FORCES IN NATURE

"Therefore whoever resists the authority resists the ordinance of God, and those who resist will bring judgment on themselves." Romans 13:12

Gravity

- Gravity: pulling force toward the center of the earth
- Weight: gravitational force exerted by earth on an object

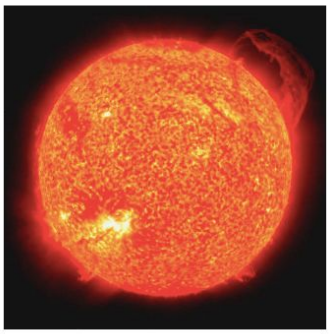
● Newton's law of universal gravitation: any two objects attract each other through gravitational force

$$\text{Force} = \frac{G \times \text{mass of object 1} \times \text{mass of object 2}}{\text{distance}^2} \quad \text{or} \quad F = \frac{G \times m1 \times m2}{d^2}$$

Where G = gravitational constant = 6.673×10^{-11} Nm^2/kg^2

● Gravitational force proportional to masses of two bodies; exerted equally on both bodies

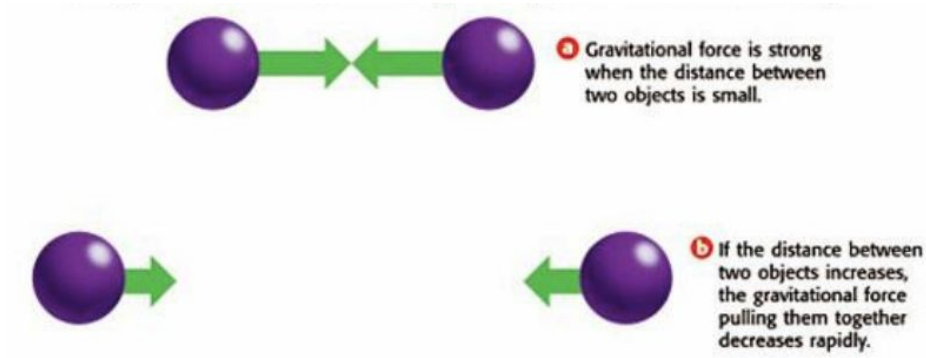
- The sun (1.98892 x 1030 kg) is the most massive object in our solar system and exerts a huge gravitational force.
- This is why all the planets stay in orbit around the sun.



[CORRECTION: The mass of the sun = 1.9882×10^{30} kg]

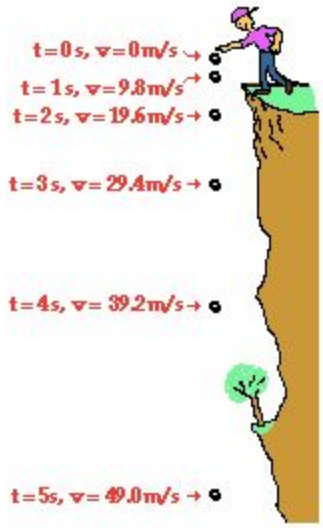
Ex: noticeable force exists between earth and pen, but not noticeable between pens

→ Gravitational force is greater when objects are closer together and less when they are farther apart



- Free-fall: fall with no effects from forces other than gravity

→ Galileo determined that free-falling objects accelerate at a constant rate of 9.81 m/s² → a falling object will add 9.81 m/s to its speed every second it falls



● Acceleration of gravity = 9.81 m/s²

Considered constant everywhere on Earth

● Free-fall distance is related to the acceleration of gravity and the time spent falling:

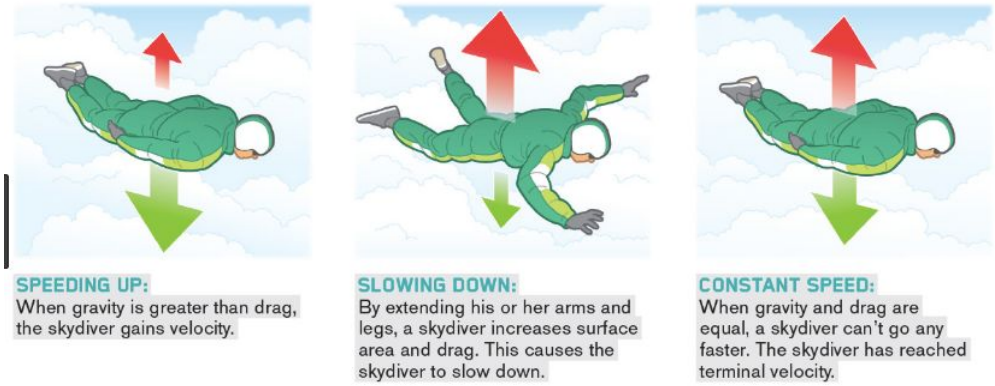
Free-fall distance = 1/2 x acceleration of gravity x time² or $d = 1/2gt^2$

Ex: How far does an object travel if it free falls for 2.00s?

$d = 1/2 \times 9.81 m/s^2 \times (2.00s)^2 = 19.6$ m

● Acceleration of gravity is the same for all objects on Earth, regardless of size, weight, or density

● Other forces such as drag (air resistance) may slow an object's fall; drag exerts an upward force on a falling object, slowing its fall



- Terminal velocity: velocity at which the object will stop speeding up because the force of drag equals the object's weight
- Weight = mass x acceleration of gravity or F(weight) = m x g

Ex: What is the weight of a 2000.kg piano? → F(weight) = 2000.kg x 9.81m/s² = 19,600N (remember that force is always in Newtons!)

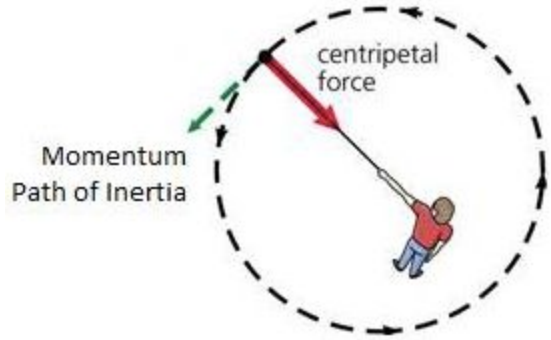
Circular motion

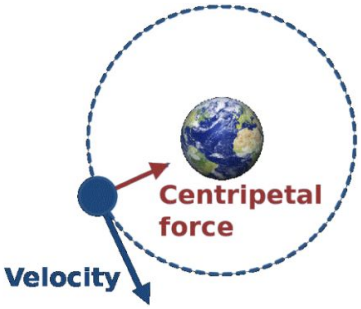
- Swinging a weight attached to a string causes the direction of motion to change constantly

→ according to Newton's first law, there must be an outside force acting upon the weight to change its direction

- Centripetal force: force that causes the object to travel in a curved path rather than in a straight line

→ Object's inertia would cause the object to travel in a straight line once the outside force is absent

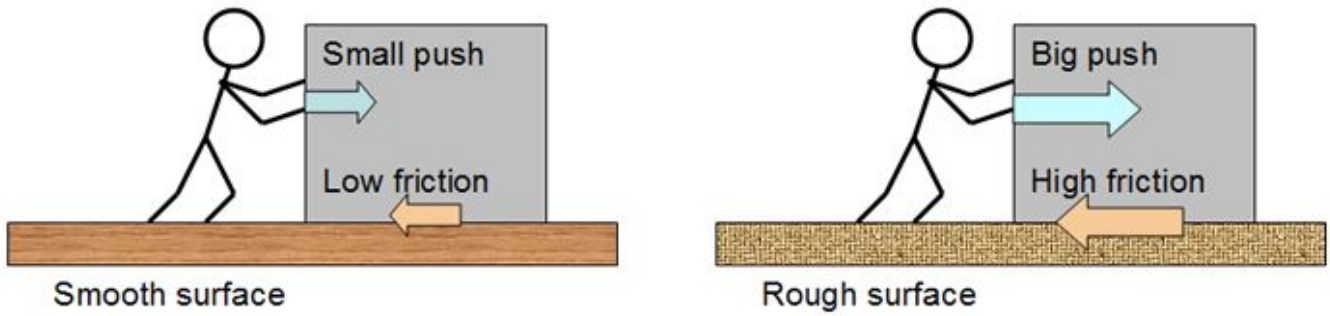




- Planets' orbits, moon revolving around earth due to gravity

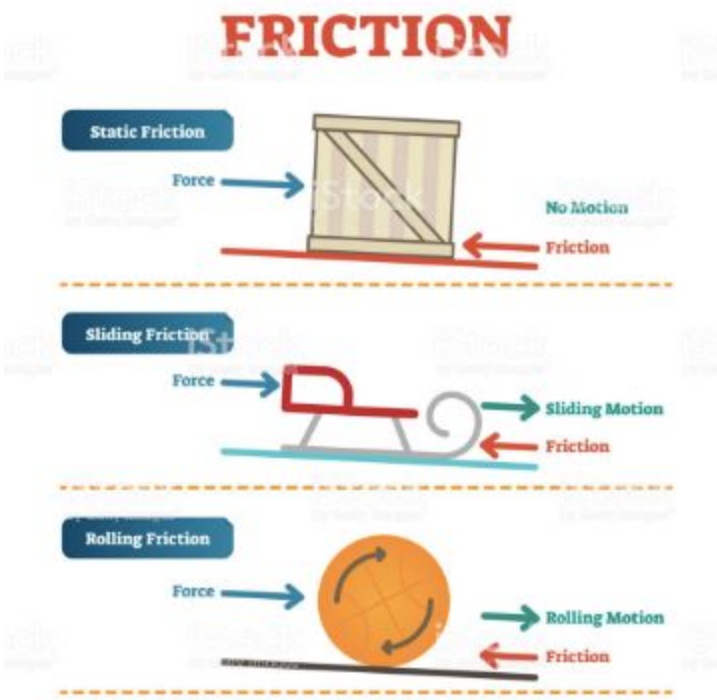
Friction

- Friction: force acting in resistance to an object's motion through a fluid or across a surface



● Kinetic friction: affects sliding objects already in motion; remains constant and acts to slow objects down

Static friction: affects stationary objects, preventing them from moving at all



● Friction depends only on the weight of the object and the nature of the surfaces that are in contact

Each object has its own coefficient of kinetic friction (μ):

Kinetic friction force = coefficient of kinetic friction x weight of object or

F(kinetic friction)= (μ) x F(weight)

● Force of friction acts in the opposite direction of motion

Ex: What is the frictional force on a 22N wooden chair if it is pushed across a hardwood floor whose coefficient of friction is 0.40?

→ F(kinetic friction) = 0.40 x 22N = 8.8N