Units and Prefixes

4th Sep

Countries all over the world have agreed to use the SI system of units.

There are seven BASE units in the SI system. All other SI units can be expressed in terms of these base units.

Time in seconds, s

Length in metres, m

Mass in kilograms, kg

Current in amperes, A

Temperature in kelvin, K

Amount of substance in moles, mol

Luminous intensity in candela, cd

Resolving Vectors

10th Sep

A QUANTITY is anything that be measured (directly or indirectly).

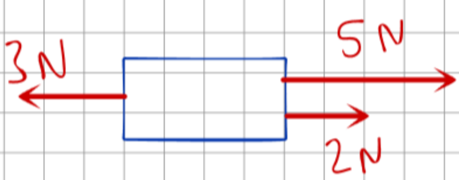
Quantities can be SCALARS (they only have a MAGNITUDE - and usually a unit), or VECTORS (they have both a MAGNITUDE and a DIRECTION).

Scalar examples: speed, mass, temperature, density, time, energy

Vector examples: velocity, weight, force, acceleration, displacement

If we are considering an object that has multiple vector quantities associated with it i.e. two forces acting on it, then we can usually add and subtract these vectors to find a RESULTANT.

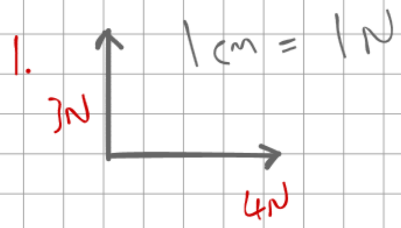
Colinear vectors (acting along the same line):



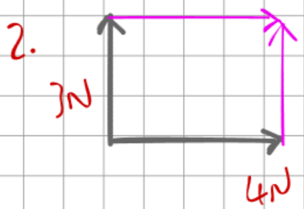
Resultant force:

If the vectors are not colinear, one of the options we have to find the resultant vector is constructing a SCALE DIAGRAM.

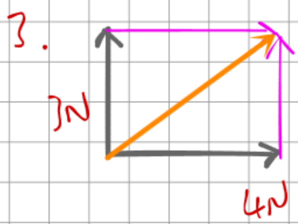
1. Choose a scale. Draw both vectors to scale STARTING FROM THE SAME POINT.



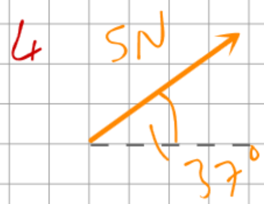
2. Complete the rectangle/square/parallelogram



3. Draw the resultant vector which goes from where the bases of the arrows meet, to where the tips of the arrows meet.



4. Measure the length of the resultant to find its magnitude, and measure its direction (usually as an angle to the horizontal).



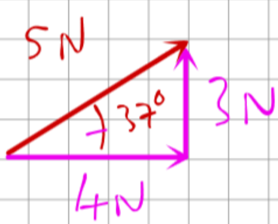
Components of Vectors

Any vector can be broken down into two COMPONENTS (smaller parts, that when summed together give us the original vector). Usually the components of a vector are PERPENDICULAR to each other, more often than not we use HORIZONTAL and VERTICAL components.

For example:

This vector:

can be broken into:



We say this vector has a HORIZONTAL COMPONENT of 4 N to the right, and a VERTICAL COMPONENT of 3 N upwards.

One method of finding the components of a vector is by using a SCALE DIAGRAM, the other method is by using TRIGONOMETRY.

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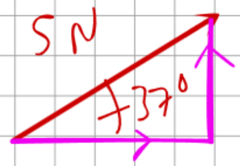


$\sin\theta = \frac{opp}{hyp}$

$hyp \times \sin\theta = opp$

$\cos\theta = \frac{adj}{hyp}$

$hyp \times \cos\theta = adj$

Vertical component = $5\,N \times \sin 37$
$= 3\,N$

Horizontal component = $5 \times \cos 37$
$= 4\,N$

If we know the magnitude of the components of a vector, then we can use pythagorean theorem to find the magnitude of the vector itself (this method also works for finding the magnitude of the resultant of any two perpendicular vectors).

For example:

Magnitude of resultant = $\sqrt{4^2 + 3^2}$
$= \sqrt{25}$
$= 5\,N.$

Translational Equilibrium

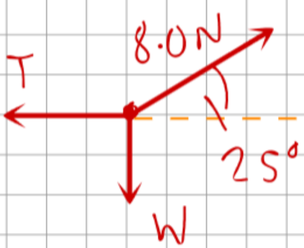
16th Sep

If an object is in translational equilibrium then all of the forces on the object are balanced; there is NO RESULTANT FORCE.

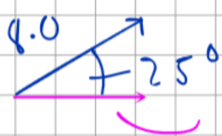
This means any upwards forces are balanced by downwards ones, any leftwards forces are balanced by rightwards ones.

One useful technique is to choose two perpendicular lines of action i.e. vertical and horizontal, and resolve all forces acting on an object into components that act along these lines of action.

For example; This object is in equilibrium. Find the magnitude of the force acting downwards, and of the force acting leftwards.



Resolving horizontally;



$8.0 \cos 25 = 7.3\,N$

In equilibrium hence; $T = 7.3\,N$ (leftwards).

Resolving vertically;

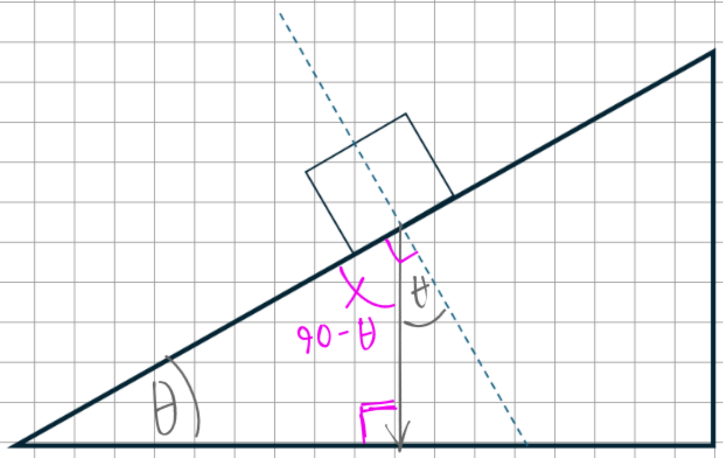
$8.0 \sin 25 = 3.4\,N$

In equilibrium hence; $W = 3.4\,N$ (downwards)

Objects on a Slope 18th Sep

If we have an object on an inclined surface and we are trying to resolve forces we use two different lines of action, rather than horizontal and vertical.

Instead we use PARALLEL to the slope/along the slope and NORMAL to the slope. This is useful as we often have to deal with friction acting along the slope and contact forces normal to the slope.



The angle between the vertical (line of action of weight) and the normal to the slope is always the SAME as the angle between the SLOPE AND THE HORIZONTAL.

1) A car rests on a hill which has an inclination of 5.00°. The car weighs 7,000N. Find:

(i) The friction force between the car and the road.

(ii) The reaction force between the car and the road.

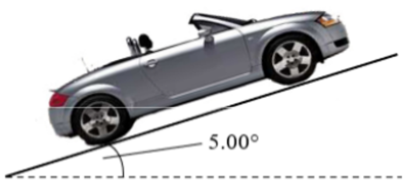
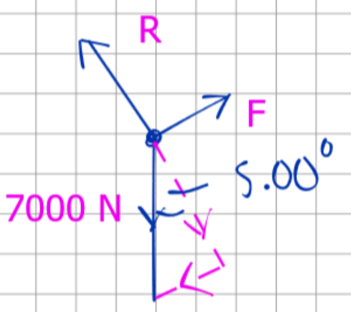
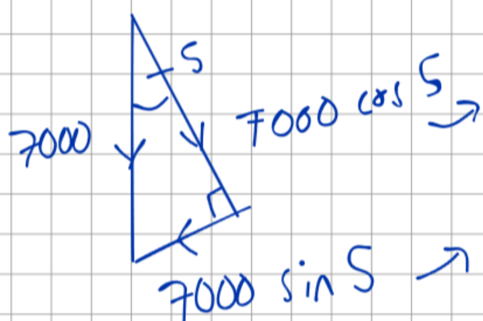


Fig. 1



(i)



component of weight acting into the slope

component of the weight acting down the slope

In equilibrium, so F = component of weight acting down slope

$$F = 7000 \sin 5$$
$$= 610 \text{ N}$$

(ii) In equilibrium, so R = component of weight acting into the slope

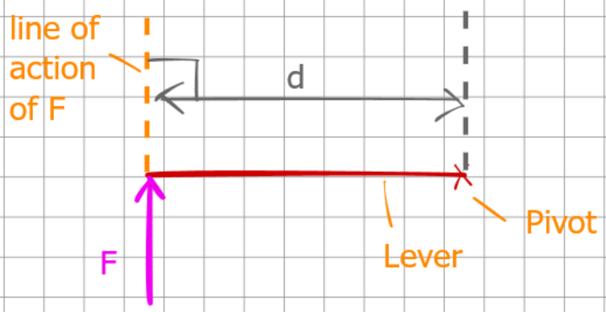
$$R = 7000 \cos 5$$
$$= 6970 \text{ N}.$$

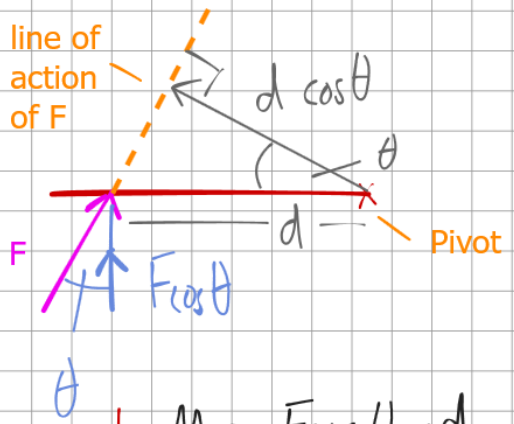
Moments

23rd Sep

A turning effect of a force is called a moment (sometimes referred to as torque).

Definition: a moment is a PRODUCT of the MAGNITUDE of a FORCE and the PERPENDICULAR DISTANCE between the LINE OF ACTION of the force and the PIVOT.





$$M = Fd$$

1. $M = F\cos\theta \times d$
2. $M = F \times d\cos\theta$

If the line of action of a force passes through the pivot point, then the force will have no turning effect and no moment (perpendicular distance is zero).

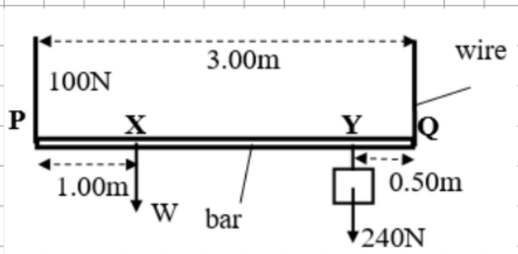
If a force is not perpendicular to a lever we either:

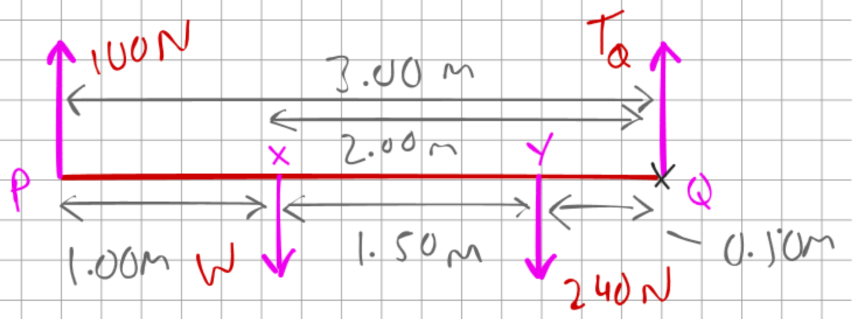
- Multiply the component of the force that is perpendicular to the lever by the distance to the pivot (1.)

OR

- Multiply the force by the component of the distance that is perpendicular to the line of action of the force (2.)

The PRINCIPLE OF MOMENTS: if an object is in rotational equilibrium then the SUM OF THE CLOCKWISE MOMENTS is EQUAL TO the SUM OF THE ANTICLOCKWISE MOMENTS





a) Moments about Q. In equilibrium so; ACW = CW

$$(W \times 2.00) + (240 \times 0.50) = 100 \times 3.00$$

$$2W + 120 = 300$$

$$2W = 180$$

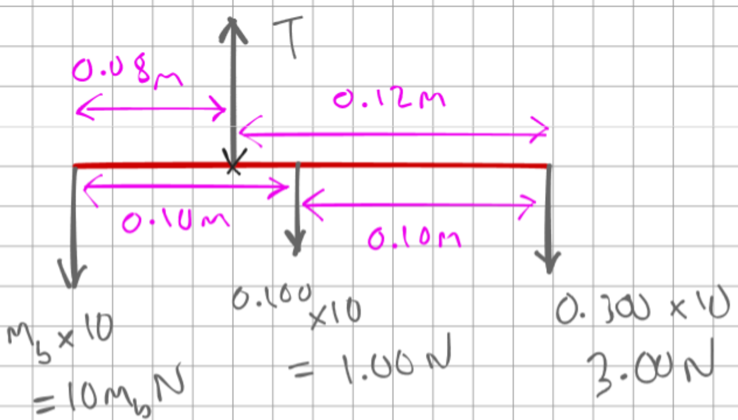
$$W = 90\text{N}$$

b) In equilibrium so; $90 + 240 = 100 + T_Q$

$$T_Q = 230\text{ N}.$$

3.

a)



b) ACW = CW

$$(10m_b \times 0.08) = (1.00 \times 0.02) + (3.00 \times 0.12)$$

$$0.8m_b = 0.02 + 0.36$$

$$0.8m_b = 0.38$$

$$m_b = \frac{0.38}{0.8}$$

$$= 0.475\text{ kg}$$

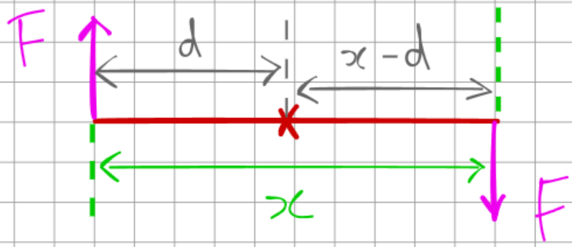
c) $T = 4.75 + 1.00 + 3.00$

$$= 8.75\text{ N}$$

Couples

24th Sep

A couple is produced by a pair of forces acting in opposite directions, along different (but parallel) lines of action that produce moments in the same direction.



$$M = Fd + F(x - d)$$

$$M = Fd + Fx - Fd$$

$$\boxed{M = Fx}$$ moment of a couple

As the forces are the same magnitude we can calculate the moment of the couple by multiplying the magnitude of the force by the perpendicular distance between the force's lines of action.