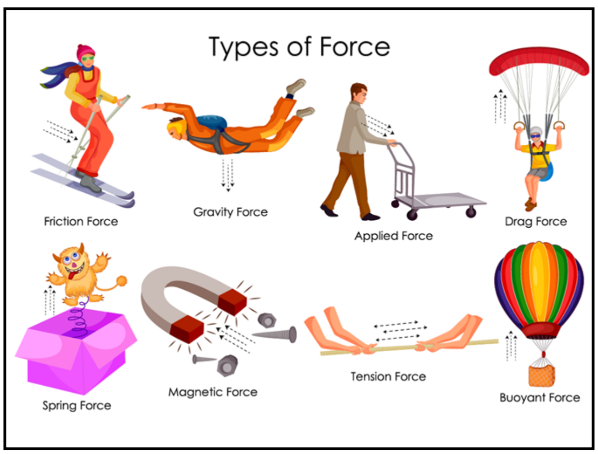
Dynamics

(Motion with Forces)

Forces

- Intuitively, we experience force as a push or a pull on an object. (Pushing a shopping cart or a stalled car, pulling a wagon)
- Applying a force on an object does not always cause motion.
  - pushing the school probably won't move it
- Forces are vector quantities, measured in Newtons (N)



Fundamental Forces of Nature

- Strong Nuclear Force
  - Holds nucleus of atom together
- Weak Nuclear Force
  - Between subatomic particles
- Gravitational Force
  - Between all objects
- Electromagnetic Force
  - Between charged particles

Newton's 1st Law

- Every body continues in its state of rest or of uniform speed in a straight line unless acted on by a nonzero net force.
- This is also known as the law of inertia.

Newton's 2nd 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.

$$F = ma$$

Newton's 3rd Law

- Whenever one object exerts a force on a second object, the second exerts an equal and opposite force on the first.

OR

- Forces always come in pairs

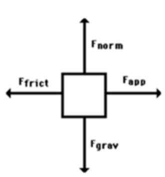
Translational Equilibrium

- An object is said to be in translational equilibrium when the vector sum of all forces acting on the object is zero.

$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum F_z = 0$$

Free Body Diagrams

- A free body diagram is used to represent the forces acting on an object.



- The forces should be drawn proportionally.

Weight

- Weight is defined as the force of gravity acting on an object.

$$W = mg$$

Normal Force

- A force normal (perpendicular) to the surface that an object is sitting on.
- This force is due to Newton's 3rd Law.

Frictional Force

- Force opposing the motion of an object on a surface.

Friction

- Friction exists between two solid surfaces because even the smoothest looking surface is quite rough on a microscopic and atomic scale.
- As we try to slide an object across another surface the atoms of each surface rub against each other impeding the motion and generating heat.

https://phet.colorado.edu/sims/html/friction/latest/friction_en.html

Kinetic Friction

- This sliding friction is called **kinetic friction**.
- For given surfaces, experiments show that the frictional force is approximately proportional to the normal force.
- The frictional force seems to have nothing to do with the amount of surface area in contact.

Kinetic Friction

$$F_{fk} = \mu_k F_N$$

- Where μ_k is the coefficient of kinetic friction.
- μ_k depends only on the nature of the two surfaces involved.

Static Friction

- Another type of friction is called **static friction**.
- Static friction refers to a force parallel to the two surfaces that can arise even when they are not sliding.

Static Friction

- Suppose an object such as a desk is resting on a horizontal floor.
  - If no horizontal force is exerted on the desk, there also is no friction force.
  - If you exert a force on the desk and it doesn't move, then the friction force is equal to the force that you are applying.
  - If you push with enough force, then the desk will start to move and kinetic friction takes over

Static Friction

- At this point, you have exceeded the maximum force of static friction, which is given by:

$$F_{fs} = \mu_s F_N$$

- Where μ_s is the coefficient of static friction.

One last note about friction

- You may have noticed that it is often easier to keep a heavy object moving than it is to start it moving in the first place.
- This is consistent with the fact that μ_s is generally greater than μ_k.