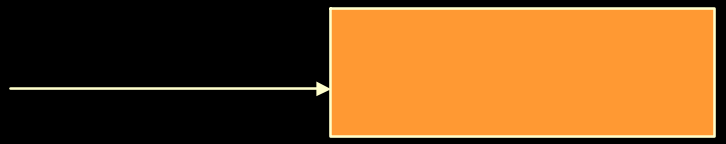
Physics 2001, Professor Merry

Chapter 2

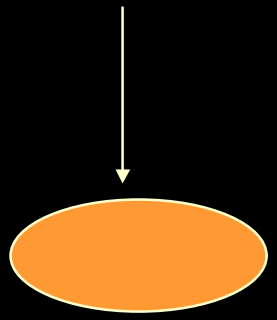
Newton's Laws

Force (F)

- A push or pull acting on a body.
- Usually causes some distortion of the body, a change in its velocity, or both



Force to the right



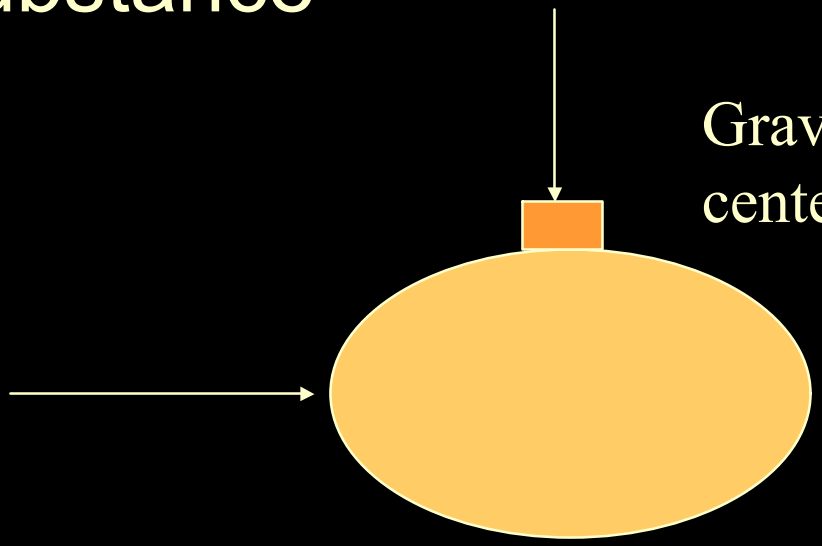
Force Down

Units of Force:

- Newton (SI) force required to accelerate 1kg by 1m/s^2
- Dyne " 1 g by 1cm/s^2
- Pound (British)

Weight (W)

- The force of gravity acting on a substance



Gravity acts down, toward the center of the earth.

Newton's first law of motion

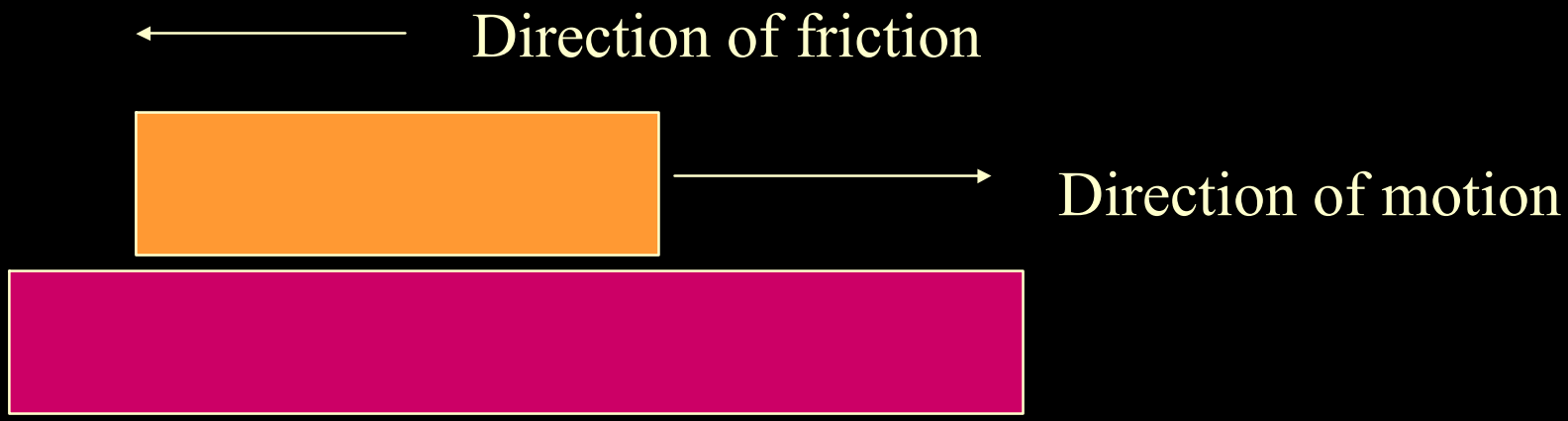
- An object will remain at rest or in motion with constant velocity unless acted on by a net external force.
- Often called the law of inertia (resistance to change in motion)

Moving, stays moving

At rest, stays at rest.

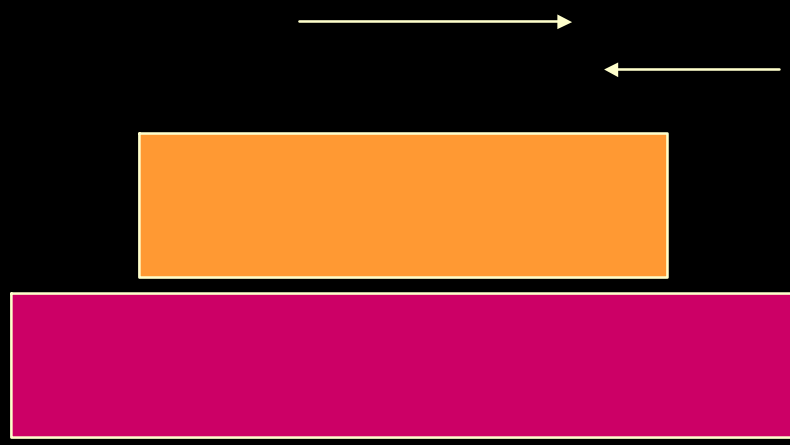
Friction

- A force of resistance to relative motion between two bodies or substances.
- Very important in motion.



Static Friction

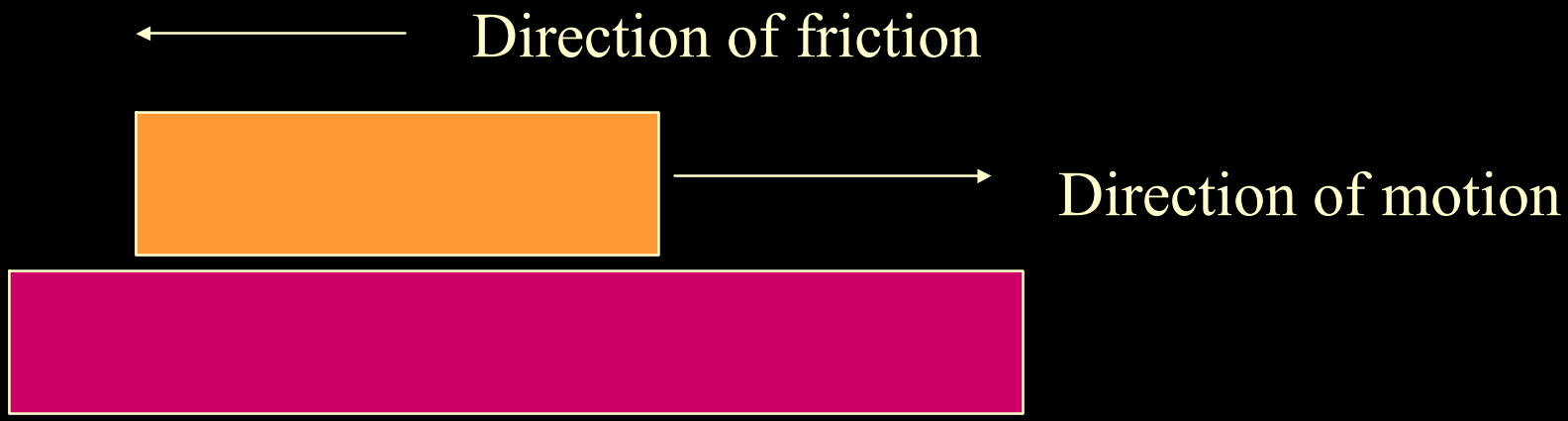
- Force of resistance between the surfaces of two bodies which are not moving relative to each other.



If we try to move to the right, static friction pushes left, against us.

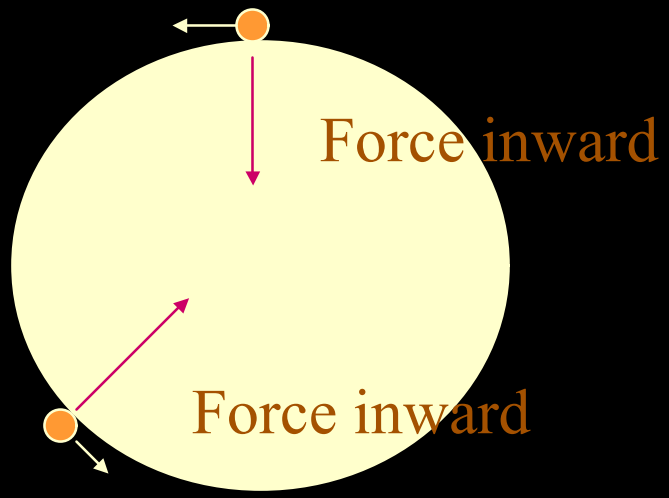
Kinetic

- **Kinetic friction** Friction between two substances that are in contact and moving relative to each other.



Centripetal Force

- Name applied to the force acting to keep an object moving along a circular path. It is directed toward the center of the circle.



Mass

- (From Chapter 1): measure of an objects inertia, or resistance to change in motion (acceleration),
- measured in Kg (SI Units)
- or Slugs (British Units)

Mass vs. Weight

- Mass is constant, but weight changes with location
- A 10 kg object has a weight of 10 x 9.8 or 98 Newtons on earth.
- On the moon the 10 kg mass will have a weight of about $1/6^{th}$ that or 12 newtons.

Determining Mass from Weight

- On earth we multiply the mass by the acceleration of gravity here to determine the weight.
- The acceleration of gravity in SI units is 9.8 m/s^2
- m= 5kg, what is w? w= m x g
- w= 5kg x 9.8 m/s^2 or 49 Newtons
- (1 newton = 1 kg $m/s^{2)}$

Newton's second law of motion

- An object is accelerated whenever a net external force acts on it. The net force equals the object's mass times its acceleration.
- F=ma *Note this is a vector relation. Acceleration and force are vectors. Thus acceleration is in the same direction as force.*

F=ma Problem

- A force of 20 N is applied to a mass of 4kg
- What is the acceleration?
- F = ma
- 20 N (kg $m/s^{2)}$= 4kg x a (divide both sides by 4)
- (20/4) (kg $m/s^{2)}$/kg = a =
- a = 5 m/s^2

Centripetal Force

- F=ma
- Centripetal Acceleration $a = v^2/R$
- Thus centripetal $F = mv^2/R$

Centripetal Force Problem

- A 500 kg car is going round a curve of 50 m at 20 m/s. What is the centripetal force?
- m=500 kg, R=50m, v=20m/s F = ?
- $F = mv^2/R = 500 \times (20)^2/50$ (kg x$(m/s)^2$ /m)
- F = 500 x 400 /50 = 4000 N

SI Units

- The International System of Units or SI Units (see table 2.1 page 60)
- An internally consistent system of units within the metric system.
- some (SI) units:distance: m; Area:m^2 ; velocity: m/s; time: s; Force: Newton; acceleration:m/s^2; mass: kg

Free Fall:

- acceleration vs. Motion of Objects Thrown straight up vs. Projectile Motion

Projectile Motion

- motion of objects shot upwards at an angle between the vertical and horizontal. Vertical and Horizontal Components are independent.
- Cannon Ball vs straight up throw.
- Vertical component obeys $v = v_o + at$.
- Horizontal component has constant velocity.

Simple Harmonic Motion

- Vibratory motion with a constant frequency.
- Due to restoring force which increases with displacement
- Example (spring, F= kx, etc.)

Falling Body with Air Resistance

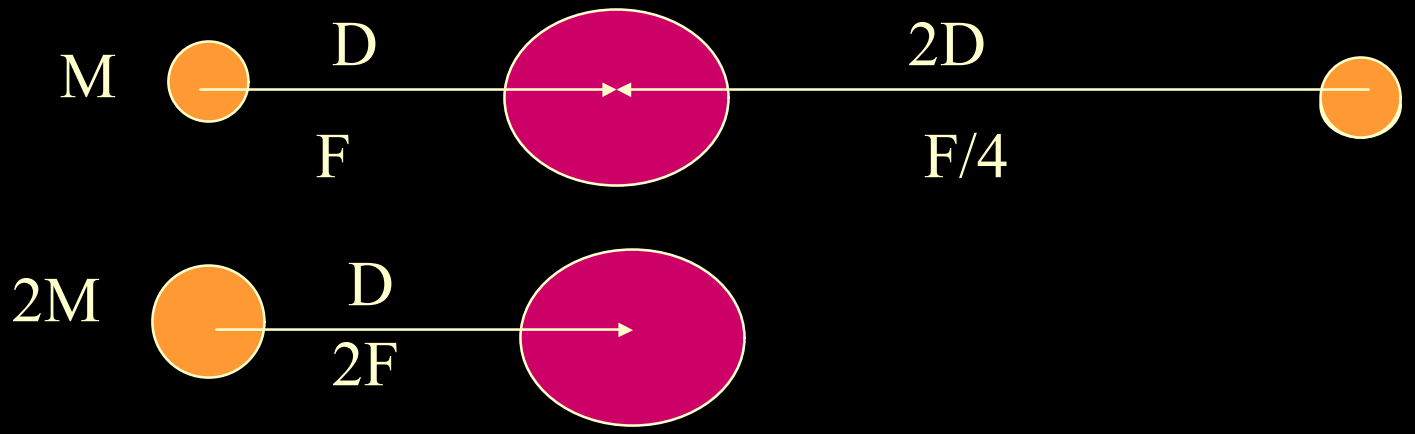
- Air resistance increases depending on an objects surface area and shape, and with velocity.
- As a result falling objects can reach a fixed, or terminal velocity
- Sky divers, rain, and other falling objects falling a large distance experience this.

Newton's third law of motion

- Forces always come in pairs
- when one object exerts a force on a second object, the second exerts an equal and opposite force on the first.
- A boy pushes on the wall with 40 N.
- What happens?
- Wall pushes back at 40 N!

Newton's law of universal gravitation

- Every object exerts a gravitational pull on every other object.
- The force is proportional to the masses of both objects and inversely proportional to the square of the distance between them.



$F=k \times m_1 \times m_2/d^2$

- $F=k \times m_1 \times m_2/d^2$
- $K= G =6.67 \times 10^{-11}$ N-m^2/kg^2
- This constant G is called the gravitational constant, G. It is the same value as far as we know for all masses in the universe.

Ratios in Gravity

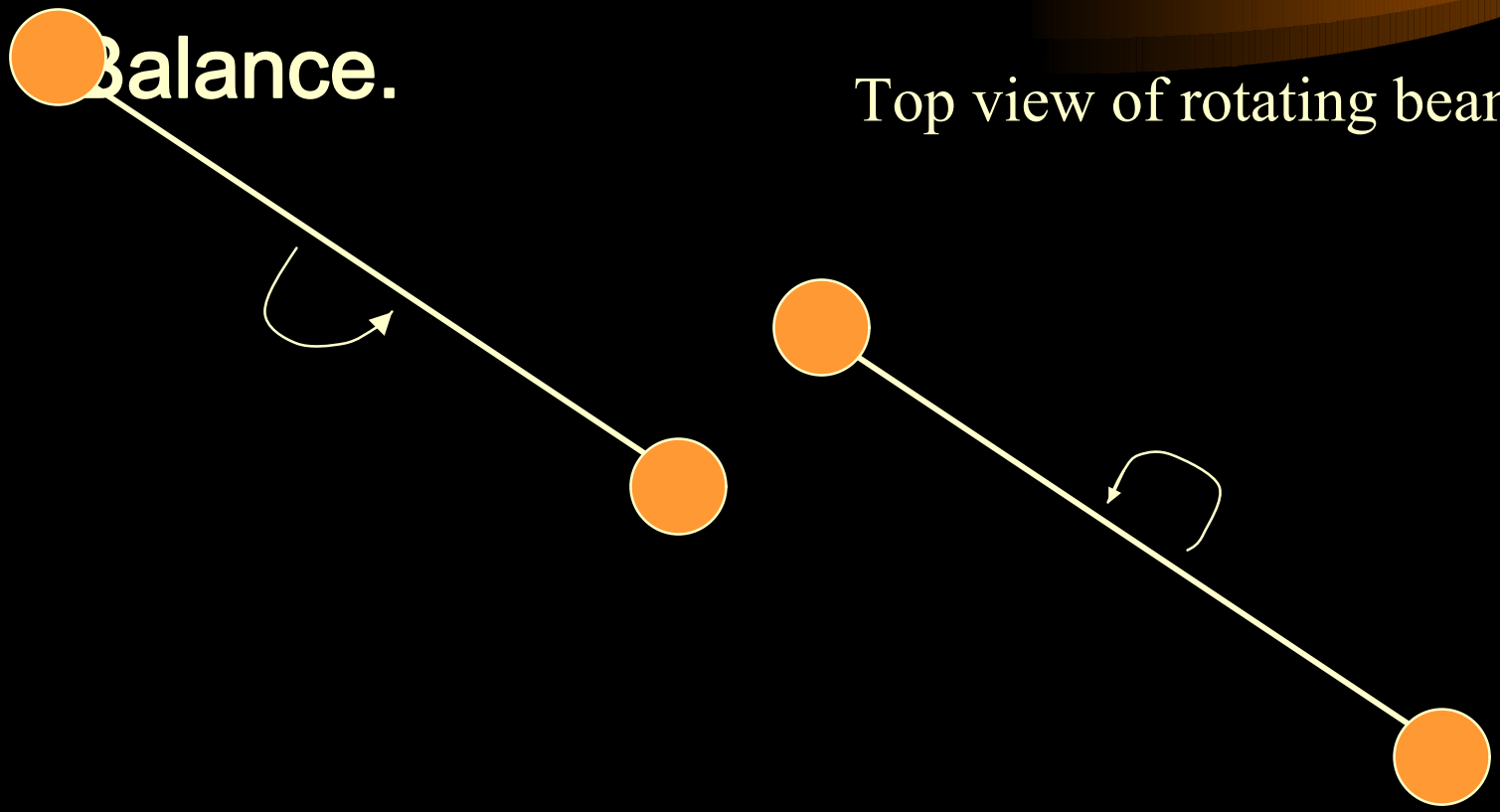
- $F_1 = G\, m_1 m_2/(D_1)^2 \quad F_2 = G\, m_1 m_2/(D_2)^2$
- When we divide F_1 by F_2 we get
- $F_1 / F_2 = G\, m_1 m_2/(D_1)^2 / G\, m_1 m_2/(D_2)^2$
- G, $m_1 m_2$ all cancel and we get $1/(D_1)^{2/}$ $1/(D_2)^{2/}$
- $F_1 / F_2 = (D_2)^{2/}(D_1)^2$
- $(F_1 / F_2)^{1/2} = (D_2)^{/}(D_1)$
- Sq.rt of the ratio of forces or weights = inverse of ratio of distances.

Gravity Ratio Problem

- **A satellite weighs 40 pounds at a distance of 10,000 miles from the earth's center**
- **If the distance were doubled what would it's weight be?**
- **We know $D_2 = 2 \times D_1$ From our formula**
- **$F_1/F_2 = (D_2)^2/(D_1)^2$ $D_2 = 2D_1$ $(D_2)^2 = 4 (D_1)^2$**
- **$(D_2)^2/(D_1)^2 = 4 = F_1/F_2 = 40/F_2$**
- **$F_2 = 40/4 = 10$**

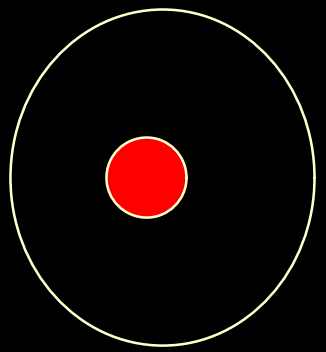
Cavendish Balance

- The Law of Universal Gravitation was first measured with the **Cavendish Balance.**



Orbit

- The path of a body as it moves under the influence of gravity of second body. An example is the path of a planet or a comet as it moves around the Sun.

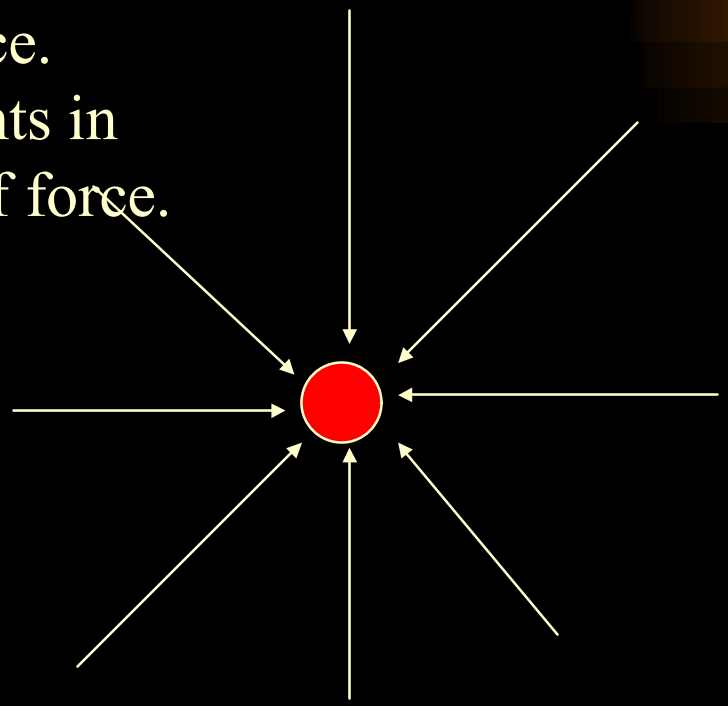


Force Fields

- Certain Forces exist independent of the presence of an object
- E.G. the moon is always moving about the earth, but it always is attracted to it, regardless of its location.
- A Force field is the force which would be experienced from gravity or some other force if there were a particle there.
- Force Fields:
  - Gravity or any other type of action at a distance type force.

Force Field Graphic

Closer lines mean greater force.
Arrow points in direction of force.

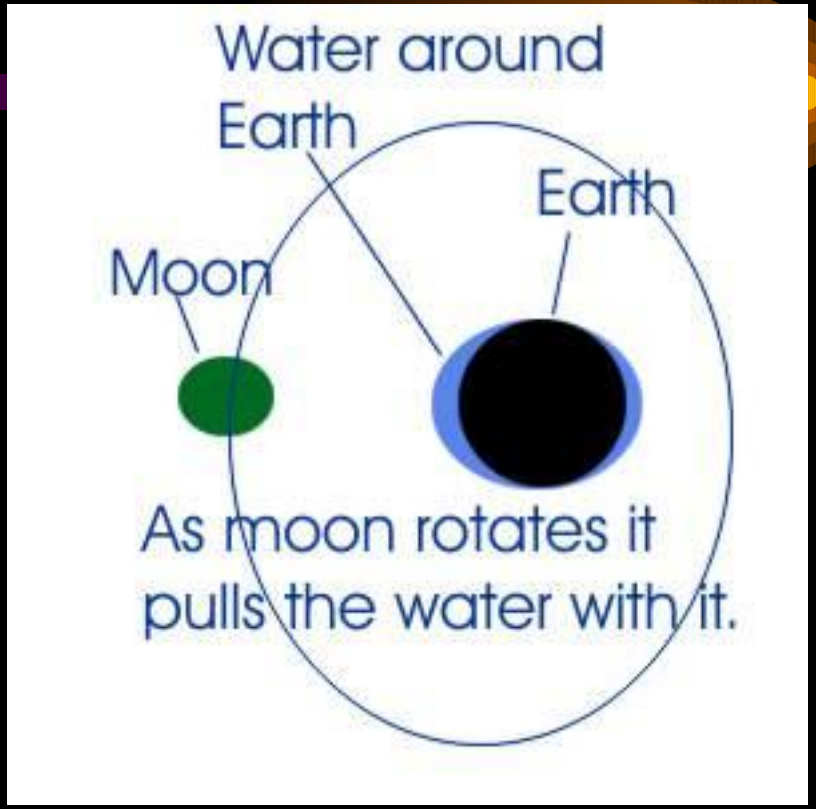


Four Basic Types of Forces

- nuclear strong
- nuclear weak
- gravitational
- electromagnetic.

Tides

- The periodic rises and falls in the level of the water in the ocean.
- Caused primarily by the variation of the force of gravity on the surface of the earth as the surface spins away and toward the moon.



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