4.2.1 The principle of moments

videos

A moment is the turning effect of a force about a point (or pivot). It is defined as:

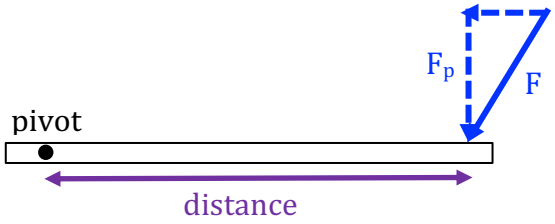
$$moment = force \times distance$$

where distance = the perpendicular distance between the line of action of the force and the pivot

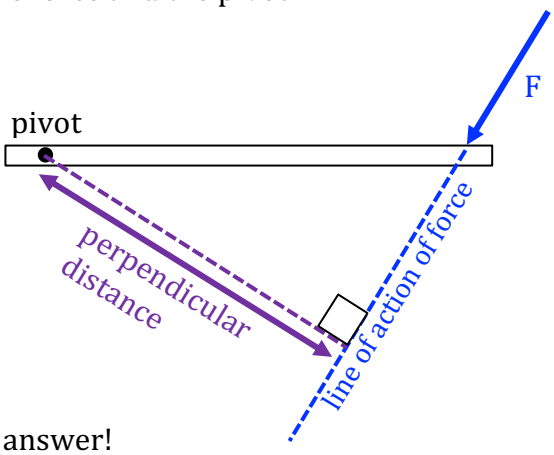
A moment has the unit *Nm* (*newton-metre*).

When the force is at right angles (see diagram above), we just multiply the force by the distance from the force to the pivot.

When the force is at an angle, we must take the perpendicular component (F_p) of the force x distance:



Alternatively, we multiply the force by the perpendicular distance between the line of action of the force and the pivot:

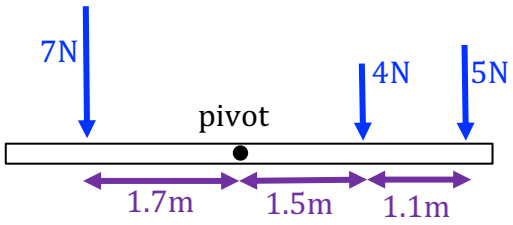


You get the same answer!

When there is more than one moment acting on an object, the result moment is the sum of individual moments. At A-level, we only deal with moments in 2 dimensions. This means that there will be moments that turn the object clockwise and moments that turn the object anticlockwise. When we add

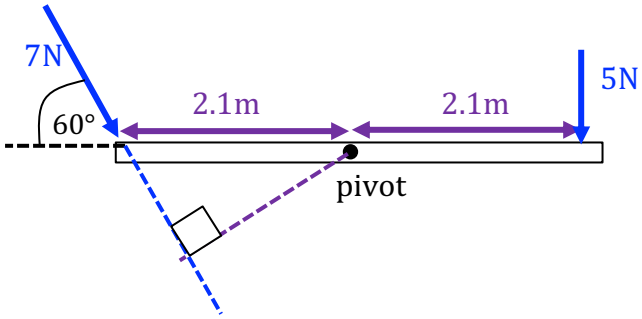
moments we can just take clockwise moments to be positive and anticlockwise moments to be negative.

(1) What is the resultant moment about the pivot for the following?



(2) What direction will the beam turn?

(3) What is the resultant moment about the pivot for the following? (Hint: Use the 'perpendicular distance for the anticlockwise moment.)



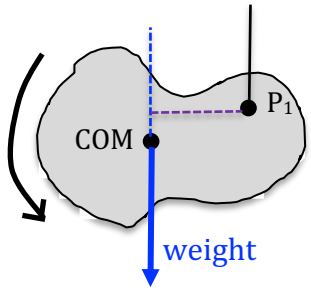
We say that the moments are balanced when there is no resultant moment acting. This occurs when:

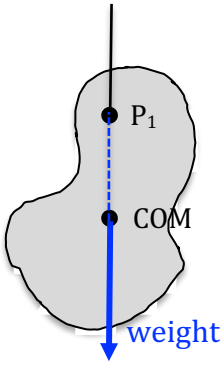
$$sum\ of\ clockwise\ moments = sum\ of\ anticlockwise\ moments$$

This is known as the 'principle of moments'.

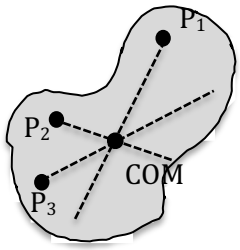
Centre of mass

If the line of action of a force passes through the pivot point there is no turning effect. When we suspend an object from one point P, the weight of the object (which acts downwards from the centre of mass) will cause the object to rotate to a position where the centre of mass (COM) is directly below the pivot point. In this position the line of action of the weight passes through the pivot and there will be no turning effect.





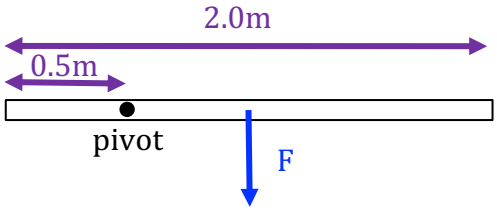
The point of suspension P can be moved to a new position. Again the object will come to rest with the COM directly below P. This can be used to locate the COM.



If we suspend the object from three points (P1, P2, P3) and draw lines directly downwards in each case. We can locate the COM where the lines intersect.

COM producing a moment

Now consider the following:



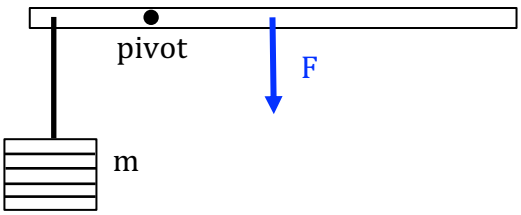
A beam with a mass of 200g is suspended from a non-central pivot point.

(4) What do you think the force F represents?

(5) What is the size of force F?

(6) What is the resultant moment on the beam?

With the addition of a known mass (m), we can use this technique to work out the mass of a beam of unknown mass. The equipment used is shown below:



(7) Using the principle of moments (see above) explain how you would obtain the mass of the beam.