# 7.1 Vectors as Forces

We usually associate force with muscular exertion, such as pulling a sled, lifting a book, shooting a basketball, or pedalling a bicycle. There are example of force where muscular action is not present, such as the attraction of the Moon to Earth, the attraction of a magnet to the fridge, the thrust exerted by an engine when gas combusts in its cylinders, or the force exerted by shock absorbers to reduce vibration.

Force is defined as something that either pushes or pulls on an object. On Earth, force is the product of the mass of an object and the acceleration due to gravity (9.8 $m/s^2$), measured in Newtons, N.

***Resultant and Composition of Forces***

The resultant of several forces is the single force that can be used to represent the combined effect of all the forces. The individual forces that make up the resultant are called the components of the resultant.

***Equilibrant of Several Forces***

The equilibrant is the opposite vector to the resultant. When the equilibrant is applied to the object, this force maintains the object in a state of equilibrium.

***Minds On:*** Two children, James and Fred, are pushing on a rock. James pushes with a force of 80 N in an easterly direction, and Fred pushes with a force of 60 N in the same direction. Determine the resultant and the equilibrant of these two forces.

Just like with vectors in Chapter 6, we can use a parallelogram or a triangle to determine the resultant and equilibrant vectors when two or more forces are combined, if they are not collinear. The notation is shown below:

***Forces in Equilibrium***

Three non-collinear forces

Three collinear forces

***Example 1:*** Two forces of 20 N and 40 N act at an angle of 30° to each other. Determine the resultant of these two forces.

***Resolving a Vector into its Components***

When we take a single force and break it into its two components, the process is called resolution. We can do this using the horizontal and vertical components of the force vector as shown:

***Resolution of a Vector into Horizontal and Vertical Components***

If the vector $\vec{f}$ is resolved into its respective horizontal and vertical components, $\vec{f_x}$ and $\overrightarrow{f_y}$, then

***Example 2:*** Kayla pulls on a rope attached to her sleigh with a force of 200 N. If the rope makes an angle of $20^{o}$ with the horizontal, determine:

a) The force that pulls the sleigh forward
b) The force that tends to lift the sleigh

***Example 3:*** a) Is it possible for three forces of 15 N, 18 N, and 38 N to keep a system in a state of equilibrium?
b) Three forces having magnitudes 3 N, 5 N, and 7 N are in a state of equilibrium. Calculate the angle between the two smaller forces.

***Example 4:*** A mass of 20 kg is suspended from a ceiling by two lengths of rope that make angles of $60^{o}$ and $45^{o}$ with the ceiling. Determine the tension in each of the ropes.