

A Dictionary of
Science

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relates one variable to one or more other variables. If y is a function of x , written $y = f(x)$, a change in x produces a change in y , and if x is known, y can be determined. x is the **independent variable** and y is the **dependent variable**.

functional A function of a function. Functionals are used very extensively in the quantum-mechanical many-body problem, statistical mechanics, and quantum field theory.

functional group The group of atoms responsible for the characteristic reactions of a compound. The functional group is $-\text{OH}$ for alcohols, $-\text{CHO}$ for aldehydes, $-\text{COOH}$ for carboxylic acids, etc.

fundamental See HARMONIC.

fundamental constants (universal constants) Those parameters that do not change throughout the universe. The charge on an electron, the speed of light in free space, the Planck constant, the gravitational constant, the electric constant, and the magnetic constant are all thought to be examples. It has been suggested that some fundamental constants might change with time, although there is no conclusive evidence that this occurs.

 SEE WEB LINKS

- Values of fundamental physical constants from NIST

fundamental interactions The four different types of interaction that can occur between bodies. These interactions can take place even when the bodies are not in physical contact and together they account for all the observed forces that occur in the universe. While the unification of these four types of interaction into a single theory has long been the aim of physicists, this has not yet been fully achieved. See also ELEMENTARY PARTICLES; GAUGE THEORY; UNIFIED-FIELD THEORY.

The **gravitational interaction**, some 10^{40} times weaker than the electromagnetic interaction, is the weakest of all. The force that it generates acts between all bodies that have mass and the force is always attractive. The interaction can be visualized in terms of a classical ***field of force** in which the strength of the force falls off with the square of the distance between the interacting bodies (see NEWTON'S LAW OF GRAVITATION). The hypothetical gravitational quantum, the **graviton**, is also a useful concept in some contexts. On

the atomic scale the gravitational force is negligibly weak, but on the cosmological scale, where masses are enormous, it is immensely important in holding the components of the universe together. Because gravitational interactions are long-ranged, there is a well-defined macroscopic theory in general relativity. At present, there is no satisfactory quantum theory of gravitational interaction.

The **weak interaction**, some 10^{10} times weaker than the electromagnetic interaction, occurs between ***leptons** and in the decay of hadrons. It is responsible for the ***beta decay** of particles and nuclei. In the current model, the weak interaction is visualized as a force mediated by the exchange of virtual particles, called intermediate vector bosons. The weak interactions are described by ***electroweak theory**, which unifies them with the electromagnetic interactions.

The **electromagnetic interaction** is responsible for the forces that control atomic structure, chemical reactions, and all electromagnetic phenomena. It accounts for the forces between charged particles, but unlike the gravitational interaction, can be either attractive or repulsive. Some neutral particles decay by electromagnetic interaction. The interaction is either visualized as a classical field of force (see COULOMB'S LAW) or as an exchange of virtual ***photons**. As with gravitational interactions, the fact that electromagnetic interactions are long-ranged means that they have a well-defined classical theory given by ***Maxwell's equations**. The quantum theory of electromagnetic interactions is described by ***quantum electrodynamics**.

The **strong interaction**, some 10^2 times stronger than the electromagnetic interaction, functions only between ***hadrons** and is responsible for the force between nucleons that gives the atomic nucleus its great stability. It operates at very short range inside the nucleus (10^{-15} metre) and is visualized as an exchange of virtual mesons. The strong interactions are described by ***quantum chromodynamics**.

fundamental units A set of independently defined ***units of measurement** that forms the basis of a system of units. Such a set requires three mechanical units (usually of length, mass, and time) and, in some systems, one electrical unit; it has also been found convenient to treat certain other quantities as fundamental, even though they

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