Notes Ch 4 Forces and Newton's Laws of Motion

A force is any push or pull

There are currently four known forces in the universe:

Gravitational - inverse square law, always attractive, extends forever
Electromagnetic - inverse square law, repels or attracts, extends forever
Strong - nuclear force, up to 10 femtometers, holds protons together
Weak - nuclear force, dictates radioactive decay, quark flavour changing,

possibly a contact force, only over very short distances

Examples of forces we deal with in this class:
pushes/pulls - typically something pushes or pulls directly on the object of interest
Tension - pull only from a cord, rope, chain, etc.
Gravity - weight, mg
Friction - static and kinetic, can do either positive or negative work
Normal - support force normal (perpendicular) to supporting surface
Spring - a push or pull that varies with the stretch of the spring
Centripetal - force that cause objects to move in a circular path
Net force - the sum of all forces acting on an object

Newton's Laws of Motion

1st Law (Law of Inertia) - An object in motion maintains a constant velocity (both speed and direction) unless a net outside force acts on the object. Also, an object at rest remains at rest, unless acted upon by a net outside force.

2nd Law - The resulting acceleration on an object is directly proportional to the force applied to the object. The resulting acceleration on an object is inversely proportional to the mass of the object. Hence a =F/m. We prefer to say F=ma, but the previous is more accurate to what Newton was describing.

3rd Law - For every action force, there exists an equal but opposite reaction force occurring at the same location at the same moment. Remember force always occur in pairs and that these pair forces act on different objects.

Mass - Inertia

The amount of matter in an object is known as mass. Inertia is another name for mass. Inertia is a measure of how hard it is to accelerate an object. In space where gravity

may be low or you may be in orbit to create a low apparent weight of an object, that object will still be just as difficult to accelerate. Mass never changes.

Weight - mg - F_g - gravitational force

The weight of an object is not fixed, rather it depends on another mass pulling with gravitational force. Both mass contribute to the total weight of the object. Ex. - on Earth 1 kg weigh 9.8 Newtons, but the same 1 kg mass weighs about 1.63 Newtons on the moon because the moon has less mass with which to pull. Because the force of gravity increases with an objects mass linearly and that object becomes harder to accelerate as its mass increases linearly, all objects accelerate the same due to gravitational forces (ignoring air resistance). Therefore a feather and an elephant fall with the same acceleration in a vacuum on Earth.

Free Body Diagrams (and Body Free Diagrams)

Vectors of all real forces (net force and centripetal force are summations and therefore not individual vectors) are added using vector addition. The resulting acceleration can then be calculated. Acceleration along component vectors can also be found independently.

Friction - caused by microscopic “mountains and valleys” on the surface of all substances. These imperfections rub against one another. Friction always opposes the intended movement between the two contact surfaces. There are two types of friction: static - when objects are held in place, and kinetic - when objects slide past one another while in contact. When a ball rolls, we will consider only static friction to be acting, unless the ball is said to be rolling and sliding. μ (mu) is the coefficient of friction. This value can be between zero and about 6 (as far as I know), but the coefficient of static friction is greater than that of kinetic friction between the same surfaces.

Terminal Velocity - When objects fall in the presence of a fluid (think air resistance) the object will only be able to reach a certain max velocity called terminal velocity. As it falls through the fluid, the resistant force increases thereby lowering the net force. Eventually the resistant force equals the pull of gravity and the object no longer accelerates, $a = 0$, and maintains a constant velocity for the remainder of the fall.

Normal force - The term normal is a math term meaning perpendicular. When an object is supported from moving by another object (barring tension) that force is called the support force or normal force and acts perpendicular to the supporting surface.

Apparent weight is another idea that really is talking about the normal force. When asked for apparent weight, find the normal force.

Net force - The sum of all forces acting on an object. Remember, an object cannot act on itself, so we label outside forces only. If the net force is non-zero, then the object must be accelerating. If the net force is zero then the object is not accelerating and may be at rest or moving with constant velocity.

Centripetal force (not centrifugal) - The sum of all forces making an object follow a circular (curved) path. We find the centripetal force by adding all the forces parallel (and anti-parallel) to the radial vector of the circular path described by the object. Centripetal force always points toward the center of the circle being described. If the object is also changing speed while moving in a circle, then the object also has tangential acceleration as well as centripetal acceleration. If an object is not moving linearly, then a centripetal force must be present.