Forces

Weight and Normal Force

Fnet = F1 + F2 + F3 + …

- The sum of all forces on an object is the Fnet.
- According to the Second Law, Fnet = ma.

If an object is at rest or moving at constant velocity, it is NOT ACCELERATING. No Net Force. Net Force Equals Zero.

Net Force at zero means all the forces are BALANCED or "IN EQUILIBRIUM."

Free Body Diagram

- Draw the object as a dot.
- Draw all the Forces acting on the body as arrows with appropriate direction.
- The sum of all the Forces acting on the body is the net Force, Fnet.
- If the Fnet is not zero, the object is accelerating in the direction of the Fnet.

Weight

- Fg = mg   (mass in kg; g depends on where you are located; F in Newtons, downward)

- g = 9.8 m/s^2 on earth
- g = 1.7 m/s^2 on moon
- g = 3.7 m/s^2 on Mars
- At constant velocity drifting in space, g = 0

Normal Force

- If an object has weight but is at rest on a horizontal surface, there must be an opposing force to balance out the weight.

- The normal force, Fn, is perpendicular to the object and to the surface counterbalances the weight of the object. (In mathematics "normal" means perpendicular)

- Fnet = Fn + Fg = 0 (at rest)

Example

My mass is 80 kg.

Fg = mg = 80 x 9.8 = 784 Newtons downward.

But I am not moving......The floor exerts a normal force that opposing weight, Fn = 784 Newtons upward.

Situation

- A 5.0 kg object is pullsed across a floor with an applied force of 20 Newtons. The accelerationof the object is measured to be 3.0 m/s^2. But F does not equal ma ?!?!?!
- Fnet = 5 x 3 = 15 Newtons, not Fapply = 20 Nt
- Where has the other 5 Newtons gone?
- Ff = 5 Newtons

Friction

- Always opposite the direction of the motion.
- Ff = u Fn

- Dependent on the nature of the materials, u, and the Fn
- Independent of surface area

Static Friction versus Kinetic Friction

- Kinetic Friction is the friction while an object is moving: $F_f = u(kinetic) \times F_n$

- Static Friction is the friction while the object is at rest: $F_f = u(static) \times F_n$

- Static Friction is always greater than Kinetic Friction: $u(static) > u(kinetic)$

Example

- A force of 50 Newtons is used to drag a 10 kg object across a horizontal table. If a frictional force of 15 Newtons is present on the object, calculate the unbalanced force on the object and the acceleration of the object.

Solution to Example

- Fapply = 50 Nt
- Fnet = Fapply – Ff = 50 Nt – 15 Nt = 35 Nt
- (N.B. Fnet is the "extra" force)
- Fnet = 35 Nt = m a = (10 kg) a
- a = 35/10 = 3.5 m/s^2

Example

- A student drags an object across a lab table at constant velocity using an applied force of 12 Nt. Calculate the kinetic frictional force present on the object.

- The object is moving with constant velocity so acceleration = 0 so Fnet = 0

- Fnet = 0 = Fapply – Ff = 12 Nt – Ff.   Ff = 12 Nt

Group Activity

- 1. In order to keep an object weighing 20 Nt moving at constant speed along a horizontal surface, a force of 10 Nt is required. The force of friction between the surface and the object is how much?

- 2.   A horizontal force of 15 Nt pulls a 5 kg block along a horizontal surface. If the force produces an acceleration of 2 m/s2, what is the frictional force acting on the block?

Group Activity

- 3.   A force of 40 Nt applied horizontally is required to push a 20 kg box at constant velocity across the floor. What is the coefficient of friction between the box and the floor?

- 4.   A 100 Nt box is moving on a horizontal surface. A force of 10 Nt applied parallel to the surface is required to keep the box moving at constant velocity. What is the coefficient of kinetic friction?