [oscillators](#).

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covalent bond

is: a [bond](#) in which one or more [electrons](#) is shared between two (or more) [atoms](#). [[P11.4](#)]

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covalent bonding

is: a type of [chemical bonding](#) in which the [chemical bonds](#) are created by [electron pairs](#) shared between [atoms](#). [P8.4]

has typical energy: of 1 to 5 eV. [P7.1]

is characterized: by an increased [electron density](#) between the [nuclei](#) of the [atoms](#). [P11.4]

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creep

is: the condition in which the [strain](#) in a material exhibits a slow [time](#)-dependence under constant [stress](#) in the region of [plasticity](#). [P7.6]

Flexible Learning Approach to Physics - Glossary

critical

describes: the condition inside a nuclear reactor (or similar device) in which a [nuclear chain reaction](#) is just able to self-sustain at a steady rate, i.e. where, on average, exactly one [neutron](#) released in the [fission](#) of one [nucleus](#) goes on to produce [fission](#) in one further [nucleus](#). [P9.3]

Contrast with [subcritical](#), [supercritical](#).

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critical angle

for: [light rays](#) passing from a [medium](#) of given [refractive index](#) into a [medium](#) of lesser [refractive index](#)

is: the minimum [angle of incidence](#) that corresponds (via [Snell's law](#)) to an [angle of refraction](#) of 90° . A [ray](#) meeting the [interface](#) at a greater [angle of incidence](#) will suffer [total internal reflection](#) unless special steps are taken to frustrate the process. [[P5.7](#), [P6.2](#)]

critical damping

is: the condition in which a [damped oscillator](#) just fails to [oscillate](#) and comes to rest in the shortest possible [time](#) following release from a given [position](#). It is the intermediate condition between [light damping](#) (i.e. [underdamping](#)) and [heavy damping](#) (i.e. [overdamping](#)). [P5.2]

is accompanied by: no more than one overshoot of the [equilibrium](#) value before coming to rest.

is exemplified electrically: by a [series a.c. circuit](#) containing a [capacitor](#) of [capacitance](#) C , an [inductor](#) of [inductance](#) L , and a [resistor](#) of [resistance](#) R , wherein the [damped oscillations](#) of stored [charge](#) (or [current](#)) are critically damped when $R = 2\sqrt{L/C}$. [P5.4]

is exemplified mechanically: by a [damped mechanical oscillator](#) containing an [oscillating body](#) of mass m , a [spring](#) of [spring constant](#) k , and a [linear damping force](#) with [damping coefficient](#) b , wherein [oscillations](#) are critically damped when $b = 2\sqrt{km}$. [P5.4, P5.5]

is described by: $x(t) = (H + Jt) e^{-\gamma t/2}$ where $\gamma = b/m$ for a [mechanical oscillator](#), and $\gamma = R/L$ for an [electrical oscillator](#). H and J are [constants](#) determined by the [initial conditions](#).

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critical mass

is: the [mass](#) of a [fissile material](#) that is just capable of maintaining a [nuclear chain reaction](#). [P9.3]

therefore is: the [mass](#) of a [fissile material](#) that is just capable of keeping a [nuclear chain reaction](#) at the [critical condition](#). [P9.3]

critical opalescence

is: a phenomenon displayed by normally [transparent fluids](#) under the conditions that define the [critical point](#). Illuminated by a beam of [light](#), the substance takes on an intensely white, diffuse cloudy appearance. [[P7.4](#)]

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critical point

of a substance

is: the unique [point](#) on a [PVT-surface](#) (or some similar [surface](#)), or on one of its [projections](#), representing the [state](#) in which the [liquid](#) and [vapour](#) phases of a substance become indistinguishable. [[P7.4](#)]

See also [critical opalescence](#).

Flexible Learning Approach to Physics - Glossary

critical pressure

is: the [pressure](#) of a substance at its [critical point](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

critical temperature

is: the [temperature](#) of a substance at its [critical point](#).

is also: the maximum [temperature](#) at which a [gas](#) can be [liquefied](#) by an [isothermal](#) process. [[P7.4](#)]

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critical volume

is: the [volume](#) of a substance at its [critical point](#). [P7.4]

critically damped

See [critical damping](#).

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cross product

See [vector product](#).

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cross-sectional area

generally is: the [area](#) of intersection of a geometrical solid and a [plane](#). Usually the [plane](#) is [normal](#) to an [axis](#) of [symmetry](#), but could be some other specified direction. [[M2.1](#)]

See also [prism](#).

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crown glass

is: a glass of relatively low [refractive index](#) and thus low [dispersive power](#).
[P6.4]

is used as a component: in an [achromatic doublet](#). [P6.4]

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crystal

is: any material with a [crystalline structure](#).

crystalline structure

is: a regular array of [atoms](#) in [three-dimensional space](#) that can be described by associating the same arrangement of one or more [atoms](#) with every [point](#) of a given [three-dimensional lattice](#). [[P11.4](#)]

Flexible Learning Approach to Physics - Glossary

cubic equation

is: a [polynomial equation](#) of [degree](#) 3. [M1.4]

cubic function

is: a [polynomial function](#) of [degree](#) 3. [[M1.3](#)]

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cuboid

is: any [rectangular block](#). [M2.1]

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current

See [electric current](#).

Flexible Learning Approach to Physics - Glossary

current balance

is: a device designed to measure the [force](#) between two [current](#)-carrying [coils](#) or wires. [[P4.3](#)]

can be used: to measure currents accurately and hence to determine the current of magnitude one [ampere](#). [[P4.3](#)]

current divider equations

are: a pair of [equations](#) which describe the way in which an [electric current](#) is divided between two [resistors](#) in [parallel](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

curve

is: a continuous [set](#) of [points](#), often (though not necessarily) in a [plane](#).

Flexible Learning Approach to Physics - Glossary

cut-off wavelength

of: a [continuous X-ray spectrum](#).

is: the sharply defined [wavelength](#), below which there is no [continuous spectrum](#). [P8.3]

corresponds to: the situation in which the maximum [kinetic energy](#) of an [incident electron](#) is entirely radiated away as a single [X-ray photon](#). [P8.3]

Flexible Learning Approach to Physics - Glossary

cycle

of: a [periodic motion](#) (or a more general [oscillation](#))

is: the [motion](#) or behaviour which occupies exactly one [period](#). [P5.1]

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cyclotron

is: a device which can [accelerate charged particles](#) by applying a [periodic electric field](#) to the [particle](#) as it moves, constrained in a [circular](#) or [spiral](#) path, by an applied [magnetic field](#). [P4.3]

cyclotron frequency

is: the [frequency](#) of the [circular](#) or [helical](#) motion of a [charged particle](#) in a [uniform magnetic field](#). [P4.3]

is dependent: only on the [particle's charge-to-mass ratio](#) q/m and on the [magnetic field strength](#) B :

$$f_{\text{cyclotron}} = \frac{|q|B}{2\pi m}. \quad [\text{P4.3}]$$

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cyclotron motion

of: a [charged particle](#)

in: a [magnetic field](#)

is: the [periodic motion](#) of the [particle](#) in the [plane perpendicular](#) to the [magnetic field](#). [[P4.3](#)]

Flexible Learning Approach to Physics - Glossary

cyclotron period

is: the [time](#) to complete one [period](#) of [cyclotron motion](#) and the [reciprocal](#) of the [cyclotron frequency](#). [[P4.3](#)]

d'Alembert ratio test

is: one of several tests for the [convergence](#) or [divergence](#) of a [series](#). If a_n is the n^{th} term in the [series](#), the test consists of calculating:

$$R = \lim_{n \rightarrow \infty} \left(\frac{a_{n+1}}{a_n} \right)$$

There are three possible outcomes:

$R < 1$ implying [convergence](#),

$R > 1$ implying [divergence](#),

$R = 1$ implying that the test is incapable of providing a definite answer.

[M1.7]

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DC, d.c.

See [direct current](#).

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DC circuit, d.c. circuit

is: an [electrical circuit](#) in which a [direct current](#) flows, or may be presumed to flow. [[P4.1](#)]

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DC isolation, d.c. isolation

of: two [circuits](#)

is: their separation such that they may have independent [d.c. potentials](#) but yet may be mutually influenced by each other's [a.c. currents](#). [[P4.4](#)]

can be achieved: via the [mutual inductance](#) between the [circuits](#), through a [transformer](#) or via a [capacitor](#). [[P4.1](#), [P4.4](#), [P5.4](#)]

damped (electrical) oscillator

is: an [electrical system](#) in which a quantity such as [charge](#) or [current](#) exhibits [oscillatory](#) behaviour while energy is [dissipated](#) to the [environment](#).

is exemplified: by a [circuit](#) in which an [inductance](#) L , [capacitance](#) C , and [resistance](#) R are connected in [series](#), so that the [charge](#) q stored in the [capacitor](#) at [time](#) t obeys the [differential equation](#):

$$L \frac{d^2 q}{dt^2} = -\frac{1}{C} q - R \frac{dq}{dt}$$

and is consequently described, in the case of [light damping](#) ($R^2 < 4L/C$), by an [oscillation](#) with an [exponentially decaying amplitude](#):

$$q(t) = q_0 e^{-\gamma t/2} \cos(\omega t + \phi)$$

where $\gamma = R/L$, $\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$ and q_0 and ϕ are [arbitrary constants](#). [[P5.4](#), [P5.5](#)]

See [critical damping](#). [[P5.4](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

damped oscillator

See [damped \(electrical\) oscillator](#), [damped \(mechanical\) oscillator](#).

damped (mechanical) oscillator

is: a [mechanical system](#) in which a quantity such as [displacement](#) exhibits [oscillatory](#) behaviour while [energy](#) is [dissipated](#) to the [environment](#).

is exemplified: by a [particle](#) of [mass](#) m on a spring of [spring constant](#) k , moving subject to a [damping force](#) with [damping coefficient](#) b so that its displacement from equilibrium, x , at [time](#) t satisfies the [equation of motion](#):

$$m \frac{d^2 x}{dt^2} = -kx - b \frac{dx}{dt}$$

and is consequently described in the case of [light damping](#) ($b^2 < 4mk$) by an [oscillation](#) with an [exponentially decaying amplitude](#):

$$x(t) = x_0 e^{-\gamma t/2} \cos(\omega t + \phi)$$

where $\gamma = b/m$, $\omega = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$ and x_0 and ϕ are [arbitrary constants](#). [[P5.2](#), [P5.5](#)]

See [critical damping](#) and [heavy damping](#).

damped oscillation

See [damped \(electrical\) oscillator](#), [damped \(mechanical\) oscillator](#).

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damping

is: any phenomenon involving dissipation (such as [friction](#), [viscosity](#) or [electrical resistance](#)) that causes a [system](#) (particularly an [oscillating system](#)) to lose [energy](#). [[M6.3](#), [P5.2](#), [P5.4](#)]

See [damping force](#), [damping constant](#).

damping coefficient

is: the constant b that appears in the equation for a [linearly damped harmonic](#)

[oscillator](#): $m \frac{d^2x}{dt^2} + b \frac{dx}{dt} + kx = 0$.

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damping constant

for: an [oscillating particle](#) of [mass](#) m subject to a [dissipative force](#) of [magnitude](#) bv , where v , is the [speed](#) of the [particle](#)

is given: by $\gamma = b/m$. [[P5.2](#)]

is equal: to twice the [decay constant](#) α for the [amplitude](#) of the [oscillation](#). [[P5.2](#)]

See [damping force](#), [damped mechanical oscillator](#).

Flexible Learning Approach to Physics - Glossary

damping force

in: a [mechanical oscillator](#).

is: a [dissipative force](#) which opposes the [motion](#) and which therefore causes [damping](#). [[M6.3](#), [P5.2](#), [P5.4](#)]

See [damping constant](#).

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data

is: recorded information, particularly numerical or [statistical](#) information that can be used in an analysis or [calculation](#).

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daughter isotope

See [daughter nucleus](#).

Flexible Learning Approach to Physics - Glossary

daughter nucleus

is: an [isotope](#) produced in the [radioactive decay](#) of a [parent nucleus](#). [P9.2]

de Broglie hypothesis

states: that the [propagation](#) of all [matter](#) is determined by an associated [de Broglie wave](#), from which the [diffraction](#) and [interference](#) behaviours may be predicted. [[P10.2](#)]

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de Broglie wave

is: a [wave](#) associated with the [propagation](#) of [matter](#). [P10.2]

can be used: to predict the [diffraction](#) and [interference](#) behaviours of [matter](#). [P10.2]

See [de Broglie wavelength](#).

de Broglie wavelength

of: a [particle](#) or, more generally, of a free [quantum](#)

is given: by $\lambda_{\text{dB}} = h/p$, where p is the [magnitude](#) of the [momentum](#) of the [particle](#) and h is [Planck's constant](#). [[P10.2](#), [P11.1](#), [P11.2](#)]

determines: the [diffraction](#) when the [quantum](#) meets an obstacle. [[P11.1](#), [P11.2](#)]

Flexible Learning Approach to Physics - Glossary

Debye model

is: a [model](#) of the [specific heats](#) of [solids](#)

postulates: that the [solid](#) behaves like an [elastic body](#) capable of exhibiting [quantized oscillations](#) characterized by a specific distribution of classical [frequencies](#). [P11.4]

predicts: that near [absolute zero](#) the [specific heat](#) is proportional to T^3 , where T is the [absolute temperature](#). [P11.4]

Flexible Learning Approach to Physics - Glossary

decay

is: a general term describing the tendency to decrease with [time](#).

See [decay constant](#).

Flexible Learning Approach to Physics - Glossary

decay channels

are: the different ways in which a particular [radioactive nucleus](#) may [decay](#).
[P9.3]

decay constant

is: the [constant of proportionality](#), α that relates the rate of [radioactive decay](#), R to the number, N of [unstable nuclei](#) present: $R = \alpha N$. [P9.2]

is: a property of [radionuclides](#), unaffected by the physical or chemical environment. [P9.2]

more generally is: the [reciprocal](#) of the [time constant](#) τ in any [exponential decay](#) process: $A(t) = A_0 e^{-\alpha t} = A_0 e^{-t/\tau}$. [P5.2]

Flexible Learning Approach to Physics - Glossary

deceleration

is: the slowing down of an object, and an associated reduction in [speed](#). [[M4.1](#), [P2.1](#)]

is commonly misconstrued: as negative [acceleration](#). This may be, but is not necessarily, the case, since [acceleration](#) is a [vector quantity](#) and has an associated sign. [[P2.1](#)]

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decibel, dB

is: a [unit](#) of ([acoustic](#)) [intensity level](#). [P5.7]

permits representation: of [intensity level](#) in terms of a reference [intensity level](#):

given a sound of [intensity](#) I (measured in W m^{-2}), its [intensity level](#) is given by

$$\beta = 10 \times \log_{10} \left(\frac{I}{I_0} \right) \text{decibel}$$

where $I_0 = 1 \times 10^{-12} \text{ W m}^{-2}$. Audible, non-painful sounds usually have [intensity levels](#) in the range 0 to 120 dB. [P5.7]

Flexible Learning Approach to Physics - Glossary

decimal number

is: a number expressed in [base](#) ten notation, so that 345.6 means $3 \times 10^2 + 4 \times 10^1 + 5 \times 10^0 + 6 \times 10^{-1}$. [[M1.2](#)]

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decimal places

describes: the number of [digits](#) which a [decimal number](#) has after the decimal point. [[M1.2](#)]

Flexible Learning Approach to Physics - Glossary

decreasing function

is: a [function](#) $f(x)$ for which $f(a) > f(b)$ for all $a < b$. [M4.4]

exists: on an [interval](#) if $f'(x)$ is negative at all [points](#) of the [interval](#). [M4.4]

definite integral

of: a [function](#) $f(x)$ defined on an [interval](#) from $x = a$ to $x = b$

is denoted: $\int_a^b f(x) dx$

where the values a and b are known as the lower and upper limits of integration, $f(x)$ is called the [integrand](#), and the symbol dx is the [element of integration](#) which shows that x is the [integration variable](#) with respect to which the [integration](#) is to be performed. [[M5.1](#), [M5.2](#), [P2.4](#)]

is defined: by the [limit](#) of a sum:

$$\int_a^b f(x) dx = \lim_{\Delta x \rightarrow 0} \left(\sum_{i=1}^n f(x_i) \Delta x_i \right) \text{ with } \Delta x_i = x_{i+1} - x_i$$

where the [sequence](#) of values x_1, x_2, \dots, x_{n+1} is such that $a = x_1 < x_2 < \dots < x_{n+1} = b$, and Δx is the largest of the Δx_i . [[M5.1](#), [M5.2](#), [P2.4](#)]

may be interpreted: for a given [function](#) between given [limits](#), as the [area under a graph](#) of that [function](#) between the given [limits](#), provided that due regard is paid to signs ([areas](#) of regions below the horizontal [axis](#) must be treated as negative quantities). [[M5.1](#), [M5.2](#), [P2.4](#)]

can be evaluated: according to the [fundamental theorem of calculus](#) using

$$\int_a^b f(x) dx = [F(x)]_a^b = F(b) - F(a)$$

where $F(x)$ is any [indefinite integral](#) of $f(x)$ (i.e. any function $F(x)$ that satisfies $dF/dx = f(x)$). [[M5.1](#), [M5.2](#), [P2.4](#)]

also can be evaluated: by means of [numerical integration](#). [[M5.1](#), [M5.2](#), [P2.4](#)]

Flexible Learning Approach to Physics - Glossary

degeneracy

is: the phenomenon in which different [quantum states](#) of a [system](#) (e.g. the [states](#) of [electrons](#) in an [atom](#)) have the same characteristic [energy](#) and therefore belong to the same [energy level](#) of the [system](#). [[P8.3](#)]

therefore is also: the existence of more than one independent [wavefunction](#), characterized by different [sets](#) of [quantum numbers](#), corresponding to the same [energy level](#). [[P10.3](#)]

Flexible Learning Approach to Physics - Glossary

degenerate

describes: an [energy level](#) or a [wavefunction](#), when [degeneracy](#) is present.
[\[P10.3\]](#)

Flexible Learning Approach to Physics - Glossary

degree, °

is: the [unit](#) of [plane angle](#) corresponding to 1/360th of a [circle](#), written as 1°. In other words, a [rotation](#) through 360° is a full [rotation](#). [[M1.6](#)]

is equal: to 0.01745 [radian](#), (to five [decimal places](#)). [[M2.1](#)]

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degree Celsius, °C

is: a non-[SI unit](#) of [temperature](#) and temperature difference.

is defined: to be equal in size to the [SI unit](#) of [absolute temperature](#), the [kelvin](#) (K), but the zeros of the [thermodynamic Kelvin temperature scale](#) and the [Celsius temperature scale](#) are different ($0\text{ °C} = 273.15\text{ K}$).

Flexible Learning Approach to Physics - Glossary

degree (of a differential equation)

is: the highest [power](#) to which the highest [order](#) of [derivative](#) in the [differential equation](#) is raised. [[M6.1](#)]

for: a [linear differential equation](#) is equal to 1. [[M6.1](#)]

degree (of a polynomial)

is: the [integer](#) n that appears in a [polynomial expression](#) of the form

$a_0 + a_1x + a_2x^2 + \dots + a_{n-1}x^{n-1} + a_nx^n = 0$, that is, the highest [power](#) of the [variable](#) in the [polynomial expression](#). [[M1.3](#), [M1.4](#)]

Flexible Learning Approach to Physics - Glossary

degrees of freedom

of: a [system](#)

are: the characteristics of a [system's](#) configuration that can be varied independently. [P5.1]

are exemplified: by the three [position coordinates](#) that determine the location of a [particle](#) in [three-dimensional space](#).

correspond: to the [independent variables](#) required to describe the [motion](#) of the [system](#) fully. [P7.5]

are reduced: by constraints in the [system](#) which limit the possible [motions](#). For instance, a [system](#) consisting of two independent [particles](#) has six degrees of freedom, but a 'dumb-bell' in which two particles are separated by a fixed [distance](#) has only five degrees of freedom (these can be thought of as three [translational](#) and two [rotational](#) degrees of freedom). [P7.5]

Demoivre's theorem

states: that for any [real number](#), n

$$[\cos(\theta) + i \sin(\theta)]^n = \cos(n\theta) + i \sin(n\theta) \quad [\text{M3.3, P5.5}]$$

Flexible Learning Approach to Physics - Glossary

denominator

is: the number or [expression](#) at the bottom of a [fraction](#). [[M1.1](#)]

Flexible Learning Approach to Physics - Glossary

density

of: a [uniform body](#) of [mass](#) M and [volume](#) V

is: the [mass](#) per [unit volume](#) of the [body](#), M/V

is defined more generally: at a point in a (possibly non-[uniform](#)) [body](#) by

$$\rho = \lim_{\Delta V \rightarrow 0} \left(\frac{\Delta m}{\Delta V} \right)$$

where Δm is the mass of a small [element](#) of the [body](#), of [volume](#) ΔV centred on the specified [point](#).

Flexible Learning Approach to Physics - Glossary

dependent error

in: a [measurement](#)

when: the [errors](#) arising in the [measurement](#) are being analysed

is: any [error](#) whose size is determined, wholly or partly, by the size of another. [[P1.2](#)]

See [uncertainty](#).

Flexible Learning Approach to Physics - Glossary

dependent variable

in: an [experiment](#) (or a [calculation](#))

is: the quantity whose value is monitored by the [experimenter](#) (or by the person doing the [calculation](#)). [P1.3]

is controlled by: the value of the [independent variable](#) to which it is connected by a [set](#) of [experimental observations](#) (or by a [mathematical function](#)). [M1.3]

on graphs is plotted: conventionally along the vertical [axis](#). [P1.3]

depth of field

is: the range of [distances](#) of an [object](#) from a [lens](#), for which the [image](#) will appear to be sharp for a particular [lens position](#). [P6.4]

increases: as the [lens aperture](#) is reduced in size. [P6.4]

Contrast with [depth of focus](#).

Flexible Learning Approach to Physics - Glossary

depth of focus

is: the range of [lens positions](#) for which the [image](#) of an [object](#) will appear to be sharp for a particular [distance](#) of the [object](#) from the [lens](#). [P6.4]

increases: as the [lens aperture](#) is reduced in size. [P6.4]

Contrast with [depth of field](#).

Flexible Learning Approach to Physics - Glossary

derivative

of: a [function](#) $y = f(x)$

is: its [rate of change](#) with respect to x at any particular value of x

is given by:

$$f'(x) = \frac{dy}{dx} = \lim_{\Delta x \rightarrow 0} \left(\frac{\Delta y}{\Delta x} \right) = \lim_{\Delta x \rightarrow 0} \left[\frac{f(x + \Delta x) - f(x)}{\Delta x} \right]$$

where $f'(x)$ is known as the first derivative or derived function.

is defined: over any [domain](#) in which a unique [limit](#) exists for all values of x .
[[M4.1](#), [M4.2](#), [P2.1](#)]

derived function

See [derivative](#).

Flexible Learning Approach to Physics - Glossary

derived units

are: [SI units](#) created by specified combinations of the [base units](#). [[P1.1](#)]

See Table 2 in Section 0 of the [Maths handbook](#) for a detailed listing.

destructive interference

is: the condition in which the [superposition](#) of two [oscillations](#) or [waves](#) results in an [oscillation](#) or [wave](#) with smaller [amplitude](#) than either of the original [oscillations](#) or [waves](#). When the two [oscillations](#) or [waves](#) are [in anti-phase](#), the [amplitude](#) of their resultant is the difference of their [amplitudes](#). [[P5.1](#), [P5.6](#), [P5.7](#), [P6.1](#)]

also known as: destructive superposition.

destructive superposition

See [destructive interference](#).

Flexible Learning Approach to Physics - Glossary

determinism

is: a belief that the [Universe](#) operates according to laws whose nature is such that the [state](#) of the [Universe](#) at one [time](#) completely determines its [state](#) at any later [time](#). [[P10.2](#)]

Flexible Learning Approach to Physics - Glossary

deterministic system

is: a [system](#) for which a complete knowledge of the [laws](#) governing it and of its [initial state](#) allows its subsequent evolution in [time](#) to be predicted exactly.

[M6.1]

Flexible Learning Approach to Physics - Glossary

deuterium

is: the [isotope](#) of hydrogen that has [mass number](#) $A = 2$. [[P9.3](#)]

is also called: heavy hydrogen. [[P9.3](#)]

Flexible Learning Approach to Physics - Glossary

deuteron

is: a [deuterium nucleus](#), ${}^2_1\text{H}$. [P9.3]

is also represented: as D or sometimes d. [P9.3]

Flexible Learning Approach to Physics - Glossary

deviation

is: the difference between a particular [measurement](#) x_i (from a [set](#) of [measurements](#)) and the [mean](#) $\langle x \rangle$ of that [set](#). The deviation of the i^{th} [measurement](#) is therefore $d_i = x_i - \langle x \rangle$. [[P1.2](#)]

See also [standard deviation](#).

Flexible Learning Approach to Physics - Glossary

diameter

of: a [circle](#), [sphere](#) or [ellipse](#).

is: a [line segment](#) passing through the centre of the [circle](#), [sphere](#) or [ellipse](#).
[M2.1]

touches: the boundary at two 'diametrically opposite' [points](#). [M2.1]

is also: the [length](#) of such a [line segment](#), which will be twice the [radius](#) in the case of a [circle](#) or [sphere](#), but will depend on orientation in the case of an [ellipse](#). [M2.1]

Flexible Learning Approach to Physics - Glossary

diatomic ideal gas

is: an [ideal gas](#) in which the [internal energy](#) is a [function](#) of [temperature](#) T that (classically) rises from $3nRT/2$ at low [temperature](#), to $5nRT/2$ at moderate [temperature](#) (due to the excitation of the [rotational degrees of freedom](#)), to $7nRT/2$ at high [temperature](#) (due to the excitation of [vibrations](#)). [P7.4]

can be used: to [model](#) the behaviour of a [real gas](#) with two [atoms](#) per [molecule](#) at low [density](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

dielectric

is: a term used to describe an [insulator](#) in situations where its [dielectric constant](#) is (or may be) of significance (e.g. between the plates of a [capacitor](#)). [P4.5]

Flexible Learning Approach to Physics - Glossary

dielectric constant

of: a [medium](#)

is: the [ratio](#) of the [permittivity](#) of the [medium](#) to the [permittivity of free space](#), ϵ_0 . [[P4.5](#)]

is synonymous: with [relative permittivity](#), ϵ_r .

difference

See [operation](#).

differential equation

is: an [equation](#) which involves the [first derivative](#) and/or [higher derivatives](#) of a quantity. [[P5.3](#), [P5.4](#), [M6.1](#)]

has as its order: the [order](#) of the highest [derivative](#) appearing in the [equation](#). [[M6.1](#), [P5.3](#), [P5.4](#)]

has as its degree: the highest [power](#) of the [derivative](#) of highest [order](#) appearing in the [equation](#). [[M6.1](#), [P5.3](#), [P5.4](#)]

has a general solution: which involves one or more [arbitrary constants](#) with values that have to be determined by [boundary conditions](#) which are characteristic of the problem being considered. [[M6.1](#), [P5.3](#), [P5.4](#)]

See differential equations in the [Maths handbook](#) for further details.

differential operator

is: an [operator](#) (i.e. a symbolic instruction to carry out a [mathematical operation](#)) that involves the process of [differentiation](#). [M4.3]

usually acts: on whatever is immediately to its right. [M4.3]

is exemplified: by $\hat{p}_x = -i\hbar \frac{d}{dx}$ which, in [quantum mechanics](#), corresponds to the [x-component](#) of [momentum](#). [P10.4]

is also exemplified: by $\hat{E}_{\text{kin}} = -\frac{\hbar^2}{2m} \frac{d^2}{dx^2}$ which, in [quantum mechanics](#), corresponds to the [kinetic energy](#) of a particle moving in one [dimension](#). [P10.4]

See also [eigenfunction](#), [eigenvalue](#) and [eigenvalue equation](#).

differentiation

is: the process of finding the [derived function](#), or [derivative](#), of a [function](#).
[[M4.1](#), [M4.2](#)]

Flexible Learning Approach to Physics - Glossary

diffraction

is: the ability of [waves](#) to bend around obstacles or to be spread by [apertures](#).
[[P5.7](#), [P6.1](#), [P6.2](#)]

depends for its amount: on the relationship between the [wavelength](#) of the [wave](#) and the size of the obstacle or [aperture](#). [[P5.7](#), [P6.1](#), [P6.2](#)]

is negligible: when the [wavelength](#) is much less than the size of the obstacle or [aperture](#). [[P5.7](#), [P6.1](#), [P6.2](#)]

is greatest: when the [wavelength](#) is about the same size as the obstacle or [aperture](#). [[P5.7](#), [P6.1](#), [P6.2](#)]

diffraction grating

is: an optical device consisting of a flat plate with a series of equally spaced, parallel slits on its [surface](#). The distance between the slits is usually a few [wavelengths](#) of the [radiation](#) involved, and is called the [grating spacing](#). The plate may be [transparent](#) (a [transmission grating](#)) or [reflecting](#) (a [reflection grating](#)) and the slits may have been produced by ruling them with an appropriate machine (ruled grating), or by taking a cast of an existing ruled grating (replica grating). [[P6.1](#)]

produces: when illuminated by [normally incident monochromatic light](#) of [wavelength](#) λ an [interference pattern](#) which has primary [intensity](#) maxima at angles θ_n from the straight-through position given by

$$\sin \theta_n = \frac{n\lambda}{d}$$

where n is the order of diffraction and d is the [grating spacing](#). [[P5.5](#), [P6.1](#)]

diffraction pattern

is: an [interference pattern](#) from an identifiable obstruction, for example a [circular aperture](#) or slit, or a pair of slits (as in [Young's experiment](#)), or an array of slits (as in a [diffraction grating](#)). [[P5.7](#), [P6.1](#), [P6.2](#)]

See [diffraction](#).

Flexible Learning Approach to Physics - Glossary

diffuse reflection

is: [reflection](#) from a rough [surface](#), so that [rays incident](#) from the same direction are [reflected](#) in different directions by different parts of the [surface](#). [[P5.7](#)]

Flexible Learning Approach to Physics - Glossary

diffusion

is: the process by which [molecules](#) spread from regions of high to low concentration. [[P7.5](#)]

therefore is: a [transport process](#). [[P7.5](#)]

Flexible Learning Approach to Physics - Glossary

digit

is: a symbol used in the specification of a number 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 are the ten digits used to specify [decimal numbers](#). [[M1.2](#), [P1.1](#)]

Flexible Learning Approach to Physics - Glossary

dimension

of: a [coordinate system](#) (e.g. a system of [Cartesian coordinates](#))

is: a 'direction' in which measurements may be made (usually) independently of measurements in other dimensions. In the case of [Cartesian coordinates](#) the directions of the [x-axis](#), [y-axis](#) and [z-axis](#) each represent one of three independent dimensions. The number of dimensions (the dimensionality of the system) is therefore the minimum number of [coordinates](#) needed to uniquely identify any [point](#) in the region covered by the system of [coordinates](#).

See also [dimensional analysis](#) and [dimensions](#) for a different meaning.

dimensional analysis

is: the process of assigning appropriate combinations of [dimensions](#) to [physical](#) quantities and using such assignments to test the plausibility of proposed relationships between [physical](#) quantities. [[M1.3](#), [P1.1](#)]

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dimensionless

refers: to a quantity with no overall [dimensions](#), such as a pure number or a [ratio](#) of two quantities which have the same [dimensions](#). [[M1.2](#), [P1.1](#)]

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dimensionless ratio

is: a [ratio](#) of two quantities which have the same [dimensions](#). [[M1.2](#)]

Flexible Learning Approach to Physics - Glossary

dimensions

are: basic [measurable](#) quantities such as [mass](#) (M), [length](#) (L) and [time](#) (T).
[M1.2]

can be used: singly or in appropriate combinations to characterize [physical](#) quantities. [Speed](#), for example, can be [measured](#) in the same [units](#) as the [ratio](#) of a [length](#) to a [time](#) and is therefore said to have the same dimensions as [length/time](#), a relationship shown by writing $[\text{speed}] = [\text{length/time}] = \text{L T}^{-1}$. Quantities with [units](#) that differ only by a [dimensionless](#) conversion factor are said to have the same dimensions. [M1.2, P1.1]

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diminished

means: made smaller — as for an [image](#) formed by a [lens](#) or a [mirror](#), when the [image](#) is smaller than the [object](#). [[P6.3](#)]

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diopetre

is: the [unit](#) of [optical power](#) of a [lens](#), being the [reciprocal](#) of the [focal length](#) of the [lens](#) and expressed in m^{-1} . [[P6.3](#)]

dipole

See [electric dipole](#), [magnetic dipole](#).

dipole moment

See [electric dipole moment](#), [magnetic dipole moment](#).

Flexible Learning Approach to Physics - Glossary

direct current

is: an [electric current](#) whose [direction](#) does not vary with [time](#). [P4.1]

more generally refers: to other associated electrical quantities whose [direction](#) or [polarity](#) does not vary with [time](#), e.g. d.c. [voltage](#). [P4.1]

is abbreviated: DC at the beginning of a sentence, and d.c. elsewhere. [P4.1]

direct integration

is: a method of [solution](#) which can be applied to [differential equations](#) of the form $\frac{dy}{dx} = f(x)$. [[M6.1](#), [M6.2](#)]

See [inverse differentiation](#).

directed line segment

is: a [line](#) of finite [length](#) with an arrow head drawn on it. The [length](#) and orientation of such a [line](#) can be used to represent the [magnitude](#) and [direction](#) of a [vector](#) or a [vector quantity](#) in a diagram or illustration. [M2.4]

direction (of a vector)

is: a characteristic property of a [vector](#) which determines its orientation with respect to a [system of coordinates](#). [P2.2]

usually is specified: in two [dimensions](#) relative to a [two-dimensional Cartesian coordinate system](#), by quoting the [angle](#) (measured in the anticlockwise sense) from the positive [x-axis](#) to the [vector](#). [P2.2]

may be more generally specified: by expressing the vector in terms of its [components](#) relative to a given [Cartesian coordinate system](#).

See scalars and vectors in the [Maths handbook](#).

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direction (of propagation)

is: the direction of [motion](#) of a [wave](#). [[P5.6](#), [P6.1](#)]

See [transverse wave](#) and [longitudinal wave](#).

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direction cosines

of: a [straight line](#) relative to a [three-dimensional](#) system of [Cartesian coordinates](#).

are: three numbers that represent the [cosines](#) of the angles between the line and the [coordinate axes](#). [M2.2]

are: in the same [ratio](#) as the [direction ratios](#) of the line.

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direction ratios

for: a [straight line](#)

in: [three dimensions](#)

are: the [constants](#) l, m, n in the [equation](#) for the [straight line](#):

$\frac{x-a}{l} = \frac{y-b}{m} = \frac{z-c}{n}$, where (a, b, c) is a [point](#) on the [line](#). [M2.2]

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directly proportional

describes: two variables x and y , if their [ratio](#) x/y remains [constant](#) as x and y are varied. [[M1.1](#)]

is symbolized: by $x \propto y$. [[M1.1](#)]

generally is abbreviated: to 'proportional'. [[M1.1](#)]

See [constant of proportionality](#).

Contrast with [inversely proportional](#).

Flexible Learning Approach to Physics - Glossary

directrix

See [conic section](#).

Flexible Learning Approach to Physics - Glossary

disc

is: a [circle](#) together with the [points](#) enclosed by its [circumference](#). [[M2.1](#)]

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discharge tube

is: a device used to investigate the [conduction](#) of [electricity](#) through a [gas](#).
[P8.1]

consists: in its simplest form, of a [gas](#)-filled glass tube containing an [anode](#) and a [cathode](#), in which the [pressure](#) can be reduced by means of a pump. [P8.1]

Flexible Learning Approach to Physics - Glossary

discrete (variable)

is: a [variable](#) that only takes certain separated values and is therefore not a [continuous variable](#). [M1.3]

Flexible Learning Approach to Physics - Glossary

discriminant

for: a [quadratic equation](#) $ax^2 + bx + c = 0$

is: the quantity $b^2 - 4ac$. [[M1.3](#), [M1.4](#)]

determines: the number of times that the [graph](#) of the [quadratic function](#) will intersect the [x-axis](#), i.e., the number of [roots](#) that the [equation](#) has. [[M1.3](#), [M1.4](#)]

dispersion

is: the phenomenon in which a [wave](#) travels through a material with a [phase speed](#) that depends on its [frequency](#). [[P5.6](#), [P6.1](#), [P6.2](#), [P6.3](#), [P10.3](#)]

arises from: variation of the [refractive index](#) of the material with the [frequency](#) of the [wave](#), for an [electromagnetic wave](#). [[P5.6](#), [P6.1](#), [P6.2](#), [P6.3](#), [P10.3](#)]

therefore causes: [light](#) of different [frequencies](#) to be [refracted](#) by different [angles](#) on entering the material, and hence enables [light](#) of different frequencies to be refracted in different directions. [[P5.6](#), [P6.1](#), [P6.2](#), [P6.3](#), [P8.2](#), [P10.3](#)]

dispersion relation

of: a given type of [wave](#) in a specified [medium](#)

is: an [expression](#) which describes the variation of the [wave's wavelength](#) (or some related quantity such as [wavenumber](#)) with the [frequency](#) of the [wave](#).
[P10.3]

is exemplified: for an [electromagnetic wave](#) of [wavelength](#) λ travelling through a [medium](#) with a [frequency](#)-dependent [refractive index](#) $\mu(x)$, by $\lambda = c/f\mu(f)$ where c is the [speed of light in a vacuum](#).

is also exemplified: by the dispersion relation for the [de Broglie wave](#) of a [free particle](#) $\omega = \frac{\hbar k^2}{2m}$, where ω is the [angular frequency](#) and k is the corresponding [angular wavenumber](#).

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dispersive power

is: the ability of an [optical medium](#) to produce [dispersion](#) for a given [optical power](#) or [focal length](#). High or low dispersive power corresponds to high or low [refractive index](#), respectively. [P6.4]

Flexible Learning Approach to Physics - Glossary

displacement

from: one [point](#) in [space](#) to another

is: the change in [position](#) from the first [point](#) to the second. [P2.1]

is represented: by a [vector](#). The displacement \mathbf{s} from a [point](#) with [position vector](#) \mathbf{r}_1 to a [point](#) with [position vector](#) \mathbf{r}_2 is given by $\mathbf{s} = \mathbf{r}_2 - \mathbf{r}_1$. [P2.2]

has magnitude: equal to the [distance](#) between the two [points](#). [P2.2]

has direction: along the [line](#) from the first [point](#) to the second. [P2.2]

may be measured: from any selected reference [point](#), unlike a [position vector](#). [P2.2]

has as its SI unit: the [metre](#) (m). [M2.4]

in one dimension can be represented: by a single [scalar component](#) s_x . If the selected reference [point](#) is at the initial [position](#) of the [particle](#), then the displacement of the [particle](#) at [time](#) t is $s_x = x(t) - x(0)$. [M4.1, P2.1]

in linear motion is given: for displacement of an object from its [position](#) at [time](#) t_1 to its [position](#) at [time](#) t_2 by the [area under](#) the corresponding [velocity-time graph](#) between t_1 and t_2 . [M5.1]

displacement-time graph

for: a [particle](#) moving in one [dimension](#)

is: a [graph](#) of the [displacement](#) (from an agreed reference point) of the [particle](#) against [time](#). The convention is to plot the [displacement](#) vertically and the [time](#) horizontally. The [gradient](#) of the displacement-time graph is the [velocity](#) in that [dimension](#). [[P2.1](#)]

Flexible Learning Approach to Physics - Glossary

dissipation

is: the [irreversible](#) loss of [energy](#) by a [system](#) to its [environment](#) as a result of the action of [dissipative forces](#).

dissipative forces

are: [forces](#) arising from [friction](#), [viscosity](#) or similar effects that cause a reduction in relative [motion](#), and are usually accompanied by the production of [heat](#). [[P5.2](#)]

dissociation

is: the process of breaking a [molecule](#) (or part of a [molecule](#)) into its constituent [atoms](#). [[P8.2](#)]

Flexible Learning Approach to Physics - Glossary

distance

from: one [point](#) to another

is: the [magnitude](#) of the [displacement](#) from the first [point](#) to the second.
[M4.1]

therefore is: a positive quantity. [P2.1, P2.2]

has as its SI unit: the [metre](#). [P2.2]

See basic coordinate geometry in the [Maths handbook](#).

See also [path length](#).

Flexible Learning Approach to Physics - Glossary

distance-time graph

is: a [graph](#) used in the analysis of [one-dimensional linear motion](#), where the [distance](#) of an object from a reference point is plotted against the [time](#). [[P2.1](#)]

Flexible Learning Approach to Physics - Glossary

distant-action force

is: a [force](#) that always exists between two [particles](#) without their being in contact and regardless of any intervening [matter](#).

is exemplified: by the [gravitational force](#). [P3.1]

Flexible Learning Approach to Physics - Glossary

distribution

of: values of a given physical quantity x

over: a number of [particles](#) or entities.

is: a [function](#) $f(x)$ which specifies the fraction of the total number of [particles](#) which have values of x lying within the small [interval](#) between x and $x + \Delta x$.
[M5.4]

is defined: so that this [fraction](#) is equal to $f(x)\Delta x$. [M5.4]

Flexible Learning Approach to Physics - Glossary

divergent (integral)

is: an [improper integral](#) with no finite value. [M5.2]

divergent sequence

is: a [sequence](#) that does not [converge](#). [[M1.7](#)]

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divergent series

is: a [series](#) that does not [converge](#). [[M1.7](#)]

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diverging lens

is: a [lens](#) which increases the divergence or reduces the convergence of [light rays](#) passing through it. [[P6.3](#)]

is also called: a [concave lens](#) or a [negative lens](#). [[P6.3](#)]

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divisor

See [operation](#).

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domain (of a function)

of: a [function](#)

is: the range of values of the [independent variable](#) over which the [function](#) is defined. [[M1.3](#)]

Doppler effect

is: the effect in which the [observed frequency](#) of a [wave](#) (such as an [acoustic wave](#) or an [electromagnetic wave](#)) is changed when the source of the [wave](#) and the [observer](#) are moving with respect to each other. [P5.7]

causes: an increase in the [observed frequency](#) of the [wave](#) if the source and [observer](#) are moving closer together, and a decrease in the [observed frequency](#) of the [wave](#) if the source and [observer](#) are moving apart. [P5.7]

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dose equivalent

is: a quantity that quantifies the biological hazard of [ionizing radiation](#) [P9.3]

is defined: as the product of the [absorbed dose](#) and the appropriate [radiation weighting factor](#). [P9.3]

has as its SI unit: the [sievert](#), Sv. [P9.3]

dot product

See [scalar product](#).

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dots (...)

See [ellipsis](#).

double angle formulae

are: a class of [trigonometric identities](#). [M1.6]

See trigonometric functions in the [Maths handbook](#) for details.

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double bond

is: a [chemical bond](#) between two [atoms](#), which is equivalent to two single [bonds](#). [P8.4]

arises: in electronic theories of [bonding](#), from the sharing of two pairs of [electrons](#). [P8.4]

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double cone

is: the [surface](#) produced by extending to [infinity](#) (in both directions) every [straight line](#) on the [surface](#) of a [cone](#). [[M2.3](#)]

double-argument identities

are: members of a class of [hyperbolic function identities](#). [M4.6]

See hyperbolic functions in the [Maths handbook](#).

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doublet

in: a [line spectrum](#)

consists: of two [spectral lines](#) whose [wavelengths](#) are almost equal. [P8.2]

arises: when two [transitions](#) have almost the same [energy](#) difference.

appears: if at all, in each order of [diffraction](#) from a [diffraction grating](#) (except in the zeroth order). [P8.2]

Flexible Learning Approach to Physics - Glossary

driven oscillations

describes: the behaviour exhibited by a [driven oscillator](#). [[P5.4](#), [P5.5](#)]

driven oscillator

is: an [oscillating system](#) that is supplied with [energy](#) (continuously or [periodically](#)) by an externally applied [driving force](#).

is exemplified: by a [mechanical oscillator](#) consisting of a [particle](#) of [mass](#) m moving in one [dimension](#) along the [x-axis](#) subject to a [restoring force](#) $-kx$ a [damping force](#) $-bv_x$ and a [driving force](#) $F_0 \sin(\Omega t)$, so that its [displacement](#) from [equilibrium](#), x at [time](#) t satisfies the [equation of motion](#):

$$m \frac{d^2 x}{dt^2} = -kx - b \frac{dx}{dt} + F_0 \sin(\Omega t)$$

and consequently will eventually exhibit forced [oscillations](#) described by

$$x(t) = A_0 \sin(\Omega t + \phi)$$

where $A_0 = \frac{F_0 / m}{\sqrt{(\omega_0^2 - \Omega^2)^2 + (\gamma\Omega)^2}}$ and $\phi = \arctan\left(\frac{-\gamma\Omega}{\omega_0^2 - \Omega^2}\right)$ with $\omega_0 = \sqrt{k/m}$ and $\gamma = b/m$. [[P5.2](#), [P5.3](#)]

is also exemplified: by an [electrical oscillator](#) consisting of an inductance L in series with a [capacitance](#) C and a [resistance](#) R driven by an applied [voltage](#) $V_0 \sin(\Omega t)$. In such a [system](#) the charge q stored on the [capacitor](#) at [time](#) t is described by the same equations as the driven mechanical oscillator, subject to the replacement of m , k , b and F_0 by L , $(1/C)$, R and V_0 , respectively. [[P5.4](#)]

has angular frequency: Ω which is completely independent of the natural [frequency](#) ω of the [oscillating system](#) in the absence of [driving](#) or [damping forces](#). [[P5.4](#)]

displays amplitude: A_0 , which is generally dependent on the [angular frequency](#) (Ω) of the driver and which may exhibit [resonance](#) at a particular driving [frequency](#). [[P5.4](#)]

driving force

is: one of a trio of [forces](#) that determine the behaviour of a [driven oscillator](#): [restoring force](#), [damping force](#) and driving force. [[P5.2](#), [P5.3](#), [P5.5](#)]

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ductile region

is: the part of the [loading curve](#) (the [graph](#) of [stress](#) against [strain](#)) of a material over which it exhibits [plasticity](#).

is also called: the [plastic region](#). [[P7.6](#)]

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dummy variable

is: the [variable](#) of [integration](#) which is used in a [definite integral](#). [M5.2]

is named: 'dummy' since it does not appear in the final answer, so its identity is unimportant. [M5.2]

more generally is: in a particular calculation, any variable that does not appear in the final result of that calculation.

dynamic equilibrium

is: a [state](#) of a multi-member [system](#) in which there is no [time](#)-dependence in the average properties of the [system](#) as a whole, but in which there are changes and fluctuations in the [states](#) of the individual members of the [system](#). [P7.6]

dynamic friction

See [sliding friction](#).

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dynamics

is: the study of how [forces](#) give rise to changes in [motion](#). [P2.3]

Compare with [kinematics](#).

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dynamo

is: a device that generates an [induced voltage](#) by [rotating](#) a [coil](#) within a [magnetic field](#). [P4.4]

produces: depending on the arrangement of the connections to the external [circuit](#), an output which may be either [a.c.](#) or [d.c.](#) An [a.c.](#) dynamo is also known as an [alternator](#). [P4.4]

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e

is: a numerical [constant](#), whose value to eight [decimal places](#) is 2.718 281 83
[M1.5]

can be defined: by

$$e = \lim_{n \rightarrow \infty} (1 + 1/n)^n. \quad [\text{M1.5}]$$

equivalently can be defined: by

$$e = \lim_{m \rightarrow 0} (1 + m)^{1/m}. \quad [\text{M1.5}]$$

is the basis: of the [exponential function](#) e^x . [M1.5]

is used: as the [base](#) of [natural logarithms](#). [M1.5]

is: an [irrational number](#). [M1.5]

Contrast with the (italic) e used to represent the [charge](#) on the [proton](#).

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e

is: the symbol used to represent the [electric charge](#) on a [proton](#), one of the [fundamental physical constants](#).

has the value: $1.602 \times 10^{-19} \text{C}$, to three [decimal places](#).

is equal in magnitude: to the negative [charge](#) carried by the [electron](#). [P3.3]

See [quantization of charge](#).

Contrast with the (non-italic) e used to represent the [base](#) of [natural logarithms](#).

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Earth satellite

is: any object in [orbit](#) around the Earth, whether natural (the Moon) or artificial (e.g. communication or meteorological satellites). [[P2.6](#)]

must have: an [orbit](#) that is [circular](#) or [elliptical](#) (to a first approximation). [[P2.6](#)]

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earth potential

is usually defined: to be at zero [potential](#) and is used as a reference [potential](#) in conventional [circuit measurements](#). [[P4.1](#)]

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earthed

describes: a [conducting body](#), or a [point](#) on a [body](#), that is connected to the Earth by an [electrically conducting](#) pathway. [P4.1]

implies: that the [conducting body](#) or [point](#) is at [earth potential](#). (The Earth may be regarded as an enormous reservoir of mobile [charge](#) at a fixed [potential](#) ([earth potential](#)), so any [conducting body](#) (or [point](#)) that is earthed will quickly acquire [earth potential](#).) [P4.1]

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earthing

is: the process of connecting a [body](#) to the Earth by a [conducting](#) pathway so that it is [earthed](#). [P4.1]

allows: [charge](#) on a [charged conductor](#) to flow to the Earth until the [electric potential](#) of the [conductor](#) is equal to that of the Earth, i.e. is at [earth potential](#). [P4.1]

is a special case: of [charge sharing](#). [P3.3]

Flexible Learning Approach to Physics - Glossary

eccentricity

of: a given [conic section](#)

is: the [ratio](#) of the distance PF from any point P on the conic section to a [focus](#) F of the conic section, to the [perpendicular](#) distance PD from the point P to the [directrix](#) (i.e. $e = PF/PD$). [M2.3]

is exemplified: by the eccentricity e of an [ellipse](#) for which $0 \leq e < 1$, and the [lengths](#) of the [semi-major axis](#) a and the [semi-minor axis](#) b are related by

$$b = a\sqrt{1 - e^2}.$$

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eddy current

is: an [induced current](#) which circulates entirely within the body of a [conductor](#). [P4.4]

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effective area

of: a (current-carrying) [coil](#) of N turns, all in the same [plane](#) and each of geometrical [area](#) A

is equal: to NA [[P4.3](#)]

See [magnetic dipole moment](#).

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efficiency

of: a piece of equipment

generally is: the [dimensionless ratio](#) of the amount of a physical quantity extracted from the equipment to the amount of the same physical quantity supplied to the equipment.

Flexible Learning Approach to Physics - Glossary

efficiency (of a heat engine)

is: the [ratio](#) of the useful [work](#) delivered from the [heat engine](#), to the [heat](#) supplied to the [heat engine](#), $\eta = \Delta W / (Q_1 - Q_2)$. [[P7.4](#)]

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efficiency of a reversible heat engine

operating: between two fixed [temperatures](#) T_{hot} and T_{cold}

is: $\eta = 1 - T_{\text{cold}}/T_{\text{hot}}$. [[P7.4](#)]

eigenfunction

of: a mathematical [operator](#) as used in [quantum mechanics](#).

is: a [function](#) $\psi(x)$ which, when operated on by the [operator](#), produces a [real number](#) multiplied by $\psi(x)$. The [real number](#) is the [eigenvalue](#) of the [operator](#).
[[P10.4](#), [P11.1](#), [P11.2](#), [P11.3](#)]

See [eigenvalue](#), [eigenvalue equation](#) and [spatial wavefunction](#).

eigenvalue

of: a mathematical [operator](#) as used in [quantum mechanics](#).

is: the [real number](#) which appears when the [operator](#) acts on one of its [eigenfunctions](#) to produce the [eigenfunction](#) multiplied by a [real number](#).
[[P10.4](#), [P11.1](#), [P11.2](#), [P11.3](#)]

See [eigenfunction](#), [eigenvalue equation](#) and [energy level](#).

eigenvalue equation

is: an [equation](#) in which an [operator](#) acts on an [eigenfunction](#) to produce the [eigenfunction](#), multiplied by an [eigenvalue](#). That is, for an [operator](#) \hat{O} ,

$$\hat{O}f = \lambda f$$

where f is an [eigenfunction](#) of \hat{O} , and λ is the [eigenvalue](#) of \hat{O} belonging to the particular [eigenfunction](#). [[P10.4](#), [P11.1](#), [P11.2](#), [P11.3](#)]

permits: more than one (and possibly an infinite number) of [eigenvalues](#) and [eigenfunctions](#) for a given [operator](#). In physical problems \hat{O} is most commonly a [differential operator](#), but it can take other forms. In [quantum physics](#), f is commonly a [spatial wavefunction](#) (i.e. an [eigenfunction](#) of the [energy operator](#), the [Hamiltonian](#)). [[P10.4](#), [P11.1](#), [P11.2](#), [P11.3](#)]

Einstein model

is: a [model](#) of the [specific heat](#) of a [solid](#).

postulates: that a [solid](#) behaves as though composed of independent [quantum harmonic oscillators](#) characterized by a common classical [frequency](#). [P11.4]

predicts: that the [specific heat](#) will be small near [absolute zero](#). [P11.4]

See [Debye model](#).

Einstein's mass-energy equation

is: the [equation](#), $E = mc^2$, which gives the mass m associated with an amount of [energy](#) E , where c is the [speed of light](#) in a [vacuum](#). [[P2.4](#), [P9.1](#)]

is one of the consequences: of [Einstein's special theory of relativity](#). [[P2.4](#), [P9.1](#)]

Einstein's photoelectric equation

is: an [equation](#) that relates the maximum [kinetic energy](#) of [electrons](#) released in the [photoelectric effect](#) to the [frequency](#) f of the incident [light](#), the [work function](#) ϕ of the [surface](#) and [Planck's constant](#) h :

$$hf - \phi = \frac{1}{2} m_e v_{\max}^2. \quad [\text{P10.1}]$$

Einstein's special theory of relativity

is based: on two [postulates](#):

Postulate 1: The [laws of physics](#) can be written in the same form in all [inertial frames of reference](#).

Postulate 2: The [speed of light \(in a vacuum\)](#) has the same [constant](#) value, c in any [inertial frame of reference](#).

has deep consequences: among which are these:

1. If two spatially separated [events](#) are [measured](#) as [simultaneous](#) in one [inertial frame](#), they will not generally be [measured](#) as [simultaneous](#) in another [inertial frame](#) which is moving relative to the first frame.
2. If a clock is [measured](#) as moving in an [inertial frame](#), it will also be [measured](#) as running slow (losing time) in that [inertial frame](#).
3. If an object is [measured](#) as moving in an [inertial frame](#), it will also be [measured](#) as contracted in the direction of its [motion](#) in that [inertial frame](#). Moreover, its [mass](#) will be [measured](#) as greater than if it were at rest.

has been confirmed: repeatedly by [experiment](#).

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elastic

describes: the ability of a [body](#) to recover fully from a distortion and to store [energy](#) (as [strain potential energy](#)) while distorted, so long as it is not strained beyond its [elastic limit](#). [[P2.4](#), [P5.2](#), [P5.7](#)]

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elastic body

is: a deformable [body](#) that returns to its original shape when the cause of any deformation is removed, unless the amount of deformation exceeds the [elastic limit](#) of the body. [[P2.4](#)]

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elastic collision

is: a [collision](#) during which the total [kinetic energy](#) of the [system](#) of [interacting bodies](#) is [conserved](#). [[P2.4](#), [P2.5](#)]

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elastic limit

of: an [elastic body](#).

is: the maximum change in [length](#) under which the [body](#) still obeys [Hooke's law](#). [[P2.3](#)]

is also: the maximum [stress](#) that a [solid](#) can sustain without undergoing permanent deformation. [[P7.6](#)]

equivalently is: the [point](#) on the [loading curve](#) which marks the end of the [elastic region](#) and the start of the [plastic region](#). [[P7.6](#)]

is also called: the [yield point](#). [[P7.6](#)]

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elastic material

is: a material which fully recovers its previous physical and mechanical [state](#), with zero [strain](#), when the [stress](#) is removed. [[P7.6](#)]

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elastic modulus

See [modulus of elasticity](#).

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elastic region

is: the part of the [loading curve](#) of a material, over which the material behaves as an [elastic material](#). [P7.6]

extends: from zero [stress](#) to the [elastic limit](#) or [yield point](#). [P7.6]

Flexible Learning Approach to Physics - Glossary

electric cell

is: a device essentially consisting of two dissimilar [electrodes](#) dipping into an [electrolyte solution](#). [Chemical reactions](#) between the [electrodes](#) and [electrolyte](#) produce [ions](#). When the cell is connected to an external [circuit](#), there is a flow of [charge](#) within the [electrolyte](#) and around the external [circuit](#), i.e. the cell is a source of [direct current](#). [P4.5]

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electric charge

is: a fundamental property of [matter](#) which determines whether or not [particles](#) or [bodies](#) experience [electrical interactions](#). [P3.3]

is classified: into two types: positive and negative. Charges of the same type repel each other, charges of opposite types attract each other. [P3.3]

is carried: by some [fundamental particles](#), e.g. the [electron](#) carries a charge of $-e$, the [proton](#) a charge of $+e$. Some others carry none, e.g. the [neutron](#) is uncharged. [P3.3]

has as its SI unit: the [coulomb](#) (C), where $1\text{ C} = 1\text{ A s}$ (i.e. 1 [ampere second](#)).

See [quantization of charge](#).

Flexible Learning Approach to Physics - Glossary

electric current

through: a [surface](#)

is: the rate dq/dt at which (net) [charge](#) q is transferred across that [surface](#).
[P4.1, P5.5]

is due: in [metallic conductors](#), to the movement of [electrons](#). In other [media](#), it can be due to the movement of other [charged particles](#) (e.g. [ions](#) in [solution](#)).
[P4.1]

has direction: which is defined conventionally as the [direction](#) in which positive [charge](#) would move, though in many cases the current is actually a flow of negatively-[charged particles](#) in the opposite [direction](#). [P4.1]

has as its SI unit: the [ampere](#) (A). [P4.1]

electric dipole

consists: of equal and opposite [electric charges](#) $+q$ and $-q$ separated by a [distance](#) d [P3.3]

can be found: in [molecules](#) containing a variety of [atoms](#), where the [electrons](#) forming the [bonds](#) between [atoms](#) of different [chemical elements](#) are not shared equally between the two [atoms](#) involved. The result is equivalent to a dipole, in which one [atom](#) has a slight positive [charge](#) and the other a slight negative [charge](#). [P3.3]

See [electric dipole moment](#). [P3.3]

electric dipole moment

is: the product of the [charge magnitude](#) and [charge](#) separation in an [electric dipole](#). For a [dipole](#) consisting of [charges](#) $+q$ and $-q$ separated by a [distance](#) d , the dipole moment is qd . [[P3.3](#)]

is strictly: a [vector](#) quantity whose [magnitude](#) is as defined above, and whose [direction](#) is the same as for the [displacement](#) from the negative to the positive [charge](#).

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electric field

throughout: a region of [space](#)

is: a [vector field](#) that gives rise to an [electrical force](#) on a [test charge](#) placed at any [point](#) in the region. [[P3.1](#)]

is defined: at any [point](#) specified by a [position vector](#) \mathbf{r} , as the [electrostatic force](#) per [unit positive charge](#) that would act on a [test charge](#) placed at that [point](#). So, generally,

$$\mathbf{E}(\mathbf{r}) = \frac{\mathbf{F}_{\text{el}}(\text{on } q \text{ at } \mathbf{r})}{q}$$

whether the [test charge](#) q is positive or negative. [[P3.1](#), [P3.2](#)]

is related: to the [electric potential](#) by the requirement that it points in the direction of most rapid decrease of the potential, and has a [magnitude](#) given at every point by the [magnitude](#) of the rate of change of the potential in that direction (e.g. in the [radial](#) direction from an isolated point [charge](#), so that $E_r = -dV_{\text{el}}/dr$). It therefore always points in a [direction](#) at [right angles](#) to [lines](#) or [surfaces](#) of [equal potential](#), and from high potential towards low potential. [[P3.1](#), [P3.3](#)]

has as its SI unit: the [newton](#) per [coulomb](#) (N C^{-1}) or, equivalently, the [volt](#) per [metre](#) (V m^{-1}). [[P3.1](#), [P3.3](#)]

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electric field lines

are: a means of representing an [electric field](#). [P3.3]

are drawn: so that at any [point](#) the [tangent](#) to the line represents the [direction](#) of the [field](#) at that [point](#). [P3.3]

therefore are directed: away from a positive [charge](#) and towards a negative [charge](#). [P3.3]

have spacing: which is related to the [electric field strength](#), i.e. where the lines are close together the [field](#) is strong and where they are further apart the [field](#) is weaker. [P3.3]

always cut: [equipotential surfaces](#) at [right angles](#). Where these are closest together, their [rate of change](#) is greatest, and so there the [electric field](#) is strongest. [P3.1, P3.3]

Flexible Learning Approach to Physics - Glossary

electric field strength

at: any [point](#)

is: the [magnitude](#) of the [electric field](#) at that [point](#). [P3.1]

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electric potential

at: a given [point](#) in [space](#)

is: the [electric potential energy](#) per [unit positive charge](#) at that [point](#). [[P3.1](#), [P3.3](#)]

is also: the [electric potential difference](#) (i.e. [voltage](#) difference) between the given [point](#) and a [point](#) at which the [electric potential energy](#) is defined to be zero. In an [electrical circuit](#) the [earth](#), or the negative [terminal](#) of a [power supply](#), is usually taken to be at zero potential. [[P3.1](#), [P3.3](#)]

has as its SI unit: the [volt](#), (V). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

electric potential difference

between: [point](#) A and [point](#) B in an [electric field](#)

is: the difference $V_B - V_A$, in [electric potential energy](#) per [unit positive charge](#) between the two [points](#) (i.e. $\Delta V_{\text{el}} = \Delta E_{\text{el}}/q$). [[P2.6](#), [P4.1](#)]

is therefore: the negative of the [work](#) done per [unit charge](#) by an [electric field](#) when a [unit charge](#) is moved from A to B. [[M2.6](#)]

is also called: voltage difference. [[P4.1](#)]

has as its SI unit: the [volt](#), (V), where $1 \text{ V} = 1 \text{ J C}^{-1}$ (i.e. 1 [joule](#) per [coulomb](#)). [[P4.1](#)]

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electric potential energy

is: the [energy](#) a [charged particle](#) has by virtue of its [position](#) in an [electric field](#). [[P3.1](#), [P3.3](#), [P4.1](#)]

requires for its full definition: a [position](#) of zero electric potential energy to be arbitrarily chosen, since only differences in electric potential energy are physically meaningful. [[P3.1](#), [P3.3](#)]

changes: in going from [point](#) A to [point](#) B, by an amount equal to the negative of the [work](#) done by the [electric field](#) when the [charged particle](#) is moved from A to B. [[P3.1](#)]

is exemplified: by the electric potential energy of a [particle](#) of [charge](#) q_2 in the [electric field](#) of a [particle](#) of [charge](#) q_1 , when the [distance](#) between the two [particles](#) is d . Subject to the conventional choice that $E_{\text{el}} = 0$ when $r \rightarrow \infty$, this is given by

$$E_{\text{el}} = \frac{q_1 q_2}{4\pi\epsilon r}$$

where ϵ is the [permittivity](#) of the [medium](#) between the charges. [[P3.1](#), [P3.3](#)]

is related: to the [electric potential](#) V_{el} in a region by $E_{\text{el}} = qV_{\text{el}}$, so when a [charge](#) q moves through a voltage difference (i.e. an [electric potential difference](#)) ΔV_{el} , the change in electric potential energy ΔE_{el} , is given by $\Delta E_{\text{el}} = q\Delta V_{\text{el}}$. [[P4.1](#)]

often is referred: to as 'electrical energy' or electrostatic potential energy. [[P3.1](#), [P3.3](#)]

has as its SI unit: the [joule](#) (J).

Flexible Learning Approach to Physics - Glossary

electrical

means: pertaining to electricity.

See also [electrostatics](#) and [electromagnetism](#).

Flexible Learning Approach to Physics - Glossary

electrical breakdown

in: an [electrical insulator](#) which is subjected to an [electric field](#) above a certain threshold

occurs: when some of the [electrons](#) become detached from their parent [atoms](#) and flow through the material – which thus becomes, temporarily, an [electrical conductor](#). [P3.3]

electrical components

is: a general term for electrical devices, particularly those that are used in [circuits](#).

Flexible Learning Approach to Physics - Glossary

electrical conductor

is: a material containing an abundance of mobile [charged particles](#) that are free to move throughout the whole of the material. [[P3.3](#), [P4.1](#)]

has: a low [resistivity](#). [[P4.1](#)]

has typically: in terms of the [band theory](#) of [solids](#), a partly filled [valence band](#) at [absolute zero](#). [[P11.4](#)]

is exemplified: by any [metal](#). [[P3.3](#), [P4.1](#), [P11.4](#)]

is the opposite: of an [electrical insulator](#). [[P3.3](#), [P11.4](#)]

Flexible Learning Approach to Physics - Glossary

electrical energy

is: [energy](#) supplied by an [electrical power supply](#).

See also [electric potential energy](#).

Flexible Learning Approach to Physics - Glossary

electrical insulator

is: a material containing a negligible number of mobile [charged particles](#).
[P3.3, P4.1]

has: an extremely high [resistivity](#). [P4.1]

has typically: in terms of the [band theory](#) of [solids](#), an empty [conduction band](#) separated by a substantial gap (e.g. 5 eV) from a full [valence band](#) at [absolute zero](#). [P11.4]

is the opposite: of an [electrical conductor](#). [P3.3]

can be used: to prevent the flow of [current](#) between points at different [potential](#). [P4.1]

See also [electrical breakdown](#).

electrical interaction

See [electromagnetic interaction](#).

electrical oscillator

is essentially: an [inductor](#) connected across a [capacitor](#) to form a simple [circuit](#) in which [charge](#) stored on the [capacitor](#) may [oscillate](#), possibly also containing a [resistor](#) (to provide [damping](#)) and possibly subject to an externally supplied [voltage](#) to make it a [driven oscillator](#).

See [simple harmonic oscillator](#), [damped electrical oscillator](#), [driven oscillator](#), as appropriate.

Flexible Learning Approach to Physics - Glossary

electricity

is: a general term for [electric charge](#), whether [static](#) or moving, as in an [electric current](#).

electrochemical series

is: a listing of [chemical elements](#) in order of their [electrode potential](#). The further apart two [elements](#) are in the series, the greater is the [open circuit voltage](#) ([e.m.f.](#)) produced when they form the two [electrodes](#) in a simple [electric cell](#). The [element](#) with the greater (more positive) [electrode potential](#) forms the positive [terminal](#) of the [cell](#). [P4.5]

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electrode

is: an [electrically conducting](#) structure used to emit or collect [charge](#), often (though not always) a metal plate or grid.

electrode potential (of an element)

is: the [open circuit voltage](#) (e.m.f.) obtained by using the [element](#) to make one [terminal](#) of an [electric cell](#), whose other [terminal](#) is a hydrogen [electrode](#). The (theoretical) [magnitude](#) of the [open circuit voltage](#) (e.m.f.) of any simple [cell](#) is found by subtracting the two electrode potentials one from the other. [[P4.5](#)]

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electrolyte

is: a substance, usually in the form of a [solution](#), which allows the [conduction](#) of [electricity](#) by the movement of positive and negative [ions](#). [P4.5]

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electrolytic capacitor

is: a [capacitor](#) whose plates are made from two different materials separated by an [electrolyte](#).

must be connected: the correct way round in a [d.c. circuit](#). [P4.5]

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electromagnet

is: a [coil](#) or [solenoid](#) wound around a core of [ferromagnetic](#) material and which then exhibits strong [magnetic induction](#) when a [current](#) flows. [[P4.2](#)]

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electromagnetic force

is: the total [force](#) on a [charged particle](#) in an [electric field](#) and/or [magnetic field](#), found by adding the separate [electrostatic force](#) and [magnetic force](#) that would be produced by each [field](#) acting independently. [P4.3]

is described: by the [Lorentz force law](#).

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}). \quad [\text{P4.3}]$$

is also called: the [Lorentz force](#). [P4.3]

arises: from the [electromagnetic interaction](#), one of the four known [fundamental interactions](#) in nature. [P9.2]

electromagnetic induction

is: the phenomenon that results in the production of an [induced voltage](#) in a [conductor](#) by changing a [magnetic field](#) near the [conductor](#), or by moving the [conductor](#) within a [magnetic field](#) ([motional induction](#)). [[P4.4](#)]

See [Faraday's law](#) and [Lenz's law](#).

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electromagnetic interaction

is: the [fundamental interaction](#) that gives rise to [electromagnetic force](#). [P9.2]

comprises: together with the [weak](#), [strong](#) and [gravitational interactions](#), the four known [fundamental interactions](#) of nature. [P9.2]

See [gravitational force](#), [strong nuclear force](#), [weak nuclear force](#).

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electromagnetic pick-up

is: the [induced voltage](#) caused in a [circuit](#) by [magnetic field](#) fluctuations near the [circuit](#). [P4.4]

electromagnetic radiation

is: [radiation](#) consisting of fluctuating [electric](#) and [magnetic fields](#) that can [propagate](#) through [space](#), or through suitable [media](#), as [electromagnetic waves](#) characterized by a [wavelength](#) λ and a [frequency](#) f . Many aspects of the interaction of electromagnetic radiation with [matter](#) require the use of [quantum theory](#) for their accurate description.

is exemplified: by familiar phenomena such as visible [light](#), [radio waves](#) and [X-rays](#), which are all parts of the [electromagnetic spectrum](#), corresponding to different [wavelengths](#) of electromagnetic radiation.

can transfer: [energy](#) and [momentum](#). [[P7.3](#)]

See [radiation pressure](#).

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electromagnetic spectrum

is: the complete range of [electromagnetic waves](#). [[P6.1](#), [P7.3](#)]

extends: from long-[wavelength radio waves](#), through [microwaves](#), [infrared](#), [visible light](#), [ultraviolet](#) and [X-rays](#) to short-[wavelength \$\gamma\$ -rays](#). [[P6.1](#), [P7.3](#)]

electromagnetic wave

is: a pattern of mutually [perpendicular](#), [oscillating electric](#) and [magnetic fields](#) that can travel through a [vacuum](#) at the [speed of light](#), c . [P6.1]

is a form: of [transverse wave](#). [P6.1]

is characterized: in the simplest case (a [linearly polarized](#), [monochromatic](#), [plane wave](#)), by its [direction of propagation](#), [plane of polarization](#), [amplitude](#), [wavelength](#) and [frequency](#). (In a [vacuum](#) the [wavelength](#) and [frequency](#) are related by $c = f\lambda$). [P6.1]

has speed: c/μ in materials other than a [vacuum](#), where μ is the [refractive index](#) of the material. [P6.1]

Flexible Learning Approach to Physics - Glossary

electromagnetism

is: the branch of [physics](#) that encompasses all [electrical](#) and [magnetic](#) phenomena, including the interactions of [charges](#) and [magnets](#) with [electric](#) and [magnetic fields](#) and the production and [propagation](#) of [electromagnetic waves](#). [[P4.2](#)]

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electromotive force (e.m.f.)

is: an alternative term for the [open circuit voltage](#) of a [voltage generator](#).
[\[P4.1\]](#)

is not: a [force](#) in the sense defined by [Newton's second law](#).

Flexible Learning Approach to Physics - Glossary

electron

is: an [elementary particle](#) that is a constituent of every [atom](#). [P3.3, P8.1]

has: [charge](#) $-e = -1.602 \times 10^{-19}$ C and [mass](#) $m = 9.109\,56 \times 10^{-31}$ kg, approximately 1/1836 times the [mass](#) of a [proton](#). [P3.3, P8.1]

is liberated: from [atoms](#) when the [atoms](#) are [ionized](#) in a [discharge tube](#), as deduced by its discoverer J.J. Thomson (1856-1940). [P8.1]

has: no known internal structure at the time of this writing. [P8.1]

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electron antineutrino

is: an [elementary particle](#), the [antiparticle](#) of the [electron neutrino](#). [P9.2]

always accompanies: the [electron](#) emitted in [\$\beta^-\$ -decay](#). [P9.2]

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electron band

See [energy band](#).

Flexible Learning Approach to Physics - Glossary

electron cloud

in: the [quantum model](#) of the [atom](#)

is: the concept that replaces the [electron orbits](#) of more primitive models, such as the [Bohr model](#).

has: for a given [stationary state](#) of the [atom](#), a [density](#) at every point that is proportional to the [probability density](#) $|\Psi(r, \theta, \phi)|^2$ of the associated [wavefunction](#). [P11.3]

Flexible Learning Approach to Physics - Glossary

electron diffraction

is: the [diffraction](#) of [electrons](#) by a regular array of [atoms](#) (as in a [crystal](#)).
[P7.1]

is a consequence: of the [wave](#)-like behaviour of [electrons](#), as described by [quantum physics](#). [P7.1]

results in: a [diffraction pattern](#) with sharp [local maxima](#) of [intensity](#) in directions determined by [Bragg's law](#). [P7.1]

See [de Broglie wave](#).

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electron microscope

is: a [microscope](#) that uses the (short [wavelength](#)) [wave](#)-like behaviour of beams of [electrons](#) to produce [images](#) with much better [resolution](#) than those possible with [optical microscopes](#). [[P7.1](#)]

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electron neutrino

is: an [elementary particle](#) that has zero [charge](#) and such a small [mass](#) (if any) that it is currently indistinguishable from zero.

always accompanies: the [positron](#) which is emitted in β^+ -decay. [P9.2]

Flexible Learning Approach to Physics - Glossary

electron pair

is: two [electrons](#) that occupy the same [quantum state](#) apart from having opposed [spins](#).

Flexible Learning Approach to Physics - Glossary

electron shell

See [shell](#).

electron spin

is: the intrinsic [angular momentum](#) of an [electron](#). [P8.3]

is described: by an [electron spin quantum number](#) $s = 1/2$ and hence permits two possible values for the [spin magnetic quantum number](#), $m_s = 1/2$ or $m_s = -1/2$, implying that the z -component of the spin must be either $+\hbar/2$ or $-\hbar/2$ when measured along an arbitrarily chosen [z-axis](#). [P8.3]

creates: [electron spin magnetism](#). [P4.2]

helps to account: for the [magnetic](#) properties of the [electron](#) and those of [atoms](#) that contain [unpaired electrons](#). [P8.3]

electron spin magnetism

is: an intrinsic property of an [electron](#) (like [electric charge](#)), such that the [electron](#) behaves as a [magnet](#) with a measurable [magnetic dipole moment](#).
[P4.2]

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electron subshell

See [subshell](#).

Flexible Learning Approach to Physics - Glossary

electron tunnelling

is: a special case of [quantum tunnelling](#), in which an [electron tunnels](#) through a [potential barrier](#) whose height exceeds the total [energy](#) of the [electron](#). [[P10.4](#)]

is important: in various electronic devices, including the [tunnel diode](#).

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electronegativity

is: a numerical measure of the ability of an [atom](#) to attract [electrons](#) to itself during [chemical reactions](#). [P8.4]

is highest: (~4.0) in the region of the [periodic table](#) occupied by fluorine and chlorine. [P8.4]

electronic configuration

is: a description of the distribution of [electrons](#) within [shells](#) and [subshells](#) in an [atom](#), using the [quantum numbers](#) that describe the [quantum states](#) of the [electrons](#). [P8.3, P8.4]

often is presented: in shorthand form using the s-p-d-f notation for [subshells](#). For example, the [ground state](#) configuration of sodium is represented as $1s^2 2s^2 2p^6 3s^1$, meaning that

- in the $n = 1$ [shell](#) (the lowest-[energy shell](#), closest to the [nucleus](#)), there are two [electrons](#) in the s [subshell](#) (the [subshell](#) in which ($l = 0$)). This [subshell](#) is full.
- in the $n = 2$ [shell](#), there are two [electrons](#) in the s [subshell](#) ($l = 0$)
- in the $n = 2$ [shell](#), there are six [electrons](#) in the p [subshell](#) ($l = 1$)
- in the $n = 3$ [shell](#), there is one [electron](#) in the s [subshell](#) ($l = 0$) [P8.3, P8.4]

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electronic structure

is: a synonym for [electronic configuration](#). [P8.3]

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electronvolt, eV

is: a non-[SI unit](#) of [energy](#).

is defined: as the [kinetic energy](#) gained by an [electron](#) when it is [accelerated](#) through a [potential difference](#) of 1 [volt](#). [[P8.3](#), [P9.1](#)]

is equal: to 1.602×10^{-19} J (to four [significant figures](#)). [[P3.3](#)]

is commonly used: in large multiples such as MeV ($1 \text{ MeV} = 10^6 \text{ eV}$) and GeV ($1 \text{ GeV} = 10^9 \text{ eV}$) in [nuclear physics](#) and [elementary particle physics](#). [[P9.1](#)]

Flexible Learning Approach to Physics - Glossary

electrostatic constant

is: the [physical constant](#) $1/(4\pi\epsilon_0)$ that appears in [Coulomb's law](#). [P3.1]

has the value: $1/(4\pi\epsilon_0) = 8.988 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$ (to four [significant figures](#)). [P3.1]

See [Coulomb's law](#), [permittivity of free space](#) (ϵ_0) [P3.1]

electrostatic force

is: the [force](#) that acts on a [charged body](#) due to its location in a static [electric field](#). For a [test charge](#) q located at a [point](#) with [position vector](#) \mathbf{r} , where the [electric field](#) is $\mathbf{E}(\mathbf{r})$, the electrostatic force is

$$\mathbf{F}_{\text{el}}(\text{on } q \text{ at } \mathbf{r}) = q\mathbf{E}(\mathbf{r}). \quad [\text{P3.3}]$$

is exemplified: by the [force](#) (described by [Coulomb's law](#)) that one [charged particle](#) exerts on another by virtue of the [electric field](#) that it creates. Two [particles](#) with [charge](#) of the same sign repel one another, and two [particles](#) with [charge](#) of the opposite sign attract one another. [\[P3.1\]](#)

is given: for a positive [unit charge](#) by the negative [derivative](#) of [electric potential energy](#) in the direction of maximum change (e.g. in the [radial direction](#) from an isolated point [charge](#), $F_r = -dE_{\text{el}}/dr$). [\[P3.1, P3.3\]](#)

electrostatic induction

is: the process by which a region of an initially [uncharged](#) object can become [charged](#) due to the influence of an [electric field](#) (usually due to another [charged](#) object) which causes a rearrangement of [charge](#) on the original object. [[P3.3](#)]

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electrostatic potential energy

See [electric potential energy](#).

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electrostatic screening

is created: by a perfectly [conducting](#) shell containing no free [charges](#). [[P3.3](#)]

ensures: that no [electric field](#) can exist inside the shell. [[P3.3](#)]

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electrostatics

is: the study of the [electrical interaction](#) between [charged particles](#) which are not moving in relation to one another, or in relation to the [observer](#). [[P3.3](#)]

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element

is: a small part of something, often of a given solid [body](#), or a [volume](#) of [fluid](#). For example, a [body](#) of [mass](#) M may be considered to be composed of many separate elements of [mass](#) Δm_i such that $\sum_i \Delta m_i = M$.

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element (chemical)

See [chemical element](#).

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element (of a set)

is: an entity that is a member of a [set](#).

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element of integration

is: an [infinitesimal](#) increment in the [variable](#) with respect to which an [integration](#) is to be performed. [[M5.1](#), [M5.2](#)]

is exemplified: by the dx which appears at the end of the [definite integral](#)

$$\int_a^b f(x) dx. \quad [\text{M5.1}, \text{M5.2}]$$

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elementary entity

See [mole](#).

elementary functions

are: a slightly ill-defined class of [functions](#) including the common (and 'uncomplicated') [functions](#), such as [sine](#), [logarithm](#) and [arctangent](#). [[M1.7](#)]

See the [Maths handbook](#), which includes graphs of many of these functions.

elementary particles

are: [subatomic particles](#) believed, or formerly believed, not to have any constituents. Examples include [electrons](#), [protons](#), [neutrons](#) and [photons](#). It is now widely believed that [protons](#) and [neutrons](#) are in fact composed of constituents called quarks, and a modern listing of 'truly' elementary particles would consist of three families: the leptons (including the [electron](#)), the quarks (including the charged constituents of many other 'elementary particles'), and the exchange particles (including the [photon](#) and the various other particles that are responsible for the [fundamental interactions](#) between quarks and leptons).

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elimination (of a variable)

is: the process of manipulating given [equations](#) to obtain an [equation](#) which does not involve the specified [variable](#), especially in the context of [simultaneous linear equations](#). [M1.4]

is exemplified: by eliminating y between the [equations](#) $x + y = 1$ and $x - y = 2$ to yield $2x = 3$. [M1.4]

ellipse

is: a [conic section](#) shaped like a flattened [circle](#), that may be described by an [equation](#) of the form

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1, \text{ where } b = a\sqrt{1 - e^2} \text{ with } 0 \leq e < 1,$$

the longest [diameter](#) of which ($2a$) is called the [major axis](#), and the shortest [diameter](#) of which ($2b$) is called the [minor axis](#). [[M2.3](#), [P3.2](#)]

See conic sections in the [Maths handbook](#) for further details.

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ellipsis

consists: of three dots, thus ...

is often used: to indicate that an [expression](#) or [sequence](#) continues in a similar fashion, as in 1, 2, 3, 4, ... [[M1.1](#), [M2.3](#), [P3.2](#)]

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emission

of: [electromagnetic radiation](#)

is: the outcome of any process whereby the internal energy of a [system](#) is wholly or partly transformed into energy carried away by [electromagnetic radiation](#).

should be contrasted: with [absorption](#) and [reflection](#).

more generally, is: the process of giving out.

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emission lines

are: characteristic [frequencies](#) or [wavelengths](#) that are particularly prominent in an [emission spectrum](#). [P8.2]

correspond individually: to the [radiation](#) emitted in a [transition](#) between two [bound states](#) of an [atom](#) or [molecule](#). [P8.2]

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emission line spectrum

is: an [emission spectrum](#) consisting of [emission lines](#). [P8.2]

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emission spectrum

of: [electromagnetic radiation](#) (usually [emitted](#) from a specified source)

is: the distribution of [spectral brightness](#) with respect to the [wavelength](#) or [frequency](#) of the [radiation](#).

shows: the [set](#) of [wavelengths](#) at which the [excited atoms](#) or [molecules](#) in the source emit [radiation](#). [P8.2]

may consist: of characteristic [emission lines](#) (in which case the [spectrum](#) is referred to as the [emission line spectrum](#)). [P8.2]

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emission transition

in: the [Bohr model](#) for [atomic](#) hydrogen

occurs: when the [electron](#) moves from one [bound state](#) to another [bound state](#) of lower [energy](#). [P8.2]

gives rise: to emitted [electromagnetic radiation](#) whose [frequency](#) is given by the [Planck-Einstein formula](#). [P8.2]

is more generally: any [transition](#) between different [quantum states](#) that results in the [emission](#) of [radiation](#).

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emissivity

of: a [surface](#)

is: a constant $\epsilon \leq 1$, which is introduced into [Planck's function](#) for the [spectral brightness](#) of a [black body](#) in order that it should more closely represent the [spectrum](#) of [radiation](#) coming from the [surface](#). [P7.3]

is useful: only over a specified range of [wavelengths](#). [P7.3]

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empirical

means: based on [experiment](#) and/or observation.

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emulsion

is: the thin layer on a [photographic film](#) which contains the [light](#) sensitive material used to record [optical images](#) in a [camera](#). [P6.4]

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energy

of: a [body](#) or [system](#)

is: a measure of its capacity to do [work](#). [P2.4]

can exist: in several different forms. The energy that a [body](#) has because of its [motion](#) is called its [kinetic energy](#) (see also [rotational](#), [translational](#) and [vibrational kinetic energy](#)); while energy arising from its [position](#) in relation to other bodies with which it is interacting or from its internal configuration is called its [potential energy](#) (see also [electrical](#), [gravitational](#) and [strain](#) potential energy). [P2.4, P2.5]

is sometimes named: to reflect the situation in which it arises, e.g. [mechanical energy](#), [acoustic energy](#), [heat](#) and [mass energy](#).

remains: for an isolated [system](#), [constant](#) in sum over all its different forms, according to the principle of [conservation of energy](#) (see also [first law of thermodynamics](#)). [P2.4, P2.5]

may be converted: from one form into another, subject to various limitations (see also [second law of thermodynamics](#)). [P2.4, P2.5]

is: a [scalar quantity](#), with [dimensions](#) ML^2T^{-2} . [P2.5]

has as its SI unit: the [joule](#) (J), where $1\text{ J} = 1\text{ N m} = 1\text{ kg m}^2\text{ s}^{-2}$. [P2.4, P2.5]

See also [equipartition of energy](#) and [internal energy](#).

Flexible Learning Approach to Physics - Glossary

energy band

for: [electrons](#) (or other [charged particles](#))

in: a [solid](#)

is: a set of narrowly separated [energy levels](#) that the [electrons](#) (or other [charged particles](#)) may occupy. (Note that the energy bands are a property of the [solid](#) as a whole, not of the individual [atoms](#) within the [solid](#).) [P11.4]

is formed: from an [energy level](#) for the [electrons](#) in individual [atoms](#), which becomes split and broadened by the influence of other nearby [atoms](#) in the [solid](#). [P11.4]

is usually separated: from other bands, just as the individual [electron energy level](#) from which it is derived is separated from other [energy levels](#) (though it is also possible for different bands to overlap). [P11.4]

See also, [band theory](#), [conduction band](#) and [valence band](#).

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energy density

is: stored [energy](#) per [unit volume](#) of a [medium](#). [P4.5]

is given by: $\epsilon_0 \epsilon_r E^2 / 2$, in an [electric field](#) of [magnitude](#) E , where ϵ_0 is the [permittivity of free space](#) and ϵ_r is the [relative permittivity](#) of the [medium](#) in which the [field](#) is present. [P4.5]

is given by: $B^2 / (2\mu_0 \mu_r)$, in a [magnetic field](#) of [magnitude](#) B where μ_0 is the [permeability of free space](#), and μ_r is the [relative permeability](#) of the [medium](#) in which the [field](#) is present. [P4.5]

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energy level

of: a [system](#)

in: a bound [system](#), for example, in an [atom](#) or [nucleus](#)

and, furthermore, in: a [quantum state](#) of the bound [system](#)

is: one of several [energies](#) which the [particle](#) can have, and which appear as [energy eigenvalues](#) of the [time-independent Schrödinger equation](#). [[P8.2](#), [P10.3](#), [P10.4](#)]

is also: according to [quantum mechanics](#), a discrete value of [energy](#), so long as the [particle](#) is in a [bound state](#). If the [particle](#) can occupy the level for only a very short [length of time](#), the [Heisenberg uncertainty principle](#) implies a spread in the measured values of the level's [energy](#), but the energy level remains discrete. [[P8.4](#), [P10.2](#), [P10.3](#)]

conventionally is: negative; the configuration of zero [potential energy](#) being chosen so that the particle's negative [potential energy](#) outweighs its positive [kinetic energy](#). [[P10.3](#)]

always includes: non-zero [kinetic energy](#), even at the lowest of energy levels: according to [quantum mechanics](#), a [particle](#) confined can never be still (see [zero point energy](#)). [[P8.4](#)]

will be: [degenerate](#) if more than one [quantum state](#) of the [system](#) corresponds to the [energy](#) of the level.

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energy level diagram

for: a [particle](#) in a bound [system](#), such as an [atom](#) or [nucleus](#)

shows: all the (conventionally) negative [energy levels](#) corresponding to [bound states](#) of the [system](#), extending from the [ground level](#) to the [ionization level](#), each one characterized by the [quantum numbers](#) of the [state](#) (or [states](#) if the [energy level](#) is [degenerate](#)). [[P8.2](#), [P9.2](#)]

also shows: above the [ionization level](#), the [continuum](#) of (conventionally) positive [energy levels](#) corresponding to the [unbound states](#), in which the [particle](#) is free from the rest of the [system](#). [[P8.2](#), [P9.2](#)]

Flexible Learning Approach to Physics - Glossary

enlarged

means: made larger — as for an [image](#) formed by a [lens](#) or a [mirror](#), when the [image](#) is larger than the [object](#). [[P6.3](#)]

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entrance pupil

is: the [image](#) of the [aperture stop](#) of an [optical system](#), formed by all the [lenses](#) which precede it. [[P6.4](#)]

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entropy

of: a [system](#)

is: a [function of its state](#). [P7.4]

requires for its full definition: a [state](#) of fixed entropy to be arbitrarily chosen, since only differences in entropy are physically meaningful.

changes: in going from a [state](#) a to a [state](#) b when a and b are linked by a [reversible isothermal process](#) involving [heat](#) transfer ΔQ_{rev} at [temperature](#) T by

the amount $\Delta S = \frac{\Delta Q_{\text{rev}}}{T}$. [P7.4]

more generally differs: between two [states](#) a and b which are linked by an arbitrary [reversible process](#), by the amount $\Delta S = S_b - S_a = \int_a^b \frac{dQ}{T}$ where the [integral](#) is evaluated over the [reversible process](#). (This remains true even if the [state](#) is changed from a to b by some other process.) [P7.4]

is exemplified: by the entropy of n [moles](#) of [ideal gas](#) at [temperature](#) T and occupying [volume](#) V :

$$S = \frac{3nR}{2} \log_e \left(\frac{T}{T_0} \right) + nR \log_e \left(\frac{V}{V_0} \right) + S_0$$

where R is the [molar gas constant](#) and S_0 is the entropy arbitrarily assigned to a [state](#) with [temperature](#) T_0 and [volume](#) V_0 . [P7.4]

provides: a measure of the extent to which [energy](#) transferred in the process is **not** available to do useful [work](#). [P7.4]

in effect is: a [measure](#) of disorder. [P7.4]

has as its SI unit: J K^{-1} . [P7.4]

See also [second law of thermodynamics](#) and [principle of entropy increase](#).

Flexible Learning Approach to Physics - Glossary

envelope

of: a [wave group](#)

is: a curve or [surface](#) serving to characterize the group by moving with the [group speed](#), and modulating the [amplitudes](#) of the individual [waves](#) that make up the group, as they move through the group at their individual [phase speeds](#).

Flexible Learning Approach to Physics - Glossary

environment

is: that part of the [Universe](#) which does *not* constitute the [system](#) being studied. [[P7.3](#), [P7.4](#)]

equating real and imaginary parts

is: a procedure which allows an [equation](#) involving [complex numbers](#) to be rewritten as two [equations](#) involving only [real numbers](#). The procedure consists of equating the [real parts](#) of the [expressions](#) on either side of the equality, and then equating the [imaginary parts](#). [M3.1]

Flexible Learning Approach to Physics - Glossary

equation

is: an equality between two [algebraic expressions](#). [M1.1]

See also [solution](#) and [identity](#).

Flexible Learning Approach to Physics - Glossary

equation of a circle

of: [radius](#) R

centred: on the [origin](#)

is: $x^2 + y^2 = R^2$. [[M2.2](#)]

See conic sections in the [Maths handbook](#).

equation of a line in three dimensions

in: a [three-dimensional](#) system of [Cartesian coordinates](#)

is: $\frac{x-a}{l} = \frac{y-b}{m} = \frac{z-c}{n}$ where (a, b, c) are the [coordinates](#) of a [point](#) on the line, and the [constants](#) l, m, n determine the direction of the line. [[M2.2](#)]

Flexible Learning Approach to Physics - Glossary

equation of a plane

in: a [three-dimensional](#) system of [Cartesian coordinates](#)

is: $ax + by + cz = d$, where a , b , c and d are [constants](#). [[M2.2](#)]

Flexible Learning Approach to Physics - Glossary

equation of a straight line

in: [standard form](#)

is: $y = mx + c$ where m is the [gradient](#) (or [slope](#)) of the [straight line](#) and c is the [intercept](#) on the [y-axis](#). [[M2.2](#), [M1.3](#), [P1.3](#)]

also can be written: in the form $ax + by + c = 0$. [[M2.2](#)]

equation of motion

is: an [equation](#) that expresses (explicitly or implicitly) the position of a moving object as a function of [time](#). Such [equations](#) often take the form of [differential equations](#) and are usually obtained from [Newton's second law of motion](#).

[M6.1]

Flexible Learning Approach to Physics - Glossary

equation of state

for: any substance

is: an [equation](#) (usually an approximation) which relates the [mass](#) m or number of [moles](#) n of a fixed quantity of the substance to its [volume](#) V , [pressure](#) P , and [temperature](#) T (and/or any other relevant [thermodynamic coordinates](#)). [P7.2]

is exemplified: by the [equation of state of an ideal gas](#), $PV = nRT$. [P7.2]

equation of state of an ideal gas

is: the [equation](#) $PV = nRT$, which relates the number n of [moles](#), the [volume](#) V , the [pressure](#) P and the [temperature](#) T of a sample of [ideal gas](#), where $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ is the [molar gas constant](#). [[P7.2](#), [P7.3](#), [P7.4](#)]

is also known: as the [ideal gas law](#), and may be written in a variety of ways. A particularly common form is $PV = NkT$, where N is the number of [molecules](#) in the sample and $k = 1.380 \times 10^{-23} \text{ J K}^{-1}$ is [Boltzmann's constant](#). [[P7.2](#), [P7.3](#), [P7.4](#)]

Flexible Learning Approach to Physics - Glossary

equiangular

describes: a [polygon](#) when all of its [interior angles](#) are equal. [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

equidistant

describes: two points which are at the same [distance](#) from a third. [M2.1]

Flexible Learning Approach to Physics - Glossary

equilateral

describes: a [polygon](#) whose sides are all of the same [length](#). (Used especially in the case of an [equilateral triangle](#).) [M2.1]

equilateral polygon

is: a [polygon](#) whose sides are of equal [length](#). [M2.1]

equilateral triangle

is: a [triangle](#) with three equal sides, and hence with three equal [angles](#) each of 60° (or, equivalently, of $\pi/3$ [radians](#)). [[M1.6](#), [M2.1](#)]

equilibrium

is: the condition of a [system](#) in which its [state](#) of [motion](#) remains unchanged, i.e. the total [linear momentum](#) \mathbf{P} and total [angular momentum](#) \mathbf{L} are [constant vectors](#). [[P5.1](#), [P7.3](#)]

See also [mechanical equilibrium](#), [translational equilibrium](#) and [rotational equilibrium](#).

Flexible Learning Approach to Physics - Glossary

equilibrium state

of: a [system](#)

is: any [state](#) of the [system](#) in which it is in equilibrium ([stable](#), [unstable](#) or [neutral](#)), usually specified in terms of appropriate [\(thermodynamic\) coordinates](#). [[P7.3](#), [P7.4](#)]

is exemplified: by any set of values for n , P , V and T which satisfy the [equation of state of an ideal gas](#). [[P7.3](#), [P7.4](#)]

Flexible Learning Approach to Physics - Glossary

equilibrium surface

See [PVT-surface](#).

Flexible Learning Approach to Physics - Glossary

equilibrium system

is: a [system](#) in an [equilibrium state](#).

equipartition of energy theorem

is: a [theorem](#) of classical [statistical mechanics](#) which relates the average [microscopic internal energy](#) of a [system](#) $\langle E_{\text{int}} \rangle$ to the [temperature](#) via the number of [degrees of freedom](#) present in the [system](#).

states that: if there are f [degrees of freedom](#), then the [mean internal energy](#) per [molecule](#) will be given by $\langle E_{\text{int}} \rangle = fkT/2$, where T is the [absolute temperature](#), and k is [Boltzmann's constant](#). [P7.5]

Flexible Learning Approach to Physics - Glossary

equipotential contour

of: a specified [potential](#)

is: a curve passing only through [points](#) at which the specified [potential](#) has the same (arbitrarily chosen) value. [[P3.1](#)]

has the property: that at any [point](#) it is at [right angles](#) to the [field](#) associated with the [potential](#). [[P3.1](#)]

usually is drawn: so that the [potential](#) changes by a fixed amount between consecutive equipotential contours. This means that consecutive contours are close together where the [field](#) is strong. [[P3.1](#)]

often is abbreviated: to 'equipotential'. [[P3.1](#)]

equipotential line

See [equipotential contour](#).

Flexible Learning Approach to Physics - Glossary

equipotential surface

of: a specified [potential](#)

is: a [surface](#) passing only through [points](#) at which the specified [potential](#) has the same (arbitrarily chosen) value. [[P3.1](#), [P3.3](#)]

has the property: that at any [point](#) it is [perpendicular](#) to the [field](#) associated with the [potential](#). [[P3.1](#), [P3.3](#)]

usually is drawn: so that the [potential](#) changes by a fixed amount between consecutive equipotential [surfaces](#). This means that consecutive [surfaces](#) are close together where the [field](#) is strong. [[P3.1](#), [P3.3](#)]

often is abbreviated: to 'equipotential'. [[P3.1](#)]

Flexible Learning Approach to Physics - Glossary

equivalent circuit

is: a [circuit](#) which produces identical effects to a [circuit](#) which it has replaced. [\[P4.1\]](#)

can be used: as an aid to [circuit](#) analysis. [\[P4.1\]](#)

Flexible Learning Approach to Physics - Glossary

erect (image)

means: upright – as for an [image](#) formed by a [lens](#) or a [mirror](#), when the [image](#) is the same way up as the [object](#). [[P6.2](#), [P6.3](#)]

Contrast with [inverted image](#).

Flexible Learning Approach to Physics - Glossary

erecting prism

is: a [prism](#) used to invert an already [inverted image](#) in an [optical system](#) and so make it [erect](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

error (of observation)

See [uncertainty](#).

Flexible Learning Approach to Physics - Glossary

error bar

consists: of lines drawn on both sides of a [point](#) on a [graph](#), to indicate the size of the [experimental error](#) on that [point](#). Lines drawn [parallel](#) to the [x-axis](#) show the size of the [uncertainty](#) in the [x-coordinate](#); lines drawn [parallel](#) to the [y-axis](#) show the size of the [uncertainty](#) in the [y-coordinate](#). [[P1.3](#)]

Flexible Learning Approach to Physics - Glossary

error function

is: a [function](#) that arises in various contexts, including the analysis of [normally distributed](#) ([Gaussian](#)) errors.

is defined: by $\text{erf}(x) = \frac{2}{\sqrt{\pi}} \int_0^x \exp(-y^2 / 2) dy$. [[M5.5](#)]

Flexible Learning Approach to Physics - Glossary

escape speed

is: the minimum [speed](#) which must be given to a [projectile](#) for it to completely escape from the [gravitational force](#) of the Earth. [[P2.4](#), [P3.2](#)]

is given: by $v_{\text{es}} = \sqrt{\frac{2GM_{\text{E}}}{R_{\text{E}}}}$

where M_{E} is the [mass](#) of the Earth, R_{E} its [radius](#) and G is [Newton's universal gravitational constant](#). [[P2.4](#), [P3.2](#)]

Flexible Learning Approach to Physics - Glossary

essential constants

are: [independent arbitrary constants](#) which appear in the [general solution](#) of a [differential equation](#). [M6.1]

Euler's formula

is: an important relationship between the [exponential](#), [sine](#) and [cosine functions](#):
 $e^{i\theta} = \cos(\theta) + i \sin(\theta)$, where $i^2 = -1$. [[M3.2](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

evaporation

is: a process whereby [liquid](#) is converted into [gas](#) (or more properly [vapour](#)) at a [temperature](#) below the [boiling point](#).

involves: the escape of those [molecules](#) with above average [kinetic energy](#) from the [liquid](#) and therefore results in the cooling of the [liquid](#).

is balanced: in a closed vessel containing [liquid](#) and [vapour](#) in [equilibrium](#), by [condensation](#).

Flexible Learning Approach to Physics - Glossary

even (function)

is: a [function](#) $f(x)$ such that $f(-x) = f(x)$. [[M1.6](#), [M4.4](#), [M5.2](#), [P11.2](#)]

Flexible Learning Approach to Physics - Glossary

event

in: [Einstein's special theory of relativity](#)

is: an idealized occurrence at a [point](#) in [space](#) and an instant of [time](#), and may therefore be located in an appropriate [frame of reference](#) by means of four [coordinates](#) (x, y, z, t).

Flexible Learning Approach to Physics - Glossary

exchange particles

See [elementary particles](#).

Flexible Learning Approach to Physics - Glossary

excitation

is: the process whereby the [electron](#) in an [atom](#) is given additional [energy](#) and so moves to a [bound state](#) of higher [energy](#). The additional [energy](#) may be provided by incoming [radiation](#), by [heating](#) or via [collisions](#) with other [particles](#), such as [electrons](#). [P8.2]

Flexible Learning Approach to Physics - Glossary

excited level

is: the [energy level](#) corresponding to each [excited state](#) for an [electron](#) in an [atom](#). [P8.2]

equivalently is: an [energy level](#) other than the [ground level](#). [P10.3]

Flexible Learning Approach to Physics - Glossary

excited state

of: an [electron](#)

in: an [atom](#) or some other [bound system](#)

is: any [bound state](#), other than the [ground state](#), for the [electron](#). [[P8.2](#), [P8.3](#)]

equivalently is: a [state](#) of the [system](#) in which the [energy](#) corresponds to an [excited level](#). [[P10.3](#)]

Flexible Learning Approach to Physics - Glossary

excluded volume

is: the [volume](#) occupied by a [gas](#) but from which [molecules](#) are excluded by virtue of their individual [volumes](#). [[P7.5](#)]

Flexible Learning Approach to Physics - Glossary

exit pupil

is: the [image](#) of the [aperture stop](#) in an [optical system](#), formed by all the [lenses](#) which follow it. [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

expansion

is: the process of making something larger in size.

Flexible Learning Approach to Physics - Glossary

expand (an expression)

of: an [expression](#) that involves [brackets](#)

describes: the process of finding an equivalent expression with fewer [brackets](#). [[M1.1](#)]

experiment

A planned investigation of natural phenomena, usually involving equipment, under conditions that are to some extent determined by the investigator.

See also [experimental data](#).

Flexible Learning Approach to Physics - Glossary

experimental data

consists: of [observations](#), particularly numerical [measurements](#), which have been obtained in an [experiment](#). [[P1.1](#)]

Flexible Learning Approach to Physics - Glossary

exponent

is: a superscript following a number or [expression](#) that indicates repeated multiplication (if the exponent is a positive [integer](#)) or some related [operation](#) in other cases. [[M1.5](#)]

See arithmetic and algebra in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

exponential change

describes: any process in which a quantity exhibits [exponential growth](#) or [exponential decay](#). If q is such a quantity, then $q = q_0 e^{kt}$ where q_0 is a [constant](#), t is an [independent variable](#) (e.g. [time](#)) and k is a positive or negative [constant](#) according to whether q is growing or decaying. [[M1.5](#)]

is exemplified: by the change in an investment when the interest is compounded continuously as can be seen from the [equation](#)

$$e^{kt} = \lim_{m \rightarrow 0} (1 + m)^{kt/m}. \quad [\text{M1.5}]$$

Flexible Learning Approach to Physics - Glossary

exponential decay

describes: an [exponential change](#) in which the changing quantity decreases with [time](#). [M1.5]

is exemplified: by the [radioactive decay law](#) $N = N_0 e^{-\lambda t}$

exponential form (of a complex number)

represents: a [complex number](#) as $z = r e^{i\theta}$ where r and θ are [real](#). r is known as the [modulus](#) of z and is usually written as $|z|$, while θ is known as the [argument](#) of z and usually is written as $\arg(z)$. Adding an [integer](#) multiple of 2π to θ leaves the value of $r e^{i\theta}$ unchanged, so the [arguments](#) of a given [complex number](#) has infinitely many possible values. The unique value that satisfies the restriction $-\pi < \theta \leq \pi$ is called the [principal value of the argument](#). [[M3.2](#), [P5.5](#)]

Compare and contrast with [Cartesian form](#) and [polar form](#), and see complex numbers in the [Maths handbook](#) for the relationship between them.

Flexible Learning Approach to Physics - Glossary

exponential function

is: the [function](#) $\exp(x) = e^x$. [\[M1.5\]](#)

has the general feature: the bigger it is, the faster it grows (or shrinks). [\[M1.5\]](#)

more specifically, has: the property of being its own [derivative](#), which makes it especially useful for doing [calculus](#) with exponential functions and [logarithms](#). [\[M1.5\]](#)

sometimes refers: to the function $f(x) = a^x$, which is related to the function $\exp(x) = e^x$ by:

$$a^x = \exp(x \log_e(a)) \quad \text{[M1.5]}$$

Flexible Learning Approach to Physics - Glossary

exponential growth

describes: an [exponential change](#) in which the changing quantity increases with [time](#). [M1.5]

Flexible Learning Approach to Physics - Glossary

exponential law

is: any [equation](#) relating two quantities, x and y , that may be written in the form $y = k a^x$, where k is any [constant](#) and a is any positive [constant](#). (Often $a = e$).
[M1.5, P1.3]

Flexible Learning Approach to Physics - Glossary

exponential representation (of a complex number)

See [exponential form \(of a complex number\)](#).

Flexible Learning Approach to Physics - Glossary

exposure

is: a measure of the total [light energy](#) reaching a [photographic film](#) or [emulsion](#). [P6.4]

determines: the imaging response of the [film](#) or [emulsion](#). [P6.4]

Flexible Learning Approach to Physics - Glossary

exposure time

is: the [time interval](#) over which a [photographic film](#) or [emulsion](#) is exposed to [light](#). [P6.4]

Flexible Learning Approach to Physics - Glossary

expression

is: a combination of numbers and [algebraic](#) symbols. [M1.1]

may be: the sum of several terms, or may be a single number or symbol.
[M1.1]

Flexible Learning Approach to Physics - Glossary

extended body

is: a [body](#) for which the size and shape are important. [[P2.8](#)]

Flexible Learning Approach to Physics - Glossary

extended image

is: an [image](#) with a finite size in an [optical system](#), being an [image](#) of an [extended object](#).

is usually shown: on a [ray diagram](#) as a [directed line segment](#) drawn at [right angles](#) to the [optical axis](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

extended object

is: an [object](#) which has a finite size in an [optical system](#), as opposed to being a [point object](#). Any actual [object](#) is an extended object. [P6.2]

is usually shown: on a [ray diagram](#) as a [directed line segment](#) drawn at [right angles](#) to the [optical axis](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

extension

is: a quantity that describes the [displacement](#) of the mobile end of a spring or some other [elastic body](#) from its natural (unextended) [position](#). [[P2.4](#)]

Flexible Learning Approach to Physics - Glossary

exterior angle

is: the [angle](#) between a side of a [polygon](#) and an adjacent side [produced](#).
[\[M2.1\]](#)

Flexible Learning Approach to Physics - Glossary

external force

is: a [force](#) whose source lies outside the [system](#) being considered. [P2.5]

is given: by the [rate of change](#) of [linear momentum](#) of the [system](#). [P2.5]

Flexible Learning Approach to Physics - Glossary

extrapolation

is: the process of using values of a [dependent variable](#), measured over a finite range of the corresponding [independent variable\(s\)](#), to estimate the value of the [dependent variable](#) corresponding to a value of the [independent variable\(s\)](#) that falls outside the measured range. [P1.3]

is exemplified: by the extension of a [graph](#) beyond the range of values within which [measurements](#) have been made. [P1.3]

Contrast with [interpolation](#).

Flexible Learning Approach to Physics - Glossary

eye lens

in: a compound [eyepiece](#)

is: the [lens](#) which is nearer to the eye. [P6.4]

also describes: the [lens](#) of the eye itself. [P6.4]

See [lens \(of eye\)](#).

Flexible Learning Approach to Physics - Glossary

eyepiece

in: an [optical](#) instrument

is: the [lens](#) nearest to the eye. [P6.4]

if compound is: the combination of [lenses](#) nearest to the eye. [P6.4]

Flexible Learning Approach to Physics - Glossary

f-number

of: a [lens](#)

is: a quantity that indicates the [ratio](#) of the [focal length](#) to the [diameter](#) of the [lens aperture](#). [P6.4]

controls: the [light](#)-gathering ability of a [lens](#) for a given [focal length](#); the higher the f-number the smaller the [aperture](#) of the [lens](#) and the greater the [depth of field](#). [P6.4]

is exemplified: by f/5.6 for a lens with a [focal length](#) 5.6 times greater than its [aperture diameter](#). [P6.4]

often is called: f-stop. [P6.4]

Flexible Learning Approach to Physics - Glossary

factor

of: a [product](#)

is: any one of the numbers or [expressions](#) that are multiplied together to create the [product](#). [[M1.1](#)]

See [operation](#).

Flexible Learning Approach to Physics - Glossary

factorial

of: a non-negative [integer](#), n

is denoted: by $n!$

is defined: as

$$n! = n(n - 1)(n - 2)(n - 3) \dots (2)(1) \text{ for } n \geq 1$$

and as $0! = 1$ for $n = 0$. [[M1.7](#)]

Flexible Learning Approach to Physics - Glossary

factorization

of: an [algebraic expression](#) (which may include [complex numbers](#))

is: the procedure by which the [expression](#) is converted into [factorized form](#).
[[M1.3](#), [M1.4](#), [M3.3](#)]

can always be carried out: for a [quadratic function](#) or any other [polynomial function](#). [[M1.3](#), [M1.4](#)]

factorized form

of: a [polynomial function](#) (especially a [quadratic function](#))

is: the form $f(x) = a(x - \alpha)(x - \beta) \dots (x - \zeta)$, which makes clear the [roots](#) of the equation $f(x) = 0$, i.e. any values of x at which the [graph](#) of the [function](#) $f(x)$ intersects the [x-axis](#). [[M1.3](#), [M1.4](#)]

See [factorization](#).

Flexible Learning Approach to Physics - Glossary

Fahrenheit

describes: a [temperature scale](#) which is related to the [Celsius scale](#) by the [equation](#) $T_F/(^{\circ}\text{F}) = 9T_C/(5^{\circ}\text{C}) + 32$ where T_F is a temperature in degrees Fahrenheit and T_C is the corresponding [temperature](#) in [degrees Celsius](#).

Flexible Learning Approach to Physics - Glossary

far point

is: the farthest [point](#) from which [light](#) entering the eye may be [imaged](#) on the [retina](#). [P6.4]

is: for a normal eye, at [infinity](#). [P6.4]

Flexible Learning Approach to Physics - Glossary

farad, F

is: the [SI unit](#) of [capacitance](#). [[P4.5](#)]

is defined: as one [coulomb](#) per [volt](#): $1 \text{ F} = 1 \text{ C V}^{-1}$. [[P4.5](#)]

See [capacitor](#). [[P4.5](#)]

Faraday's law

states: that the [magnitude](#) of the [induced voltage](#) in a [circuit](#) is numerically equal to the [rate of change](#) of the [magnetic flux linkage](#) in the [circuit](#): $V_{\text{ind}} = |d\Phi/dt|$.
[P4.4]

See also [electromagnetic induction](#) and [Lenz's law](#).

fast neutrons

are: [neutrons](#) produced directly in [nuclear fission](#) and having [kinetic energy](#) (typically 1 MeV or more) which is too high to initiate further [nuclear fission](#) in uranium, but may do so in plutonium.

Contrast with [thermal neutrons](#).

Flexible Learning Approach to Physics - Glossary

fast reactor

is: a [breeder reactor](#) which uses [fast neutrons](#) to induce [nuclear fission](#) in plutonium. [[P9.3](#)]

Fermat's principle

states: that if a [light ray](#) passes from one fixed [point](#) to another fixed [point](#), then the [time](#) taken to traverse the actual path will, to a first approximation, be equal to the [time](#) taken for [light rays](#) to traverse adjacent paths. That is, the [time](#) taken to traverse the path will be [stationary](#) with respect to small variations in the path. [[P6.2](#)]

means, in mathematical terms: that if the journey [time](#) along conceivable [rays](#) from one fixed [point](#) to the other is $T(x)$ where x is some suitable [parameter](#), then the actual path (or paths) will be determined by finding the value (or values) of x for which $dT/dx = 0$. [[P6.2](#)]

means, in physical terms: that light travels along the path which is locally of least time. [[P6.2](#)]

permits deduction: of all the basic rules and principles of [geometrical optics](#). [[P6.2](#)]

Flexible Learning Approach to Physics - Glossary

fermion

is: any [particle](#) which has an intrinsic [spin angular momentum](#) which is a half-integer multiple of $h/(2\pi)$ where h is [Planck's constant](#).

Flexible Learning Approach to Physics - Glossary

ferrites

are: ceramic materials made from [sintered](#) oxides of iron and barium. [P4.2]

can be formed: into strong [permanent magnets](#). [P4.2]

in granular form can be: bonded with plastics and used in record/erase tapes for information storage. [P4.2]

ferromagnetic

describes: a class of materials which are strongly attracted by a [permanent magnet](#) even when not permanently [magnetized](#). [P4.2]

comprise: primarily the five [elements](#) iron (Fe), cobalt (Co), nickel (Ni), gadolinium (Gd) and dysprosium (Dy), together with some associated [alloys](#). [P4.2]

fibre bundle

is: a collection of many hundreds or thousands of individual [optical fibres](#), bound together within a single sheath. [[P6.2](#)]

Flexible Learning Approach to Physics - Glossary

field

throughout: a region of [space](#)

is: a physical quantity to which a definite value can be ascribed at each [point](#) in the region, at a particular [time](#). [[P3.1](#)]

See [scalar field](#) and [vector field](#).

field ion microscope

is: a [microscope](#) that uses the ([quantum](#)) [wave](#)-like properties of a beam of [ions](#) to achieve finer [resolution](#) than is possible with an [optical](#) or (in some aspects) even an [electron microscope](#). [[P7.1](#)]

Flexible Learning Approach to Physics - Glossary

field lens

in: a compound [eyepiece](#)

is: a [lens](#) which increases the ability of the [eye lens](#) to accept incoming [rays](#) over a wide range of [angles](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

field lines

are: directed curves that provide a means of representing a [vector field](#). [P3.1]

are drawn: so that at any [point](#) the [tangent](#) to the line represents the [direction](#) of the [field](#) at that [point](#), and the spacing of the lines is related to the [field](#) strength. That is, where the lines are close together the [field](#) is strong and where they are further apart the [field](#) is weaker. [P3.1]

See also [equipotential surface](#).

Flexible Learning Approach to Physics - Glossary

field stop

is: a stop or [aperture](#) which defines the maximum [angle](#) of acceptance of [rays](#) passing through the [eye lens](#) of a compound [eyepiece](#). [P6.4]

Flexible Learning Approach to Physics - Glossary

filter circuit

is: a [circuit](#) designed to block (or pass) signals in specific [frequency](#) ranges.
[\[P5.4\]](#)

Flexible Learning Approach to Physics - Glossary

final velocity

is: the [velocity](#) at the end of a period of [time](#). [P2.1]

See [uniform acceleration equations](#).

Flexible Learning Approach to Physics - Glossary

finite series

is: a [series](#) with a limited (finite) number of [terms](#). [[M1.7](#)]

Contrast with [infinite series](#).

Flexible Learning Approach to Physics - Glossary

first derivative test

is: a test to determine the location and nature of [local extrema](#) of a given [function](#) $f(x)$.

involves: (a) finding the points at which $f'(x) = 0$, (b) investigating the behaviour of the sign of $f'(x)$ in the neighbourhood of these points. If $f'(a) = 0$ and $f'(x)$ changes from positive to negative at $x = a$ then there is a [local maximum](#) at a . If $f'(a) = 0$ and $f'(x)$ changes from negative to positive at a then there is a [local minimum](#) at a . If $f'(a) = 0$, but $f'(x)$ does not change sign at $x = a$ then further investigation is required. [[M4.4](#)]

See stationary points and graph sketching in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

first focal point

in: the [paraxial approximation](#)

is: for a convex lens, the [point](#) F_1 on the [optical axis](#), from which [rays](#) are [refracted](#) by the [lens](#) to emerge [parallel](#) to the [axis](#). [P6.3]

is: for a concave lens, the [point](#) F_1 on the [optical axis](#), from which [rays](#) which have been [refracted](#) parallel to the [axis](#) by the [lens](#), appear to emanate. [P6.3]

is also called: first focus or object focus.

See [focal length](#).

Flexible Learning Approach to Physics - Glossary

first focus

See [first focal point](#).

Flexible Learning Approach to Physics - Glossary

first ionization energy

of: an [atom](#)

is: the [energy](#) required to remove the least tightly [bound electron](#) from the [atom](#) in its [ground state](#). [[P8.4](#)]

first law of thermodynamics

states: that if a [system](#) undergoes a change from one [equilibrium state](#) to another, the difference between the [heat](#) Q supplied to the [system](#) and the [work](#) W done by the [system](#) will depend only on the initial and final [equilibrium states](#) and not on the process by which the change is brought about. [[P7.3](#), [P7.4](#), [P7.5](#)]

justifies: the introduction of a [function of state](#) known as the [internal energy](#) U which changes by an amount

$$\Delta U = Q - W$$

in the process. [[P7.3](#), [P7.4](#), [P7.5](#)]

represents: the [conservation of energy](#), but also has an additional implication. Because Q and W are not [functions of state](#), their respective contributions to U cannot be disentangled, and it does not generally make sense to speak of the 'heat content' of a [system](#). [[P7.3](#), [P7.4](#), [P7.5](#)]

first-order differential equation

is: a [differential equation](#) in which no [derivative](#) of the [dependent variable](#) of [order](#) higher than first [order](#) appears. [P5.4]

has: a [general solution](#) which always involves the introduction of an [arbitrary constant](#). This [constant](#) can only be determined in any particular situation by imposing an appropriate [boundary condition](#). [P5.4]

usually is assumed: to be of the [first degree](#) and may be written in the general form

$$a(x)\frac{dy}{dx} + b(x)y = f(x). \quad [\text{M6.2}]$$

Flexible Learning Approach to Physics - Glossary

first term (of an arithmetic progression)

See [arithmetic progression](#).

Flexible Learning Approach to Physics - Glossary

fissile

means: capable of undergoing [nuclear fission](#). [P9.3]

fission

See [nuclear fission](#).

fixed point

See [calibration point](#).

Flexible Learning Approach to Physics - Glossary

flint glass

is: a glass of relatively high [refractive index](#) and thus high [dispersive power](#).
[\[P6.4\]](#)

Flexible Learning Approach to Physics - Glossary

fluid

is: a material which is not a [solid](#) and which is incapable of sustaining [tensile stress](#), [uni-axial compressive stress](#) or [shear stresses](#) in [equilibrium](#) but can only sustain [uniform stress](#) or [volume stress](#) (i.e. [pressure](#)). [[P7.6](#)]

more simply, is: any substance which can flow. This is usually taken to mean a [liquid](#) or a [gas](#). [[P7.2](#)]

Flexible Learning Approach to Physics - Glossary

flux

of: [particles](#)

if: there are N [particles](#) per [unit length](#) moving along the [x-axis](#) each with [velocity](#) v_x

is: the net rate at which particles cross a fixed [plane](#) per [unit time](#), i.e.
 $F = Nv_x$. [[P11.1](#)]

See also [flux \(in quantum mechanics\)](#).

Flexible Learning Approach to Physics - Glossary

flux (in quantum mechanics)

of: [particles](#), in a stream of [particles](#) represented by the [spatial wavefunction](#) $\psi(x) = A \exp(ikx)$, which is an [eigenfunction](#) of the [momentum operator](#).

given that: the average number of [particles](#) per [unit length](#) is the constant $|A|^2$, and their [velocity](#) is obtained from the [momentum](#), $v_x = p_x/m = \hbar k/m$

is: the net number crossing a fixed [plane](#) per [unit time](#), i.e. $F = |A|^2 \hbar k/m$.
[\[P11.1\]](#)

Flexible Learning Approach to Physics - Glossary

flux linkage

through: a [coil](#) of N turns

is given by: $\Phi = N\phi$ where ϕ is the [magnetic flux](#) through a single turn.

Flexible Learning Approach to Physics - Glossary

flux of a vector field

across: a [surface](#) S

is defined: to be the [surface integral](#) $\int_S \mathbf{V} \cdot d\mathbf{S}$ where \mathbf{V} represents the [vector field](#), and $d\mathbf{S}$ is an [element](#) of area which is directed along an (abstractly chosen) outward pointing [normal](#) to the [surface](#) S . [[M2.6](#)]

Flexible Learning Approach to Physics - Glossary

fluxmeter

is: a [moving-coil galvanometer](#), designed with a [damping force](#) but no [restoring force](#), so that a [current](#) pulse produces a non-returning deflection whose size is [proportional](#) to the total [charge](#) passed. [P4.4]

is used: to measure [magnetic fields](#) in conjunction with a [search coil](#). [P4.4]

Flexible Learning Approach to Physics - Glossary

focal length

of: a [lens](#) or [mirror](#)

is: for [parallel](#) incident light, the [distance](#) (the [image](#) focal length) from the [lens](#) to its [image focus](#); or the distance (the [object](#) focal length) from the [lens](#) to its [object focus](#); or the [distance](#) from the [mirror](#) to the [focus](#) of the [mirror](#). For a [thin lens](#), the [image](#) focal length and [object](#) focal length are the same. [P6.3]

is: within the [Cartesian sign convention](#) a positive quantity for a [convex lens](#) or a [concave mirror](#), and a negative quantity for a [concave lens](#) or a [convex mirror](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

focal point

in: the [paraxial approximation](#)

refers: for a [lens](#) to the [object focus](#) on the [optical axis](#), from which [rays](#) are [refracted](#) by the [lens](#) to emerge [parallel](#) to the [optical axis](#); also to the [image focus](#) on the [optical axis](#), to which [parallel rays](#) converge after [refraction](#) by the [lens](#). [P6.3]

is: for a concave mirror the [point](#) (called the focus) on the [optical axis](#), to which [rays](#) parallel to the [optical axis](#) converge after [reflection](#) at the [mirror](#). [P6.3]

is: for a convex mirror the [point](#) (called the focus) on the [optical axis](#), from which [rays](#) parallel to the [optical axis](#) appear to diverge after [reflection](#) at the [mirror](#). [P6.3]

See [first focal point](#), [second focal point](#), [focal length](#).

Flexible Learning Approach to Physics - Glossary

focus (of a conic section)

See [conic section](#).

Flexible Learning Approach to Physics - Glossary

focus (of a lens)

See [focal point](#).

Flexible Learning Approach to Physics - Glossary

focus (of a mirror)

See [focal point](#).

Flexible Learning Approach to Physics - Glossary

force

in: [Newtonian mechanics](#)

describes: the amount of 'push' or 'pull' exerted on a [particle](#) which, if unopposed, causes it to depart from the [uniform motion](#) predicted by [Newton's first law of motion](#). [P2.3]

therefore is: that which causes (or tends to cause) [acceleration](#). [M5.1]

is: a [vector quantity](#), so it has both [direction](#) and [magnitude](#). [M2.4, P2.3]

is quantified: by means of [Newton's second law of motion](#), which tells us that the [acceleration](#) \mathbf{a} of a [particle](#) is [proportional](#) to the [resultant force](#) \mathbf{F} that acts on it, and inversely proportional to its mass m . Thus, in terms of [vectors](#),

$$\mathbf{F} = m\mathbf{a}$$

or in terms of [\(scalar\) components](#),

$$F_x = ma_x, \quad F_y = ma_y, \quad F_z = ma_z \quad [\text{P2.3}]$$

has as its SI unit: the [newton](#) (N). [M2.4]

Flexible Learning Approach to Physics - Glossary

force constant

in: [simple harmonic motion](#)

is: the [magnitude](#) of the [restoring force](#) per [unit extension](#). [P5.2]

Flexible Learning Approach to Physics - Glossary

force laws

are: rules that allow the prediction of the [forces](#) acting in any given situation. [P2.3]

include: [Newton's law of gravitation](#), the [law of terrestrial gravitation](#), the [laws of friction](#), [Hooke's law](#), [Coulomb's law](#) and the [Lorentz force law](#). [P2.3]

forced convection

See [convection](#).

forced oscillations

See [driven oscillator](#).

forced oscillator

See [driven oscillator](#).

forced vibration

is: [vibration](#) which occurs when a [system](#) is supplied with [energy periodically](#) in order to keep it [oscillating](#). [[P5.2](#)]

See [driven oscillator](#).

forces of adhesion

are: attractive [intermolecular forces](#) acting across a boundary or [interface](#) between two materials and tending to cause their [surfaces](#) to stick together.
[P7.6]

Flexible Learning Approach to Physics - Glossary

forces of cohesion

are: attractive [intermolecular forces](#) acting within a material and tending to hold the material together. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

Fourier's law

states: that the rate at which [heat](#) is transferred along a [uniform](#) bar of [cross-sectional area](#) A by [conduction](#) is [proportional](#) to the [temperature gradient](#) along the bar:

$$\frac{dQ}{dt} = -\kappa A \frac{dT}{dl}$$

where κ is the [thermal conductivity coefficient](#), a characteristic of the material of the bar. (The minus sign indicates that the direction of [heat flow](#) is from high [temperature](#) to low [temperature](#).) [[P7.3](#)]

Flexible Learning Approach to Physics - Glossary

fraction

is: the [ratio](#) of two [integers](#) or [algebraic expressions](#). [M1.1]

fractional error

is: a [dimensionless](#) expression for the [error](#) (i.e. [uncertainty](#)) in a quantity, obtained by dividing the [absolute error](#) by the quantity itself. [[P1.1](#), [P1.2](#)]

See also [percentage error](#).

Flexible Learning Approach to Physics - Glossary

fracture

is: the process of breaking. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

frame of reference

is: a [three-dimensional](#) physical setting, such as a laboratory, which provides the assumed context in which [events](#) takes place. [[P2.7](#)]

is normally: fixed with respect to a specific [observer](#). [[P2.3](#)]

is represented: by a [coordinate system](#), that allows a unique [position](#) to be assigned to each [event](#), and a system of suitably synchronized clocks (or some equivalent [system](#)) that enables a unique [time](#) to be assigned to each [event](#). [[P2.3](#)]

Fraunhofer diffraction

is: [diffraction](#) in which a [plane wavefront](#) (i.e. [parallel light](#)) is incident on an [aperture](#) and the resulting [diffraction pattern](#) is [observed](#) also as [plane wavefronts](#). [[P6.1](#)]

therefore: its [observation](#) involves either large [distances](#) or [lenses](#). [[P6.1](#)]

Flexible Learning Approach to Physics - Glossary

free convection

See [convection](#).

Flexible Learning Approach to Physics - Glossary

free fall

is: the [motion](#) of an object (generally close to the [surface](#) of the Earth or other large [body](#)) solely under the influence of [gravitational force](#). [[P3.2](#)]

Flexible Learning Approach to Physics - Glossary

free particle

is: a [particle](#) moving freely without any [force](#) acting on it and therefore with no changes in its [energy](#). [[P10.2](#)]

Flexible Learning Approach to Physics - Glossary

free space

is synonymous: with [vacuum](#).

Flexible Learning Approach to Physics - Glossary

freezing point

of: a substance

is: the [temperature](#) at which the [solid](#) and [liquid phases](#) of the substance can coexist in [equilibrium](#) at a specified [pressure](#) (usually, but not necessarily, [standard atmospheric pressure](#)).

is synonymous: with [melting point](#).

Flexible Learning Approach to Physics - Glossary

frequency

is: the number of [cycles](#) of a [periodic motion](#) occurring per [second](#), at any fixed [position](#). [[M6.4](#), [P5.1](#), [P5.5](#), [P5.6](#), [P5.7](#), [P6.1](#)]

therefore is equal: to the [reciprocal](#) of the [period of the motion](#): $f = 1/T$. [[M6.4](#), [P5.7](#), [P5.1](#)]

has as its SI unit: the [hertz](#) (Hz), where $1 \text{ Hz} = 1 \text{ s}^{-1}$. [[P5.4](#)]

frequency-stabilized laser

is: a [laser](#) whose [frequency](#) is stabilized by some process and so constitutes an [oscillator](#) of exceedingly high [Q-factor](#) with a very narrow [resonance bandwidth](#), and hence potential application as a [time](#) or [frequency standard](#). [P5.3]

Flexible Learning Approach to Physics - Glossary

Fresnel lens

is: a flat [lens](#), usually of large [aperture](#) and made from plastic, whose thickness (and hence [weight](#)) is reduced by a series of concentric steps in the curved [surface](#). [[P6.4](#)]

is used: where a large-[aperture](#) inexpensive [lens](#) is required, e.g. in an overhead projector or in the back window of a bus. [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

friction

is: the phenomenon whereby a [force](#) (called a [frictional force](#)) acts on a [body](#) when it is in contact with another [body](#) (or with a [viscous medium](#)) and when there is [relative motion](#), or a tendency for [relative motion](#), between those [bodies](#) (or between the [body](#) and the [medium](#)). [[P2.3](#), [P5.2](#)]

frictional force

is: a [force](#) that arises from [friction](#). [P5.2]

acts in a direction: that opposes the actual or potential [relative motion](#) that gives rise to it. [P5.2]

is, when there is actual relative motion: [sliding friction](#), the [magnitude](#) of which is given by $\mu_{\text{slide}}R$, where R is the [magnitude](#) of the [reaction force](#) on the [body](#) concerned, and μ_{slide} is a [constant](#) known as the [coefficient of sliding friction](#). [P2.3, P5.2]

is, when there is only potential relative motion: [static friction](#), the maximum [magnitude](#) of which is given by $\mu_{\text{static}}R$, where R is the magnitude of the [reaction force](#) on the [body](#) concerned, and μ_{static} is a [constant](#) known as the [coefficient of static friction](#). [P2.3, P5.2]

Flexible Learning Approach to Physics - Glossary

fulcrum

of: a turning motion

is: the line about which the motion takes place, sometimes called the [axis of rotation](#). [[P2.7](#)]

function

consists: of two [sets](#) and a rule, such that to each [element](#) of the first [set](#) (the [domain](#)) is associated a single [element](#) of the second [set](#) (the [codomain](#)). If the [domain](#) consists of the values of a [variable](#) x and the [codomain](#) consists of the values of a [variable](#) y then x is called the [independent variable](#) and y , the [dependent variable](#) and we write $y = f(x)$. In such circumstances it is usual to say that f is a function of x and that y is its value. (Note that this definition excludes the possibility of defining a function that is multi-valued.) [[M1.3](#), [M5.2](#)]

function of a function

See [composite function](#).

Flexible Learning Approach to Physics - Glossary

function of a function rule

is: a rule for differentiating [composite functions](#) (i.e. functions of functions)

states: that if y is a function of u so that $y = f(u)$ and u is a function of x so that $y = g(x)$, then

$$\frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx} = f'(u) \times g'(x) \quad [\text{M4.3}]$$

See the chain rule in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

function of state

is: any property of a [system](#) that is entirely determined at any [time](#) by the [state](#) of the [system](#) at that [time](#). In particular, it does not depend on the processes which brought the [system](#) to that [state](#). [P7.3, P7.4]

is exemplified: by the [internal energy](#) U of a fixed quantity of [ideal gas](#), which is determined by the [temperature](#) of the [gas](#) at any [time](#) (provided the [gas](#) is in [equilibrium](#)). Thus, changes in [internal energy](#) are determined by changes in [temperature](#) (one of the [thermodynamic coordinates](#) that specify the [state](#)) irrespective of the processes that bring them about. [P7.3, P7.4]

is NOT exemplified: by the [heat](#) Q supplied to a fixed quantity of [ideal gas](#). The heat required to bring about a particular change of [state](#) will generally depend on the exact process involved, not just the initial and final [states](#). [P7.3, P7.4]

function of two variables

is: a [function](#) whose [domain](#) consists of [ordered pairs](#) of values such as (x, y) where x and y are [independent variables](#). [M6.4]

fundamental

on: a string of finite [length](#) l

is: that [standing wave](#) of the string which has the greatest possible [wavelength](#) (and hence the lowest possible [frequency](#), known as the fundamental frequency). [P5.6, P5.7]

is exemplified: for a string fixed at both ends with [linear mass density](#) μ and under a [tension](#) F_T by the [standing wave](#) of [wavelength](#) $2l$ which has

(fundamental) [frequency](#) $\frac{1}{2l} \sqrt{\frac{F_T}{\mu}}$.

may be more generally applied: to other [oscillatory systems](#) that exhibit [standing waves](#).

See [harmonics](#).

fundamental constant

See [universal constant](#).

fundamental force

is: any of the four known forms of interaction ([gravitational](#), [electromagnetic](#), [strong](#), and [weak](#)) between [elementary particles](#). These interactions (particularly the [gravitational](#) and [electromagnetic interactions](#), which have unlimited ranges) are the ultimate cause of all the other 'forces' of [physics](#).

Flexible Learning Approach to Physics - Glossary

fundamental frequency

See [fundamental](#).

fundamental interaction

is: any of the four known modes ([gravitational](#), [electromagnetic](#), [strong](#), [weak](#)) by which [elementary particles](#) interact.

fundamental particle

is: a synonym for [elementary particle](#).

is sometimes used more specifically: to mean those particles that are currently thought to be truly 'elementary', thereby including [quarks](#), [leptons](#), and [exchange particles](#) but excluding composite particles such as the [proton](#) and the [neutron](#).

fundamental theorem of algebra

states: that any [polynomial](#) of [degree](#) n with [complex number coefficients](#) has, counting [repeated roots](#) an appropriate number of times, exactly n [complex roots](#). [[M1.4](#), [M3.1](#)]

fundamental theorem of calculus

relates: [definite](#) and [indefinite integrals](#) of a given [function](#) and thereby simplifies the evaluation of a [definite integral](#), provided that an [indefinite integral](#) of its [integrand](#) can be found. [[M5.1](#), [M5.2](#)]

states: that if $F(x)$ is any [indefinite integral](#) of $f(x)$ so that $\frac{dF}{dx} = f(x)$, then

$$\int_a^b f(x) dx = [F(x)]_a^b = F(b) - F(a). \quad [\text{M5.1}, \text{M5.2}]$$

Flexible Learning Approach to Physics - Glossary

fusion

can refer: to melting – the [phase transition](#) in which a [solid](#) becomes a [liquid](#), upon [absorption](#) of the requisite amount of [latent heat](#). [[P7.4](#)]

also can refer: to [nuclear fusion](#). [[P9.3](#)]

Flexible Learning Approach to Physics - Glossary

fusion curve

is: the [curve](#) on the P - T [projection](#) of the [PVT-surface](#), which separates the [solid phase](#) from the [liquid phase](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

γ -decay

is: a form of [radioactive decay](#) in which a [nucleus](#) emits a [\$\gamma\$ -ray](#) (i.e. a [photon](#) with high [energy](#), typically hundreds of keV, and possibly much higher).
[P9.2]

γ -radiation

is: a form of [electromagnetic radiation](#) emitted in [radioactive decay](#) and characterized by [wavelengths](#) shorter than those of [X-rays](#) (i.e. less than or approximately equal to 0.4 nm). [[P9.2](#)]

galvanometer

See [moving-coil galvanometer](#).

Flexible Learning Approach to Physics - Glossary

gas phase

is: a [fluid](#) phase of [matter](#) characterized by the lack of a definite [volume](#) or shape other than that imposed by a container. [[P7.1](#)]

at the microscopic level, can be described: as a [system](#) in which the [thermal kinetic energy](#) is much greater than the intermolecular [bonding energies](#). [[P7.1](#)]

Gauss' law

states: that for an [electric field](#) \mathbf{E} , in a [vacuum](#), the [flux](#) of \mathbf{E} out of a closed [surface](#) \mathbf{S} (as given by the [surface integral](#) of \mathbf{E} over \mathbf{S} with a suitably chosen outward pointing [normal](#) at each [point](#) on \mathbf{S}) is equal to the total [charge](#) enclosed by \mathbf{S} divided by the [permittivity of free space](#), so

$$\int_S \mathbf{E} \cdot d\mathbf{S} = \frac{1}{\epsilon_0} \times \left\{ \begin{array}{l} \text{the total charge} \\ \text{within the surface} \end{array} \right\} \quad [\text{M2.6}]$$

Gaussian distribution

is: a smooth [curve](#) (or the [function](#) describing such a curve) with the property that in a wide range of practical situations it represents the shape taken by the [histogram](#) of a large number of [measurements](#) of some quantity as the [measurement intervals](#) are made smaller and smaller. [P1.2]

is also known: as a normal distribution. [Measurements](#) with [histograms](#) that approach Gaussian distributions are said to be normally distributed. [P1.2]

mathematically can be described: by an [equation](#) of the form

$$y = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-(x - \langle x \rangle)/(2\sigma^2)\right],$$
 where $\langle x \rangle$ is the [mean](#) of the distribution and σ is the [standard deviation](#) of the distribution. (The [mean](#) and the [standard deviation](#) of a [set](#) of normally distributed [measurements](#) provide estimates of these two quantities.) [P1.2]

Gaussian integral

is: an [integral](#) of the form

$$\int_0^{\infty} x^{2n} \exp(-ax^2) dx, \text{ or } \int_{-\infty}^{\infty} x^{2n} \exp(-ax^2) dx$$

where n is a positive [integer](#) or zero, and a is a positive [constant](#). [[M5.5](#)]

See further integration in the [Maths handbook](#) for details of the evaluation of Gaussian integrals.

Flexible Learning Approach to Physics - Glossary

general solution

of: a [linear differential equation](#) of [order](#) n

is: a [solution](#) that involves n [essential constants](#). [[M6.1](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

generator

of: a geometrical [surface](#) (e.g. a [cone](#))

is: a [straight line](#) which when moved in a prescribed way sweeps out the geometric [surface](#). [[M2.3](#)]

Flexible Learning Approach to Physics - Glossary

generic *PVT*-surface

is: the [PVT-surface](#) of a 'typical' substance. [P7.4]

is used: to illustrate general statements about features and properties of [PVT-surfaces](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

geometric figure

is: any shape (involving [points](#), [lines](#), [curves](#), etc.) of interest to those studying geometry. [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

geometric progression

is: a [series](#) of the form:

$$\sum_{k=1}^n ar^{k-1} = a + ar + ar^2 + \dots + ar^{n-1}$$

The [constant](#), r is known as the common ratio. [[M1.7](#)]

Flexible Learning Approach to Physics - Glossary

geometric series

See [geometric progression](#).

geometric series for complex numbers

where: z is a [complex variable](#)

is: a [series](#) of the form $a + az + az^2 + \dots + az^n$, the sum of which is equal to $(1 - z^{n+1})/(1 - z)$ if $z \neq 1$. [[M3.3](#)]

Flexible Learning Approach to Physics - Glossary

geometric vector

is: a [directed line segment](#) that may be used to represent a [vector quantity](#).
[\[M2.5\]](#)

geometrical optics

is: the branch of [optics](#) which is based on the [ray approximation](#) to the [wave model of light](#). [[P6.1](#), [P6.2](#)]

assumes: that [light](#) follows paths called [rays](#) which obey the [principle of reversibility](#) and the [principle of rectilinear propagation](#), and which satisfy the [law of reflection](#) and the [law of refraction](#). [[P6.1](#), [P6.2](#)]

Flexible Learning Approach to Physics - Glossary

geometry

is: that branch of [mathematics](#) which is concerned with the properties of [space](#) and of figures in [space](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

geostationary

describes: [Earth satellites](#) which [orbit](#) in such a way that they are permanently located above a particular point on the Earth's [surface](#). Such satellites must travel with the same [angular velocity](#) as the Earth itself, and the satellite [orbit](#) must be directly above the equator. [[P2.6](#)]

also describes: the [orbit](#) for such [Earth satellites](#). [[P2.6](#)]

Flexible Learning Approach to Physics - Glossary

geosynchronous

is often used synonymously: with [geostationary](#).

is sometimes used more generally: to indicate an [Earth satellite](#) in an [orbit](#) with a 24 hour [period](#) that might be inclined at an angle to the equator. (Such a satellite would cross the same point on the equator at the same [time](#) each day, but would not be permanently located above that particular point.)

Flexible Learning Approach to Physics - Glossary

global maximum

of: a [function](#)

on: an [interval](#)

is: the greatest value of the [function](#) on that [interval](#). [M4.4]

also known as: absolute maximum.

See stationary points and graph sketching in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

global minimum

of: a [function](#)

on: an [interval](#)

is: the least value of the [function](#) on that [interval](#). [M4.4]

also known as: absolute minimum.

See stationary points and graph sketching in the [Maths handbook](#).

graded-index fibre

is: an [optical fibre](#) in which the [refractive index](#) gradually decreases from the [axis](#) of the [fibre](#) and in which [continuous refraction](#) is used to confine [light rays](#) within the [fibre](#) and away from the [surface](#) of the [fibre](#). [P6.2]

Flexible Learning Approach to Physics - Glossary

gradient

of: a [straight line](#) (or the corresponding [linear function](#))

is: a measure of the [rate](#) at which one quantity changes with another quantity. As a [graph](#) with given scales on the [Cartesian axes](#), the gradient controls the angle between the line and the horizontal.

is often used synonymously with: the slope of the [straight line](#).

is given: for a [straight line](#) drawn as a [graph](#) on conventional [Cartesian axes](#), with x horizontal and y vertical, by the [ratio](#) of a difference in y values to the corresponding difference in x values between any two [points](#) on the [straight line](#),

$$\text{i.e. gradient} = \frac{(y_2 - y_1)}{(x_2 - x_1)} = \frac{\Delta y}{\Delta x} = \frac{\text{rise}}{\text{run}} \quad [\text{M1.3, M2.2, P1.3}]$$

may be easily found: from the [gradient-intercept form](#) of the [equation of a straight line](#), $y = mx + c$, where it is represented by the constant m .

may be used more generally: at a [point](#) on a [curve](#), to refer to the gradient of the [straight line](#) that is a [tangent](#) to the [curve](#) at the [point](#).

is equal, in this more general sense; to the [derivative](#) of the [function](#) that describes the [curve](#), evaluated at the [point](#) in question

i.e. the gradient of $y = f(x)$, at $x = a$ is $f'(a)$. [M4.2]

Flexible Learning Approach to Physics - Glossary

gradient-intercept form

of: the [equation of a straight line](#)

is: $y = mx + c$

where m is the [gradient](#) (i.e. slope) of the [straight line](#) and c is the [intercept](#) of the [straight line](#) with the [y-axis](#). [[M2.2](#), [M3.1](#)]

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gram, g

is: an [SI unit](#) of [mass](#), a submultiple of one of the seven [base units](#).

is defined by: $1 \text{ g} = 10^{-3} \text{ kg}$.

Flexible Learning Approach to Physics - Glossary

graph

is: the representation of an [equation](#) or [function](#) in geometric form, normally using [Cartesian coordinates](#). In the case of a [function](#) $f(x)$ the graph is usually that of the [equation](#) $y = f(x)$. [[M1.3](#), [M5.2](#), [P1.3](#)]

graph sketching

is: the process of constructing a 'rough' [graph](#) of a [function](#), which shows the salient features of the [function](#) without requiring detailed plotting. [[M4.4](#)]

grating relation

for: a [diffraction grating](#) with slits separated by a [distance](#) d illuminated by [normally incident light](#) of [wavelength](#) λ

relates: the angles θ_n , at which n^{th} order maxima in the [diffraction pattern](#) will be found, to n , λ and d . [[P6.1](#), [P8.2](#)]

states: that $n\lambda = d \sin \theta_n$. [[P6.1](#), [P8.2](#)]

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grating spacing

is: the distance between the slits in a [diffraction grating](#). [P6.1]

gravitational constant

See [Newton's universal gravitational constant](#).

gravitational energy

See [gravitational potential energy](#).

Flexible Learning Approach to Physics - Glossary

gravitational field

throughout: a region of [space](#)

is: a [vector field](#) which gives rise to a [gravitational force](#) on a [test mass](#) placed at any [point](#) in the region. [P3.1]

is defined: at any [point](#) specified by a [position vector](#) \mathbf{r} , as the [gravitational force](#) per [unit mass](#) that would act on a [test mass](#) placed at that [point](#). So, generally,

$$\mathbf{g}(\mathbf{r}) = \frac{\mathbf{F}(\text{on } m \text{ at } \mathbf{r})}{m}$$

where m is the [test mass](#). [P3.1, P3.2]

is related: to the [gravitational potential](#) by the requirement that it points in the direction of most rapid decrease of the potential, and has a magnitude given at every point by the magnitude of the rate of change of the potential (e.g. in the [radial direction](#) from an isolated point [mass](#), so that $g_r = -dV_{\text{grav}}/dr$). It therefore always points in a [direction](#) at [right angles](#) to [lines](#) or [surfaces](#) of [equal potential](#), and from high potential towards low potential. [P3.1, P3.2]

has as its SI unit: the [newton](#) per [kilogram](#) (N kg^{-1}). [P3.1, P3.2]

Flexible Learning Approach to Physics - Glossary

gravitational field strength

at: any [point](#)

is: the [magnitude](#) of [gravitational field](#) at that [point](#). [P3.1]

therefore is also: the [magnitude](#) of the [acceleration](#) of a [unit point mass](#) in [free fall](#) due to [gravity](#) at that [point](#). [P3.2]

See also [surface gravity](#).

gravitational force

is: in [Newtonian mechanics](#), an attractive [force](#) that acts between [particles](#) having [mass](#). [P3.1]

is described: by the [universal law of gravitation](#), which says that the gravitational force on a [particle](#) of [mass](#) m_2 due to a [particle](#) of [mass](#) m_1 a [distance](#) r away is

$$\mathbf{F}_{\text{grav}} = \mathbf{F}_{21} = -\frac{Gm_1m_2}{r^2}\hat{\mathbf{r}}$$

where G is [Newton's universal gravitational constant](#) and $\hat{\mathbf{r}}$ is a [unit vector](#) pointing from m_1 to m_2 . [P3.1]

arises: from the [gravitational interaction](#), one of the [fundamental interactions](#) in nature. [P3.1, P9.2]

See also [surface gravity](#).

Flexible Learning Approach to Physics - Glossary

gravitational interaction

is: the [fundamental interaction](#) that gives rise to [gravitational force](#). [P9.2]

comprises: together with the [electromagnetic](#), [weak](#) and [strong interactions](#), the four known [fundamental interactions](#) of nature. [P9.2]

Flexible Learning Approach to Physics - Glossary

gravitational mass

is: the [mass](#) of a [body](#) as determined by the [gravitational force](#) that it experiences or exerts. (See [Newton's law of gravitation](#).) [[P2.3](#)]

Contrast with [inertial mass](#).

Flexible Learning Approach to Physics - Glossary

gravitational potential

at: a [point](#) in [space](#) where there is a [gravitational field](#)

is: the [gravitational potential energy](#) per [unit mass](#) due to the [gravitational field](#) at that [point](#). [[P3.1](#), [P3.2](#)]

has as its SI unit: the [joule](#) per [kilogram](#) (J kg^{-1}).

Flexible Learning Approach to Physics - Glossary

gravitational potential energy

is: the [potential energy](#) that a [body](#) has by virtue of its [position](#) in a [gravitational field](#). [P2.4]

requires for its full definition: a [position](#) of zero gravitational potential energy to be arbitrarily chosen, since only differences in gravitational potential energy are physically meaningful.

changes: in going from point A to point B, by an amount equal to the negative of the [work](#) done by the [gravitational field](#) when the [body](#) is moved from A to B. [P3.2]

is exemplified: by the gravitational potential energy of a [particle](#) of [mass](#) m_2 in the [gravitational field](#) of a [particle](#) of [mass](#) m_1 when the [distance](#) between the two [particles](#) is r . Subject to the conventional choice that $E_{\text{grav}} = 0$ when $r \rightarrow \infty$, this is given by

$$E_{\text{grav}} = -\frac{Gm_1m_2}{r}$$

where G is [Newton's universal gravitational constant](#). [P2.4, P3.1, P3.2, P5.2]

is related: to the gravitational potential V_{grav} in a region by $E_{\text{grav}} = mV_{\text{grav}}$, so when a [mass](#) m moves through a [gravitational potential](#) difference ΔV_{grav} , the change in gravitational potential energy ΔE_{grav} is given by $\Delta E_{\text{grav}} = m\Delta V_{\text{grav}}$. [P3.1, P3.2, P4.1]

often is abbreviated: to gravitational energy. [P3.1, P3.2]

has as its SI unit: the [joule](#) (J).

Flexible Learning Approach to Physics - Glossary

gravity

is: the phenomenon that gives rise to gravitational effects such as the [gravitational force](#) on an object.

Flexible Learning Approach to Physics - Glossary

gray, Gy

is: the [SI unit](#) of [absorbed dose](#) of [ionizing radiation](#).

is defined: by $1 \text{ Gy} = 1 \text{ J kg}^{-1}$. [[P9.3](#)]

See also [sievert](#).

Flexible Learning Approach to Physics - Glossary

grazing incidence

is: a situation in which the [angle of incidence](#) at a [surface](#) is very close to 90° .
[\[P6.2\]](#)

Flexible Learning Approach to Physics - Glossary

ground level

of: an [atom](#)

is: the [energy level](#) corresponding to the [ground state](#) of an [electron](#) in an [atom](#). [P8.2]

more generally is: the [energy level](#) corresponding to the minimum [energy](#) for a [system](#). [P10.3]

Flexible Learning Approach to Physics - Glossary

ground state

of an atom, is: the [state](#) of the [atom](#) in which all the [electrons](#) occupy the lowest possible [energy levels](#). [[P8.2](#), [P8.3](#), [P8.4](#)]

generally, is: a condition or state for a [system](#) in which its [energy](#) has the minimum value. [[P10.3](#)]

Flexible Learning Approach to Physics - Glossary

group

of: [chemical elements](#)

is: a [set](#) of [chemical elements](#), commonly placed in a vertical column in a [periodic table](#) because of similarities in chemical properties. [[P8.4](#)]

Flexible Learning Approach to Physics - Glossary

group speed

of: [wave groups](#) composed of [superpositions](#) of [waves](#) with a variety of [frequencies](#)

in: [dispersive media](#) (i.e. when [waves](#) of different [frequencies](#) propagate at different [speeds](#))

is: the [speed](#) at which the [envelope](#) of the [wave group propagates](#). [P5.6]

generally will differ: from the [phase speed](#) of any of the individual [waves](#) which contribute to the formation of the [wave group](#). [P5.6]

Flexible Learning Approach to Physics - Glossary

gyroscope

is: a spinning wheel, mounted on very low [friction](#) bearings called gimbals, which exert no [torque](#) and so allow the [axis of rotation](#) to maintain its direction through [conservation of angular momentum](#), even if the support on which the gyroscope and gimbals are mounted, alters its orientation. [[P2.8](#)]

therefore can be used: as a navigational device on ships, aeroplanes, and spacecraft. [[P2.8](#)]

half-angle formulae

are: a class of [trigonometric identities](#). [M1.6]

See trigonometric functions in the [Maths handbook](#).

half-argument identities

are: a class of [hyperbolic function identities](#). [M4.6]

See hyperbolic functions in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

half-life

of: [radioactive nuclei](#) in a prepared sample

is: the [time](#) taken for half the [nuclei](#) in the sample to [decay](#). [[M1.5](#), [P9.1](#), [P9.2](#)]

hence is: the [time](#) taken for the [activity](#) to halve. [[P9.2](#)]

is: a property of [radionuclides](#), unaffected by the physical or chemical [environment](#). [[P9.2](#)]

Flexible Learning Approach to Physics - Glossary

half-power points

on: the [power absorption curve](#) of an [oscillator](#)

are: the [frequencies](#) on either side of the [resonance](#), at which the [power absorption](#) has half its [peak value](#). [[P5.3](#)]

Hall effect

is: the creation of a [potential difference](#), the [Hall voltage](#), when a [current-carrying specimen](#) is placed in a [magnetic field](#) having a [component](#) at [right angles](#) to the [current](#). [[P4.3](#)]

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Hall probe

is: a device to measure [magnetic fields](#) using the [Hall effect](#). [P4.3]

usually contains: a [semiconductor](#) wafer and a sensitive [voltmeter](#). [P4.3]

Flexible Learning Approach to Physics - Glossary

Hall voltage

is: the [transverse potential difference](#) created by the [Hall effect](#). [P4.3]

arises: when a [current](#)-carrying specimen is placed in a [transverse magnetic field](#). [P4.3]

is: [transverse](#) to the [directions](#) of both the [magnetic field](#) and the [current](#). [P4.3]

arises from: the [Lorentz force](#) on the [current](#)-carrying [charged particles](#). [P4.3]

Flexible Learning Approach to Physics - Glossary

halogens

are: the [chemical elements](#) fluorine, chlorine, bromine, iodine and astatine. [P8.4]

occupy: [Group](#) VII of the [periodic table](#). [P8.4]

are named after: the Greek words *hals* (sea-salt) and *gennao* (I produce) because three of the [elements](#) (chlorine, bromine and iodine) can be prepared from this source. [P8.4]

Flexible Learning Approach to Physics - Glossary

Hamiltonian operator

in: [quantum mechanics](#)

is: the [differential operator](#) which corresponds to the total [energy](#) of a [system](#).
[P10.4, P11.3]

has: the [time-independent Schrödinger equation](#) as an [eigenvalue equation](#).
[P10.4, P11.3]

is represented: for a [particle](#) of [mass](#) m moving in one [dimension](#), parallel to the x -[axis](#), with a [potential energy function](#) $U(x)$, by

$$\hat{H} = \frac{-\hbar^2}{2m} \frac{d^2}{dx^2} + U(x) \quad [\text{P10.4}]$$

Flexible Learning Approach to Physics - Glossary

harmonic oscillator

is: an [oscillator](#) undergoing [simple harmonic motion](#) (SHM). [P5.3]

harmonically driven linearly damped harmonic oscillator

is: a [harmonic oscillator](#) with a [damping force](#) which is a [linear function](#) of the [velocity](#) of the [oscillator](#) (i.e. of the first [derivative](#) of the [displacement](#) of the [oscillator](#)), and which is driven by an external [driving force](#) of a simple [sinusoidal](#) form. [[P5.3](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

harmonics

for: [standing waves](#) on a string

are: the sequence of allowed [frequencies](#). The first in the series is the [fundamental](#). Those other than the [fundamental](#) are sometimes referred to as [overtones](#). [[P5.6](#), [P5.7](#)]

Flexible Learning Approach to Physics - Glossary

heat

is defined: as [energy](#) transferred as a direct result of [temperature](#) difference. [P5.2, P7.2, P7.4, P7.5]

therefore is seen: as [energy](#) undergoing a particular process rather than as a particular 'form' of [energy](#). [P5.2, P7.2, P7.4, P7.5]

contributes: along with [work](#), to changes in the [internal energy](#) of a [system](#), though it is impossible to say how much of the [internal energy](#) was provided as heat and how much as [work](#) unless the entire history of the [system](#) is known. [P5.2, P7.2, P7.4, P7.5]

may be transferred: from place to place by [conduction](#), [convection](#) or [radiation](#). [P7.3]

is also used to refer, somewhat improperly: to the [internal kinetic energy](#) of a [body](#) arising from the random [microscopic motion](#) of the [atoms](#) and [molecules](#) that it contains. [P7.3]

Flexible Learning Approach to Physics - Glossary

heat capacity

of: a [system](#) with [uniform temperature](#)

is: the [ratio](#) $\Delta Q/\Delta T$ of the [heat](#) transferred to a single-[phase system](#), to the corresponding change in [temperature](#) of the [system](#). [P7.4]

strictly should be defined: as the [limit](#) of this quantity as ΔT becomes vanishingly small, since the value of the [ratio](#) will depend on the [state](#) of the [system](#). [P7.4]

therefore also depends: on the constraints applied during heating; see [principal specific heats](#). [P7.4]

has as its SI unit: J K^{-1} . [P7.4]

See also [molar specific heat](#) and [specific heat](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

heat energy

is: an archaic term which casts [heat](#) as a 'form' of [energy](#), that is still sometimes used to refer to part or all of the [internal energy](#) of a [system](#).

is exemplified: by the statement that when one [body](#) collides [inelastically](#) with another, part of the [kinetic energy](#) is transformed into heat energy which results in a rise in [temperature](#) of the colliding [bodies](#). [P5.2]

See [heat](#).

heat engine

is: a device (such as a steam engine) where the supply and removal of [heat](#) (generally in a [closed cycle](#)) results in the device doing [work](#). [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

heavy damping

of: a [damped harmonic oscillator](#)

is: a condition in which the [oscillator](#) will not complete any [oscillations](#) before coming to rest, but having a higher level of [damping](#) than in [critical damping](#).
[[P5.2](#), [P5.5](#)]

is often used as synonymous: with [overdamping](#).

See [critical damping](#) and [light damping](#).

Heisenberg uncertainty principle

imposes: a fundamental limitation on the combined [precision](#) with which certain pairs of [observables](#) can be simultaneously determined. [[P10.2](#), [P10.3](#), [P11.1](#)]

can be regarded: as a consequence of the [wave](#) nature of matter. [[P10.2](#), [P10.3](#)]

is exemplified: for the [uncertainty](#) Δx in the x -[coordinate](#) of a [particle's position](#), and the [uncertainty](#) Δp_x in the corresponding [momentum component](#), by the relationship: $\Delta x \Delta p_x \geq \frac{h}{4\pi}$, where h is [Planck's constant](#). [[P10.2](#), [P10.3](#)]

is also exemplified: by the relationship $\Delta E \Delta t \geq \frac{h}{4\pi}$, between the [uncertainties](#) in a [measurement](#) of [energy](#) and the [time](#) taken to make the [measurement](#). [[P10.2](#), [P10.3](#), [P11.1](#)]

has nothing to do: with the methods employed to make the [measurements](#). [[P10.2](#), [P10.3](#), [P11.1](#)]

Flexible Learning Approach to Physics - Glossary

helical

in: [geometry](#)

means: pertaining to a [helix](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

helix

is: a [curve](#) drawn around a cylinder, with successive turns displaced in the axial direction. [[P4.2](#)]

Flexible Learning Approach to Physics - Glossary

henry, H

is: the [SI unit](#) of [inductance](#).

is defined: by $1 \text{ H} = 1 \text{ V s A}^{-1}$, so a closed [circuit](#) will have an [inductance](#) of 1 H when the [current](#) in it varies at a rate of 1 A s^{-1} to produce an [induced voltage](#) of 1 V. [[P4.4](#), [P4.5](#)]

is, for practical purposes: a medium sized [unit](#). Widely used [inductances](#) vary from a few microhenry to hundreds of henry. [[P4.5](#), [P5.4](#)]

See also [coefficient of mutual inductance](#) and [coefficient of self inductance](#).

Flexible Learning Approach to Physics - Glossary

hertz, Hz

is: the [SI unit](#) of [frequency](#).

is defined: by $1 \text{ Hz} = 1 \text{ s}^{-1}$, so a [frequency](#) of 1 Hz is equivalent to one [cycle](#) per [second](#). [[P5.1](#)]

Flexible Learning Approach to Physics - Glossary

hidden variable theory

is: any [theory](#) that makes use of [variables](#) which, if their values were known, would permit more precise predictions of the outcomes of [experimental measurements](#) than those of conventional [quantum theory](#). [P10.2]

implies: that [quantum theory](#) is an incomplete [theory](#), and that the 'fuzziness' of its predictions is a reflection of our limited understanding and not a feature of the [Universe](#) itself. [P10.2]

is opposed: to the conventional [Copenhagen interpretation](#) of [quantum physics](#). [P10.2]

Flexible Learning Approach to Physics - Glossary

high-pass filter

is: a [filter circuit](#) that passes high [frequency](#) signals with relatively undiminished [amplitude](#), but blocks low [frequency](#) signals. [P5.4]

Contrast with [low-pass filter](#).

higher derivatives

of: a [function](#) $y = f(x)$ with [first derivative](#) $\frac{dy}{dx} = f'(x)$

are: the derivatives $\frac{d^n y}{dx^n} = f^n(x)$ where $n \geq 2$. [\[M4.3\]](#)

Flexible Learning Approach to Physics - Glossary

histogram

is: a [graphical](#) representation of a [set](#) of [measurements](#). [P1.2]

consists of: a number of [rectangles](#), the [areas](#) of which are [proportional](#) to the number of [measurements](#) falling within a given [interval](#), represented by the width of the [rectangles](#). [P1.2]

Flexible Learning Approach to Physics - Glossary

hole

is: a vacancy in the one of the normally filled [energy bands](#) in a [solid](#). [P11.4]

behaves: like a positive [charge](#) carrier and thereby contributes to the [electrical conductivity](#) of the [solid](#). [P11.4]

hole conduction

is: [electrical conduction](#) due to mobile [holes](#), such as may occur in a p-type [semiconductor](#). [[P4.3](#)]

homogeneous differential equation

is: a [differential equation](#) in which every [term](#) involves the same single [variable](#) or one of its [derivatives](#). [[P5.3](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

homopolar generator

is: a device that generates a steady [d.c. voltage](#) by spinning a [conducting](#) disc in a [magnetic field](#). [[P4.4](#)]

Hooke's law

states: that for sufficiently small [stress](#), the [strain](#) in a material is directly proportional to the [stress](#) causing it. [[P7.6](#)]

therefore requires: that the [restoring force](#), F_x , exerted by a spring that obeys Hooke's law is [proportional](#) to the [extension](#) or [compression](#), x , of the spring from its unstretched [length](#), so that $F_x = -k_s s_x$, where k is the [spring constant](#). [[P2.3](#), [P2.4](#), [P5.1](#), [P5.2](#)]

sometimes is expressed: in terms of the applied [force](#) $F_x^{\text{app}} = -F_x$ which is required to maintain a given [extension](#). [[P2.3](#), [P2.4](#), [P5.1](#), [P5.2](#)]

leads: to the definition of a range of [elastic moduli](#) such as [Young's modulus](#), [shear modulus](#) and [bulk modulus](#). [[P7.6](#)]

horizontal asymptote

is: an [asymptote](#) which is horizontal and which therefore has zero [gradient](#).
[\[M4.4\]](#)

horizontal point of inflection

is: a [point of inflection](#) at which the first [derivative](#) is zero.

Flexible Learning Approach to Physics - Glossary

horsepower, hp

is: a non-[SI unit](#) of [power](#).

is defined: by $1 \text{ hp} = 7.457 \times 10^2 \text{ W}$. [[P2.4](#)]

Hund's rule

for: a [subshell](#) of an [atom](#) in its [ground state](#).

is: an [empirical](#) rule requiring that the number of [unpaired electrons](#) in the [subshell](#) has its maximum value. [[P8.3](#)]

Huygens' principle

states: that each [point](#) on a [wavefront](#) may be treated as a source of secondary wavelets, or [waves](#), that expand [radially](#) from their source with the same [speed](#) as the original [wave](#). [[P6.1](#)]

hydrogen bond

is: a weak [bond](#) which may occur in hydrogen-containing materials, resulting from the 'sharing' of a hydrogen [atom](#) between two other [atoms](#). [[P7.1](#)]

typically has: an [bonding energy](#) of less than 0.5 eV [[P7.1](#)]

is important: in many [organic molecules](#) and [solids](#). [[P7.1](#)]

hydrostatic pressure

is: the [pressure](#) (which is the same in all directions) developed internally in a body of [fluid](#) due to the [weight](#) of the [elements](#) of [fluid](#) above. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

hyperbola

is: a [conic section](#) that may be described by an [equation](#) of the form

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1 \text{ where } b = a\sqrt{e^2 - 1} \text{ with } e > 1,$$

though it often arises in the form of a [rectangular hyperbola](#) for which $y = k/x$.
[[M1.3](#), [M2.3](#), [P1.3](#), [P3.2](#)]

See conic sections in the [Maths handbook](#) for further details.

hyperbolic functions

are: the [functions](#) \sinh , \cosh , \tanh and (usually) the related [reciprocal functions](#) sech , cosech and coth . [[M4.6](#)]

take their name: from the fact that

$$x = a \cosh(t)$$

$$y = b \sinh(t)$$

are [parametric equations](#) for a [hyperbola](#). [[M4.6](#)]

See hyperbolic functions in the [Maths handbook](#) for further details.

hyperbolic function identities

are: [identities](#) relating the [hyperbolic functions](#), such as
 $\cosh^2(x) - \sinh^2(x) = 1$. [[M4.6](#)]

See hyperbolic functions in the [Maths handbook](#) for a detailed listing.

Flexible Learning Approach to Physics - Glossary

hypermyopia (long sight)

is: the condition in which eyes are unable to [focus](#) on [objects](#) as close as the standard [near point](#) (taken to be at 25 cm). [P6.4]

occurs: when the [lens](#) of the eye has too long a [focal length](#), even when fully [accommodated](#). [P6.4]

usually is corrected: by using an auxiliary [converging lens](#). [P6.4]

Contrast with [myopia](#).

Flexible Learning Approach to Physics - Glossary

hypotenuse

of: a [right-angled triangle](#)

is: the side opposite the [right angle](#). [[M1.6](#), [M2.1](#)]

is also: the longest side of such a [triangle](#). [[M1.6](#), [M2.1](#)]

Flexible Learning Approach to Physics - Glossary

i

symbolizes: the [algebraic](#) quantity satisfying the rule $i^2 = -1$; the basis of [imaginary numbers](#). [[M3.1](#)]

ideal elastic string

See [ideal string](#).

Flexible Learning Approach to Physics - Glossary

ideal gas

is: a [gas](#) that obeys the [ideal gas equation of state](#), $PV = nRT$, where P is the [pressure](#) of the gas, V is its [volume](#), n is the [amount](#) of [gas](#) (expressed in [moles](#)), R is the [molar gas constant](#) and T is the [absolute temperature](#). [[P7.2](#), [P7.3](#), [P7.4](#), [P7.5](#)]

exists: only as an idealized entity, but is well approximated by a [real gas](#) at sufficiently low [density](#). [[P7.2](#), [P7.3](#), [P7.4](#), [P7.5](#)]

ideal gas absolute temperature scale

is: a [temperature scale](#) based on [measurements](#) made with [real gases](#) using a [constant-volume gas thermometer](#), and extrapolated to the limit of zero [pressure](#) in which the [gas](#) may be considered to be an [ideal gas](#). [P7.2]

is defined: by the [thermometric relation](#)

$$T = \lim_{P_{\text{triple}} \rightarrow 0} \left(\frac{P}{P_{\text{triple}}} \right) \times 273.16 \text{ K}$$

where P is the [pressure](#) of a fixed [volume](#) of [gas](#) at [temperature](#) T , and P_{triple} is the [pressure](#) of the same sample of [gas](#), occupying the same [volume](#), at the [triple-point temperature](#) of H_2O which is defined to be 273.16 K. [P7.2]

ideal gas equation of state

is: a relationship between [pressure](#) P , [volume](#) V and [temperature](#) T , which is obeyed by an [ideal gas](#). [[P7.2](#), [P7.5](#)]

sometimes is referred to: as the ideal gas law. [[P7.2](#), [P7.5](#)]

is written: as

$$PV = nRT \text{ or } PV = NkT$$

where n is the number of [moles](#) of [gas](#), R is the [molar gas constant](#), and T is the [absolute temperature](#). Equivalently, N is the number of [molecules](#) in the [system](#) and k is [Boltzmann's constant](#). [[P7.2](#), [P7.5](#)]

Flexible Learning Approach to Physics - Glossary

ideal gas law

See [ideal gas equation of state](#).

Flexible Learning Approach to Physics - Glossary

ideal spring

is: an [elastic body](#) which may be [compressed](#) or [extended](#) by an external [force](#) and in which [Hooke's law](#) is obeyed. [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

ideal string

is: an [elastic](#) string which always obeys [Hooke's law](#) when it is stretched, irrespective of the amount of stretching. [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

ideal transformer

is: a [transformer](#) with 100% [flux linkage](#) between the primary and secondary [coils](#) and with 100% transfer of [electrical power](#) between the two [coils](#), with no [dissipation](#) of [power](#). [[P4.4](#)]

Flexible Learning Approach to Physics - Glossary

ideal voltage generator

is: a [voltage generator](#) with zero [output resistance](#) (i.e. zero [internal resistance](#)). [P4.1]

is symbolized: by an open [circle](#) with a labelled arrow alongside to indicate the [magnitude](#) and [polarity](#) of the [voltage](#). [P4.1]

Flexible Learning Approach to Physics - Glossary

identity

is: an [equation](#) relating two [expressions](#) that is true for all meaningful values of the [variables](#) involved in those [expressions](#). [M1.6]

is exemplified: by $(x + 1)^2 = x^2 + 2x + 1$. [M1.6]

sometimes is indicated: by using the symbol \equiv in place of the more usual $=$. [M1.6]

ill-conditioned

describes: a system of [equations](#) for which small changes in the [coefficients](#) cause large changes in the [solutions](#). [[M2.2](#)]

Flexible Learning Approach to Physics - Glossary

image

is: a representation of an [object](#). [P6.2, P6.3]

is produced: by [reflection](#) at a [mirror surface](#), or [refraction](#) at an [interface](#) between [transparent media](#) or at a combination of [interfaces](#) such as a [lens](#) or some other [optical system](#). [P6.2, P6.3]

arises: when [light rays](#) leaving a [point](#) on the [object](#) are brought back together ([real image](#)) or appear to be brought back together ([virtual image](#)) to a common [point](#). [P6.2, P6.3]

can be seen: either as a [point image](#) or an [extended image](#). [P6.2, P6.3]

image distance

is: the distance v , measured along the [optical axis](#), between an [image](#) and a [lens](#) or [mirror](#). [P6.3]

might more appropriately be termed: the [image position](#), since (according to the [Cartesian sign convention](#)) it may be a positive or negative quantity, depending on the side of the [origin](#) on which it lies. [P6.3]

See also [thin lens equation](#) and [spherical mirror equation](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

image focus

See [second focal point](#).

Flexible Learning Approach to Physics - Glossary

imaginary axis

is: the [axis](#) in a [complex plane](#) (or [Argand diagram](#)) along which the [imaginary part](#) of a [complex number](#) is represented. [[M3.1](#)]

Flexible Learning Approach to Physics - Glossary

imaginary number

is: a [complex number](#) of the form iy where y is a [real number](#) and $i^2 = -1$.
[[M1.4](#), [M3.1](#)]

therefore is: a [complex number](#) in which the [real part](#) is zero. [[M1.4](#), [M3.1](#)]

Flexible Learning Approach to Physics - Glossary

imaginary part

of: a [complex number](#), $z = x + iy$ (where x and y are [real numbers](#))

is: the term y . [[M1.4](#), [M3.1](#), [P5.5](#)]

often is denoted: by $\text{Im}(z)$. [[M1.4](#), [M3.1](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

impedance (electrical)

of: a single [electrical component](#) or a two [terminal](#) network, in which an [alternating current](#) of [peak value](#) I_0 flows in response to an externally supplied alternating [voltage](#) of peak value V_0

is: the quantity $Z = V_0/I_0$. [[P5.4](#), [P5.5](#)]

is analogous: to the [resistance](#) of a [d.c. circuit component](#). [[P5.4](#), [P5.5](#)]

is given: by $Z = \sqrt{R^2 + X^2}$ where R is the [resistance](#) and X is the [reactance](#) of the component or network. [[P5.4](#)]

has as its SI unit: the [ohm](#) (Ω). [[P5.4](#), [P5.5](#)]

generally depends: on the [angular frequency](#) of the supply (since X depends on that frequency).

is at a minimum: for a [series LCR circuit](#) at the [circuit's natural frequency](#). [[M6.3](#), [P5.3](#), [P5.4](#)]

is at a maximum: for a [parallel LCR circuit](#) at the [circuit's natural frequency](#). [[M6.3](#), [P5.3](#), [P5.4](#)]

See [complex impedance](#), [mechanical impedance](#).

Flexible Learning Approach to Physics - Glossary

impedance matching

is: a method of linking two [circuits](#) which have different [impedances](#) to ensure the maximum transfer of [power](#) between them. [P4.4]

may be achieved: using the [primary](#) and [secondary coils](#) of a [transformer](#). [P4.4]

implicit differentiation

is: a form of [differentiation](#) using the [chain rule](#). [M4.3]

is used: for differentiating [implicit functions](#) which are defined by an [equation](#) that relates the [dependent variable](#) (y) and the [independent variable](#) (x) but where neither [variable](#) is the [subject](#) of the [equation](#). [M4.3]

is done: by [differentiating](#) both sides of the [equation](#), which yields, in general, an [expression](#) in y and x for dy/dx . [M4.3]

is exemplified: by implicit differentiation of $x^2 + y^2 = a^2$ with respect to x , which yields $2x + 2y(dy/dx) = 0$, so that $(dy/dx) = -x/y$. [M4.3]

implicit function

is: a [function](#) defined by an [equation](#) that relates the [dependent variable](#) (y) and the [independent variable](#) (x) but where neither [variable](#) is the [subject](#) of the [equation](#). [[M4.3](#), [M6.1](#)]

is exemplified: by the [function](#) $y(x)$ defined by $y + \sin y = 3x$. [[M4.3](#), [M6.1](#)]

improper integral

is: a [definite integral](#) in which:

(a) one or both of the [limits of integration](#) is an infinite quantity (positive or negative), or

(b) the [integrand](#) becomes infinite at some [point](#) or [points](#) in the range of [integration](#), or

(c) both of the above apply. [[M5.2](#)]

may be evaluated: as limits of appropriate [proper integrals](#). [[M5.2](#)]

Flexible Learning Approach to Physics - Glossary

impulse

is: the product of the [force](#) acting and the [time](#) over which it acts, (i.e. impulse = $\mathbf{F} \Delta t$ for a constant force).

is: a [vector](#) quantity

has as its SI unit: the N s (i.e. [newton second](#)).

is equal: to the change in [momentum](#) which follows from the impulse, i.e. $\Delta \mathbf{p} = \mathbf{F} \Delta t$. [[P2.5](#)]

impurity conduction

is: [electrical conduction](#) due to impurities that contribute [electrons](#) or [holes](#) to a material (particularly a [semiconductor](#)). [[P11.4](#)]

Flexible Learning Approach to Physics - Glossary

in anti-phase

describes: the [phase relationship](#) between two specified [oscillations](#) such as $A = A_0 \sin(\omega t + \phi_1)$ and $B = B_0 \sin(\omega t + \phi_2)$ that have the same [angular frequency](#) ω and which respectively involve [phase constants](#) ϕ_1 and ϕ_2 that differ by an odd [integer](#) multiple of π so that $\phi_2 - \phi_1 = (2n + 1)\pi$, where n is any integer. The maxima of one [oscillation](#) then coincide with the minima of the other. [[P5.1](#), [P5.7](#), [P6.1](#)]

may also be applied: to [waves](#) at a common point (or possibly at separate points) by comparing the [oscillations](#) caused by the [waves](#) at the relevant point(s).

See [phase relationship](#), [in phase](#) and [out of phase](#).

Flexible Learning Approach to Physics - Glossary

in phase

describes: the [phase relationship](#) between two specified [oscillations](#) such as $A = A_0 \sin(\omega t + \phi_1)$ and $B = B_0 \sin(\omega t + \phi_2)$ that have the same [angular frequency](#) ω and which respectively involve [phase constants](#) ϕ_1 and ϕ_2 that differ by an [integer](#) multiple of 2π so that $\phi_2 - \phi_1 = 2n\pi$, where n is any integer. The maxima of one [oscillation](#) then coincide with the maxima of the other, as do all other stages of the [oscillation](#). [[P5.1](#), [P5.4](#), [P5.6](#), [P5.7](#), [P6.1](#)]

may also be applied: to [waves](#) at a common [point](#) (or possibly at separate [points](#)) by comparing the [oscillations](#) caused by the [waves](#) at the relevant [point\(s\)](#).

See [phase relationship](#), [in anti-phase](#) and [out of phase](#).

Flexible Learning Approach to Physics - Glossary

incident ray

is: an incoming [ray](#) which falls on (is incident on) some [surface](#) or [interface](#).
[[P6.1](#), [P6.2](#)]

Flexible Learning Approach to Physics - Glossary

incoherent

describes: two [waves](#) sufficiently unrelated that knowing the [phase](#) of one at some particular [time](#) and [position](#) does not enable the [phase](#) of the other to be predicted at some other [position](#) (if [spatially](#) incoherent) or [time](#) (if [temporally](#) incoherent). Usually the [phase difference](#) between incoherent [waves](#) varies rapidly and randomly. [[P6.1](#)]

may also be applied: in its [temporal](#) sense, to two [oscillations](#). [[P5.3](#)]

incompressible

describes: a sample of (idealized) material (usually a [liquid](#) or a [solid](#)) that cannot be compressed (i.e. which does not change its [volume](#) in response to applied [forces](#)). [[P7.2](#)]

Flexible Learning Approach to Physics - Glossary

inconsistent

describes: a [set](#) of [equations](#) that cannot all be true simultaneously. [[M1.4](#)]

Flexible Learning Approach to Physics - Glossary

increasing function

is: a [function](#) $f(x)$ for which $f(a) < f(b)$ for all $a < b$

always exists: over an [interval](#), if its [derivative](#) $f'(x)$ is positive at all points of the [interval](#). [\[M4.4\]](#)

indefinite integral

of: a [function](#) $f(x)$

is denoted: $\int f(x) dx$

where $f(x)$ is called the [integrand](#), and the symbol dx is the [element of integration](#) which shows the [integration variable](#), x with respect to which the [integration](#) is to be performed. [[M5.1](#), [M5.2](#)]

is: any [function](#) $F(x)$ such that $\frac{dF}{dx} = f(x)$. [[M5.1](#), [M5.2](#)]

is not: unique, since if $F_1(x)$ is an indefinite integral of $f(x)$, then so is $F_2(x) = F_1(x) + C$, where C is an arbitrary [constant](#). For this reason, if $F(x)$ is a particular indefinite integral of $f(x)$, it is customary to write

$$\int f(x) dx = F(x) + C$$

where C represents an arbitrary additive [constant](#), called the [constant of integration](#). [[M5.1](#), [M5.2](#)]

is also called: [inverse derivative](#) or [anti-derivative](#) or primitive of $f(x)$.

indefinite integration

is: the procedure whereby [indefinite integrals](#) are analysed and determined.
[\[M5.2\]](#)

Flexible Learning Approach to Physics - Glossary

independent

describes: a [set](#) of [simultaneous linear equations](#) with the property that none of the [equations](#) can be expressed as a sum of multiples of the other [equations](#).
[M1.4]

Flexible Learning Approach to Physics - Glossary

independent arbitrary constants

in: the [solution](#) to a [differential equation](#)

are: two or more [arbitrary constants](#) which cannot be replaced by a single [arbitrary constant](#). [M6.1]

See [essential constants](#).

Flexible Learning Approach to Physics - Glossary

independent errors

are: [errors](#) such that the size of one does not influence the size of the other.

[P1.2]

Flexible Learning Approach to Physics - Glossary

independent oscillators

are: [oscillators](#) for which the [displacement](#) of one does not affect the [restoring force](#) acting on the other. [[P5.1](#)]

Flexible Learning Approach to Physics - Glossary

independent variable

in: an [experiment](#) (or a [calculation](#))

is: the quantity whose value is set by the [experimenter](#) (or by the person doing the [calculation](#)). [P1.3]

controls: the value of any [dependent variables](#) to which it is connected by a [set of experimental observations](#) (or by a [mathematical function](#)). [M1.3]

on graphs is plotted: conventionally along the horizontal [axis](#). [P1.3]

Flexible Learning Approach to Physics - Glossary

index

is: a synonym for [power \(mathematical\)](#) or [exponent](#). [M1.1]

as a term is sometimes used: in preference to [power](#) because of the possibility of confusing [power \(mathematical\)](#) with [power \(physical\)](#). [M1.1]

Flexible Learning Approach to Physics - Glossary

induced current

is: a [current](#) produced by [electromagnetic induction](#) in a complete [circuit](#).
[P4.4]

is exemplified: by the [current](#) that flows around a closed loop of wire, placed with its [plane perpendicular](#) to a [uniform magnetic field](#), when either the [magnitude](#) of the [field](#) is changed, or when the [area](#) of the loop is altered.

Flexible Learning Approach to Physics - Glossary

induced fission

is: a process in which an [atomic nucleus](#) is induced by an external agency to undergo [nuclear fission](#). [P9.3]

is exemplified: by the [fission](#) of $^{235}_{92}\text{U}$ when induced by the [absorption](#) of a [thermal neutron](#). [P9.3]

induced magnetisation

See [magnetic induction](#).

Flexible Learning Approach to Physics - Glossary

induced voltage

in: a complete [circuit](#) of [resistance](#) R carrying an [induced current](#) I_{ind}

is: the [voltage](#) $V_{\text{ind}} = I_{\text{ind}}R$. [P4.4]

is described: in [magnitude](#) by [Faraday's law](#): $V_{\text{ind}} = |d\Phi/dt|$, where $d\Phi/dt$ is the rate of change of the [flux linkage](#) Φ through the relevant closed [circuit](#). [P4.4]

is described: in [polarity](#) by [Lenz's law](#), which says that the induced voltage will act to oppose the change that caused it. (For this reason it is sometimes said to be a back voltage or back e.m.f.) [P4.4]

may be determined in more general situations: e.g. between the ends of a [conductor](#) moving through a [magnetic field](#), so that it cuts [magnetic flux](#) at the rate $d\Phi/dt$, by applying [Faraday's law](#) and [Lenz's law](#), or by using the [Lorentz force law](#). [P4.4]

Flexible Learning Approach to Physics - Glossary

inductance

is: the property of a [coil](#) which causes an [induced voltage](#) to arise across the [coil](#) when the [current](#) in the [coil](#) is changing ([self inductance](#)), or when the [current](#) in a nearby [coil](#) is changing (mutual inductance).

is also: an abbreviation for the [coefficient of self inductance](#), L that quantifies the [self inductance](#) of a [coil](#) by means of the relation

$$V_{\text{ind}} = L \left| \frac{dI}{dt} \right|$$

where V_{ind} is the [magnitude](#) of the [induced voltage](#), and $|dI/dt|$ is the [magnitude](#) of the rate of change of the [current](#) in the [coil](#). [[P4.4](#), [P4.5](#), [P5.4](#)]

The [polarity](#) of the [voltage](#) is such as to oppose the change in the [current](#) ([Lenz's law](#)): it is a [back e.m.f.](#) The [back e.m.f.](#) generated by an inductance L is $-LdI/dt$, so the [voltage drop](#) across such an inductance is LdI/dt .

has as its SI unit: the [henry](#) (H). [[P5.4](#), [P5.5](#)]

induction (electromagnetic)

is: the phenomenon that gives rise to an [induced voltage](#) in a [conductor](#) due to the presence of a changing [magnetic field](#), or because of [relative motion](#) between the [conductor](#) and a [magnetic field](#).

induction (electrostatic)

See [electrostatic induction](#).

induction (mathematical)

is: a technique of proving a [theorem](#) by showing that *if* a result is true for some value of a [parameter](#), such as n , then it is also true for $n + 1$. Completion of the proof then consists of showing explicitly (and usually trivially) that the result is indeed true for the smallest allowable value of n .

Flexible Learning Approach to Physics - Glossary

inductive reactance

of: an [inductor](#) with [inductance](#) L when passing [alternating current](#) of [angular frequency](#) ω

is: the [ratio](#) of the [peak voltage](#) to the [peak current](#), V_0/I_0 . [[P5.4](#), [P5.5](#)]

is given: by $X_L = \omega L$. [[P5.4](#), [P5.5](#)]

See [complex inductive reactance](#), [impedance](#), [reactance](#).

Flexible Learning Approach to Physics - Glossary

inductive time constant

is: the [time](#) for the [induced voltage](#), [magnetic flux](#) or [current](#) in an [inductive circuit](#) to [decay exponentially](#) by a factor e . [[P4.5](#)]

is given: for a [circuit](#) with [resistance](#) R and [self inductance](#) L by $\tau = L/R$. [[P4.5](#)]

Flexible Learning Approach to Physics - Glossary

inductor

is: a [coil](#) designed to have a large [inductance](#) so as to produce a large [induced voltage](#) when the [current](#) in it changes. [[P4.4](#), [P4.5](#)]

typically is: a [solenoid](#) with many closely-wound turns around a [magnetic](#) material (e.g. an iron core). [[P4.5](#)]

in a circuit is: a [circuit component](#) of fixed [inductance](#) and, ideally, negligible [resistance](#). [[P5.4](#), [P5.5](#)]

inelastic collision

is: a [collision](#) during which some or all of the [kinetic energy](#) is converted into other forms of [energy](#). [[P2.4](#), [P2.5](#)]

Flexible Learning Approach to Physics - Glossary

inequality

is: a mathematical statement expressing the fact that one number (or [algebraic expression](#)) is less than, or greater than, another. [[M1.1](#)]

may be combined with: the equality to express "greater than or equal to", or, "less than or equal to".

uses: one or more of the symbols: $>$ (greater than), \geq (greater than or equal to), $<$ (less than), or \leq (less than or equal to), or their variants. The symbols \gg and \ll are used to express "much greater than" and "much less than", respectively. [[M1.2](#)]

Flexible Learning Approach to Physics - Glossary

inert gases

See [noble gases](#).

Flexible Learning Approach to Physics - Glossary

inertia

of: a [body](#)

is: the tendency of the [body](#) to continue in a [state](#) of [uniform motion](#). [P2.3]

is measured: by the [inertial mass](#) of the [body](#), according to [Newton's second law](#). [P2.3]

Flexible Learning Approach to Physics - Glossary

inertial confinement

is: [confinement](#) of a [plasma](#) by virtue of the [inertia](#) of the material in the [plasma](#) - so that it stays together for a sufficient [time](#) for [nuclear fusion](#) to begin within it. [P9.3]

requires: that the [plasma](#) be created within a very short [time](#) scale. This is done through [irradiation](#) by an intense pulsed [laser](#) beam or [beam of particles](#). [P9.3]

inertial frame of reference

is: a [frame of reference](#) in which [Newton's first law](#) holds; that is, one which is not itself [accelerating](#), and in which objects do not [accelerate](#) unless a [resultant force](#) (i.e. a net force) acts on them. [[P2.3](#)]

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inertial mass

of: a [body](#)

is: the [mass](#) of the [body](#) as determined by its [acceleration](#) in response to a known applied [force](#). (See [Newton's second law of motion](#)) [[P2.3](#)]

Contrast with [gravitational mass](#).

infinite potential well

is: a [potential well](#) with infinitely high [potential energy](#) at the edges and thus capable of confining any [particle](#), however high its (finite) [energy](#). [[P10.4](#)]

Flexible Learning Approach to Physics - Glossary

infinite series

is: a [series](#) with an unlimited number of [terms](#). [[M1.7](#)]

infinitesimal

is: a quantity that is much smaller than others under consideration, and which can be considered to vanish in an appropriate [limit](#).

infinitesimal calculus

See [calculus](#).

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infinity

is: a concept used to represent a far larger number or quantity than any other under consideration. [[M1.3](#), [M1.7](#)]

is also: used in the term “projecting to infinity” to indicate extending the varying quantity to a very distant point or time. [[M2.3](#)]

is denoted: by the [infinity symbol](#), ∞

Flexible Learning Approach to Physics - Glossary

infinity symbol, ∞

is: a symbol used to represent a far larger number or quantity than any other under consideration. [[M1.3](#), [M1.7](#)]

infrared (radiation)

is: a type of [electromagnetic radiation](#) characterized by [wavelengths](#) in the range between those of [visible light](#) and [microwaves](#) (i.e. approximately 700 nm to 1 mm).

See [electromagnetic spectrum](#).

inhomogeneous differential equation

is: a [differential equation](#) which is not a [homogeneous differential equation](#).
[M6.3]

is exemplified by: $a \frac{d^2y}{dx^2} + b \frac{dy}{dx} + cy = d$

since at least one of the [terms](#) (the one on the right) is not [proportional](#) to y nor to any one of its [derivatives](#).

Flexible Learning Approach to Physics - Glossary

initial conditions

are: the n conditions given with a [differential equation](#) of [order](#) n which specify the value of the [dependent variable](#) and of its [derivatives](#) up to [order](#) $(n - 1)$ at a particular value of the [independent variable](#). [[M6.1](#)]

are sufficient: to determine the n [essential constants](#) which appear in the [general solution](#) to the [differential equation](#). [[M6.1](#)]

describe: the [initial state](#) of a physical [system](#) at some initial [time](#) (usually $t = 0$) if the [differential equation](#) describes the behaviour of the [system](#). [[P5.4](#), [P5.5](#)]

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initial phase

is synonymous: with [phase constant](#). [[M6.3](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

initial state

of: a [system](#)

is: the [state](#) of the [system](#) at the beginning of a process.

Flexible Learning Approach to Physics - Glossary

initial velocity

is: the [velocity](#) of a [body](#) or [particle](#) at the start of a period of [time](#). [P2.1]

See [uniform acceleration equations](#).

Flexible Learning Approach to Physics - Glossary

inner shell

of: an [atom](#)

is: an (electron) [shell](#) of lower [energy](#) (i.e. higher [binding energy](#)) than most of the other [shells](#) in the [atom](#). (According to [Bohr's model of the atom](#), [electrons](#) with such [energies](#) would be in [orbits](#) of relatively small [radius](#).)

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insoluble

describes: an [equation](#) (or system of [simultaneous equations](#)) which has no [solution](#). [M1.4]

more loosely, also describes: an [equation](#) (or system of [simultaneous equations](#)) for which no formula or procedure for [solving](#) it is known. [M1.4]

Flexible Learning Approach to Physics - Glossary

instantaneous a.c. power

dissipated between: two points that differ in [voltage](#) by $V(t)$ and between which a [current](#) $I(t)$ flows

is given by: $P = V(t)I(t)$. [[P5.4](#)]

Flexible Learning Approach to Physics - Glossary

instantaneous acceleration

of: a [particle](#) (relative to a specific [frame of reference](#))

at: a given [time](#) t

is: a [vector quantity](#) that specifies the [rate of change](#) of the [particle's velocity](#) $\mathbf{v} = (v_x, v_y, v_z)$ at [time](#) t . [[M4.1](#), [P2.1](#), [P2.2](#)]

is represented: by the [vector](#) $\mathbf{a} = d\mathbf{v}/dt$. That is, $a_x = dv_x/dt$, $a_y = dv_y/dt$, $a_z = dv_z/dt$. [[M4.1](#), [P2.1](#), [P2.2](#)]

has as its SI unit: m s^{-2} . [[M4.1](#)]

can be determined: as the limiting value of [average acceleration](#), calculated over shorter and shorter [time intervals](#). [[M4.1](#), [P2.1](#), [P2.2](#)]

also can be determined: as the [gradient](#) of a [velocity-time graph](#) at [time](#) t . [[M4.1](#), [P2.1](#), [P2.2](#)]

usually is known: simply as [acceleration](#). [[M4.1](#), [P2.1](#), [P2.2](#)]

Flexible Learning Approach to Physics - Glossary

instantaneous angular speed

is: the [modulus](#) of the instantaneous [rate of change](#) of [angular position](#) with [time](#),
i.e. $\omega = |d\theta / dt|$. [[P2.6](#)]

is also: the [magnitude](#) of the [angular velocity](#).

Flexible Learning Approach to Physics - Glossary

instantaneous speed

is: the [magnitude](#) of the [instantaneous velocity](#). [M4.1]

Flexible Learning Approach to Physics - Glossary

instantaneous velocity

of: a [particle](#) (relative to a specific [frame of reference](#))

at: a given [time](#) t

is: a [vector quantity](#) that specifies how fast a [body](#) is moving and its [direction of motion](#). [[M2.4](#)]

is more specifically: the [rate of change](#) of the [particle's position](#) $\mathbf{r} = (x, y, z)$ at [time](#) t [[M4.1](#), [M5.1](#), [P2.1](#), [P2.2](#)]

is represented: by the [vector](#) $\mathbf{v} = d\mathbf{r}/dt$. That is, $v_x = dx/dt$, $v_y = dy/dt$, $v_z = dz/dt$. [[M4.1](#), [M5.1](#), [P2.1](#), [P2.2](#)]

has as its SI unit: m s^{-1} . [[M4.1](#)]

can be determined: as the limiting value of [average velocity](#), calculated over shorter and shorter [time intervals](#). [[M4.1](#), [P2.1](#), [P2.2](#)]

also can be determined: as the [gradient](#) of a [position-time graph](#) at [time](#) t . [[M4.1](#), [P2.1](#), [P2.2](#)]

usually is known: simply as velocity. [[M4.1](#), [P2.1](#), [P2.2](#)]

has: as its magnitude, the [speed](#) of the [particle](#). [[M2.4](#), [P2.1](#), [P2.2](#)]

See [relative velocity](#).

Flexible Learning Approach to Physics - Glossary

insulator (electrical)

See [electrical insulator](#).

Flexible Learning Approach to Physics - Glossary

insulator (thermal)

is: a material with a low [coefficient of thermal conductivity](#), typically less than $1.0 \text{ W m}^{-1} \text{ K}^{-1}$.

Flexible Learning Approach to Physics - Glossary

integer

is: a positive or negative whole number, or zero i.e. an [element](#) of the [set](#) $\{ \dots -2, -1, 0, 1, 2, 3, \dots \}$. [[M1.2](#)]

Flexible Learning Approach to Physics - Glossary

integral

is: a term used to refer to a [definite integral](#) or an [indefinite integral](#). [[M5.1](#), [P2.4](#)]

Flexible Learning Approach to Physics - Glossary

integral sign

is: the distorted 'S' symbol \int used (together with an [element of integration](#)) to indicate the [operation](#) of [integration](#). [[M5.1](#), [M5.2](#)]

Flexible Learning Approach to Physics - Glossary

integrand

is: the [function](#) to be integrated in a [integral](#). [[M5.1](#), [M5.2](#)]

integrating factor

is: a [function](#) by which each term of a [linear first-order differential equation](#) is multiplied, in order that the [equation](#) may be solved by [direct integration](#).
[M6.2]

integration

is: the process of analysing and evaluating an [integral](#). [[M5.1](#), [M5.2](#), [P2.4](#)]

See [definite integral](#) and/or [indefinite integral](#) for further details, or see integration in the [Maths handbook](#).

integration by parts

is: a technique of [integration](#) applicable to (some) [functions](#) that may be written as products of [functions](#), based on the formula

$$\int f(x)g(x)dx = F(x)g(x) - \int F(x)\frac{dg}{dx}dx \quad [\text{M5.3}]$$

See techniques of integration in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

integration by substitution

is: a technique of [integration](#) based on the replacement of the original [integration variable](#) by a new [integration variable](#) that is a [function](#) of the original [variable](#).

See techniques of integration in the [Maths handbook](#).

integration element

See [definite integral](#) or [indefinite integral](#).

integration variable

is: the [variable](#) over which the [integration](#) is performed.

See also [definite integral](#) or [indefinite integral](#).

Flexible Learning Approach to Physics - Glossary

intensity

of: a [wave](#) or [beam](#)

is: the amount of [energy transported](#) by the [wave](#) or [beam](#) per [unit time](#) per [unit area perpendicular](#) to the [direction of propagation](#). [[P6.1](#)]

Flexible Learning Approach to Physics - Glossary

intensity level

of: a sound of [intensity](#) I (measured in W m^{-2})

is given by:

$$\beta = 10 \times \log_{10} \left(\frac{I}{I_0} \right) \text{decibel}$$

where $I_0 = 1 \times 10^{-12} \text{ W m}^{-2}$. [[P5.7](#)]

has as its SI unit: the [decibel](#), represented by the symbol dB. Audible, non-painful sounds usually have [intensity](#) levels in the range 0 to 120 dB. [[P5.7](#)]

Flexible Learning Approach to Physics - Glossary

interaction (fundamental)

describes: the action of [fundamental forces](#) between [particles](#). [P9.1]

is classified: in four kinds: [gravitational](#), [electromagnetic](#), [strong \(nuclear\)](#) and [weak \(nuclear\)](#), although it is now known that the [weak](#) and [electromagnetic](#) interactions are linked. [P9.1]

Flexible Learning Approach to Physics - Glossary

interatomic or intermolecular forces

are: the [forces](#) that act among [atoms](#) or [molecules](#). [[P7.1](#), [P7.5](#)]

normally are important: in the [liquid phase](#) or [solid phase](#). [[P7.1](#), [P7.5](#)]

result: essentially from a combination of [electrostatic forces](#) and [quantum mechanical exchange effects](#). [[P7.1](#), [P7.5](#)]

Flexible Learning Approach to Physics - Glossary

intercept

of: a [straight line](#)

is: the constant c in the [equation of a straight line](#), $y = mx + c$. [[P1.3](#)]

therefore is: the value of y when $x = 0$, i.e. the [point](#) at which the [straight line](#) crosses the [y-axis](#). [[M2.2](#), [M3.1](#), [P1.3](#)]

more generally refers: to the common [point](#) of two [straight lines](#) that [intersect](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

intercept form

of: the [equation of a straight line](#)

is: $\frac{x}{a} + \frac{y}{b} = 1$

where the [straight line](#) meets the [x-axis](#) at a and the [y-axis](#) at b . [\[M1.3\]](#)

Flexible Learning Approach to Physics - Glossary

interface

between: one [optical medium](#) and another

is: a boundary [surface](#) at which a [ray](#) may undergo [reflection](#) or [refraction](#).
[\[P6.2\]](#)

is more generally: a [surface](#) separating two different materials.

Flexible Learning Approach to Physics - Glossary

interference

between: [coherent waves](#) in a region of [space](#)

is: the phenomenon that allows the [waves](#) to combine to result in a [wave](#) whose properties at any point are determined by the properties of the various contributing [waves](#). (The procedure for combining the individual [waves](#) in simple ([linear](#)) cases is specified by the [superposition principle](#).) [P5.6]

over the whole region produces: an [interference pattern](#). [P6.1]

See [constructive](#) and [destructive interference](#).

interference filter

when illuminated: from a specific [direction](#)

uses: the phenomenon of [interference](#) to prevent all but a narrow range of [wavelengths](#) from passing through. [[P6.1](#)]

typically consists: of a thin [transparent](#) coating on a glass base (in which case the [interference](#) is between [beams](#) successively [reflected](#) from the back and front [surfaces](#) of the coating), or of a thin cavity between two glass plates (in which case the [interference](#) is between [beams](#) successively [reflected](#) from the front and back [surfaces](#) of the cavity). [[P6.1](#)]

works: by accumulated [destructive interference](#) between all [wavelengths](#) which are not close to twice the [path length](#) between the two [reflective surfaces](#). [[P6.1](#)]

Flexible Learning Approach to Physics - Glossary

interference fringes

are: patterns of bright and dark fringes produced by the [interference](#) of two or more [coherent light beams](#). [[P6.1](#)]

can be observed: on a screen or directly. [[P6.1](#)]

are exemplified: by the two-slit [interference pattern](#) in [Young's experiment](#). [[P6.1](#)]

interference pattern

is: the [observed](#) pattern of varying [intensity](#) that results from the [interference](#) of [coherent waves](#) (usually [beams](#), often [beams](#) of [light](#)) over a region of [space](#).
[P6.1]

See [diffraction pattern](#).

Flexible Learning Approach to Physics - Glossary

interior angle

is: the [angle](#) between two adjacent sides of a [geometric figure](#), which is enclosed within the boundary of the [figure](#). [M1.6]

is exemplified: by the three interior [angles](#) of any [triangle](#), whose sum always is 180° . [M1.6]

intermolecular forces

See [interatomic or intermolecular forces](#).

Flexible Learning Approach to Physics - Glossary

internal energy

of: a [system](#)

is: the [energy](#) arising from the [kinetic energy](#) of the [system's](#) constituents and the [potential energy](#) of their mutual [interaction](#). [[P7.3](#), [P7.4](#), [P7.5](#)]

does not include: any contribution from the [motion](#) or [position](#) of the [system](#) as a whole. [[P7.3](#)]

changes: only as a result of [heat](#) transferred **to** the [system](#) or [work](#) done **by** (or **on**) the [system](#), according to the [first law of thermodynamics](#). Thus $\Delta U = \Delta Q - \Delta W$. [[P7.3](#), [P7.4](#)]

is: a [function of state](#) of the [system](#). [[P7.3](#), [P7.4](#)]

Flexible Learning Approach to Physics - Glossary

internal force

is: a [force](#) which occurs within a [system](#). [P2.5]

occurs: between a pair of [interacting bodies](#). [P2.5]

is always: one of a pair of action-reaction [forces](#) associated with the pair of interacting [bodies](#). [P2.5]

Flexible Learning Approach to Physics - Glossary

internal resistance

is: the intrinsic [resistance](#) of a [voltage generator](#). [P4.1]

is also called: output resistance. [P4.1]

is responsible: for the decrease in [terminal potential difference](#) of a non-[ideal voltage generator](#) when the [current](#) through it increases. [P4.1]

International Practical Temperature Scale 1990

is: an internationally agreed [set](#) of devices and procedures for the measurement of [temperature](#). [P7.2]

is: at the time of writing (August 1995), the latest in an evolving sequence of internationally agreed practical [temperature scales](#). [P7.2]

embodies: the best advice for those who need to [calibrate](#) and/or use [thermometry](#) which is practical but which is also as close to the [Kelvin temperature scale](#) as modern instrumentation will allow. [P7.2]

Flexible Learning Approach to Physics - Glossary

interpolation

is: the process of using values of a [dependent variable](#), measured at a finite [set](#) of values of the corresponding [independent variable\(s\)](#), to estimate the value of the [dependent variable](#) corresponding to a value of the [independent variable\(s\)](#) that falls between those at which measurements were made. [[P1.3](#)]

Contrast with [extrapolation](#).

Flexible Learning Approach to Physics - Glossary

intersect

is: what two [curves](#) (including [straight lines](#)) do if they have a [point](#) in common. [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

interval

is: an unbroken range of [real numbers](#) which may be regarded as a segment of the [number line](#). [[M4.4](#)]

usually is specified: using [inequality](#) symbols, i.e. by statements such as $-2 < x \leq 4$ or $1.2 \leq x \leq 3$. [[M4.4](#)]

may or may not include: the endpoints which are used to define it. [[M4.4](#)]

intrinsic angular momentum

See [spin angular momentum](#).

Flexible Learning Approach to Physics - Glossary

intrinsic conduction

is: [electrical conduction](#) arising from [charged particles](#) present in a pure material (especially a [semiconductor](#)). [[P11.4](#)]

Contrast with [impurity conduction](#).

Flexible Learning Approach to Physics - Glossary

invariant

under: a specified process or transformation

describes: a quantity that is left unchanged by the specified process or transformation. [[P2.5](#)]

is exemplified by: the numbers 0 and 1 which are invariant under the process of [squaring](#) numbers, or the [centre](#) of a [sphere](#) which is invariant under the process of [rotating](#) the [sphere](#) about an [axis](#) through its [centre](#). [[P2.5](#)]

Flexible Learning Approach to Physics - Glossary

inverse derivative

is: the result of [inverse differentiation](#). [M5.1]

See [indefinite integral](#).

Flexible Learning Approach to Physics - Glossary

inverse differentiation

of: a [function](#) $f(x)$

is: the process of finding another [function](#) $F(x)$ called the [inverse derivative](#) or [indefinite integral](#) of $f(x)$. [[M5.1](#), [M5.2](#)]

usually is called: [indefinite integration](#). [[M5.1](#), [M5.2](#)]

is also known as: anti-differentiation.

Flexible Learning Approach to Physics - Glossary

inverse function

of: $f(x)$

is: the [function](#) that reverses the action of $f(x)$. If f is the given [function](#) and g is its inverse, then $g(f(x)) = x$ for all x in the [domain](#) of f . [M1.3]

usually is denoted: by f^{-1} [M1.3]

should not be confused: with a [reciprocal](#). Note that a special notation is adopted when dealing with the inverses of the [exponential](#), [logarithmic](#), [trigonometric functions](#) and [hyperbolic functions](#). [M1.3]

inverse hyperbolic functions

are: the [inverse functions](#) of the basic [hyperbolic functions](#) and the [reciprocal hyperbolic functions](#).

comprise: $\operatorname{arcsinh}(x)$, $\operatorname{arccosh}(x)$, $\operatorname{arctanh}(x)$, $\operatorname{arccosech}(x)$, $\operatorname{arcsech}(x)$ and $\operatorname{arcoth}(x)$. [M4.6]

See hyperbolic functions in the [Maths handbook](#) for further details.

Flexible Learning Approach to Physics - Glossary

inverse power

is: a term used to refer to a negative [power](#) (i.e. [index](#)) or [powers](#) appearing in the [denominator](#) of a [mathematical expression](#). Thus [Newton's law of gravitation](#) (an [inverse square law](#)) may be referred to as an inverse [power law](#). [[M1.1](#)]

Flexible Learning Approach to Physics - Glossary

inverse reciprocal trigonometric functions

are: the [inverses](#) of the [reciprocal trigonometric functions](#). [M1.6]

comprise: the functions $\operatorname{arcsec}(x)$, $\operatorname{arccosec}(x)$, $\operatorname{arccot}(x)$. [M1.6]

See [inverse trigonometric functions](#) and trigonometric functions in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

inverse square law

states: that a quantity decreases as the [square](#) of some relevant [distance](#). [[P2.4](#), [P3.1](#), [P3.3](#)]

is exemplified: by [Newton's law of gravitation](#) and [Coulomb's law](#):

$$\mathbf{F}_{\text{grav}} = -\frac{Gm_1m_2}{r^2}\hat{\mathbf{r}}$$

$$\mathbf{F}_{\text{el}} = \frac{q_1q_2}{4\pi\epsilon_0r^2}\hat{\mathbf{r}} \quad [\text{P2.4}, \text{P3.1}, \text{P3.3}]$$

See also [inverse square law of illumination](#).

inverse square law of illumination

is: a [law](#) relating the [intensity](#) of [electromagnetic radiation](#), or other [wave](#), [radiating](#) from a [point](#) source to the [inverse square](#) of the [distance](#) from that source. [[P5.7](#), [P6.1](#)]

is a consequence: of [geometry](#) and the [conservation of energy](#). [[P6.1](#)]

is exemplified: by the [intensity](#) of a propagating [spherical wave](#), such as a [sound wave](#) or a [light wave](#). [[P5.7](#), [P6.1](#)]

inverse trigonometric functions

are: the [inverses](#) of the standard [trigonometric functions](#) and (usually) the [inverses](#) of the related [reciprocal trigonometric functions](#). [M1.6]

comprise: $\arcsin(x)$, $\arccos(x)$, $\arctan(x)$ and $\operatorname{arcsec}(x)$, $\operatorname{arccosec}(x)$, $\operatorname{arccot}(x)$. [M1.6]

See trigonometric functions in the [Maths handbook](#) for further details.

Flexible Learning Approach to Physics - Glossary

inversely proportional

describes: the relationship between two [variables](#), x and y , if their product xy remains [constant](#) as x and y are varied. [\[M1.1\]](#)

is symbolized: $x \propto 1/y$. [\[M1.1\]](#)

Contrast with [directly proportional](#).

Flexible Learning Approach to Physics - Glossary

inversion rule

states: that if $y = g(x)$ is a [function](#) of x which possesses an [inverse function](#) $x = h(y)$ then

$$\frac{dg}{dx} = \frac{1}{dh/dy} \quad [\text{M4.3, M5.3, M6.2}]$$

less formally, states: that $dy/dx = 1/(dx/dy)$. [\[M4.3, M5.3, M6.2\]](#)

Flexible Learning Approach to Physics - Glossary

inverted

means: upside down - as for an [image](#) formed by a [lens](#) or a [mirror](#), when the [image](#) is the other way up as compared with the [object](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

ion

is: formed from an [atom](#) or [molecule](#) that has become [electrically charged](#) by [ionization](#), usually through having lost or gained one or more [electrons](#).

can be symbolized: by means of an appropriate [chemical symbol](#) together with a superscript indicating the sign of the ion's [charge](#) and its [magnitude](#) in [units](#) of e (e.g. Na^+ , Cl^- or He^{2+}). [[P8.1](#), [P8.2](#)]

has properties: that are usually quite different from the [atom](#) or [molecule](#).

ionic bonding

is: a type of [chemical bonding](#) in which appropriate chemical substances are regarded as collections of [ions](#). The principal [force](#) between the [ions](#) is the attraction between their opposite [charges](#). [[P8.4](#)]

ionization

is: the process in which an [atom](#) is stripped of one or more of its [electrons](#).

Flexible Learning Approach to Physics - Glossary

ionization energy

of: an [atom](#) (in a specified [state](#), usually the [ground state](#))

is: the minimum [energy](#) required to just remove the most weakly [bound electron](#) from the [atom](#), and thereby to create a singly charged [ion](#). [[P8.2](#), [P8.3](#), [P8.4](#)]

is also called: the [first ionization energy](#) of the [atom](#). [[P8.2](#), [P8.3](#), [P8.4](#)]

is synonymous: with [ionization potential](#). [[P8.2](#)]

Flexible Learning Approach to Physics - Glossary

ionization level

for: an [electron](#)

in: an [atom](#)

is: the [energy level](#) that marks the boundary between the negative [energy levels](#) of the [bound states](#) of the [atom](#) and the positive [energies](#) of the [unbound states](#) in the [continuum](#). [[P8.2](#), [P8.3](#)]

therefore is: the [energy](#) below which the [electron](#) must remain [bound](#) in the [atom](#), and above which the [electron](#) becomes free from the [atom](#). [[P8.2](#), [P8.3](#)]

thus is taken: as the [energy](#) zero. [[P8.2](#), [P8.3](#)]

ionization potential

is synonymous: with [ionization energy](#). [P8.2]

Flexible Learning Approach to Physics - Glossary

ionized

describes: an [atom](#) or [molecule](#) which has become an [ion](#). [[P8.2](#), [P11.3](#)]

Flexible Learning Approach to Physics - Glossary

ionizing radiation

is: [radiation](#) ([particles](#) or [photons](#)) that can produce [ionization](#) in matter. [[P9.2](#), [P9.3](#)]

therefore is: [radiation](#) which is sufficiently [energetic](#) to supply the necessary [ionization energy](#) and which is capable of [interacting](#) with [electrons](#). [[P9.2](#), [P9.3](#)]

is exemplified: by [X-rays](#), [\$\alpha\$ -particles](#), [\$\beta\$ -particles](#), [\$\gamma\$ -radiation](#) and [neutrons](#). [[P9.2](#), [P9.3](#)]

Flexible Learning Approach to Physics - Glossary

iris

of: the eye

is: the coloured tissue in front of the [lens](#) and whose variable [aperture](#), the [pupil](#), controls the amount of [light](#) entering the eye. [[P6.4](#)]

iris diaphragm

is: a [mechanical system](#) of overlapping metal leaves which can form an [aperture](#) of variable size for a [lens](#). [P6.4]

irradiation

is: the process of exposing something to [radiation](#).

Flexible Learning Approach to Physics - Glossary

irrational number

is: a [real number](#) which cannot be expressed as a [fraction](#) (for example, e , π or, $\sqrt{2}$). [[M1.2](#), [M3.1](#)]

Flexible Learning Approach to Physics - Glossary

irreversible process

is: a process in which it is not possible to return the [system](#) undergoing the process and its [environment](#) to their original [states](#) after the process has taken place. [P7.4]

increases: the [entropy](#) of the [Universe](#) ([system](#) + [environment](#)), according to the [principle of entropy increase](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

isobaric

describes: a process that takes place at constant [pressure](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

isochoric

describes: a process that takes place at constant [volume](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

isolated system

is: a [system](#) which does not interact with its [environment](#).

has: different shades of meaning for different kinds of [system](#).

is exemplified: by a [mechanical system](#) that is not acted upon by any [external forces](#) and which neither gains or loses [energy](#). For such a [system](#), the only [forces](#) acting are [internal forces](#), and the total [energy](#) and the total [momentum](#) are [conserved](#). [[P2.4](#), [P2.5](#)]

Flexible Learning Approach to Physics - Glossary

isosceles triangle

is: a [triangle](#) with two sides of equal length, and hence with two equal [interior angles](#). [[M1.6](#)]

Flexible Learning Approach to Physics - Glossary

isotherm

is: a [curve](#) on a [PVT-surface](#) (or some similar [surface](#)), or on one of its projections, passing only through points that represent [states](#) of the same [temperature](#). [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

isothermal condition

for: a fixed quantity of [ideal gas](#)

is: a condition that characterises an [isothermal process](#) in the sense that all the [states](#) involved in the process must satisfy the condition. (Though it is not the case that all [states](#) satisfying the condition must be involved in the process.) [[P7.4](#)]

may be written: in the form $PV = \text{constant}$, where the value of the constant is characteristic of the process. [[P7.3](#), [P7.4](#)]

may also be written: in the form $P_a V_a = P_b V_b$. [[P7.3](#), [P7.4](#)]

isothermal phase transition

is: a [phase transition](#) that occurs without any change of [temperature](#).
([Temperature](#) changes during a [phase transition](#) such as [melting](#) can be brought about by changing the [pressure](#) or other external conditions during the transition.)

Flexible Learning Approach to Physics - Glossary

isothermal process

is: a process that occurs at [constant temperature](#), so that $\Delta T = 0$. [P7.3]

is characterized: for an [ideal gas](#) by the [isothermal condition](#) $PV = \text{constant}$, where P is the [pressure](#), V is the [volume](#), and the [constant](#) is determined by the [initial state](#) of the gas. [P7.3]

Flexible Learning Approach to Physics - Glossary

isotopes

of: a given [chemical element](#)

have: the same number of [protons](#) in their [nuclei](#) as all other isotopes of that [element](#), but different numbers of [neutrons](#). [P9.1]

therefore have: the same [atomic number](#) but different [mass numbers](#). [P8.1]

sometimes are referred to loosely: as [nuclides](#). [P9.1, P9.2]

Flexible Learning Approach to Physics - Glossary

iteration

is: a [numerical procedure](#) which uses a formula (called an iteration formula) to obtain a succession of [approximations](#) (usually) to the [root](#) of an [equation](#).
[M1.4]

iteration formula

See [iteration](#).

iterative methods

See [iteration](#).

Flexible Learning Approach to Physics - Glossary

I-V characteristic

for: any [circuit component](#)

of: an [electric circuit](#)

is: a [graph](#) of [current](#), I against [voltage](#), V . [[P4.1](#)]

See [linear component](#).

Josephson junction

is: a device in which a thin [electrically insulating](#) film is sandwiched between two pieces of [superconductor](#). The existence of [quantum tunnelling](#) allows this device to exhibit highly non-[classical](#) behaviour that is exploited in more complicated devices such as [SQUIDS](#). [[P11.1](#)]

Flexible Learning Approach to Physics - Glossary

joule, J

is: the ([derived](#)) [SI unit](#) of [energy](#) and [work](#).

is defined: by $1 \text{ J} = 1 \text{ N m} = 1 \text{ kg m}^2 \text{ s}^{-2}$.

represents: the [energy](#) transferred when the [point](#) of application of a [constant force](#) of [magnitude](#) one [newton](#) is [displaced](#) by one [metre](#) in the [direction](#) of the [force](#). [[P2.4](#), [P2.5](#)]

Flexible Learning Approach to Physics - Glossary

Joule heating

is: [heating](#) produced by an [electric current](#) in a [resistive circuit component](#).

is explained microscopically: in a [metal](#), as the result of [collisions](#) between [electrons](#) and [lattice ions](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

kelvin, K

is: the [SI unit](#) of [temperature](#), one of the seven [base units](#).

is defined: as 1/273.16 of the [triple-point temperature](#) of H₂O on the [thermodynamic Kelvin temperature scale](#).

is equal: to a [degree Celsius](#) (°C), though due to differences in the zero points of the [Celsius](#) and [thermodynamic Kelvin temperature scales](#), the [absolute temperature](#) of an object in kelvin (T_K) is related to its [Celsius temperature](#) (T_C) by the formula:

$$T_K/\text{K} = T_C/(\text{°C}) + 273.15 \quad [\text{P7.2}]$$

is never referred to: as degrees kelvin or °K but only as kelvin or K.

Kelvin temperature scale

See [thermodynamic Kelvin temperature scale](#).

Kepler's laws of planetary motion

describe (approximately): the basic features of planetary [motion](#). [[P2.8](#), [P3.2](#)]

state: that

1 The [orbits](#) of planets in the solar system are [ellipses](#) with the Sun at one [focus](#).

2 The [radial line](#) from the Sun to a planet sweeps out equal [areas](#) in equal [intervals](#) of [time](#).

3 The [square](#) of the [orbital period](#) is [proportional](#) to the cube of the [semi-major axis](#) of the [ellipse](#). [[P2.8](#), [P3.2](#)]

were deduced empirically: by Johannes Kepler (1571-1630). [[P3.2](#)]

were later explained: by Isaac Newton (1642-1727), using [Newton's laws of motion](#) and [Newton's law of gravitation](#). [[P3.2](#)]

Flexible Learning Approach to Physics - Glossary

kilogram, kg

is: the [SI unit](#) of [mass](#), one of the seven [base units](#). [P1.1, P2.3]

is defined: by the international prototype kilogram, which is kept at the International Bureau of Weights and Measures at Sevres in France, and takes the form of a cylinder made from a platinum-iridium [alloy](#). Replicas are kept in other [standards](#) laboratories.

Flexible Learning Approach to Physics - Glossary

kilowatthour, kWh

is: a non-[SI unit](#) of [energy](#).

is defined: by $1 \text{ kWh} = 1 \text{ kW} \times 1 \text{ h} = 3.6 \times 10^6 \text{ J}$

i.e. 3.6×10^6 [joule](#). [[P4.1](#)]

commonly is used: by [electricity](#) supply companies for billing customers and referred to in that context as the '[unit](#)' of [electrical energy](#).

Flexible Learning Approach to Physics - Glossary

kinematics

is: the branch of [mechanics](#) concerned with [motion](#) and its description, but not its causes. [[M5.1](#), [P2.3](#)]

Compare with [dynamics](#).

Flexible Learning Approach to Physics - Glossary

kinetic energy

is: the [energy](#) which an object possesses by virtue of its [motion](#). An object of [mass](#) m moving with [speed](#) v has a [translational kinetic energy](#) $E_{\text{tran}} = \frac{1}{2}mv^2$.
[P2.4]

is classified: in three types: [translational kinetic energy](#), [vibrational kinetic energy](#) and [rotational kinetic energy](#). [P2.4]

kinetic theory

is: a [theory](#) which attempts to explain the bulk [thermodynamic](#) and [transport](#) properties of [systems](#) in terms of the [interactions](#) of [atoms](#) or [molecules](#) (often treated as hard [spheres](#) in rapid unhindered motion apart from collisions and encounters with the walls of a containing vessel, and usually subject to [Newton's laws of motion](#)), and generally assuming that the [energy](#) and [momentum](#) is randomly distributed among the [particles](#) in the [system](#). [P7.5]

kinetic theory of ideal gases

is: [kinetic theory](#) specifically applied to the [model](#) system of the [ideal gas](#), leading to the [equation](#) $PV = \frac{1}{3}Nm\langle v^2 \rangle = \frac{2}{3}N\langle E_{\text{kin}} \rangle$ where $\langle v^2 \rangle$ is the [mean](#) of the [squares](#) of the molecular [speeds](#) and $\langle E_{\text{kin}} \rangle$ is the average [translational kinetic energy](#) per [molecule](#). The [gas](#) has [pressure](#) P [volume](#) V and contains N [molecules](#), each of [mass](#) m . [[P7.3](#), [P7.5](#)]

Kirchhoff's laws

for: the an [electric current](#) in a [circuit](#).

See [Kirchhoff's current law](#) and [Kirchhoff's voltage law](#).

Kirchhoff's current law

states: that the [algebraic](#) sum of the [currents](#) at a [node](#) is zero, or equivalently that the total [current](#) flowing into each [node](#) is equal to the total [current](#) flowing out of the [node](#). [[P4.1](#)]

Kirchhoff's voltage law

states: that the [algebraic](#) sum of the [voltages](#) across all [electrical components](#) in a closed loop or [mesh](#) is zero, or equivalently, the sum of the [voltage](#) increases is matched by the sum of the [voltage](#) decreases. [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

lag

See [phase lag](#).

Flexible Learning Approach to Physics - Glossary

lanthanides

are: the 14 closely similar [chemical elements](#) from La to Yb ([atomic numbers](#) from 57-70) inclusive. [[P8.4](#)]

span: a region of the [periodic table](#) in which the 4f [subshell](#) of [atoms](#) in their [ground state](#) is being progressively filled. [[P8.4](#)]

Flexible Learning Approach to Physics - Glossary

Laplace's equation

is: a [linear](#), [homogeneous](#), [second-order](#), [partial differential equation](#) of the form

$$\frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial y^2} + \frac{\partial^2 U}{\partial z^2} = 0 \quad [\text{M6.4}]$$

Flexible Learning Approach to Physics - Glossary

laser

is: a [light](#) source of high [coherence](#) that produces a nearly parallel [beam](#), often of high [intensity](#). [[P6.1](#)]

is named: for [Light](#) Amplification by [Stimulated Emission](#) of [Radiation](#). [[P6.1](#)]

laser action

is: the process by which [stimulated emission](#) produces amplification of [light](#) within the cavity of a [laser](#). [[P5.3](#)]

Flexible Learning Approach to Physics - Glossary

latent heat

is: the [heat](#) absorbed or emitted by a sample during an [isothermal phase transition](#). [[P7.4](#)]

See also [specific latent heat](#), [molar latent heat](#).

Flexible Learning Approach to Physics - Glossary

lateral magnification

in: an [optical system](#)

is: the [ratio](#) of the size of an [extended image](#) to the size of the corresponding [extended object](#), when measured [normal](#) to the [optical axis](#). [P6.3]

for a lens is called: [lens transverse magnification](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

lattice

is: a regular array of [points](#) in [space](#) that underlies the specification of [crystal structure](#) in terms of a given arrangement of one or more [atoms](#) reproduced at every [point](#) of the lattice. [[P11.4](#)]

is less rigorously: a regular array of [points](#) within a ([crystalline](#)) [solid](#) about which [atoms](#) or [ions](#) may be considered to [oscillate](#). [[P4.1](#)]

law of inertia

See [Newton's first law of motion](#).

law of physics

is: a relationship between [physical](#) variables that is believed to be valid under a wide range of circumstances and is (ideally) well supported by [experimental](#) evidence.

Flexible Learning Approach to Physics - Glossary

law of reflection

for: a [ray](#) of [light](#)

from: a [surface](#)

states: that

(i) the [reflected ray](#), the [incident ray](#) and the [normal](#) to the [surface](#) all lie in one [plane](#), and

(ii) the [angle of reflection](#) is always equal to the [angle of incidence](#): $\theta_i = \theta_R$.
[[P6.1](#), [P6.2](#)]

law of refraction

of: a [ray](#) of [light](#)

from: one [medium](#) into another

states: that

(i) the [incident ray](#), the [refracted ray](#) and the [normal](#) to the boundary all lie in one [plane](#), and

(ii) the [angle of incidence](#) θ_1 and the [angle of refraction](#) θ_2 are related by [Snell's law](#):

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{\mu_2}{\mu_1} = \text{constant}$$

where μ_1 and μ_2 are the [refractive indices](#) of the two [media](#), respectively. (The [refractive indices](#) normally depend somewhat on the [frequency](#) of the [light](#) giving rise to [dispersion](#).) [[P6.1](#), [P6.2](#)]

Flexible Learning Approach to Physics - Glossary

law of static moments

states: that a [body](#) is in [rotational equilibrium](#) if the clockwise [moments](#) balance the counter clockwise [moments](#) in every [plane](#). [[P2.7](#)]

law of terrestrial gravitation

states: that close to the Earth's [surface](#), any body of [mass](#) m experiences a [gravitational force](#) that acts vertically downwards and has [magnitude](#) mg , where g is the [magnitude of the acceleration due to gravity](#) (approximately 9.81 N m s^{-2}). [P2.3]

law of universal gravitation

was first formulated: by Isaac Newton (1642-1727). [P2.3, P3.1]

states: that every [particle](#) of [matter](#) in the [Universe](#) attracts every other [particle](#) with a [force](#) that is [directly proportional](#) to the [product](#) of the [masses](#) of the [particles](#) and [inversely proportional](#) to the [square](#) of the [distance](#) between them. [P2.3, P3.1]

can be expressed: for two [masses](#) m_1 and m_2 separated by a [distance](#) r as

$$\mathbf{F}_{\text{grav}} = \mathbf{F}_{21} = \frac{-Gm_1m_2}{r^2} \hat{\mathbf{r}}$$

as the [force](#) on m_2 due to m_1

where G is [Newton's universal gravitational constant](#) and $\hat{\mathbf{r}}$ is a [unit vector](#) pointing from m_1 to m_2 . [P2.3, P3.1, P3.2]

also known as: universal law of gravitation.

Lawson criterion

for: 'break even' conditions in a [plasma fusion reactor](#), so that [fusion energy](#) output is just equal to the [energy](#) expended to produce this output

requires: that the product of the [number density](#) of [nuclei](#) in the [plasma](#) and the [confinement time](#) be greater than a given value. This value depends on the [reaction](#) concerned and the [temperature](#). [P9.3]

LCR circuit

is: an [electrical circuit](#) containing an [inductance](#) L , a [capacitance](#) C and a [resistance](#) R .

Flexible Learning Approach to Physics - Glossary

lead

See [phase lead](#).

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lead-acid accumulator

is: a [storage cell](#) made from two lead [electrodes](#) with a sulphuric acid [electrolyte](#), 'charged' by passing a [direct current](#) through it. [[P4.5](#)]

is also: a [battery](#) of such [storage cells](#). [[P4.5](#)]

is used: to make car [batteries](#). [[P4.5](#)]

Flexible Learning Approach to Physics - Glossary

least distance of distinct vision

is: the [distance](#) from the eye to the closest [point](#) at which objects can be clearly focused (i.e. the [near point](#)). [P6.4]

varies: with age but is commonly taken to be 25 cm. [P6.4]

Flexible Learning Approach to Physics - Glossary

Leclanché dry cell

is: an electric [storage cell](#) consisting of a carbon [electrode](#) surrounded by a moist [electrolytic](#) paste enclosed in a zinc case which forms the cell's other [terminal](#).
[P4.5]

is used widely: as a portable power source, e.g. in torches and portable radios, but is increasingly being replaced by the broadly similar alkaline cell. [P4.5]

left-handed (Cartesian) coordinate system

is: a [three-dimensional Cartesian coordinate system](#) (consisting of three mutually [perpendicular coordinate axes](#) which meet at a [point](#) called the [origin](#)), in which an [observer](#) located at the [origin](#) and looking along the [z-axis](#) in the [direction](#) of increasing z finds that a left-handed screw motion through 90° (i.e. a 90° anticlockwise [rotation](#)) is needed to bring the [x-axis](#) into the position previously occupied by the [y-axis](#). [P6.2]

Contrast with [right-handed coordinate system](#), which is more commonly used.

Flexible Learning Approach to Physics - Glossary

length

is: one of the fundamental dimensional quantities of [mechanics](#) (along with [mass](#) and [time](#)).

is used: to describe the [distance](#) from one end of an object or interval to the other end.

has as its SI unit: the [metre](#) (m), one of the seven [base units](#).

Flexible Learning Approach to Physics - Glossary

lens

is: a piece of glass or other [transparent](#) material shaped so that its [surfaces](#) curve inwards or outwards. Usually the [surfaces](#) are [spherical](#) in shape. [P6.3]

is used: generally to make [parallel light](#) converge to form an [image](#), or to form [parallel light](#) from [light](#) diverging from an [object](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

lens (of eye)

is: the flexible [lens](#) of the eye. [P6.4]

has: a [focal length](#) which can be varied by change of the shape of the [lens](#), through [contraction](#) of the [ciliary muscles](#). [P6.4]

lens maker's equation

is: an [equation](#) which relates the [focal length](#) f of a [lens](#) to the [radii of curvature](#), r_1 and r_2 of its [surfaces](#) and the [refractive index](#) μ of the material used:

$$\frac{1}{f} = (\mu - 1) \left(\frac{1}{r_1} - \frac{1}{r_2} \right) \quad [\text{P6.3}]$$

lens transverse magnification

is: the [lateral magnification](#) of a [lens](#). [P6.3]

therefore is: the [ratio](#) of [image](#) height to [object](#) height measured in the [direction perpendicular](#) to the [optical axis](#) of the [lens](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

Lenz's law

states: that the polarity of any [induced voltage](#) or the [direction](#) of any [induced current](#) is such as to oppose the change causing it. (This [law](#) is a consequence of the [law](#) of [conservation of energy](#).) [[P4.4](#)]

Flexible Learning Approach to Physics - Glossary

lever arm

of: a [force](#) causing, or tending to cause, rotation about a [fulcrum](#)

is: the [perpendicular](#) distance between the [line of action](#) of the [force](#) and the [fulcrum](#). [[P4.3](#)]

lepton

See [elementary particle](#).

Lewis structure

is: a diagram, named after the American chemist Gilbert Lewis (1875-1946), which shows how the outer [electrons](#) of the [atoms](#) in a [chemical compound](#) are shared in order to create [electron pair bonds](#), in accordance with the [theory](#) of [covalent bonding](#). [[P8.4](#)]

Flexible Learning Approach to Physics - Glossary

light

is: a form of [electromagnetic radiation](#), visible to the human eye, and characterized by [wavelengths](#) in the approximate range 400 nm to 700 nm.

See [electromagnetic spectrum](#).

Flexible Learning Approach to Physics - Glossary

light damping

of: a [damped oscillator](#)

is: the condition in which the [oscillator](#) will complete many [oscillations](#) (with gradually decreasing [amplitude](#)) before coming to rest. [[P5.2](#), [P5.5](#)]

is often used as synonymous: with [underdamping](#).

See [damped mechanical oscillator](#) and/or [damped electrical oscillator](#) for further details.

Contrast with [critical damping](#) and [heavy damping](#).

Flexible Learning Approach to Physics - Glossary

light ray

is: a [directed line](#) (i.e. a [line](#) with an arrow on it) drawn to represent the passage (or potential passage) of [light](#). [[P6.1](#), [P6.2](#)]

usually is drawn: at [right angles](#) to the [wavefront](#). [[P6.1](#), [P6.2](#)]

has direction: which indicates the [direction](#) of [energy](#) flow. [[P6.1](#), [P6.2](#)]

normally is restricted: to situations in which [diffraction](#) effects are negligible. [[P6.1](#), [P6.2](#)]

Flexible Learning Approach to Physics - Glossary

light wave

is: an [electromagnetic wave](#) with a wavelength in the approximate range 400 nm to 700 nm that can be used to model certain aspects of the behaviour of [light](#).

Flexible Learning Approach to Physics - Glossary

limit

of: the [function](#) $f(x)$

as: x approaches a

if: $f(x)$ can be made as close as we wish to L by making x sufficiently close to a

is: L . [[M4.1](#), [M4.2](#), [P2.1](#)]

is indicated: by writing $\lim_{x \rightarrow a} (f(x)) = L$. [[M1.5](#)]

is exemplified: by $\lim_{x \rightarrow \infty} \left(\frac{1}{x}\right) = 0$. [[M1.5](#)]

limit of a sequence

See [convergent sequence](#).

Flexible Learning Approach to Physics - Glossary

limits of integration

refers: to the [upper limit of integration](#) and [lower limit of integration](#). [M5.1]

See [definite integral](#).

Flexible Learning Approach to Physics - Glossary

line

is: an abbreviation for [straight line](#).

Flexible Learning Approach to Physics - Glossary

line integral

from: [point](#) A to [point](#) B

along: a [curve](#) C in three (or possibly two) [dimensions](#)

of: a [vector](#) quantity $\mathbf{F}(x, y, z)$ that depends on [position](#) and is defined at all [points](#) on C

is given: by

$$\int_A^B \mathbf{F} \cdot d\mathbf{s} = \lim_{\Delta\mathbf{s} \rightarrow 0} \sum \mathbf{F} \cdot \Delta\mathbf{s}$$

where: $\Delta\mathbf{s}$ is a small [displacement](#) along C , and the sum is over a sequence of small [displacements](#) that lead from A to B along C . Note that in this definition $\mathbf{F} \cdot \Delta\mathbf{s}$ represents a [scalar product](#). [P2.4]

Flexible Learning Approach to Physics - Glossary

line of action (of a vector)

of: a [vector](#) (particularly, though not necessarily, a [force](#))

is: a construction [line](#) of indefinite [length](#) running through the [vector](#). [[P2.7](#)]

is useful: for calculating [moments](#) and in analysing problems. [[P2.7](#)]

Flexible Learning Approach to Physics - Glossary

line segment

is: a finite part of a [straight line](#).

Flexible Learning Approach to Physics - Glossary

line source

is: a source of [light](#) whose height is generally much greater than its width. Ideally the width should be less than the [wavelength](#) of the [light](#) and the height much greater than the [wavelength](#) of the [light](#). [[P6.1](#)]

Flexible Learning Approach to Physics - Glossary

line spectrum

of: [electromagnetic radiation](#) (usually from a specified source)

describes: the [emission spectrum](#) or the [absorption spectrum](#) when these involve [radiation](#) of definite characteristic [wavelengths](#). [P8.2]

is more specifically called: the [emission line spectrum](#) or the [absorption line spectrum](#). [P8.2]

Flexible Learning Approach to Physics - Glossary

linear

describes: a [linear function](#) or its corresponding [straight line graph](#). [P1.3]

Flexible Learning Approach to Physics - Glossary

linear combination

of: two quantities or [expressions](#) y_1 and y_2 (often two [solutions](#) to a [differential equation](#))

is: a quantity or [expression](#) of the form $ay_1 + by_2$, where a and b are [constants](#). [[M5.2](#), [P5.6](#)]

linear component

of: an [electric circuit](#)

is: a [circuit component](#) in which the [current](#) I is [directly proportional](#) to the applied [voltage](#) V , giving rise to an I - V characteristic that is a [straight line](#) through the [origin](#). [[P4.1](#)]

linear differential equation

in: a [dependent variable](#) y

is: a [differential equation](#) in which every term that contains y at all contains no [powers](#) of y and its [derivatives](#) other than the first, no [functions](#) of y and its [derivatives](#), and no [products](#) of y and its [derivatives](#) among themselves. [[M6.1](#), [P5.5](#)]

therefore is: of first [degree](#). [[M6.1](#)]

is exemplified: by

$$a(x)\frac{d^n y}{dx^n} + b(x)\frac{d^{n-1}y}{dx^{n-1}} + \dots + q(x)\frac{dy}{dx} + r(x)y = f(x).$$

(This is linear in y , but is also [inhomogeneous](#) unless $f(x) = 0$)

has the property: if [homogeneous](#), that a [linear combination](#) of [solutions](#) is also a [solution](#).

linear differential equation with constant coefficients

is: a [linear differential equation](#) in which the [coefficients](#) of y and its [derivatives](#) are [constants](#) rather than [functions](#) of x . [[M6.2](#), [M6.3](#)]

Flexible Learning Approach to Physics - Glossary

linear energy density

in: a [one-dimensional system](#)

is: the [energy](#) per [unit length](#). If ΔE is the [energy](#) associated with a short [length](#) Δl , centred on a [point](#) with [position coordinate](#) x at [time](#) t , then the linear energy density at [point](#) x at [time](#) t is

$$D_E(x,t) = \lim_{\Delta l \rightarrow 0} \left(\frac{\Delta E}{\Delta l} \right). \quad [\text{P5.6}]$$

has as its SI unit: the [joule](#) per [metre](#) (J m^{-1}), though this is identical to the [newton](#) (N). [\[P5.6\]](#)

Flexible Learning Approach to Physics - Glossary

linear equation

in: a [variable](#) x

is: an [equation](#) that may be written in the form $ax + b = 0$, where a and b are independent of x . [[M1.4](#)]

therefore is: a [polynomial equation](#) in x of [degree](#) 1. [[M1.4](#)]

Flexible Learning Approach to Physics - Glossary

linear form

is: an [expression](#) which involves only the first [power](#) of the [independent variable](#).

is exemplified: by $3x + 2(x - 1)$ but *not* by $3/(x - 1)$.

Flexible Learning Approach to Physics - Glossary

linear function

is: a [function](#) of the form $f(x) = ax + b$, (the right-hand side is a [linear form](#)).
[M1.4, P1.3]

therefore is: a [function](#) whose [graph](#) is a [straight line](#). [M1.3]

linear homogeneous differential equation

is: a [linear differential equation](#) of the form

$$a(x)\frac{d^n y}{dx^n} + b(x)\frac{d^{n-1}y}{dx^{n-1}} + \dots + q(x)\frac{dy}{dx} + r(x)y = 0 \quad [\text{M6.3}]$$

contains: no non-zero term that does not involve the [dependent variable](#) y or one of its [derivatives](#). [\[M6.3\]](#)

in particular contains: no [constant](#) term. [\[M6.3\]](#)

has the property: that a [linear combination](#) of its [solutions](#) is also a [solution](#).

linear inhomogeneous differential equation

is: a [linear differential equation](#) that is not [homogeneous](#). [M6.3]

Flexible Learning Approach to Physics - Glossary

linear mass density

of: a [uniform body](#) (particularly a [body](#) of [uniform cross-sectional area](#), such as a string) of [mass](#) M and [length](#) L

is: the [mass](#) per [unit length](#) of the [body](#), M/L

is defined more generally: at a [point](#) with [position coordinate](#) x in a (possibly non-[uniform](#)) [body](#) by

$$\rho(x) = \lim_{\Delta l \rightarrow 0} \left(\frac{\Delta m}{\Delta l} \right)$$

where Δm is the mass of a small [element](#) of the [body](#), of [length](#) Δl centred on the [point](#) specified by x .

Flexible Learning Approach to Physics - Glossary

linear momentum

of: a [body](#)

is given: by $\mathbf{p} = m\mathbf{v}$, where m is the [mass](#) of the [body](#) and \mathbf{v} is the [velocity](#) of the [centre of mass](#) of the [body](#). [P2.5]

is equal: for a [system](#) of [particles](#) or [bodies](#), to the [vector sum](#) of the individual momenta. [P2.5]

is fully specified: by giving *both* its [magnitude](#) and its [direction](#). [P2.5]

is conserved: for a [system](#) of [interacting](#) objects which are not subjected to [external forces](#). The [bodies collide](#) and exchange momentum with each other, but the total momentum is constant. [P2.5]

at high speeds must be replaced by: [relativistic momentum](#). [P2.5]

Flexible Learning Approach to Physics - Glossary

linear motion

of: an object

is: [motion](#) of the object along a [straight line](#).

can be represented: if the [straight line](#) is taken to be the [x-axis](#) of a [Cartesian coordinate system](#), in terms of the [instantaneous position](#), [instantaneous velocity](#) and [instantaneous acceleration](#) of the object: $x(t)$, $v_x(t)$ and $a_x(t)$. [[M4.1](#), [M5.1](#), [P2.1](#)]

Flexible Learning Approach to Physics - Glossary

linear relationship

between: two [variables](#) (x and y say)

can be represented: by a [linear function](#) or a linear (i.e. [straight line](#)) [graph](#). [[P1.3](#)]

is exemplified: by $y = mx + c$ where m and c are [constants](#).

linear restoring force

is: a [force](#), directed towards a fixed [point](#), that is [linearly proportional](#) to the [displacement](#) from that [point](#) and in the opposite direction to that [displacement](#). [P5.1]

in one dimension may be written: $F_x = -kx$, where x is the [displacement](#) from the fixed [point](#). A [particle](#) moving under the influence of such a [force](#) (and no other) will execute [simple harmonic motion](#) about the fixed [point](#). [P5.1]

linear second-order differential equation

is: a [differential equation](#) in which every term is [linear](#) in a single [variable](#) or one of its [derivatives](#), and where the highest [derivative](#) appearing is the second [derivative](#). [P5.3]

is exemplified: by the [equation](#) of the [linearly damped harmonic oscillator](#).

Flexible Learning Approach to Physics - Glossary

linear system

is: an [equilibrium system](#) in which the response of the [system](#) (e.g. the [restoring force](#)) is [linearly](#) dependent on [displacement](#) from [equilibrium](#). [[P5.1](#)]

linearity

of: an [equation](#) (such as the [wave equation](#), the [time-dependent Schrödinger equation](#), or a general [linear homogeneous differential equation](#))

is: a property whereby if y_1 and y_2 are both [solutions](#), then so is any [linear combination](#) of the form $ay_1 + by_2$, where a and b are [constants](#). [P5.6]

linearization

is: the procedure whereby a non-[linear relationship](#) between two or more [variables](#) (x and y say) is represented by a [linear relationship](#) between two or more other [variables](#) (u and v say) which are expressed in terms of the original [variables](#). In appropriate circumstance, this process may allow the [constants](#) involved in the original non-[linear relationship](#) to be determined from an analysis based on the corresponding [linear relationship](#). [P1.3]

also can describe: the procedure whereby a non-[linear relationship](#) between [variables](#) is [approximated](#) by a [linear relationship](#) between the same [variables](#). [M6.1, P1.3]

linearly damped harmonic oscillator

is: a [harmonic oscillator](#) with a [damping force](#) which depends linearly on the [velocity](#) of the [oscillator](#), or on the [first derivative](#) of the [displacement](#) of the [oscillator](#). [P5.3]

is exemplified: by a [damped mechanical oscillator](#) with the equation of motion

$$m \frac{d^2x}{dt^2} = -kx - b \frac{dx}{dt}$$

linearly independent

describes: a [set](#) (e.g. a [set](#) of [functions](#)) in which no [element](#) can be expressed as a [linear combination](#) of other [elements](#) of the [set](#).

Flexible Learning Approach to Physics - Glossary

linearly polarized

describes: an [electromagnetic wave](#) whose [electric field oscillates](#) in the same [plane](#) at all [points](#). [[P6.1](#)]

also known as: plane polarized.

liquid phase

is: the [state](#) of [fluid matter](#) characterized by a definite [volume](#) but no definite shape. [[P7.1](#)]

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Lissajous figures

are: figures which result when two [simple harmonic motions](#), which may differ in [amplitude](#), [frequency](#) or [phase](#), are added in [perpendicular](#) directions. [[P5.1](#)]

normally are viewed: on an oscilloscope. [[P5.1](#)]

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litre, ℓ

is: a non-[SI unit](#) of [volume](#).

is defined: by $1 \ell = 10^{-3} \text{ m}^3$ (i.e. 10^{-3} [metre](#) cubed).

Flexible Learning Approach to Physics - Glossary

load resistor

is: a [resistor](#) that is treated as 'external' to the [circuit](#) that supplies it with [current](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

loading curve

is: a [graph](#) of [stress](#) against [strain](#) for a material.

Flexible Learning Approach to Physics - Glossary

local action

is: the destruction or permanent change of an [electrode](#) in a [storage cell](#) as a result of chemical [reactions](#). [P4.5]

local extrema

is: a collective term for [local maxima](#) and [local minima](#). [[M4.4](#)]

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local maximum

is: a [point](#) $(a, f(a))$ on the [graph](#) of a [function](#) $f(x)$ for which $f(x) \leq f(a)$ for all [points](#) x close to a . At such a [point](#), $df/dx = 0$ and $f(x)$ is said to be [stationary](#).

always exists: if $df/dx = 0$ and $d^2f/dx^2 < 0$. This is a sufficient condition.
[[M4.4](#), [P6.2](#)]

See stationary points and graph sketching in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

local minimum

is: a [point](#) $(a, f(a))$ on the [graph](#) of a [function](#) $f(x)$ for which $f(x) \geq f(a)$ for all [points](#) x close to a . At such a [point](#), $df/dx = 0$ and $f(x)$ is said to be [stationary](#).

always exists: if $df/dx = 0$ and $d^2f/dx^2 > 0$. This is a sufficient condition.
[[M4.4](#), [P6.2](#)]

See stationary points and graph sketching in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

localized particle

is: a [particle](#) whose [position](#) is known, at least within prescribed limits. [[P10.2](#)]

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locus

is: a collection of [points](#) specified by some conditions. [[M2.1](#)]

logarithm to base 10

of: a number, x

is: the number, y which satisfies the [equation](#), $x = 10^y$. [M1.5]

usually is written: as $\log_{10}(x)$ or $\log_{10} x$. [M1.5]

sometimes is called: the [common logarithm](#). (This does *not* imply that it is more common than the [natural logarithm](#) in physics!) [M1.5]

Flexible Learning Approach to Physics - Glossary

logarithm to base a

of: a number, x

is: the number, y which satisfies the [equation](#), $x = a^y$. [M1.5]

usually is written: as $\log_a(x)$. [M1.5]

Flexible Learning Approach to Physics - Glossary

logarithm to base e

of: a number, x

is: the number, y which satisfies the [equation](#), $x = e^y$. [M1.5]

usually is written: as $\log_e(x)$, $\log_e x$ (or sometimes $\ln x$). [M1.5]

is known: as the natural logarithm. [M1.5]

less commonly is called: the Napierian logarithm or the hyperbolic logarithm. [M1.5]

logarithmic decrement

in: [damped harmonic motion](#)

is: the [natural logarithm](#) of the [ratio](#) of two successive [displacement](#) maxima, i.e. $\log_e [A(t + T)/A(t)]$, where T is the [period](#) of the [oscillation](#). [P5.2]

is equal approximately: to $\pi\gamma/\omega_0$, where γ is the [damping constant](#) and ω_0 is the [natural frequency](#) of the [oscillation](#). [P5.2]

See [damped mechanical oscillator](#).

logarithmic function

is: a general term used to refer to any [function](#) that is the [inverse](#) of a [function](#) of the form $y = a^x$. [[M1.5](#)]

is indicated symbolically: by $x = \log_a(y)$, (so $x = \log_a(a^x)$), where the positive [constant](#) a is said to be the [base](#) of the logarithmic function. [[M1.5](#)]

Flexible Learning Approach to Physics - Glossary

long sight

See [hypermytropa](#).

Flexible Learning Approach to Physics - Glossary

longitudinal wave

is: a [wave](#) in which the disturbances that constitute the [wave](#) involve [displacements](#) along the [direction of propagation](#) of the [wave](#). [P5.6]

is exemplified: by a [sound wave](#).

Contrast with [transverse wave](#).

Flexible Learning Approach to Physics - Glossary

Lorentz force law

is: the general [equation](#) for the [electromagnetic force](#), or [Lorentz force](#), \mathbf{F} on a [particle](#) of [charge](#) q in an [electric field](#) \mathbf{E} and/or [magnetic field](#) \mathbf{B} . [[P4.3](#)]

is given: by $\mathbf{F} = q [\mathbf{E} + \mathbf{v} \times \mathbf{B}]$. [[P4.3](#)]

Lorentz force

on: a [charged particle](#)

in: an [electric field](#) and/or a [magnetic field](#)

is found: by adding the separate [forces](#) that would be produced by each [field](#) acting independently, as described by the [Lorentz force law](#). [[M2.7](#), [P4.3](#)]

is also called: the [electromagnetic force](#). [[M2.7](#), [P4.3](#)]

Flexible Learning Approach to Physics - Glossary

low-pass filter

is: a [filter circuit](#) that passes low-[frequency](#) signals with relatively undiminished [amplitude](#), but blocks high-[frequency](#) signals. [[P5.4](#)]

Contrast with [high-pass filter](#).

Flexible Learning Approach to Physics - Glossary

lower limit (of summation)

See [summation symbol](#).

lower limit (of integration)

See [definite integral](#).

Lyman series

See [series \(spectroscopic\)](#).

Flexible Learning Approach to Physics - Glossary

Mach number

for: the [speed](#) of an object through a [fluid](#)

is: the [ratio](#) of the [speed](#) of the object to the local [speed](#) of [sound](#). [P5.7]

Flexible Learning Approach to Physics - Glossary

macroscopic

describes: size scales sufficiently large that no account need be taken of the behaviour of individual [atoms](#) or [molecules](#). [[P7.2](#), [P7.5](#)]

Flexible Learning Approach to Physics - Glossary

magnet

is: a [body](#) which exhibits [magnetism](#). [P4.2]

may: be either a [permanent magnet](#) or an [electromagnet](#).

Flexible Learning Approach to Physics - Glossary

magnetic

is: the property of being attracted by a [magnet](#).

Flexible Learning Approach to Physics - Glossary

magnetic confinement

of: a [plasma](#)

is achieved: by means of a [magnetic field](#) which produces an [electromagnetic force](#) on the [plasma](#) to prevent it from making contact with the vessel walls.

[P9.3]

See [plasma confinement](#).

Flexible Learning Approach to Physics - Glossary

magnetic dipole

is: a pair of equal strength magnetic [north](#) and [south poles](#), as found in a bar [magnet](#). [P4.2]

more generally is: any source of a [magnetic field](#) of the same configuration as that produced by a short bar [magnet](#). [P4.2]

is exemplified: by a single loop of wire enclosing an [area](#) A and carrying a [current](#) I .

magnetic dipole moment

of: a [magnetic dipole](#)

is: a [vector](#) quantity μ that determines the [torque](#) acting on the [magnetic dipole](#) when it is placed in a given [magnetic field](#) (the [torque](#) depends on the orientation of the [magnetic dipole](#)). [P4.3]

is defined: as having a [magnitude](#) given by the [ratio](#) of the maximum [torque magnitude](#) to the [magnitude](#) of the [magnetic field](#): $\mu = \Gamma/B$. (In [vector](#) form the [torque](#) is written as $\Gamma = \mu \times \mathbf{B}$) [P4.3]

is exemplified: for a [magnetic dipole](#) consisting of a single loop of wire of [area](#) A carrying a [current](#) I , by $\mu = IA$. If the loop has N turns, all in the same [plane](#) and each of [area](#) A then $\mu = NIA$. [P4.3]

Flexible Learning Approach to Physics - Glossary

magnetic field

throughout: a region of [space](#)

is: a [vector field](#) which gives rise to a [magnetic force](#) on moving [charged particles](#) at each [point](#) in the region, provided they are not travelling parallel to the magnetic field at the [point](#) in question. [P3.1]

is defined: at any [point](#) specified by a [position vector](#) \mathbf{r} , as the [vector quantity](#) $\mathbf{B}(\mathbf{r})$ whose [direction](#) is identical to that in which the [north pole](#) of a vanishingly small compass needle, free to rotate in three [dimensions](#), would point, and whose magnitude $B(\mathbf{r})$, is obtained from the [magnitude](#), F_{mag} , of the [magnetic force](#) that acts - by virtue of the [Lorentz force law](#) - on a [particle](#) of [charge](#) q as it moves through the [point](#) \mathbf{r} in a [direction](#) at [right angles](#) to the magnetic field with a [speed](#) v_{\perp}

$$F_{\text{mag}} = |q|v_{\perp}B(\mathbf{r})$$

So
$$B(\mathbf{r}) = \frac{F_{\text{mag}}(\text{on } q \text{ as it moves through } \mathbf{r})}{|q|v_{\perp}} \quad [\text{P4.2}]$$

may be more simply defined: as the [vector field](#) $\mathbf{B}(\mathbf{r})$ that determines the [magnetic force](#) \mathbf{F}_{mag} on a [particle](#) of [charge](#) q travelling with [velocity](#) \mathbf{v} at the point \mathbf{r} through the relationship

$$\mathbf{F}_{\text{mag}} = q\mathbf{v} \times \mathbf{B}(\mathbf{r}). \quad [\text{P4.3}]$$

has as its SI unit: the [tesla](#) (T), where $1 \text{ T} = 1 \text{ N s C}^{-1} \text{ m}^{-1}$. [P4.2]

also may be denoted: $\mathbf{B}(x, y, z)$, since $\mathbf{r} = (x, y, z)$. [P4.2]

Flexible Learning Approach to Physics - Glossary

magnetic field lines

are: a means of representing a [magnetic field](#) using [directed curves](#) (i.e. [curves](#) with arrows on them). [[P4.2](#)]

are drawn: so that at any [point](#) the [magnetic field](#) is [tangential](#) to the line and points in the [direction](#) indicated by the [direction](#) of the field line. [[P4.2](#)]

therefore are directed: away from [north magnetic poles](#) and towards [south magnetic poles](#). (This direction is that in which the [north pole](#) of a freely suspended compass needle would point - which means of course that the north geographical pole of the Earth is actually a [south magnetic pole](#)!) [[P4.2](#)]

have spacing: which is related to the [magnitude](#) of the [magnetic field](#), i.e. where the lines are close together the field is strong and where they are further apart the field is weaker. [[P4.2](#)]

Flexible Learning Approach to Physics - Glossary

magnetic field strength

at: any [point](#)

is: the [magnitude](#) of the [magnetic field](#) at that [point](#). [[P4.3](#)]

Flexible Learning Approach to Physics - Glossary

magnetic flux

loosely is: the 'amount of [magnetic field](#)' enclosed by a [circuit](#). [P4.4]

more precisely is: for a loop of [area](#) A whose [axis](#) makes an [angle](#) θ with a [uniform magnetic field](#) \mathbf{B} , the quantity $\phi = BA \cos \theta$. [P4.4]

has as its SI unit: the [weber](#) (Wb), where $1 \text{ Wb} = 1 \text{ T m}^2$. [P4.4]

Flexible Learning Approach to Physics - Glossary

magnetic flux density

is: the [strength of a magnetic field](#), expressed in terms of the [magnetic flux](#) per [unit area](#) when the [area](#) is at 90° to the field [direction](#). [P4.4]

has as its SI unit: Wb m^{-2} . ($1 \text{ Wb m}^{-2} = 1 \text{ T}$). [P4.4]

Flexible Learning Approach to Physics - Glossary

magnetic flux linkage

for: a [circuit](#) of N turns, each enclosing a [magnetic flux](#) ϕ

is: $\Phi = N\phi$. [[P4.4](#)]

has as its SI unit: the [weber](#) (Wb). [[P4.4](#)]

conventionally is expressed also: in [units](#) of Wb turns. [[P4.4](#)]

Flexible Learning Approach to Physics - Glossary

magnetic force

is: the [force](#) F_{mag} produced by a [magnetic field](#) on a moving [charged particle](#), or on a stream of [charged particles](#) constituting an [electric current](#). [P4.3]

is quantified: for a [particle](#) with [charge](#) q and [velocity](#) v in a magnetic [field](#) B by $F = qv \times B$. [P4.3]

is quantified: for a wire of [length](#) l carrying a [current](#) I in a [uniform magnetic field](#) B by $F_{\text{mag}} = Il \times B$, where l is a [vector](#) of [length](#) l in the direction of the conventional [current](#). [P4.3]

Flexible Learning Approach to Physics - Glossary

magnetic induction

is: the creation of temporary [magnetic](#) properties in a material through the presence of an external [magnetic field](#). [P4.2]

Flexible Learning Approach to Physics - Glossary

magnetic monopole

is: a (hypothetical) isolated north or south [magnetic pole](#). [P4.2]

Flexible Learning Approach to Physics - Glossary

magnetic pole

is: one of the two centres within a [magnetic dipole](#) at which the lines of [magnetic field](#) appear to originate or terminate. [[P4.2](#)]

is classified: in two types: north magnetic poles and south magnetic poles. The [forces](#) between poles are such that like poles repel and unlike poles attract. [[P4.2](#)]

Flexible Learning Approach to Physics - Glossary

magnetic (orbital) quantum number

See [orbital magnetic quantum number](#), m_l .

magnetic (spin) quantum number

See [spin magnetic quantum number](#), m_s .

Flexible Learning Approach to Physics - Glossary

magnetically coupled

describes: a situation in which one [circuit](#) is influenced [electrically](#) by [electrical](#) changes in a nearby [circuit](#) through the mechanism of [electromagnetic induction](#) and [mutual induction](#). [P4.4]

magnetically hard

describes: materials, such as steel, which retain much of their [induced magnetism](#) when the magnetizing [magnetic field](#) is removed. [[P4.2](#)]

See [magnetic induction](#) and [permanent magnetism](#). [[P4.2](#)]

Flexible Learning Approach to Physics - Glossary

magnetically soft

describes: materials, such as soft iron, which retain very little of their [induced magnetization](#) when the magnetizing [magnetic field](#) is removed. [P4.2]

See [magnetic induction](#). [P4.2]

Flexible Learning Approach to Physics - Glossary

magnetism

is: the mutual attraction or mutual repulsion of two [bodies](#) that produce [magnetic fields](#). [[P4.2](#)]

Flexible Learning Approach to Physics - Glossary

magnetron

is: an electronic device which generates [microwaves](#) using the [resonance](#) of [electromagnetic waves](#) confined in a cavity. [[P5.3](#)]

Flexible Learning Approach to Physics - Glossary

magnifying power

is: the [ratio](#) of the [angles](#) subtended at an [observer's](#) eye by an [optical image](#) and by the [object](#) from which it is derived, when that [object](#) is placed at the [near point](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

magnitude (of a complex quantity)

See [modulus \(of a complex number\)](#).

Flexible Learning Approach to Physics - Glossary

magnitude (of a real quantity)

See [modulus \(of a real number\)](#).

Flexible Learning Approach to Physics - Glossary

magnitude (of a vector or vector quantity)

for: a [vector](#) (or [vector quantity](#)) $\mathbf{v} = (v_x, v_y, v_z)$.

is: a [scalar quantity](#) that describes the 'size' or '[length](#)' of the [vector](#) $\mathbf{v} = (v_x, v_y, v_z)$. [[M2.4](#), [M2.5](#), [P2.1](#), [P2.2](#), [P2.7](#)]

is always: positive. [[M2.4](#), [M2.5](#), [P2.1](#), [P2.2](#), [P2.7](#)]

is denoted: by $|\mathbf{v}|$ or simply by v . [[M2.4](#), [M2.5](#), [P2.1](#), [P2.2](#), [P2.7](#)]

is defined: by $|\mathbf{v}| = (v_x^2 + v_y^2 + v_z^2)^{1/2}$ [[M2.4](#), [M2.5](#), [P2.1](#), [P2.2](#), [P2.7](#)]

Flexible Learning Approach to Physics - Glossary

magnitude of the acceleration due to gravity

in: the absence of any other influences

is: the [magnitude](#) of the [acceleration due to gravity](#) of a falling [body](#) close to the Earth's [surface](#).

is also: the [magnitude](#) of the [gravitational field](#) close to the Earth's [surface](#).

is denoted: by g . [[P2.2](#)]

varies: from place to place across the Earth's [surface](#), but generally is within $\pm 0.028 \text{ m s}^{-2}$ of 9.805 m s^{-2} . [[P3.2](#)]

Flexible Learning Approach to Physics - Glossary

magnitude of the area under a graph

refers: to the [sum](#) of the (positive) [areas](#) of the various distinct regions contained between a given [graph](#) and a given [axis](#) between given [limits](#). [M5.4]

Compare with [area under a graph](#), which is the corresponding [sum](#) of (signed) areas.

Flexible Learning Approach to Physics - Glossary

main group elements

See [typical elements](#).

Flexible Learning Approach to Physics - Glossary

mains voltage

is: the [voltage](#) supplied by standard power sockets connected to the national (mains) electricity supply. [[P5.4](#)]

Flexible Learning Approach to Physics - Glossary

major arc

is: the larger of the two [arcs of a circle](#) joining two [points](#) on the [circumference](#) that are not at opposite ends of a [diameter](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

major axis

is: the longest diameter of an [ellipse](#).

Flexible Learning Approach to Physics - Glossary

major segment

is: the region bounded by the [major arc](#) of a [circle](#) and the [chord](#) that joins its end [points](#). [[M2.1](#)]

many universe interpretation

in: [quantum physics](#)

suggests: that all possible paths for all [particles](#) are actually followed. In our [Universe](#), when we detect a [particle](#) which has, for example, passed through a slit, we only see the end result of one path, but all the other paths have led to different results in an [infinity](#) of other universes. [P10.2]

is opposed: to the [Copenhagen interpretation](#) of [quantum physics](#). [P10.2]

Flexible Learning Approach to Physics - Glossary

mass

is: one of the fundamental dimensional quantities of [mechanics](#) (along with [length](#) and [time](#)).

is: a property that determines both the [acceleration](#) an object will experience in response to an applied [force](#) (according to [Newton's second law](#)) and the [magnitude](#) of the [gravitational force](#) it will experience in response to a given [gravitational field](#). These ways of interpreting mass are (at present) believed to be equivalent. [[M5.1](#), [P1.1](#)]

has as its SI unit: the [kilogram](#) (kg), one of the seven [base units](#). [[P1.1](#), [P2.3](#)]

should not be confused: with [weight](#). [[P2.3](#)]

is also: an abbreviation used to indicate a [particle](#) or [body](#) of non-zero mass.

Flexible Learning Approach to Physics - Glossary

mass defect

is: the difference between the total [mass](#) of the free [protons](#) and [neutrons](#) of which a [nucleus](#) is made and the (smaller) [mass](#) of the [nucleus](#) itself. [[P9.1](#)]

is attributed: to the [mass energy](#) equivalence of the [binding energy](#) when the [protons](#) and [neutrons](#) are bound together. [[P9.1](#)]

Flexible Learning Approach to Physics - Glossary

mass energy

of: an object

is: the [energy](#) the object has by virtue of its [mass](#), as described by [Einstein's mass-energy equation](#): $E = mc^2$. [[P2.4](#), [P9.1](#)]

Flexible Learning Approach to Physics - Glossary

mass number

of: an [atom](#)

is: the total number of [protons](#) and [neutrons](#) (i.e. the total number of [nucleons](#)) in the [nucleus](#) of the [atom](#). [[P8.1](#), [P9.1](#)]

usually is denoted: by the symbol A . [[P8.1](#), [P9.1](#)]

is: for all known [isotopes](#) the closest whole number to the [relative atomic mass](#) A_r of the [isotope](#). [[P8.1](#), [P9.1](#)]

Flexible Learning Approach to Physics - Glossary

mass spectrometer

is: a device that uses [electric](#) and [magnetic fields](#) to determine the [masses](#) of [molecules](#) and submolecular particles, including [atoms](#), [nuclei](#) and (some) [elementary particles](#). (Strictly speaking it is used to determine the mass of a related [ion](#), rather than the [electrically neutral particles](#) themselves.) [[P4.3](#), [P8.1](#), [P9.1](#)]

is also used: to determine the [relative abundances](#) of various kinds of particles within a given sample.

occurs: in various types, using different arrangements of [fields](#).

Flexible Learning Approach to Physics - Glossary

mass spectrometry

is: the study of [ionic masses](#) using a [mass spectrometer](#). [P4.3]

Flexible Learning Approach to Physics - Glossary

mass spectrum

is: the output from a [mass spectrometer](#). [P8.1]

shows: the [relative abundance](#) of the various [ions](#) derived from a sample, as a [function](#) of their [mass](#). [P8.1]

typically takes the form: of a [graph](#) in which [ion current](#) is plotted against [charge-to-mass ratio](#) (or possibly against [relative atomic mass](#)). [P8.1]

Flexible Learning Approach to Physics - Glossary

mathematical

means: pertaining to [mathematics](#).

Flexible Learning Approach to Physics - Glossary

mathematical model

of: a physical situation or problem

is: an [equation](#) or a system of [equations](#) (possibly [differential equations](#)) that represent the situation or problem. [[M6.1](#)]

Flexible Learning Approach to Physics - Glossary

mathematics

is: the study of number, order, shape, form and numerical [data](#), including their representation by abstract symbols and the rules for manipulating those symbols.

Flexible Learning Approach to Physics - Glossary

matter

is: a general term for material substance irrespective of its specific form.

Maxwell-Boltzmann energy distribution

is: a [distribution function](#) which describes the number of [molecules](#) in a [gas](#) that have [energy](#) in a small [interval](#) between E and $E + \Delta E$, usually taken in the limit as ΔE tends to zero. [P7.5]

is given: by

$$n(E)\Delta E = 2\pi N \left(\frac{1}{\pi kT} \right)^{3/2} E^{1/2} e^{-E/kT} \Delta E$$

where k is [Boltzmann's constant](#), N is the total number of [molecules](#) in the [gas](#) and T is the [absolute temperature](#) of the [gas](#). [P7.5]

Maxwell-Boltzmann speed distribution

is: a [distribution function](#) which describes the number of [molecules](#) in a [gas](#) that possess a [speed](#) in a small [interval](#) between v and $v + \Delta v$, usually taken in the limit as Δv tends to zero. [P7.5]

is given: by

$$n(v)\Delta v = 4\pi N \left(\frac{m}{2\pi kT} \right)^{3/2} v^2 \exp(-mv^2 / 2kT) \Delta v$$

where k is [Boltzmann's constant](#), m is the [mass](#) of a [molecule](#), N is the total number of [molecules](#) in the [gas](#) and T is the [absolute temperature](#) of the [gas](#). [P7.5]

Maxwell's theory of electromagnetism

is: a [classical theory](#) of [electromagnetic](#) phenomena based on a set of [partial differential equations](#) that relate the [electric](#) and [magnetic fields](#) in a region to the [charges](#) and [currents](#) in and around that region, and to any non-uniformities or inconstancies in the [fields](#) within that region.

predicts: the existence of [electromagnetic waves](#) that travel through a [vacuum](#) with [speed](#) $c = 1/\sqrt{\epsilon_0\mu_0}$

Flexible Learning Approach to Physics - Glossary

mean (of values)

of: n values $x_1, x_2, x_3, x_4, \dots, x_{n-2}, x_{n-1}, x_n$ of a quantity x

is symbolized: by $\langle x \rangle$. [[P1.1](#), [P1.2](#)]

is obtained: by adding all those quantities together and dividing the resulting [sum](#) by n . Thus

$$\langle x \rangle = \frac{x_1 + x_2 + x_3 + x_4 + \dots + x_{n-2} + x_{n-1} + x_n}{n} \quad [\text{P1.1, P1.2}]$$

Flexible Learning Approach to Physics - Glossary

mean (of a distribution)

of: a normalized [distribution](#) $f(x)$, i.e. a [distribution](#) for which $\int_a^b f(x) dx = 1$.

is: the [integral](#) $\int_a^b x f(x) dx$ where the [upper and lower limits](#) a and b depend on the range of possible values for the quantity x . [[M5.4](#)]

Flexible Learning Approach to Physics - Glossary

mean collision frequency

of: a [molecule](#) in a [gas](#)

is: the average number of [collisions](#) per second made by a [molecule](#) in the [gas](#).
[P7.5]

therefore is: the [reciprocal](#) of the [mean free time](#). [P7.5]

Flexible Learning Approach to Physics - Glossary

mean free path

of: a [molecule](#) in a [gas](#)

is: the average [distance](#) which the [molecule](#) will travel between [collisions](#) with other [molecules](#). [[P7.5](#)]

therefore is: the [product](#) of the [average speed](#) and the [mean free time](#). [[P7.5](#)]

Flexible Learning Approach to Physics - Glossary

mean free time

for: a [molecule](#) in a [gas](#)

is: the average [time](#) spent by the [molecule](#) between [collisions](#) with other [molecules](#). [P7.5]

therefore is: the [reciprocal](#) of the [mean collision frequency](#). [P7.5]

Flexible Learning Approach to Physics - Glossary

measure

means: (as a verb) to determine a quantitative value.

also means: (as a noun) a quantity that expresses in quantitative terms the extent to which a given quality is present.

See also [measurement](#).

Flexible Learning Approach to Physics - Glossary

measurement

is: a process that determines the (usually) numerical value of a quantity.

is also: used to describe the numerical value itself.

more specifically is: in [quantum mechanics](#), a process that entails the interaction of a [system](#) with a measuring device, the possible outcomes of which are restricted by the [state](#) of the [system](#) immediately prior to the measurement.

Flexible Learning Approach to Physics - Glossary

mechanical

means: pertaining to [mechanics](#).

Flexible Learning Approach to Physics - Glossary

mechanics

is: the branch of [physics](#) concerned with the [motion](#) of [bodies](#) or [systems](#) with (effectively) a finite number of [degrees of freedom](#) and the response of such bodies to [forces](#).

traditionally is: divided into the branches of [statics](#), [kinematics](#) and [dynamics](#).

Flexible Learning Approach to Physics - Glossary

mechanical energy

of: a physical [system](#)

is: the [sum](#) of the [kinetic energy](#) and the [potential energy](#) of the [system](#). [P2.4]

mechanical equilibrium

is: the condition in which a [system](#) is in both [translational equilibrium](#) and [rotational equilibrium](#). [[P2.7](#)]

mechanical impedance

of: a [driven damped mechanical oscillator](#) in which a [periodic driving force](#) $F_0 \sin(\Omega t)$ produces [velocity oscillations](#) described by $v_0 \sin(\Omega t - \delta)$

is: the quantity $Z_m = F_0/v_0$

is given: for a mass m oscillating on a spring of [spring constant](#) k and subject to a damping force of magnitude bv (where v is the speed of the particle), by

$$Z_m = \sqrt{b^2 + \left(\frac{k}{\Omega} - \Omega m\right)^2}$$

has as its SI unit: N s m^{-1} .

Compare with [impedance \(electrical\)](#).

Flexible Learning Approach to Physics - Glossary

mechanical oscillator

is essentially: a [mass](#) on a [spring](#), possibly subject to a [damping force](#) and a [driving force](#).

See [simple harmonic oscillator](#), [damped mechanical oscillator](#), [driven oscillator](#), as appropriate.

Flexible Learning Approach to Physics - Glossary

median

of: a [triangle](#)

is: a [line](#) drawn from one [vertex](#) of the [triangle](#) to the mid-[point](#) of the [opposite side](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

medium

is: a material of interest

is exemplified by: an [optical medium](#).

Flexible Learning Approach to Physics - Glossary

medium (for elastic waves)

is: a deformable material in which an [equilibrium state](#) can be identified and in which [energy](#) is required to bring about (at least some) deformations from the [equilibrium state](#). [P5.6]

is exemplified: by an [elastic solid](#), and by an open body of water in a [uniform gravitational field](#). [P5.6]

Flexible Learning Approach to Physics - Glossary

medium (for light)

is: a [transparent](#) material through which [light](#) can travel. [P6.2]

includes: a [vacuum](#) as a special case, even though it does not consist of any 'substance' in the normal sense. [P6.2]

Flexible Learning Approach to Physics - Glossary

melting point

of: a substance

is: the [temperature](#) at which the [solid](#) and [liquid phases](#) of the substance can coexist in [equilibrium](#) at a specified [pressure](#) (usually, but not necessarily, [standard atmospheric pressure](#)).

is synonymous: with [freezing point](#).

Flexible Learning Approach to Physics - Glossary

meniscus

is: the curved [surface](#) of a [liquid](#), usually when it is in contact with a [solid surface](#). [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

mercury barometer

is: a device for measuring one [pressure](#) relative to another (commonly [atmospheric pressure](#) relative to a [vacuum](#)). [P7.2]

consists: of mercury contained in a U-tube. [P7.2]

works: when the two [pressures](#) are applied to the two sides. The difference is registered as a level difference. The [pressure](#) difference ΔP is related to the level difference h by the formula $\Delta P = \rho gh$, where ρ is the [density](#) of mercury and g the [magnitude of the acceleration due to gravity](#). [P7.2]

Flexible Learning Approach to Physics - Glossary

mercury-in-glass thermometer

is: a glass [capillary](#) with a bulb containing mercury. Changes in [temperature](#) cause the glass and mercury to expand (or contract) by different amounts, and the result is that the [meniscus](#) moves to different positions in the [capillary](#). [[P7.2](#)]

can be calibrated: by marking [meniscus](#) positions corresponding to fixed points such as the [boiling](#) and [freezing points](#) of water, and then [interpolating](#) between them. [[P7.2](#)]

Flexible Learning Approach to Physics - Glossary

mesh

within: a [circuit](#)

is: any continuous closed path. [[P4.1](#)]

is often called: a loop.

Flexible Learning Approach to Physics - Glossary

metal

is: a material that can be modelled as an array of positive [ions](#) immersed in a pool of free [electrons](#). [[P7.1](#)]

therefore is: an excellent [electrical conductor](#). [[P7.1](#)]

See [metallic bond](#) and [metallic bonding](#).

Flexible Learning Approach to Physics - Glossary

metallic bond

is: a [bond](#) that does not involve the localization of any [electron](#) with a particular [atom](#). [[P11.4](#)]

has: the [bonding electrons](#) effectively free to move throughout the [lattice](#) of a ([crystalline](#)) [solid](#), so the [electrons](#) are shared by the [crystal](#) as a whole. [[P11.4](#)]

See [metallic bonding](#).

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metallic bonding

is: the type of [chemical bonding](#) that holds [metals](#) together. A simple [model](#) for a [metal](#) is an array of positive [ions](#) immersed in a sea of free [electrons](#), and the [bonding](#) arises partly from [electrostatic attraction](#) between the [ions](#) and the intervening [electrons](#). [[P7.1](#), [P8.4](#)]

therefore is: a type of [chemical bonding](#) in which an [atom](#) shares its [bonding electron\(s\)](#) with a very large number of other [atoms](#). [[P8.4](#)]

See [metallic bond](#).

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method of least squares

is: a numerical method for determining the [gradient](#) and [intercept](#) of the [straight line](#) that best fits a given [set](#) of [data](#) points. [P1.3]

assumes: that the [errors](#) in the [independent variable](#) are negligible and that the [error](#) in each [measurement](#) is the same. [P1.3]

See statistics in the [Maths handbook](#) for further details.

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method of mixtures

is: a standard [calorimetry](#) procedure, in which [heat](#) from an object whose [heat capacity](#) is already known, is supplied to another object whose [thermal](#) properties are under investigation. Or vice versa. [[P7.4](#)]

method of undetermined coefficients

is: a method for finding a [particular solution](#) to some types of [linear inhomogeneous differential equations](#). [M6.3]

is based: on equating [coefficients](#) of like terms when a trial [solution](#) is substituted into the [equation](#). [M6.3]

Flexible Learning Approach to Physics - Glossary

metre, m

is: the [SI unit](#) of [length](#), one of the seven [base units](#). [[P1.1](#)]

is defined: as the [distance light](#) travels in a [vacuum](#) in $1/299\,792\,458$ [second](#). [[P1.1](#)]

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microscope

is: an instrument for viewing nearby objects with high [magnifying power](#).

[P6.4]

microscopic

describes: size scales below visibility by the human eye and sufficiently small that the behaviour of [molecules](#), or [atoms](#) may need to be considered. [[P7.2](#), [P7.5](#)]

Flexible Learning Approach to Physics - Glossary

microstructure

of: a material, especially a [solid](#),

is: the actual structure at the [atomic](#) level, which reflects the ideal [state](#) of the [atom](#) positions, modified by the presence of impurities and defects. [[P7.6](#)]

microwave radiation

is: a form of [electromagnetic radiation](#) characterized by [wavelengths](#) in the approximate range 1 mm to 0.03 m.

See [electromagnetic spectrum](#).

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millibar, mbar

is: a non-[SI unit](#) of [pressure](#).

is defined: as one thousandth of a [bar](#), where

$10^3 \text{ mbar} = 1 \text{ bar} = 10^5 \text{ N m}^{-2} = 10^5 \text{ Pa} (= 1.013 25 \text{ atm})$. [[P7.2](#)]

Flexible Learning Approach to Physics - Glossary

Millikan's oil drop experiments

are: a series of [experiments](#) first performed by Robert Millikan (1868-1953).
[P3.3]

used: balanced [gravitational](#) and [electrostatic forces](#) on [charged](#) oil drops, to make the first accurate determinations of the [charge](#) on the [electron](#), $-e$. [P3.3]

Flexible Learning Approach to Physics - Glossary

minimum deviation

of: a [light ray](#)

passing: through a [prism](#)

occurs: when the [ray](#) passes through the [prism](#) symmetrically. This is the arrangement which gives the maximum possible [dispersion](#). [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

minor arc

is: the smaller of the two [arcs of a circle](#) joining two [points](#) on the [circumference](#) that are not at opposite ends of a [diameter](#). [\[M2.1\]](#)

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minor axis

is: the shortest diameter of an [ellipse](#).

Flexible Learning Approach to Physics - Glossary

minor segment

is: the region bounded by the [minor arc](#) of a [circle](#) and the [chord](#) that joins its end [points](#). [[M2.1](#)]

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minute of arc, '

is: a [unit](#) of [angular measure](#). [M1.6]

is equal: to 1/60 of a [degree](#). [M1.6]

is abbreviated: arcmin. [M1.6]

is exemplified: by $20' = 20 \text{ arcmin} = 1^\circ/3$. [M1.6]

See also [second of arc](#). [M1.6]

Flexible Learning Approach to Physics - Glossary

mirage

is: an [optical](#) illusion arising from [continuous refraction](#). [[P6.2](#)]

Flexible Learning Approach to Physics - Glossary

mirror

is: a [surface](#) at which [reflection](#) can take place. Its quality is determined in part by its [reflectivity](#). [[P6.2](#)]

mirror transverse magnification

is: the [ratio](#) of [image](#) height to [object](#) height measured in the [direction perpendicular](#) to the [optical axis](#) of the [mirror](#). [P6.3]

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missing mass

See [mass defect](#).

Flexible Learning Approach to Physics - Glossary

mixed partial derivative

are: [partial derivatives](#) of second or higher [order](#) that involve (partial) [differentiation](#) with respect to two or more [independent variables](#). [M6.4]

Flexible Learning Approach to Physics - Glossary

mixed symmetry

of: a [function](#) $f(x)$

is found: when the [function](#) is neither an [even function](#) nor an [odd function](#). Such a [function](#) may be written as a [sum](#) of odd and even parts by writing it in the form

$$f(x) = \frac{1}{2}[f(x) + f(-x)] + \frac{1}{2}[f(x) - f(-x)] \quad [\text{M5.2}]$$

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mode

See [modes of vibration](#).

Flexible Learning Approach to Physics - Glossary

model

is: an artificial construction invented to represent or to simulate the properties, the behaviour, or the relationships among individual parts of the real entity being studied. [[P1.1](#)]

often is: a [mathematical model](#). [[P1.1](#)]

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moderator

in: a [nuclear fission reactor](#)

is: a material whose function is to slow down [fast neutrons](#) to produce [thermal neutrons](#) and hence to maintain the [nuclear chain reaction](#). [P9.3]

Flexible Learning Approach to Physics - Glossary

modes of vibration

of: a [body](#)

are: the different types of [vibration](#) ([linear](#), torsional, pendulum-like, etc.) that the [body](#) can exhibit simultaneously. [[P5.1](#)]

See [normal modes](#).

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modulus (of a complex number)

of: the [complex number](#) $z = x + iy$.

is denoted: by $|z|$. [[M3.1](#), [P5.5](#), [P10.3](#)]

is defined: by $|z| = (x^2 + y^2)^{1/2}$. [[M3.1](#), [P5.5](#), [P10.3](#)]

is always: positive. [[M3.1](#), [P5.5](#), [P10.3](#)]

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modulus (of a real number)

of: a [real number](#) x

is denoted: by $|x|$. [[M1.2](#), [P2.7](#)]

is defined: by $|x| = (x^2)^{1/2}$. [[M1.2](#), [P2.7](#)]

is always: positive. [[M1.2](#), [P2.7](#)]

is synonymous: with the absolute value or magnitude.

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modulus of elasticity

is: the [ratio](#) of [stress](#) to [strain](#) in an [elastic material](#), within the region of validity of [Hooke's law](#) where these are [linearly related](#). [P7.6]

is exemplified: by [bulk modulus](#), [shear modulus](#), and [Young's modulus](#). [P5.7]

Flexible Learning Approach to Physics - Glossary

molar gas constant

is: the [physical constant](#) R that appears in the [equation of state of an ideal gas](#); $PV = nRT$. [[P7.2](#), [P7.3](#), [P7.4](#), [P7.5](#)]

has: the value $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ (to four [significant figures](#)). [[P7.2](#), [P7.3](#), [P7.4](#), [P7.5](#)]

is related: to [Boltzmann's constant](#) k and [Avogadro's constant](#) N_A by $R = N_A k$.

is synonymous: with [universal gas constant](#).

See also [mole](#).

Flexible Learning Approach to Physics - Glossary

molar heat capacity

See [molar specific heat](#).

molar latent heat

is: the amount of [heat](#) absorbed or emitted per [mole](#) of a substance during an [isothermal phase transition](#). [P7.4]

has as its SI unit: J mol^{-1} . [P7.4]

See also [latent heat](#), [specific latent heat](#).

Flexible Learning Approach to Physics - Glossary

molar mass

is: the [mass](#) per [mole](#) of a substance. [[P7.2](#)]

has as its SI unit: kg mol^{-1} . [[P7.2](#)]

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molar specific heat

is simply: the [heat capacity](#) per [mole](#) of a substance. [P7.4, P7.5]

should not be confused: with [specific heat](#), which is [heat capacity](#) per [kilogram](#) of a substance. [P7.4, P7.5]

is quantified: as $C = \Delta Q/n\Delta T$ where n is the number of moles of the substance in the sample. (Strictly speaking the molar heat capacity should be defined as the limit of this [ratio](#) as ΔT becomes vanishingly small, since the [heat capacity](#) depends on the [state](#) of the sample.) [P7.4]

depends: on the constraints applied during [heating](#): may be the molar specific heat C_V at [constant volume](#), or may be the molar specific heat C_P at [constant pressure](#). [P7.4]

has as its SI unit: $\text{J mol}^{-1}\text{K}^{-1}$. [P7.4]

sometimes is referred to: as molar specific heat capacity. [P7.4, P7.5]

Compare with [specific heat](#), [principal specific heats](#).

Flexible Learning Approach to Physics - Glossary

mole, mol

is: the [SI unit](#) of [amount of substance](#), one of the seven [base units](#). [[P7.1](#), [P7.2](#)]

is defined: as the amount of a substance that contains the same number of elementary entities as the number of [atoms](#) in 12 g of the ^{12}C [isotope](#) of carbon. (Measurements show that 12 g of the ^{12}C contain (to four [significant figures](#)) 6.022×10^{23} [atoms](#) of ^{12}C) The elementary entities may be [atoms](#) or [molecules](#). For example, one mole of MgF_2 contains 6.022×10^{23} magnesium [atoms](#) and 12.044×10^{23} fluorine [atoms](#). [[P7.1](#), [P7.2](#)]

facilitates: the evaluation of the [molar mass](#) of a substance, the numerical value of the [molar mass](#) in [grams](#) per mole being obtained by adding together the [relative atomic masses](#) of the [atoms](#) in the [molecule](#). The [relative atomic mass](#) of magnesium is 24.3, and of fluorine is 19.0. Thus, one mole of MgF_2 has a [mass](#) of $[24.3 + (2 \times 19.0)]$ g, or approximately 62.3 g. [[P7.1](#), [P7.2](#)]

See [Avogadro's constant](#) and [Avogadro's number](#).

Flexible Learning Approach to Physics - Glossary

molecular beam

is: a stream of directed [molecules](#)

is created: by allowing the [molecules](#) to escape from a container through a fine slit by [molecular](#) impacts on the slit space into a region beyond, where the [pressure](#) is lower. The [pressure](#) must be sufficiently low to avoid intermolecular [collisions](#) within the slit. Usually, the directionality of the [beam](#) is improved using a second slit placed behind the first. [P7.5]

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molecule

is: the smallest freely existing part of a [chemical element](#) or [chemical compound](#) that retains the chemical identity of that [chemical element](#) or [chemical compound](#). [P7.1, P8.1]

therefore is usually: a group of [atoms](#) bound together. For [compounds](#) composed of identical molecules, the type and relative number of each sort of [atom](#) present in each molecule is indicated by the [chemical formula](#) of that substance. For example, a molecule of water contains one [atom](#) of oxygen and two [atoms](#) of hydrogen, and is represented by H₂O. [P7.1, P8.1]

exceptionally: some molecules consist of single [atoms](#) (e.g. [noble gases](#)).

Flexible Learning Approach to Physics - Glossary

moment

of: a [vector](#) \boldsymbol{v} about a [point](#) P

is: the [vector product](#) $\boldsymbol{s} \times \boldsymbol{v}$ of the [vector](#) \boldsymbol{v} with a [displacement vector](#) \boldsymbol{s} from the point P to any [point](#) on the [line of action](#) of the [vector](#). [M2.7]

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moment of a force

for: a [force](#) \mathbf{F} causing, or tending to cause, [rotation](#) about a point P

is: a [measure](#) of the turning effect of the [force](#). [[P2.7](#), [P4.3](#)]

is given: by $\mathbf{r} \times \mathbf{F}$ where \mathbf{r} is a [displacement vector](#) from P to any point on the [line of action](#) of \mathbf{F} . [[M2.7](#), [P2.7](#)]

is therefore: identical to the [torque](#) of \mathbf{F} about P. [[P2.7](#)]

is mainly used: when dealing with [coplanar forces](#), in which case the [resultant](#) moment of the forces about P may be obtained by adding the [magnitudes](#) of the individual moments (found by multiplying the [magnitude](#) of the [force](#) by the [perpendicular](#) distance between P and the [line of action](#) of the [force](#)) subject to the sign convention that those forces that promote anticlockwise [rotation](#) have positive moments while those that promote clockwise [rotation](#) have negative moments. [[P2.7](#), [P4.3](#)]

Flexible Learning Approach to Physics - Glossary

moment of inertia

of: a [body](#)

is: a [measure](#) of its reluctance to be [rotationally accelerated](#). [[P2.7](#), [P2.8](#)]

is calculated: from the distribution of [mass](#) in the [body](#) about the [axis of rotation](#). [[P2.7](#), [P2.8](#)]

may be defined: in terms of [mass elements](#) Δm_i located at [perpendicular distances](#) r_i from the [axis of rotation](#) by

$$I = \sum_i r_i^2 \Delta m_i \quad [\text{P2.7}, \text{P2.8}]$$

may be defined: in terms of [infinitesimal elements](#) by

$$I = \int r^2 dm$$

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moment of momentum

is: a synonym for [angular momentum](#).

momentum

See [linear momentum](#) and [angular momentum](#)

Flexible Learning Approach to Physics - Glossary

monatomic ideal gas

is: an [ideal gas](#) (and therefore obeying $PV = nRT$) in which the [internal energy](#) at any [temperature](#) T is given by $U = 3NkT/2$. [[P7.4](#)]

can be used: to [model](#) the behaviour of a [real gas](#) of single [atoms](#) (that have no effective [rotational](#) or [vibrational degrees of freedom](#)) at low [density](#). [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

monochromatic

describes: [light](#) which may be modelled by [electromagnetic waves](#) of a single [wavelength](#) (or [frequency](#)) or by [photons](#) of a single [energy](#). [[P6.1](#), [P6.3](#)]

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monolayer

is: a very thin layer of [molecules](#), just one [molecule](#) thick. [[P8.1](#)]

Flexible Learning Approach to Physics - Glossary

most probable speed

of: [gas molecules](#)

corresponds: to the peak in the [speed distribution function](#). [P7.5]

See [Maxwell-Boltzmann speed distribution](#).

Flexible Learning Approach to Physics - Glossary

motion

is: continuous change of [position](#).

motional induction

is: [electromagnetic induction](#) arising from the [motion](#) of an [electrical conductor](#) within (and relative to) a [magnetic field](#). [[P4.4](#)]

moving-coil galvanometer

is: a generic term for [ammeters](#) and [voltmeters](#) that use the [equilibrium](#) orientation of a pivoted [current](#) carrying [coil](#) in a [magnetic field](#) (subject to some suitable restoring [force](#) or [torque](#)) to make [electrical measurements](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

multi-electron atom

is: an [atom](#) containing more than one [orbital electron](#). [[P8.3](#)]

multi-valued function

is: an improper use of [function](#), describing situations in which two or more values are associated with a single value of the [argument](#). [M1.3]

is exemplified: by $f(x) = \sqrt{x}$, which can take on two values of opposite signs unless (as is usual) the convention is adopted that \sqrt{x} only represents the positive [square root](#) of x . [M1.3]

Flexible Learning Approach to Physics - Glossary

multimeter

is: an instrument for measuring [resistance](#), and [voltages](#) or [currents](#) (either [d.c.](#) or [a.c.](#)). [[P4.1](#)]

multiple roots

are: [roots](#) having the same value, but which must be counted separately for the purposes of the [fundamental theorem of algebra](#). [M4.4]

are exemplified: by the two [roots](#) of $x^2 - 2x + 1 = 0$, both of which are equal to 1. [M4.4]

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multiplicity

of: a [root](#) α of a [polynomial equation](#) $p(x) = 0$

is: the number of times the [factor](#) $(x - \alpha)$ occurs in the [factorized form](#) of $p(x)$. [[M3.1](#)]

Flexible Learning Approach to Physics - Glossary

mutual inductance

See [coefficient of mutual inductance](#).

Flexible Learning Approach to Physics - Glossary

mutual induction

is: the production of an [induced voltage](#) in one [coil](#) or [circuit](#) due to the changing [current](#) in another [coil](#) or [circuit](#). [[P4.4](#)]

See [coefficient of mutual inductance](#).

Flexible Learning Approach to Physics - Glossary

myopia (short sight)

is: the condition in which eyes are unable to focus on objects as far away as the standard [far point](#) (taken to be at [infinity](#)). [P6.4]

occurs when: the [lens](#) of the eye has too short a [focal length](#), even when [unaccommodated](#). [P6.4]

usually is corrected: by an auxiliary [diverging lens](#). [P6.4]

n-type semiconductor

is: a [semiconductor](#) in which the majority of mobile [charge carriers](#) are negatively [charged](#) (usually [electrons](#)). [[P11.4](#)]

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***n*-dimensional**

describes: an object or situation which requires the use of a [coordinate system](#) with n independent [axes](#) for its adequate description. [[P2.1](#), [P2.2](#)]

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natural angular frequency

is: the [angular frequency](#) that a [harmonic oscillator](#) would have if it were neither [damped](#) nor [driven](#). [P5.4]

is exemplified: by a pure [LC circuit](#), in which the [charge](#) (and the [current](#)) have a natural angular frequency $\omega_0 = \sqrt{\frac{1}{LC}}$. [P5.4]

natural exponential function

is: the [function](#), e^x . [M1.5]

is so called: to distinguish it from the [function](#), a^x .

See [exponential function](#). [M1.5]

Flexible Learning Approach to Physics - Glossary

natural frequency

is: the [frequency](#) that a [simple harmonic oscillator](#) has if it is neither [damped](#) nor [driven](#). [[P5.2](#), [P5.3](#), [P5.4](#)]

is exemplified: by an [electrical oscillator](#), in which the [charge](#) (and the [current](#)) have a natural frequency $f_0 = \frac{1}{2\pi} \sqrt{\frac{1}{LC}}$. [[P5.4](#)]

is exemplified: by a [mechanical oscillator](#), in which the oscillating [mass](#) m has a natural frequency $f_0 = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$, where k is the [spring constant](#). [[P5.2](#)]

natural logarithm

See [logarithm to base e](#).

Flexible Learning Approach to Physics - Glossary

natural number

is: a positive whole number, an [element](#) of the [set](#) {1, 2, 3, ...}. [[M1.2](#), [M3.1](#)]

Flexible Learning Approach to Physics - Glossary

natural radioactive series

is: any of the four [nuclear decay chains](#) arising from naturally occurring (very long-lived) [unstable nuclei](#). [[P9.2](#)]

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natural unit

is: a [unit](#) that is defined in terms of a natural, reproducible quantity. [P1.1]

is exemplified: by the [second](#), which is defined in terms of periods of the radiation from a specified source (but not by the kilogram).

also describes: any [unit](#) in a (non-SI) system in which specified [fundamental constants](#) (usually the [speed of light in a vacuum](#) and [Planck's constant](#), and sometimes [Newton's universal gravitational constant](#)) are each set equal to 1.

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near point

is: the nearest [point](#) from which [light](#) entering the eye may be [imaged](#) on the [retina](#). [[P6.4](#)]

is generally taken to be: 25 cm for a normal eye. [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

negative lens

is: a [lens](#) having a negative [optical power](#). [P6.3]

See also [concave lens](#) or [diverging lens](#).

Flexible Learning Approach to Physics - Glossary

nested (brackets)

describes: [brackets](#) that enclose an [expression](#) that itself includes [brackets](#). In a [calculation](#), the contents of the innermost [brackets](#) must be evaluated first.

[M1.1]

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net force

See [resultant force](#).

neutral equilibrium

of: a [system](#)

describes: a [state](#) of [equilibrium](#) in which a small disturbance of the [system](#) does not result in any tendency for the [system](#) to return to its [initial equilibrium state](#), nor for it to depart further from its [initial equilibrium state](#). [P5.1]

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neutral point

is: a [point](#) in [space](#) where two or more [vector fields](#) combine to give a [resultant](#) of zero. [[P3.1](#)]

Flexible Learning Approach to Physics - Glossary

neutrino

is: a fundamental [subatomic particle](#) that has zero charge and such a small [mass](#) (if any) that it is currently indistinguishable from zero. [[P9.2](#)]

is classified: in six kinds: the [electron neutrino](#) and [antineutrino](#), the muon neutrino and [antineutrino](#), and the tauon neutrino and [antineutrino](#). [[P9.2](#)]

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neutron

is: an [uncharged elementary particle](#) found in the [nucleus](#) of every [atom](#), except for the lightest form of hydrogen (whose [nucleus](#) is a single [proton](#)). [[P3.3](#), [P8.1](#), [P9.1](#)]

has mass: 1.675×10^{-27} kg, i.e. a [relative atomic mass](#) of 1.009 slightly greater than that of the [proton](#): $m_n/m_p \approx 1.001$. [[P3.3](#), [P8.1](#)]

is of size: 10^{-15} m, similar to that of the [proton](#). (The 'size' of an [elementary particle](#) needs careful definition, so this statement should be treated with caution.) [[P3.3](#)]

is thought to contain: [charged](#) constituents called [quarks](#). [[P8.1](#), [P9.1](#)]

can be counted: in any particular [nucleus](#) by subtracting the relevant [atomic number](#) Z from the [mass number](#) A . [[P8.1](#)]

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neutron diffraction

is: the [diffraction](#) of [neutrons](#) by a regular array of [atoms](#) (as in a [crystal](#)).
[P7.1]

is a consequence: of the [wave](#)-like behaviour of [neutrons](#), as described by [quantum physics](#). [P7.1]

results in: a [diffraction pattern](#) with sharp [local maxima](#) of [intensity](#) in directions determined (in sufficiently simple cases) by [Bragg's law](#). [P7.1]

See [de Broglie wave](#).

Flexible Learning Approach to Physics - Glossary

newton, N

is: the [SI unit](#) of [force](#). [P2.3]

is defined: by $1 \text{ N} = 1 \text{ kg m s}^{-2}$, so a constant force of 1 N will cause a mass of 1 [kilogram](#) to [accelerate](#) at a rate of 1 [metre](#) per [second squared](#) in the direction of the force. [P2.3]

is roughly: the [weight](#) of an apple!

Flexible Learning Approach to Physics - Glossary

Newton's law of cooling

for: the rate of heat transfer by a combination of [conduction](#), [convection](#), and [radiation](#) in everyday situations

is: a 'rule of thumb' which is actually very reliable so long as [temperature](#) differences are not large. [[P7.3](#)]

states: that $\frac{dQ}{dT} = hA \Delta T$ where h is used here, as in [convection](#), as a general purpose [empirical heat loss coefficient](#) whose value has to be measured, guessed, or looked up, A is the effective area of the [surface](#) from which the [heat](#) is being transferred, and ΔT is the [temperature](#) difference between that [surface](#) and the surroundings. [[P7.3](#)]

Newton's law of gravitation

is: the [law](#), first formulated by Isaac Newton (1642-1727), which describes the [gravitational force](#) between [masses](#). [[P3.1](#)]

states: that for two [particles](#) of [masses](#) m_1 and m_2 separated by a [distance](#) r , the force \mathbf{F}_{21} on mass m_2 due to mass m_1 is,

$$\mathbf{F}_{\text{grav}} = \mathbf{F}_{21} = \frac{-Gm_1m_2}{r^2} \hat{\mathbf{r}}$$

where $G = 6.673 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ is [Newton's universal gravitational constant](#), and $\hat{\mathbf{r}}$ is a [unit vector](#) pointing from m_1 to m_2 . The [force](#) is therefore an attractive one, directed along the [line](#) joining the [masses](#). [[P2.3](#), [P3.3](#)]

Newton's law of viscosity

is: an [empirical law](#) that describes the behaviour of some [fluids](#) under a limited range of conditions. (Such fluids are called [Newtonian fluids](#).) [P7.6]

states: that when a [shear stress](#) is applied to a [fluid](#), the [velocity gradient](#) that it produces in the direction [perpendicular](#) to the [stress](#) is [proportional](#) to the applied [shear stress](#), and the resulting [velocity](#) decreases with [distance](#) from the [plane](#) over which the [shear stress](#) is applied, so

$$\sigma_x = -\eta \frac{dv_x}{dy}$$

where η is a constant, known as the [coefficient of viscosity](#), that is characteristic of the ([state](#) of the) [fluid](#). [P7.6]

Flexible Learning Approach to Physics - Glossary

Newton's laws of motion

is: a collective phrase for [Newton's first law](#), [Newton's second law](#) and [Newton's third law](#). [[P2.3](#)]

Newton's first law of motion

for: the [motion](#) of a [particle](#)

states: that every [particle](#) continues in a state of [motion](#) with constant [velocity](#) unless acted on by unbalanced [forces](#). (If the [particle](#) is initially at rest, this [velocity](#) is zero.) [P2.3]

implies: that if no unbalanced force acts on a [particle](#) that starts from the [origin](#) at [time](#) $t = 0$ with [initial velocity](#) u_x and moves along the [x-axis](#), then the subsequent motion of that [particle](#) is described by the [uniform motion equations](#): $s_x = u_x t$, $v_x = u_x$ and $a_x = 0$. [P2.3]

can be regarded: as defining a class of [frames of reference](#); the [inertial frames of reference](#).

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Newton's second law of motion

for: the [motion](#) of a [particle](#)

states: that the [total force](#) acting on the [particle](#) is equal to the product of the [particle's mass](#) and its [acceleration](#). [[M5.1](#), [P2.3](#)]

is expressed: if the [particle](#) moves along the [x-axis](#), by the [scalar equation](#)
 $F_x = ma_x$. [[M5.1](#)]

is expressed: in three [dimensions](#), by the [vector equation](#) $\mathbf{F} = m\mathbf{a}$. [[P2.3](#)]

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Newton's third law of motion

for: the [motion](#) of a [body](#)

states: that when two [bodies](#) interact, the [force](#) exerted by the first on the second is equal in [magnitude](#) and opposite in [direction](#) to the [force](#) exerted by the second on the first. [P2.3]

is equivalent to: the principle of [conservation of momentum](#). [P2.5]

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Newton's theorem

states: that the [gravitational](#) effects outside any [spherically symmetric body](#) of [mass](#) M are the same as those of a [point mass](#) M located at the object's geometric centre. [[P3.2](#)]

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Newton's universal gravitational constant

is: the [fundamental constant](#) G that appears in [Newton's universal law of gravitation](#). [P2.6]

has: the value $G = 6.673 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ (to four [significant figures](#)). [P2.6]

is synonymous: with [universal gravitational constant](#) and gravitational constant.

Newton-Raphson formula

is: an [iteration formula](#) used to find approximate [solutions](#) to [equations](#) of the form $f(x) = 0$. [[M4.5](#)]

has the form: $x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$ (provided $f'(x_n) \neq 0$)

where x_n is the n^{th} approximation to the [solution](#), and x_{n+1} is the $(n + 1)^{\text{th}}$ approximation. [[M4.5](#)]

Newton-Raphson method

See [Newton-Raphson formula](#).

Newtonian fluid

is: a [fluid](#) in which there is a [linear relationship](#) between the [velocity gradient](#) and the [viscous force](#) or the [viscous shear stress](#). ([Newton's law of viscosity](#).
[P7.6])

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Newtonian mechanics

is: a branch of [physics](#) which attempts to explain the [motion](#) (including the lack of [motion](#)) of objects in terms of the [forces](#) acting on them. [[P2.3](#)]

is based: on [Newton's laws of motion](#). [[P2.3](#)]

incorporates: other important principles such as the [conservation of energy](#), [conservation of momentum](#), and [conservation of angular momentum](#). [[P2.3](#), [P2.5](#), [P2.7](#), [P2.8](#)]

also known as: classical mechanics.

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noble gases

are: the [gaseous chemical elements](#) helium, neon, argon, krypton, xenon and radon, whose [molecules](#) consist of single [atoms](#). [P8.4]

are placed: in a [group](#) of the [periodic table](#). [P8.4]

are so-named: because of their marked reluctance to 'lower' themselves by combining with other [chemical elements](#) to form [compounds](#). [P8.4]

are also called: inert gases.

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node (in a standing wave)

is: a [position](#) at which the disturbance caused by the [standing wave](#) remains zero. [[P5.6](#), [P10.3](#)]

always can be found: at a fixed boundary of a [standing wave](#), as a result of the [destructive superposition](#) of an incoming [wave](#) and a [wave in anti-phase](#) that is [reflected](#) from the boundary. [[P11.2](#)]

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node (in a spatial wavefunction)

in: a [spatial wavefunction](#) $\psi(x)$ (i.e. an [eigenfunction](#) of [energy](#))

is: any point (specified by a value of x) at which $\psi(x) = 0$, so that the corresponding [wavefunction](#) $\psi(x, t)$ is also zero at that point for all values of t .
[P11.2]

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node (in a circuit)

is: a junction between two or more connections to [electrical components](#) in the [circuit](#). [P4.1]

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non-conservative force

is: a [force](#) which is not a [conservative force](#), so that there is no unique [potential energy](#) at each [point](#) and the [work](#) that it does between two [points](#) is dependent on the path chosen. [P2.4]

is exemplified: by [frictional forces](#) and muscular [forces](#). [P2.4]

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non-inertial frame of reference

is: a [frame of reference](#) in which [Newton's first law](#) does not hold. [P2.3]

therefore is: one which is itself [accelerating](#) and in which objects may [accelerate](#) without any [resultant force](#) acting. [P2.3]

Flexible Learning Approach to Physics - Glossary

non-linear differential equation

is: any [differential equation](#) which is not a [linear differential equation](#). [M6.1]

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non-linear systems

are: [equilibrium systems](#) in which the [restoring force](#), or the response of the [system](#), is not [linearly](#) dependent on the [displacement](#) from [equilibrium](#). [P5.1]

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non-negative integer

is: any of the [natural numbers](#) or the number 0. [M3.1]

therefore is: any [element](#) of the [set](#) $\{0, 1, 2, 3, \dots\}$. [M3.1]

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normal

to: a chosen [line](#) or [surface](#) or [interface](#)

is: a [line](#) drawn at [right angles](#) to the chosen [line](#) or [surface](#) or [interface](#), and meeting it at a [point](#) of interest such as the [point of incidence](#) of a [light ray](#).
[[M1.6](#), [M2.3](#), [P5.7](#), [P6.1](#), [P6.2](#)]

normal distribution

See [Gaussian distribution](#).

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normal incidence

is: the condition in which one entity (e.g. a [light ray](#)) approaches another (e.g. the [surface](#) of a [plane mirror](#)) at [right angles](#).

Flexible Learning Approach to Physics - Glossary

normal modes

of: two or more [coupled oscillators](#)

are: independent [steady state oscillations](#) of the [coupled oscillators](#). If the [system](#) is set [oscillating](#) in a single normal mode then the [system](#) continues to [oscillate](#) in this mode. [P5.3]

permit the description: of any [coupled oscillation](#), as a [superposition](#) of normal modes. Usually the [frequencies](#) of these normal modes differ and so any [superposition](#) of them produces [beating](#). [P5.3]

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normalization

of: a given [wavefunction](#) $\Phi(x, t)$, (or, where appropriate, its spatial part $\phi(x)$)

is: the process of determining a ([complex](#)) [constant](#) c such that $\Psi(x, t) = c\Phi(x, t)$ is a [normalized wavefunction](#) that satisfies the condition

$$\int_{-\infty}^{\infty} |\Psi(x, t)|^2 dx = 1. \quad [\text{P10.4, P11.2}]$$

ensures: that the probability of finding the [particle](#) described by $\Psi(x, t)$ somewhere is 1.

also ensures: that the [squared modulus](#) of the [wavefunction](#) at any [point](#) gives the [probability density](#) of finding the [particle](#) at that [point](#). [P10.3]

more generally is: the process of multiplying a [function](#) or quantity by an appropriately selected [factor](#) in order that the resulting [product](#) should satisfy a specified 'normalization condition.'

normalized wavefunction

is: a [wavefunction](#) which has been subjected to [normalization](#) and therefore satisfies the condition:

$$\int_{-\infty}^{\infty} |\Psi(x,t)|^2 dx = 1. \quad [\text{P10.3}, \text{P10.4}, \text{P11.2}]$$

normally distributed

See [Gaussian distribution](#).

Flexible Learning Approach to Physics - Glossary

north magnetic pole

is: the pole of a compass needle which, when allowed to move freely under the influence of the Earth's [magnetic field](#), points in a northerly direction. (This means that the Earth's north geographic pole is close to a [south magnetic pole](#)!)
[P4.2]

is: the [magnetic pole](#) from which [magnetic field lines](#) emerge and diverge.
[P4.2]

sometimes is called: the north-seeking pole. [P4.2]

See [magnetic pole](#).

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n^{th} root of unity

is: a [complex number](#), z such that $z^n = 1$ for some [integer](#), n . Any given [complex number](#) has n distinct n^{th} roots. [[M3.3](#)]

Flexible Learning Approach to Physics - Glossary

nuclear binding energy graph

is: a [graph](#) showing the [binding energy](#) per [nucleon](#) in [nuclei](#) plotted against [mass number](#). [[P9.1](#)]

shows that: the [binding energy](#) per [nucleon](#) is highest for [nuclei](#) with [mass numbers](#) close to that of iron.

Flexible Learning Approach to Physics - Glossary

nuclear chain reaction

is: a sequence of [nuclear fission reactions](#) in which [neutrons](#) released in the [fission](#) of one [nucleus](#) produce [induced fission](#) in further [nuclei](#). [[P9.3](#)]

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nuclear decay chain

is: a sequence of [radioactive decays](#) of [nuclei](#) in which the [daughter nucleus](#) from one [decay](#) becomes the [parent nucleus](#) for the next. [P9.2]

stops: when a [stable daughter nucleus](#) is produced. [P9.2]

nuclear decay channel

is: one of the ways in which a [nucleus](#) can undergo [radioactive decay](#). Some [nuclei](#) have more than one possible decay channel, e.g. the ${}^{214}_{83}\text{Bi}$ [nucleus](#) can undergo either β^- -[decay](#) ${}^{214}_{83}\text{Bi} \rightarrow {}^{214}_{84}\text{Po} + e^- + \bar{\nu}_e$, or α -[decay](#) ${}^{214}_{83}\text{Bi} \rightarrow {}^{210}_{81}\text{Po} + {}^4_2\text{He}$. [[P9.2](#)]

nuclear fission

is: the splitting of an [atomic nucleus](#). The [nucleus](#) that splits generally has a large [mass number](#) and usually splits into two smaller [nuclei](#) and a number of [neutrons](#), with a net conversion of [mass energy](#) into [kinetic energy](#). [P9.3]

nuclear fusion

is: the combining of two [atomic nuclei](#) into one [nucleus](#) (and possibly other [particles](#)). If the initial [nuclei](#) have very low [mass numbers](#), there is generally a net conversion of [mass energy](#) into [kinetic energy](#). [[P9.3](#)]

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nuclear model (of the atom)

provides: a description of the internal structure of the [atom](#) in which it is presumed that a positively [charged](#) centrally located [nucleus](#), accounting for the major part of the [atom's mass](#), is surrounded by negatively [charged electrons](#) which account for its chemical properties. [[P8.1](#)]

nuclear fission reactor

is: a [reactor](#) in which [energy](#) is derived from the process of [nuclear fission](#). (All currently operating commercial nuclear reactors are fission reactors.)

nuclear fusion reactor

is: a [reactor](#) in which [energy](#) is derived from the process of [nuclear fusion](#).
(Such reactors are still under development and are not yet commercially viable.)

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nucleon

is: basic building block of all [nuclei](#). [P9.1]

is classified: in two kinds: [neutrons](#) and [protons](#). [P9.1]

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nucleus

is: the tiny, positively [charged](#) core of an [atom](#), which accounts for nearly all of the [mass](#) of the [atom](#). [[P8.1](#)]

consists: of [protons](#) and [neutrons](#). [[P8.1](#)]

has diameter: typically 10^{-14} m. [[P8.1](#)]

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nuclide

is: that [atom](#) of an [element](#) which is distinguished by a particular number of [neutrons](#) in its [nucleus](#) and their [internal energy state](#). [[P9.1](#), [P9.2](#)]

therefore is: an [isotope](#) of the [element](#), but may be further distinguished by its [internal energy state](#). [[P9.1](#), [P9.2](#)]

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number density

is: the number of [molecules](#) (or any other specified entities) per [unit volume](#).
[P7.5]

can be calculated: as $n_{\rho} = \rho/m$, given the [mass density](#) ρ and the [molecular mass](#) m . [P7.5]

has as its SI unit: m^{-3} .

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number line

is: the representation of the [set](#) of all [real numbers](#) as a [straight line](#) with each [point](#) on the line corresponding to a unique number and with all [points](#) to the left of any given point representing lesser numbers than that represented by the given point, and all [points](#) to the right representing greater numbers. [[M1.1](#)]

Flexible Learning Approach to Physics - Glossary

numerator

is: the top of a [fraction](#). [M1.1]

numerical integration

is: a procedure whereby a [definite integral](#) may be (approximately) evaluated by using an appropriate finite [sum](#) to provide an estimate of the [limit](#) of a [sum](#) that defines the [integral](#). [M5.1]

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numerical procedures

are: methods of finding a numerical [approximation](#) to a quantity of interest (usually to the [root](#) of an [equation](#)) by manipulating numbers, rather than by dealing with abstract [algebraic](#) quantities. [[M1.4](#)]

Flexible Learning Approach to Physics - Glossary

object

in: [optics](#)

is: a source of [light rays](#), either as a [point object](#) or as an [extended object](#).
[\[P6.3\]](#)

Flexible Learning Approach to Physics - Glossary

object distance

is: the distance u measured along the [optical axis](#), between an [object](#) and a [lens](#) or [mirror](#). [P6.3]

might be more appropriately termed: the object [position](#), since, within the [Cartesian sign convention](#), it may be a positive or negative quantity, depending on which side of the [origin](#) it lies. [P6.3]

See also [thin lens equation](#) and [spherical mirror equation](#).

Flexible Learning Approach to Physics - Glossary

object focus

See [first focal point](#).

Flexible Learning Approach to Physics - Glossary

objective (lens)

is: the [lens](#) or combination of [lenses](#) in an [optical](#) instrument, which is positioned nearest to the [object](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

observable

in: [quantum mechanics](#), but also in general,

is: a [measurable](#) physical quantity for a [system](#), such as [position](#), [momentum](#) or [energy](#). [[P10.4](#)]

Flexible Learning Approach to Physics - Glossary

observation

is: the act of an [observer](#) that results in a [measurement](#).

results: in [quantum mechanics](#), in an unavoidable and to some extent unpredictable disturbance of the [system](#) being [measured](#).

Flexible Learning Approach to Physics - Glossary

observer

in: [physics](#)

is: one who [observes](#), [measures](#) and records [data](#).

is not necessarily: one who directly sees what he or she [observes](#) and [measures](#) using an observation system. (This distinction is especially important in [Einstein's special theory of relativity](#).)

Flexible Learning Approach to Physics - Glossary

obtuse angle

is: an [angle](#) between 90° and 180° . [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

odd (function)

is: a [function](#) $f(x)$ such that $f(-x) = -f(x)$. [[M1.6](#), [M4.4](#), [M5.2](#), [P11.2](#)]

is also known as: antisymmetric.

Flexible Learning Approach to Physics - Glossary

ohm, Ω

is: the [SI unit](#) of [resistance](#).

is defined: by $1 \Omega = 1 \text{ V A}^{-1}$ (i.e. 1 [volt](#) per [ampere](#)). [[P4.1](#)]

Ohm's law

is: an [empirical](#) relation between [current](#) I and [voltage](#) V of the form $V = IR$, where R (the [resistance](#)) has a [constant](#) value for a wide range of V and I .
[[P4.1](#), [P5.5](#)]

describes: the behaviour of certain [metals](#), provided the [temperature](#) is maintained at a [constant](#) value, and characterizes the behaviour of various [circuit components](#), particularly [resistors](#). [[P4.1](#)]

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ohmic resistor

is: an [electrical circuit component](#) in which [Ohm's law](#) is satisfied. [[P4.1](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

one-dimensional

describes: an object or situation which requires the use of a [coordinate system](#) with only *one* independent [axis](#) for its adequate description. [[P2.1](#), [P2.2](#)]

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one-dimensional box

in: [quantum physics](#)

is: an idealized confinement in which a [particle](#) is able to move freely in two [dimensions](#) but with its [motion](#) restricted or confined in one [dimension](#). The [Heisenberg uncertainty principle](#) then allows us to set two of the [momentum components](#) to be zero, hence [one-dimensional motion](#). [[P10.3](#), [P10.4](#)]

can be visualized: as the space between two parallel infinite [planes](#) separated by a [distance](#) D measured along the one [dimension](#). The [particle's potential energy](#) is usually taken to be zero from $x = 0$ to $x = D$ and to be infinite outside this region. [[P10.3](#), [P10.4](#)]

Flexible Learning Approach to Physics - Glossary

one-dimensional SHM

is: [simple harmonic motion](#) in one spatial [dimension](#), or [simple harmonic motion](#) describable in terms of [displacements](#) from [equilibrium](#) in one [coordinate](#) only.
[P5.1]

one-dimensional wave

is: a [wave](#) whose mathematical description involves only a single [independent variable](#) (e.g. x) in addition to the [time](#) t . [[M6.4](#)]

Flexible Learning Approach to Physics - Glossary

open circuit

is: a path of very high (effectively infinite) [resistance](#). [P4.1]

generally is used: in the context of a [voltage generator](#) supplying zero [current](#). [P4.1]

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open circuit voltage

is: the [terminal potential difference](#) of a [voltage generator](#) when no [current](#) is being supplied by the generator. [[P4.1](#), [P4.5](#)]

is also called: the [electromotive force \(e.m.f.\)](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

operation (mathematical)

is: the process of applying an [operator](#) to a [function](#). [M1.1]

Flexible Learning Approach to Physics - Glossary

operations (of arithmetic)

are: addition, subtraction, multiplication and division. Addition results in a sum, subtraction results in a difference, multiplication results in a product, and division (by a divisor) results in a quotient (often known as a [ratio](#)). [M1.1]

Flexible Learning Approach to Physics - Glossary

operator

is: a symbolic instruction to carry out some ([mathematical](#)) action on a [function](#). [[P10.4](#), [P11.3](#)]

can range: from simple multiplication by a number, to quite complicated acts such as taking repeated [derivatives](#) with respect to a given [variable](#). [[P10.4](#), [P11.3](#)]

may correspond: in [quantum mechanics](#), to an [observable](#) such as [momentum](#) or [kinetic energy](#), (in which particular cases the operator is a [differential operator](#)). [[P10.4](#), [P11.3](#)]

Flexible Learning Approach to Physics - Glossary

opposite side

in: a [right-angled triangle](#)

is: the side, other than the [hypotenuse](#), that is opposite to a specified [angle](#).
[\[M1.6\]](#)

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optic nerve

is: the bundle of nerve fibres which carry [electrical](#) impulses from the receptor cells of the [retina](#) to the brain. [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

optical

means: pertaining to optics, the study of [light](#) and its [propagation](#).

Flexible Learning Approach to Physics - Glossary

optical axis

is: a [line](#) drawn through the [axis](#) of [symmetry](#) of a [set](#) of [lenses](#) or [mirrors](#). The components are arranged with their [surfaces normal](#) to the [axis](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

optical density

is: a property which ranks [transparent optical media](#) in terms of [refractive index](#). Higher [refractive index](#) corresponds to higher optical density. [[P6.2](#)]

Flexible Learning Approach to Physics - Glossary

optical element

is: a part of an [optical system](#) that [transmits](#) or [reflects light](#): typically a [lens](#) or a [mirror](#).

Flexible Learning Approach to Physics - Glossary

optical fibre

is: a very thin strand of glass (usually of the order of 0.2 mm or less in [diameter](#)). [P6.2]

is used: to confine [light rays](#) at a sufficiently small [angle](#) to the [axis](#) of the fibre, by [total internal reflections](#) and thereby to convey these [rays](#) up to many [kilometres](#) with little [power](#) loss. Usually many individual fibres are bundled together to form a cable. [P6.2]

optical medium

See [medium \(for light\)](#).

optical path length

is: the [product](#) of the actual (geometrical) [length](#) of a [light](#) path in a [transparent](#) material and the [refractive index](#) of that material. [[P6.1](#)]

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optical power (of a lens)

is: the [reciprocal](#) of the [focal length](#) of a lens, expressed in m^{-1} or [dioptries](#).
[P6.3]

measures: the ability of the [lens](#) to converge ([positive lens](#)) or diverge ([negative lens](#)) incident [light](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

orbit

is: the path followed by an object moving in a [field](#) of [force](#). [[P3.2](#)]

Flexible Learning Approach to Physics - Glossary

orbital (in classical physics)

means: pertaining to an [orbit](#).

Flexible Learning Approach to Physics - Glossary

orbital (in quantum physics)

is: an alternative term for the [wavefunction](#) that provides a [mathematical](#) description of the [quantum state](#) of an [electron](#) in an [atom](#) or [molecule](#). [P8.3]

also describes: the various attempts to depict the information contained in the [wavefunction](#) diagrammatically (see [electron cloud](#)). [P8.3]

Flexible Learning Approach to Physics - Glossary

orbital angular momentum

is: in [classical physics](#), the [angular momentum](#) associated with [orbital motion](#).

is: in the [quantum mechanics](#) of the [atom](#), the [observable](#) of [magnitude](#) L represented by the [operator](#),

$$\hat{L} = -i\hbar \left(y \frac{\partial}{\partial z} - z \frac{\partial}{\partial y}, z \frac{\partial}{\partial x} - x \frac{\partial}{\partial z}, x \frac{\partial}{\partial y} - y \frac{\partial}{\partial x} \right)$$

and with \hat{L}^2 having the [eigenvalues](#) $l(l+1)\hbar^2$, where l is the [orbital angular momentum quantum number](#).

orbital angular momentum quantum number

is: the [quantum number](#) l that characterizes the [subshells](#) of an [atom](#). [[P8.3](#), [P8.4](#)]

can have: any one of the integer values $0, 1, 2, \dots, n - 1$, where n is the [principal quantum number](#). [[P8.3](#), [P8.4](#)]

determines: the [magnitude](#) $L^2 = l(l + 1)\hbar^2$ of the square of the [orbital angular momentum](#) of an [atomic electron](#). [[P8.3](#), [P8.4](#)]

Flexible Learning Approach to Physics - Glossary

orbital electron

is: an [electron](#) bound to an [atom](#) or [ion](#).

orbital magnetic quantum number

is: the [quantum number](#) m_l that describes the orientation of the [orbital angular momentum](#) of an [atomic electron](#) relative to an arbitrarily chosen [z-axis](#). [P8.3]

may have: any [integer](#) value ranging from $-l$ to $+l$, where l is the [orbital angular momentum quantum number](#), implying that the [z-component](#) of the [orbital angular momentum vector](#) may take on any value $L_z = m_l \hbar$. [P8.3]

labels: [degenerate energy levels](#) within a [subshell](#) in an [atom](#). [P8.3]

Flexible Learning Approach to Physics - Glossary

orbital period

of: an object following a closed [orbit](#)

is: the [time](#) required for an object to complete one full [orbit](#). [P3.2]

Flexible Learning Approach to Physics - Glossary

order (of a derivative)

is: the number of times the original [function](#) has been [differentiated](#) to produce the [derivative](#).

is indicated: by the superscript at the top of the [differential operator](#), e.g. the 2 in $\frac{d^2 f}{dx^2}$ or $\frac{\partial^2 \Psi}{\partial x \partial t}$.

Flexible Learning Approach to Physics - Glossary

order (of a differential equation)

is: the [order](#) of the highest [derivative](#) in the [differential equation](#). [M6.1]

order (of a singularity)

See [singularity](#).

Flexible Learning Approach to Physics - Glossary

order of degeneracy

of: an [energy level](#)

is given: by the number of [linearly independent wavefunctions](#) that share this same [energy level](#). ('Linearly independent' implies that none of the [wavefunctions](#) can be expressed as a [linear combination](#) of the others.) [[P10.3](#), [P11.3](#)]

See [degeneracy](#).

order of diffraction

See [diffraction grating](#).

order of interference

generally is: a whole number that characterizes the relative locations of various prominent features in an [interference pattern](#). [P6.1]

often is more simply: the number of full [wavelengths](#) in the [optical path difference](#) between two interfering beams at an [interference](#) maximum. [P6.1]

is exemplified by: the [integer](#) n in the [grating relation](#) $n\lambda = d \sin \theta_n$, which describes the angles at which bright [intensity](#) maxima are seen when [light](#) of a single [wavelength](#) λ from a line source is [incident normally](#) on a [diffraction grating](#) in which adjacent slits are separated by [distance](#) d . [P6.1]

Flexible Learning Approach to Physics - Glossary

order of magnitude

is: an [approximation](#) to the value of a quantity which rounds the value up or down to the nearest integer [power of ten](#). For example, if one quantity is roughly 10^3 times another, the former quantity is said to be three orders of magnitude greater than the latter. [[P1.1](#)]

is indicated: by \sim , which may be read as 'has the order of magnitude'. For example $2.4 \times 10^{-7} \sim 10^{-7}$ and $876.5 \sim 10^3$. [[M1.2](#)]

Flexible Learning Approach to Physics - Glossary

ordered pair

is: a pair of numbers or quantities written in such a way that their order is significant.

is exemplified: by the ordered pair (2, 5) which might represent the x - and y -[coordinates](#) of a [point](#) on a [graph](#) that would be quite different from (5, 2).
[[M2.2](#), [M2.5](#), [P1.3](#), [P2.2](#)]

ordered multiple

is: a [set](#) of numbers or quantities arranged, according to a certain rule, to represent an entity and such that any change in the order represents a change (or a potential change) in the represented entity.

is exemplified: by the [ordered triple](#) representing the [coordinates](#) of a [point](#) in [three-dimensional](#) space; the point (1, 2, 3) is different from the point (2, 1, 3) because of the rule that the first number appearing in the triple represents the x -coordinate, the second number the y -coordinate, and so on.

ordered triple

is: a [set](#) of three [elements](#), often written in the form (a, b, c) , in which the relative position of each [element](#) indicates its significance. [[M2.5](#), [P2.2](#)]

is exemplified: by the [position coordinates](#) (x, y, z) of a [point](#) in [space](#). [[M2.5](#), [P2.2](#)]

ordinary differential equation

is: a [differential equation](#) in which the [dependent variable](#) depends on only one [independent variable](#). [[M6.1](#)]

Flexible Learning Approach to Physics - Glossary

organic

in: chemistry

means: relating to the chemistry of carbon

more commonly means: pertaining to living, or once living, things.

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origin

is: the [point](#) corresponding to the [coordinates](#) (0, 0, 0) in a system of [Cartesian coordinates](#).

more generally, is: the [point](#) in a [coordinate system](#) from which [coordinates](#) are measured.

can be defined: in any number of [dimensions](#). [[M1.3](#), [M2.2](#), [P1.3](#)]

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orthogonal

means: at [right angles](#).

orthogonal component vector (of a vector)

is: one of a [set](#) of mutually [perpendicular vectors](#) that may be summed together using [vector addition](#) to produce a [resultant](#) that is equal to the given [vector](#).
[M2.4]

is exemplified: for a [particle](#) moving with [velocity](#) \mathbf{v} in a [uniform magnetic field](#), by the orthogonal component vectors \mathbf{v}_p and \mathbf{v}_n that are respectively [parallel](#) and [perpendicular](#) to the field; $\mathbf{v}_p + \mathbf{v}_n$. [M2.4]

orthogonal resolution (of a vector)

is: the process whereby a given [vector](#) is split into [orthogonal component vectors](#) along a chosen [set](#) of mutually [perpendicular directions](#). [[M2.4](#)]

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oscillatory

means: pertaining to [oscillation](#).

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oscillation

is: a back and forth motion, usually [periodic](#) or at least approximately [periodic](#), in one or more [dimensions](#). [M6.4]

is also: a [periodic](#) or approximately [periodic](#) variation in a physical quantity such as a [voltage](#), a [pressure](#) or a [density](#). [M6.4]

See [simple harmonic motion](#).

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out of phase

describes: the [phase relationship](#) between two specified [oscillations](#) that are not [in phase](#). [[P5.1](#), [P5.6](#), [P6.1](#)]

is sometimes used: in the phrase 'exactly out of phase' to mean '[in anti-phase](#).' [[P5.1](#), [P5.6](#), [P6.1](#)]

may be applied: to [waves](#) at a common [point](#) (or possibly at separate [points](#)) by comparing the [oscillations](#) caused by the [waves](#) at the relevant [point\(s\)](#). [[P5.6](#), [P6.1](#)]

Contrast with [in phase](#).

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outer shell

of: an [atom](#)

is: an (electron) [shell](#) of higher [energy](#) (i.e. lower [binding energy](#)) than all of the other occupied [shells](#) in the [atom](#). (According to [Bohr's model of the atom](#), [electrons](#) with such [energies](#) would be in [orbits](#) of relatively large [radius](#).)

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output resistance

See [internal resistance](#).

overdamping

is: the condition in which a [damped harmonic oscillator](#) is subject to such a strong [damping force](#) that it is unable to complete a single [oscillation](#) and is unable to return to rest as rapidly as in the case of [critical damping](#). [[P5.2](#), [P5.4](#)]

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overtones

are: the [harmonics](#), other than the first or [fundamental](#), that can be supported by a vibrating [system](#) such as a string with fixed ends. [[P5.7](#)]

Flexible Learning Approach to Physics - Glossary

π

is: a mathematical [constant](#) given to eight [decimal places](#) by $\pi = 3.141\ 582\ 65$.

See [pi](#).

p-type semiconductor

is: a [semiconductor](#) in which the majority of mobile [charge carriers](#) are positively [charged](#) (usually [holes](#)). [[P11.4](#)]

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P-T diagram

of: a [thermodynamic system](#) with [equilibrium states](#) characterized by [pressure](#) P , [volume](#) V , and [temperature](#) T

is: a [projection](#) of the [PVT-surface](#) of the [system](#) onto a plane parallel to the P - and T -[axes](#).

is used: to show the variation of P with T during a process.

pair annihilation

is: a process in which a [particle](#) (e.g. an [electron](#)) and its corresponding [antiparticle](#) (e.g. a [positron](#)) interact destructively and annihilate each other, releasing [energy](#) in the form of [\$\gamma\$ -rays](#).

is exemplified: by the [reaction](#) $e^+ + e^- \rightarrow 2\gamma$. [[P9.2](#)]

paired electrons

are: two [electrons](#) in a single [atom](#) that have identical [quantum numbers](#) apart from their respective values of the [spin magnetic quantum number](#) m_s . [P8.3]

Flexible Learning Approach to Physics - Glossary

parabola

is: a [conic section](#) that may be described by an equation of the form

$$y = ax^2 + bx + c \text{ where } a \neq 0$$

though it often arises in other forms, such as the [factorized form](#) and the [completed square form](#). [[M1.3](#), [M1.4](#), [M2.3](#), [P1.3](#), [P2.2](#), [P3.2](#)]

is exemplified: by the [trajectory](#) of a [projectile](#) moving under the sole influence of a [uniform gravitational field](#). [[P2.2](#)]

See conic sections in the [Maths handbook](#) for further details.

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paraboloid

is: the [two-dimensional surface](#) produced by [rotating](#) a [parabola](#) about its [axis of symmetry](#) [M2.3]

has the property: that any [ray](#) of [light](#) travelling [parallel](#) to the [axis](#) that is [reflected](#) from the inner [surface](#) of a paraboloid will pass through the [focus](#) of the original [parabola](#). [P2.3]

may be represented: by the equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} = \frac{z}{c}$

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parallax

is: a change in the apparent [direction](#) or [position](#) of an object due to movement of the [observer](#). Objects at different [distances](#) from an [observer](#) will exhibit different amounts of parallax for a given movement of the [observer](#). [P1.1]

can lead: to errors of [measurement](#) in situations where the [measurement](#) depends on the alignment of two objects such as the scale on a meter and a pointer indicating a reading on that scale. [P1.1]

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parallel

is: a term used to describe [lines](#) or [curves](#) in two [dimensions](#), and [planes](#) or [surfaces](#) in three [dimensions](#), that have the property that the shortest [distance](#) between them is the same everywhere. [[M2.1](#)]

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parallel (connection)

describes: [circuit components](#) joined so as to provide alternative paths between two [nodes](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

parallel (light)

describes: [light](#) that may be represented by [parallel rays](#).

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parallel (vectors)

describes: [vectors](#) which point in the same [direction](#) or in exactly opposite [directions](#). However, the term is ambiguous since it is sometimes restricted to mean the same [direction](#) while the complimentary term [antiparallel](#) is used to indicate exactly opposite [directions](#). [[M2.4](#)]

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parallel-axis theorem

states: that if the [moment of inertia](#) of a [body](#) of [mass](#) M about any [axis](#) through its [centre of mass](#) is I , then its [moment of inertia](#) about a [parallel axis](#) at a [perpendicular distance](#) r from the original [axis](#) will be $I + Mr^2$. [P2.7]

parallel LCR circuit

is: an [LCR circuit](#) in which the [inductance](#), [capacitance](#) and [resistance](#) are connected in [parallel](#).

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parallelogram

is: a [quadrilateral](#) in which opposite sides are [parallel](#). [[M2.1](#)]

parallelogram rule (for addition of vectors)

is: a [geometric](#) rule in which two [vectors](#) are represented by two adjacent sides of a [parallelogram](#), and their [vector sum](#) is represented by the diagonal drawn through the [point](#) where they [intersect](#). [[M2.4](#), [M2.5](#), [P2.2](#)]

states: that if the tail of [vector \$B\$](#) is placed at the tail of [vector \$A\$](#) and the parallelogram which they define is completed, then the [vector \$C\$](#) from their tails to the diagonally opposite [vertex](#) of the [parallelogram](#) represents the [sum](#) of [vectors \$A\$](#) and [vector \$B\$](#) . [[M2.4](#), [M2.5](#), [P2.2](#)]

is: an alternative to the [triangle rule](#) as a geometric way of representing the addition of two [vectors](#). [[M2.4](#), [M2.5](#)]

Flexible Learning Approach to Physics - Glossary

parameter

is: a [variable](#) used in an [expression](#) that defines another [variable](#). [[M1.3](#), [M2.3](#), [M4.3](#)]

is also: a value of a [variable](#) used as a label for classification purposes. [[M1.3](#), [M2.3](#), [M4.3](#)]

See [parametric equations](#).

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parametric differentiation

is: a process based on the [chain rule](#) that enables [functions](#) defined by [parametric equations](#) to be [differentiated](#). If two related [variables](#), x and y are each expressed in terms of a [parameter](#) t (so that $x = f(t)$ and $y = g(t)$), then $\frac{dy}{dx} = \frac{dy}{dt} / \frac{dx}{dt}$.

[M4.3]

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parametric equations

of: a given [equation](#) (e.g. of the [standard equation](#) of a [conic section](#))

are: [equations](#) in which each of the [variables](#) in the given [equation](#) is expressed in terms of one or more new [variables](#) known as [parameters](#).

are exemplified: by the parametric equations of a [circle](#):

$x = a \cos \theta$ and $y = a \sin \theta$ where θ is the [parameter](#),

since using the identity $\sin^2 \theta + \cos^2 \theta = 1$ to eliminate the [parameters](#) θ leads to the [standard equation](#) of the [circle](#) ($x^2 + y^2 = a^2$). [[M2.3](#), [M4.3](#)]

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parametric function

is: a [function](#) defined by [parametric equations](#). [M4.3]

paraxial approximation

is: an [approximation](#) which can be applied in [ray optics](#) when all the [rays](#) are either [parallel](#) to or at a small [angle](#) to the [optical axis](#).

See also [paraxial ray](#). [P6.3]

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paraxial ray

is: a [light ray](#) which is either [parallel](#) to or at a small [angle](#) to the [optical axis](#) (usually less than 10°), before and after [refraction](#) or [reflection](#). [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

parent isotope

See [parent nucleus](#).

Flexible Learning Approach to Physics - Glossary

parent nucleus

is: an [unstable isotope](#) that decays to produce a [daughter nucleus](#). [P9.2]

partial derivative

is: a [derivative](#) of a [function](#) of several (i.e. two or more) [variables](#). For a [function](#) of two [variables](#), such as $y = f(x, t)$ we can define

$$\frac{\partial y}{\partial x} = \lim_{\Delta x \rightarrow 0} \left(\frac{f(x + \Delta x, t) - f(x, t)}{\Delta x} \right)$$

and
$$\frac{\partial y}{\partial t} = \lim_{\Delta t \rightarrow 0} \left(\frac{f(x, t + \Delta t) - f(x, t)}{\Delta t} \right)$$

[[M6.4](#), [P5.6](#)]

partial differential equation

is: a [differential equation](#) involving [partial derivatives](#). [[M6.1](#), [M6.4](#), [P5.6](#)]

partial fractions

of: a [function](#) of the form $p(x)/q(x)$, where $p(x)$ and $q(x)$ are [polynomials](#) and the [degree](#) of $q(x)$, is greater than or equal to that of $p(x)$.

are: the [functions](#) $f_i(x) = r_i(x)/s_i(x)$, whose [sum](#) is $p(x)/q(x)$ where $s_i(x)$ is a [polynomial](#) of [degree](#) 1 or 2, or a [power](#) of such a [polynomial](#), and $r_i(x)$ is a [polynomial](#) of lower [degree](#). [[M5.5](#)]

are used: in evaluating certain [integrals](#).

See further integration in the [Maths handbook](#).

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partial reflection

is: [reflection](#) at a [surface](#) or [interface](#), such that only part of the [light](#) (as [measured](#) by its [intensity](#)) is [reflected](#), the rest being [absorbed](#) or [transmitted](#).
[P6.2]

Flexible Learning Approach to Physics - Glossary

partial sum

for: an [infinite series](#):

$$\sum_{k=1}^{\infty} a_k = a_1 + a_2 + a_3 + a_4 + \dots$$

is: the sum of the first n terms:

$$S_n = \sum_{k=1}^n a_k = a_1 + a_2 + a_3 + a_4 + \dots + a_n \quad [\text{M1.7}]$$

partially polarized

describes: [light](#) in which the [oscillations](#) of the [electric field](#) occur preferentially along some particular [axis](#), but in which its [oscillations](#) along other [axes](#) are not negligible. [[P6.1](#)]

Flexible Learning Approach to Physics - Glossary

particle

in: [classical physics](#), particularly [mechanics](#)

is: an object that can be treated as occupying a single [point](#) in [space](#), at any [time](#). [[P2.1](#), [P2.2](#), [P2.4](#)]

is thought of: as having no size, shape or internal [motion](#) (such as [spin](#) or [vibration](#)). [[P2.1](#), [P2.2](#), [P2.4](#)]

is emulated: by the [centre of mass](#) of an [extended object](#). [[P2.1](#), [P2.2](#)]

is: the simplest possible example of a ([classical](#)) [physical system](#).

more generally, is: (especially in [quantum physics](#)) a fundamental constituent of [matter](#), such as an [elementary particle](#) or (exceptionally) an [atom](#) or [molecule](#).

See also [quantum](#).

particle (fundamental)

See [fundamental particle](#).

particle density function

of: a [one-dimensional quantum system](#) consisting of a stream of [particles](#), represented by a [spatial wavefunction](#) $\psi(x)$.

is: $P(x) = \psi^*(x) \psi(x) = |\psi(x)|^2$. [P11.1]

represents: the average [number density](#) of [particles](#) at any [point](#), x . So the number of particles in the region $a \leq x \leq b$ will be $\int_a^b P(x) dx$. [P11.1]

has as its SI unit: m^{-1} . [P11.1]

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particle flux

of: a [one-dimensional quantum system](#) consisting of a stream of [particles](#) represented by the [spatial wavefunction](#) $\psi(x) = A \exp(ikx)$, which is an [eigenfunction](#) of the [momentum operator](#),

given that: the average number of [particles](#) per [unit length](#) is the constant $|A|^2$, and their [velocity](#) is obtained from the [momentum](#), $v_x = p/m = \hbar k/m$

is: the net number crossing a fixed [plane](#) per [unit time](#), i.e. $F = |A|^2 \hbar k/m$.
[P11.1]

has as its SI unit: s^{-1} .

Flexible Learning Approach to Physics - Glossary

particular solution

is: a [solution](#) of a [differential equation](#), which involves no [arbitrary constants](#).
[[M6.1](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

pascal, Pa

is: the [SI unit](#) of [pressure](#).

is defined: by $1 \text{ Pa} = 1 \text{ N m}^{-2}$, so it is the [pressure](#) that when acting [uniformly](#) over a flat [surface](#) of [area](#) 1 ([metre](#)) squared causes a total [force](#) of [magnitude](#) 1 [newton](#) to act in a direction [perpendicular](#) to that [surface](#). [[P7.2](#)]

Pascal's principle

states: that an externally applied [pressure](#) on a confined [fluid](#) is transmitted [uniformly](#) in all directions to all [elements](#) of the [fluid](#) and to the containing [body](#). [[P7.6](#)]

Paschen series

See [series \(spectroscopic\)](#).

path difference

usually refers: to the difference between the [distances](#) travelled by two [coherent waves](#), from their source to the [point](#) where they meet and where [interference](#) effects may be [observed](#). [[P6.1](#)]

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path length

is: the distance between given [points](#) measured along a specified path.

is given: by $\int_A^B |ds|$ where A and B are the given [points](#), and ds is an [element](#) of [displacement](#) along the path.

Pauli exclusion principle

states: that no two [electrons](#) in an [atom](#) can ever occupy the same [quantum state](#). [P8.3]

more generally states: that no two [fermions](#) can simultaneously occupy the same [quantum state](#). [P7.1]

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peak value

of: a quantity that varies [sinusoidally](#) with [time](#), such as $y = A \sin(\omega t + \phi)$

is synonymous with: its [amplitude](#) A . (Peak values of [sinusoidally](#) varying [current](#) and [voltage](#) are usually written as I_0 and V_0 , respectively.) [[P5.4](#)]

Flexible Learning Approach to Physics - Glossary

pencil of rays

is: a narrow [beam](#) of [parallel](#) or nearly [parallel rays](#). [[P6.2](#)]

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pendulum

is: a [periodic](#) swinging [system](#), driven by a [gravitational restoring force](#).
[P5.1]

has: in the simple ([undamped](#)) case, [period](#) $T = 2\pi\sqrt{l/g}$ where l is the [length](#) of the pendulum, and g is the [magnitude of the acceleration due to gravity](#). [P5.1]

Flexible Learning Approach to Physics - Glossary

pendulum clock

is: a clock based on the regular [oscillations](#) of a swinging [pendulum](#). [[P5.3](#)]

Flexible Learning Approach to Physics - Glossary

penetration depth

in: [quantum physics](#)

of: a stream of [particles](#) penetrating [quantum mechanically](#) into a [potential step](#) or [potential barrier](#) where the [potential energy](#) is greater than the total [particle energy](#)

is: the [distance](#) d at which the [probability density function](#) has decreased to $1/e$ of its initial value. [[P11.1](#)]

Flexible Learning Approach to Physics - Glossary

percentage

of: one number with respect to another

is equal: to the [fraction](#) that the first forms of the second, when the [denominator](#) is converted to 100. [[M1.1](#)]

is expressed: as the [numerator](#) of that [fraction](#), followed by the percentage symbol, %. [[M1.1](#)]

therefore can be calculated: as the first number divided by the second, multiplied by 100%. [[M1.1](#)]

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percentage error

is: the [fractional error](#) expressed as a [percentage](#). [P1.1, P1.2]

is: obtained by multiplying the [fractional error](#) by 100%. [P1.1, P1.2]

Flexible Learning Approach to Physics - Glossary

perfect square

is: a number or [algebraic expression](#) that may be written as the [square](#) of another number or algebraic expression. [[M1.4](#)]

is exemplified: by $9x^2 + 12x + 4$, which can be written as $(3x + 2)^2$. [[M1.4](#)]

Flexible Learning Approach to Physics - Glossary

perimeter

is: the [length](#) of a closed [curve](#), such as the [circumference of a circle](#) or the [sum](#) of the [lengths](#) of the sides of a [polygon](#). [[M2.1](#)]

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period (of motion)

is in general: the [time interval](#) over which a repeating [motion](#) or event recurs. [[M6.4](#)]

is in particular: the [time](#) taken for an [oscillating system](#) to complete one full [cycle](#) (i.e. one complete [oscillation](#)). [[P5.1](#), [P5.4](#), [P5.5](#)]

therefore is: the [reciprocal](#) of the [frequency](#): $T = 1/f$. [[P5.7](#), [P6.1](#)]

is also: 2π times the [reciprocal](#) of the [angular frequency](#): $T = 2\pi/\omega$. [[M5.1](#), [P5.7](#), [P6.1](#)]

is exemplified: by a [particle](#) of [mass](#) m executing [simple harmonic motion](#) along the [x-axis](#), under the influence of a [force](#) $F_x = -k_s x$, where the period is given by

$$T = 2\pi\sqrt{m/k_s} \quad [\text{P5.1}]$$

is also exemplified: by an [orbiting particle](#), where the period is the [time](#) taken to complete one [orbit](#). [[P2.6](#)]

is also exemplified: by a ([periodic](#)) [wave](#), where the period is the [time](#) required for one complete [cycle](#) of the [wave](#) (i.e. one complete [oscillation](#) at any fixed [point](#) on the path of the [wave](#)). [[P5.6](#), [P6.1](#)]

periodic function

is: a [function](#) $f(x)$, such that $f(x + na) = f(x)$ for all values of x , where n is any [integer](#) and a is a [constant](#). The smallest (non-zero) value of a for which this relation holds true is known as the period of the [function](#). [[M1.6](#), [M5.2](#), [M6.3](#)]

Flexible Learning Approach to Physics - Glossary

periodic process

is: a process in which identical events occur at regular [intervals of time](#). [[P1.1](#), [P5.1](#)]

See [period of motion](#).

periodic series

is: a series of [chemical elements](#), commonly placed in a horizontal row in a [periodic table](#). Across the row, [atomic number](#) increases in steps of one, and there is a variation in chemical properties that is repeated within other corresponding series, in other rows, of the [periodic table](#). [P8.4]

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periodic table

is: a tabular listing of the [chemical elements](#), arranged in [periodic series](#) so as to emphasize the repetition of certain behavioural characteristics with increasing [atomic number](#). [P8.4]

in modern versions, also shows: the corresponding [periodicities](#) of the [electronic configurations](#) of the [atoms](#) of the [elements](#), which determine the chemical properties of the [elements](#). [P8.4]

Flexible Learning Approach to Physics - Glossary

periodic wave

is: a repetitive [wave](#) characterized by a [wavelength](#) and a [period](#). In the case of a periodic [wave](#) described by the [function](#) $y = f(x, t)$, the [wavelength](#) λ is the shortest [length](#) such that $f(x + \lambda, t_1) = f(x, t_1)$ for all x , and the [period](#) T is the shortest [time](#) such that $f(x_1, t + T) = f(x_1, t)$ for all t . [P5.6]

causes: an [oscillation](#) at any particular constant value of x [P5.4]

is exemplified: by a [sinusoidal wave](#) $y = A \sin [kx - \omega t + \phi]$, where $k = 2\pi/\lambda$ and $\omega = 2\pi/T$. [P5.4]

Flexible Learning Approach to Physics - Glossary

periodicity

is: the property of regular repetition shown by a [periodic function](#). [M1.6]

Flexible Learning Approach to Physics - Glossary

permanent magnet

is: a [magnet](#) which maintains its [magnetism](#) in the absence of any [electric current](#) being applied. [[P4.2](#)]

Flexible Learning Approach to Physics - Glossary

permanent magnetism

is: the property of a [permanent magnet](#) in exhibiting [magnetism](#). [P4.2]

Flexible Learning Approach to Physics - Glossary

permeability

of: a material [medium](#)

is: a property of the material that determines the [magnitude](#) B , of the [magnetic field](#) within the material, produced by a given [current](#). [P4.2, P4.5]

appears, for example: in the [equation](#) for the [magnitude](#) of the [magnetic field](#) at a [distance](#) r from a long steady [electric current](#) I : $B = \mu_0 I / (2\pi r)$ [P4.2]

is equal: to the [permeability of free space](#) μ_0 times the [relative permeability](#) μ_r of the material.

is equal: in a [vacuum](#), to the [permeability of free space](#), μ_0 . [P4.2]

Flexible Learning Approach to Physics - Glossary

permeability of free space

is: a [constant](#) defined so as to enable [SI units](#) to be used consistently in [equations](#) relating to [magnetic fields](#). Its value arises via the definition of the [ampere](#), and is by definition $4\pi \times 10^{-7} \text{ T m A}^{-1}$. [[P4.2](#)]

See also [relative permeability](#).

Flexible Learning Approach to Physics - Glossary

permittivity

of: a material [medium](#)

is: a property of the material that determines the [magnitude](#) E of the [electric field](#) within the material produced by a given [charge](#). [P3.3, P4.5]

appears, for example: in the [equation](#) for the [magnitude](#) of the [electric field](#) at a [distance](#) r from a [point charge](#) q : $E = |q|/(4\pi\epsilon r^2)$. [P4.5]

also appears, for example: in the [equation](#) for the [capacitance](#) of parallel plates of [area](#) A separated by a distance d and filled with the material:
 $C = \epsilon A/d$. [P4.5]

is equal: if the material is a [dielectric](#), to the [permittivity of free space](#) ϵ_0 , times the [relative permittivity](#) ϵ_r of the material. [P3.3, P4.5]

is equal: in a [vacuum](#), to the [permittivity of free space](#), ϵ_0 . [P4.5]

Flexible Learning Approach to Physics - Glossary

permittivity of free space

is: a [fundamental constant](#) with the value $8.854 \times 10^{-12} \text{ N}^{-1} \text{ m}^{-2} \text{ C}^2$
(= $8.854 \times 10^{-12} \text{ F m}^{-1}$), to four [significant figures](#). [[P3.1](#), [P3.3](#)]

often appears: in combination with other [constants](#), e.g. in $1/(4\pi\epsilon_0)$ which is sometimes known as the [electrostatic constant](#): $1/(4\pi\epsilon_0) = 8.988 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$. [[P3.1](#), [P3.3](#)]

Flexible Learning Approach to Physics - Glossary

perpendicular

describes: a [line](#) or [plane](#) that is at [right angles](#) (90°) to another [line](#) or [plane](#).
[[M1.6](#), [M2.1](#)]

perpendicular bisector

is: a [line](#) which intersects a [line segment](#) at [right angles](#) and divides it into two parts of equal [length](#). [[M2.1](#)]

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perpendicular height

is: the height of a [geometric figure](#) measured in the direction [perpendicular](#) to its base. [[M2.1](#)]

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phase

of: an [oscillation](#) described by a [periodic function](#)

is: the [argument](#) of that [function](#). [[P5.1](#), [P5.4](#), [P5.5](#)]

determines: the stage that the [oscillator](#) has reached in its [cycle](#). [[P5.1](#), [P5.4](#)]

is exemplified: for the [oscillation](#) $y = A \sin(\omega t + \phi)$, by the quantity $(\omega t + \phi)$. (The additive term ϕ which is independent of the [time](#) t is called the [phase constant](#) or the [initial phase](#) of the [oscillation](#).) [[P5.1](#), [P5.4](#), [P5.5](#)]

may be generalized: to the case of a [wave](#), e.g. the phase of the [wave](#) $y = A \sin(kx - \omega t + \phi)$ at [position](#) x and [time](#) t is $(kx - \omega t + \phi)$. [[P5.6](#)]

is: a number, *not* an [angle](#), though it may be given an angular interpretation, in which case it may be referred to as the phase angle. [[P5.1](#), [P5.4](#)]

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phase angle

See [phase](#).

Flexible Learning Approach to Physics - Glossary

phase change

See [phase transition](#).

Flexible Learning Approach to Physics - Glossary

phase constant

is: the value of the [phase](#) when $t = 0$ (also known as the [initial phase](#)). [[P5.1](#), [P5.4](#), [P5.5](#)]

is exemplified: by the [constant](#) ϕ that appears in the [general solution](#) of the [SHM equation](#) when that solution is written in the form $y = y_0 \sin(\omega t + \phi)$. [[M6.3](#), [P5.5](#)]

is also exemplified: by the [constant](#) ϕ that appears in the equation describing a [sinusoidal wave](#) when the equation is written in the form $y = A \sin(kx - \omega t + \phi)$. [[P5.6](#)]

conventionally is quoted: in the range $0 \leq \phi < 2\pi$. [[P5.1](#)]

is: a number, *not* an [angle](#), though it may be given an angular interpretation. [[M1.6](#), [M6.3](#), [M6.4](#)]

See [phase](#).

phase difference

between: two [oscillations](#) with the same [angular frequency](#) ω such as $A = A_0 \sin(\omega t + \phi_1)$ and $B = B_0 \sin(\omega t + \phi_1)$ (which might be caused at specified [points](#) by [waves](#))

is: a [measure](#) of the extent to which the two [oscillations](#) (or the [waves](#) causing them) are out of step. [[P5.4](#), [P6.1](#)]

is given: by $\phi = \phi_2 - \phi_1$, but is conventionally restricted to the range $0 \leq \phi < 2\pi$ by subtracting an appropriate integer multiple of 2π from ϕ .

may also be interpreted: as an [angle](#), in which case its value is quoted in [radians](#), or as the equivalent number of [degrees](#). [[P5.4](#), [P6.1](#)]

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phase lag

between: two [oscillations](#) with the same [angular frequency](#) ω ,

$$A = A_0 \sin(\omega t + \phi_1) \text{ and } B = B_0 \sin(\omega t + \phi_2)$$

is: when the [phase difference](#) $\phi = \phi_2 - \phi_1$ is in the range $-\pi < \phi < 0$. [\[P5.4\]](#)

Contrast with [phase lead](#).

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phase lead

between: two [oscillations](#) with the same [angular frequency](#) ω ,

$$A = A_0 \sin(\omega t + \phi_1) \text{ and } B = B_0 \sin(\omega t + \phi_2)$$

is: when the [phase difference](#) $\phi = \phi_2 - \phi_1$ is in the range $0 < \phi < \pi$. [[P5.4](#)]

Contrast with [phase lag](#).

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phase relationship

between: two [oscillations](#) with the same [angular frequency](#) ω ,
 $A = A_0 \sin(\omega t + \phi_1)$ and $B = B_0 \sin(\omega t + \phi_2)$

is determined: by their [phase difference](#) $\phi = \phi_2 - \phi_1$

if $-\pi < \phi < 0$, it is said that B lags A by $|\phi|$

if $\phi = 0$, it is said that B is [in phase](#) with A ;

if $0 < \phi < \pi$, it is said that B leads A by ϕ ;

if $\phi = \pi$, it is said that B is [in anti-phase](#) with A ;

For values of ϕ outside the range $-\pi < \phi \leq \pi$, an appropriate integer multiple of 2π should be added to or subtracted from ϕ to bring it within that range.

[P5.4]

may also be applied: to [waves](#) at a common [point](#) (or possibly at separate [points](#)) by comparing the [oscillations](#) caused by the [waves](#) at the relevant [point\(s\)](#).

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phase speed

is: the [speed](#) at which points of constant [phase](#) (e.g. a peak of the [wave](#)) move in [travelling waves](#). [[P5.6](#)]

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phase transition

in: a substance

is: a change in bulk properties which, for pure substances, is often found to occur within a vanishingly small range of [temperature](#). [P7.4]

is exemplified: by the [melting](#) of a [solid](#) to form a [liquid](#). [P7.1, P7.4]

is also exemplified: by changes in the [crystalline structure](#) of [solids](#). [P7.4]

is accompanied: in some phase transitions, including the [solid-liquid-vapour](#) ones, by [latent heats](#) (but this is not true of *all* phase transitions). [P7.4]

See [fusion](#), [sublimation](#), [vaporization](#).

phases of matter

are: the various 'forms' of [matter](#), specifically [solid](#), [liquid](#) or [gas](#). Sometimes additional phases are recognized, such as [plasmas](#). [[P7.1](#), [P7.3](#)]

are sometimes referred to: as 'states of matter', but [state](#) has a more specific meaning and is best avoided in this general context.

phasor

is essentially: a [rotating vector](#) which is used to describe the [amplitude](#) and [phase](#) of a [sinusoidal oscillation](#), (which might be the [oscillation](#) caused at a specified [point](#) by a [sinusoidal wave](#)). The '[magnitude](#)' of the phasor is called its [amplitude](#) and is equal to the [amplitude](#) of the associated [oscillation](#). The 'direction' of the phasor is determined at any [time](#) t by the [angle](#) between the phasor and an arbitrarily chosen fixed [axis](#), this [angle](#) is called the [phase](#) of the phasor and is equal to the [phase](#) of the associated [oscillation](#). If the value of the [phase](#) at [time](#) $t = 0$ is equal to the [phase constant](#) ϕ of the [oscillation](#), and the rate of change of the [phase](#) is determined by the [angular frequency](#) ω of the [oscillation](#), then the [oscillation](#) itself will be represented by the [projection](#) of the phasor onto the chosen fixed [axis](#). [[P5.1](#), [P5.4](#)]

is used: to find the result of [superposing](#) two or more [simple harmonic oscillations](#) acting together, either in the same direction or in different directions. This is achieved by representing each [oscillation](#) by a phasor and then adding the phasors in a similar manner to [vectors](#) to find the [resultant](#) phasor, which represents the [superposed oscillations](#). [[P5.1](#), [P5.4](#)]

phasor model

is: a way of representing [oscillatory motion](#) in general, and [simple harmonic motion](#) in particular, that is especially useful when considering the result of combining two or more oscillations at a point. [[P5.1](#)]

See [phasor](#).

photoelectric effect

is: the phenomenon whereby [electrons](#) are ejected from [metals](#) which are illuminated by [electromagnetic radiation](#) of suitable [frequency](#) (usually [ultraviolet radiation](#)). [P10.1]

occurs: when each ejected [electron](#) completely absorbs the [energy](#) of a single [photon](#).

cannot be explained: by the [classical wave model](#) of [electromagnetic radiation](#). [P10.1]

was explained: by Albert Einstein (1879-1955) (see [Einstein's photoelectric equation](#)) by assuming that the interaction [energy](#) of [electromagnetic radiation](#) occurs in discrete [quanta](#), given by the [Planck-Einstein formula](#):

$$E = hf$$

where h is [Planck's constant](#) and f is the [frequency](#) of the [electromagnetic radiation](#). [P10.1]

Flexible Learning Approach to Physics - Glossary

photoelectron

is: an [electron](#) that has been ejected from an [atom](#) (or a material) by a [photon](#).
[[P8.3](#), [P10.1](#)]

photoelectron spectroscopy

is: a type of [spectroscopy](#) that examines the [energies](#) of the [photoelectrons](#) produced by bombarding an [atom](#) (or a material) with [radiation](#) of a fixed [frequency](#). [P8.3]

provides: a [measure](#) of the [threshold energies](#) (i.e. [binding energies](#)) of the [electrons](#) in the [atom](#) (or the material). [P8.3]

photoelectron spectrum

is: a plot of [photoelectron current](#) against [threshold energy](#) that reveals the [binding energies](#) of [atomic electrons](#). [P8.3]

photographic film

is: the flexible plastic strip which carries the [light](#) sensitive [emulsion](#) for recording optical [images](#) in a [camera](#). [[P6.4](#)]

photoionization

is: [ionization](#), or removal of one or more [electrons](#) from an [atom](#), by [absorption](#) of [light](#), often [ultraviolet radiation](#) or even shorter [wavelength radiation](#).
[P10.1]

photomultiplier

is: a sensitive device used to detect [light](#) down to the level of single [photons](#).
[P10.1]

can produce: a large pulse of [electrons](#), and hence a [current](#) pulse, for each [photon](#) absorbed. The size of the [current](#) pulse can be made [proportional](#) to the [energy](#) of the [photon](#), and with suitable electronic equipment, individual [photons](#) can be counted and distinguished by [energy](#). [P6.4, P10.1]

Flexible Learning Approach to Physics - Glossary

photon

is: a [quantum](#) of [electromagnetic radiation](#). [[P10.1](#), [P10.2](#)]

has: a discrete amount of [energy](#), given by the [Planck-Einstein equation](#) $E = hf$ where f is the [frequency](#) of the [radiation](#), and h is [Planck's constant](#). [[P10.1](#), [P10.2](#)]

has: a discrete amount of [momentum](#), given in [magnitude](#) by $p = E/c = h/\lambda$ (where c is the [speed of light](#) in a [vacuum](#)) and with a [direction](#) that is the same as the photon's [direction](#) of [motion](#). [[P10.1](#), [P10.2](#)]

as a concept, is: at the heart of the [quantum theory of electromagnetic radiation](#). [[P8.2](#)]

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physical

means: pertaining to [physics](#).

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physical optics

is: that part of [optics](#) in which it is not valid to treat the [propagation](#) of [light](#) in terms of [rays](#) and it is necessary to take account of the [wave](#)-like aspect of [light](#). [P6.1]

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physics

is: a high and noble calling for good people with fine minds.

is also: the branch of science concerned with the behaviour of [space](#), [time](#), [matter](#) and [radiation](#). [[P1.1](#)]

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pi, π

is: the mathematical [constant](#) obtained by dividing the [circumference](#) of any [circle](#) by its [diameter](#).

[M1.6]

is: an [irrational number](#). [M1.6]

is given: to eight [decimal places](#) by $\pi = 3.141\ 582\ 65$. [M1.6]

piezoelectric

describes: some materials, such as quartz, which react to an imposed [electric field](#) by changing their size or shape. If an [oscillating](#) field is applied to the material then high [Q-factor mechanical oscillations](#) result. [[P5.3](#)]

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pinhole camera

is: a [camera](#) with no optically [refracting](#) components, and in which [focusing](#) is achieved by the use of a very small [aperture](#). [P6.4]

Flexible Learning Approach to Physics - Glossary

pitch

sometimes is used: as a synonym for [frequency](#). [P5.7]

more properly is: a subjective quality of a musical note or sound that may be used to assign it a position in an appropriately defined scale. [P5.7]

Planck's constant

is: the [fundamental constant](#) h that has the value $h = 6.6262 \times 10^{-34}$ J s (to five [significant figures](#)). [[P10.1](#), [P10.2](#)]

appears: in practically every [equation](#) of [quantum physics](#), but *never* in the [equations](#) of [classical physics](#). [[P8.2](#), [P10.1](#), [P10.2](#)]

Planck's equation

may be written: $E = hf$

where h is [Planck's constant](#). [[P10.1](#), [P10.2](#)]

relates: the [energy](#) E of a single [photon](#) to the [frequency](#) f of [monochromatic light](#) composed of such [photons](#). [[P10.1](#)]

is also known: as Planck's law, Planck's formula or (in a more specific context) the [Planck-Einstein formula](#). [[P10.1](#)]

Planck's function

describes: the [spectral brightness](#) at [wavelength](#) λ of [black-body radiation](#) from a source at [temperature](#) T . [P7.3, P10.1]

is given by: $R_\lambda = \frac{2hc^2}{\lambda^5 [\exp(hc / \lambda kT) - 1]}$ where h is [Planck's constant](#), c is the [speed of light in a vacuum](#) and k is [Boltzmann's constant](#). [P7.3]

is based: on the [quantized interactions](#) of [electromagnetic waves](#) in a cavity with the [atoms](#) in the walls, where the [atoms](#) are treated as [oscillators](#) with [states](#) of distinct [energy](#). [P10.1]

Planck-Einstein formula

for: a [quantum system](#) making a [transition](#) between a [state](#) of (initial) [energy](#) E_i and a [state](#) of (final) [energy](#) E_f

relates: the [frequency](#) f of the [electromagnetic radiation emitted](#) or [absorbed](#) by the system to the [magnitude](#) of the [energy](#) change $\Delta E = |E_i - E_f|$. [[P8.2](#), [P10.1](#), [P10.2](#), [P11.3](#)]

may be written: $|E_i - E_f| = \Delta E = hf$, where h is [Planck's constant](#). [[P8.2](#), [P10.2](#), [P11.3](#)]

results from: the combination of [Planck's equation](#) and the [conservation of energy](#).

Flexible Learning Approach to Physics - Glossary

plane (geometric)

is: a [surface](#) such that a [straight line](#) that joins any two [points](#) on the [surface](#) lies in the [surface](#). [M2.1]

can be represented: by the general [equation](#) $ax + by + cz = d$ where a , b , c and d are [constants](#). [M2.2]

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plane angle

is: an [angle](#) measured in a [plane](#).

has as its SI unit: the [radian](#) (rad).

Flexible Learning Approach to Physics - Glossary

plane mirror

is: a flat [reflecting surface](#) in which the largest irregularities are (ideally) much smaller than the [wavelength](#) of [light](#). [[P6.1](#), [P6.2](#)]

Flexible Learning Approach to Physics - Glossary

plane of polarization

for: a [linearly polarized electromagnetic wave](#)

is: the [plane](#) containing the [electric field vector](#) and the [direction of propagation](#). [[P6.1](#)]

Flexible Learning Approach to Physics - Glossary

plane of rotation

of: a [particle](#)

is: the [plane](#) in which the [rotation](#) is confined. [P2.8]

more generally is: for a [body rotating](#) about a well-defined [axis of rotation](#), any plane [perpendicular](#) to the [axis of rotation](#). [P2.8]

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plane polarized

See [linearly polarized](#).

Flexible Learning Approach to Physics - Glossary

plane wave

is: a [wave](#) in two or three [dimensions](#) characterized by a constant, [uniform wave vector](#). [[P5.6](#)]

has: [wavefronts](#) which are [straight lines](#) or [planes](#), in two or three [dimensions](#), respectively. [[P5.6](#), [P6.1](#)]

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plane wavefront

is: the flat [wavefront](#) of a [plane wave](#). [P6.1]

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plano-concave lens

is: a [lens](#) having one [concave surface](#) and one flat [surface](#). [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

plano-convex lens

is: a [lens](#) having one [convex surface](#) and one flat [surface](#). [[P6.3](#)]

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plasma

is: [matter](#) consisting of partially or fully [ionized atoms](#) and free [electrons](#) with overall [charge](#) neutrality, coexisting in a [gas-like phase](#) or [state](#). [[P9.3](#)]

is usually distinguished: by cooperative [particle](#) behaviour and the screening of (reducing the effects of) any applied [electric](#) or [magnetic fields](#). [[P9.3](#)]

occurs: as the [temperature](#) of [matter](#) is increased above 10^5 K. [[P8.2](#)]

can be found: around and within stars. [[P8.2](#)]

also has been produced: with some difficulty, in the laboratory. [[P8.2](#)]

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plasma confinement

is: containment of a [plasma](#) (typically of [deuterium](#) or [tritium](#) or a mixture of these), often at sufficiently high [temperature](#) and [density](#) that [nuclear fusion](#) can take place within it. [[P9.3](#)]

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plasma state

See [plasma](#).

Flexible Learning Approach to Physics - Glossary

plastic region

is: the part of the [loading curve](#), (the [graph](#) of [stress](#) against [strain](#)) of a material over which it exhibits [plasticity](#). [P7.6]

is also called: the [ductile region](#). [P7.6]

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plasticity

is: the property of a [solid body](#) to undergo a permanent change in shape or size when subjected to a [stress](#) larger than the [yield point](#). [P7.6]

Flexible Learning Approach to Physics - Glossary

plotting graphs

is: the process of drawing an [accurate graph](#), as opposed to [sketching](#). [M1.3]

Contrast with [sketching graphs](#).

plum-pudding model

was: an early [model](#) of the atom, proposed by J. J. Thomson (1856-1940), following his discovery of the [electron](#). [[P8.1](#)]

supposed: that a large (possibly very large) number of negatively [charged electrons](#) move in concentric [circular orbits](#) within a compensating cloud of positive [charge](#). [[P8.1](#)]

Flexible Learning Approach to Physics - Glossary

point

is: a geometrical object that occupies a [position](#) but has no size or [extension](#).
[M2.1]

may be specified: relative to a given [coordinate system](#) by an appropriate set of [position coordinates](#) or by an appropriate [position vector](#).

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point discharge

is: the neutralization of [charge](#) on a [conductor](#) around any sharp point or edge. [[P3.3](#)]

arises: because [electrons](#) and [ions](#) in the surrounding air are [accelerated](#) by the enhanced [electric field](#) close to the point. [[P3.3](#)]

Flexible Learning Approach to Physics - Glossary

point image

is: an [image](#) of a [point object](#). [P6.3]

can be treated: as having zero size. [P6.3]

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point object

is: an idealized [object](#) without size or extension which can be treated as a source of [light](#) (i.e. from which [light rays](#) diverge). [[P6.2](#), [P6.3](#)]

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point of incidence

is: the [point](#) of contact of an [incident ray](#) with a [surface](#) or [interface](#). [[P6.2](#)]

Flexible Learning Approach to Physics - Glossary

point of inflection

is: a [point](#) on a [graph](#) where the direction of curvature changes from downwards to upwards, or vice versa. [[M1.3](#)]

more technically is: a [point](#) on the [graph](#) of a [function](#) at which the [second derivative](#) of the [function](#) changes sign. (This implies that the [second derivative](#) is zero at a [point](#) of inflection, but the converse is not necessarily true.) At such a [point](#), a [tangent](#) to the [graph](#) crosses the [graph](#) itself.

may or may not have: the [first derivative](#) of the [function](#) vanishing. When this additional condition is satisfied, the point of inflection is said to be a [horizontal point of inflection](#), and is a particular kind of [stationary point](#). [[M1.3](#), [M4.4](#), [P6.2](#)]

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point source

is: a source of [light](#) of (ideally) zero size. [[P6.1](#)]

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point-gradient form

of: the [equation of a straight line](#)

is: $y - y_0 = m(x - x_0)$

where the [straight line](#) passes through the [point](#) (x_0, y_0) , and has [gradient](#) m .
[[M1.3](#), [M2.2](#)]

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poise, P

is: a non-[SI unit](#) of [viscosity](#).

is defined: by $1 \text{ P} = 0.1 \text{ Pa s}$ (i.e. 0.1 [pascal second](#)). [[P7.6](#)]

polar angle

See [polar coordinates](#).

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polar axis

See [polar coordinates](#).

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polar coordinates

are: [coordinates](#) in which the [position](#) of a [point](#) in a [plane](#) is determined by its [distance](#) from a chosen [point](#) called the [origin](#) and the [angle](#) (called the polar angle) between a [straight line](#) joining the [point](#) to the [origin](#) and a chosen fixed [line](#) (called the polar axis) emanating from the [origin](#). [[M2.2](#), [P2.3](#)]

polar form (of a complex number)

represents: the [complex number](#) as $z = r [\cos (\theta) + i \sin (\theta)]$, where r and θ are [real](#). r is known as the [modulus](#) of z and is usually written as $|z|$, while θ is known as the [argument](#) of z and is usually written as $\arg(z)$. (Adding an [integer](#) multiple of 2π to θ leaves the value of z unchanged, so the [argument](#) of a given [complex number](#) has infinitely many possible values. However the unique value that satisfies the restriction $-\pi < \theta \leq \pi$ is called the [principal value of the argument](#), and it is this value that is conventionally quoted when specifying a [complex number](#) in polar form.) [[M3.2](#), [P5.5](#)]

Compare and contrast with [Cartesian form](#) and [exponential form](#), and see complex numbers in the [Maths handbook](#) for the relationship between these forms.

polar representation (of a complex number)

See [polar form \(of a complex number\)](#).

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polarity

of: a [voltage](#) or [potential difference](#) between two [points](#)

is: the specification of which point is at the higher potential. [[P4.4](#)]

is determined: for [induced voltages](#) by [Lenz's law](#). [[P4.4](#)]

is determined: for the [open circuit voltage](#) of an [electric cell](#) by the relative locations of its [electrode](#) materials in the [electrochemical series](#). [[P4.5](#)]

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polarization (in a cell)

is: the concentration of [ions](#) and/or bubbles of [gas](#) around an [electrode](#) in an [electric cell](#). [P4.5]

causes: the [cell's open circuit voltage](#) (e.m.f.) and [current](#) to fall from their initial values. [P4.5]

requires: the inclusion of chemical depolarizers in most commercial [electric cells](#). [P4.5]

polarization (of electromagnetic radiation)

describes: the direction of [oscillation](#) of the [electric field](#) of an [electromagnetic wave](#). At every point this direction must lie in the [plane](#) that is [perpendicular](#) to the [direction of propagation](#) of the [wave](#), but it may be oriented in various ways within that ([transverse](#)) plane. If the same direction may be associated with the oscillation at every point the radiation is said to be [linearly polarized](#). If the direction varies randomly and unpredictably then the radiation is said to be [unpolarized](#). Other [states](#) of polarization are also possible, but are generally more complicated. [[P6.1](#)]

polarizing filter

is: a filter that [transmits](#) only [light](#) of a given [linear polarization](#). [P6.1]

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polaroid

is: a commercially produced plastic material capable of acting as a [polarizing filter](#). [P6.1]

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pole (of a lens)

is: the [point](#) at which the curved boundary of the [lens](#) or [mirror surface](#) [intersects](#) the [optical axis](#).

is also called: the [vertex](#). [[P6.3](#)]

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pole (of a magnet)

See [magnetic pole](#).

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pole (of a parabola)

is synonymous: with [vertex](#). [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

polygon

is: a [geometric figure](#) consisting of [straight lines](#) and enclosing a single [area](#).
[\[M2.1\]](#)

polynomial equation

of: [degree](#) n [M1.4]

is: an [equation](#) of the form

$$a_0 + a_1 x + a_2 x^2 + \dots + a_{n-1} x^{n-1} + a_n x^n = 0$$

where n is a positive [integer](#), and $a_n \neq 0$. (The $n + 1$ [constants](#)

$a_0, a_1, a_2, \dots, a_{n-2}, a_{n-1}$ and a_n are called the [coefficients](#) of the [polynomial](#).)
[M1.4]

polynomial expression

of: [degree](#) n [M1.4]

is: an [expression](#) of the form

$$a_0 + a_1 x + a_2 x^2 + \dots + a_{n-1} x^{n-1} + a_n x^n$$

where n is a positive [integer](#), and $a_n \neq 0$. [M1.4]

Flexible Learning Approach to Physics - Glossary

polynomial function

of: [degree](#) n

is: any [function](#) of the form

$$f(x) = a_0 + a_1 x + a_2 x^2 + \dots + a_{n-2} x^{n-2} + a_{n-1} x^{n-1} + a_n x^n$$

where n is a positive [integer](#), and $a_n \neq 0$. [[M1.3](#), [M1.4](#)]

is exemplified: by $f(x) = x^5 + 3x^3 - x + 2$.

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population

in: [statistics](#)

is: a collection of items about which information is sought. [P1.1]

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Porro prisms

are: [erecting prisms](#). [P6.4]

commonly are used: in binoculars. [P6.4]

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position

of: a [point](#) in [space](#)

in: three [dimensions](#)

is: the property that enables the [point](#) to be located by means of an appropriate set of [position coordinates](#), or by an appropriate [position vector](#) relative to a [coordinate system](#). [[M4.1](#)]

is also used to refer: to the [position coordinates](#) or the position vector, as in a particle at position (x, y, z) , or at position \mathbf{r} .

can be specified: in [linear motion](#) by a single [coordinate](#) such as $x(t)$ and this is then referred to as 'the position'. [[M4.1](#), [M5.1](#)]

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position coordinates

specify: the location of any [point](#) in [space](#). [[P2.1](#), [P2.2](#)]

uniquely determine: the location of any [point](#) in an [n-dimensional space](#), if there are n (independent) [coordinates](#). [[P2.1](#), [P2.2](#)]

usually are presented: in the form of an [ordered multiple](#) e.g. an [ordered pair](#) (x, y) [[P2.1](#), [P2.2](#)]

also are: the [components](#) of the [position vector](#) of that [point](#), so we may write (in two-[dimensions](#)) $\mathbf{r} = (x, y)$. [[P2.1](#), [P2.2](#)]

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position of equilibrium

of: a [system](#) in [stable equilibrium](#)

is: the [position](#) taken up naturally by the [system](#), in which no [resultant forces](#) act. When the [system](#) is displaced from this [position](#) the [restoring forces](#) are directed so as to return the [system](#) to this [equilibrium position](#). [P5.1]

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position vector

of: a [point](#) in [space](#) (relative to a specified [coordinate system](#))

is: the [vector](#) which connects the [origin](#) of the [coordinate system](#) to the [point](#).
[[M2.5](#), [P2.1](#), [P2.7](#)]

is: a special class of [displacement](#) (i.e. [displacement](#) from the [origin](#) of the specified [coordinate system](#).) [[M2.5](#), [P2.1](#), [P2.7](#)]

has magnitude: equal to the [distance](#) from the [origin](#) to the [point](#). [[M2.5](#), [P2.1](#), [P2.7](#)]

has direction: along the [line](#) from the [origin](#) to the [point](#). [[M2.5](#), [P2.1](#), [P2.7](#)]

has components: equal to the [position coordinates](#) of the [point](#), so (in two-[dimensions](#)) $\mathbf{r} = (x, y)$. [[P2.2](#)]

position-time graph

is: a [graph](#) of the [position](#) of an object against [time](#). The convention is to plot the [position](#) vertically and the [time](#) horizontally. The [gradient](#) of the [tangent](#) to the position-time [graph](#) at any particular [time](#) is the [instantaneous velocity](#) at that [time](#). [[M4.1](#),[P2.1](#)]

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positive lens

is: a [lens](#) having a positive [optical power](#). [P6.3]

See also [convex lens](#) or [converging lens](#). [P6.3]

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positron

is: the [antiparticle](#) of the [electron](#). [P9.2]

has: the same [mass](#) as the [electron](#) but opposite (and therefore positive) [charge](#).
The [magnitude](#) of the [charge](#) is the same as that of the [electron](#). [P9.2]

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postulate

is: a statement assumed to be true for the purpose of formulating an argument.

is exemplified: by the postulates of [Einstein's special theory of relativity](#).

potential

See [electric potential](#), [gravitational potential](#) and [equipotential surface](#).

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potential barrier

is: a region of [space](#) where a [particle's potential energy](#) is significantly higher than in the surrounding [space](#). [[P10.4](#), [P11.1](#)]

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potential difference, p.d.

See [electric potential difference](#).

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potential divider

See [voltage divider](#).

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potential energy

of: a [body](#)

is: [energy](#) (i.e. the capacity to do [work](#)) that it has by virtue of its [position](#), shape or internal configuration.

is exemplified: by [gravitational potential energy](#), [strain potential energy](#) and [electrostatic potential energy](#). [[P2.4](#), [P11.1](#)]

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potential energy function

is: a [scalar function](#) of [position](#) which gives the [potential energy](#) of a [particle](#) in [space](#). [[P10.4](#)]

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potential step

is: a region where a [particle's potential energy](#) suddenly increases or decreases. [[P11.1](#)]

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potential well

is: a region of [space](#) where a [particle's potential energy](#) is significantly lower than in the surrounding [space](#). [[P10.4](#)]

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power (mathematical)

is: a superscript following a number or [expression](#) that indicates repeated multiplication (if the exponent is a positive [integer](#)) or some related [operation](#) in other cases. [[M1.5](#)]

is exemplified: by the [square](#) of a quantity, as in $x^2 = x \times x$, where x is said to be raised to the power 2. [[M1.1](#)]

is exemplified: by the [square root](#) of a number $\sqrt{x} = x^{1/2}$, which is said to be raised to the power 1/2. [[M1.1](#)]

is exemplified: by the [reciprocal](#) of a number $1/x = x^{-1}$, which is said to be raised to the power -1. [[M1.1](#)]

See arithmetic and algebra in the [Maths handbook](#).

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power (physical)

is: the rate at which [energy](#) is transferred or converted. [P4.1]

is defined: as the rate of doing [work](#) (i.e. the rate of transferring [energy](#) from one form to another). [M2.6]

therefore can be written: as $P = dW/dt$. [P2.4]

is exemplified: by the power delivered by a [constant force](#) \mathbf{F} , when its point of application moves with constant [velocity](#) \mathbf{v} , which is given by $P = \mathbf{F} \cdot \mathbf{v}$. [P2.4]

is exemplified: by the power consumed by an [electrical component](#) across which there is a [potential difference](#) V and in which there is a [current](#) I , which is given by $P = IV$. If the [electrical component](#) is an [ohmic resistor](#), R , then $P = IV = I^2R = V^2/R$. [P4.1]

has as its SI unit: the [watt](#) (W); $1 \text{ W} = 1 \text{ J s}^{-1}$. [P2.4, P4.1]

See [conservation of energy](#).

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power absorption curve

is: a [graph](#) showing the [mean power](#) transferred per [cycle](#) to an [oscillator](#) by a [driving force](#) as a [function](#) of the driving [frequency](#).

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power factor

for: a [driven oscillator](#)

varies: with the [oscillator's frequency](#). [P5.3]

is: the factor by which the [power](#) absorption of the [oscillator](#) is reduced from its maximum value on [resonance](#). [P5.3]

is given: by the [square](#) of the [sine](#) of the [angle](#) by which the [displacement lags](#) the [driving force](#). [P5.3]

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power law

is: any [expression](#) relating two quantities, x and y that may be written in the form $y = kx^n$, where k and n are [constants](#). [[M1.1](#), [M1.5](#), [P1.3](#)]

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power series

is: a [series](#) of the form

$$P_n(x) = a_0 + a_1(x - a) + a_2(x - a)^2 + a_3(x - a)^3 + \dots + a_n(x - a)^n \quad [\text{M1.7, M4.5}]$$

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power supply

is: a [battery](#) or [voltage generator](#) which is capable of maintaining its [voltage](#) when [current](#) is drawn from it.

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powers of ten

are: numbers of the form 10^n , where n is usually an [integer](#). [M1.2]

sometimes refers: to the [power](#) n itself. [M1.2]

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powers of ten notation

is: a notation in which a number is written as the product of an [integer power of ten](#) and a number (normally between 0 and 10). [[P1.1](#)]

is exemplified: by 73 874, which is written as 7.3874×10^4 . [[P1.1](#)]

is also known: as [scientific notation](#). [[P1.1](#)]

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precession

of: an [axis of rotation](#)

is: the [rotation](#) of the [axis of rotation](#), produced by the application of a [torque](#) which is [perpendicular](#) to the [axis of rotation](#). [[P2.8](#)]

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precision

is: a [measure](#) of the extent to which a particular [measurement](#) from a [set](#) of similar [measurements](#) differs from other members of the [set](#). [[P1.1](#)]

is also: a [measure](#) of the extent to which a [measurement](#) (or value) is free of [random error](#). [[P1.1](#)]

linguistically is: perverse. The greater the precision, the smaller is its numerical value. A clearer way of expressing it is to say that a quantity is 'precise to within plus-or-minus so-much'. [[P1.1](#)]

can be quantified: as (typically) plus or minus two [standard errors of the mean](#), but conventions differ. [[P1.1](#)]

Compare with [accuracy](#).

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pressure

is: a [macroscopic](#) property of a [system](#), defined as the [magnitude](#) of the [perpendicular force](#) per [unit area](#) exerted by the [system](#) on any [plane area](#).
[P7.2]

has as its SI unit: the [pascal](#) (Pa), where $1 \text{ Pa} = 1 \text{ N m}^{-2}$. [P7.2]

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primary coil

in: a [transformer](#) or [mutual induction circuit](#)

is: the part of the [circuit](#) which is connected directly to the input from some external source. [[P4.4](#)]

primitive

See [indefinite integral](#).

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principal maxima

in: the [interference pattern](#) of a [diffraction grating](#)

are: the most prominent [intensity](#) maxima. [[P6.1](#)]

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principal molar specific heats

are: the [specific heats](#) C_p and C_v at constant [pressure](#) and at constant [volume](#), respectively. [[P7.4](#)]

See also [ratio of specific heats](#).

principal quantum number

for: an [electron energy level](#)

in: an [atom](#)

is: the [quantum number](#) n which is used to label the [electron energy level](#) according to the [shell](#) that contains the [electrons](#). [[P8.3](#), [P8.4](#)]

can have: one of the [integer](#) values 1, 2, 3, ... [[P8.3](#), [P8.4](#)]

is essentially equivalent: for the hydrogen [atom](#), to [Bohr's quantum number](#). [[P8.2](#)]

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principal rays

in: a [ray diagram](#)

for: a [lens](#) or [mirror](#)

are: the defining [rays](#) which can be used to find the relative positions of [object](#) and [image](#). [P6.3]

are classified: in two types. One type travels parallel to the [optical axis](#) and then passes through (or appears to pass through) the [first](#) or [second focal points](#) of the [lens](#) or the [focal point](#) of the [mirror](#). The other type passes undeviated through the centre of the [lens](#) or [reflects](#) from the [pole](#) of the [mirror](#) with equal [angles of incidence](#) and [reflection](#). [P6.3]

principal value (of the argument)

is: a value of the [argument of a complex number](#) which lies within a specified range. The range usually chosen is $-\pi < \arg(z) \leq \pi$. [[M3.2](#), [P5.5](#)]

principle of conservation of charge

See [conservation of charge](#).

principle of conservation of mechanical energy

See [conservation of mechanical energy](#).

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principle of entropy increase

states: that in any process, the [entropy](#) of the [Universe](#) never decreases. [P7.4]

more precisely, states: that $\Delta S_{\text{universe}} \geq 0$, where the equality holds for [reversible](#) processes and the inequality for [irreversible](#) processes. [P7.4]

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principle of rectilinear propagation

states: that [light](#) travels in [straight lines](#) in a [uniform medium](#). [P6.2]

is: a basic principle of [geometric optics](#). [P6.2]

principle of reversibility

in: [optics](#)

states: that the result of reversing the direction of a [light ray](#) is another valid [light ray](#). [P6.2]

is: a basic principle of [geometric optics](#). [P6.2]

principle of superposition

states, in general: that the total of several separate but similar effects (for example, [magnetic fields](#) due to various sources) is the [sum](#) of the individual effects. [P4.2]

applies only: when the [equations](#) describing the effects are [linear](#). [P5.1, P5.5, P6.1]

states, for example: that the [gravitational](#) (or [electric](#) or [magnetic](#)) [field strength](#) at any point due to a distribution of [masses](#) (or [charges](#) or [magnetic poles](#)) is found by adding the contributions of the individual [masses](#) (or [charges](#) or [magnetic poles](#)) at that point. [P3.1]

also states, for example: that if two or more [waves](#) meet in a region of [space](#), then at each instant of [time](#) the net disturbance at any [point](#) is given by the [sum](#) of the disturbances created by each of the [waves](#) individually. [P5.1, P5.6, P5.7, P6.1]

and in a different context, states as well: that in a [circuit](#) made up of [linear components](#) and containing several [voltage generators](#), the resulting [current](#) in, or [voltage](#) across, any [linear component](#) will be the [algebraic sum](#) of those [currents](#) or [voltages](#) produced in or across that [linear component](#) when each of the [voltage generators](#) is taken in turn, with all other [voltage generators](#) replaced by [short circuits](#). [P4.1]

principle of virtual work

is: a procedure in which an imagined [displacement](#) of a [system](#) and the [calculation](#) of the [work done](#) leads to a result which is independent of the [displacement](#) and thus represents a valid statement about the [system](#) itself.
[P7.6]

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prism

is: a [three-dimensional geometrical](#) form with two parallel faces that are identical in size and shape and which has a constant cross section parallel to those faces. If one of the parallel faces is treated as the base, the [volume](#) of the prism is given by the product of the [area](#) of that face and the [perpendicular height](#).
[M2.1]

in optics, is: a piece of (good quality) glass in the shape of a [triangular](#) prism (i.e. a solid body whose cross section at any point along one [axis](#) is a [triangle](#) of [uniform](#) size). Such prisms may be used for [total internal reflection](#), as in binoculars, or for the [dispersion](#) of [light](#) to reveal the different colours ([wavelengths](#)) contained in a single [beam](#). [P6.2, P6.3]

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prism angle

is: the [angle](#) between the [refracting](#) faces of a [prism](#). [P6.3]

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probability

is: a quantitative [measure](#) of the relative likelihood of a particular outcome resulting from a specified procedure.

may be: [normalized](#), so that the [sum](#) of the probabilities of all possible outcomes is 1.

is exemplified: by the probability of obtaining a six with one roll of a fair die being $1/6$.

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probability density

for: a [one-dimensional quantum system](#), consisting of a [particle](#) with [potential energy](#) $U(x)$ in a [state](#) described by a [wavefunction](#) $\Psi(x, t)$

is: $P(x, t) = \Psi^*(x, t)\Psi(x, t) = |\Psi(x, t)|^2$. [[M5.4](#), [P10.3](#), [P10.4](#), [P11.1](#), [P11.2](#)]

determines: according to the [Born probability hypothesis](#), the probability at [time](#) t of finding the [particle](#) in the small region of the [x-axis](#) between x and $x + \Delta x$. This [probability](#) is [proportional](#) to $P(x, t)\Delta x$, and will be equal to $P(x, t)\Delta x$ if the [wavefunction](#) has been [normalized](#). [[M5.4](#), [P10.3](#), [P10.4](#), [P11.1](#), [P11.2](#)]

is independent: of [time](#) for [stationary states](#) and can then be written as $P(x) = |\psi(x)|^2$, where $\psi(x)$ is the [spatial part of the wavefunction](#) $\Psi(x, t)$. [[M5.4](#), [P10.3](#), [P10.4](#), [P11.1](#), [P11.2](#)]

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probable error

in: a single quantity subject to n independent [errors](#) $\pm e_1, \pm e_2, \dots \pm e_n$.

is: the quantity $E = \sqrt{e_1^2 + e_2^2 + e_3^2 + \dots + e_n^2}$ [\[P1.2\]](#)

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produced

describes: a [straight line segment](#) AB when it is extended beyond A or B.
[\[M2.1\]](#)

product

See [operation](#).

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product formulae

are: a class of [trigonometric identities](#). [[M1.6](#)]

See trigonometric functions in the [Maths handbook](#).

product identities

are: a class of [hyperbolic function identities](#). [M4.6]

See hyperbolic functions in the [Maths handbook](#).

product rule (of differentiation)

is: $\frac{d}{dx}[f(x)g(x)] = \frac{df}{dx}g(x) + f(x)\frac{dg}{dx}$. [\[M4.2\]](#)

projectile

is: an object that is launched into the air near the Earth's surface and whose subsequent [motion](#) is determined by the influence of [gravity](#) (and, possibly [air resistance](#)). [P2.2]

has motion: which (in the absence of [air resistance](#)) is characterized, in the absence of other [forces](#), by a [uniform](#) horizontal [velocity component](#) and a [uniform](#) vertical [acceleration component](#). [P2.2]

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projection

of: a [vector](#) \mathbf{b} onto a [vector](#) \mathbf{a} .

is: the ([scalar](#)) [component](#) of the [vector](#) \mathbf{b} in the [direction](#) of \mathbf{a} . [[M2.6](#), [P5.1](#)]

is given: by $\frac{\mathbf{a} \cdot \mathbf{b}}{|\mathbf{a}|}$. [[M2.6](#)]

See [scalar component](#).

propagation

means: the act of travelling from place to place.

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proper integral

is: a [definite integral](#) in which the [upper and lower limits](#) are both finite, and the [integrand](#) does not become infinite anywhere in the [range of integration](#).

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proportional

See [directly proportional](#), [inversely proportional](#), [proportionality](#).

proportionality

is possessed: by two quantities if a change by a [factor](#) in one of them implies a change by the same [factor](#) in the other. If the quantity y is [proportional](#) to x , their relationship is written as $y \propto x$. [[P1.1](#)]

proportionality constant

See [constant of proportionality](#).

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proton

is: the [nucleus](#) of the lightest kind of hydrogen [atom](#) and a fundamental constituent of all other [nuclei](#), their number being represented by the [atomic number](#) Z . [[P3.3](#), [P8.1](#)]

has: a positive [charge](#) $+e \approx 1.602 \times 10^{-19} \text{ C}$ where the [charge](#) on the [electron](#) is $-e$ [[P3.3](#), [P8.1](#)]

has: a [mass](#) equal to $1.673 \times 10^{-27} \text{ kg}$, which is approximately 1836 times the [mass](#) of an [electron](#) and represents a [relative atomic mass](#) of 1.007, slightly less than that of the [neutron](#) which it resembles in some ways (for instance, the typical [nuclear](#) size scale of 10^{-15} m may be taken to roughly represent the 'diameter' of both [particles](#)). [[P3.3](#), [P8.1](#)]

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pulse

See [solitary wave](#).

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pupil

is: the variable [aperture](#) in the [iris](#) through which [light](#) enters the eye. [[P6.4](#)]

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PVT-surface

for: a given [amount](#) (usually expressed in [moles](#)) of any substance whose [equilibrium states](#) are determined by any two of the variables [pressure](#), [volume](#) and [temperature](#).

is: a continuous [two-dimensional surface](#) formed by plotting the [pressure](#), [volume](#) and [temperature](#) of every [equilibrium state](#) of the substance on three [perpendicular axes](#). Each [point](#) on the [surface](#) thus represents a possible [equilibrium state](#), and the whole [surface](#) may be regarded as a representation of the [equation of state](#) of the relevant amount of that substance. [[P7.2](#), [P7.3](#), [P7.4](#)]

for an ideal gas is: a [graphical](#) representation of the [equation of state of an ideal gas](#) ($PV = nRT$) for a fixed value of n . [[P7.2](#), [P7.3](#), [P7.4](#)]

is also referred to: as the equilibrium surface, though this term may also be applied to more general [systems](#) for which P , V , and T are not appropriate [thermodynamic coordinates](#). [[P7.2](#), [P7.3](#), [P7.4](#)]

often is drawn: in [two-dimensional](#) projections in which P is plotted against V , P against T , or V , against T . [[P7.2](#), [P7.3](#), [P7.4](#)]

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pyrometer

is: a device for analysing the [light](#) (or more generally the [electromagnetic spectrum](#)) emitted by a hot object. [[P7.2](#)]

can be used: as a [thermometer](#), since the [spectrum](#) is a well-characterized [function](#) of [temperature](#). Indeed the [International Practical Temperature Scale 1990](#) known as [IPTS-90](#) recommends its use above 961.78 °C. [[P7.2](#)]

Pythagoras's theorem

states: that the [square](#) of the [hypotenuse](#) in a [right-angled triangle](#) is equal to the [sum](#) of the [squares](#) of the other two sides. [[M1.6](#), [M2.1](#), [P2.1](#)]

may be written: $a^2 + b^2 = c^2$. [[M1.6](#), [M2.1](#), [P2.1](#)]

Q-factor (quality factor)

See [quality factor](#).

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Q-value

is: the amount of [kinetic energy](#) released as a result of a [nuclear reaction](#).
[P9.1]

is: for a [nuclear decay](#), the [kinetic energy](#) shared by the [decay](#) products. [P9.1]

always is: for a spontaneous reaction, greater than zero: $Q \geq 0$. [P9.1]

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quadrant

is: a quarter of a [circle](#) or disc, being a region bounded by a [circular arc](#) and two [diameters](#) that intersect at [right angles](#). [M2.1]

is also: a quarter of a ([two-dimensional](#)) [Cartesian coordinate system](#), being a region bounded by two [axes](#) that intersect at [right angles](#).

quadratic equation

is: a [polynomial equation](#) of [degree](#) 2, i.e. an [equation](#) of the form $ax^2 + bx + c = 0$, where $a \neq 0$. [[M1.3](#), [M1.4](#)]

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quadratic expression

is: an [expression](#) of the form $ax^2 + bx + c$, where $a \neq 0$. [M1.4]

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quadratic function

is: a [function](#) of the form $f(x) = ax^2 + bx + c$, where $a \neq 0$. [[M1.3](#), [M1.4](#)]

quadrilateral

is: a four-sided [polygon](#). [[M2.1](#)]

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quality factor (Q -factor)

for: an [oscillator](#)

is: a 'figure of merit' describing the quality of the [oscillator](#). [P5.2]

is: the factor by which the [power](#) absorption of a [driven oscillator](#) on [resonance](#) exceeds that for the [oscillator](#) when the [frequency](#) of the [driving force](#) is well away from the [resonance frequency](#). [P5.3]

is equal: to the [ratio](#) of the [resonance frequency](#) to the [resonance bandwidth](#) between the two [half-power points](#). [P5.3]

is also given: by 2π times the [magnitude](#) of the [reciprocal](#) of the fractional [energy](#) loss over one [period](#) of [oscillation](#), i.e. $Q = 2\pi E(t)/|(\Delta E)_T|$. [P5.2]

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quanta

is: the plural of [quantum](#).

quantization

See [quantized](#).

quantization of charge

is the observation: that all experimentally isolated [charges](#) are (positive or negative) [integer](#) multiples of the [charge](#) e , where $e = 1.602 \times 10^{-19}$ C (to four [significant figures](#)). [[P3.3](#)]

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quantized quantity

describes: a quantity which has only certain separated or discrete values, as opposed to a continuous range of values. [P10.3]

appears: often in [quantum physics](#) but not in [classical physics](#) (except for the allowed [frequencies](#) of [standing waves](#) – from which the idea of [quantum physics](#) evolved). [P8.2]

is exemplified: in the [Bohr model](#) for [atomic](#) hydrogen, by the [atomic electron](#) having only certain values for the [magnitude](#) of its [angular momentum](#) about the [nucleus](#) ([Bohr quantization condition](#)), which leads also to quantized [energy levels](#) for the [atomic electron's bound states](#). [P8.2, P8.3]

is also exemplified: when [electromagnetic radiation](#) interacts with [matter](#), by the [energy](#) transfers being quantized in terms of [photons](#) ([quantum theory of electromagnetic radiation](#)). [P8.2]

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quantum

is: a term that can be applied both to [matter](#) and to [electromagnetic radiation](#) in order to avoid referring to either as '[particles](#)' or '[waves](#)'. These latter terms can be used only in certain circumstances ('[particles](#)' for [interactions](#), '[waves](#)' for [propagation](#)), whereas the term 'quantum' refers to both types of behaviour. [[P10.1](#), [P10.3](#)]

often referred to: as a [particle](#). [[P10.1](#), [P10.3](#)]

See also [photon](#).

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quantum field theory

is: the branch of [quantum theory](#) that concerns [systems](#) with an infinite number of [degrees of freedom](#), and may be contrasted with [quantum mechanics](#) which concerns [systems](#) with a finite number of [degrees of freedom](#).

is used: mainly in the study of [elementary particles](#).

is characterized: by consistency with [Einstein's special theory of relativity](#).

quantum harmonic oscillator

is: a [quantum mechanical system](#) in which a [particle](#) of [mass](#) m moves (in [one dimension](#)) under the influence of a [potential energy function](#) $U(x) = k_s x^2 / 2$ [P11.2]

has: [energy levels](#) $E_n = (n + 1/2)hf$, where $n = 0, 1, 2, 3, \dots$, and h is [Planck's constant](#). [P11.2]

has: [spatial wavefunctions](#) $\psi(x) = A_n f_n(x) \exp(-\alpha x^2 / 2)$ where $n = 0, 1, 2, 3, \dots$,

A_n is a constant, $f_n(x)$ is a particular [polynomial function](#) of x of [degree](#) n with n [nodes](#), and $\alpha = (2\pi/h)$ [P11.2]

has: [zero point energy](#) $E_0 = hf/2$ when $n = 0$. [P11.2]

exhibits: [classical behaviour](#) as n approaches [infinity](#). [P11.2]

quantum mechanical exchange effects

are: phenomena in [quantum mechanics](#) arising from the requirement that [observable](#) properties of [systems](#) containing several identical [particles](#) should be unchanged by the interchange of the [coordinates](#) of those [particles](#). (Such effects have no direct analogues in [classical physics](#).)

quantum mechanics

is: a wide-ranging [theory](#) that describes the behaviour of [mechanical systems](#) (such as a particle moving under the influence of a given [potential energy function](#)) in situations where the laws and methods of [classical mechanics](#) may be inapplicable. [[M6.4](#), [P7.1](#), [P8.3](#), [P10.3](#)]

more formally is: the branch of [quantum theory](#) that concerns [systems](#) with a finite number of [degrees of freedom](#), and may be contrasted with [quantum field theory](#) which concerns [systems](#) with an infinite number of [degrees of freedom](#).

may be formulated: in a number of equivalent ways, one such formulation being Erwin Schrödinger's wave mechanics. [[M6.4](#), [P7.1](#), [P8.3](#), [P10.3](#)]

was founded: mainly by European physicists between 1925-1927. [[M6.4](#), [P7.1](#), [P8.3](#), [P10.3](#)]

is used: mainly in the study of microscopic [systems](#) such as [molecules](#), [atoms](#) and [nuclei](#). [[M6.4](#), [P7.1](#), [P8.3](#), [P10.3](#)]

is characterized: by the existence of a ([de Broglie](#)) [wave](#) description of [matter](#) and by the ensuing [Heisenberg uncertainty principle](#) and the impossibility of simultaneously determining the [position](#) and [momentum](#) of a [particle](#) with arbitrarily high [precision](#), thus denying the possibility that an [electron](#) in an [atom](#) moves in a well defined observable [orbit](#).

is also characterized: by the occurrence of [quantized quantities](#); by the use of [probability](#) (as in the [Born probability interpretation](#) of the [wavefunction](#)); and by inconsistency with [Einstein's special theory of relativity](#).

See [quantum](#) and [Schrödinger equation](#).

Flexible Learning Approach to Physics - Glossary

quantum model (of the atom)

See [Schrödinger model](#).

quantum number

for: a confined [particle](#)

is: a quantity whose possible values characterize the possible [eigenfunctions](#) ([wavefunctions](#)) of the [particle](#). [P8.3]

is exemplified: for a [particle](#) confined in one [dimension](#) between parallel plates, by the **one** quantum number n (which can have the value 1 or 2 or 3, etc.) which is required to specify each of the [particle's](#) possible [energy eigenfunctions](#) ([spatial wavefunctions](#)). [P11.2]

is exemplified: for a [particle](#) that is confined in three [dimensions](#) in a cube, by the **three** quantum numbers n_1, n_2, n_3 (n_1, n_2 and n_3 can each be equal to 1 or 2 or 3, etc.) which are required to specify each of the [particle's](#) possible [energy eigenfunctions](#) ([spatial wavefunctions](#)). [P11.2]

most usually is: a number (or one of a [set](#) of such numbers) specifying a particular [energy eigenfunction](#) ([spatial wavefunction](#)) and the corresponding [energy eigenvalue](#) ([energy level](#)) of the confined [particle](#). [P10.3, P10.4]

is exemplified: for [electrons](#) in an [atom](#), by the [principal quantum number](#) n the [orbital angular momentum quantum number](#) l , the [orbital magnetic quantum number](#) m_l and the [spin magnetic quantum number](#) m_s . [P8.3, P11.3]

Flexible Learning Approach to Physics - Glossary

quantum physics

is: the broad area of [physics](#) that concerns the theoretical and experimental study of phenomena such as the [photoelectric effect](#), [Compton scattering](#), [electron diffraction](#) and the [spectra](#) of [atoms](#), which cannot be adequately described on the basis of [classical physics](#). [[P10.1](#), [P10.2](#)]

applies: to objects of all sizes, but its consequences are more commonly [observable](#) at an [atomic](#) scale. [[P10.2](#)]

has had great success: in describing the behaviour of [nuclei](#), [atoms](#), [molecules](#) and the properties of [solids](#), using [quantum mechanics](#); and in describing the behaviour of [elementary particles](#), using [quantum field theory](#). [[P10.1](#), [P10.2](#)]

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quantum state

of: a [system](#)

in: [quantum mechanics](#) (or, more generally, [quantum physics](#))

is: the most complete description of the properties of a [system](#) allowed by its [wavefunction](#). It may include the values that various [observables](#) (such as [momentum](#) and [energy](#)) will be found to have if measured, or it may be confined to statements about the relative [probability](#) of various possible outcomes of a [measurement](#). [[M6.4](#), [P7.1](#), [P8.3](#), [P8.4](#), [P10.3](#), [P10.4](#)]

is specified: in sufficiently simple cases, by the values of a set of [quantum numbers](#). [[M6.4](#), [P7.1](#), [P8.3](#), [P8.4](#), [P10.4](#)]

See [stationary state](#).

Flexible Learning Approach to Physics - Glossary

quantum theory

is: the theoretical part of [quantum physics](#). It encompasses [quantum mechanics](#) and [quantum field theory](#).

is also: used to indicate the early pre-[quantum mechanics](#) stage of [quantum physics](#).

Flexible Learning Approach to Physics - Glossary

quantum theory of electromagnetic radiation

holds: that when [electromagnetic radiation](#) is emitted or absorbed by [matter](#), the [energy](#) transfers are in terms of the [emission](#) or [absorption](#) of [photons](#). They are *not* continuous: arbitrarily small [energy](#) transfers are *not* possible. [P8.2]

holds: that the [energy](#) of a [photon](#) is given by $E = hf$, where f is the [frequency](#) of the associated [radiation](#) and h is [Planck's constant](#). [P8.2]

more generally is: a wide ranging and very mathematical branch of [quantum theory](#).

Flexible Learning Approach to Physics - Glossary

quantum tunnelling

is: the process by which a [particle](#) tunnels through a [potential barrier](#) to the other side, even though the presence of the [particle](#) within the [potential barrier](#) (where its [potential energy](#) would exceed its total [energy](#)) is forbidden by [classical physics](#). [[P10.2](#), [P10.4](#)]

is made possible: by the [quantum](#) nature of [matter](#). [[P10.2](#)]

is also called: barrier penetration. [[P10.4](#)]

Flexible Learning Approach to Physics - Glossary

quark

See [elementary particle](#).

Flexible Learning Approach to Physics - Glossary

quartic equation

is: any fourth-[degree polynomial equation](#) that may be written in the form:

$$ax^4 + bx^3 + cx^2 + dx + e = 0$$

where a , b , c , d , and e are [constants](#), and $a \neq 0$. [\[M1.4\]](#)

Flexible Learning Approach to Physics - Glossary

quartic function

is: a [polynomial function](#) of [degree](#) 4. [[M1.3](#)]

Flexible Learning Approach to Physics - Glossary

quartz crystal oscillator

is: an [electrical oscillator](#) and [mechanical oscillator](#) combined. [P5.3]

is sustained: by the [piezoelectric](#) properties of a quartz crystal. [P5.3]

works: when an [electric field](#) deforms the crystal, so that the [energy](#) of the [oscillation](#) is stored in the crystal as [mechanical energy](#), and the crystal, in recovering, produces an [electric field](#) and therefore a [current](#), whose [energy](#) now is stored in the rest of the [circuit](#) as [electrical energy](#), and so on around again. [P5.3]

in other words, is like: an [electrical oscillator](#), with the [capacitor](#) mainly replaced by the quartz crystal.

Flexible Learning Approach to Physics - Glossary

quasistatic process

in: [thermodynamics](#)

is: a process in which the [state](#) of a [system](#) changes sufficiently slowly that it is always [infinitesimally](#) close to an [equilibrium state](#). [[P7.3](#), [P7.4](#)]

therefore can be shown: as a pathway on the equilibrium [\(PVT\)-surface](#) of a [system](#). [[P7.3](#), [P7.4](#)]

but never can be achieved: fully in practice, because it would take an infinite length of [time](#). [[P7.3](#), [P7.4](#)]

quotient

See [operation](#).

Flexible Learning Approach to Physics - Glossary

quotient of two complex numbers

for: $Z_1 = a_1 + ib_1$ and $Z_2 = a_2 + ib_2$

is: $\frac{Z_1}{Z_2} = \frac{a_1a_2 + b_1b_2 + i(a_2b_1 + a_1b_2)}{a_2^2 - b_2^2}$ [M3.1]

quotient rule (of differentiation)

states that: $\frac{d}{dx} \left[\frac{f(x)}{g(x)} \right] = \frac{f'(x)g(x) - f(x)g'(x)}{[g(x)]^2}$ [M4.2]

Flexible Learning Approach to Physics - Glossary

r.m.s.

is: an abbreviation for [root-mean-square](#). [P5.4]

Flexible Learning Approach to Physics - Glossary

radial

means: pertaining to the direction measured outwards or inwards, directly away from or towards a [centre](#) or [origin](#).

Flexible Learning Approach to Physics - Glossary

radial coordinate

of: a [point](#) in a system of [polar coordinates](#)

is: the [distance](#) from the [origin](#) to the [point](#). [M2.2]

radial probability density

is: the factor $4\pi r^2 |R_{nl}(r)|^2$, that arises in calculating the [probability density](#) $|\psi(r, \theta, \phi)|^2$, where $R_{nl}(r)$ is the [radial](#) part of the [spatial wavefunction](#) $\psi(r, \theta, \phi)$ in [Schrödinger's model of the hydrogen atom](#). [P11.3]

represents: the [probability](#) per unit increment of r of finding the [electron](#) at distance r from the [nucleus](#).

Flexible Learning Approach to Physics - Glossary

radian, rad

is: a [dimensionless derived unit](#) of [plane angle](#). [[M1.6](#), [M2.1](#)]

is defined: by requiring that, for any [circle](#), the [arc](#) subtended at the [circumference](#) by an [angle](#) of 1 radian at the [centre](#) has a [length](#) equal to that of the [circle's radius](#); so there are 2π radians in one complete [revolution](#) of 360° and $1 \text{ radian} \approx 57.3^\circ$. [[M1.6](#), [M2.1](#)]

See [degree](#).

Flexible Learning Approach to Physics - Glossary

radiation (α -, β -, γ -)

is: a general term for the [particles](#) (e.g. [\$\alpha\$ -particles](#) and [\$\beta\$ -particles](#)) and [electromagnetic radiation](#) (e.g. [\$\gamma\$ -rays](#)) emitted during [nuclear reactions](#), particularly [radioactive decay](#).

radiation (electromagnetic)

See [electromagnetic radiation](#).

radiation (general)

refers: to anything travelling in a stream, especially [subatomic particles](#) or [electromagnetic waves](#).

See [radiation \(\$\alpha\$ -, \$\beta\$ -, \$\gamma\$ -\)](#) and [electromagnetic radiation](#).

Flexible Learning Approach to Physics - Glossary

radiation (thermal)

is: one of three ways (the other two being [conduction](#) and [convection](#)) in which [heat](#) can be transferred. [P7.3]

operates: not only in [transparent](#) materials ([gases](#), [liquids](#) and [solids](#)), but also in a [vacuum](#). [P7.3]

works: through [emission](#) and [absorption](#) of [energy](#) carried by [electromagnetic radiation](#). [P7.3]

can be understood: very precisely in [microscopic](#) terms, provided that the [surface](#) emitting the radiation can be treated as that of an idealized [black-body](#). (The next best [approximation](#) is to characterize the [surface](#) by a constant [emissivity](#) $\varepsilon \leq 1$.) The total [power emitted](#) per [unit area](#) of a [black-body](#) at [temperature](#) T is described by [Stefan's law](#) ($R = \sigma T^4$), and its [spectral brightness](#) is described by [Planck's function](#). [P7.3]

goes: both ways. When a hot [body](#) and a cold [body](#) exchange [heat](#) by radiation, *both* [bodies emit](#) and *both* [bodies absorb](#), so the net [heat](#) flow is a difference. In some applications where there is a large [temperature](#) difference, the [heat emitted](#) by the cold [body](#) is small enough that it can be safely neglected. [P7.3]

Flexible Learning Approach to Physics - Glossary

radiation pressure

is: [pressure](#) exerted on a [surface reflecting](#) or [absorbing electromagnetic radiation](#) as a consequence of the [momentum](#) carried by that [radiation](#). [[P10.1](#)]

radiation weighting factor, RWF

is: a measure of the ability of [ionizing radiation](#) to [ionize](#) the [molecules](#) of living tissue. [X-rays](#) are defined to have $RWF = 1$ and other [radiations](#) have their RWF determined relative to [X-rays](#). [[P9.3](#)]

See [dose equivalent](#).

Flexible Learning Approach to Physics - Glossary

radio waves

are: [electromagnetic waves](#) with [wavelengths](#) greater than approximately 0.03 m.

See [electromagnetic spectrum](#).

radioactive decay

is: the spontaneous [decay](#) of an [unstable nucleus](#) (usually of one of the heavier [elements](#)) into a lighter [nucleus](#) by the [emission](#) of [\$\alpha\$ -particles](#) or [\$\beta\$ -particles](#) or [\$\gamma\$ -radiation](#). [[P9.1](#), [P9.2](#)]

radioactive decay equation

See [radioactive decay law](#).

radioactive decay law

is: the [law](#) which governs the number of [nuclei](#) $N(t)$ of a [radioactive isotope](#) that will remain in a sample after a given [time](#) t has elapsed. [[P1.3](#), [P9.2](#)]

is: exponential: $N(t) = N_0 e^{-\lambda t}$, where N_0 is the initial number of [nuclei](#) and λ is the [decay constant](#). [[P1.3](#), [P9.2](#)]

arises: as a solution to the [first-order differential equation](#) $dN/dt = -\lambda N$. [[M6.2](#)]

Flexible Learning Approach to Physics - Glossary

radioactive nucleus

is: a [nucleus](#) which is [unstable](#) and which therefore spontaneously [decays](#).
[\[P9.1\]](#)

radioactivity

See [radioactive decay](#).

radiocarbon dating

is: a method of dating (finding the age of) a sample that contains carbon absorbed from the atmosphere. The age is obtained by finding the relative amounts of the [radioactive](#) $^{14}_6\text{C}$ [isotope](#) and the [stable](#) $^{12}_6\text{C}$ [isotope](#). [P9.2]

is used mainly: in archaeology and for studies of relatively recent geological events (less than 50000 years ago). It can give the age of wood, shell, bone and other forms of organic material. [P9.2]

is also known: as carbon dating. [P9.2]

Flexible Learning Approach to Physics - Glossary

radioisotope

is: an [isotope](#) which is [unstable](#) and which therefore undergoes [radioactive decay](#). [[P9.2](#)]

radionuclide

is: a [nuclide](#) which is [unstable](#) and which therefore undergoes [radioactive decay](#). [[P9.2](#)]

Flexible Learning Approach to Physics - Glossary

radius

is: the [distance](#) from the [centre](#) of a [circle](#) to a [point](#) on its [circumference](#), or the [distance](#) from the [centre](#) of a [sphere](#) to a [point](#) on its [surface](#). [[M2.1](#), [M2.3](#)]

is also: the [distance](#) (which will vary with orientation) from the [centre](#) of an [ellipse](#) to a [point](#) on its [perimeter](#). [[M2.3](#)]

Flexible Learning Approach to Physics - Glossary

radius of curvature

for: a [spherical surface](#)

is: the [radius](#) of the [sphere](#) of which the [surface](#) forms a part. [[P2.6](#), [P6.3](#)]

can be: according to a commonly adopted [sign convention](#), positive or negative for a [convex](#) or [concave surface](#), respectively. (See [Cartesian sign convention](#).) [[P2.6](#), [P6.3](#)]

Flexible Learning Approach to Physics - Glossary

radius of gyration

of: a [body](#) of [mass](#) M

about: a particular [axis of rotation](#)

is: the [distance](#) k from the [axis of rotation](#) that a [particle](#) of (the same) [mass](#) M would have to be, in order for its [moment of inertia](#) I about the [axis](#) to be the same as that of the real [body](#). [P2.7]

therefore is defined: by $I = Mk^2$. [P2.7]

Flexible Learning Approach to Physics - Glossary

radius vector

of: a [point](#)

in: a [polar coordinate system](#) (including [spherical polar coordinates](#))

is: a [directed line segment](#), from the [origin](#) to the [point](#). (Its magnitude is the [radial coordinate](#) of the point.) [[M2.2](#)]

Flexible Learning Approach to Physics - Glossary

random error

in: a [measurement](#)

is: the kind of [error](#) that causes the results to be distributed around a [mean value](#) and so reduces the [precision](#). [[P1.1](#), [P1.2](#)]

arises: from many causes, including non-[systematic](#) instrumental errors such as limitations in the scale on which the [measurement](#) is based. [[P1.1](#), [P1.2](#)]

can be reduced: (within limits) by [averaging](#) repeated [measurements](#). [[P1.1](#), [P1.2](#)]

limits: the [precision](#) of a [measurement](#).

Contrast with [systematic error](#) which determines [accuracy](#).

Flexible Learning Approach to Physics - Glossary

random motion

can characterize: the [motion](#) of one [particle](#) over a very long [time](#), or many particles over an arbitrary [time](#). [[P7.5](#)]

is defined: by the absence of any preferred [direction](#) or [speed](#). In the case of the [motion](#) of one [particle](#), this means that at some [time](#) the [particle](#) will be found to be moving in any pre-specified direction with any pre-specified [speed](#). [[P7.5](#)]

Flexible Learning Approach to Physics - Glossary

range

is: the [distance](#) between the [point](#) from which a [projectile](#) is launched and the [point](#) at which it lands. If the two [points](#) are at the same vertical height, the range is sometimes referred to as the horizontal range. [[P2.2](#)]

Flexible Learning Approach to Physics - Glossary

range of integration

for: a [definite integral](#)

is: the range of values bounded by the [lower](#) and [upper limits of integration](#).
[\[M5.2\]](#)

Flexible Learning Approach to Physics - Glossary

rarefaction

in: a [medium](#)

is: a region where the [pressure](#) and hence the [density](#) of the [medium](#) are lower than [average](#). [[P5.7](#)]

Flexible Learning Approach to Physics - Glossary

rate of change

is: the [derivative](#) of a [function](#) with respect to its [independent variable](#). [[M4.1](#), [M4.2](#)]

usually refers: to situations where the [independent variable](#) is [time](#), but is not entirely restricted to such cases. [[M4.1](#), [M4.2](#)]

Flexible Learning Approach to Physics - Glossary

ratio

of: two quantities

is: one quantity divided by the other quantity.

is also: known as quotient.

Flexible Learning Approach to Physics - Glossary

ratio of specific heats

for: a substance

is: the [ratio](#) of the [principal specific heats](#), $\gamma = c_p/c_v$. [P7.4]

is equivalently: the [ratio](#) of the [molar specific heats](#) $\gamma = C_p/C_v$. [P7.4]

is exemplified: for a [monatomic ideal gas](#), by $\gamma = 5/3$ [P7.4]

is also exemplified: for a [diatomic ideal gas](#), by $\gamma = 7/3$ [P7.4]

Flexible Learning Approach to Physics - Glossary

rational number

is: a number which can be expressed as a [fraction](#). [[M1.2](#), [M3.1](#)]

more precisely is: a number which can be expressed in the form m/n where m and n are [integers](#). [[M1.5](#)]

Flexible Learning Approach to Physics - Glossary

rationalization

is: the [algebraic](#) procedure whereby a [differential equation](#) is manipulated to remove all [fractional powers](#) of [derivatives](#). [M6.1]

is more generally: any procedure that removes [fractional powers](#) from the [denominator](#) of an [algebraic](#) or numerical [fraction](#).

Flexible Learning Approach to Physics - Glossary

rationalizing a (complex) quotient

is: the process of converting a [complex quotient](#) (such as $(3 + 2i)/(1 + 4i)$) to the form $x + iy$ where x and y are [real numbers](#). [M3.1]

involves: multiplying the [numerator](#) and the [denominator](#) of the [quotient](#) by the [complex conjugate](#) of the [denominator](#).

See complex numbers in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

ray

is: that part of a [straight line](#) that extends from a given [point](#) in one [direction](#) only. [[M2.1](#)]

is also used: as an abbreviation for [light ray](#).

Flexible Learning Approach to Physics - Glossary

ray approximation

is: the [approximation](#) to the [wave model of light](#) in which [diffraction](#) effects may be ignored and [light](#) treated as though it travels along [rays](#). [P6.2]

provides the basis: for [geometrical optics](#).

Flexible Learning Approach to Physics - Glossary

ray diagram

in: [geometrical optics](#)

is: a diagram which is used to find the relative positions of [object](#) and [image](#) for a [lens](#) or [mirror](#), using the [principal rays](#). [[P6.3](#)]

Rayleigh criterion

is: an arbitrary criterion establishing the condition in which the [optical images](#) of two [point-like objects](#) can be said to be [resolved](#) by the [optical system](#) that created them [P6.4]

requires: that the central [diffraction](#) maximum of one image should fall on or beyond the first [diffraction](#) minimum of the other. [P6.4]

implies: for a [circular aperture](#) of [diameter](#) d , that the angular separation of the two [objects](#), as measured (in radians) at the [aperture](#), should be at least $(1.22 \text{ radian})\lambda/d$, where λ is the [wavelength](#) of the [radiation](#) used. [P6.4]

Flexible Learning Approach to Physics - Glossary

reactance

of: a reactive [circuit component](#) in an [a.c. circuit](#)

is: the [impedance](#) of the [circuit component](#). [P5.4]

has the symbol: X . [P5.4]

has as its SI unit: the [ohm](#) (Ω). [P5.4]

generally depends: on the [angular frequency](#) of the [alternating current](#)

is exemplified: for a [capacitor](#), by the reactance $X_C = 1/(\omega C)$. [P5.4]

is exemplified: for an [inductor](#), by the reactance $X_L = \omega L$. [P5.4]

Flexible Learning Approach to Physics - Glossary

reaction

is: a process in which an entity or a group of entities is transformed to produce one or more different entities.

is exemplified: by a [chemical reaction](#).

Flexible Learning Approach to Physics - Glossary

reaction force

of: a [solid surface](#)

against: an oppressing object

is: in [equilibrium](#) on a horizontal surface, equal and opposite to the [weight](#) of the object (or to the [sum](#) of the [weight](#) plus any additional [forces](#) pressing the object into the [solid](#)). [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

reactive

describes: [electrical components](#) in an [a.c. circuit](#) whose [impedance](#) depends upon the supply [frequency](#). [P5.4]

is exemplified: by [capacitors](#) and [inductors](#). [P5.4]

See [reactance](#).

Flexible Learning Approach to Physics - Glossary

reactor

is: a device designed to contain a [reaction](#).

See [nuclear fission reactor](#) and [nuclear fusion reactor](#).

Flexible Learning Approach to Physics - Glossary

real axis

is: the [axis](#) in a [complex plane](#) (or [Argand diagram](#)) along which the [real part](#) of a [complex number](#) is measured. [[M3.1](#)]

normally is: the horizontal [axis](#). [[M3.1](#)]

Flexible Learning Approach to Physics - Glossary

real depth

of: an [object](#) below an [interface](#) between [transparent media](#), when the [object](#) is viewed by [refraction](#) from above the [interface](#)

is: the [distance](#) from the [interface](#) to the object. [P6.2]

See [apparent depth](#).

Flexible Learning Approach to Physics - Glossary

real gas

is: a [gas](#) that actually exists, in contrast to an [ideal gas](#), which does not. [P7.2]

generally is: a complicated [system](#). [P7.3]

but usually can be modelled: at low [pressure](#), by the [equation of state of an ideal gas](#) $PV = nRT$, provided that there are no [phase changes](#). [P7.3]

often is modelled: by [equations of state](#) which allow for the undoubted facts that [atoms](#) or [molecules](#) in a [gas interact](#) and have [volume](#). [P7.3]

Flexible Learning Approach to Physics - Glossary

real image

is formed: where the [light rays](#) from a [point object](#) converge to a [point](#), after [reflection](#) at a [mirror](#) or [refraction](#) at a [lens](#). [[P6.2](#), [P6.3](#)]

can be formed: on a screen. [[P6.2](#), [P6.3](#)]

Flexible Learning Approach to Physics - Glossary

real line

is: the [set](#) of all [real numbers](#). [M3.1]

is also: the infinite [line](#) representing such numbers. [M3.1]

is the same: as the [real axis](#) in an [Argand diagram](#). [M3.1]

Flexible Learning Approach to Physics - Glossary

real number

is: an ordinary number, such as 3.44 or -198.0 . [[M1.4](#)]

can be expressed: as a [decimal number](#) (possibly with an infinite number of [decimal places](#)). [[M1.2](#), [M3.1](#)]

can represent: a [measurable](#) physical quantity, when used in conjunction with appropriate [units](#). [[M1.2](#), [M3.1](#)]

Flexible Learning Approach to Physics - Glossary

real part

of: a [complex number](#) $x + iy$ (where x and y are [real numbers](#))

is: the term x . [[M1.4](#), [M3.1](#), [P5.5](#)]

often is denoted: by $\text{Re}(z)$. [[M3.1](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

rearrangement (of an equation)

results: from performing a valid [algebraic](#) manipulation. [[M1.1](#)]

provides: a different, but equivalent, way, of expressing the initial relationship. [[M1.1](#)]

Flexible Learning Approach to Physics - Glossary

reciprocal

of: a given number or [expression](#)

is: the result of dividing 1 by the given number or [expression](#). [M1.1]

is exemplified: by the reciprocal of x , which is $1/x$ or x^{-1} . [M1.1]

is exemplified: by the reciprocal of $1/x$ which is x . [M1.1]

is exemplified: by the reciprocal of a [fraction](#) y/x which is x/y . [M1.1]

reciprocal function

of: a function $f(x)$

is: a [function](#) of the form $R(x) = 1/f(x)$. [M1.3]

is exemplified: by the [reciprocal trigonometric functions](#).

reciprocal hyperbolic functions

are: the [cosech](#), [sech](#) and [coth functions](#). [M4.6]

are: [reciprocals](#) of the basic [hyperbolic functions](#): [sinh](#), [cosh](#) and [tanh](#). [M4.6]

See hyperbolic functions in the [Maths handbook](#).

reciprocal rule (of differentiation)

states that: $\frac{d}{dx}\left(\frac{1}{F(x)}\right) = -\frac{F'(x)}{[F(x)]^2}$ [M4.2]

reciprocal trigonometric functions

are: the cosecant, secant and cotangent [functions](#). [M1.6]

are: the [reciprocals](#) of the standard [trigonometric functions](#): [sine](#), [cosine](#) and [tangent](#). [M1.6]

often are referred to: simply as [trigonometric functions](#). [M1.6]

See trigonometric functions in the [Maths handbook](#) for further details.

reciprocal trigonometric ratios

are: the cosecant, secant and cotangent. [[M1.6](#)]

are: the [reciprocals](#) of the standard [trigonometric ratios](#): sine, cosine and tangent. [[M1.6](#)]

often are referred to: simply as [trigonometric ratios](#). [[M1.6](#)]

See trigonometric functions in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

rectangle

is: a [parallelogram](#) in which all [interior angles](#) are [right angles](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

rectangular block

is: a [prism](#) in which the base is a [rectangle](#) and the [angle](#) between any two adjacent edges is 90° . [[M2.1](#)]

rectangular hyperbola

is: a [hyperbola](#) with [orthogonal asymptotes](#). [[M2.3](#)]

can be represented: by the [equation](#) $xy = c^2$, where c is a constant. [[M2.3](#)]

See conic sections in the [Maths handbook](#).

rectilinear propagation

is: travel in [straight lines](#).

is exemplified: by the travel of [light](#) in a [uniform medium](#) under conditions where [diffraction](#) is insignificant. [[P6.2](#)]

Flexible Learning Approach to Physics - Glossary

reduction formula

for: an [integral](#) which involves a [power](#) of x (or of some [function](#) of x)

is: an [equation](#) which relates the [integral](#) to another [integral](#) of the same form but involving a lower [power](#) of x (or of the [function](#) of x). [[M5.5](#)]

See further integration in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

reflected ray

is: a [light ray](#) leaving a [surface](#) or [interface](#) following the [reflection](#) of an [incident ray](#). [[P6.1](#), [P6.2](#)]

reflection

is: a process in which an entity or agency (e.g. a [ray](#) of [light](#)) encountering a [surface](#) or [interface](#) returns through its original [medium](#) after the encounter rather than being [absorbed](#) at the [interface](#) or [transmitted](#) ([refracted](#)) into the new [medium](#). [P6.2]

See [law of reflection](#).

Flexible Learning Approach to Physics - Glossary

reflection coefficient

in: [quantum physics](#)

for: a stream of [particles](#)

encountering: a [potential step](#) or [potential barrier](#)

can be determined: from [quantum mechanics](#). [P11.1]

is defined as:

$$R = \frac{\text{flux of reflected particles}}{\text{flux of incident particles}} \quad \text{[P11.1]}$$

reflection diffraction grating

is: a form of [diffraction grating](#) in which the [diffracted beams](#) are produced by [reflection](#) from a [surface](#) that has been ruled with many closely spaced, narrow [parallel lines](#). [[P6.1](#)]

Flexible Learning Approach to Physics - Glossary

reflectivity

is: a [measure](#) of the [efficiency](#) with which [reflection](#) takes place at a [surface](#) or [interface](#). [[P6.2](#)]

Flexible Learning Approach to Physics - Glossary

reflex angle

is: an [angle](#) between 180° and 360° . [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

refracted ray

is: a [ray](#) formed from an [incident ray](#) by [transmission](#) either across an [interface](#) at which the [refractive index](#) changes abruptly, or through a region of varying [refractive index](#). [[P6.1](#), [P6.2](#)]

refraction

is: the process in which the [direction](#) of a [light ray](#) changes either at the boundary between two [transparent](#) materials of different [refractive index](#) or through a region of varying [refractive index](#). [[P6.2](#)]

more generally is: the process by which a [wave's direction](#) of [propagation](#) is changed as it travels through varying materials. The bending is a direct consequence of the different [speeds](#) of the [wave](#) in the different materials - [dispersion](#). [[P5.7](#), [P6.1](#)]

See [law of refraction](#).

Flexible Learning Approach to Physics - Glossary

refractive index

of: a [transparent](#) material

is: the [ratio](#) of the [speed of light](#) in a [vacuum](#) to the [speed of light](#) in the material. [[P6.1](#)]

generally depends: on the [frequency](#) of the [light](#).

usually is symbolized: by μ . [[P6.1](#), [P6.2](#)]

Flexible Learning Approach to Physics - Glossary

regula falsi

is: a [numerical procedure](#) for locating the [root](#) of an [equation](#). [M1.4]

Flexible Learning Approach to Physics - Glossary

regular polygon

is: a [polygon](#) in which each of the sides is of equal [length](#) and each of the [interior angles](#) is of the same size. [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

relative abundance

refers to: relative numbers of [atoms](#) of the various [isotopes](#) of an [element](#), that are found in the analysis of a sample of [matter](#). [[P8.1](#)]

often means specifically: the relative abundances of [isotopes](#) in naturally occurring samples on Earth. [[P8.1](#)]

Flexible Learning Approach to Physics - Glossary

relative atomic mass

of: an [atom](#)

is given: by

$$A_r = \frac{\text{mass of atom}}{1 \text{ u}} = \frac{12 \times \text{mass of atom}}{\text{mass of one } ^{12}\text{C atom}}$$

where 1 u stands for one [atomic mass unit](#). (Relative atomic masses of other [particles](#) may be defined in a similar way.) [[P7.1](#), [P8.1](#)]

formerly was known: as 'atomic weight'. [[P8.1](#)]

is numerically equal: to the [mass](#) in grams of one [mole](#) of the substance. So it can be determined by comparing the [masses](#) of appropriately prepared [macroscopic](#) samples of matter. [[P7.1](#), [P7.2](#)]

for a naturally occurring element, is obtained: by multiplying the relative atomic mass of each of its [isotopes](#) by the corresponding [relative abundance](#) and adding together the resulting products. [[P8.1](#)]

Flexible Learning Approach to Physics - Glossary

relative maximum

See [local maximum](#).

Flexible Learning Approach to Physics - Glossary

relative minimum

See [local minimum](#).

Flexible Learning Approach to Physics - Glossary

relative molecular mass

is given: by

$$\frac{\text{mass of molecule}}{1 \text{ u}} = \frac{12 \times \text{mass of molecule}}{\text{mass of one } ^{12}\text{C atom}}$$

where 1 u represents one [atomic mass unit](#). [P8.1]

numerically is equal: to the [mass](#) in grams of one [mole](#) of the substance. [P7.2]

formerly was known: as 'molecular weight'. [P8.1]

Flexible Learning Approach to Physics - Glossary

relative permeability

of: a material

is: the [dimensionless ratio](#) μ/μ_0 of its [permeability](#) μ to the [permeability of free space](#) μ_0 .

is therefore: the [factor](#) by which the [magnetic field strength](#) due to an arbitrary [current](#) distribution is increased from its value in [vacuum](#), by the presence of the material. [[P4.4](#), [P4.5](#)]

Flexible Learning Approach to Physics - Glossary

relative permittivity

of: a material

is: the [dimensionless ratio](#) $\epsilon_r = \epsilon/\epsilon_0$ of the [permittivity](#) ϵ of the material to the [permittivity of free space](#) ϵ_0 . [[P3.3](#), [P4.5](#)]

is therefore: the [factor](#) by which the [electric field strength](#) due to an arbitrary [charge](#) distribution is reduced in the [medium](#) compared with its value in [free space](#). [[P3.3](#)]

Flexible Learning Approach to Physics - Glossary

relative velocity

of: an object relative to a [point](#) from which its [displacement](#) is **s**

is: the [rate of change](#) of the [displacement](#) with respect to [time](#): ds/dt . [P2.1]

has: a [magnitude](#) known as the 'relative speed' of the object with respect to the reference point.

Flexible Learning Approach to Physics - Glossary

relativistic momentum

of: a [particle](#) of [mass](#) m travelling with [velocity](#) \mathbf{v} , (which may be close to the [velocity](#) of [light](#))

is: according to [Einstein's special theory of relativity](#),

$$\mathbf{p} = \frac{m\mathbf{v}}{\sqrt{1 - \frac{v^2}{c^2}}} \text{ where } c \text{ is the } \text{speed of light in a vacuum.} \quad [\text{P2.5}]$$

agrees: with the definition of [linear momentum](#) in [Newtonian mechanics](#) ($\mathbf{p} = m\mathbf{v}$) for low [speeds](#) (when $|\mathbf{v}| \ll c$), but differs markedly at high [speeds](#).

ensures: that the principle of [conservation of momentum](#) is valid at all [speeds](#) (up to c). [P2.5]

relativity

See [Einstein's special theory of relativity](#).

Flexible Learning Approach to Physics - Glossary

repeated root

is: a [root](#) of a [polynomial equation](#) which appears more than once in the [factorized form](#) of the [polynomial](#). [[M1.4](#)]

is exemplified: by the repeated root a in $(x - a)^2(x - b) = 0$. [[M1.4](#)]

Flexible Learning Approach to Physics - Glossary

reprocessing

is: the recovery of materials that are either valuable or particularly hazardous from the spent fuel rods of a [nuclear fission reactor](#). [P9.3]

Flexible Learning Approach to Physics - Glossary

resistance

is: the [ratio](#) of the [voltage difference](#) between the ends of a [conductor](#) to the [current](#) in that [conductor](#): $R = V/I$ [[P4.1](#), [P5.5](#)]

determines: the [power](#) dissipated in the [conductor](#), $P = IV = I^2R = V^2/R$. [[P4.1](#)]

has as its SI unit: the [ohm](#) (Ω) where $1 \Omega = 1 \text{ V A}^{-1}$. [[P4.1](#)]

more generally refers: to any [dissipative force](#). [[P5.2](#)]

Flexible Learning Approach to Physics - Glossary

resistance thermometer

is: a device for [measuring temperature](#), based on the variation with [temperature](#) of [electrical resistance](#) in a wire (often a platinum wire). The [resistance](#) is usually monitored with the aid of a [bridge circuit](#). [P7.2]

can be used: over a wide range of [temperatures](#). [P7.2]

Flexible Learning Approach to Physics - Glossary

resistive heating

See [Joule heating](#).

Flexible Learning Approach to Physics - Glossary

resistivity

of: a material

is: an intrinsic [electrical](#) property of the material. [[P4.1](#)]

permits: computation of the [resistance](#), R of a sample of the material of specified shape and size. For a sample of [length](#) l , [cross-sectional area](#) A and resistivity ρ : $R = \rho l/A$ [[P4.1](#)]

has as its SI unit: the $\Omega \text{ m}$ [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

resistor

is: a device for restricting the flow of [charge](#) in an [electric circuit](#).

Flexible Learning Approach to Physics - Glossary

resolution (of a vector)

is: the process of splitting the [vector](#) into its [component vectors](#) along an appropriately chosen [set](#) of [directions](#). [[M2.1](#), [M2.4](#)]

See also [orthogonal resolution](#).

Flexible Learning Approach to Physics - Glossary

resolution

is: a measure of performance of an instrument (e.g. an [optical](#) instrument) in its ability to produce or distinguish two [images](#) of two objects which are, or appear to be, very close together. [P6.4]

See also [angular resolving power](#) and [Rayleigh criterion](#).

Flexible Learning Approach to Physics - Glossary

resolve

means: to be able to distinguish as separate two narrowly separated points or objects, according to some appropriate criterion. [P6.4]

See [resolution](#) and [Rayleigh criterion](#).

Flexible Learning Approach to Physics - Glossary

resolving power

See [angular resolving power](#).

Flexible Learning Approach to Physics - Glossary

resonance

is: the condition in which a [driven oscillator](#) responds with maximum [amplitude](#) or [velocity](#) to a [periodic driving force](#). [[P5.3](#), [P5.4](#), [P5.5](#), [M6.3](#)]

occurs: for [lightly damped systems](#), when the [frequency](#) of the [driving force](#) is close to the [natural frequency](#) of the [oscillator](#). [[P5.3](#), [P5.4](#), [P5.5](#), [M6.3](#)]

Flexible Learning Approach to Physics - Glossary

resonance absorption bandwidth

of: a [driven oscillator](#)

is: the [frequency](#) difference between the two [half-power points](#) on the [power absorption curve](#) of the [oscillator](#). [P5.3]

Flexible Learning Approach to Physics - Glossary

resonance angular frequency

of: an [oscillator](#)

is: the [angular frequency](#) at which [resonance](#) occurs. [P5.3]

Flexible Learning Approach to Physics - Glossary

resonance frequency

of: an [oscillator](#)

is: the [frequency](#) at which [resonance](#) occurs. [[P5.3](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

rest energy

of: a [particle](#) of [rest mass](#) m_0

is: the [energy](#) $E_0 = m_0c^2$ that the [particle](#) would have by virtue of its [mass](#) alone, even if [free](#) and at rest, according to [Einstein's mass-energy equation](#). [P9.1]

is also called: rest mass energy. [P9.1]

Flexible Learning Approach to Physics - Glossary

rest mass

of: a [particle](#)

is: the [mass](#), m_0 , of the [particle](#) as [measured](#) when it is at rest relative to the [observer](#). [[P9.1](#)]

Flexible Learning Approach to Physics - Glossary

rest mass energy

See [rest energy](#).

Flexible Learning Approach to Physics - Glossary

restoring force

is: a [force](#) which is always directed towards a single [equilibrium](#) position.
[[P2.4](#), [P5.1](#)]

is exemplified: by the [force](#) that tends to return the end of a spring to its unextended [position](#). [[P2.4](#)]

Flexible Learning Approach to Physics - Glossary

resultant (vector)

is: the [vector](#) that results from combining two (or more) [vectors](#) together using the [operations](#) of [vector addition](#) and [scaling](#). [[M2.4](#), [M2.5](#), [P2.2](#)]

is exemplified: by the resultant [force](#) of a [set](#) of [forces](#) $\mathbf{F} = \mathbf{F}_1 + \mathbf{F}_2 + \dots$; the resultant [torque](#) of a [set](#) of [torques](#) $\mathbf{\Gamma} = \mathbf{\Gamma}_1 + \mathbf{\Gamma}_2 + \dots$; the resultant moment of a set of moments, etc. [[P2.3](#), [P2.7](#)]

resultant force

See [resultant \(vector\)](#).

resultant moment

See [resultant \(vector\)](#).

resultant torque

See [resultant \(vector\)](#).

Flexible Learning Approach to Physics - Glossary

retina

is: the [light](#) sensitive [surface](#) at the back of the eye, made up of two types of cell, the [rods](#) and the [cones](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

reversed image

is: the kind of [image](#) which is seen in a [plane mirror](#): right and left appear to be interchanged but top and bottom do not. [P6.2]

can be understood: by supposing that the [mirror](#) occupies the (x, y) -[plane](#) of a [right-handed Cartesian coordinate system](#), and then recognizing that a [point object](#) with [coordinates](#) (X, Y, Z) will correspond to a [point image](#) with [coordinates](#) $(X, Y, -Z)$. This implies that the reversed image of a [right-handed coordinate system](#) will be a [left-handed coordinate system](#). [P6.2]

Flexible Learning Approach to Physics - Glossary

reversible

describes: a process which allows the [system](#) undergoing it and the [environment](#) to be returned to their original [states](#) after the process has taken place. According to the [principle of entropy increase](#), the [entropy](#) of the [Universe](#) (i.e. [system](#) + [environment](#)) is unchanged by a reversible process. [\[P7.4\]](#)

Flexible Learning Approach to Physics - Glossary

revolution

is: the turning motion of a [body](#) about an [axis](#) which does not necessarily (especially in astronomy) pass through the [centre of mass](#) of the [body](#).

is exemplified: by the revolution of the planets about the Sun.

Compare and contrast with [rotation](#).

Flexible Learning Approach to Physics - Glossary

rhombus

is: a [parallelogram](#) in which all sides are equal. [M2.1]

Flexible Learning Approach to Physics - Glossary

right angle

is: an [angle](#) of 90° (or, equivalently, $\pi/2$ [radians](#)). [[M1.6](#), [M2.1](#)]

corresponds: to a [rotation](#) through one quarter of a complete [revolution](#). [[M1.6](#), [M2.1](#)]

Flexible Learning Approach to Physics - Glossary

right-angled triangle

is: a [triangle](#) in which one of the three (interior) [angles](#) is a [right angle](#).
[[M1.6](#), [M2.1](#)]

Flexible Learning Approach to Physics - Glossary

right-hand grip rule

is: a rule for determining the [direction](#) of the [magnetic field](#) associated with a [current](#).

states: if you point the extended thumb of your right hand in the direction of the [current](#), then the fingers of your right hand curl around your thumb in the same sense that the [magnetic field lines](#) curl around the [current](#). [P4.2]

is also: a rule for determining the sense of the [rotation](#) associated with an [angular velocity](#) ω , an [angular momentum](#) L , or a [torque](#) Γ .

Flexible Learning Approach to Physics - Glossary

right-hand rule

is: a rule for working out the [direction](#) of a [vector product](#) such as $\mathbf{a} \times \mathbf{b}$.

states: if you align the straightened fingers of your right hand with the [vector](#) \mathbf{a} and twist your wrist so that when you close your palm your fingers come into alignment with the [vector](#) \mathbf{b} , then the direction of your extended right thumb shows the sense in which $\mathbf{a} \times \mathbf{b}$ is [perpendicular](#) to \mathbf{a} and \mathbf{b} . [[M2.7](#), [P4.3](#)]

more briefly states: the direction of $\mathbf{a} \times \mathbf{b}$ is the direction of your extended right thumb, when the fingers of your right hand sweep from \mathbf{a} to \mathbf{b} .

See [corkscrew rule](#) and [right-hand screw rule](#).

See also vector product in the [Maths handbook](#).

right-hand screw rule

is: a rule for working out the [direction](#) of a [vector product](#) such as $\mathbf{a} \times \mathbf{b}$.
[M2.7, P2.8]

states: that the [vector](#) $\mathbf{a} \times \mathbf{b}$ points in the [direction](#) in which a right-handed screw will advance when the slot in its head is turned from the [direction](#) of \mathbf{a} to the [direction](#) of \mathbf{b} . [M2.7, P2.8]

See the [right-hand rule](#) and the [corkscrew rule](#).

right-handed (Cartesian) coordinate system

is: a [three-dimensional Cartesian coordinate system](#) (consisting of three mutually [perpendicular coordinate axes](#) which meet at a [point](#) called the [origin](#)) in which an [observer](#) located at the [origin](#) and looking along the [z-axis](#) in the [direction](#) of increasing z finds that a right-handed screw motion through 90° (i.e. a 90° clockwise [rotation](#)) is needed to bring the [x-axis](#) into the position previously occupied by the [y-axis](#). [[P2.7](#), [P6.2](#)]

Contrast with [left-handed coordinate system](#).

Flexible Learning Approach to Physics - Glossary

rigid body

is: a body of fixed shape. When [revolving](#), all parts of a rigid body have the same [axis of rotation](#) and the same [angular speed](#) about this [axis](#). [[P2.3](#), [P2.8](#)]

Flexible Learning Approach to Physics - Glossary

ringing time

is: the [time](#) required for a [damped oscillator](#) with a high [Q-factor](#) (i.e. only a [lightly damped oscillator](#)) to reduce its [energy](#) by a factor of e^{-1} . [[P5.2](#)]

is equal: to $Q/2\pi$ [[P5.2](#)]

Flexible Learning Approach to Physics - Glossary

rise

is: a term arising in the informal definition [gradient](#) = rise/[run](#)

represents: the difference in vertical [coordinate](#) value (usually denoted by Δy) between two [points](#) on a [straight line](#). (The [run](#) represents the corresponding change in horizontal [coordinate](#) value (often denoted Δx)). [[P1.3](#)]

Flexible Learning Approach to Physics - Glossary

rods

are: one of two types of [light](#) sensor present in the [retina](#), the other type being [cones](#). [[P6.4](#)]

are: the more sensitive and provide vision at low [light](#) levels, but do not provide colour vision. [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

root

of: an [equation](#)

is: a value of the [independent variable](#) that makes the [equation](#) true, i.e. a [solution](#) of the [equation](#). [[M1.1](#), [M4.1](#), [M4.4](#)]

Flexible Learning Approach to Physics - Glossary

root-mean-square (r.m.s.) current

of: a given [alternating current](#)

is: the steady [d.c. current](#) which, when flowing through a [resistor](#), causes [energy](#) to be dissipated at the same rate as the given [alternating current](#). [P5.4]

is given: for a [sinusoidally](#) varying [current](#) $I(t) = I_0 \sin(\omega t + \phi)$ by

$I_{\text{rms}} = I_0 / \sqrt{2}$. (Similarly, the [root-mean-square voltage](#) is given by

$V_{\text{rms}} = V_0 / \sqrt{2}$.) [P5.4]

See [root-mean-square value](#).

Flexible Learning Approach to Physics - Glossary

root-mean-square (r.m.s) speed

for: a [speed](#) distribution of [gas molecules](#)

is: the [square root](#) of the [mean](#) of the [squares](#) of the [speeds](#). [P7.5]

is obtained: by dividing the [sum](#) of the [squares](#) of the [speeds](#) by the total number of [molecules](#) and then taking the [square root](#). [P7.5]

See [root-mean-square value](#).

root-mean-square value (r.m.s.)

(1) **of:** n values, $x_1, x_2, x_3, \dots, x_n$

is:
$$x_{\text{rms}} = \sqrt{\frac{x_1^2 + x_2^2 + \dots + x_n^2}{n}} = \left(\frac{1}{n} \sum_{i=1}^n x_i^2 \right)^{1/2}$$

(2) **of:** a continuously varying quantity $f(x)$, over the interval $a \leq x \leq b$ (often a period of a [periodic function](#)).

is:
$$f_{\text{rms}} = \left\{ \frac{1}{(b-a)} \int_a^b [f(x)]^2 dx \right\}^{1/2}$$

Flexible Learning Approach to Physics - Glossary

root-mean-square (r.m.s.) voltage

See [root-mean-square \(r.m.s.\) current](#).

Flexible Learning Approach to Physics - Glossary

roots of unity

are: the n [complex numbers](#) that satisfy the [equation](#) $z^n = 1$. [M3.2]

Flexible Learning Approach to Physics - Glossary

rotation

is: the turning motion of a [body](#) about an [axis](#), normally (especially in astronomy) about an axis through its [centre of mass](#).

is exemplified: by the rotation of the Earth about its axis.

Compare and contrast with [revolution](#).

Flexible Learning Approach to Physics - Glossary

rotational equilibrium

of: a [system](#)

is: the condition in which the total [angular momentum](#) of the [system](#) is [constant](#).

requires: that the [resultant](#) external [torque](#) acting on the [system](#) is zero. [P2.7]

implies: for a [rigid body](#), that the [angular acceleration](#) of the [body](#) is zero (though it does not necessarily imply that the [angular velocity](#) is zero). [P2.7]

is a necessary condition: for [static equilibrium](#) in which there is no [motion](#).

See also [translational equilibrium](#).

Flexible Learning Approach to Physics - Glossary

rotational kinetic energy

is: the [kinetic energy](#) which a [body](#) possesses by virtue of its [rotation](#). [P2.7]

is given: for a [body](#) with [moment of inertia](#) I about some [axis](#), [rotating](#) with [angular speed](#) ω about that [axis](#), by $\frac{1}{2} I\omega^2$. [P2.7]

rounding

See [rounding-down](#), [rounding-up](#).

Flexible Learning Approach to Physics - Glossary

rounding-down

takes place: when the number of figures in a value is reduced and the last of the remaining figures is unchanged from its original value. [[M1.2](#), [P1.1](#)]

takes place only: if that last figure would have been followed by 0, 1, 2, 3 or 4. [[M1.2](#), [P1.1](#)]

Flexible Learning Approach to Physics - Glossary

rounding errors

are: [errors](#) that arise as a result of [rounding](#). [[M1.2](#)]

Flexible Learning Approach to Physics - Glossary

rounding-up

takes place: when the number of figures in a value is reduced, and the last of the remaining figures is increased by one from its original value. [[M1.2](#), [P1.1](#)]

takes place only: if that last figure would have been followed by 5, 6, 7, 8 or 9. [[M1.2](#), [P1.1](#)]

Flexible Learning Approach to Physics - Glossary

run

is: a term arising in the informal definition $\text{gradient} = \text{rise}/\text{run}$.

represents: the difference in horizontal [coordinate](#) value (usually denoted Δx) between two [points](#) on a [straight line](#). (The [rise](#) represents the corresponding change in vertical [coordinate](#) value (often denoted Δy)). [[P1.3](#)]

Flexible Learning Approach to Physics - Glossary

Rydberg atoms

are: [atoms](#) with large values of the [principal quantum number](#) n (say $n > 20$).
[P8.2]

can have: a large [radius](#) r compared with the [Bohr radius](#) a_0 . [P8.2]

have: [energy levels](#) very close to the [ionization level](#) and so are very easily [ionized](#). [P8.2]

Rydberg constant

is: the [physical constant](#) R (a convenient combination of [fundamental constants](#)) that appears in the [expressions](#) for the [wavelengths](#) of the [spectral lines](#) in the [Bohr model](#) for the hydrogen [atom](#). [P8.2]

has: the value $R = 1.097 \times 10^7 \text{ m}^{-1}$ (to four [significant figures](#)). [P8.2]

is defined: by

$$R = \frac{m_e e^4}{8 \epsilon_0^2 h^3 c} \quad \text{[P8.2]}$$

permits: use of [spectroscopic measurements](#) of [wavelengths](#), which are amongst the most precise [measurements](#) in science, to find the best values for the [fundamental constants](#). [P8.2]

strictly: should be written as R_∞ since, as written, it is derived from the [Bohr model](#) of hydrogen using a stationary [nucleus](#) around which the [electrons](#) [revolve](#). This [approximation](#) is equivalent to treating the [nucleus](#) as having a very large mass (ideally infinite) compared to the [electron](#). In reality, both [electron](#) and [nucleus](#) [revolve](#) around their common [centre of mass](#).

Flexible Learning Approach to Physics - Glossary

s-p-d-f notation

is: the notation which is used to indicate the [subshell](#) that [electrons](#) occupy in an [atom](#) according to the value of the [orbital angular momentum quantum number](#) l . The letter s denotes $l = 0$, p denotes $l = 1$, d denotes $l = 2$, f denotes $l = 3$.

[P8.3]

Flexible Learning Approach to Physics - Glossary

sample

in: [statistics](#)

is: that part of a [population](#) from which [data](#) is taken, usually in the hope that it will be representative of the [population](#) as a whole. [[P1.1](#)]

Flexible Learning Approach to Physics - Glossary

saturated bond

between: [atoms](#)

in: a [molecule](#), or [solid](#)

is: a [bond](#) to which no further [atoms](#) may be added. [[P11.4](#)]

Flexible Learning Approach to Physics - Glossary

saturated vapour

is: a [vapour](#) in [equilibrium](#) with its [liquid](#) (or [solid](#)) [phase](#).

responds to: any [isothermal compression](#) or [expansion](#) by [condensing](#) or [evaporating](#), thus changing the quantity of [vapour](#) while maintaining the original [pressure](#). [[P7.4](#)]

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saturated vapour pressure

is: the [pressure](#) of a [saturated vapour](#). [P7.4]

is represented: as a [function](#) of [temperature](#) by the [vaporization curve](#).
[P7.4]

Flexible Learning Approach to Physics - Glossary

scalar

describes: a quantity, which can be completely specified by a single number together with an appropriate [unit](#) of [measurement](#). [[M2.4](#), [M2.5](#), [P2.2](#)]

is exemplified: by [mass](#), [temperature](#) and [electric potential](#).

Flexible Learning Approach to Physics - Glossary

scalar components (of a vector)

in: the \mathbf{i} (or x), \mathbf{j} (or y) and \mathbf{k} (or z) [directions](#)

if: the [vector](#) \mathbf{v} is represented in the form $v_x \mathbf{i} + v_y \mathbf{j} + v_z \mathbf{k}$ or the form (v_x, v_y, v_z)

are: the [scalars](#) v_x , v_y , and v_z , respectively. [M2.5]

should not be confused with: [component vectors](#).

Flexible Learning Approach to Physics - Glossary

scalar field

throughout: some region of space

is: a quantity which can be specified fully by a number and an appropriate [unit](#) at each [point](#) within that region. [P3.1]

therefore is: a [field](#) $\phi(\mathbf{r})$ which associates a definite value of the [scalar quantity](#) ϕ with each [point](#) specified by [position vector](#) \mathbf{r} (in short, a [scalar](#) valued [function](#) of \mathbf{r}). [P3.1]

Flexible Learning Approach to Physics - Glossary

scalar product

of: two [vectors](#) $\mathbf{a} = (a_x, a_y, a_z)$ and $\mathbf{b} = (b_x, b_y, b_z)$

is: a [scalar quantity](#) denoted by $\mathbf{a} \cdot \mathbf{b}$. [[M2.6](#)]

is defined: by $\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}| |\mathbf{b}| \cos \theta$, where $|\mathbf{a}|$ and $|\mathbf{b}|$ are the [magnitudes](#) of the [vectors](#), and θ is the [angle](#) from the [direction](#) of \mathbf{a} to the [direction](#) of \mathbf{b} . [[M2.6](#), [P2.4](#)]

can be computed: in terms of [scalar components](#), using

$$\mathbf{a} \cdot \mathbf{b} = a_x b_x + a_y b_y + a_z b_z \quad [\text{M2.6, P2.2, P2.4}]$$

has the property: that $\mathbf{a} \cdot \mathbf{b} = \mathbf{b} \cdot \mathbf{a}$

also is known as: the dot product.

See scalar product in the [Maths handbook](#) for further details.

Flexible Learning Approach to Physics - Glossary

scalar quantity

is: a quantity that may be represented by a [scalar](#). [M2.4]

as a term, is used interchangeably: with the term [scalar](#). [M2.4]

scalar triple product

is: a product involving three [vectors](#) which may be written in any of the equivalent forms

$$\mathbf{a} \cdot (\mathbf{b} \times \mathbf{c}) = \mathbf{b} \cdot (\mathbf{c} \times \mathbf{a}) = \mathbf{c} \cdot (\mathbf{a} \times \mathbf{b}) \quad [\text{M2.7}]$$

See scalar product in the [Maths handbook](#).

scalene triangle

is: a [triangle](#) in which no two sides have the same length. [M2.1]

Flexible Learning Approach to Physics - Glossary

scaling (of a geometric figure)

of: a [geometric figure](#)

is: the process of multiplying the [length](#) of each side of the [geometric figure](#) by the same number, to produce a new [figure](#) which has the same shape as the original but a different size. [\[M2.1\]](#)

Flexible Learning Approach to Physics - Glossary

scaling (of a vector)

is: the process of multiplying a [vector](#), \mathbf{a} by a [scalar](#), α , to produce another [vector](#) $\alpha\mathbf{a}$. The scaled [vector](#) $\alpha\mathbf{a}$ points in the same [direction](#) as \mathbf{a} if $\alpha > 0$, and in the opposite [direction](#) if $\alpha < 0$. The [magnitude](#) of $\alpha\mathbf{a}$ is given by $|\alpha| |\mathbf{a}|$.

[[M2.4](#), [P2.2](#)]

Flexible Learning Approach to Physics - Glossary

scanning tunnelling microscope, STM

is: an instrument which uses [quantum tunnelling](#) to measure the vertical [displacement](#) of a probe tip with a [dimension](#) of a few nanometers as it is moved parallel the [surface](#) of a [conducting](#) material, by monitoring (and maintaining) the [tunnelling current](#) between the [surface](#) and the probe. [P7.1]

measures: the profile of the [surface](#) with an approximate [resolution](#) of 10^{-10} m. [P7.1]

can be used: to build up [three-dimensional](#) representations of the [atomic structure](#) on the [surface](#) of the material. [P7.1]

Flexible Learning Approach to Physics - Glossary

scattering experiments

are: a wide and important class of [experiments](#). [P8.1]

entail: [bodies](#) being investigated by using them as 'targets' in [collisions](#) with other [bodies](#), often referred to as 'projectiles'. [P8.1]

normally cause: alteration in the paths of the projectiles, which then are said to have been 'scattered' by the target. [P8.1]

normally use: simple projectiles (such as [electrons](#)) and involve [observing](#) the way in which they are scattered by complicated targets. This strategy has permitted much progress in [physics](#). [P8.1]

Schrödinger equation

is: an ambiguous term that might mean either the [time-dependent Schrödinger equation](#) or the [time-independent Schrödinger equation](#) according to context.

See the relevant entry for further details.

Schrödinger model

is: a detailed [mathematical model](#) of the atom based on [quantum mechanics](#). [P8.3, P11.3]

was formulated: by Erwin Schrödinger (1887-1961) and others around 1925/26. [P8.3, P11.3]

specifies: that many of the [physical quantities](#) normally associated with [atomic electrons](#) are [quantized](#), and that severe restrictions are placed on others. [P8.3, P11.3]

implies: for example, that it is impossible to determine the [position](#) and [momentum](#) of an [electron](#) simultaneously with arbitrarily high [precision](#) (see [Heisenberg uncertainty principle](#)), so the idea that the [electron](#) follows a [classical \(Newtonian\) orbit](#) has to be abandoned. Instead, the [quantum state](#) of the [electron](#) is specified by four [quantum numbers](#) which correspond to a particular [wavefunction](#) or [orbital](#). [P8.3, P11.3]

is also called: the quantum model (of the atom). [P8.3]

Flexible Learning Approach to Physics - Glossary

scientific notation

is: a standard way of representing numbers and numerical quantities. [[M1.2](#), [M1.5](#), [P1.1](#)]

consists: of a [decimal number](#) with one [digit](#) before the decimal point, multiplied by a [power of ten](#), and followed by appropriate [units](#). The total number of [digits](#) is the number of [significant figures](#). [[M1.2](#), [M1.5](#), [P1.1](#)]

is exemplified: by the [speed of light in a vacuum](#) to four [significant figures](#): $2.998 \times 10^8 \text{ m s}^{-1}$. [[M1.2](#), [M1.5](#), [P1.1](#)]

is also known: as [standard form](#), standard index form, floating point notation and [powers of ten notation](#). [[M1.2](#), [M1.5](#), [P1.1](#)]

Flexible Learning Approach to Physics - Glossary

search coil

is: a small [coil](#), that may be used to measure the strength of a [magnetic field](#).
[P4.4]

operates: on the basis of [electromagnetic induction](#). Quickly turning the coil within a steady [field](#), or removing it from the [field](#), gives rise to a pulse of [current](#). The total [charge](#) that flows in this pulse is [proportional](#) to the change in [flux linkage](#), so its measurement by means of a suitably [calibrated ballistic galvanometer](#) (or [fluxmeter](#)) reveals the [magnetic field strength](#). [P4.4]

Flexible Learning Approach to Physics - Glossary

secant, sec

See [trigonometric function](#).

Flexible Learning Approach to Physics - Glossary

sech

See [hyperbolic function](#).

Flexible Learning Approach to Physics - Glossary

second, s

is: the [SI unit](#) of [time](#), one of the seven [base units](#). [P1.1]

is defined: as the duration of 9 192 631 770 periods of the [radiation](#) corresponding to the [transition](#) between two designated [energy levels](#) (hyperfine levels of the [ground state](#)) of caesium-133. [P1.1]

See [caesium atomic clock](#).

Flexible Learning Approach to Physics - Glossary

second derivative

is: the [derivative](#) of a [derivative](#). [M4.3]

is symbolized: by $f''(x)$ or $\frac{d^2y}{dx^2}$ or some similar symbol. [M4.3]

See [higher derivative](#) for further details.

second derivative test

is: a test to determine the location and nature of a [local extremum](#) of a given function $f(x)$. [[M4.4](#)]

involves: (a) finding the points at which $f'(x) = 0$, (b) investigating the behaviour of the sign of $f''(x)$ at those points. If $f'(a) = 0$, and $f''(a) < 0$ there is a [local maximum](#) at $x = a$. If $f'(a) = 0$, and $f''(a) > 0$ there is a [local minimum](#) at $x = a$. If $f'(a) = 0$, and $f''(a) = 0$ then further investigation is required. [[M4.4](#)]

See stationary points and graph sketching in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

second focal point

is also called: the image focus or [second focus](#). [P6.3]

See [focal length](#).

Flexible Learning Approach to Physics - Glossary

second focus

is also called: the [image focus](#) or [second focal point](#). [P6.3]

See [focal length](#).

second law of thermodynamics

describes: all manner of physical processes in such a way as to predict the direction in which they will proceed spontaneously.

can be stated: in various ways, all of which are interrelated:

- No process is possible whose sole result is the transfer of [heat](#) from a colder to a hotter [body](#).
- No process is possible in which the sole result is the transfer of [heat](#) from a [body](#) and its complete conversion into [work](#).
- No process is possible that would lead to a net decrease in the [entropy](#) of the [Universe](#), $\Delta S_{\text{universe}} \geq 0$.
- Any spontaneous process is [irreversible](#) and leads to an increase in the [entropy](#) of the [Universe](#).

See also [principle of entropy increase](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

second of arc, "

is: a [unit](#) of [plane angle](#). [M1.6]

is equal: to 1/60 of a [minute of arc](#) (arcmin). [M1.6]

is abbreviated: arcsec. [M1.6]

is exemplified: by $20'' = 20 \text{ arcsec} = 1 \text{ arcmin}/3$. [M1.6]

second-order differential equation

is: a [differential equation](#) containing a second-[order derivative](#) of the [dependent variable](#) (e.g. d^2y/dx^2), but no [higher derivative](#). [[P5.4](#), [P5.5](#)]

Flexible Learning Approach to Physics - Glossary

secondary coil

in: a [transformer](#) or [mutual induction circuit](#)

is: the part of the [circuit](#) in which there is an [induced voltage](#) due to changes in the [primary coil](#). [P4.4]

usually is thought of: as the output from the [transformer](#). [P4.4]

Flexible Learning Approach to Physics - Glossary

secondary wavelets

See [Huygens' principle](#).

Flexible Learning Approach to Physics - Glossary

sector

of: a [circle](#)

is: the region bounded by a [circular arc](#) and the [straight line segments](#) that join the centre of the [circle](#) to the end points of that [arc](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

segment

of: a [circle](#)

is: the region bounded by a [circular arc](#) and the [chord](#) that joins the end points of that [arc](#). [[M2.1](#)]

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self inductance

See [coefficient of self inductance](#).

self-induction

is: the production of an [induced voltage](#) in a [circuit](#) due to a changing [current](#) within the [circuit](#) itself. [[P4.4](#)]

opposes: the change that causes it. [[P4.4](#)]

See also [coefficient of self inductance](#), [inductor](#), [Lenz's law](#). [[P4.4](#)]

Flexible Learning Approach to Physics - Glossary

semicircle

is: half a [circle](#). [[M2.1](#)]

is more precisely: a [segment](#) of a [circle](#), such that the [chord](#) joining its end points is a [diameter](#) of the [circle](#). [[M2.1](#)]

semiconductor

is: a material containing a relatively small but significant number of mobile charged particles. [[P4.1](#), [P11.4](#)]

has: a [resistivity](#) between that of good [conductors](#) (i.e. [metals](#)) and [insulators](#), most typically in the range 10^{-2} to $10^2 \Omega \text{ m}$. [[P4.1](#), [P11.4](#)]

has typically: in terms of [band theory](#) of [solids](#), at [absolute zero](#), an empty [conduction band](#) at a gap 1 eV, or less above a full [valence band](#). [[P11.4](#)]

is exemplified: by silicon and germanium, which are used for the construction of electronic devices. [[P4.1](#)]

See [p-type semiconductor](#) and [n-type semiconductor](#).

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semi-major axis (of an ellipse)

is: half of the [major axis](#) of the [ellipse](#).

See [ellipse](#).

Flexible Learning Approach to Physics - Glossary

semi-minor axis (of an ellipse)

is: half of the [minor axis](#) of the [ellipse](#).

See [ellipse](#).

Flexible Learning Approach to Physics - Glossary

sense

defines: for a [force](#), which of the two possible [directions](#) in which the [force](#) acts along its [line of action](#).

defines: for a [torque](#), which of the two possible orientations the [torque](#) has along the [axis of rotation](#).

Flexible Learning Approach to Physics - Glossary

sense of rotation

defines: one of the two possible [directions](#) of [rotation](#) around an [axis of rotation](#). [[P2.7](#), [P4.3](#)]

Flexible Learning Approach to Physics - Glossary

separable

describes: an [ordinary differential equation](#) which can be written in the form $dy/dx = f(x)g(y)$ and which can be solved (at least implicitly) by the [separation of variables](#).

also describes: a solution of a [partial differential equation](#) which can be written as the product of two [functions](#), each of which is itself a [function](#) of a different [independent variable](#). [M6.4]

separable differential equation

See [separable](#).

Flexible Learning Approach to Physics - Glossary

separation constant

of: a [partial differential equation](#) which has a [separable solution](#), and which can be rearranged to produce an equation whose left-hand and right-hand sides involve different [independent variables](#)

is: a [constant](#) that can be equated to either side of the final [equation](#) described above, since the two sides of the [equation](#) are independent yet equal, so they must both be equal to the same constant. [M6.4]

is exemplified: by the constant E that arises when the [one-dimensional time-dependent Schrödinger equation](#), with time-independent [potential energy](#) $U(x)$ and [separable stationary state solution](#) $\Psi(x, t) = \psi(x) \phi(t)$, is rewritten to yield two [ordinary differential equations](#) (one of them the [time-independent Schrödinger equation](#)) for the [spatial](#) and [temporal parts of the wavefunction](#). [M6.4]

separation of variables

is: a method of solving any [differential equation](#) which can be written in the form $dy/dx = f(x)g(y)$.

entails: rearranging the equation and integrating both sides to obtain $\int g(y) dy = \int f(x) dx$ which may (in favourable cases) be evaluated and rearranged to give y as a function of x . [[M6.2](#)]

Flexible Learning Approach to Physics - Glossary

sequence

is: an ordered [set](#) of numbers. [[M1.7](#)]

Flexible Learning Approach to Physics - Glossary

series (connection)

describes: [electrical components](#) connected end to end, as the links of a chain, so that the [current](#) through each is the same. [[P4.1](#), [P5.5](#)]

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series (mathematical)

is: the [sum](#) of a [sequence](#) of numbers. The [sequence](#) may be either finite or infinite, and the series is said to be finite or infinite accordingly. [[M1.7](#)]

Flexible Learning Approach to Physics - Glossary

series (spectroscopic)

in: a [characteristic emission spectrum](#) or [absorption line spectrum](#)

is: the [set](#) of [spectral lines](#) which arise when [electrons](#) make [transitions](#) from initial [quantum states](#) characterized by initial [principal quantum numbers](#) n_i to a specific final [state](#) characterized by a specific final [principal quantum number](#) n_f .

is exemplified: for the [spectrum](#) of [atomic](#) hydrogen, by the Lyman series for $n_f = 1$, the [Balmer series](#) for $n_f = 2$, the Paschen series for $n_f = 3$, etc.

Flexible Learning Approach to Physics - Glossary

series expansion

of: a given [function](#) (possibly over a restricted [domain](#))

is: a [power series](#) which is equivalent to the given [function](#). [[M1.7](#)]

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series LCR circuit

is: an [LCR circuit](#) in which the [resistor](#), [capacitor](#) and [inductor](#) are connected in [series](#).

Flexible Learning Approach to Physics - Glossary

series limit

for: a [spectroscopic series](#)

is: the shortest possible [wavelength](#) in the series. Successive members of the series become closer and closer together in [wavelength](#), converging to the series limit. [P8.2]

can be computed: in an [emission line spectrum](#) by setting $n_1 = n_\infty$, i.e. when the initial [energy level](#) corresponds to $E = 0$ and the [electron](#) in its initial [state](#) is no longer bound to the [atom](#) at all. [P8.2]

See [spectroscopic series](#).

Flexible Learning Approach to Physics - Glossary

set

is: a collection of entities (often, though not necessarily, numbers) that are defined by some characteristic which they all have in common, making them members or [elements](#) of the set, and which distinguishes them from entities that are not members of the set. [[M1.2](#)]

is exemplified: by the positive whole numbers. [[M1.2](#)]

is denoted: by listing the entities inside braces which signifies that they are [elements](#) (members) of the set. For example the set of non-negative whole numbers can be denoted by {1, 2, 3, ...}. [[M1.2](#)]

has its membership indicated: by the symbol \in , which means 'is a member of (a particular set)'. [[M1.2](#)]

Flexible Learning Approach to Physics - Glossary

set of complex numbers

is: the [set](#) of all numbers of the form $a + ib$, where a and b are [real numbers](#) and i is an [algebraic](#) quantity satisfying the rule $i^2 = -1$. [[M3.1](#)]

Flexible Learning Approach to Physics - Glossary

shear modulus

of: a material

is: an [elastic modulus](#), conventionally denoted G . [P7.6]

is defined: as the [ratio](#) of the applied [shear stress](#) σ_s to the resulting [shear strain](#) ε_s :

$$G = \frac{\sigma_s}{\varepsilon_s} \quad [\text{P7.6}]$$

has as its SI unit: N m^{-2} or Pa (i.e. [pascal](#)). [P7.6]

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shear strain

in the simplest case, is: a measure of the deformation of a material in which two [parallel surfaces](#) separated by a [perpendicular](#) distance y undergo a relative displacement, parallel to their original planes, of magnitude Δx . [[P7.6](#)]

is given: by the [ratio](#) of the [parallel](#) relative [displacement](#) to the [perpendicular distance](#) between the [surfaces](#), so $\epsilon_s = \Delta x/y$. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

shear stress

is: a [stress](#) σ_S resulting from the application of a [force](#) to a [surface](#), in a direction parallel to that [surface](#). [P7.6]

is given: by the [ratio](#) of the [magnitude](#) of the [force](#) to the [area](#) of the [surface](#) over which it acts, so $\sigma_S = F_{\parallel}/A$. [P7.6]

Flexible Learning Approach to Physics - Glossary

shell

is: a grouping of [electrons](#) within an [atom](#), in which the [electrons](#) have the same [principal quantum number](#) n . [[P8.3](#), [P8.4](#)]

therefore describes: [electrons](#) which, to a zeroth [approximation](#), have the same [energy](#). [[P8.3](#), [P8.4](#)]

SHM equation

is: a [differential equation](#) of the form

$$\frac{d^2y}{dt^2} + \omega^2y = 0. \quad [\text{P5.3}, \text{M6.3}]$$

describes: the [motion](#) of any object that is undergoing ([undamped](#), [unforced](#)) [simple harmonic motion](#). The [parameter](#) ω determines the [period](#) of the [oscillations](#), which is equal to $2\pi/\omega$. [\[M6.3\]](#)

See [simple harmonic motion](#).

Flexible Learning Approach to Physics - Glossary

short circuit

is: a path of very low (effectively zero) [resistance](#) within a [circuit](#). [[P4.1](#)]

usually is: unwanted, accidental. [[P4.1](#)]

sometimes is: catastrophic, when it forms directly across the [terminals](#) of a [power supply](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

short sight

See [myopia](#).

Flexible Learning Approach to Physics - Glossary

shunt resistor

is: a [resistor](#) connected in [parallel](#) with some other [circuit component](#). [P4.1]

commonly is: a [resistor](#) connected in [parallel](#) with an [ammeter](#) to reduce its [current](#) sensitivity. [P4.1]

Flexible Learning Approach to Physics - Glossary

shutter speed

is: the [time](#) for which the [aperture](#) of a [camera](#) remains open. (Note that it is a [time](#) not a [speed](#).) [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

SI units

are: an internationally agreed system of [units](#) based on the [metre](#), [kilogram](#), [second](#), [ampere](#), [kelvin](#), [mole](#) and [candela](#). [[P1.1](#)]

stands for: *Système International d'Unités*. [[P1.1](#)]

are used: almost universally by the scientific community. [[P1.1](#)]

See Tables 1 to 5 in Section 0 of the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

siemens, S

is: the [SI unit](#) of [conductance](#).

is defined: by $1 \text{ S} = 1 \text{ } \Omega^{-1}$ (i.e. one [reciprocal ohm](#) or inverse ohm).

is used: in the measurement of [conductivity](#), for which the [SI unit](#) is the siemens per [metre](#) (S m^{-1}). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

sievert, Sv

is: the [SI unit](#) of [dose equivalent](#) of [ionizing radiation](#).

is defined by: $1 \text{ Sv} = 1 \text{ J kg}^{-1}$ (i.e. 1 [joule](#) per [kilogram](#)). [Dose equivalents](#) measured in Sv are related to [absorbed doses](#) measured in [gray](#) (Gy) via a [radiation weighting factor](#). The [dose equivalent](#) in sievert equals the [absorbed dose](#) in [gray](#) times the [radiation weighting factor](#). [P9.3]

Flexible Learning Approach to Physics - Glossary

sign convention

is: an agreed means of attributing positive and negative signs to the quantities that arise in various calculations.

is exemplified: by the [Cartesian sign convention](#) of [geometrical optics](#).
[P6.3]

Flexible Learning Approach to Physics - Glossary

significant figures

are: the meaningful [digits](#) in a number. [[M1.2](#), [P1.1](#)]

indicate: its [precision](#). [[M1.2](#), [P1.1](#)]

do not include: zeros to the left of the first non-zero [digit](#), as in 0.00876. [[M1.2](#), [P1.1](#)]

may or may not include: zeros at the end of a number, particularly a whole number, as in 9400. These are ambiguous. [[M1.2](#), [P1.1](#)]

are totally unambiguous: in [scientific notation](#), which avoids the need to write down any zeros that are not significant either to the right or to the left of the significant figures. For example, 9.4×10^3 has two significant figures, while 9.400×10^3 implies that both zeros are significant. [[M1.2](#), [P1.1](#)]

silicon p-n junction photodiode

is: a [semiconducting](#) device that enables the [intensity](#) of a [light beam](#) to control or generate a [current](#) in an [electric circuit](#). [[P10.1](#)]

Flexible Learning Approach to Physics - Glossary

similar

describes: two [geometric figures](#) which are identical in shape, irrespective of their size. [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

similar triangles

are: [triangles](#) that are identical in shape, irrespective of their size. [P1.6]

have: the same [interior angles](#). [P1.6]

also have: corresponding sides that are in the same [ratio](#) to each other.
[M1.6]

simple harmonic motion (SHM)

of: a [particle](#) of [mass](#) m moving in the x -direction about the [equilibrium position](#) $x = 0$ under the influence of a [restoring force](#) $F_x = -kx$, that is always directed towards $x = 0$ and which is [proportional](#) to the [displacement](#) x from that [point](#)

is: an [oscillatory](#) form of [linear motion](#) in which the [displacement](#) of the [particle](#) at [time](#) t from an [equilibrium position](#) is given by

$$x(t) = A \sin(\omega_0 t + \phi)$$

where the [amplitude](#) A and [phase constant](#) ϕ are [arbitrary constants](#) determined by the initial conditions, and the [angular frequency](#) ω_0 is a constant determined by the force constant k and the [mass](#) m as given by $\omega_0 = \sqrt{k/m}$. [[M5.1](#), [P5.4](#), [P5.5](#)]

can be described: by a [differential equation](#) (called the [SHM equation](#)) of the form:

$$\frac{d^2 x}{dt^2} + \omega_0^2 x = 0. \quad [\text{M6.3, P5.5}]$$

simple harmonic oscillations

See [simple harmonic motion](#).

simple harmonic oscillator

is: any [oscillatory system](#) that exhibits [oscillations](#) which can be described by an [equation](#) of the form

$$\frac{d^2x}{dt^2} + \omega_0^2x = 0.$$

with solutions of the form $x(t) = A \sin(\omega_0t + \phi)$

is exemplified: by a [mechanical oscillator](#) exhibiting [simple harmonic motion](#).

is also exemplified: by an [electrical circuit](#) in which an [inductor](#) of [inductance](#) L is connected across a charged [capacitor](#) of [capacitance](#) C , with the result that the [charge](#) q on the [capacitor](#) satisfies the [differential equation](#)

$$\frac{d^2q}{dt^2} + \omega_0^2q = 0 \text{ where } \omega_0 = \sqrt{\frac{1}{LC}}$$

and where the [charge](#) then is given at [time](#) t by $q(t) = q_0 \sin(\omega_0t + \phi)$, with q_0 and ϕ [arbitrary constants](#).

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simple pendulum

is: a pendulum consisting of a single [mass](#) suspended by a light thread which is very long compared to the size of the suspended [mass](#). [[P5.1](#)]

exhibits: [simple harmonic oscillations](#) in the [angle](#) between the thread and the vertical, provided that [angle](#) is always small. The [period](#) of the [oscillation](#) is $T = 2\pi\sqrt{l/g}$ where l is the [length](#) of the thread, and g is the [magnitude of the acceleration due to gravity](#).

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simplify

is: the process of writing an [algebraic expression](#) in a equivalent but simpler form. [M1.1]

more specifically, means: to [express](#) in a shorter form, especially by using [brackets](#) and extracting [common factors](#). [M1.1]

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simultaneous

means: at the same [time](#).

more specifically means: at the same [time](#), as measured in a given [frame of reference](#) (an important proviso in [Einstein's special theory of relativity](#)).

simultaneous linear equations

are: a number of [equations](#), which are [linear](#) in each of the [independent variables](#) and which are required to be true simultaneously. [[M1.4](#)]

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sine, sin

See [trigonometric function](#).

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sine rule

for: a [triangle](#)

is: a [set](#) of independent relations between the [sines](#) of [angles](#) in the [triangle](#) and the lengths of sides opposite the [angles](#):

$$\frac{a}{\sin(\hat{A})} = \frac{b}{\sin(\hat{B})} = \frac{c}{\sin(\hat{C})} \quad [\text{M1.6}]$$

See trigonometric functions in the [Maths handbook](#) for further details.

single-valued function

describes: a [function](#) which can have only a single value at each [point](#) in [space](#) at a given [time](#). [[M1.3](#), [P10.4](#)]

is exemplified: by the [wavefunction](#) for a [particle](#), which must be a single-valued [function](#) since it relates to the [probability](#) of finding the [particle](#) at the [point](#). [[M1.3](#), [P10.4](#)]

See [multi-valued function](#). [[M1.3](#)]

singular solution

is: a [particular solution](#) of a [non-linear differential equation](#), which cannot be obtained from the [general solution](#) by the usual assignment of particular values to the [essential constants](#). [[M6.1](#)]

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singularity

of: a [function](#) $f(x)$ which can be written in the form $g(x)/(x - p)^n$ in the neighbourhood of $x = p$, where $g(x)$ is finite and non-zero at $x = p$,

is: the point $x = p$ (at which the singularity is of order n .) [[M5.2](#)]

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sinh

See [hyperbolic function](#).

Flexible Learning Approach to Physics - Glossary

sintered

describes: a material formed by heating a mixture of its ingredients to promote [atomic diffusion](#) (and hence [bonding](#)) but without causing [melting](#).

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sinusoidal

describes: any [function](#) that has a graph of the same 'wavy' shape as that of a [sine](#) or [cosine function](#). [[M1.6](#)]

also describes: the [graph](#) itself. [[M1.6](#)]

is exemplified: by any [function](#) of the form $A \sin(kx + \phi)$ or $B \cos(kx + \phi)$ or $G \cos(kx) + H \sin(kx)$, where A , B , G , H , k and ϕ are all constants. [[M1.6](#)]

sinusoidal wave

is: a [periodic wave](#) described (in one [spatial dimension](#)) by a [function of two variables](#) of the form $y(x, t) = A \sin [k(x - vt) + \phi]$, where $y(x, t)$ represents the disturbance caused by the wave (e.g. a [transverse displacement](#)) at [position](#) x and [time](#) t and the [constants](#) A , k , v and ϕ are the [amplitude](#), [angular wavenumber](#), [propagation speed](#) and [phase constant](#) respectively. [[M6.4](#), [P5.6](#)]

may be generalized: to two or three [dimensions](#), and may be represented mathematically in a variety of different ways e.g. using complex numbers,

$$y(x, t) = \text{Re} \left[A e^{i(kx - \omega t + \phi)} \right], \text{ where } \omega = kv. \quad [\text{M6.4}, \text{P5.6}]$$

can be represented: by the [cosine function](#) as well. By writing $\phi = \theta + \pi/2$, and using an appropriate [trigonometric identity](#) it is possible to rewrite the 'sine wave' given above as the 'cosine wave' $y(x, t) = A \cos [k(x - vt) + \theta]$. [[M6.4](#), [P5.6](#)]

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sketching graphs

is: the process of drawing a rough [graph](#), which shows the qualitative features of the [function](#), but does not attempt to achieve accuracy. [[M1.3](#)]

Contrast with [plotting graphs](#).

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skew

describes: [straight lines](#) which are not [parallel](#) but which do not meet at any [point](#). [M2.2]

Flexible Learning Approach to Physics - Glossary

skewed

describes: a [distribution](#) of values which is asymmetric rather than a [symmetric \(e.g. normal\) distribution](#).

sliding friction

is: a [force](#) of [friction](#) which acts on a solid [surface](#) in contact with another [surface](#) when the two are in relative [motion](#). [[P2.3](#), [P7.6](#)]

has a direction: which opposes the relative [motion](#) that causes it. [[P2.3](#), [P7.6](#)]

has a magnitude: which is [directly proportional](#) to the [magnitude](#) R of the [reaction force](#) acting on the [surface](#) of interest from the other [surface](#), so that $F_{\text{slide}} = \mu_{\text{slide}}R$, where μ_{slide} is a [constant](#), called the [coefficient of sliding friction](#), that is characteristic of the [surfaces](#) involved (including their state of lubrication). [[P2.3](#), [P7.6](#)]

also known as: dynamic friction.

Compare with [static friction](#), which is generally greater in any given situation.

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slope

See [gradient](#).

smooth function

is: a [function](#) whose [graph](#) does not contain any sharp kinks or sudden discontinuous jumps. [[M4.4](#)]

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Snell's law

states: that when a [light ray](#) passes from one material of [refractive index](#) μ_1 to another material of [refractive index](#) μ_2 it undergoes [refraction](#), and the [angle of incidence](#) θ_1 and [angle of refraction](#) θ_2 are related by:

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{\mu_2}{\mu_1} = \text{constant.} \quad [\text{P5.7, P6.1, P6.2}]$$

is sometimes expressed: in terms of the respective speeds of [light](#) in the two materials v_1 and v_2 , in which case

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{v_1}{v_2} \quad [\text{P6.1}]$$

as a term, normally is used: as a synonym for the [law of refraction](#), and is applicable to [sound](#) as well as [light](#). [\[P5.7\]](#)

solar cell

is: a device that uses [electromagnetic radiation](#) (usually from the Sun) to generate an [electric current](#). [P10.1]

See [silicon p-n junction photodiode](#).

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solenoid

is: an extended [current](#)-carrying [coil](#). [[P4.2](#)]

has the shape: of a [helix](#). [[P4.2](#)]

generates: a [uniform magnetic field](#) throughout much of the [volume](#) within the solenoid. [[P4.2](#)]

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solid of revolution

is: a mathematical solid which can be obtained by [rotating](#) a suitable [curve](#) about a specified [line](#) or [axis](#). [[M5.4](#)]

Flexible Learning Approach to Physics - Glossary

solid phase

is: the general form of matter which is characterized by having a definite [volume](#) and shape at fixed [temperature](#) and [pressure](#), when in equilibrium.
[\[P7.1\]](#)

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solitary wave

is: an isolated (i.e. non-[periodic](#)) disturbance that satisfies an appropriate [wave equation](#). [[P5.6](#)]

often is referred to: as a pulse. [[P5.6](#)]

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soluble

in: [mathematics](#)

describes: an [equation](#) (or system of [equations](#)) which can be solved. [M1.4]

solution (chemical)

is: a material (usually, but not necessarily, a [liquid](#)) in which one substance is homogeneously mixed with another, and which can only be separated into those original substances by transforming one or both of them through a process such as [freezing](#) or [boiling](#), or by means of an appropriate [chemical reaction](#).

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solution (mathematical)

of: an [equation](#)

is: a value, or an [expression](#) for the [dependent variable](#) in terms of the [independent variable\(s\)](#), such that when substituted into the [equation](#) the resulting [expression](#) is an [identity](#). [[M1.4](#), [M6.1](#)]

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solving the equations

means: finding the [solution\(s\)](#) of the [equations](#). [[M1.4](#), [M6.1](#)]

Flexible Learning Approach to Physics - Glossary

sound

is: the phenomenon associated with the [propagation](#) of [longitudinal pressure waves](#) ([sound waves](#)) through a [medium](#). [P5.7]

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sound energy

is: [energy](#) transported by [sound waves](#), and associated with the coordinated [vibrations](#) of the [molecules](#) of the [medium](#) through which the [sound](#) travels, as opposed to the random [vibrations](#) of [molecular thermal motion](#). [[P5.7](#)]

is also called: [acoustic energy](#). [[P5.7](#)]

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sound wave

is: a [longitudinal wave](#) consisting of alternate [compressions](#) and [rarefactions](#) of the [medium](#) through which the sound is travelling. [[P5.7](#)]

may transport: [acoustic energy](#) (i.e. [sound energy](#)) from place to place. [[P5.7](#)]

Flexible Learning Approach to Physics - Glossary

south magnetic pole

is: the [magnetic pole](#) of a compass needle which, when allowed to move freely under the influence of the Earth's [magnetic field](#), points in a southerly direction. (This means that the Earth's south geographic pole is close to a [north magnetic pole](#)!) [P4.2]

is: the [magnetic pole](#) towards which [magnetic field lines](#) converge. [P4.2]

is called: in some texts, the south-seeking [pole](#). [P4.2]

See [magnetic pole](#). [P4.2]

Flexible Learning Approach to Physics - Glossary

space

is: the [set](#) of all possible [positions](#).

more abstractly is: a [set](#) with properties similar to those of 'real' space (e.g. the *PVT* 'space' that contains the [equilibrium surface](#) of a fixed quantity of [gas](#)).

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spatial

means: pertaining to [space](#).

Flexible Learning Approach to Physics - Glossary

spatial coherence

of: [waves](#)

is: their characteristic of maintaining [coherence](#) over some region of [space](#).
[\[P6.1\]](#)

usually is: limited by the nature of the source.

spatial part of the wavefunction

See [spatial wavefunction](#) and contrast with [temporal wavefunction](#).

spatial wavefunction

is: that part of a [separable solution](#) to the [time-dependent Schrödinger equation](#) that depends only on [spatial coordinates](#) and is therefore independent of [time](#). [P6.4, P10.3, P10.4]

is exemplified: in one [dimension](#) by the factor $\psi(x)$ that appears in the [stationary state wavefunction](#)

$$\Psi(x, t) = \psi(x) \phi(t) \quad [\text{M6.4, P10.3, P10.4}]$$

is therefore: a [solution](#) of the [time-independent Schrödinger equation](#) and consequently is an [eigenfunction](#) of the [energy operator](#). [P10.4]

Flexible Learning Approach to Physics - Glossary

specific activity

is: the [activity](#) per [unit mass](#) of a [radioactive](#) sample. [[P9.2](#)]

Flexible Learning Approach to Physics - Glossary

specific heat

is also known: as 'specific heat capacity' or 'kilogram specific heat'. [[P7.4](#), [P7.5](#), [P11.4](#)]

is: the [heat](#) required per [unit mass](#) of a substance per unit rise in [temperature](#). [[P7.4](#), [P7.5](#), [P11.4](#)]

more succinctly, is: the [heat capacity](#) per [unit mass](#). [[P7.4](#), [P7.5](#)]

is given: by $c = \Delta Q/m\Delta T$, where ΔQ is the [heat](#) required to raise the [temperature](#) of a sample of [mass](#) m by an amount ΔT . (Strictly speaking the specific heat should be defined as the [limit](#) of this [ratio](#) as ΔT becomes vanishingly small, since the specific heat depends on the [state](#) of the sample and will generally have a value that depends on [temperature](#).) [[P7.4](#), [P7.5](#)]

also depends: on the constraints applied during [heating](#): see [principal specific heats](#). [[P7.4](#), [P7.5](#)]

is the subject: of the [Einstein model](#) and the [Debye model](#), and a good deal of other theoretical work. [[P11.4](#)]

has as its SI unit: $\text{J kg}^{-1} \text{K}^{-1}$. [[P7.4](#), [P7.5](#)]

See also [molar specific heat](#).

specific latent heat

is: the amount of [heat](#) absorbed or emitted per [unit mass](#) by a substance during an [isothermal phase transition](#). [P7.4]

has as its SI unit: J kg^{-1} . [P7.4]

See also [latent heat](#); [molar latent heat](#).

Flexible Learning Approach to Physics - Glossary

spectral brightness

is: the [power emitted](#) per [unit area](#) per [unit wavelength](#) range by a [radiating surface](#). [P7.3]

varies: with [wavelength](#). [P7.3]

generally depends: on the [temperature](#) and nature of the [emitting surface](#). [P7.3]

is described: in its variation with [temperature](#) T and [wavelength](#) λ , for a [black-body](#), by [Planck's function](#). [P7.3]

is also called: spectral emittance. [P7.3]

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spectral emittance

See [spectral brightness](#).

Flexible Learning Approach to Physics - Glossary

spectral lamp

is: a [light](#) source with which the [emission spectrum](#) of a substance may be studied. [[P8.2](#)]

is only useful: for substances which may be [vaporized](#) by moderate [heating](#), since it works by [vaporizing](#) the substance and then [exciting](#) the [atoms](#) by means of [collisions](#) with an [electron](#) beam (i.e. an [electric current](#)). [[P8.2](#)]

spectral lines

See [line spectrum](#).

Flexible Learning Approach to Physics - Glossary

spectrometer

is: an [optical](#) instrument for separating [light](#) into its constituent [wavelengths](#) and [measuring](#) these [wavelengths](#). [P6.4]

usually contains: a [collimator](#), which produces a narrow [parallel rectangular beam](#) of [light](#) from a slit, and a [telescope](#), which allows this [parallel beam](#) to be [observed](#). [P8.2]

also contains: between the [collimator](#) and the [telescope](#), a [dispersion](#) device, which makes the various constituent wavelengths in the [beam](#) travel in different directions and thus appear at different angles when viewed through the [telescope](#). [P8.2]

usually contains: as the [dispersion](#) device, a [diffraction grating](#) (or a [triangular glass prism](#).) [P8.2]

permits determination: of the [wavelength](#), λ , using the [grating relation](#), $n\lambda = d \sin \theta_n$, by [measuring](#) the [angle](#) θ_n through which the [light](#) of [wavelength](#) λ is [diffracted](#) in [order](#) n by a [grating](#) of known [grating spacing](#) d . [P8.2]

spectroscopic series

See [series \(spectroscopic\)](#).

Flexible Learning Approach to Physics - Glossary

spectroscopy

is: the branch of science which is concerned with the production, measurement, analysis and interpretation of [spectra](#). [[P8.2](#)]

Flexible Learning Approach to Physics - Glossary

spectrum

of: [electromagnetic radiation](#) (usually from a specified source)

is: the distribution of [spectral brightness](#) (or some similar quantity) with respect to the [wavelength](#) or [frequency](#) (or possibly the corresponding [photon energy](#)) of the [radiation](#). [P8.2]

may be displayed: as a [graph](#), or as a photographic image of a [dispersed](#) band of [light](#), or as a mathematical [function](#) (see [black-body spectrum](#) and [Planck's function](#)).

may be classified: as a [continuous spectrum](#) if it includes non-zero contributions across a wide and unbroken range of [wavelengths](#); as a [line spectrum](#) if certain narrowly defined [wavelength](#) ranges are particularly prominent; or as a band spectrum if certain moderately broad ranges of [wavelength](#) are dominant.

may also be classified: as an [emission spectrum](#) if the observed [radiation](#) was emitted by the source, or as an [absorption spectrum](#) if the observed [radiation](#) is that which remains after [radiation](#) with a [continuous spectrum](#) has passed through the specified source.

Flexible Learning Approach to Physics - Glossary

speed

is: the [magnitude](#) of [velocity](#). [[M2.4](#), [M4.1](#), [P2.1](#), [P2.2](#), [P7.5](#)]

is therefore: a positive quantity. [[M2.4](#), [M4.1](#), [P2.1](#), [P2.2](#), [P7.5](#)]

has as its SI unit: m s^{-1} . [[M2.4](#), [M4.1](#), [P2.1](#), [P2.2](#), [P7.5](#)]

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speed (of a film)

is: the sensitivity to [light](#) of a [photographic film](#) or [emulsion](#). [[P6.4](#)]

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speed of light

or of: any [electromagnetic radiation](#)

in: a [vacuum](#)

is: a fundamental physical constant with the value $3.00 \times 10^8 \text{ m s}^{-1}$, to three [significant figures](#). [P6.1]

more precisely, is now defined: to be exactly $2.997\,924\,58 \times 10^8 \text{ m s}^{-1}$. [P6.1]

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speed of propagation

of: a [wave](#)

is: the [speed](#) at which it moves in the [direction](#) of [propagation](#). [[M6.4](#), [P5.6](#), [P5.7](#)]

is equal: for a simple non-[dispersive wave](#), to the [phase speed](#). [[M6.4](#), [P5.6](#), [P5.7](#)]

is equal: for a [periodic wave](#), to the product of the [wavelength](#) and the [frequency](#) of the [wave](#). [[P5.7](#)]

is equal: to the [group speed](#), where there is [dispersion](#) (i.e. where the [frequency](#) is dependent on [wavelength](#)) and the [wave](#) may be a [superposition](#) of several different components with different [frequencies](#) and hence different [phase speeds](#). [[M6.4](#), [P5.6](#), [P5.7](#)]

Flexible Learning Approach to Physics - Glossary

sphere

is: a [surface](#) in three [dimensions](#), every [point](#) of which is a fixed [distance](#) (the [radius](#)) from a fixed [point](#) (the [centre](#)). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

spherical

in: [geometry](#)

means: pertaining to a [sphere](#). [[M2.1](#)]

spherical aberration

in: a [lens](#) or a [mirror](#)

causes: distortion in the image produced by the lens or mirror, due to the variation of [focal length](#) with [radial distance](#) from the [optical axis](#) for [rays incident](#) on the [lens](#) or [mirror](#). [P6.4]

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spherical lens

is: a [lens](#) with two [spherical surfaces](#). [[P6.3](#)]

spherical mirror

is: a [mirror](#) with a curved [reflecting surface](#) having a single [radius of curvature](#). [[P6.3](#)]

spherical mirror equation

is: a general [equation](#) relating the [object position](#) u , the [image position](#) v and the [focal length](#) f for [spherical mirrors](#) in the [paraxial approximation](#):

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \text{ (Cartesian sign convention) [P6.3]}$$

Compare with [thin lens equation](#).

spherical polar coordinates

are: coordinates (r, θ, ϕ) in which the position of a point is determined by: its distance r from a chosen point, called the origin; the angle θ between the line from the point to the origin and a chosen plane containing the origin; and the angle ϕ measured in the chosen plane, from a chosen line through the origin to the projection of the line from the origin to the point. [P11.3]

are normally restricted: so that $0 \leq \theta < 2\pi$ and $-\pi/2 \leq \phi \leq \pi/2$, but other (equivalent) restrictions are also used.

Flexible Learning Approach to Physics - Glossary

spherical symmetry

is: a condition in which all relevant properties depend (or may depend) on the [distance](#) from some fixed [point](#), but not on [direction](#).

is exemplified: by a [spherical body](#) whose [density](#) depends only on the [distance](#) r from the [centre](#) of the [sphere](#). [[P3.2](#)]

spherical wave

is: a [wave](#) which has [radially](#) expanding [spherical wavefronts](#) of the kind that come from a [point source](#). [\[P6.1\]](#)

spherical wavefront

is: a [wavefront](#) of a [spherical wave](#). [P6.1]

spin (angular momentum)

is: an intrinsic property of [fundamental particles](#) such as [protons](#), [neutrons](#) and [electrons](#). [[P8.3](#), [P9.2](#)]

is similar: in [quantum theory](#), to [orbital angular momentum](#), so is often referred to as intrinsic angular momentum or spin angular momentum. [[P8.3](#), [P9.2](#)]

is represented: in [quantum mechanics](#), by the [vector observable](#) \mathbf{S} of [magnitude](#) S and with S^2 having the [eigenvalues](#) $S^2 = s(s+1)\hbar^2$ where s is the [spin angular momentum quantum number](#).

See also [electron spin](#).

spin angular momentum quantum number

is: the [quantum number](#) s that determines the [magnitude](#) of the [spin angular momentum](#) of a [particle](#). [P8.3]

has: a unique, positive, [integer](#) or half-[integer](#) value for each [particle](#) (e.g. $s = 1/2$ for the [electron](#)). [P8.3]

determines: the magnitude of the square of the [spin angular momentum](#) of the [particle](#) as $S^2 = s(s+1)\hbar^2$.

spin magnetic quantum number

is: the [quantum number](#) m_s which describes the component of the [spin angular momentum](#) of a [particle](#) along an arbitrarily chosen [z-axis](#) (usually the [direction](#) of an imposed [magnetic field](#)). [P8.3]

may have: any of the values $-s, -s + 1, -s + 2, \dots, s - 1, s$, where s is the [spin angular momentum quantum number](#), implying that the [z-component](#) of the [spin angular momentum vector](#) may take on any value $S_z = m_s \hbar$ (for the [electron](#) m_s can have the values $+1/2$ or $-1/2$, so the [z-component](#) of the [spin angular momentum](#) of an [electron](#) can have the value $+\hbar/2$ or $-\hbar/2$). [P8.3]

Flexible Learning Approach to Physics - Glossary

spiral

is: the [locus](#) of a [point](#) that moves repeatedly around a fixed [origin](#) while its [distance](#) from that [origin](#) progressively increases.

splitting the numerator

is: a technique that enables [integrals](#) of the form

$$\int \frac{px + q}{ax^2 + bx + c} dx \text{ or } \int \frac{px + q}{\sqrt{ax^2 + bx + c}} dx$$

to be written in terms of two simpler [integrals](#).

works: by writing the [numerator](#), $px + q$, as a multiple of the [derivative](#) of $ax^2 + bx + c$, plus a [constant](#). [[M5.5](#)]

See further integration in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

spontaneous fission

is: a process in which an [atomic nucleus](#), usually one with a large [mass number](#), spontaneously undergoes [nuclear fission](#) (i.e. breaks up to form (typically) two less massive [nuclei](#) and a number of [neutrons](#)). [P9.3]

generally occurs: only in artificially-created [nuclei](#). [P9.3]

Flexible Learning Approach to Physics - Glossary

spring constant

for: a spring obeying [Hooke's law](#)

is: the [coefficient](#) which relates the change in [length](#) of the spring to the [tension](#) or [compression](#) needed to stretch or compress the spring. [[P2.3](#)]

is equivalently: the [coefficient](#) k_s which determines the [restoring force](#) that the spring exerts. When the spring is [extended](#) by an amount x along the [x-axis](#) from its natural (unextended) [state](#) it exerts a [restoring force](#) $F_x = -k_s x$. [[P2.4](#), [P5.1](#)]

Flexible Learning Approach to Physics - Glossary

square

is: a [rectangle](#) in which all four sides are of equal [length](#). [[M2.1](#)]

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square (of a number)

is: the [product](#) of the number multiplied by itself. [[M1.1](#)]

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square roots

of: any number p

are: the two numbers s such that $s^2 = p$ (and $p^{1/2} = s$). [M1.1]

are exemplified: by the square roots of 9, which are 3 and -3 . [M1.1]

are: [real numbers](#) if p is [real](#) and positive. Otherwise they are [complex numbers](#).

may be indicated: by the symbol $\sqrt{\quad}$, although usually this symbol is reserved for the positive square root (for example, usually $\sqrt{9} = 3$, not -3). [M1.1]

Flexible Learning Approach to Physics - Glossary

SQUID

is: a [superconducting quantum interference](#) device. [P11.1]

is used: to measure very weak [magnetic fields](#).

Flexible Learning Approach to Physics - Glossary

stability line

on: a plot of the number of [neutrons](#) N ($N = A - Z$) in [nuclei](#) against number of [protons](#) Z

is: the [line](#) joining the [points](#) which represent [stable nuclei](#). For light [nuclei](#), $N \approx Z$, and for heavier [nuclei](#) $N > Z$. [[P9.2](#)]

Flexible Learning Approach to Physics - Glossary

stable

describes: [nuclear](#) and sub-[nuclear particles](#) that do not [decay](#) (or, at least, that are so long-lived that their [decay](#) has never been [observed](#)). [[P9.1](#)]

Flexible Learning Approach to Physics - Glossary

stable equilibrium

of: a [system](#)

describes: a [state](#) of [equilibrium](#) in which any small disturbance of the [system](#) results in a tendency for the [system](#) to return to its [initial equilibrium state](#).

[P5.1]

Flexible Learning Approach to Physics - Glossary

standards

are: realizable methods of determining fixed values of physical quantities to high [precision](#) and high [accuracy](#). [P1.1]

play: a vital part in determining the [precision](#) and [accuracy](#) with which [units](#) of [measurement](#) may be established and maintained. [P1.1]

underpin: the [precision](#) and [accuracy](#) of any [experimental measurement](#) that uses [units](#). [P1.1]

Flexible Learning Approach to Physics - Glossary

standard atmosphere, atm

is: a non-[SI unit](#) of [pressure](#)

is defined: by $1 \text{ atm} = 1.013\,25 \times 10^5 \text{ N m}^{-2}$. [[P7.2](#)]

standard deviation

is: a quantity related to the spread in repeated [measurements](#) $x_1, x_2, x_3, x_4, x_5, \dots x_n$ of a particular quantity x . The greater the spread, the greater the standard deviation. [[P1.2](#)]

more formally, is defined: as $\sigma_n = \sqrt{\frac{d_1^2 + d_2^2 + \dots + d_n^2}{n}}$ where $d_i = x_i - \langle x \rangle$ is the [deviation](#) of the i^{th} [measurement](#), and $\langle x \rangle$ is the [mean](#) of the n [measurements](#). [[P1.2](#)]

implies: when n is large and the distribution of [measured](#) values is a [normal distribution](#), that about 68% of the readings will lie within $\pm\sigma_n$ of the [mean](#) value, 95% within $\pm 2\sigma_n$ and 99.7% within $\pm 3\sigma_n$. Equivalently, the likelihood that any particular [measurement](#) will lie within $\pm\sigma_n$ of the [mean](#) value is about 68%, $\pm 2\sigma_n$ is 95%, etc. [[P1.2](#)]

See statistics in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

standard equations

are: the most commonly encountered [equations](#) representing the various [conic sections](#) in terms of [Cartesian coordinates](#). [[M2.3](#)]

See conic sections in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

standard error of the mean

of: n repeated [measurements](#) $x_1, x_2, x_3, x_4, x_5, \dots x_n$ of a quantity x

when: the [measurements](#) form a [normally distributed population](#).

is: a [measure](#) of how close the [mean](#) of the [measurements](#) is likely to be to the 'true' value of x , in the absence of [systematic errors](#). [P1.2]

is given: by

$$s_m = \frac{\sigma_n}{\sqrt{n-1}}$$

In the absence of [systematic error](#), the [mean](#), $\langle x \rangle$, of a large number of ([normally distributed](#)) [measurements](#) of a quantity x has a 68% chance of lying within $\pm s_m$ of the 'true' value, a 95% chance of lying within $\pm 2s_m$ and a 99.7% chance of lying within $\pm 3s_m$. [P1.2]

therefore provides: a direct measure of the [precision](#) of an [experimental](#) value: the [precision](#) can be taken to be $\pm 2s_m$ regardless of its [accuracy](#). Nevertheless, in common laboratory practice, the [precision](#) usually is taken to be $\pm 2\sigma_n$, which is numerically larger and therefore *less precise*. [P1.1]

See statistics in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

standard form

(1) is used synonymously: with [standard equations](#). [M2.3]

(2) is used synonymously: with [scientific notation](#).

standard integrals

are: the 'well known' [integrals](#) of a number of standard [functions](#), including [polynomial functions](#), [logarithmic](#) and [exponential functions](#), and [trigonometric functions](#). [M5.2]

See Table 15 in Section 5 of the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

standard temperature and pressure, s.t.p.

is: a [temperature](#) of 273.15 K (= 0.00 °C) and a [pressure](#) of 1.01×10^5 Pa (= 1.00 atm). [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

standing wave

is: a [wave](#) which does not [propagate](#) (sometimes called a stationary wave).
[M6.4, P5.6]

may be regarded: as a [superposition](#) of [waves](#) of equal [amplitude](#) and [wavelength](#) moving in opposite [directions](#). [M6.4, P5.6]

is exemplified by: the [wave](#)

$$\begin{aligned}y(x, t) &= A \sin(kx - \omega t) + A \sin(kx + \omega t) \\ &= 2A \sin(kx) \sin(\omega t)\end{aligned}\quad \text{[M6.4, P5.6]}$$

has: [nodes](#) (i.e. [points](#) at which the disturbance caused by the [wave](#) is permanently zero) at points separated by half the [wavelength](#) of the [superposed travelling waves](#).

Flexible Learning Approach to Physics - Glossary

standing wave mode

is: a [mode](#) of [oscillation](#) of a confined [system](#) in which the endpoints are [nodes](#) and the behaviour between those nodes can be described by a [standing wave](#) of a single [wavelength](#). [P10.3]

has: a [wavelength](#) equal to an integer multiple of twice the [distance](#) between the endpoints. [P10.3]

persists: without change (except for [decay](#)), if excited individually. [P10.3]

is represented: by an [eigenfunction](#) of the [equation](#) for [wave propagation](#) when the [boundary conditions](#) are zero [amplitude](#) at each end. [P10.3]

Flexible Learning Approach to Physics - Glossary

state

is: used to refer to the condition of a [system](#). Its exact meaning varies according to circumstance, but it generally implies a sufficiently detailed account of the condition of a [system](#) to distinguish it from any other condition that would behave differently in the circumstances under discussion. The nature of the required account is indicated by an appropriate qualifier as in [mechanical](#) state, [thermodynamic](#) state, [quantum state](#), [bound state](#), [equilibrium state](#), [stationary state](#), etc.

is specified: in [classical physics](#) by the values of various observable physical quantities (e.g. [pressure](#), [volume](#) and [temperature](#) for an [equilibrium state](#) of a fixed quantity of [ideal gas](#)).

is specified: in [quantum mechanics](#) by a [wavefunction](#) that determines the [probability](#) that [measurements](#) of [observables](#) will yield specified [eigenvalues](#) of the [operator](#) corresponding to the [observable](#).

Flexible Learning Approach to Physics - Glossary

static equilibrium

describes: a situation in which a [mechanical system](#) remains at rest, with no [resultant force](#) or [torque](#) acting. [P2.3]

requires: [translational equilibrium](#) and [rotational equilibrium](#), as necessary (but not sufficient) conditions. [P2.3]

Flexible Learning Approach to Physics - Glossary

static friction

is: a [force](#) of [friction](#) which acts on a solid [surface](#) in contact with another [surface](#) when there is an applied external [force](#) tending to cause sliding of one [surface](#) across the other, but no actual [relative motion](#). [P2.3]

has a direction: which opposes the relative [motion](#) that would arise in its absence. [P2.3, P5.2]

has a magnitude: which is [proportional](#) to the [magnitude](#) R of the [reaction force](#) acting on the [surface](#) of interest from the other [surface](#), so that $F_{\text{static}} = \mu_{\text{static}} R$, where μ_{static} is a [constant](#), called the [coefficient of static friction](#), characteristic of the [surfaces](#) involved (including their [state](#) of lubrication). [P2.3, P5.2]

exists: only so long as there is no actual sliding [motion](#) between the two [surfaces](#). [P7.6]

Compare with [sliding friction](#), which is generally less in any given situation.

Flexible Learning Approach to Physics - Glossary

statics

is: the study of [systems](#) which are in [static equilibrium](#). [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

stationary

describes: a [function](#) $f(x)$ at any [point](#) where the [tangent](#) to its [graph](#) is horizontal. [[P6.2](#)]

therefore describes: a [function](#) $f(x)$ at any [point](#) where its [derivative](#) is zero. [[M4.4](#)]

Flexible Learning Approach to Physics - Glossary

stationary (function)

refers: to a function $f(x)$ at its [stationary point](#), where $\frac{df}{dx} = 0$. [M4.4]

Flexible Learning Approach to Physics - Glossary

stationary orbit

of: an [electron](#) in the [Bohr model](#) of the [atom](#)

is: an [orbit](#) in which the [electron](#), although [accelerating](#), does not [emit electromagnetic radiation](#) as required by [classical physics](#). [P11.3]

was postulated: by Niels Bohr (1885-1962) to explain the stability of the hydrogen [atom](#). [P11.3]

Flexible Learning Approach to Physics - Glossary

stationary point

is: a [point](#) $(a, f(a))$ on the [graph](#) of the [function](#) $f(x)$ at which the [tangent](#) to the [graph](#) is horizontal and the [function](#) therefore is [stationary](#). [[M4.4](#), [P6.2](#)]

therefore is: a [point](#) at which the [function's derivative](#) $f'(x) = 0$. [[M4.4](#), [P6.2](#)]

is exemplified: by a [local maximum](#) or [local minimum](#) or [point of inflection](#) (with horizontal [tangent](#)). [[M4.4](#), [P6.2](#)]

Flexible Learning Approach to Physics - Glossary

stationary state

of: a [quantum mechanical system](#)

is: a [state](#) described by a [wavefunction](#) in which the [spatial](#) and [temporal](#) parts are [separable](#), so in one [dimension](#), $\Psi(x, t) = \psi(x) \phi(t)$, where $\psi(x)$ is a [solution](#) of the [time-independent Schrödinger equation](#) corresponding to a unique [energy eigenvalue](#). [P10.3, P10.4]

therefore has: a [probability density function](#) $P(x, t) = |\Psi(x, t)|^2$ which is independent of [time](#) and so may be written as $P(x) = |\psi(x)|^2$ [P10.4]

is: [stable](#). A [system](#) prepared in one of its stationary states will remain in this [state](#), if isolated. [P10.3]

is: the [quantum mechanical](#) equivalent of one of the [standing wave modes](#) of a [classical oscillatory system](#). [P10.3]

Flexible Learning Approach to Physics - Glossary

stationary wave

See [standing wave](#).

Flexible Learning Approach to Physics - Glossary

statistical mechanics

is: a powerful and wide-ranging branch of [physics](#) that is concerned with the behaviour of [systems](#) of such a nature and involving sufficiently many [degrees of freedom](#) that mathematical methods developed in the field of [statistics](#) are of use in their study.

predicts: amongst other things, and in appropriate circumstances, the likely [distribution](#) of [energy](#) amongst the [particles](#) of a [system](#). [P7.5]

Flexible Learning Approach to Physics - Glossary

statistics

is: the branch of [mathematics](#) which is concerned with analysis of quantitative [data](#). [[P1.1](#)]

Flexible Learning Approach to Physics - Glossary

steady state (motion)

describes: the behaviour of a [system](#) once any [transient](#) behaviour has [decayed](#) away.

often refers specifically: to the [motion](#) produced in a [driven oscillator](#) once the [transient motion](#) has [decayed](#) away. [[P5.3](#), [P5.5](#)]

Stefan's constant

is: a useful [constant](#) that appears in [Stefan's law](#) and which is equal to a particular combination of [fundamental constants](#):

$$\sigma = 2\pi^5 k^4 / (15h^3 c^3) = 5.6697 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}. \quad [\text{P7.3}]$$

Flexible Learning Approach to Physics - Glossary

Stefan's law

states: that the total [power radiated](#) per [unit area](#) by a [black-body](#) at [temperature](#) T is given by $R = \sigma T^4$ where σ is [Stefan's constant](#). [P7.3]

can be derived: from [Planck's function](#), by [integrating](#) the [expression](#) that it provides for the [spectral brightness](#) of a [black-body](#) over all possible [wavelengths](#). [P7.3]

Flexible Learning Approach to Physics - Glossary

step-down transformer

is: a [transformer](#) whose output [voltage](#) on the [secondary coil](#) is less than the input [voltage](#) on the [primary coil](#), as a result of the [transformer turns ratio](#) being less than unity. [[P4.4](#)]

Flexible Learning Approach to Physics - Glossary

step-up transformer

is: a [transformer](#) whose output [voltage](#) on the [secondary coil](#) is greater than the input [voltage](#) on the [primary coil](#), as a result of the [transformer turns ratio](#) being greater than unity. [[P4.4](#)]

stepped-index fibre

is: an [optical fibre](#) in which the [refractive index](#) changes abruptly at some [distance](#) from the [axis](#) of the fibre and in which [total internal reflection](#) at this [interface](#) is used to confine [light rays](#) within the [fibre](#) and away from the [surface](#) of the [fibre](#). [P6.2]

Stern-Gerlach experiment

is: a classic [experiment](#) in which a beam of (silver) atoms travelling through a non-[uniform magnetic field](#) is split into two sub-beams. [P8.3]

demonstrates: [quantization](#) of orientation in a [magnetic field](#). (The results were eventually interpreted in terms of the [spin magnetic quantum number](#).) [P8.3]

Flexible Learning Approach to Physics - Glossary

stimulated emission

is: the process in which an incoming [photon](#) stimulates an [atom](#) in an [excited state](#) to [radiate](#) another [photon](#) of the same [frequency](#), [phase](#) and [direction](#).

is: the process underlying the operation of a [laser](#). [[P5.3](#), [P10.1](#)]

Flexible Learning Approach to Physics - Glossary

Stokes' law

is: an [empirical](#) law of limited validity

states: that the [magnitude](#) of the [force](#) due to [viscosity](#), on a [spherical body](#) moving through a [fluid](#) is [directly proportional](#) to the [product](#) of the [relative speed](#) v , the [coefficient of viscosity](#) of the [fluid](#) η , and the [radius](#) of the [sphere](#) r .

So $F = 6\pi\eta rv$. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

stops

are: preset [aperture](#) adjustments on a [lens](#), changing the [f-number](#) of the [lens](#).
[\[P6.4\]](#)

Flexible Learning Approach to Physics - Glossary

storage cell

is: a [cell](#) (such as a [lead-acid accumulator](#)) whose [open circuit voltage](#) (e.m.f.) results from a [chemical reaction](#) that can be reversed by passing an [electric current](#) through the [cell](#). [[P4.5](#)]

Flexible Learning Approach to Physics - Glossary

straight line

is: the path of shortest [distance](#) between two [points](#). [M2.1]

See [equation of a straight line](#).

Flexible Learning Approach to Physics - Glossary

straight line segment

is: the part of a [straight line](#) passing through two given [points](#) that lies between the two [points](#). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

strain

is: a [dimensionless](#) quantity which measures the fractional distortion in a material produced by an applied [stress](#). [[P7.6](#)]

See also [tensile strain](#), [shear strain](#) and [volume strain](#).

Flexible Learning Approach to Physics - Glossary

strain energy

is: an abbreviation for [strain potential energy](#). [P2.4]

Flexible Learning Approach to Physics - Glossary

strain potential energy

is: the [potential energy](#) possessed by an object by virtue of its deformation from its [equilibrium](#) shape. [[P2.4](#), [P5.2](#)]

is exemplified: by a spring obeying [Hooke's law](#), with [spring constant](#), k_s , extended or compressed by [displacement](#) x which has strain potential energy $E_{\text{pot}} = \frac{1}{2}k_s x^2$. [[P2.4](#), [P5.2](#)]

Flexible Learning Approach to Physics - Glossary

stress

is: a [force](#) acting [uniformly](#) through or across an [area](#) of a material, divided by the [area](#) over which it acts. [[P7.6](#)]

See also [tensile stress](#), [shear stress](#) and [volume stress](#).

Flexible Learning Approach to Physics - Glossary

strong interaction

is: the strongest of the [fundamental interactions](#) between [elementary particles](#).
[[P9.1](#), [P9.2](#)]

has: a short range, roughly equivalent to a typical [nuclear diameter](#)

is responsible: for the strong interaction between nucleons that binds together the [neutrons](#) and [protons](#) in [nuclei](#). [[P9.1](#), [P9.2](#)]

is often called: the strong nuclear force. [[P9.2](#)]

strong interaction between nucleons

See [strong interaction](#).

Flexible Learning Approach to Physics - Glossary

strong nuclear force

See [strong interaction](#).

Flexible Learning Approach to Physics - Glossary

subatomic particle

is: a general term for [particles](#) with [diameters](#) that are less than the typical [atomic](#) size scale of 10^{-10} m. (Such diameters may be rather loosely defined.)
[P8.1]

is exemplified: by the [proton](#), [neutron](#) and [electron](#). [P8.1]

Flexible Learning Approach to Physics - Glossary

subcritical

describes: a [nuclear chain reaction](#) which fails to be self-sustaining because, on average, less than one [neutron](#) released in each [fission](#) of a [nucleus](#) goes on to produce [fission](#) in a further [nucleus](#). [P9.3]

Contrast with [critical](#).

Flexible Learning Approach to Physics - Glossary

subject (of an equation or formula)

is: the single [variable](#) which is expressed in terms of others. [[M1.1](#)]

is exemplified: in the [equation](#) $F = ma$, by F . [[M1.1](#)]

Flexible Learning Approach to Physics - Glossary

sublimation

is: a [phase change](#) in which a [solid](#) is converted directly into a [gas](#) (or [vapour](#)), or vice versa, without passing through a [liquid phase](#). [[P7.4](#)]

See also [latent heat](#), [sublimation curve](#).

Flexible Learning Approach to Physics - Glossary

sublimation curve

on: a [P-T diagram](#)

is: the curve that separates the [solid phase](#) from the [vapour \(gas\) phase](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

subscript

is: a symbol or number which is written beneath another symbol. [M1.7]

is used: to identify particular members of a [sequence](#). [M1.7]

is exemplified: for the [sequence](#), x_1 , x_2 and x_3 , by the numerals 1, 2 and 3. [M1.7]

Flexible Learning Approach to Physics - Glossary

subset

describes: all the [elements](#) of a [set](#) A when they are also [elements](#) of a larger [set](#) B. [[M1.2](#)]

is denoted: by $A \subset B$. [[M1.2](#)]

Flexible Learning Approach to Physics - Glossary

subshell

is: a grouping of [electrons](#) within a [shell](#) (i.e. having the same [principal quantum number](#) n), which also have the same [orbital angular momentum quantum number](#) l . [[P8.3](#), [P8.4](#)]

therefore describes: [electrons](#) which, to a first [approximation](#), have the same [energy](#). [[P8.3](#), [P8.4](#)]

Flexible Learning Approach to Physics - Glossary

subsidiary maxima

in: the [interference pattern](#)

from: a [diffraction grating](#)

are: the less prominent [intensity](#) maxima which are found between the [principal maxima](#). [[P6.1](#)]

Flexible Learning Approach to Physics - Glossary

subsonic

means: travelling at a [speed](#) that is slower than the [speed](#) of [sound](#). [P5.7]

Flexible Learning Approach to Physics - Glossary

substitution

is: a method of solving, or trying to solve, [simultaneous equations](#). [M1.4]

Flexible Learning Approach to Physics - Glossary

subtended angle

of: two [points](#) A and B, at a third [point](#) C not on the [line](#) passing through A and B,

is: the [angle](#) \hat{ACB} at C. [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

successive ionization energies

are: the [energies](#) required to remove successively each of the [electrons](#) from an [atom](#) or [ion](#), beginning with the least tightly [bound electron](#) and proceeding to the most tightly [bound](#). [[P8.3](#)]

Flexible Learning Approach to Physics - Glossary

sum

See [operation](#).

Flexible Learning Approach to Physics - Glossary

sum (of vectors)

is: the [vector](#) which results from the [vector addition](#) of two or more [vectors](#).
[\[M2.4\]](#)

Flexible Learning Approach to Physics - Glossary

sum formulae

are: a class of [trigonometric identities](#). [[M1.6](#)]

See trigonometric functions in the [Maths handbook](#).

sum identities

are: a class of [hyperbolic function identities](#). [M4.6]

See hyperbolic functions in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

sum of a series

See [convergent series](#).

sum rule for differentiation

is: $\frac{d}{dx}(f(x) + g(x)) = \frac{df(x)}{dx} + \frac{dg(x)}{dx}$ [\[M4.2\]](#)

sum rule for integration

is: $\int (f(x) + g(x)) dx = \int f(x) dx + \int g(x) dx$ [[M5.2](#)]

summation over addition rule

is:
$$\sum_{i=1}^N (x_i + y_i) = \sum_{i=1}^N x_i + \sum_{i=1}^N y_i \quad [\text{M1.7}]$$

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summation symbol, Σ

is: the symbol which is used to denote the [operation](#) of performing a [sum](#).
[M1.7]

$$\sum_{k=1}^n a_k = a_1 + a_2 + a_3 + \dots + a_n$$

where $k = 1$ indicates the lower limit of the summation, the [integer](#) n above the summation symbol indicates the upper limit of the summation, and k is the summation variable that ranges over the [integer](#) values between the lower and upper limits. [M1.7]

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summation variable

See [summation symbol](#).

Flexible Learning Approach to Physics - Glossary

superconductivity

is: the sudden disappearance of [electrical resistance](#) that occurs in some materials below a characteristic [critical temperature](#). [P8.4]

normally occurs: below 25 K but in 1986 a new class of material was discovered that exhibit superconductivity well above 25 K. These new materials are known as high-[temperature superconductors](#) and most of them are compounds that contain [lanthanides](#) and [transition elements](#). [P8.4]

Flexible Learning Approach to Physics - Glossary

superconductor

is: a material whose [resistivity](#) drops to zero when its [temperature](#) falls below a critical [transition temperature](#) T_c . [[P4.1](#), [P11.1](#)]

Flexible Learning Approach to Physics - Glossary

supercritical

describes: the condition in which a [nuclear chain reaction](#) proceeds at an ever-increasing rate, with an explosive release of [energy](#), because more than one [neutron](#) released in each [fission](#) of a [nucleus](#) goes on to produce [fission](#) in further [nuclei](#). [[P9.3](#)]

See also [critical](#).

superelastic collision

is: a [collision](#) in which the total [kinetic energy](#) is increased (usually by the release of some stored [potential energy](#) during the [collision](#)). [[P2.5](#)]

Flexible Learning Approach to Physics - Glossary

superposition

is: the addition of [oscillations](#) or [waves](#) in which the [superposition principle](#) is applied. [[P5.1](#)]

is also: the result of such an addition.

superposition principle

See [principle of superposition](#).

Flexible Learning Approach to Physics - Glossary

superscript

is: a symbol or number written above another symbol. [M1.7]

is used: identically to a [subscript](#), but generally is employed in situations where the two need to be distinguished. [M1.7]

is exemplified: by n in the [binomial coefficient](#), ${}^n C_r$. [M1.7]

Flexible Learning Approach to Physics - Glossary

supersonic

describes: anything travelling at a [speed](#) greater than the [speed](#) of [sound](#).
[\[P5.7\]](#)

Flexible Learning Approach to Physics - Glossary

supplementary angles

are: two [angles](#) whose [sum](#) is 180° . [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

surface

is: the boundary of a real or imagined [body](#).

more formally is: a connected and restricted [set](#) of [points](#) in (a possibly abstract) [space](#) such that by imposing a suitable system of [coordinates](#) on the surface, the location of any one of its [points](#) may be fixed relative to any other of its [points](#) with fewer coordinates than would be needed to locate a general [point](#) in the [space](#).

is exemplified: by the surface of a [sphere](#), the [points](#) of which can be located with respect to one another by means of two [coordinates](#) (e.g. latitude and longitude) even though points in general require three [coordinates](#) for their unique specification.

generally implies: the existence of a relationship between the [coordinates](#) of the [space](#) in which the surface is located, such as the [equation of state of an ideal gas](#) which specifies its [two-dimensional equilibrium surface](#) in [three-dimensional PVT](#) space.

Flexible Learning Approach to Physics - Glossary

surface energy

is: the [energy](#) per [unit area](#) of [surface](#) arising from the difference between [molecular forces](#) at the [surface](#) of a material and those within the bulk of the material.

Flexible Learning Approach to Physics - Glossary

surface gravity

is: the [gravitational field \$g\$](#) , (or, equivalently, the [acceleration due to gravity](#)) at the [surface](#) of the Earth or any other massive [body](#). [P3.2]

is given: for the Earth, in [magnitude](#), by

$$g = GM_E / R_E^2$$

where G is [Newton's universal gravitational constant](#), M_E is the [mass](#) of the Earth and R_E the [radius](#) of the Earth. [P3.2]

Flexible Learning Approach to Physics - Glossary

surface integral

of: a [function](#) $f(x, y, z)$ defined at all points on a [surface](#) \mathbf{S}

is: the limit of the [sum](#) of terms of the form $f(X, Y, Z)\Delta\mathbf{S}$, where $\Delta\mathbf{S}$ is an element of area of the [surface](#) \mathbf{S} and $f(X, Y, Z)$ is the value of $f(x, y, z)$ at some point within that element.

is exemplified: by the [integral](#) $\int_S \mathbf{V} \cdot d\mathbf{S}$ where \mathbf{V} represents a [vector field](#) defined on \mathbf{S} and $d\mathbf{S}$ is a [vector element of integration](#) with [magnitude](#) dS directed along an outward pointing [normal](#) to \mathbf{S} at every [point](#). [M2.6]

See also [flux of a vector field](#).

Flexible Learning Approach to Physics - Glossary

surface of revolution

is: the [surface](#) obtained by [rotating](#) a [curve](#) (or part of a [curve](#)) about a given [line](#) or [axis](#). [[M5.4](#)]

Flexible Learning Approach to Physics - Glossary

surface tension

in: the [surface](#) of a [liquid](#)

is: the property tending to minimize the [area](#) of the [surface](#).

numerically is equal: to the [energy](#) per [unit area](#) needed to increase the [surface area](#) under [isothermal](#) conditions, or the [force magnitude](#) acting per [unit length](#) on the [surface](#). [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

suspensory ligaments

are: the ring of ligaments which tie the [lens](#) of the eye to the surrounding [ciliary muscles](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

symmetric function

means: [even function](#). [[M1.6](#), [M5.2](#)]

Flexible Learning Approach to Physics - Glossary

symmetry

is: any one of the classes of operations that leave the essential features of a [system](#) unchanged.

is exemplified: by the [rotational](#) symmetry of a [sphere](#) about any axis through its centre. [[P2.5](#)]

Flexible Learning Approach to Physics - Glossary

symmetry argument

is: an argument that relies on the belief that a [system](#) would be unchanged in its essential features under certain actions, such as the exchange of two identical [particles](#), or [rotation](#) about a specified [axis](#).

Flexible Learning Approach to Physics - Glossary

symmetry relations

are: a class of [trigonometric identities](#). [M1.6]

See trigonometric functions in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

system

is: a general term referring to that portion of the [Universe](#) which is to be identified as the subject of a study or investigation. The rest of the [Universe](#) is said to constitute the [environment](#) of the system. [[P7.3](#), [P7.4](#)]

is used: with various qualifiers according to circumstance, as in [thermodynamic](#) system, [mechanical](#) system, [quantum](#) system, etc.

See [state](#).

Flexible Learning Approach to Physics - Glossary

systematic error

in: a [measurement](#)

is: the kind of [error](#) that systematically shifts all readings in the same direction away from the true value and consequently also shifts the [mean](#) and so reduces the [accuracy](#). [[P1.1](#), [P1.2](#)]

is: hard to detect. Either the [experiment](#) is designed to anticipate it and to cancel it out, or it biases the [measured](#) value. If this happens, only disagreement of the measured value with the results of a different kind of [experiment](#) will bring it to light. [[P1.1](#), [P1.2](#)]

limits: the [accuracy](#) of a [measurement](#).

Contrast with [random error](#) which determines [precision](#).

Flexible Learning Approach to Physics - Glossary

table of values

is: a systematic way of displaying the value of a [function](#) corresponding to various values of its [independent variable](#). [[M1.3](#)]

often provides: the basis for a [graph](#). [[M1.3](#)]

Flexible Learning Approach to Physics - Glossary

tangent

at: a given [point](#) on a [curve](#)

is: a [straight line](#) that touches the given [curve](#) at the given [point](#) and which has the same [gradient](#) as the [curve](#) at that [point](#). The [gradient](#) of the tangent to a [point](#) on a curved [graph](#) defines the [gradient](#) of the [graph](#) at that [point](#). [[M1.5](#), [M2.1](#), [M2.2](#), [M2.3](#), [M4.1](#), [M4.2](#)]

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tangent, tan

See [trigonometric function](#).

Flexible Learning Approach to Physics - Glossary

tanh

See [hyperbolic function](#).

Flexible Learning Approach to Physics - Glossary

Taylor expansion or series for $f(x)$ near $x = 0$

for: values of x in some specified [domain](#)

is: a [series](#) (quite possibly an [infinite series](#)) of the form

$$f(0) + f'(0)\frac{x}{1!} + f''(0)\frac{x^2}{2!} + f^{(3)}(0)\frac{x^3}{3!} + f^{(4)}(0)\frac{x^4}{4!} + \dots$$

where the [sum of the series](#) is the value of $f(x)$. [M4.5]

Flexible Learning Approach to Physics - Glossary

Taylor expansion or series for $f(x)$ near $x = a$

for: values of x in some specified [domain](#)

is: a [series](#) (quite possibly an [infinite series](#)) of the form

$$f(a) + f'(a)\frac{(x-a)}{1!} + f''(a)\frac{(x-a)^2}{2!} \\ + f^{(3)}(a)\frac{(x-a)^3}{3!} + f^{(4)}(a)\frac{(x-a)^4}{4!} + \dots$$

where the [sum of the series](#) is the value of $f(x)$. [[M4.5](#)]

Flexible Learning Approach to Physics - Glossary

Taylor polynomial of degree n for $f(x)$ near $x = 0$

is: a [polynomial](#) of the form

$$f(x) = f(0) + f'(0)\frac{x}{1!} + f''(0)\frac{x^2}{2!} + f^{(3)}(0)\frac{x^3}{3!} \\ + f^{(4)}(0)\frac{x^4}{4!} + \dots + f^{(n)}(0)\frac{x^n}{n!}$$

provided that the [derivatives](#) $f(0)$, $f'(0)$, \dots , $f^{(n)}(0)$ all exist. [[M4.5](#)]

is: a [Taylor series](#) for $f(x)$ near $x = 0$ truncated to $n + 1$ terms.

Flexible Learning Approach to Physics - Glossary

Taylor polynomial of degree n for $f(x)$ near $x = a$

is: a [polynomial](#) of the form

$$f(a) + f'(a)\frac{(x-a)}{1!} + f''(a)\frac{(x-a)^2}{2!} + f^{(3)}(a)\frac{(x-a)^3}{3!} \\ + f^{(4)}(a)\frac{(x-a)^4}{4!} + \dots + f^{(n)}(a)\frac{(x-a)^n}{n!}$$

provided that the [derivatives](#), $f^{(m)}(a)$ (for $0 \leq m \leq n$), all exist. [M4.5]

is: a [Taylor series](#) for $f(x)$ near $x = a$ truncated to $n + 1$ terms.

Flexible Learning Approach to Physics - Glossary

telescope

is: a device which allows [observation](#) of a [parallel beam](#) of [light](#) from a distant object or as produced by a [collimator](#), with high [angular magnification](#). [[P6.4](#), [P8.2](#)]

is exemplified: by the final observation stage of a [spectrometer](#). [[P6.4](#), [P8.2](#)]

Flexible Learning Approach to Physics - Glossary

temperature

of: a [thermodynamic system](#)

is: the property which indicates whether there is [thermal equilibrium](#). Two objects in [thermal equilibrium](#) with each other are said to have the same temperature. [P7.2]

is: a [function of state](#) of the [system](#). [P7.3]

is related: to the [internal energy](#) U of the [system](#). For an [ideal gas](#) of [point particles](#) this relationship takes the form $U = 3nRT/2$ implying that the temperature is proportional to the average [translational kinetic energy](#) of the [particles](#) that make up the [gas](#). However, in other [systems](#) the relationship may be more complicated. [P7.3]

when increasing, generally corresponds: to increasing [internal energy](#) of the [system](#). But it is not necessarily true that an increase in [internal energy](#) corresponds to an increase in temperature. [P7.3]

Flexible Learning Approach to Physics - Glossary

temperature coefficient of resistance

of: a material (in a given [state](#))

is: the mean fractional change of [resistance](#) per unit [temperature](#) rise between 0°C and 100°C:

$$\alpha = \frac{R_{100} - R_0}{100^\circ\text{C} \times R_0} \quad [\text{P4.1}]$$

generally is: positive for a [metal](#). [P4.1]

often is: negative for a [semiconductor](#). [P4.1]

See [temperature coefficient of resistivity](#).

Flexible Learning Approach to Physics - Glossary

temperature coefficient of resistivity

of: a material (in a given [state](#))

is: the mean fractional change of [resistivity](#) per unit [temperature](#) rise between 0°C and 100°C :

$$\alpha = \frac{\rho_{100} - \rho_0}{100^{\circ}\text{C} \times \rho_0}$$

is defined more generally: over any suitable [temperature](#) range, by applying the [linear](#) relation

$$\rho = \rho_0 [1 + \alpha(T - T_0)]$$

where ρ is the [resistivity](#) at [temperature](#) T and ρ_0 is the [resistivity](#) at [temperature](#) T_0 . [[P11.4](#)]

generally is: positive for a [metal](#), due to the increase in [lattice vibrations](#) with increasing [temperature](#). [[P11.4](#)]

often is: negative for a [semiconductor](#), due to increase in the number of mobile [charged particles](#) with increasing [temperature](#). [[P11.4](#)]

Flexible Learning Approach to Physics - Glossary

temperature gradient

is: the [rate of change](#) of [temperature](#) with [position](#) along an axis or across some region, dT/dx . [[P7.3](#)]

is exemplified: by the temperature gradient along a metal rod, one end of which is maintained at a relatively high [temperature](#) while the other end is at a relatively low [temperature](#).

Flexible Learning Approach to Physics - Glossary

temperature scale

relates: a particular physical property to the corresponding [temperature](#).
[P7.2]

ideally is: fundamental (such as the [ideal gas absolute temperature scale](#) or the [thermodynamic Kelvin temperature scale](#)) and/or internationally agreed (such as [IPTS-90](#)). [P7.2]

is also exemplified: by [centigrade temperature scales](#) and the [Celsius scale](#).
[P7.2]

Flexible Learning Approach to Physics - Glossary

temporal

means: pertaining to [time](#).

Flexible Learning Approach to Physics - Glossary

temporal coherence

of: [waves](#)

is: their characteristic of maintaining [coherence](#) over some period of [time](#).
[P6.1]

usually is: limited by the nature of the source.

temporal part of the wavefunction

See [temporal wavefunction](#) and contrast with [spatial wavefunction](#). [[M6.4](#), [P10.3](#), [P10.4](#)]

Flexible Learning Approach to Physics - Glossary

temporal wavefunction

is: that part of a [separable solution](#) to the [time-dependent Schrödinger equation](#) that depends only on [time](#). [M6.4]

is exemplified: in one [dimension](#) by the factor $\phi(t) = \exp(-iEt/\hbar)$ that appears in the [stationary state wavefunction](#) $\Psi(x, t) = \psi(x)\phi(t)$. [M6.4, P10.3, P10.4]

Flexible Learning Approach to Physics - Glossary

tensile force

is: a [force](#) which acts to stretch a material and therefore to produce [tensile strain](#). [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

tensile strain

is: the [strain](#) σ_T within a material caused by the application of a [tensile force](#).
[P7.6]

is given: by the increase in [length](#) Δl of the material divided by the original undistorted [length](#) l , so $\epsilon_T = \Delta l/l$. [P7.6]

Flexible Learning Approach to Physics - Glossary

tensile stress

is: the [stress](#) σ_T resulting from a [tensile force](#) acting over a [surface](#) in a material. [[P7.6](#)]

is given: by the [ratio](#) of the [perpendicular component](#) of the [tensile force](#) to the cross-sectional area over which it acts, so $\sigma_T = F_{\perp}/A$. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

tension

is: that property of a stretched [elastic body](#) that tends to restore the body to its natural [length](#). [[P2.3](#)]

is also: the [force](#) which such a stretched body will apply to an attached object. [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

term

See [expression](#).

Flexible Learning Approach to Physics - Glossary

terminal

is: a structure, typically a metal plate or wire, through which [electric current](#) may be supplied.

Flexible Learning Approach to Physics - Glossary

terminal potential difference

is: the [potential difference](#) between the [terminals](#) of a [voltage generator](#). [P4.1]

will vary: for a non-[ideal voltage generator](#), according to the [resistance](#) of the rest of the [circuit](#). [P4.1]

See [open circuit voltage](#).

Flexible Learning Approach to Physics - Glossary

terminal velocity

is: the final [velocity](#) reached by a [body](#) falling in a [viscous medium](#), when the [weight](#), the [viscous force](#) and the [buoyancy force](#) give zero [resultant force](#).
[[M4.2](#), [P7.6](#)]

Flexible Learning Approach to Physics - Glossary

terrestrial telescope

is: a [telescope](#) whose final [image](#) is [erect](#). [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

tesla, T

is: the [SI unit](#) of [magnetic field strength](#).

is defined: by $1 \text{ T} = 1 \text{ N C}^{-1} \text{ m}^{-1} \text{ s}$. So, a [uniform magnetic field](#) has a [strength](#) B of 1 tesla, if a [particle](#) with a [charge](#) of 1 [coulomb](#) moving with a [speed](#) of 1 [metre](#) per [second](#) in a [direction perpendicular](#) to that [field](#) experiences a [magnetic force](#) of 1 [newton](#). Alternatively (and equivalently), a [uniform magnetic field](#) has a [strength](#) B of 1 T if a wire carrying a [current](#) of 1 A in a [direction perpendicular](#) to the [field](#) experiences a [force](#) of 1 [newton](#) per [metre length](#) of wire, so $1 \text{ T} = 1 \text{ N m}^{-1} \text{ A}^{-1}$. [[P4.2](#), [P4.3](#)]

is exemplified: by the [magnetic field](#) near a typical bar magnet, which has a [strength](#) of about 10^{-1} T .

Flexible Learning Approach to Physics - Glossary

test charge

is: an (imaginary) [electrically charged body](#), whose nature is such that it may be used to determine the [electric field](#) at a point (by experiencing a measurable [force](#) due to the [field](#)) without causing any significant disturbance to the [field](#). [[P3.1](#), [P3.3](#)]

Flexible Learning Approach to Physics - Glossary

test mass

is: an (imaginary) [body](#), whose nature is such that it may be used to determine the [gravitational field](#) at a point (by experiencing a measurable [force](#) due to the [field](#)) without causing any significant disturbance to the [field](#). [[P3.1](#), [P3.3](#)]

Flexible Learning Approach to Physics - Glossary

theorem

is: a [mathematical](#) proposition that may be proved, or which it is hoped will be proved.

Flexible Learning Approach to Physics - Glossary

theory

is: a connected and coherent set of (scientific) concepts and relationships which is (ideally) capable of making predictions that can be tested by [experiment](#) or [observation](#).

Flexible Learning Approach to Physics - Glossary

thermal

means: pertaining to [temperature](#).

thermal conduction

See [conduction \(of heat\)](#).

thermal conductivity

See [conduction \(of heat\)](#).

thermal conductivity coefficient

See [coefficient of thermal conductivity](#).

Flexible Learning Approach to Physics - Glossary

thermal contact

is: the condition in which [heat](#) can be transferred between two [bodies](#), or between a [system](#) and its [environment](#). [[P7.2](#), [P7.3](#)]

Flexible Learning Approach to Physics - Glossary

thermal equilibrium

of: a [system](#)

means: that no net transfer of [heat](#) is taking place. [[P7.2](#), [P7.3](#)]

justifies: the introduction of [temperature](#) and [thermometry](#). We say that if two [bodies](#) (one of which might be a [thermometer](#)) are in thermal equilibrium then they are at the same [temperature](#). [[P7.2](#), [P7.3](#)]

can be recognized: by the [constancy](#) of its [thermal](#) properties and the [uniformity](#) of its [temperature](#).. [[P7.2](#), [P7.3](#)]

Flexible Learning Approach to Physics - Glossary

thermal expansion (or contraction)

is: [expansion](#) (or [contraction](#)) due to [temperature](#) changes.

See also [thermal expansivity](#).

Flexible Learning Approach to Physics - Glossary

thermal expansivity

is: the ability of a material to change its [volume](#) in response to a change in [temperature](#) and thus exhibit the phenomenon of [thermal expansion](#).

arises: in a [solid](#), from the [thermal](#) agitation of [atoms](#) subject to a [potential energy function](#) that is not [symmetric](#) about its minimum. [P11.4]

Flexible Learning Approach to Physics - Glossary

thermal kinetic energy

is: the [kinetic energy](#) associated with the random [thermal motion](#) at a given [temperature](#).

thermal neutrons

are: [neutrons](#) with a [kinetic energy](#) of approximately 0.04 eV – i.e. the [energy](#) that they would have in [thermal equilibrium](#) with their surroundings at room [temperature](#) (i.e. at about 300 K). [[P9.3](#)]

Flexible Learning Approach to Physics - Glossary

thermal reservoir

ideally is: a part of the [environment](#) of a [system](#) that absorbs or supplies any required amount of [heat](#) without undergoing a change of [temperature](#). [[P7.3](#), [P7.4](#)]

Flexible Learning Approach to Physics - Glossary

thermistor

is: a [thermally](#) sensitive [resistor](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

thermocouple

is: a [circuit](#) in which two different [metals](#) are brought into contact at two distinct junctions. [[P7.2](#)]

can be used: as a [thermometer](#). [[P7.2](#)]

works: by the [electrical potential difference](#) created when the junctions are at different [temperatures](#). [[P7.2](#)]

is widely used: because it is small, cheap and reliable. [[P7.2](#)]

may be used: over a wide range of [temperatures](#), by selecting appropriate pairs of [metals](#). [[P7.2](#)]

Flexible Learning Approach to Physics - Glossary

thermodynamic coordinates

are: the [macroscopic](#) properties of a [system](#) that may be used to specify its [state](#), or more particularly its [equilibrium state](#).

are exemplified: by [pressure](#) P , [volume](#) V , [temperature](#) T , and [internal energy](#) U : quantities that are [functions of state](#). [P7.3]

thermodynamic equilibrium

See [thermal equilibrium](#).

thermodynamic Kelvin temperature scale

is: a [temperature scale](#) based on [heat](#) flow under carefully controlled conditions.

is also: perhaps the most fundamental of all [temperature scales](#). [P7.2]

rarely is used: in practice, since it is essentially identical to the far more practical [ideal gas absolute temperature scale](#) over a very wide range of [temperatures](#). [P7.2]

is defined: by the [thermometric relation](#)

$$T = \left(\frac{Q}{Q_{\text{triple}}} \right) \times 273.16 \text{ K}$$

where Q is the quantity of [heat](#) that flows in or out of a [system](#) at [temperature](#) T in a [reversible isothermal process](#) that links one [adiabat](#) to another, and Q_{triple} is the quantity of [heat](#) that flows in or out if the [system](#) in a [reversible isothermal process](#) at the [triple-point temperature](#) (defined to be 273.16 K) that returns the [system](#) from the second [adiabat](#) to the first. [P7.2]

thermodynamics

is: the study of [temperature](#) and [heat](#), and the interrelations of those quantities with [matter](#) and [energy](#) in general. [[P7.1](#), [P7.2](#), [P7.3](#)]

Flexible Learning Approach to Physics - Glossary

thermometer

is: a device for [measuring temperature](#) on a specified [temperature scale](#). [P7.2]

Flexible Learning Approach to Physics - Glossary

thermometric property

is: a property of [matter](#) which depends on [temperature](#). [P7.2]

is selected: for reasons of sensitivity, convenience, or tradition. [P7.2]

is used: as a means of relating [temperature](#) differences to a generally recognized [temperature scale](#) such as the [Celsius scale](#). [P7.2]

Flexible Learning Approach to Physics - Glossary

thermometric relation

is: an [equation](#) which relates the value of some [thermometric property](#) between given [fixed points](#), to the [temperature](#) on a particular [temperature scale](#). [P7.2]

Flexible Learning Approach to Physics - Glossary

Thévenin resistance

of: any [circuit](#) between two [terminals](#)

is: the [resistance](#) R_{Th} of the single [resistor](#) in an equivalent [circuit](#) described by [Thévenin's theorem](#). [P4.1]

is equal: to the net [resistance](#) between the two [terminals](#) when all [voltage generators](#) between the [terminals](#) are replaced by [short circuits](#). [P4.1]

Thévenin voltage

of: any [circuit](#) between two [terminals](#)

is: the [voltage](#) V_{Th} of the [ideal voltage generator](#) in an equivalent [circuit](#) described by [Thévenin's theorem](#). [[P4.1](#)]

is equal: to the [open circuit voltage](#) between the two [terminals](#). [[P4.1](#)]

Thévenin's theorem

states: that for the purpose of calculating the [current](#) and [voltage](#) in a [load resistor](#), any two-[terminal](#) network of [voltage generators](#) and [resistors](#) can be replaced by an equivalent [circuit](#) consisting of a single [ideal voltage generator](#) in [series](#) with a single [resistor](#). [P4.1]

Flexible Learning Approach to Physics - Glossary

thin lens

is: a [lens](#) whose thickness is much less than the [object distance](#) and [image distance](#) and the [radius of curvature](#) of each of its [surfaces](#), and so can be neglected.

[P6.3]

Flexible Learning Approach to Physics - Glossary

thin lens equation

is: an [equation](#) which relates the [object position](#) u , the [image position](#) v and the [focal length](#) f of a [thin lens](#):

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \text{ ([Cartesian sign convention](#))}. \quad [\text{P6.3}]$$

Compare with [spherical mirror equation](#).

third law pair

is: a pair of [forces](#) of equal [magnitude](#) that act in opposite [directions](#) on two interacting [bodies](#) or entities and which are necessarily 'equal and opposite' by virtue of [Newton's third law of motion](#). [[P2.3](#)]

Thomson's e/m experiment

is: a classic [experiment](#) in which J. J. Thomson (1856-1940) determined the [charge-to-mass ratio](#) of the [electron](#) by subjecting [cathode rays](#) (i.e. streams of high speed [electrons](#)) to mutually [perpendicular electric](#) and [magnetic fields](#).
[P8.1]

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three-dimensional

describes: an object or situation which requires the use of a [coordinate system](#) with *three* independent [axes](#) for its adequate description. [[P2.1](#), [P2.2](#)]

threshold energy

is: a general term used to indicate the minimum amount of [energy](#) required to achieve a certain condition (e.g. the minimum amount of [energy](#) that will just unbind a certain [bound state](#)).

Flexible Learning Approach to Physics - Glossary

threshold frequency

for: a particular material

is: a [frequency](#) of [electromagnetic radiation](#) f_t below which the [radiation](#) cannot eject [electrons](#) from the material. [[P10.1](#)]

corresponds: to [photons](#) whose [energy](#) is just large enough to overcome the [work function](#) ϕ of the material and eject [photoelectrons](#) of zero [kinetic energy](#). [[P10.1](#)]

is given: from [Einstein's photoelectric equation](#), by $hf_t = \phi$. [[P10.1](#)]

is: a characteristic of each material and its surface preparation. [[P10.1](#)]

Flexible Learning Approach to Physics - Glossary

tides

are: the [motion](#) of ocean water on the Earth's [surface](#) produced by changes, across the Earth's [diameter](#), in the [gravitational fields](#) due to the Moon and to the Sun. [[P3.2](#)]

Flexible Learning Approach to Physics - Glossary

time

is: one of the fundamental dimensional quantities of [mechanics](#) (along with [mass](#) and [length](#)).

allows: events occurring at the same place to be distinguished from one another.

has as its SI unit: the [second](#) (s), one of the seven [base units](#). [[P1.1](#)]

Flexible Learning Approach to Physics - Glossary

time constant

in: [exponential decay](#)

is: the [time](#) τ required for a [decaying](#) quantity to reduce to e^{-1} of its original value. [P5.2]

therefore is: the [reciprocal](#) of the [decay constant](#) α

$$A(t) = A_0 e^{-\alpha t} = A_0 e^{-t/\tau} \quad \text{[P5.2]}$$

time-dependent Schrödinger equation

of: a [system](#)

is: the fundamental [partial differential equation](#) of [quantum mechanics](#) whose [solutions](#) are the [wavefunctions](#) that describe the possible ([quantum](#)) [states](#) of the [system](#). [M6.4, P10.4]

has: a specific form that depends on the problem in hand.

is exemplified: for a [particle](#) of [mass](#) m moving in one [dimension](#) with [potential energy](#) $U(x)$ by

$$i\hbar \frac{\partial \Psi(x,t)}{\partial t} = \frac{-\hbar^2}{2m} \frac{\partial^2 \Psi(x,t)}{\partial x^2} + U(x) \Psi(x,t)$$

time-independent Schrödinger equation

of: a [system](#)

is: a [differential equation](#), derived from the [time-dependent Schrödinger equation](#) for the [system](#) in the case where the [wavefunction](#) is [separable](#), whose [solutions](#) (called [spatial wavefunctions](#)) depend only on [spatial variables](#) (i.e. not [time](#)) and are the [energy eigenfunctions](#) of the [system](#). [[M6.4](#), [P10.4](#)]

therefore can be written: as an [eigenvalue equation](#) of the total [energy operator](#) (the [Hamiltonian operator](#)) with [eigenvalues](#) that correspond to the possible values of the total [energy](#) of the [system](#). [[M6.4](#), [P10.4](#), [P11.1](#)]

has: a specific form that depends on the problem in hand.

is exemplified: for a [particle](#) of [mass](#) m moving in one [dimension](#) with [potential energy](#) $U(x)$ by

$$\frac{-\hbar^2}{2m} \frac{d^2 \psi(x)}{dx^2} + U(x) \psi(x) = E \psi(x) \quad [\text{M6.4, P10.4, P11.1}]$$

toroid

See [torus](#).

Flexible Learning Approach to Physics - Glossary

toroidal solenoid

is: a [solenoid](#) which is curved into a [circle](#) by bringing its ends together.

[\[P4.2\]](#)

Flexible Learning Approach to Physics - Glossary

torque

is: the [moment](#) of a [force](#) about a given [point](#). [[M2.7](#), [P2.7](#), [P2.8](#)]

is given: as $\Gamma = \mathbf{r} \times \mathbf{F}$. [[M2.7](#), [P2.7](#), [P2.8](#)]

Flexible Learning Approach to Physics - Glossary

torr

is: a non-[SI unit](#) of [pressure](#) equal to 133.322 [pascal](#). [[P7.2](#)]

very nearly is: the [pressure](#) exerted by a column of mercury 1 mm high. [[P7.2](#)]

Flexible Learning Approach to Physics - Glossary

torsional

means: pertaining to a twisting [motion](#).

Flexible Learning Approach to Physics - Glossary

torus

is: a shape similar to that of a bagel or ring-shaped dough-nut. [[P4.2](#)]

is also called: a toroid. [[P4.2](#)]

Flexible Learning Approach to Physics - Glossary

total force

See [resultant force](#).

Flexible Learning Approach to Physics - Glossary

total internal reflection

of: a [wave](#)

travelling: from one [medium](#), to another [medium](#) in which its [speed](#) is greater (i.e. for which the [refractive index](#) is smaller)

occurs: when the [angle of incidence](#) exceeds the [critical angle](#). The [interface](#) acts like a [mirror](#), the [wave](#) is [reflected](#) back into the first [medium](#) and no [refraction](#) occurs. [[P5.7](#), [P6.2](#)]

Flexible Learning Approach to Physics - Glossary

trajectory

is: the path through [space](#) followed by a moving [body](#), especially a [projectile](#).
[\[P2.2\]](#)

Flexible Learning Approach to Physics - Glossary

transformer

is: a device that can change (transform) an [a.c. voltage](#), from one value to another, with high [power](#) transfer efficiency. [P4.4]

consists: of two [coils](#) wound on a common core, with the [primary coil](#) connected to an [a.c.](#) input. [P4.4]

works: because [mutual induction](#) produces an [induced voltage](#) in the [secondary coil](#). Depending on the transformer [turns ratio](#), the [induced voltage](#) on the [secondary coil](#) may be stepped up or down compared with the [voltage](#) on the [primary coil](#). [P4.4]

Flexible Learning Approach to Physics - Glossary

transient

describes: short lived behaviour that a [system](#) displays in response to a sudden change or disturbance. [[P5.5](#)]

Flexible Learning Approach to Physics - Glossary

transient current

refers: to the initial [current](#) in an [electrical circuit](#), following some kind of disturbance, before the [steady state](#) becomes established. [[P4.5](#)]

Flexible Learning Approach to Physics - Glossary

transient motion

refers: to the initial [motion](#) produced in a [driven oscillator](#), soon after the [driving force](#) has been applied and before the [steady state motion](#) has become established as the dominant [motion](#). [P5.3]

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transition

is: a process in which the [state](#) of a [quantum system](#) is abruptly changed. Usually this involves transferring [energy](#) from the [system](#) ([emission](#)) or to the [system](#) ([absorption](#)), often by [emitting](#) or [absorbing photons](#) of [electromagnetic radiation](#). [[P8.3](#), [P10.3](#)]

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transition elements

are: the [chemical elements](#) that span a region of the [periodic table](#) in which a d [subshell](#) of [atoms](#) in their [ground state](#) is being progressively filled. [P8.4]

consist mainly: of the three series; Sc to Zn (3d filling), Y to Cd (4d filling), and Lu to Hg (5d filling). [P8.4]

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transition temperature

is: the [temperature](#) T_c below which a material becomes a [superconductor](#).

[P4.1]

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translation

of: a [rigid body](#)

is: a form of [motion](#) in which there is no [rotation](#) of the [body](#) with respect to itself, so that every part moves parallel to every other part. [[P2.3](#), [P2.7](#)]

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translational equilibrium

of: a [system](#)

is: the condition in which the total [linear momentum](#) of the [system](#) is [constant](#).

requires: that the [resultant](#) external [force](#) acting on the [system](#) is zero. [[P2.3](#), [P2.7](#)]

implies: for a [body](#) of fixed [mass](#), that the [acceleration](#) of the [body](#) is zero, so that it remains in [uniform \(linear\) motion](#). [[P2.3](#), [P2.7](#)]

is a necessary condition: for [static equilibrium](#) in which there is no [motion](#).

See also [rotational equilibrium](#).

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translational kinetic energy

is: the [energy](#) that a [body](#) has by virtue of the [motion](#) of its [centre of mass](#).
[P2.4]

is given: by $E_{\text{tran}} = \frac{1}{2}mv^2$ or equivalently by $E_{\text{tran}} = p^2/(2m)$, where the [mass](#) of the [body](#) is m and its [speed](#) is v . [P2.5]

is: for a collection of [bodies](#) (or [particles](#)), the [sum](#) of the individual translational kinetic energies. [P2.4]

is conserved: in [elastic collisions](#). [P2.4]

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transmission

is: a process in which an entity or agency (e.g. a [ray](#) of [light](#)) encountering a [surface](#) or [interface](#) between [media](#), enters the new [medium](#) and continues to travel in that [medium](#) rather than being [absorbed](#) at the [interface](#) or [reflected](#) back into the original [medium](#). [[P6.2](#)]

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transmission coefficient

for: a stream of [particles](#) encountering a [potential step](#) or [potential barrier](#)

is defined: by

$$T = \frac{\text{flux of transmitted particles}}{\text{flux of incident particles}}. \quad [\text{P11.1}]$$

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transmission diffraction grating

is: a form of [diffraction grating](#) in which the [diffracted beams](#) are produced by [transmission](#) through a [transparent surface](#) which has been ruled with many closely spaced, narrow [parallel lines](#). [[P6.1](#)]

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transparent

describes: a [medium](#) that [transmits light](#).

Flexible Learning Approach to Physics - Glossary

transport process

in: a bulk [macroscopic system](#)

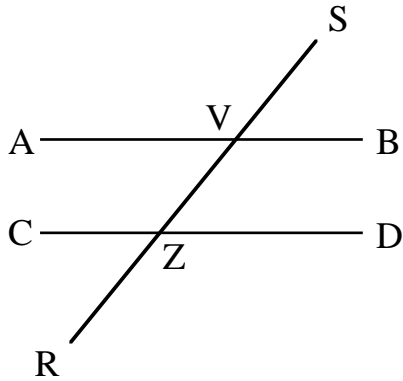
is: any physical phenomenon which involves the movement of [matter](#) or [energy](#) from one place to another by transfer of [particles](#).

is exemplified: in a [gas](#), by [diffusion](#), [viscosity](#) and [thermal conduction](#).
[\[P7.5\]](#)

Flexible Learning Approach to Physics - Glossary

transversal

is: a [line](#) RS crossing a pair of [parallel lines](#) AB and CD and intersecting them at points V and Z respectively (see Figure). [\[M2.1\]](#)



has: [angles](#) RZC and RVA equal (corresponding angles). [\[M2.1\]](#)

also has: [angles](#) RZC and DZS equal ([alternate angles](#)). [\[M2.1\]](#)

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transverse

means: at [right angles](#) to.

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transverse magnification

is: the [ratio](#) of the [transverse dimensions](#) of an [optical image](#) to those of the [object](#) from which the [image](#) is derived. [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

transverse wave

is: a [wave](#) in which the 'disturbance' that constitutes the [wave](#) is [perpendicular](#) (i.e. [transverse](#)) to the [direction](#) of [propagation](#) of the [wave](#). [[M6.4](#), [P5.6](#), [P6.1](#), [P11.1](#)]

Contrast with [longitudinal wave](#).

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trapezium

is: a [quadrilateral](#) in which two opposite sides are [parallel](#). [[M2.1](#)]

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travelling wave

given: a physical quantity that may be [measured](#) throughout some region and which possesses a well defined [equilibrium](#) value at each [point](#) in that region,

is: a disturbance from [equilibrium](#) in that quantity, moving from place to place. [[M6.4](#), [P5.6](#)]

See [periodic wave](#) and [solitary wave](#), and contrast with [standing wave](#). See also [sinusoidal wave](#).

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triangle

is: a [polygon](#) with three sides.

is called: an [isosceles triangle](#) if two sides are of equal [length](#). [M2.1]

is called: an [equilateral triangle](#) if three sides are of equal [length](#). (See [regular polygon](#).) [M2.1]

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triangle rule (for vector addition)

is: a [geometric](#) rule in which two [vectors](#) are represented by two sides of a [triangle](#) and their [vector sum](#) is represented by the third side. [[M2.4](#), [M2.5](#), [P2.2](#)]

states: that if the tail of [vector \$B\$](#) is placed at the head of [vector \$A\$](#) then the [vector \$C\$](#) from the tail of [vector \$A\$](#) to the head of [vector \$B\$](#) represents the sum of [vectors \$A\$](#) and [vector \$B\$](#) . [[M2.4](#), [M2.5](#), [P2.2](#)]

Compare with [parallelogram rule](#).

Flexible Learning Approach to Physics - Glossary

triatomic ideal gas

is: an [ideal gas](#) that may be used to model a [real gas](#) with three [atoms](#) per [molecule](#) at low [density](#). [P7.4]

trigonometric functions

are: [functions](#) which are equivalent to the [trigonometric ratios](#) (sine, cosine, tangent) for [arguments](#) in the range 0 to $\pi/2$, but are defined for all [real](#) values. (The tangent [function](#) is undefined for values of the [argument](#) which are odd [integer](#) multiples of $\pi/2$.) [[M1.6](#)]

often are taken: to include the [reciprocal trigonometric functions](#) (cosecant, secant, cotangent). (The cotangent [function](#) is undefined for values of the [argument](#) which are even [integer](#) multiples of $\pi/2$.) [[M1.6](#)]

are all: [periodic functions](#). [[M1.6](#)]

strictly consist; of two distinct classes of [functions](#), those whose [domain](#) is the set of [real numbers](#), and those whose [domain](#) is the [set](#) of [angles](#), but this distinction is deliberately blurred by measuring [angles](#) in [radians](#) to ensure that the [periodicity](#) is the same (apart from the [dimensionless unit radian](#)) in both cases.

See trigonometric functions in the [Maths handbook](#) for further details.

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trigonometric identities

are: relationships between [trigonometric functions](#) which are independent of the value of the [argument](#). [M1.6]

include:

$$\sin(\alpha + \beta) = \sin(\alpha)\cos(\beta) + \cos(\alpha)\sin(\beta)$$

$$\cos(\alpha + \beta) = \cos(\alpha)\cos(\beta) - \sin(\alpha)\sin(\beta)$$

$$\sin(2\alpha) = 2\sin(\alpha)\cos(\alpha)$$

$$\cos(2\alpha) = \cos^2(\alpha) - \sin^2(\alpha)$$

$$\cos(2\alpha) = 1 - 2\sin^2(\alpha)$$

$$\cos(2\alpha) = 2\cos^2(\alpha) - 1$$

$$\cos^2(\alpha/2) = \frac{1}{2}(1 + \cos(\alpha))$$

$$\sin^2(\alpha/2) = \frac{1}{2}(1 - \cos(\alpha))$$

$$\sin(\alpha) + \sin(\beta) = 2\sin\left(\frac{\alpha + \beta}{2}\right)\cos\left(\frac{\alpha - \beta}{2}\right)$$

$$\sin(\alpha) - \sin(\beta) = 2\cos\left(\frac{\alpha + \beta}{2}\right)\sin\left(\frac{\alpha - \beta}{2}\right)$$

$$\cos(\alpha) + \cos(\beta) = 2\cos\left(\frac{\alpha + \beta}{2}\right)\cos\left(\frac{\alpha - \beta}{2}\right)$$

$$\cos(\alpha) - \cos(\beta) = -2\sin\left(\frac{\alpha + \beta}{2}\right)\sin\left(\frac{\alpha - \beta}{2}\right)$$

and many others. [M1.6]

See trigonometric functions in the [Maths handbook](#) for a more detailed listing.

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trigonometric ratios

are: [ratios](#) involving the sides of a [right-angled triangle](#). [[M1.6](#)]

depend only: on the value of a particular [angle](#) of the [triangle](#). [[M1.6](#)]

may be generalized: to produce the [trigonometric functions](#), whose names they share. [[M1.6](#)]

See trigonometric functions in the [Maths handbook](#).

Flexible Learning Approach to Physics - Glossary

trigonometry

is: the study of [right-angled triangles](#) and the related [trigonometric ratios](#) and [trigonometric functions](#). [\[M1.6\]](#)

triple bond

is: a [bond](#) between two [atoms](#) of a chemical substance, which is equivalent to three single [bonds](#). [[P8.4](#)]

arise: from the sharing of three [electron pairs](#). [[P8.4](#)]

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triple point

is: a [point](#) on the P - T [projection](#) of a [PVT-surface](#), at which three different [phases](#) (for example [solid](#), [liquid](#), and [vapour](#)) can coexist at the same [pressure](#) and [temperature](#), each [phase](#) having the same [molar volume](#) (or [density](#)).

[P7.2P7.4]

triple-point cell

for: H₂O

is: an [apparatus](#) rather like a double-walled version of a thermos flask. [P7.2]

has: an inside space held at the [temperature](#) of 273.16 K at which [solid](#), [liquid](#), and [vapour](#) H₂O are in [equilibrium](#) together. [P7.2]

also has: an outside jacket evacuated to a [vacuum](#) as in a thermos flask, in order to act as a [thermal insulator](#). [P7.2]

moreover, has: an extra jacket, between the [vacuum](#) and the inside space, where the H₂O is held. When prepared, this H₂O has at least some of each of the [phases](#) – [solid](#), [liquid](#), and [vapour](#) – in [equilibrium](#) together, which can happen only at the [triple-point temperature](#). [P7.2]

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triple-point line

is: a [straight line](#) on a [PVT-surface](#). [P7.4]

is: [parallel](#) to the [volume axis](#). [P7.4]

passes: through [points](#) that represent [states](#) in which three [phases](#) coexist in [equilibrium](#). [P7.4]

is: of finite [length](#). [P7.4]

delineates: the finite range of [volume](#) where three [phases](#) of the sample can coexist. [P7.4]

triple-point pressure

is: the unique [pressure](#) that corresponds to the [triple point](#) of a substance.

[P7.4]

triple-point temperature

is: the unique [temperature](#) that corresponds to the [triple point](#) of a substance.

is exemplified: by the [temperature](#) of the [triple point](#) of H₂O which, by definition, is exactly 273.16 K [[P7.2](#)]

triple-point volume

is: one of the [volumes](#) along the [triple-point line](#) of a fixed quantity of a given substance. [[P7.4](#)]

is specified: by particular conditions, such as the requirement that the sample should contain one [mole](#) of the substance and that it should be purely [liquid](#). [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

tritium

is: the [isotope](#) of hydrogen which has [mass number](#) $A = 3$. [[P9.3](#)]

is: a [radioisotope](#) which emits [\$\beta\$ -particles](#). [[P9.3](#)]

does not occur: naturally. [[P9.3](#)]

can be produced: artificially in [nuclear fusion reactions](#). [[P9.3](#)]

Flexible Learning Approach to Physics - Glossary

triton

is: a [tritium nucleus](#), ${}^3_1\text{H}$ also represented as T or sometimes t. [[P9.3](#)]

Flexible Learning Approach to Physics - Glossary

tuning circuit

is: an [electrical circuit](#) which contains both [inductance](#) and [capacitance](#). [P5.3]

behaves: as an [electrical oscillator](#), which may be [driven](#) by an applied [voltage](#). [P5.3]

has: a [resonance frequency](#) and a narrow [resonance absorption bandwidth](#). [P5.3]

can: select and respond only to a very narrow range of applied [frequencies](#). [P5.3]

tunnel diode

is: a device that can be used to control the flow of [current](#) in a suitable [electric circuit](#), and which operates by virtue of [quantum tunnelling](#) [[P11.1](#)]

tunnel junction

is: an electronic device which switches [electrical currents](#) using [quantum tunnelling](#). [[P10.2](#)]

turbulence

is: the situation in which [forces](#) of [friction](#) are produced by uncoordinated or irregular internal [motions](#) of a [gas](#) or a [liquid](#). [[P2.3](#)]

Flexible Learning Approach to Physics - Glossary

turning point

in: any [graph](#) of the form $y = f(x)$

is: any [point](#) at which the value of y changes from increasing to decreasing or *vice-versa* as the value of x is altered. [M1.3]

therefore is: a [point](#) $(a, f(a))$ on the [graph](#) of the [function](#) $f(x)$ at which the [derivative](#) $f'(x) = 0$ and the [tangent](#) to the [graph](#) does not cross the [graph](#) itself. [M4.4]

is exemplified: by [local maxima](#) and [local minima](#). [M4.4]

in particular is exemplified: by a [position](#), during an [oscillation](#), where the [magnitude](#) of the [displacement](#) reaches a maximum value, and the [oscillation](#) begins to move back towards the [position](#) of [equilibrium](#). [P5.1]

Flexible Learning Approach to Physics - Glossary

turns ratio

in: a [transformer](#)

is: the [ratio](#) of the number of turns N_s on the [secondary coil](#) to the number of turns N_p on the [primary coil](#) of the [transformer](#). [P4.4]

is equal: in an [ideal transformer](#), to the [ratio](#) of the [induced voltage](#) V_s in the [secondary coil](#) to the applied [voltage](#) V_p in the [primary coil](#): $V_s/V_p = N_s/N_p$. [P4.4]

two-dimensional

describes: an object or situation which requires the use of a [coordinate system](#) with *two* independent [axes](#) for its adequate description. [[P2.1](#), [P2.2](#)]

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two-point form

of: the [equation of a straight line](#)

is:
$$\frac{y - y_1}{x - x_1} = \frac{y_2 - y_1}{x_2 - x_1}$$

where (x_1, y_1) and (x_2, y_2) are both [points](#) on the [straight line](#). [[M1.3](#), [M2.2](#)]

Flexible Learning Approach to Physics - Glossary

typical elements

are: a [set](#) of [chemical elements](#) whose [atoms](#) have [ground state](#) outer [electronic configurations](#) of the type ns^x , where $n = 1$ to 7 inclusive and $x = 1$ or 2 , or of the type $ns^2 np^x$ where $n = 1$ to 7 inclusive and $x = 1$ to 6 inclusive. [[P8.4](#)]

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ultrasonic waves

are: [sound waves](#) with a [frequency](#) greater than the highest [frequency](#) normally audible to healthy young humans.

usually have: [frequencies](#) in the range 20 kHz to 5 MHz. [[P5.7](#)]

ultraviolet radiation

is: a type of [electromagnetic radiation](#) which is characterized by [wavelengths](#) in the range between those of [X-rays](#) and [visible light](#) (i.e. approximately 5 nm to 400 nm allowing a considerable overlap with [X-rays](#)).

See [electromagnetic spectrum](#).

Flexible Learning Approach to Physics - Glossary

unaccommodated (eye)

is: an eye in which the [ciliary muscles](#) (which control the [lens](#)) are fully relaxed. [[P6.4](#)]

is focused: at its [far point](#) (usually [infinity](#)). [[P6.4](#)]

Contrast with [accommodated eye](#). [[P6.4](#)]

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unbalanced bridge

is: a [bridge circuit](#) with a non-zero output [voltage](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

unbound state

of: a [quantum system](#)

is: a [state](#) of a composite [system](#) in which the components of the [system](#) may be arbitrarily far apart and in which their separation may be altered by an [infinitesimal](#) change in the [energy](#).

is: in [Schrödinger's model of the hydrogen atom](#), one of the [states](#) whose [energy](#) belongs to the [continuum](#) of [energy levels](#) above the [ionization level](#), and in which the [electron](#) is freed from the [atom](#). [P8.2]

is reached: when an [electron](#) from one of the [bound states](#) in the [atom](#) is given enough [energy](#) so that its [energy](#) becomes positive thus exceeding the zero energy that is conventionally assigned to the [ionization level](#). [P8.2]

Flexible Learning Approach to Physics - Glossary

uncertainty

in: the value of a physical quantity

is: a quantitative indication of the lack of [precision](#) and/or [accuracy](#) in the value of the physical quantity. [[P1.1](#), [P1.2](#)]

may be shown explicitly: by writing the quantity in a form such as 1.2 ± 0.2 , where 0.2 is the uncertainty in this case. [[P1.1](#), [P1.2](#)]

by default is implied: by the number of [significant figures](#) in the quoted value. [[P1.1](#), [P1.2](#)]

See [random error](#) and [systematic error](#).

See also [Heisenberg uncertainty principle](#) for a fundamental limitation.

in an experiment, may be known as: error.

Flexible Learning Approach to Physics - Glossary

underdamping

of: a [damped harmonic oscillator](#)

is: the condition in which the [oscillator](#) is subject to such a weak [damping force](#) that it is unable to return to rest as rapidly as a [critically damped oscillator](#).
[P5.2, P5.4]

is characterised: by [oscillations](#) whose [amplitude decays exponentially](#) with [time](#). [P5.4]

is often used as synonymous: with [light damping](#).

uni-axial compressional strain

is: the [strain](#) within a material caused by the application of [uni-axial compressional stress](#). [[P7.6](#)]

is equal: to the change in [length](#) of the material divided by the original undistorted [length](#). [[P7.6](#)]

has: a negative sign. [[P7.6](#)]

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uni-axial compressional stress

is: the [stress](#) resulting from a uni-axial [compressional force](#) acting over a [surface](#) in a material. [[P7.6](#)]

has a magnitude: obtained by dividing the [magnitude](#) of the [perpendicular component](#) of the [force](#) by the [area](#) over which it acts. [[P7.6](#)]

has: a negative sign. [[P7.6](#)]

Flexible Learning Approach to Physics - Glossary

uni-axial rotation

of: a [rigid body](#)

is: a [rotation](#) of the [body](#) about a axis that is fixed with respect to the [body](#) [[P2.7](#), [P2.8](#)]

is exemplified: by the [rotation](#) of a door as it swings on its hinges. [[P2.7](#), [P2.8](#)]

Flexible Learning Approach to Physics - Glossary

uniform

means: independent of [position](#).

Compare with [constant](#).

Flexible Learning Approach to Physics - Glossary

uniform acceleration

of: a [particle](#)

is: [acceleration](#) at a [uniform](#) rate, that is therefore also a [constant](#) rate in this case. [[M4.1](#), [P2.1](#)]

is described: for a [particle](#) moving along the [x-axis](#), by the [uniform acceleration equations](#). [[M4.1](#), [P2.1](#)]

is also called: constant acceleration. [[M4.1](#), [P2.1](#)]

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uniform acceleration equations

for: a [particle](#) undergoing [uniform acceleration](#) in [one-dimensional \(linear\) motion](#)

relate: the [displacement](#) s_x and [final velocity](#) v_x at [time](#) t to the [initial velocity](#) u_x at [time](#) $t = 0$ and the ([constant](#)) [acceleration](#) a_x . [[P2.1](#), [P2.2](#)]

are given: by

$$v_x = u_x + a_x t$$

$$s_x = u_x t + \frac{1}{2} a_x t^2$$

$$v_x^2 = u_x^2 + 2a_x s_x$$

where the [displacement](#), s_x is taken to be zero when $t = 0$. [[P2.1](#), [P2.2](#)]

Flexible Learning Approach to Physics - Glossary

uniform circular motion

is: a special type of [motion](#) in which a [particle](#) travels at a [constant](#) rate around a [circular](#) path.

is characterized: by the [radius](#) r of the [circle](#), the [angular speed](#) ω of the [particle](#), and the [speed](#) of the [particle](#), which is $v = r\omega$. [P2.6]

is also characterized: by the [acceleration](#) of the [particle](#), which points towards the [centre](#) of the [circle](#) and has [magnitude](#) $r\omega^2$. [P2.6]

Flexible Learning Approach to Physics - Glossary

uniform field

is: a [scalar field](#) or a [vector field](#) that has the same value at every [point](#). In the case of a [vector field](#) both the [magnitude](#) and the [direction](#) of the [field](#) must be the same everywhere. Such [fields](#) may be represented by the same [vector](#) at every [point](#). [[M2.6](#), [P3.3](#)]

therefore is: a [field](#) in which the [field lines](#) are everywhere [parallel](#). [[P3.1](#)]

is not necessarily: a [constant field](#), which is (strictly) a field that does not change with [time](#). [[P3.3](#)]

Flexible Learning Approach to Physics - Glossary

uniform medium

is: a [medium](#) whose properties are independent of [position](#) within the [medium](#).

Flexible Learning Approach to Physics - Glossary

uniform (linear) motion

of: a [particle](#)

is: a special type of [motion](#) in which the [particle](#) moves along a [straight line](#) at a constant [velocity](#). [P2.1]

therefore is characterized: by zero [acceleration](#). [P2.1]

can be represented: by a [velocity-time graph](#) which is a [straight line](#), [parallel](#) to the [time-axis](#). [P2.1]

Flexible Learning Approach to Physics - Glossary

uniform motion equations

for: a [particle](#) in [uniform motion](#)

are: a [set](#) of [equations](#) which describe [one-dimensional](#) ([linear](#)) [motion](#) with [uniform velocity](#) (i.e. with [acceleration](#) $a_x = 0$). [[P2.1](#), [P2.2](#)]

relate: the [displacement](#) s_x and [velocity](#) v_x at [time](#) t to the [initial velocity](#) u_x at [time](#) $t = 0$. [[P2.1](#), [P2.2](#)]

are given: by

$$s_x = u_x t$$

$$v_x = u_x = \text{constant}$$

$$a_x = 0$$

where the [displacement](#), s_x is taken to be zero when $t = 0$. [[P2.1](#), [P2.2](#)]

Flexible Learning Approach to Physics - Glossary

uniform speed

is: a special type of [motion](#) in which a [particle](#) moves at a [constant](#) rate, covering equal [distances](#) in equal [times](#), irrespective of the [direction](#) of [motion](#). [P2.1]

is also known as: constant speed.

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uniform stress

See [volume stress](#).

Flexible Learning Approach to Physics - Glossary

uniform velocity

is: a [velocity](#) that is [constant](#), i.e. unchanging with respect to [time](#). [M4.1]

See [uniform motion](#).

uniqueness theorem

is: a [theorem](#) which asserts that a certain result will be unique provided that certain specified conditions are met. [[M6.1](#)]

Flexible Learning Approach to Physics - Glossary

unit

is: a quantity that, by general agreement, provides the basis for a system of measurement. [[P1.1](#)]

is exemplified: by the SI units of the [metre](#), [kilogram](#) and [second](#). [[P1.1](#)]

permits: expression of the values of [physical quantities](#) as products of appropriate numbers and units. [[P1.1](#)]

Flexible Learning Approach to Physics - Glossary

unit cell

is: a conventionally chosen set of [points](#) in [space](#) which, when regularly repeated throughout [space](#), produces one of the 14 fundamentally different [three-dimensional lattices](#) (three of which have cubic unit cells) [[P11.4](#)]

Flexible Learning Approach to Physics - Glossary

unit area

is: an [area](#) of one square [unit](#). The square [unit](#) may be a square [metre](#), for example.

Flexible Learning Approach to Physics - Glossary

unit potential difference

is: a [potential difference](#) of one [unit](#). The [unit](#) may be a [volt](#), for example.

Flexible Learning Approach to Physics - Glossary

unit length

is: a [length](#) of one [unit](#). The [unit](#) may be a [metre](#), for example.

Flexible Learning Approach to Physics - Glossary

unit (point) charge

is: a particle with an [electric charge](#) of one [unit](#). The [unit](#) may be a [coulomb](#), for example.

Flexible Learning Approach to Physics - Glossary

unit (point) mass

is: a [particle](#) with a [mass](#) of one [unit](#). The [unit](#) may be a [kilogram](#), for example.

Flexible Learning Approach to Physics - Glossary

unit time

is: an [interval](#) of [time](#) of one [unit](#). The [unit](#) may be a [second](#), for example.

Flexible Learning Approach to Physics - Glossary

unit vector

in: the [direction](#) of any [vector](#) \mathbf{a} ,

is: a [vector](#) of [magnitude](#) 1, given by $\hat{\mathbf{a}} = \frac{\mathbf{a}}{|\mathbf{a}|}$. [[M2.5](#), [P2.8](#)]

is denoted: for the [directions](#) of the [Cartesian axes](#) x , y and z by \mathbf{i} , \mathbf{j} and \mathbf{k} .
These are sometimes referred to as [Cartesian unit vectors](#). [[M2.5](#), [P2.7](#), [P2.8](#), [P3.1](#)]

Flexible Learning Approach to Physics - Glossary

unit volume

is: a [volume](#) of one cubic [unit](#). The cubic [unit](#) may be a [metre](#) cubed, for example.

Flexible Learning Approach to Physics - Glossary

unit wavelength

is: a [wavelength](#) of one unit. The unit may be a [metre](#), for example.

Flexible Learning Approach to Physics - Glossary

universal constant

is: any [constant](#) that is believed to have the same value throughout the [Universe](#). [P1.1]

is synonymous: with fundamental constant.

Flexible Learning Approach to Physics - Glossary

universal gas constant

is: the [physical constant](#) R that appears in the [equation of state of an ideal gas](#); $PV = nRT$. [P7.2]

has: the value $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ (to four [significant figures](#)). [P7.2]

is related: to [Boltzmann's constant](#) k and [Avogadro's constant](#) N_A by $R = N_A k$.

is synonymous: with [molar gas constant](#).

universal gravitational constant

is: the [fundamental constant](#) G that appears in [Newton's universal law of gravitation](#). [[P2.3](#), [P3.2](#)]

has: the value $G = 6.672 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ (to four [significant figures](#)). [[P2.3](#), [P3.1](#), [P3.2](#)]

is synonymous: with [Newton's universal gravitational constant](#) and [gravitational constant](#).

universal law of gravitation

See [law of universal gravitation](#).

Flexible Learning Approach to Physics - Glossary

Universe

is: the [system](#) being studied, plus its [environment](#). [[P7.3](#), [P7.4](#)]

is also: the cosmos, the totality of [matter](#) and [energy](#) in existence.

Flexible Learning Approach to Physics - Glossary

unknown (variable)

in: an [equation](#)

is: an [independent variable](#), the value of which is to be found by [solution of the equation](#). [M1.4]

Flexible Learning Approach to Physics - Glossary

unpaired electron

is: an [electron](#) that is not [paired](#) with another of opposite [spin](#). [[P8.3](#)]

See [Hund's rule](#).

Flexible Learning Approach to Physics - Glossary

unpolarized

describes: [light](#) in which there is no preferred [direction](#) of [polarization](#).
[\[P6.1\]](#)

Flexible Learning Approach to Physics - Glossary

unstable equilibrium

of: a [system](#)

describes: a [state](#) of [equilibrium](#) in which a small disturbance of the [system](#) results in a tendency for the [system](#) to depart further from its [initial equilibrium state](#). [P5.1]

Flexible Learning Approach to Physics - Glossary

unstable nucleus

is: a [nucleus](#) that will eventually undergo [radioactive decay](#).

is characterized: by a [time](#) interval $\tau_{1/2}$ called the [half-life](#), which determines the [probability](#) that the [nucleus](#) will [decay](#) within a given time from any specified starting time, $P(t) = 1 - 2^{-t/\tau_{1/2}}$.

is alternatively characterized: by a [decay constant](#) $\lambda = \log_e 2/\tau$, so that $P(t) = 1 - e^{-\lambda t}$.

Flexible Learning Approach to Physics - Glossary

upper limit (of integration)

See [definite integral](#).

Flexible Learning Approach to Physics - Glossary

upper limit (of summation)

See [summation symbol](#).

Flexible Learning Approach to Physics - Glossary

upthrust

See [buoyancy force](#).

Flexible Learning Approach to Physics - Glossary

vacuum

is ideally: in [classical physics](#), a region of [space](#) in which there is no [matter](#).

is in practice: a region of [space](#) in which there is inevitably a [gas](#), but a [gas](#) of very low [density](#).

is: in [quantum theory](#) (specifically [quantum field theory](#)), a complicated [state](#) in its own right in which [particles](#) may be found due to [quantum](#) fluctuations.

Flexible Learning Approach to Physics - Glossary

valence band

in: a [solid](#)

is: the highest [electron energy band](#) that is filled or partly filled at [absolute zero](#). It contains the highest [energy electrons](#), and therefore the most weakly [bound electrons](#). [P11.4]

Flexible Learning Approach to Physics - Glossary

valence electrons

in: an [atom](#)

are: the outermost [electrons](#), which participate in [bonding](#) via sharing or transfer to neighbouring [atoms](#). [[P7.1](#)]

Flexible Learning Approach to Physics - Glossary

valency

of: an [element](#)

is: the property that determines its ability to combine with other [elements](#).
[P8.4]

is equal: to the number of [atoms](#) of hydrogen that combine with one [atom](#) of the [element](#). [P8.4]

alternatively can be determined: if the [element](#) does not combine with hydrogen, from the known valency of another [element](#) with which it does combine. [P8.4]

van der Waals bonding

is: a weak [bond](#) resulting from the interaction of [electric dipole moments](#) (or distortions from [spherical symmetry](#)) of two [atoms](#) or [molecules](#). [P7.1]

has energy: typically on the scale of milli[electronvolts](#). [P7.1]

van der Waals equation of state

is: a modification of the [ideal gas equation of state](#). [P7.5]

takes into account: the finite size of the [molecules](#) of the [gas](#) (the [excluded volume](#) effect) and the effect of long-range [interactions](#) ([intermolecular forces](#)) on the [gas pressure](#). [P7.5]

is written: as
$$\left(P + \frac{a}{V_m^2} \right) (V_m - b) = RT,$$

where V_m represents the [volume](#) per [mole](#), R is the [molar gas constant](#) and a and b can be regarded as [empirical constants](#), although they relate to [intermolecular forces](#) and to the [excluded volume](#) effect respectively. [P7.5]

Flexible Learning Approach to Physics - Glossary

van der Waals force

is: an attractive [force](#) between [electric dipoles](#) which are induced in electrically neutral [atoms](#) or [molecules](#) by asymmetrical [electron](#) distributions. [[P3.3](#)]

Flexible Learning Approach to Physics - Glossary

vaporization

is: the [phase transition](#) in which a [liquid](#) becomes a [vapour](#). [[P7.4](#)]

See also [latent heat](#). [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

vaporization curve

of: a substance

is: the curve on the P - T projection of the substance's [PVT-surface](#) that separates the [vapour phase](#) from the [liquid phase](#). [[P7.4](#)]

Flexible Learning Approach to Physics - Glossary

vapour

is: a [gas](#) at a [temperature](#) which is less than its [critical temperature](#). [P7.4]

Flexible Learning Approach to Physics - Glossary

variable

is: a quantity whose value may vary. [[M1.3](#)]

is: a quantity whose (unknown) value is designated by a [mathematical](#) symbol for the purpose of performing [mathematical operations](#). [[M1.1](#)]

Flexible Learning Approach to Physics - Glossary

vector

is: a [mathematical](#) entity which can be represented by a [directed line segment](#) (an arrow). [[M2.4](#), [M2.5](#), [P2.1](#)]

can be used: to represent a physical quantity that has [magnitude](#) and [direction](#). (Such quantities are called [vector quantities](#).) [[P2.1](#)]

can be formed: by adding together given vectors (i.e. [vector addition](#)) or by multiplying a given vector by a number (i.e. by [scaling](#)). [[P2.1](#), [P2.2](#)]

usually is denoted: in printed texts by bold symbols such as $\boldsymbol{\alpha}$, \boldsymbol{E} , \boldsymbol{r} , and \boldsymbol{F} .

is also denoted: in handwriting by a wavy line underneath it (\underline{a} , \underline{E} , etc.); the wavy underline is a printer's mark meaning 'make the character bold'. [[M2.4](#), [M2.5](#)]

can be represented: in n -[dimensions](#), by n [scalar components](#) which are usually presented in the form of an [ordered multiple](#) such as an [ordered pair](#) in two-[dimensions](#) or an [ordered triple](#) in three-[dimensions](#). [[P2.2](#)]

Flexible Learning Approach to Physics - Glossary

vector addition

is: the [operation](#) of adding two (or more) [vectors](#) together to obtain a [vector sum](#) that is itself a [vector](#). [M2.4]

can be represented graphically: by means of the [triangle rule](#) or, equivalently, the [parallelogram rule](#). [M2.4]

is expressed algebraically: (for [three-dimensional vectors](#)) by the rule

$$\begin{aligned}\mathbf{a} + \mathbf{b} &= (a_x, a_y, a_z) + (b_x, b_y, b_z) \\ &= (a_x + b_x, a_y + b_y, a_z + b_z)\end{aligned}\quad [\text{P2.2}]$$

Flexible Learning Approach to Physics - Glossary

vector algebra

is: the branch of [mathematics](#) concerned with the behaviour of [vectors](#) under the [operations](#) of [vector addition](#) and [scaling](#) and with the formation of [scalar products](#) and [vector products](#). [[M2.4](#)]

Flexible Learning Approach to Physics - Glossary

vector difference

between: two [vectors](#) $\mathbf{a} = (a_x, a_y, a_z)$ and $\mathbf{b} = (b_x, b_y, b_z)$

is: the [sum](#) of the [vectors](#) \mathbf{a} and $-\mathbf{b}$

is given: in terms of [components](#), by

$$\begin{aligned}\mathbf{a} - \mathbf{b} &= (a_x, a_y, a_z) - (b_x, b_y, b_z) \\ &= (a_x - b_x, a_y - b_y, a_z - b_z)\end{aligned}\quad [\text{M2.4, P2.2}]$$

Flexible Learning Approach to Physics - Glossary

vector field

throughout: some region of space

is: a quantity that may be fully specified by a [vector quantity](#) at each [point](#) within that region. [[P3.1](#)]

therefore is: a [field](#) $\mathbf{A}(\mathbf{r})$ which associates a definite value of the [vector](#) quantity \mathbf{A} with each [point](#) specified by [position vector](#) \mathbf{r} . In short, it is a [vector](#) valued [function](#) of \mathbf{r} . [[P3.1](#)]

is said to be: [uniform](#), if all the [vectors](#) specifying the field are [parallel](#) in [direction](#) and have the same [magnitude](#) at every point within the field. [[M2.6](#), [P3.1](#)]

Flexible Learning Approach to Physics - Glossary

vector product

of: two [vectors](#) $\mathbf{a} = (a_x, a_y, a_z)$ and $\mathbf{b} = (b_x, b_y, b_z)$

is: a [vector](#) quantity denoted by $\mathbf{a} \times \mathbf{b}$. [[M2.7](#), [P2.7](#), [P2.8](#), [P4.3](#)]

has a magnitude: $|\mathbf{a}||\mathbf{b}|\sin\theta$, where $|\mathbf{a}|$ and $|\mathbf{b}|$ are the [magnitudes](#) of the [vectors](#), and θ is the [angle](#) from the [direction](#) of \mathbf{a} to the [direction](#) of \mathbf{b} . [[M2.7](#), [P2.7](#), [P2.8](#), [P4.3](#)]

has a direction: [perpendicular](#) to \mathbf{a} and \mathbf{b} in the sense given by the [right-hand rule](#). [[M2.7](#), [P2.7](#), [P2.8](#), [P4.3](#)]

therefore may be written: $|\mathbf{a}||\mathbf{b}|\sin\theta\hat{\mathbf{n}}$, where $\hat{\mathbf{n}}$ is an appropriately directed [unit vector](#).

can be computed: in terms of [scalar components](#), using

$$\mathbf{a} \times \mathbf{b} = (a_y b_z - b_y a_z, a_z b_x - b_z a_x, a_x b_y - b_x a_y) \quad [\text{M2.7}]$$

has the property: that $\mathbf{a} \times \mathbf{b} = -\mathbf{b} \times \mathbf{a}$ (note the minus sign) [[M2.7](#)]

is also called: cross product. [[P2.7](#)]

See vector product in the [Maths handbook](#) for further details.

Flexible Learning Approach to Physics - Glossary

vector quantity

is: a quantity which has both [magnitude](#) and [direction](#) and which satisfies the rules of [vector algebra](#) (see [vector addition](#) and [scaling](#)). [[P2.2](#)]

is represented: by a [vector](#). [[M2.4](#), [M2.5](#), [P2.2](#)]

as a term, is used interchangeably: with the term [vector](#). [[M2.4](#), [M2.5](#)]

Flexible Learning Approach to Physics - Glossary

vector sum

of: two [vectors](#) $\mathbf{a} = (a_x, a_y, a_z)$ and $\mathbf{b} = (b_x, b_y, b_z)$

is: the [vector](#) that results from the [vector addition](#) of those [vectors](#). [[M2.4](#), [P2.2](#)]

may be constructed graphically: by means of the [triangle rule](#) or the [parallelogram rule](#). [[M2.4](#), [P2.2](#)]

is expressed algebraically: (for [three-dimensional vectors](#)) by the rule

$$\begin{aligned}\mathbf{a} + \mathbf{b} &= (a_x, a_y, a_z) + (b_x, b_y, b_z) \\ &= (a_x + b_x, a_y + b_y, a_z + b_z)\end{aligned}\quad [\text{M2.4, P2.2}]$$

vector triple product

is: a product of three vectors which may be written as $\mathbf{a} \times (\mathbf{b} \times \mathbf{c})$. Note that the brackets are essential here since $\mathbf{a} \times (\mathbf{b} \times \mathbf{c})$ is generally quite different from $(\mathbf{a} \times \mathbf{b}) \times \mathbf{c}$. [[M2.7](#)]

can be evaluated: from the identity $\mathbf{a} \times (\mathbf{b} \times \mathbf{c}) = \mathbf{b}(\mathbf{a} \cdot \mathbf{c}) - \mathbf{c}(\mathbf{a} \cdot \mathbf{b})$ (the [bac cab rule](#)). [[M2.7](#)]

See scalar product in the [Maths handbook](#).

velocity

See [instantaneous velocity](#).

Flexible Learning Approach to Physics - Glossary

velocity selector

is: a device for selecting [charged particles](#) of a particular [velocity](#), using a combination of an [electric field](#) and a [magnetic field](#). [[P4.3](#)]

Flexible Learning Approach to Physics - Glossary

velocity-time graph

for: a [particle](#) moving with [linear motion](#) along the [x-axis](#)

is: a [graph](#) of the [velocity](#) v_x of the [particle](#) against [time](#) t [[M5.1](#)]

conventionally is plotted: with [velocity](#) vertical and [time](#) horizontal.
[[M4.1](#), [P2.1](#)]

has: as its [gradient](#) at any particular [time](#), the [instantaneous acceleration](#) at that [time](#). [[M4.1](#), [P2.1](#)]

Flexible Learning Approach to Physics - Glossary

vertex (of a parabola)

informally is: the [turning point](#) of a [parabola](#), or similar curve. [M1.3]

more formally, is: the point on a [parabola](#) that is closest to the [directrix](#).
[M1.3, M2.3]

See [pole](#).

See also [vertices \(of a polygon\)](#) for a different meaning.

Flexible Learning Approach to Physics - Glossary

vertex (of a lens)

is: the point at which the [optical axis intersects](#) the curved [surface](#) of a [lens](#).
[P6.3]

is synonymous: with [pole \(of a lens\)](#). [P6.3]

Flexible Learning Approach to Physics - Glossary

vertical asymptote

See [asymptote](#).

Flexible Learning Approach to Physics - Glossary

vertically opposite

describes: the pairs of equal [angles](#) that are produced opposite one another when two [straight lines](#) intersect. [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

vertices (of a polygon)

are: the corners of the [polygon](#) (the singular of vertices is vertex). [[M2.1](#)]

Flexible Learning Approach to Physics - Glossary

vibration

is synonymous: with [oscillation](#).

vibrational kinetic energy

is usually: [kinetic energy](#) associated with the [oscillatory motion](#) of parts of a [system](#) relative to its [centre of mass](#).

should usually be: distinguished from any [translational kinetic energy](#) arising from the motion of the [centre of mass](#) of an [oscillator](#).

is exemplified by: the vibrational kinetic energy of the molecules in a [diatomic ideal gas](#).

Flexible Learning Approach to Physics - Glossary

virtual image

is: an [image](#) from which [light rays](#) appear to diverge. [[P6.2](#)]

may be created: by [reflection](#) at a [mirror](#) or [refraction](#) at a [lens](#). [[P6.3](#)]

cannot be formed: on a screen, since [rays](#) do not actually pass through it but only appear to have come from it. [[P6.2](#), [P6.3](#)]

Flexible Learning Approach to Physics - Glossary

virtual object

is located: at the place towards which [rays](#) converge, before they are deflected by some interposed component such as a [lens](#) or a [mirror](#). [[P6.3](#)]

Flexible Learning Approach to Physics - Glossary

viscosity

is: the phenomenon of internal [friction](#) in a [fluid](#), leading to [energy dissipation](#) and [stresses](#) due to distortion of [fluid elements](#). [[P2.3](#), [P7.6](#)]

arises microscopically: from the [transport](#) of [molecular momentum](#) between adjacent layers of [fluid](#) in relative [motion](#). There is a net [transport](#) of [momentum](#) from regions of high [momentum](#) to regions of low [momentum](#), this tends to reduce the [momentum](#) difference between the layers and therefore the relative [motion](#). [[P7.5](#)]

is therefore: a [transport process](#).

is also: an abbreviation for the [coefficient of viscosity](#), which is a measure of the difficulty with which a fluid flows (higher for treacle and motor oil than for water). [[P5.2](#)]

Flexible Learning Approach to Physics - Glossary

viscous

means: pertaining to [viscosity](#).

Flexible Learning Approach to Physics - Glossary

viscous forces

are: [forces](#) arising from [viscosity](#). [P5.2]

are a result: at the [molecular](#) level, of the transfer of [momentum](#) from one 'layer' in a moving [fluid](#) to another, or to a body moving through the fluid. [P5.2]

See [Stokes' law](#).

Flexible Learning Approach to Physics - Glossary

visible light

is: [light](#) that can be detected by the human eye.

Flexible Learning Approach to Physics - Glossary

visible spectrum

is: the range of different colours of [light](#) that make up white [light](#). [P6.2]

can be seen: by allowing a [beam](#) of white [light](#) to undergo [dispersion](#) in a glass [prism](#), or some similar [optical](#) device. [P6.2]

broadly corresponds: to different [wavelengths](#) in the approximate range 750 nm to 400 nm though the perception of colour by humans involves other factors. The different colours normally recognized (in the English language) within the visible spectrum (in order of decreasing [wavelength](#)) are red, orange, yellow, green, blue, indigo and violet. [P6.2]

Flexible Learning Approach to Physics - Glossary

visual acuity

is: the ability of the eye to [resolve](#) detail in an object, or to distinguish two objects which are or appear to be narrowly separated. [[P6.4](#)]

is also: the [resolution](#) limit of the eye. [[P6.4](#)]

Flexible Learning Approach to Physics - Glossary

vitreous humour

is: the clear jelly-like [fluid](#) which fills the eye and helps it to keep its shape.

[\[P6.4\]](#)

vitrification

is: a process for reducing the [volume](#) of high-level [radioactive](#) waste by converting it into [solid](#) glass blocks. [[P9.3](#)]

Flexible Learning Approach to Physics - Glossary

volt, V

is: the [SI unit](#) of [electrical potential](#) and [potential difference](#).

is defined: by $1 \text{ V} = 1 \text{ W A}^{-1}$, so it is the [potential difference](#) between two points on a [conductor](#) such that a [current](#) of 1 [ampere](#) flowing between them dissipates a [power](#) of 1 [watt](#). [[P3.3](#), [P4.1](#)]

Flexible Learning Approach to Physics - Glossary

voltage

See [electric potential](#), [electrical potential difference](#). [P4.1]

Flexible Learning Approach to Physics - Glossary

voltage difference

See [electric potential difference](#).

Flexible Learning Approach to Physics - Glossary

voltage divider

is: a [circuit](#) which produces an output [voltage](#) that is a predetermined fraction of the [voltage](#) from a [voltage generator](#). [P4.1]

in its simplest form, consists: of two [resistors](#) connected in [series](#) with the supply [voltage](#), with the output being the [voltage](#) across one of the [resistors](#). [P4.1]

Flexible Learning Approach to Physics - Glossary

voltage divider equation

is: an [equation](#) which describes the [voltage](#) across a [resistor](#) that is in [series](#) with another [resistor](#) and a [voltage generator](#). [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

voltage drop

between: two [points](#)

is: the [magnitude](#) of the difference in [electrical potential](#) between the two [points](#)

Flexible Learning Approach to Physics - Glossary

voltage generator

is: a device that acts as a source of [potential difference](#), e.g. a [battery](#) or a [dynamo](#). [[P5.5](#)]

Flexible Learning Approach to Physics - Glossary

voltmeter

is: a device for measuring [voltage difference](#). [[P4.1](#)]

is connected: to the two points between which the [potential difference](#) is to be [measured](#), and therefore is in [parallel](#) with one or more [circuit components](#). [[P4.1](#)]

ideally has: a very high [resistance](#), so that it does not affect the [circuit](#) to which it is connected. [[P4.1](#)]

Flexible Learning Approach to Physics - Glossary

volume

is: the quantity of [space](#) occupied by a [body](#), object or sample. [[P7.2](#)]

has as its SI unit: m^3 .

volume of revolution

is: the [volume](#) of a [solid of revolution](#). [[M5.4](#)]

Flexible Learning Approach to Physics - Glossary

volume strain

is: the [strain](#) ϵ_{vol} within a material caused by the application of a [volume stress](#) (i.e. a [pressure](#)). [P7.6]

is given: by $\epsilon_{\text{vol}} = -\Delta V/V$, where ΔV is the increase in [volume](#) of the material and V is the original [volume](#), (note the minus sign, and that ΔV is negative if the [volume](#) decreases). [P7.6]

therefore is: positive if the [volume](#) decreases. [P7.6]

Flexible Learning Approach to Physics - Glossary

volume stress

is: the [stress](#) σ_{vol} resulting from a change in the [compressional forces](#) acting [perpendicularly](#) and [uniformly](#) over all [surfaces](#) of a [body](#) (i.e. a change in [pressure](#) ΔP). [P7.6]

is given: by the increase in the inward [perpendicular component](#) of the [force](#) divided by the [area](#) over which it acts, so $\sigma_{\text{vol}} = \Delta P$. [P7.6]

therefore is: positive if the applied pressure increases. [P7.6]

is also called: a uniform stress. [P7.6]

Flexible Learning Approach to Physics - Glossary

watt, W

is: the [SI unit](#) of [power](#).

is defined: by $1 \text{ W} = 1 \text{ J s}^{-1}$, so it is the [power](#) that transfers [energy](#) at the rate of 1 [joule](#) per [second](#). [[P2.4](#), [P4.1](#)]

Flexible Learning Approach to Physics - Glossary

wave

is: a 'disturbance' that varies with [position](#) and [time](#), and satisfies a [wave equation](#). [P5.6]

is exemplified: by a [sinusoidal transverse displacement](#) wave

$y = A \sin [kx - \omega t + \phi]$ that satisfies the [one-dimensional wave equation](#); where A is the [amplitude](#), $k = 2\pi/\lambda$ is the [angular wavenumber](#), $\omega = 2\pi/T$ is the [angular frequency](#), and ϕ is the [phase constant](#). [P5.6]

See [travelling wave](#) and [standing wave](#).

See also [periodic wave](#) and [solitary wave](#).

Flexible Learning Approach to Physics - Glossary

wave equation

is: the [linear partial differential equation](#) which describes the [motion](#) of any [travelling wave](#). [[M6.4](#), [P5.6](#)]

in its simplest form, is given: by

$$\frac{\partial^2 \Psi}{\partial x^2} - \frac{1}{v^2} \frac{\partial^2 \Psi}{\partial t^2} = 0$$

where $v^2 = \omega^2/k^2$, in which form it is usually referred to as 'the' wave equation. [[M6.4](#), [P5.6](#)]

Flexible Learning Approach to Physics - Glossary

wave form

of: a [wave](#) at a given [position](#)

is: a representation of the disturbance that the [wave](#) causes at the given [position](#) over a given [time](#). If the disturbance that constitutes the [wave](#) is defined by a [function](#) $f(x, t)$, then the wave form at the [point](#) $x = x_1$ may be represented by the [graph](#) of $y = f(x_1, t)$. [[M6.4](#), [P5.6](#)]

Flexible Learning Approach to Physics - Glossary

wave group

is: the result of combining several different [waves](#) with slightly different [frequencies](#) (usually via the [principle of superposition](#)). [P5.6, P10.4]

generally has: in a [system](#) that exhibits [dispersion](#), an [envelope](#) that travels at a [group speed](#) that is different from the [phase speed](#) of the individual [waves](#) that make up the group. [P5.6, P10.4]

See also [wave packet](#).

Flexible Learning Approach to Physics - Glossary

wave mechanics

See [quantum mechanics](#).

Flexible Learning Approach to Physics - Glossary

wave model of light

is: a highly successful [mathematical model](#) of [light](#) that accounts for many [optical](#) phenomena in terms of [classical electromagnetic waves](#). [P6.2]

is unable: to account for certain aspects of the behaviour of [light](#) particularly its interaction with [matter](#); these are now explained in terms of [quantum theory](#). [P6.2]

Flexible Learning Approach to Physics - Glossary

wave packet

is: the 'disturbance' that results from the [superposition](#) of many different [waves](#), usually with different [amplitudes](#) and slightly different wavelengths and/or frequencies. [[P10.2](#), [P10.4](#)]

can be used: in [quantum mechanics](#) to represent the [wavefunction](#) of a [localized particle](#). [[P10.2](#), [P10.4](#)]

See also [wave group](#).

Flexible Learning Approach to Physics - Glossary

wave profile

is: the 'shape' of a [wave](#) at any given [time](#). If the disturbance that constitutes the [wave](#) is defined by a [function](#) $f(x, t)$ then the wave profile at a given [time](#) $t = t_1$ may be represented by the [graph](#) of the [function](#) $y = f(x, t_1)$. [[M6.4](#), [P5.6](#)]

Flexible Learning Approach to Physics - Glossary

wave train

is: a finite part of a [wave](#) that is sufficiently large to encompass several wavelengths. [[P5.6](#)]

Flexible Learning Approach to Physics - Glossary

wave vector

is: a generalization of the [scalar angular wavenumber](#) to a [vector quantity](#) which characterizes [waves propagating](#) in [two-](#) or [three-dimensions](#). [P5.6]

has magnitude: equal to $2\pi/\lambda$. [P5.6]

has direction: [parallel](#) to the [direction](#) of [propagation](#). [P5.6]

usually is denoted: by the symbol \mathbf{k} . [P5.6]

more properly is referred to: as the [angular wave vector](#), but this term is almost never used in practice. [P5.6]

is also referred to: as the propagation vector.

Flexible Learning Approach to Physics - Glossary

wave/particle duality

is: the assertion, in [quantum physics](#), that some [systems](#) (e.g. [photons](#), [electrons](#), [atoms](#)) may exhibit either [wave](#)-like or particle-like behaviour, according to circumstance. [[P10.1](#)]

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wavefront

of: a [wave](#)

is: a [line](#) (in [two-dimensions](#)) or a [surface](#) (in [three-dimensions](#)) that passes only through [points](#) at which the [phase](#) of a [wave](#) has the same value. It is a [surface of constant phase](#). [[P5.6](#), [P6.1](#), [P6.2](#)]

at any point, is always: at [right angles](#) to the [direction](#) of [propagation](#) of the [wave](#). [[P5.6](#)]

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wavefunction

of: a [physical system](#)

in: [quantum mechanics](#)

is: a [mathematical function](#) that describes the [quantum state](#) of the [system](#) and specifies its [quantum mechanical](#) behaviour. [[P10.3](#)]

always corresponds: to a particular [quantum state](#). [[P8.3](#)]

is: a [complex](#) quantity, $\Psi(x, t)$, which depends on [position](#) and [time](#). [[M6.4](#), [P10.3](#), [P10.4](#), [P11.1](#)]

contains: all the information we can know about the [system](#). [[M6.4](#), [P10.3](#), [P10.4](#), [P11.1](#)]

is exemplified: by the [stationary state solutions](#) of the [time-dependent Schrödinger equation](#), which are the wavefunctions corresponding to [states](#) of definite [energy](#). [[M6.4](#), [P10.3](#), [P10.4](#), [P11.1](#)]

See also [spatial wavefunction](#) and [temporal wavefunction](#).

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wavelength

is: the [distance](#) λ between any two adjacent equivalent [points](#) of a (spatially) [periodic wave](#). [[M6.4](#), [P5.6](#), [P5.7](#)]

is exemplified: in the case of a [sinusoidal wave](#), by the [distance](#) between adjacent [wave](#) crests at a given [time](#). [[M6.4](#), [P5.6](#), [P5.7](#)]

more colloquially, is: the [distance](#) from one peak to the next or, equivalently, from one trough to the next. [[P6.1](#)]

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wavenumber

is: the number of spatial [cycles](#) of a [wave](#) per [unit length](#). [[P5.6](#), [P10.2](#)]

is equal: to the [reciprocal](#) of the [wavelength](#): $\sigma = 1/\lambda$. [[P5.6](#), [P10.2](#)]

as a term, is also widely used: to describe the quantity $k = 2\pi/\lambda$, which is more properly referred to as the [angular wavenumber](#). [[P5.6](#), [P10.2](#)]

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weak interaction

is: the fundamental [interaction](#) that is ultimately responsible for [radioactive \$\beta\$ -decay](#).

has nothing to do: with weak [bonds](#) ([van der Waals bonds](#)). [[P9.2](#)]

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weber, Wb

is: the [SI unit](#) of [magnetic flux](#).

is defined by: $1 \text{ Wb} = 1 \text{ T m}^2$, so it is the [magnetic flux](#) through an [area](#) of 1 ([metre](#)) squared placed [perpendicular](#) to a [uniform magnetic field](#) of strength 1 [tesla](#). [[P4.4](#)]

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weight

is: a [vector quantity](#). [[M2.4](#)]

is: the [gravitational force](#) exerted on an object by the Earth (or the Moon or some other [massive body](#)). [[M2.4](#), [P2.3](#), [P2.6](#)]

has direction: from the [centre of mass](#) of the object towards the centre of the Earth. Near the [surface](#) of the Earth, the weight of an object acts vertically downwards. [[P2.3](#), [P3.2](#)]

has magnitude: given by the [product](#) of the object's [mass](#) and g the [magnitude of the acceleration due to gravity](#) on Earth. [[P2.3](#), [P3.2](#)]

more strictly, is: the [resultant gravitational force](#) exerted on the object by all other objects in the [Universe](#). [[P3.1](#)]

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weightlessness

is experienced: by astronauts in [orbiting](#) vehicles, and parachutists in early free fall (no [air resistance](#)), because they are not being supported by any [reaction force](#). [P3.2]

is: somewhat of a misnomer, since they still have [weight](#). What they don't have is any [reaction force](#) against their [weight](#). [P3.2]

white light

is: a specific mix of the various colours of [light](#) belonging to the [visible spectrum](#), such that the overall effect is similar to that of ordinary daylight. [P6.2]

more strictly, is: in terms of the [wave model of light](#), a mixture of [waves](#) of different [wavelengths](#), with the [amplitude](#) of each [wave](#) such that the combined effect of their [superposition](#) is similar to that of daylight. [P6.2]

can be simulated visually: by the combination of just a few [wavelengths](#) (e.g. red, green and blue, as in a colour television). [P6.2]

but in physics, is strictly: [light](#) with a [continuous emission spectrum](#), containing a continuous distribution of [wavelengths](#) over the entire [visible spectrum](#). Such a [spectrum](#) is produced by a hot object (e.g. the Sun) with a [surface temperature](#) of about 5800 K. [P8.2]

can be dispersed: by a [diffraction grating](#) or a [prism](#) into all the colours of the rainbow. [P8.2]

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work

is: [energy](#) transferred between a [system](#) and its [environment](#) by any means that does not directly involve [temperature](#) differences (i.e. by any means other than [heat](#) transfer). [[P7.3](#), [P7.4](#)]

is exemplified: by the ([mechanical](#)) work $\mathbf{F} \cdot \mathbf{s}$ done by a [constant force](#) \mathbf{F} acting over a [displacement](#) \mathbf{s} . [[P2.4](#), [P7.3](#), [P7.4](#)]

can be determined: if the [force](#) varies as its point of application moves along a

given path, as a [limit](#) of a [sum](#) (i.e. a [line integral](#)) $\int_A^B \mathbf{F} \cdot d\mathbf{s} = \lim_{\Delta s \rightarrow 0} \sum \mathbf{F} \cdot \Delta \mathbf{s}$.

[[M2.6](#)]

has as its SI unit: the [joule](#) (J), where $1 \text{ J} = 1 \text{ N m} = 1 \text{ kg m}^2 \text{ s}^{-2}$. [[P2.5](#)]

See also [first law of thermodynamics](#).

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work done

See [work](#).

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work function

of: a material, usually a [metal](#)

is: the **minimum** [energy](#) required to remove [electrons](#) from the material. Thus when [electromagnetic radiation](#) of [frequency](#) f (i.e. of [energy](#) hf) impinges on the material, the **maximum** [kinetic energy](#) of the ejected [electrons](#) will be given by:

$$E = hf - \phi \quad [\text{P10.1}]$$

See [threshold frequency](#).

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work-energy theorem

states: that when a single [resultant force](#) does [work](#) on a [system](#), the [kinetic energy](#) of the [system](#) increases by an amount which is equal to the [work](#) done on the [system](#). [[P2.4](#)]

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x-axis

generally is: an [axis](#) of a [graph](#) showing values of a [variable](#) x . [P1.3]

as a term, is often used: to describe the horizontal [axis](#) of any [graph](#), irrespective of the quantity actually being plotted on that [axis](#). [P1.3]

is also: one [axis](#) of a [Cartesian coordinate system](#).

X-rays

are: a form of [electromagnetic radiation](#), characterized by [wavelengths](#) in the range between those of [\$\gamma\$ -rays](#) (gamma-rays) and [ultraviolet radiation](#) (i.e. in the approximate range 0.5 nm to 100 nm).

See [electromagnetic spectrum](#).

X-ray diffraction

is: the [diffraction](#) of [X-rays](#) by a regular array of [atoms](#) (as in a [crystal](#)).
[P7.1]

results in: a [diffraction pattern](#) with sharp [local maxima](#) of [intensity](#) in directions determined by [Bragg's law](#). [P7.1]

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y-axis

generally is: an [axis](#) of a [graph](#) showing values of a [variable](#) y . [P1.3]

as a term, is often used: to describe the vertical [axis](#) of any [graph](#), irrespective of the quantity actually being plotted on that [axis](#). [P1.3]

is also: one [axis](#) of a [Cartesian coordinate system](#).

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y-intercept

See [intercept](#).

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yield point

is: the maximum [stress](#) that a [solid](#) can sustain without undergoing permanent deformation. [P7.6]

therefore is: the point on the [loading curve](#) which marks the end of the [elastic region](#) and the start of the [plastic region](#). [P7.6]

is also called: the [elastic limit](#). [P7.6]

Young's experiment

is: a classic demonstration of [interference](#). [P6.1]

has as input: [light](#) of [wavelength](#) λ [normally incident](#) on two narrow [parallel](#) slits which are separated by a small [distance](#) d . [P6.1]

has as output: an [interference pattern](#) consisting of alternate bright and dark bands ([interference fringes](#)) on a distant screen. The bright fringes of [order](#) n are [observed](#) at [angles](#) θ_n from the straight-through [direction](#) given by

$$n\lambda = d \sin \theta_n$$

where $n = 0, \pm 1, \pm 2, \dots$ [P6.1]

Young's modulus

of: a material

is: an [elastic modulus](#), conventionally denoted Y (or exceptionally E), that is particularly relevant to thin rods or narrow rails. [[P5.7](#), [P7.6](#)]

is defined: as the [ratio](#) of the applied [tensile stress](#) σ_T to the resulting [tensile strain](#) ε_T :

$$Y = \frac{\sigma_T}{\varepsilon_T} = \frac{F/A}{\Delta l/l} \quad [\text{P7.6}]$$

where F/A is the [magnitude](#) of the [perpendicular force](#) per unit [cross-sectional area](#), and $\Delta l/l$ is the fractional change in [length](#). [[P5.7](#)]

has as its SI unit: N m^{-2} or Pa. [[P5.7](#)]

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z-axis

generally is: an [axis](#) of a [graph](#) showing values of a [variable](#) z . [[M2.2](#), [P1.3](#)]

as a term, is often used: to describe the third [axis](#) of any [three-dimensional graph](#), irrespective of the quantity actually being plotted on that [axis](#). [[M2.2](#), [P1.3](#)]

is also: one [axis](#) of a [Cartesian coordinate system](#).

Zeeman effect

is: the splitting of [atomic energy levels](#) and their associated [spectral lines](#) in the presence of a [magnetic field](#). [P8.3]

is caused: by the [magnetic field](#), which removes the [degeneracy](#) of [energy levels](#) of [electron subshells](#). [P8.3]

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zero point energy

is: the minimum [kinetic energy](#) for a confined [particle](#), resulting from the [wave](#) nature of [matter](#) as described by [quantum mechanics](#). [[P10.4](#), [P11.2](#)]

is exemplified: by the [ground state energy](#) of a [particle](#) in a [one-dimensional box](#), which is [inversely proportional](#) to the [square](#) of the [length](#) of the box. [[P10.4](#), [P11.2](#)]

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zero vector

is: a [vector](#) of zero [magnitude](#) that may be associated with any [direction](#).
[[M2.4](#), [M2.5](#)]

is denoted: as $\mathbf{0}$ and plays a similar role to the number zero in the [set](#) of [real numbers](#). [[M2.4](#), [M2.5](#)]

is defined: by the requirement that $\mathbf{a} + \mathbf{0} = \mathbf{a}$ for any [vector](#) \mathbf{a} . [[P2.2](#)]

is included: in the [set](#) of all [vectors](#), to ensure that the rules of [vector algebra](#) are consistent. [[M2.4](#), [M2.5](#)]

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zeros (of a function)

are: the values of the [independent variables](#) of the [function](#), for which the [function](#) is zero. [[M1.4](#)]

also are: the [roots](#) of the [equation](#) $f(x) = 0$. [[M1.4](#)]

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zeroth law of thermodynamics

states: that if two of three separate [systems](#) can in separate [experiments](#) be shown to be in mutual [thermal equilibrium](#) with the third, then they will be found to be in mutual [thermal equilibrium](#) with each other. [P7.2]

sounds: so obvious as to make it unnecessary to glorify it with a name. In fact, as its name suggests, it was a bit of an afterthought. [P7.2]

but logically is: very important, because it leads directly to the concept of [temperature](#) and the setting up of [temperature scales](#) and the various procedures for [temperature measurement](#). [P7.2]