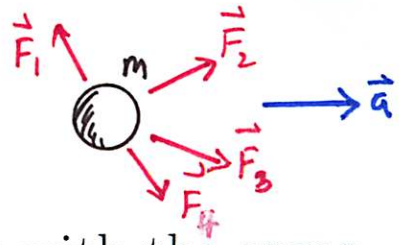
NEWTON'S SECOND LAW!

$$\sum \mathbf{F} = M\mathbf{a}.$$



The net force on an object is a vector with the same length and magnitude as the acceleration vector of the object times its inertial mass M. Units are chosen so that the unit of force is a kilogram times a meter per second per second.

Forces of Nature:

• Gravity: any mass attracts any other mass. The force has infinite range. Gravity is the weakest force in nature, but dominates since it is not shielded by anything.

• Electromagnetism: any charge attracts or repels any other charge. The force has infinite range, but the universe consists of equal amounts of positive and negative charge, and matter has no net charge, so electromagnetic forces are difficult to notice ordinarily, although they are about 10^{38} times stronger than gravity! Molecules and atoms are held together by the electromagnetic force.

• Weak force: the weak force changes the "flavor" of quarks. It is about 10^{33} times stronger than gravity,

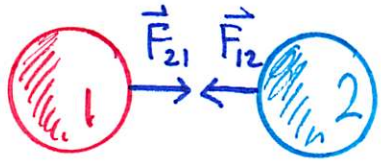
but has a range so short it acts only *inside* protons and neutrons. It is the weak force that make the sun shine.

• Strong force: the strong force acts between quarks, and in effect holds the nucleus of the atom together. It has a very short range, about the same as the radius of a proton or neutron. It is about 10^{40} times stronger than gravity.

Inertial & Non-Inertial Frames of Reference:

The laws of motion apply only in frames of reference that are *not accelerating*, which are called *inertial frames*. In an accelerating frame of reference, the laws of motion can't be applied, since for example the frame of reference could always be accelerating in a way to cancel out the actual acceleration of an object, without affecting the forces acting on it.

Beware that most of what the text says about *weight,* etc., is either wrong or confusing. Just ignore it. In physics, there is never a valid reason to even use the term "weight." If, for example, you are talking about the force of gravity, just say "the force of gravity!"



Newton's Third Law:

When objects 1 and 2 exert forces on one another, $\mathbf{F}_{12}$ and $\mathbf{F}_{21}$ have the same magnitude.

Hooke's Law:

In doing problems illustrating the application of the 2nd and 3rd Laws, springs are convenient to include. A spring, when stretched a distance x from equilibrium, exerts a force $\mathbf{F}_s = -\hat{\mathbf{i}}kx$, where k is a constant with units of Newtons per meter.