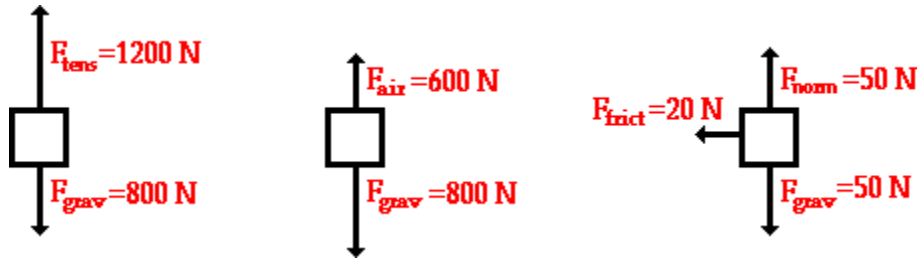


## Determining the Net Force

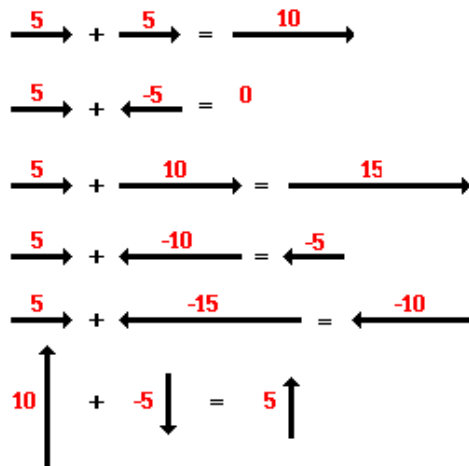
Newton's First Law of Motion states:

*An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.*

In the statement of Newton's first law, the unbalanced force refers to that force that does not become completely balanced (or canceled) by the other individual forces. If either all the vertical forces (up and down) do not cancel each other and/or all horizontal forces do not cancel each other, then an unbalanced force exists. The existence of an unbalanced force for a given situation can be quickly realized by looking at the force diagram for that situation. Force diagrams for three situations are shown below. Note that the actual magnitudes of the individual forces are indicated on the diagram.

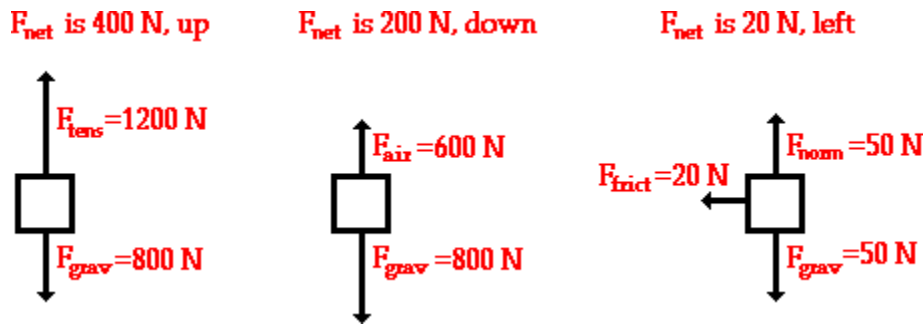


In each of the above situations, there is an unbalanced force. It is commonly said that in each situation there is a *net force* acting upon the object. The net force is the vector sum of all the forces that act upon an object. That is to say, the net force is the sum of all the forces, taking into account the fact that a force is a vector and two forces of equal magnitude and opposite direction will cancel each other out. At this point, the rules for summing vectors (such as force vectors) will be kept relatively simple. Observe the following examples of summing two forces:




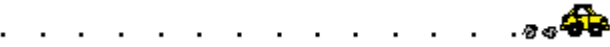



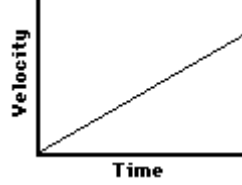
Observe in the diagram above that a downward vector will provide a partial or full cancellation of an upward vector. And a leftward vector will provide a partial or full cancellation of a rightward vector. The addition of force vectors can be done in the same manner in order to

determine the net force (i.e., the vector sum of all the individual forces). Consider the three situations below in which the net force is determined by summing the individual force vectors that are acting upon the objects.



**Quick Quiz**

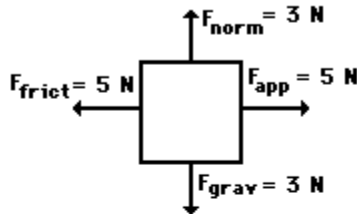
As mentioned earlier, a net force (i.e., an unbalanced force) causes an acceleration. In a previous unit, several means of representing accelerated motion (position-time and velocity-time graphs, ticker tape diagrams, velocity-time data, etc.) were discussed. Combine your understanding of acceleration and the newly acquired knowledge that a net force causes an acceleration to determine whether or not a net force exists in the following situations.

Description of Motion	Net Force: Yes or No?
	YES. There is a net force since there is an acceleration.
	NO. There is no net force since there is not an acceleration.
	YES. There is a net force since there is an acceleration.
	NO. There is a no net force since there is not an acceleration (zero slope on a v-t graph means zero acceleration).
	YES. There is a net force since there is an acceleration (the slope on a v-t graph means acceleration).
	YES. There is a net force since there is an acceleration (the slope on a v-t graph means acceleration).

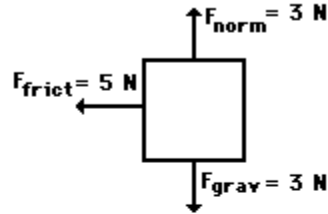
**Now let's check your understanding:**

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

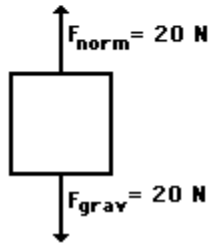
**Situation A**



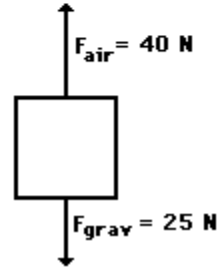
**Situation B**



**Situation C**



**Situation D**



Work for Situation A:

The net force is **zero Newtons**. All the individual forces balance each other (i.e., cancel each other out).

Work for Situation B:

The net force is **5 Newtons, left**. The vertical forces balance each other (i.e., cancel each other out). The leftward force (friction) remains unbalanced.

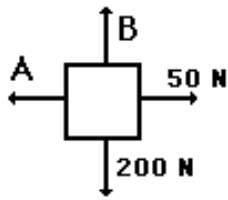
Work for Situation C:

The net force is **zero Newtons**. All the individual forces balance each other (i.e., cancel each other out).

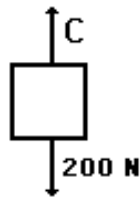
Work for Situation D:

The net force is **15 Newtons, up**. The upward force of air resistance is only partially balanced by the downward force of gravity - 15 N of upward force remains unbalanced.

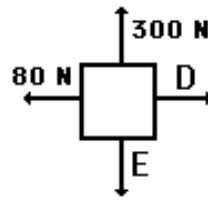
2. Free-body diagrams for four situations are shown below. The net force is known for each situation. However, the magnitudes of a few of the individual forces are not known. Analyze each situation individually and determine the magnitude of the unknown forces.



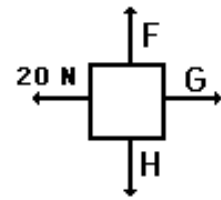
$$F_{\text{net}} = 0 \text{ N}$$



$$F_{\text{net}} = 900 \text{ N, up}$$



$$F_{\text{net}} = 60 \text{ N, left}$$



$$F_{\text{net}} = 30 \text{ N, right}$$

**A = 50 N** (the horizontal forces must be balanced)

**B = 200 N** (the vertical forces must be balanced)

**C = 1100 N** (in order to have a net force of 200 N, up)

**D = 20 N** (in order to have a net force of 60 N, left)

**E = 300 N** (the vertical forces must be balanced)

**F = H = any number** you wish (as long as F equals H)

**G = 50 N** (in order to have a net force of 30 N, right)