Chapter 4

The Laws of Motion

Force is a push or pull; measured in the unit of Newtons

Newton's 1st Law-inertia; object at rest stays at rest or object in motion stays at constant velocity unless some outside force acts on it and causes acceleration

Newton's 2nd Law-use the formula F=ma

Newton's 3rd Law-every action creates an equal but opposite reaction

SI Units of force are Newtons=mass * acceleration (F=ma)

$N=kg * m/s^2$

(U.S. unit of force is a pound.)

Tension (T) is a special name for a force in a cable or rope which pulls it tight.

Apply Laws of Motion and the conditions of Static Equilibrium

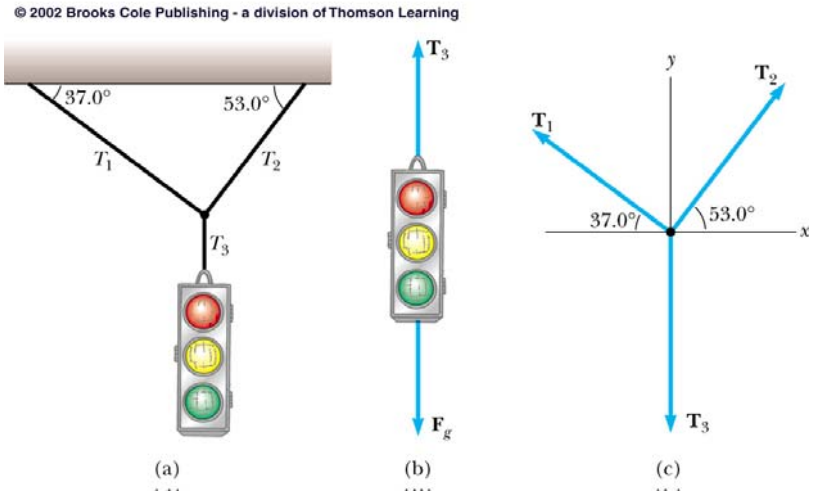
$\sum F=ma=0$ $\sum F_x=0$ and $\sum F_y=0$

First make a Free Body Diagram

- Must identify all the forces acting on the object of interest
- Choose an appropriate coordinate system
- If the free body diagram is incorrect, the solution will likely be incorrect

Conditions of Equilibrium

- An object either at rest or moving with a constant velocity is said to be in *equilibrium*
- The net force acting on the object is zero



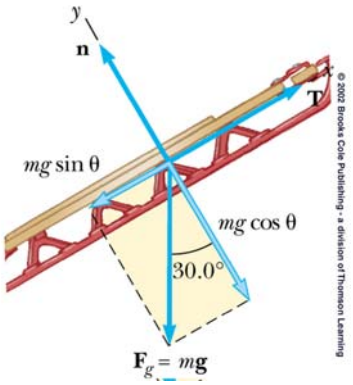
$\sum F_x = -T_1\cos 37 + T_2\cos 53 = ma = 0$ since in static equilibrium

$\sum F_y = T_1 \sin 37 + T_2 \sin 53 - T_3 = 0$

solve 2 equations/2 unknowns to find all tensions.

T_3 is the tension caused by the weight of the stoplight. Weight = mass * acceleration of gravity.

- If object is on an **incline**, rotate the superimposed x-y coordinate system to have the x-axis parallel to the line of motion.
- An object puts its force of weight on the surface that it is resting on, and the surface applies a normal force back, call the "Normal Force" or F_n.
- **This F_n is always perpendicular to the surface whether it is horizontal or inclined.**
- There is no F_n if the object is hanging vertically.
- Force due to gravity, <u>mg or F_g or weight</u>, always points down to the center of the earth.



Use the angle Θ off of the horizontal axis then x-component will use cosine and y-component will use sin function.

So, **<u>x-comp</u> of weight or mg =<u>mgcos60</u>**

and **<u>y-comp</u> of weight=<u>mgsin60</u>**

Moving away from static equilibrium, Newton's 2nd Law, objects can accelerate and move without constant velocity.

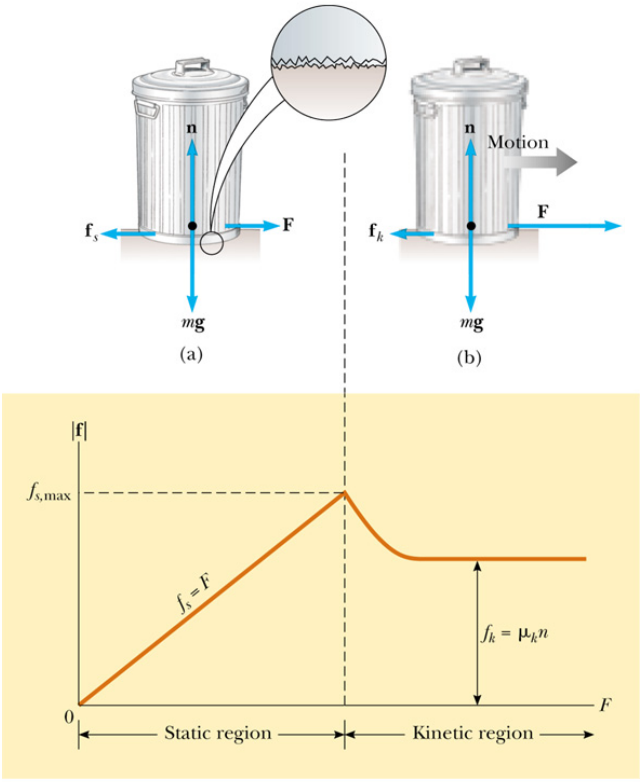
$\sum F \neq 0$, so $\sum F = ma$

Another force is that of friction, $\mathbf{F_f = \mu F_n}$, where μ is a constant called the **coefficient of friction**.

Coefficient of friction is not a force. It is a unit less value; see below.

The μ is a unit less ($\mu = F_f/F_n$; newtons cancel) value that describes the contact between two surfaces. There is actually two types of friction and coefficients of friction, that of static and also kinetic.

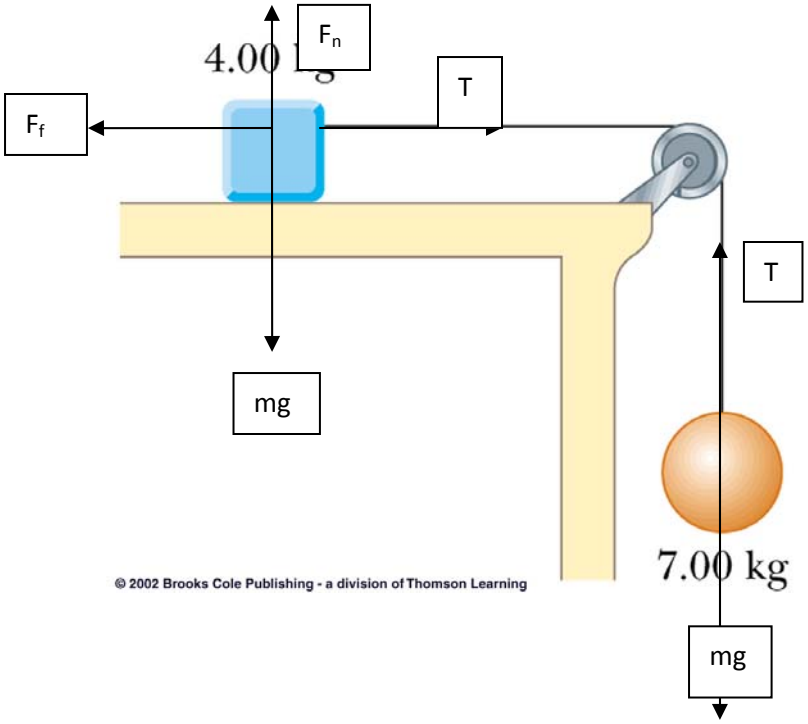
F_f is a force vector which should appear on the FBD, and it points in the direction opposite motion and is parallel to the surface.



Static Friction	Kinetic Friction
$\sum F_x = F - F_s = ma$	$\sum F_x = F - F_k = ma$
$\sum F_y = -mg + F_n = ma = 0$	$\sum F_y = -mg + F_n = ma = 0$

If moving at constant velocity, a=0.

Usually, a=0 in the vertical direction, when talking about object moving horizontally.



$\sum F_x=T-F_f=ma$ $\sum F_x=0$ none

$\sum F_y=F_n-mg=ma$ $\sum F_y=T-mg=ma$

The T for the blue block = the T for the orange ball; because they are tied together.

The acceleration for the blue block and orange ball is also =; again because they are tied together.

a to the right or up; is +

a to the left or down; is -