64.3: Forces

We know of four fundamental forces in Nature: the gravitational force, the electromagnetic force, and two nuclear forces (Table 64.3.1) We're all familiar with the gravitational force (which is keeping you attached to the ground as you read this). Most of the other forces you encounter in everyday life are electromagnetic in nature. The strong nuclear force is responsible for holding atomic nuclei together against the mutual electrostatic repulsion of protons, and is also responsible for nuclear fusion reactions that occur in the Sun and in hydrogen bombs. The weak nuclear force is responsible for a process called β decay, in which a neutron in an atomic nucleus decays into a proton, electron, and anti-neutrino, and the electron escapes from the atom in the process.

Table 64.3.1. The four forces.

Force	Vector boson
Gravitational	Graviton (?)
Electromagnetic	Photon
Strong nuclear	Gluon
Weak nuclear	W, Z

According to the Standard Model, each of these forces is mediated by a particle called a vector boson. In effect, each force is thought to be caused by the exchange of these particles. [1]

The electromagnetic and weak nuclear forces have been (somewhat) unified into a combined "electroweak theory", although this theory is not entirely complete. Many physicists believe that the electromagnetic, strong nuclear, and weak nuclear forces can be shown to be different aspects of a single underlying force, and thus all covered by a single "Grand Unified Theory". No Grand Unified Theory has yet been discovered.

Our best theory of gravity to date is Einstein's General Theory of Relativity, and has so far been shown to be consistent with experimental results. However, general relativity says that the gravitational force is due to the curvature of space-time; this is at odds with the Standard Model view, which is that gravity is caused by the exchange of particles called gravitons. No experiment has yet detected the existence of gravitons, and it's uncertain whether or not general relativity is the correct final theory of gravity.

Some physicists believe that it may be possible to show that all four forces (including gravity) are aspects of a single underlying force, and covered by a theory called the "Theory of Everything". Such a theory (which is essentially a grand unified theory plus gravity) has not yet been found, nor is it known whether such a theory even exists. Some theories such as string theory have been proposed, but are far from being experimentally verified. These are issues to be worked out by future generations of physicists.

[1] The gravitational force is not considered to be part of the Standard Model.