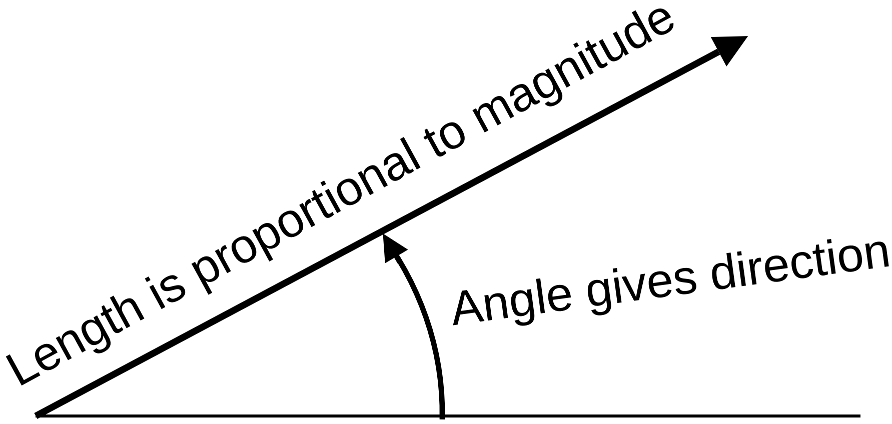
2. FORCES and MOMENTS

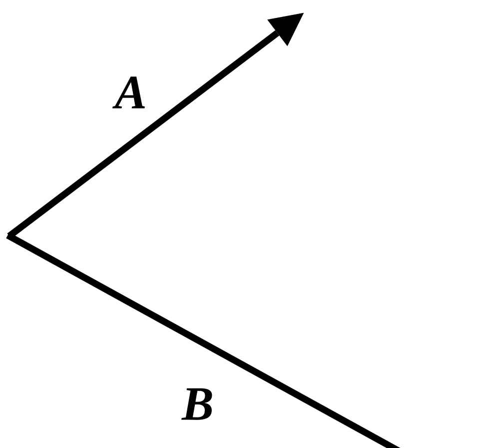
Definition of a Force:
That which moves, or tends to move, a body from a state of rest or uniform motion in a straight line.

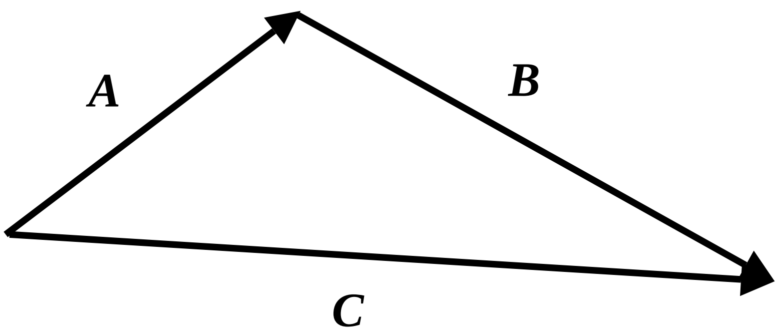
A force is a vector quantity:
i.e. it has both **magnitude** and **direction**.

As such, we can represent a force graphically by means of an arrow of a given length pointing in a particular direction.



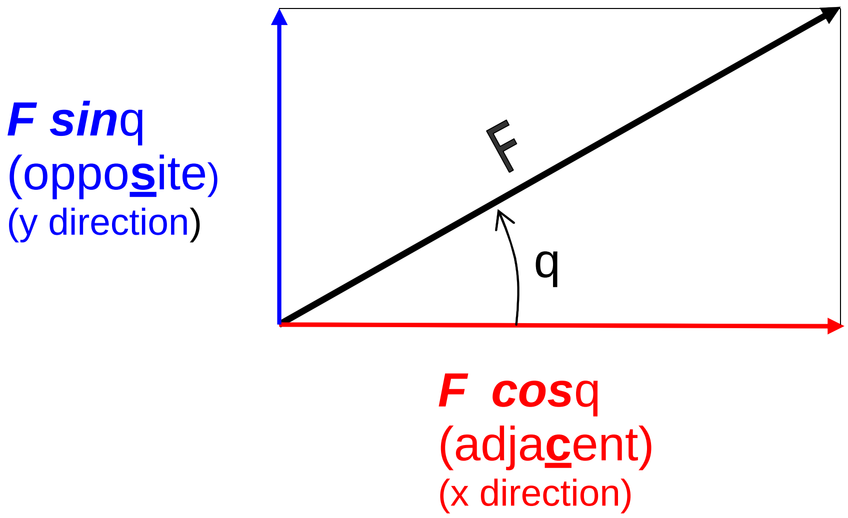
If two or more forces act on a body we may find their combined effect by adding them vectorially. The combined effect of two or more forces is known as their resultant.



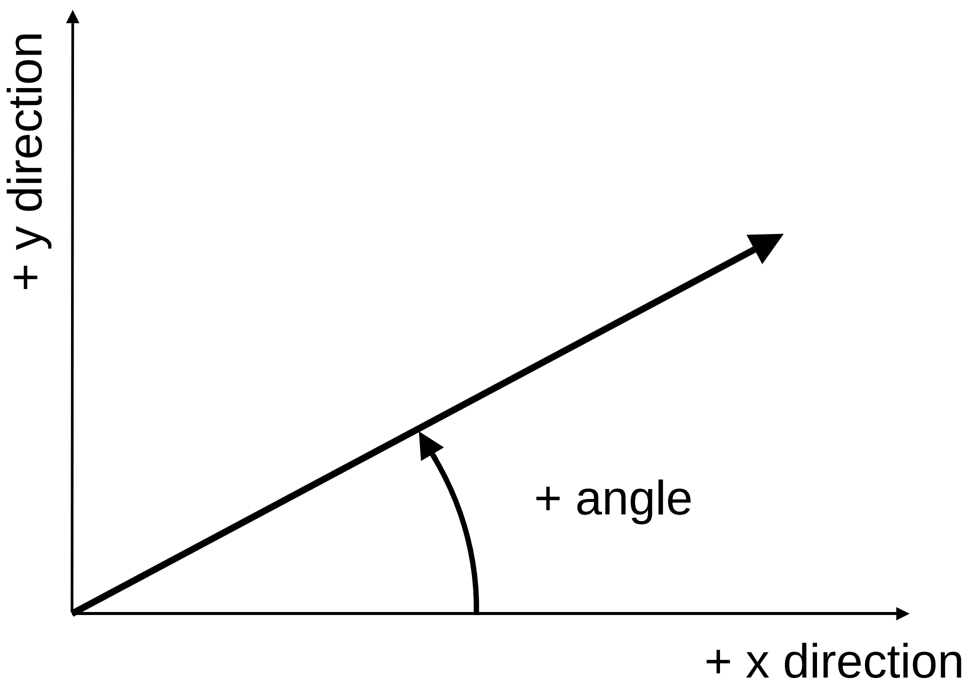


$$\vec{A}+\vec{B}=\vec{C}$$

Just as we can combine two or more forces to obtain a resultant, we can also split (or resolve) a single force into two or more <u>components</u>. The most useful form of this splitting is into two components at right angles to each other.

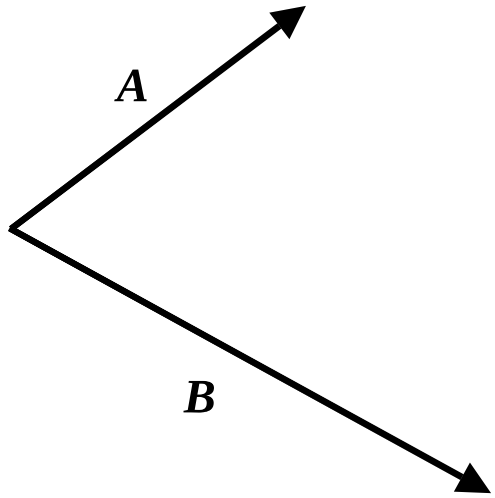


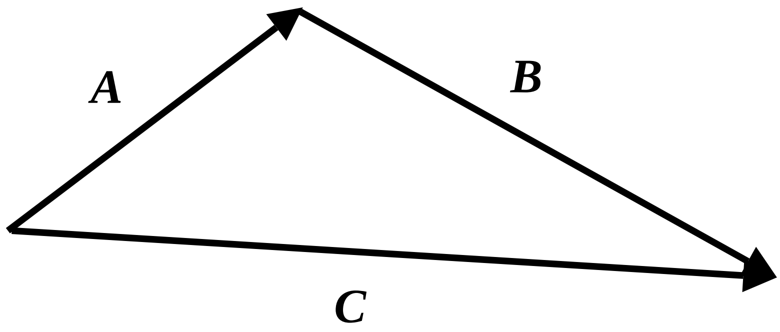
Importance of a sign convention:



Vector combining using <u>components</u>:

We showed above that vectors could be added graphically by joining them nose to tail:

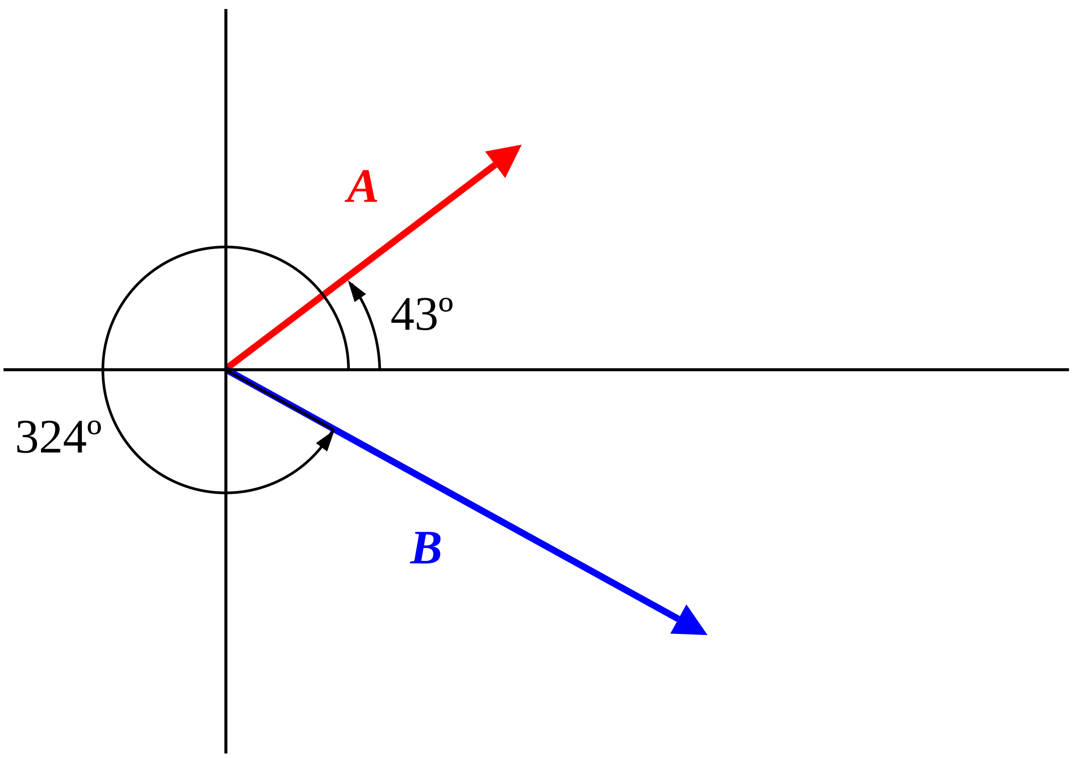




$$\vec{A}+\vec{B}=\vec{C}$$

(1mm = 1N)

We can achieve the same result by splitting each vector into its components, adding the components, then combining the added components to obtain the resultant.



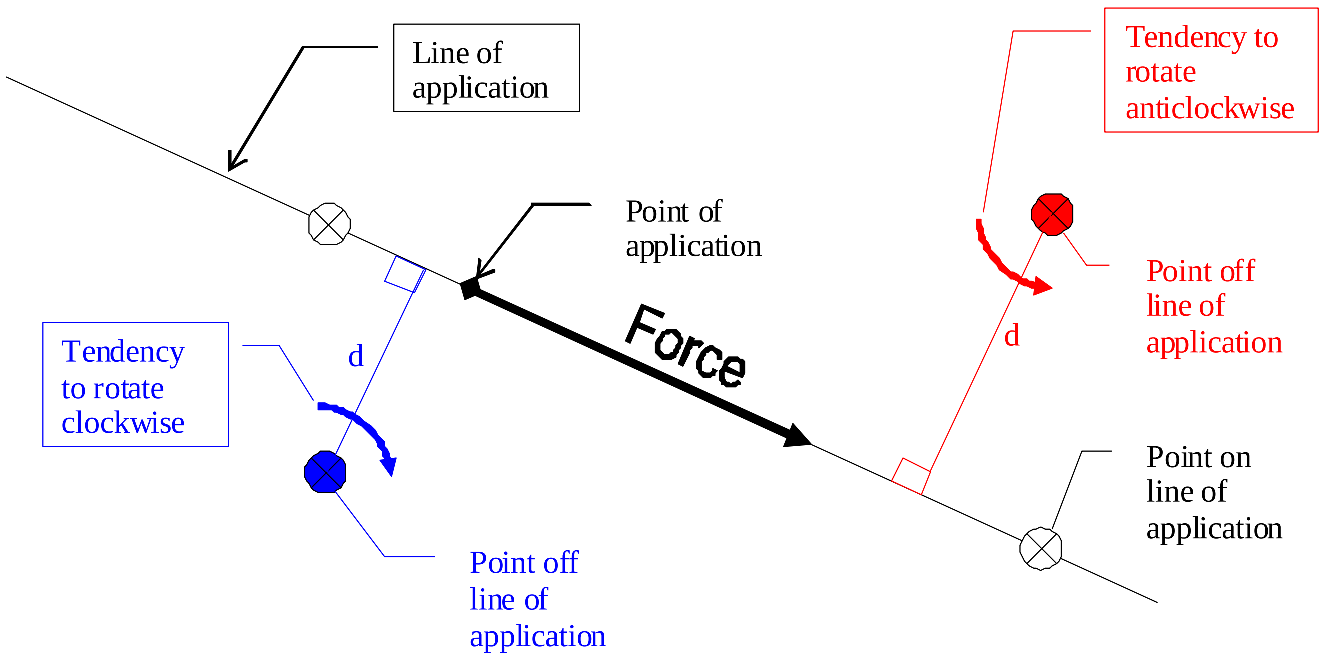
	Force (N)	angle (°)	F cos(angle)	F sin(angle)
A	44	43	32.18	30.01
B	68	324	55.01	-39.97
summation			87.19	-9.96
			(ÓFx)	(ÓFy)
Resultant	magnitude =	**87.76**	**N**	
	angle =	**353.48**	°	

$$magnitude = \sqrt{(\sum F_x)^2 + (\sum F_y)^2}$$

$$\theta = \arctan2\left(\sum F_x, \sum F_y\right) + 360^0 \text{ if } \arctan2\left(\sum F_x, \sum F_y\right) \text{ is negative.}$$

The ROTATIONAL EFFECTS of a FORCE

A force acting on a body will tend to rotate it about any point which is not on its line of action. The line of action of a force extends infinitely in the direction of the force in both positive and negative directions.



The rotational effect of a force is known as the moment of a force, or more simply just as a moment.

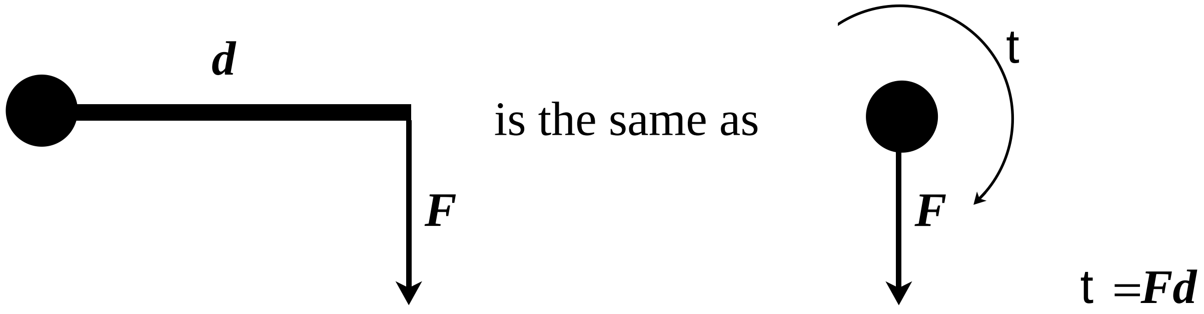
The moment of a force about a point is defined as the product of the force x the perpendicular distance from the point to the line of action of the force.

i.e. $$M = F \times d$$

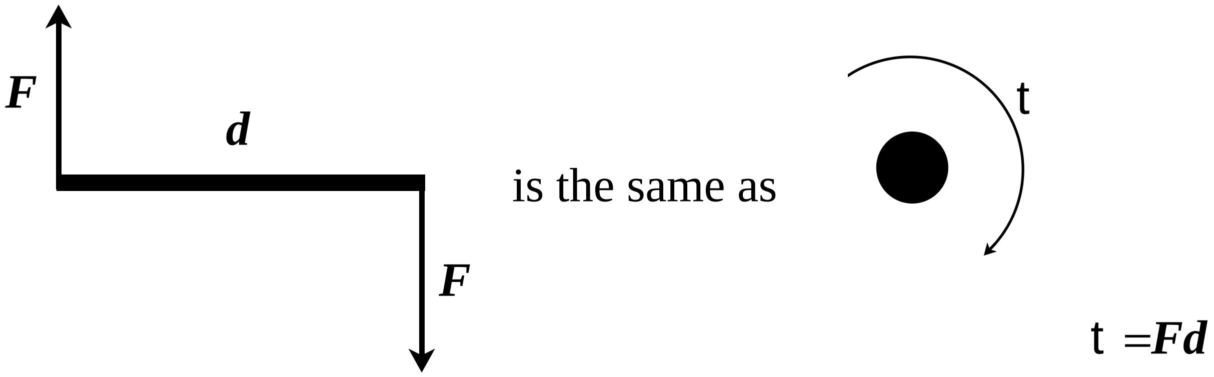
Note that moments can be clockwise (positive) or anticlockwise (negative).

The moment of a force is also a vector quantity.

The effect of a force at any point off its line of action is both to rotate and to translate.



If we wish to eliminate the translational effect ***(F)***, we can apply equal and opposite forces as shown below.



The product ***F***x***d*** is known as the moment of a couple, a pure twisting effect, or a torque.

The effect of a torque is the same irrespective of where it is actually applied. i.e. irrespective of where the point is about which we take moments, we obtain the same result.

This can be experienced when tightening the wheel nuts on a car using a star brace. Irrespective of the fact that the nuts are off centre, the wheel tends to turn when the tightening torque is applied.