Section 2.3: Free Body Diagrams

Objects are acted upon by a number of forces simultaneously. If we want to analyze these cases, we have to find the **net, resultant or unbalanced force (symbol F_{net}). The Net, Resultant or Unbalanced Force** is found when the vector sum of all the forces acting on the object is found. The Net force is a single force that has the same effect as several forces acting simultaneously. The forces that act on an object may be in the same direction, directly opposing, perpendicular to each other or acting at an angle to each other. Because forces are vectors, net forces may be found algebraically or by vector diagrams.

$$\mathbf{F_{net} = F_1 + F_2 + F_3 +} \qquad \textbf{Or} \qquad F_{Net} = \Sigma F$$

- **If the net force acting on the object is zero then the object is at rest or moving at a constant speed.**
- **If the net force acting on the object is not zero then the object must be accelerating.**

To find the net force acting on an object:

- draw a **free body force diagram** (FBD) that shows all the forces that are acting on the body.
- find the net force by adding all the forces acting on the object.
  - If an object has forces acting in the x and y direction then it may be necessary to write a F_{net} statement for both the x and y direction.

To draw a free body force diagram:

1. Draw a diagram of the object isolated from it surroundings. This can be simplified by drawing a box to represent the object.

2. Locate, with a point, the approximate center of mass of the object.

3. From the point, draw a force vector to represent each force acting on the object.

4. **Do not include forces that the object exerts on the other objects.**

Common Forces that may be included on a Free Body Force Diagram (FBD)

1. F_A - Applied force (This is usually a push or pull)

2. F_f - Frictional force
   - If an object is on a horizontal surface, there is usually a frictional force acting on the object. If an object is falling, there is also a frictional force acting on the object often referred to as air resistance.
   - The frictional force always opposes the motion of the object.

3. F_N - If an object is on a surface or leaning against a surface then a normal force acts on the object. The normal force is a force that is perpendicular to the surface on which the object is resting. It is the force that acts to push the surfaces together.

4. F_g - Force of gravity. This force acts on all objects.

5. F_T or T - Force of tension. If a rope/cable/string/guy wire is attached to an object then a tension exists in the rope/cable/string/guy wire.

Example: Draw a free body force diagram to show the forces acting on a sailboat.

Pull

Pull

Pull

Pull

Two forces have been omitted on the sailboat. One is the atmospheric pressure pushing down on the boat. This force is rarely drawn in free body diagrams. The other is the air resistance as the boat moves forward. Since the boat is moving with the wind, the air resistance is small compared to the water resistance. Therefore, it was left out.

Examples

1. Draw free body diagrams for each of the following objects. Then write a F_{NET} statement for the x and y direction. Finally, state whether the object has a positive, negative or zero acceleration.

   i) a book on a table

   ii) a book being pushed along the table surface at a constant speed

   iii) a book is accelerated across a desk

iv) A hockey puck moving across ice.

v) A fridge magnet

vi) A person on a "round up ride"

vii) A box at rest on an incline

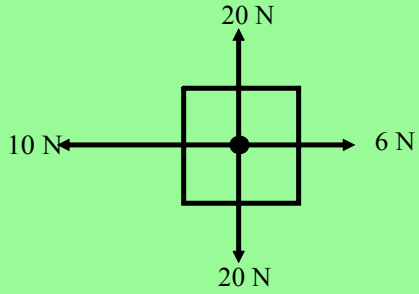
viii) A box on a frictionless incline

ix) A box moving up an incline

x) A falling object (Neglect air resistance)

xi) A falling object (Air resistance is not negligible).

2. Find the unbalance force of the object below.



2. Two sled dogs are attached to a sled. One pulls to the west with a force of 60 N and the other pulls to the south with a force of 100 N. If these are the only two forces acting on the sled, what is the unbalanced force on the sled?