DYNAMICS REVIEW

Dynamics – the study of why things move

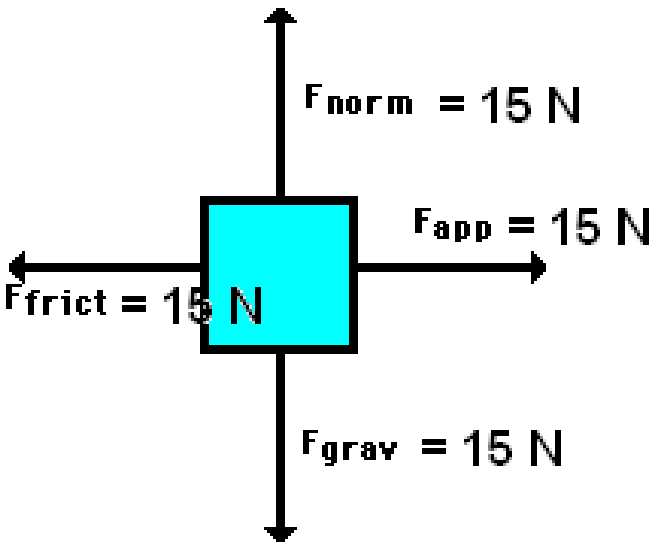
Force

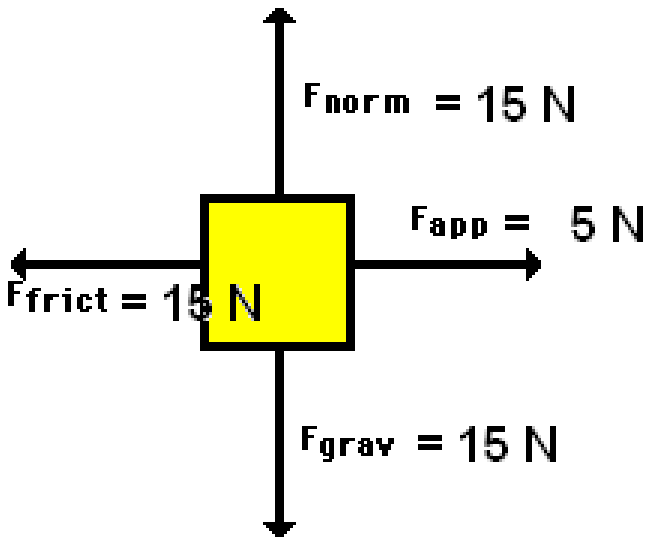
- a push or a pull on an object
- Cause acceleration (changes in velocity)
- Symbol $\vec{F}$, vector
- Measured in Newtons (symbol N)

Free Body Diagrams

- Represents the isolated object and all forces acting on it

Ex. Describe the motion of the objects shown





Balanced Forces

- The forces cancel each other out and the object behaves as though no forces are acting on it
  - Not moving
  - Not accelerating

Unbalanced Forces

- There is a net force acting on the object
  - The object is accelerating in the direction of the net force

Force of Gravity

- Force of attraction between all objects
- Also called the weight

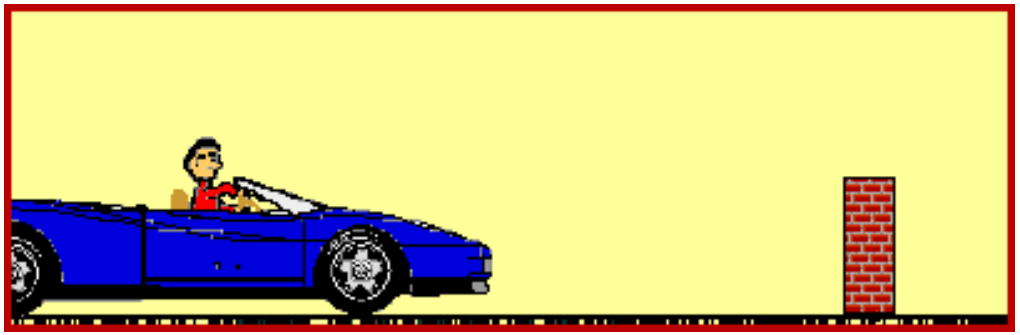
$$\boxed{\overrightarrow{F_g} = m\vec{g}}$$

Normal Force

- Perpendicular force to any two surfaces that are in contact with each other

Newton's First Law

"An object will remain at rest or in uniform motion unless acted upon by an external unbalanced force"




IF LEFT TO ITSELF A BODY WILL MOVE WITH UNIFORM VELOCITY IN ONE AND THE SAME DIRECTION.
GALILEO — I SAID A RIGHT AT THE CORNER, AND THEN A LEFT!

Newton's Second Law

"The acceleration of an object is proportional to the unbalanced force that is acting on it"

$$\overrightarrow{F_{net}} = m\vec{a}$$

Example 1: What is the acceleration of a 5.0 kg bowling ball that experiences a force of 60 N [E] and a force of 50 N [W]?

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

$$=$$

$$\vec{F}_{net} = 60N[E] + 50[W] = 10N[E]$$

$$\vec{a} = \frac{\vec{F}_{net}}{m} = \frac{10N}{5\,kg} = 2\,m/s^2\,[E]$$

Example 2: A 50 kg block of ice experiences an applied horizontal force of 80 N [W] as it accelerates at 1.2 m/s^2 [W] against a force of friction. Determine the magnitude and direction of the frictional force acting on the block.

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

$$\vec{F}_{app} + \vec{F}_f = m\vec{a}$$

$$F_f = m\vec{a} - F_{app} = 50(1.2) - 80\,N[W]$$

$$= 60 - 80[W] = -20\,N[W]$$

$$= 20\,N[E]$$

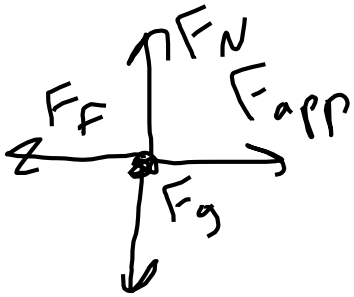
Friction

- Force that resists motion or attempted motion between objects in contact
- Always acts in the direction opposite to the direction of the motion

Static Friction tends to prevent stationary objects from moving

Kinetic Friction acts against objects that are already moving

$$\vec{F}_f = \mu \vec{F}_N$$



Example 3: Determine the coefficient of friction if a 40 kg mass requires 300 N of applied force to keep it moving with no acceleration.

$$\vec{F}_{net} = m\vec{a} = 0$$

$$F_{app} + F_f = 0$$

$$F_{app} = -F_f$$

$$F_{app} = -\mu m g$$

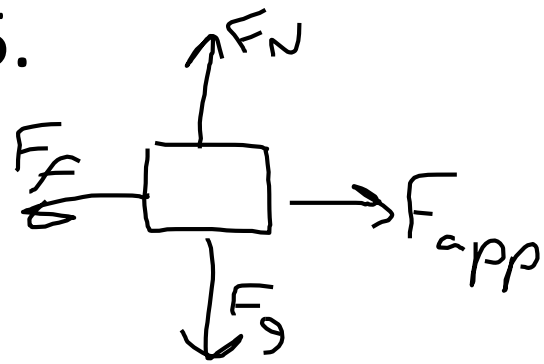
$$\mu = -\frac{F_{app}}{mg} = -\frac{-(-300)}{40 \times 9.8}$$

$$= 0.77$$

Newton's Third Law

"For every action force, there exists a reaction force that is equal in magnitude but opposite in direction."

Example 4: Determine the distance travelled by a 55 kg toboggan and rider, who starts from rest, in 15 s. The toboggan and rider experience an applied force of 155 N, and the coefficient of friction between the toboggan and the snow is 0.15.



$F_{net_y} = 0$

$F_N - F_g = 0$

$F_N = F_g = mg$

$F_f = \mu F_N = \mu m g = 0.15(55)(9.8) = 80.9\,N$

$\vec{F}_{net_x} = \vec{F}_{app} - \vec{F}_f = m\vec{a}$

$\vec{a} = \frac{F_{app} - F_f}{m} = \frac{155 - 80.9}{55} = 1.3\,m/s^2$

$a = 1.3\,m/s^2$ $t = 15\,s$ $V_0 = 0\,m/s$

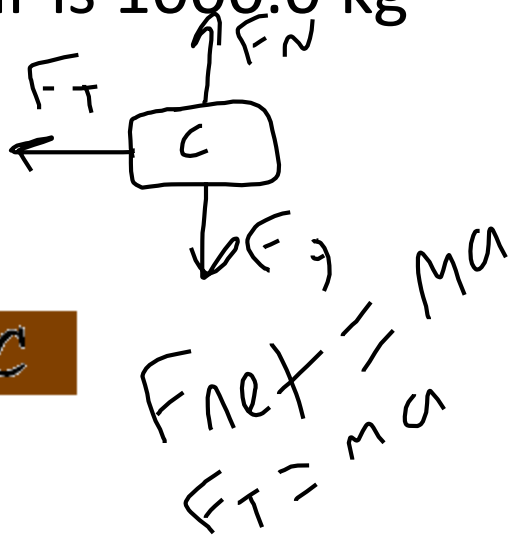
$d = ?$

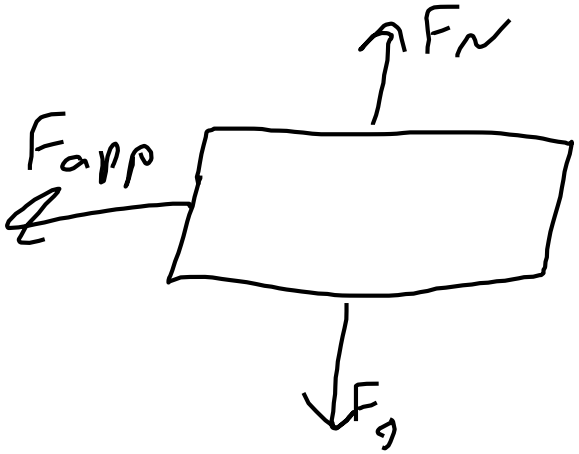
$d = V_0 t + \frac{1}{2} a t^2 = \frac{1}{2}(1.3)(15)^2$

$= 150\,m$

Something New – Tension!

Example 5: A train engine pulls 2 boxcars and a caboose. If the engine applies a constant force of 5000.0 N to pull the boxcars and caboose, determine the acceleration of the system, and the force between the two cars. Assume each car is 1000.0 kg and the caboose is 700.0 kg.





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

$$a = \frac{F_{net}}{m} = \frac{5000\,N}{2700\,kg}$$

$$= 1.852\ m/s^2$$

$$F_T = m_c a = 700.0\,kg \times 1.852 = 1296\,N$$

$$F_{net} = ma$$

$$F_{12} - F_T = ma$$

$$F_{12} = m_{BC} a + F_T$$

$$= 1000(1.852) + 1296$$

$$= 3148\,N$$