

# Forces

**“Push,” “Pull,” or “Lift up”**

# Four Fundamental Forces

- 1. Strong Force – holds the nucleus together
  - $10^{-15}$  m range, strongest force
- 2. Electromagnetic ( $10^{-2}$  strength as strong force), acts at  $1/r^2$
- 3. Weak Force ( $10^{-13}$  strength as strong force), acts at  $10^{-18}$  m, beta decay
- 4. Gravitational Force ( $10^{-38}$  strength as strong force), acts at  $1/r^2$

# Some Types of Forces

- 1. Friction  $F_f = \mu F_n$
- 2. Normal  $F_n = F_g$  perpendicular to surface
- 3. Spring  $F_{sp} = kx$  (Hooke's Law)
- 4. Tension  $F_t$  pull exerted by a string, rope, cable
- 5. Thrust  $F_{thrust}$  Force that moves rockets, plane, cars....same direction as acc
- 6. Weight  $F_g = mg$  depends on g, straight down to the center of the earth

# Sir Isaac Newton

- 1643 – 1727
- Calculus, Laws of Motion, Optics
- Cambridge University
- Principia (1687)
- Alchemist (mercury poisoning)
- Questioned the Trinity
- Never married.....few friends.....loner

# Newton's First Law

- Every body continues in its state of rest or of uniform speed in a straight line unless acted upon by a non net force.
- The tendency of a body to maintain its state of rest or uniform motion in a straight line is called inertia.
- Mass is a measure of the inertia of a body.
- Mass is the same universally. (does not change)

# First Law Examples

- Large rock harder to move than small stone
- Body in straight constant velocity will continue in that same straight constant velocity unless acted upon by a non net force. Ice skater, puck on ice

# Newton's Second Law

- The acceleration of an object is directly proportional to the net force acting on it and is inversely proportional to its mass. The direction of the acceleration is in the direction of the net force acting on the object.
- $a = F/m$
- $F = ma$
- Force is measured in Newtons =  $\text{kg m/s}^2$

# Example of the Second Law

- Nicole is pushing a shopping cart around Stop N Shop. Her cart has mass 100 kg and it is accelerating at  $3 \text{ m/s}^2$ .
- Force =  $m \times a = 100 \times 3 = 300$  Newtons



# Newton's Third Law

- Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.
- To every action there is an equal and opposite reaction.

# Examples of Newton's Third Law

- It hurts when I kick a desk because the desk kicks back.
- Walking is pushing back against the floor and the floor pushing forward.
- The earth exerts gravitational force on the moon and the moon exerts an equal but opposite gravitational force on the earth.

# Group Activity

- Weight is a Force  $F_g = mg$
- 1. What is my weight on earth if my mass is 80 kg?
- 2. What is my wife's weight if her mass is 50 kg ?
- 3. What is my weight on the moon if  $g = 1.7 \text{ m/s}^2$ ? On Mars if  $g = 3.7 \text{ m/s}^2$ ? Drifting in space at constant velocity?