Dynamics

To date, we have talked about the world of kinematics, the study motion. Dynamics is the study of what causes the various types of motion. Bridging these two schools of physics together creates the larger branch of physics called **mechanics**.

Historical View

The ancient Greeks believed that to achieve constant motion, constant force must be applied and therefore, the greater the force, the greater the velocity. Removing the force caused the object to return to a state of rest, a reasonable yet inaccurate theory of motion. The Greeks did not have a concept of friction. Galileo on the other hand had some pretty good insight. He correctly concluded that an object would keep moving in a straight line unless friction or some other force stops it.

Newton

Newton took Galileo's ideas and ran. In 1687 Newton published a book called *Principia Mathematica.* This book summarized Galileo's as well as Newton's ideas of inertia and motion. This book outlined the tenants of his three laws.

1. Every object maintains a state of rest or uniform motion in a straight line unless acted upon by an unbalanced external force

2. An object's rate of acceleration is directly proportional to the unbalanced external force placed on the object and is indirectly proportional to the object's mass.

$$\vec{F}_{net} = m\vec{a}$$

3. Every action has an equal and opposite reaction.

EXERCISE

Using Newton's laws, explain,

1. Why cars skid off the road around curves when conditions are icy.

2. Why shopping carts are harder to turn, push or stop when they are full.

3. How a snowmobile works.

Friction

Friction can be broken into two categories. **Kinetic** and **Static**

Kinetic Friction: Is the resistive force that opposes the motion of all ***moving*** objects. It **always** acts in **counter parallel** (exact opposite direction) to the motion,

Static Friction: Is the resistive force that opposes any applied force that ***attempts to start*** an object in motion. Static friction works up to a **maximum**. Ex: if you calculated the static friction to be 5N but only 4N "push" is applied, then the amount of friction in the system is 4N. 5N simply implies the maximum static frictional force. Static friction attempts to keep the system motionless or $\vec{F}_{net} = \vec{0}N$

Friction always opposes motion. Friction always robs a moving object of it energy of motion (kinetic energy) or always attempts to prevent an object form starting to move.

FACTS ABOUT FRICTION:

- **Static** friction is always greater than **kinetic** friction. $\mu_s > \mu_k$ ←Greek symbol *meu*
- Force of friction **IS INDEPENDENT OF SURFACE AREA!** This implies that the maximum force of friction between two surfaces is **only** dependent on the properties of the two surfaces. The surface area is irrelevant.
- Force of friction is given by the formula

$$F_f = \mu F_N$$

Where F_f is the force of friction in Newtons, F_N is the normal force acting on the object and μ is the coefficient of friction.

Common Coefficients of Friction

Materials	μ_s	μ_k
Steel on steel	0.74	0.57
Aluminum on steel	0.61	0.47
Copper on steel	0.53	0.36
Rubber on concrete (dry)	1.0	0.8
Rubber on concrete (wet)	0.3	0.25
Wood on wood	0.25-0.5	0.2
Glass on glass	0.94	0.4
Teflon on Teflon	0.04	0.04
Teflon on steel	0.04	0.04
Waxed wood on wet snow	0.14	0.1
Waxed wood on dry snow	0.10	0.04
Metal on metal (lubricated)	0.15	0.06
Ice on ice	0.1	0.03
Synovial joints in humans	0.01	0.003
Very rough surfaces		1.5

source: http://www.physics.ucf.edu/~saul/Common/06-Forces/FrictionCoeffs.html

Examples:

1. Find the minimum stopping distance of a car, of mass 1000kg, that is driving at a 108 km/h if
   a) The car has ABS brakes and is on dry concrete
   b) The car has ABS brakes and is on wet concrete
   c) The car in a) does not have abs brakes and the wheels lock
   d) The car in b) does not have abs brakes and the wheels lock