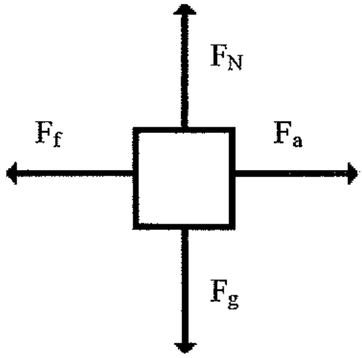


Free body diagrams (otherwise known as FBD's) are simplified representations of an object (the **body**) in a problem. This body is **free** because the diagram will show it without its surroundings; i.e. the body is 'free' of its environment. This eliminates unnecessary information which might be given in a problem.

FBDs are special examples of vector diagrams. They are used to show the relative magnitude and direction of all forces acting upon an object in a given situation.

The *length of the arrow* in a free-body diagram reflects the **magnitude of the force.** The *direction of the arrow* shows the **direction** in which a force is acting. Each arrow in the diagram is labeled to indicate the type of force acting on the object. It is generally customary in a free-body diagram to represent the object by a box (or dot) and to draw the arrows from the center of the box/dot outward in the direction that the force is acting. These diagrams will be used throughout our study of physics.

TYPES OF FORCES

Gravity, F_g

The first force we will investigate is that due to gravity. It is called the **gravitational force** (or the object's **weight**). We know that the magnitude of the acceleration due to gravity (if on Earth) is approximately $\mathbf{g} = 9.8\ m/s^2$. We can calculate *magnitude* of this force using the equation:

$$\mathbf{F_g = mg}$$

where $\mathbf{F_g}$ is the force of gravity (measured in Newtons, N)
and **m** is the mass of the object (measured in kg).

Example

If Oscar and his trash can have a mass of 52.8 kg, determine the magnitude of their weight.

Normal, F_N

The **normal force** prevents objects from 'falling' into whatever it is they are sitting upon. It is always *perpendicular* to the surface with which an object is in contact. For example, if Oscar's garbage can is on the floor, then we say that the can experiences a normal force *by* the floor; and because of this force, the can does not fall into the floor. The normal force on the can points upward, perpendicular to the floor.

Friction, F_f

Related to the normal force is the **frictional force**. The two are related because they are both due to the surface in contact with the body. Whereas the normal force was perpendicular to the surface, the frictional force is parallel. Furthermore, friction opposes motion, and so it always points in the direction opposite that of the object's direction of motion. If Oscar's can is being pushed to the right, then the force of friction acts to the left; if Oscar's can is being pushed south, then the force of friction acts north.

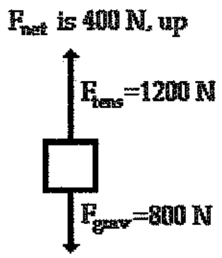
Push and Pull, F_a

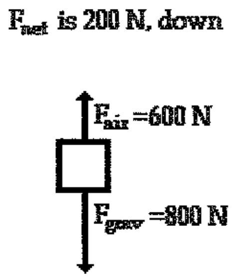
Another force which may act on an object could be any physical push or pull. This could be caused by a person pushing a crate on the floor, a child pulling on a wagon, or Snffle-upagus pushing Oscar's can along the street. This force is often referred to as the *applied force.*

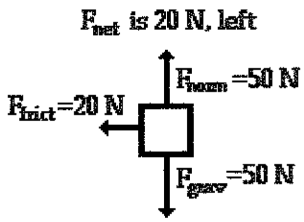
Tension, F_T

Tension is the force which is transmitted through a string, rope, cable or wire. The tension force is directed along the length of the string, rope, etc.

The vector sum of all the forces which act upon an object is called the net force.

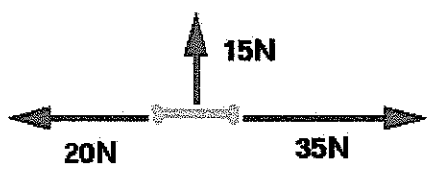






Review of Vector Addition

Three dogs are fighting over a bone. One is pulling to the left with a force of 20 N, another to the right with a force of 35 N and the third upward with a force of 15 N. What is the net force on the bone?



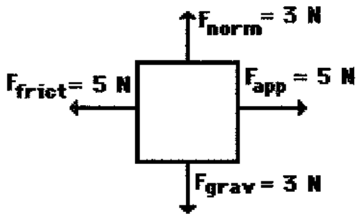
Worksheet Free-Body Diagrams

Practice Problems

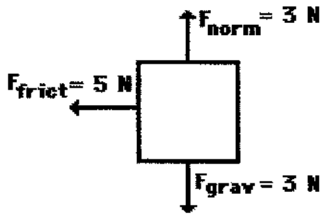
Answer the following questions on your own paper.

1. Free-body diagrams for four situations are shown below. For each situation, determine the net force acting upon the object.

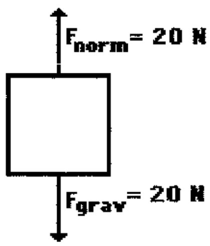
Situation A



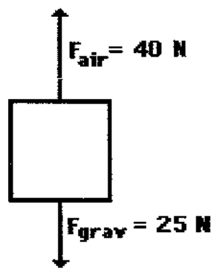
Situation B



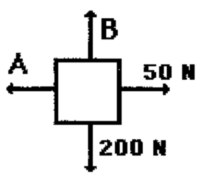
Situation C



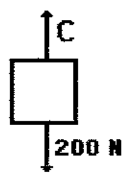
Situation D



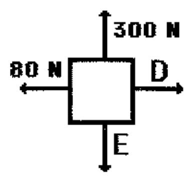
2. FBDs for four situations are shown below. The net force is known for each situation. However, the magnitudes of a few of the individual forces are not known. Analyze each situation and determine the magnitude of the unknown forces.



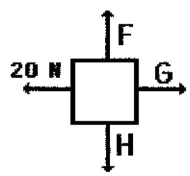
F_{net} = 0 N



F_{net} = 900 N, up



F_{net} = 60 N, left



F_{net} = 30 N, right

If an object is at rest or moving with constant velocity, $F_{net} = 0$ N.
If an object is uniformly accelerating, $F_{net} \neq 0$ N.

3. Draw FBDs for the following situations.

   a) A book is at rest on a table-top.

   b) A girl is suspended motionless from a bar which hangs from the ceiling by two ropes.

   c) An egg is free-falling from a nest in a tree.

   d) A flying squirrel is gliding (no *wing flaps*) from a tree to the ground at constant velocity. Consider air resistance.

   e) A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance.

   f) A rightward force is applied to a book in order to move it across a desk at constant velocity. Consider frictional forces. Neglect air resistance.

   g) A college student rests a backpack upon his shoulder. The pack is suspended motionless by one strap from one shoulder.

   h) A skydiver is descending with a constant velocity. Consider air resistance.

   i) A force is applied to the left to drag a sled across loosely-packed snow with a leftward acceleration.

   j) A football is moving upwards towards its peak after having been *booted* by the punter.

   k) A car is coasting to the right and slowing down.

Which of the following can be found in Oscar's trash can?

a bowling alley, a goat, a piano, a pool, a train set, chickens, Fluffy the Elephant