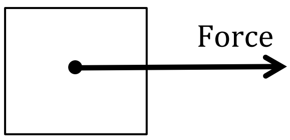
## 4.1.1 Scalars and vectors

videos

Physical quantities can be divided into scalars and vectors. Vector quantities, such as force, have a size and a direction. Scalar quantities, such as mass, have a size only.

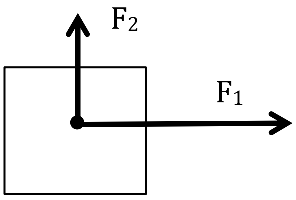
*(1)✐Divide the following physical quantities into scalars or vectors: speed, velocity, momentum, temperature, distance, displacement, acceleration, time*

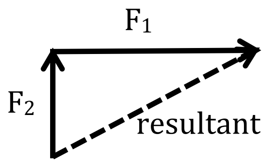
We can represent vector quantities using arrows. The length of the arrow gives an indication of the size of the physical quantity and the direction is shown by the direction the arrow points.

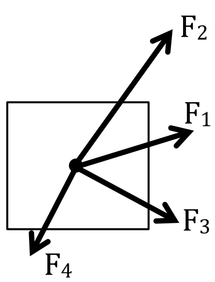


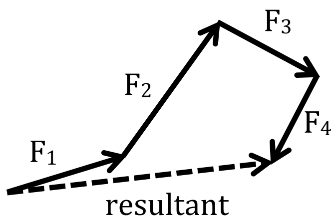

The diagram above shows a force acting on an object. The dot in the centre of the object represents the centre of mass of the object. (A force which acts through the centre of mass will not cause any rotation.)

Often, more than one force will act simultaneously on the object. If this is the case, we need to work out the resultant force. We can do this by adding force vectors together. When we add vectors we add them tip-to-tail, and the resultant vector is an arrow drawn from the tail of the first vector to the tip of the last vector:

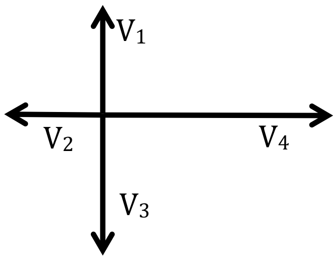


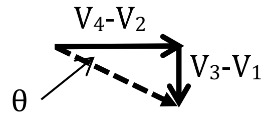



If we find that when we add up forces, the resultant force is zero (i.e. the arrows add in such a way that the tip of the last arrow lands back at the tail of the first arrow), then we say that the forces are balanced.
Often we need to construct a scale diagram to work out the resultant vector quantity. However, if the vectors are at right angles it is often a simple task to work out the resultant force, by cancelling opposing forces, using Pythagoras' theorem and some trigonometry. Here is an example:



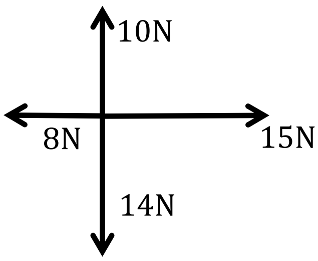




$$resultant = \sqrt{(V_4 - V_2)^2 + (V_3 - V_1)^2}$$

$$\theta = \tan^{-1}\left(\frac{V_3 - V_1}{V_4 - V_2}\right)$$

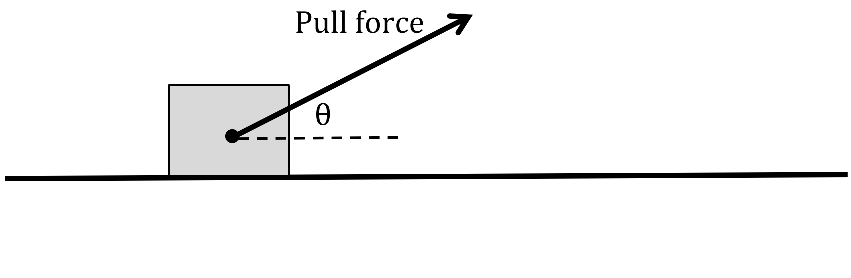
First we work out the work out the resultant vertical component ($V_3$-$V_1$), and the resultant horizontal component ($V_4$-$V_2$). When we add these together we can use Pythagoras' theorem ($a^2$=$b^2$+$c^2$) to find the size of the resultant. Finally we use the tan function to work out the angle at which the resultant acts.

*(2)✎Using the technique above, find the resultant force for the situation below:*

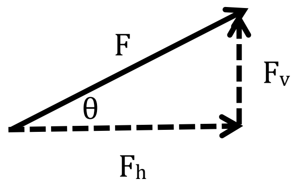



**Resolving vectors**

We have seen that we can add vectors together to make a resultant vector. We can also do the reverse and separate one vectors it into a number of different vectors. This is often useful in analysing situations where we are interested the vector components acting in certain directions. Let us look at an example:



In the situation above we have an object which is being pulled along a surface, but the pull force is at an angle to the surface. What we might be interested in is what is the size of the force which contributes to the horizontal movement. To find this we resolve the pull force into a horizontal ($F_h$) and vertical component ($F_v$):




Because the two component vectors are at right angles to each other we can use a bit of trigonometry to work out their sizes:

$$F_h = Fcos(\theta)$$

$$F_v = Fsin(\theta)$$

*(3)✐Resolve the following force vector into a vertical and horizontal component:*