KING EDWARD VI
HANDSWORTH GRAMMAR
SCHOOL FOR BOYS

KING EDWARD VI
ACADEMY TRUST
BIRMINGHAM

Year 12
Applied Mathematics
M2 4 Moments Booklet

HGS Maths

Dr Frost Course

Name: _____

Class: _____

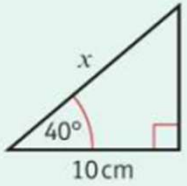
Contents

Prior knowledge check

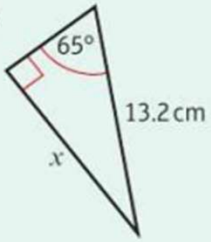
Prior knowledge check

1 Find the value of x in each of the following:

a

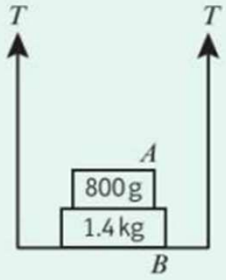


b



← GCSE Mathematics

2 Masses A and B rest on a light scale-pan supported by two strings, each with tension T.



Find:

a the value of T

b the normal reaction of the scale-pan on mass B

c the normal reaction of mass B on mass A.

← Year 1, Chapter 10

4.1) Moments

A moment has magnitude (Nm) and direction (clockwise or anticlockwise). It is the turning effect.

It is calculated as:

SIMPLE CASE where F and d and perpendicular: $F \times d$, but more generally:

$$Fdsin\theta$$

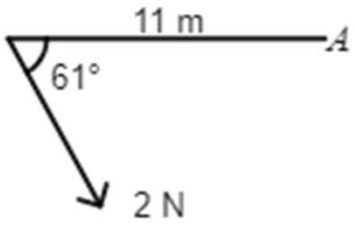
i.e. the product of the force causing the turn and the distance from the PIVOT and where the force acts. θ is the acute angle between the line which connects the force to the pivot and the direction of F.

Notes

Worked Example

646a: Calculate the moment of a force about a point.

Find the moment of the force about the point A.



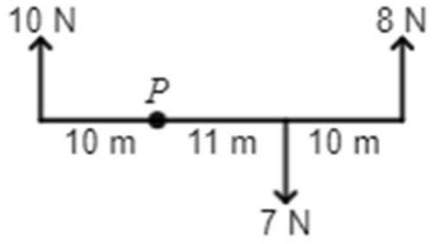
Give your answer correct to 1 decimal place.

Nm anticlockwise

Worked Example

646b: Calculate the resulting moment of perpendicular forces about a point.

Find the resultant moment about the point P.

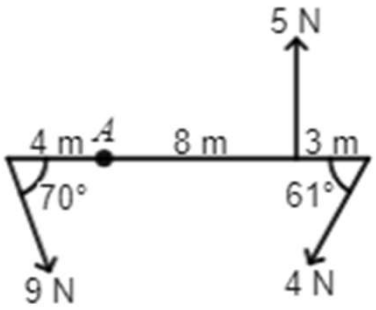


Nm clockwise

Worked Example

646c: Calculate the resulting moment of inclined forces about a point.

Find the resultant moment about the point A.



Give your answer correct to 1 decimal place.

Nm clockwise

T.72: Ex 4A all Qs, P.33: 4.1 all Qs

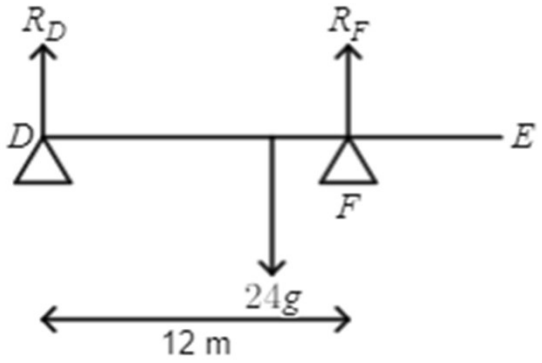
4.2) Resultant Moments

Notes

Worked Example

646d: Determine the reaction forces on a uniform rod resting on two supports.

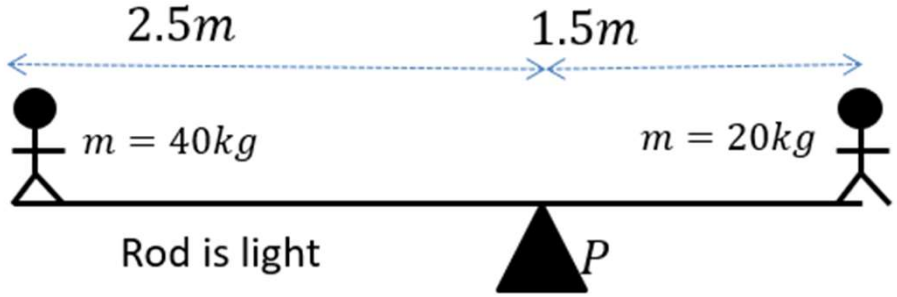
A uniform rod DE of mass 24 kg and length 18 m rests in equilibrium on supports at D and F with $DF = 12$ m.



Find the force exerted by each of the supports.

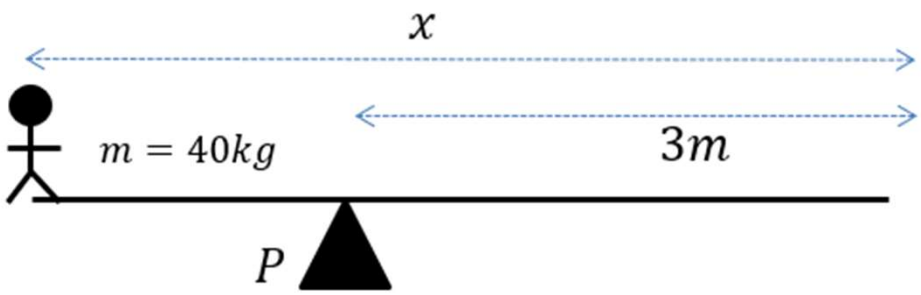
Worked Example

Find the resultant moment acting about P



Worked Example

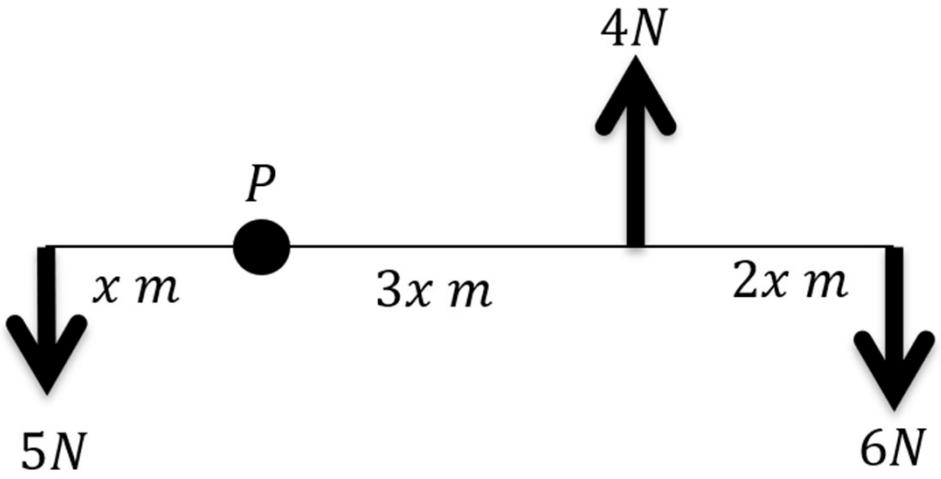
The rod is light. Calculate the resultant moment acting about P.



T.74: Ex 4B Qs 1-2, P.34: 4.2 Qs 1-2

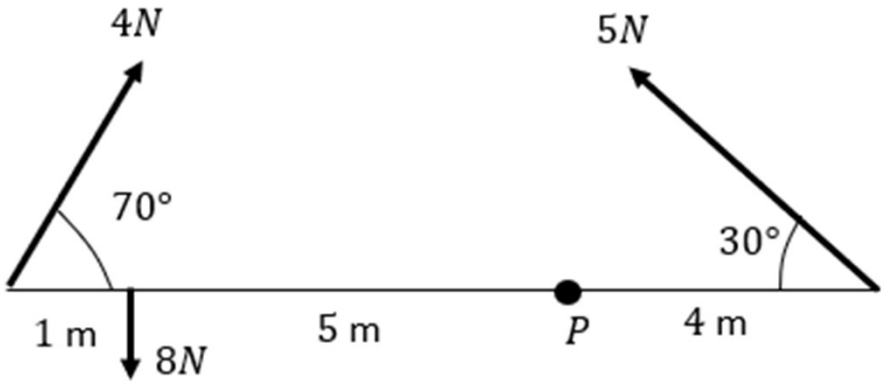
Worked Example

A set of forces act on a light rod.
The resultant moment of P is $26\ Nm$ clockwise. Find the value of x



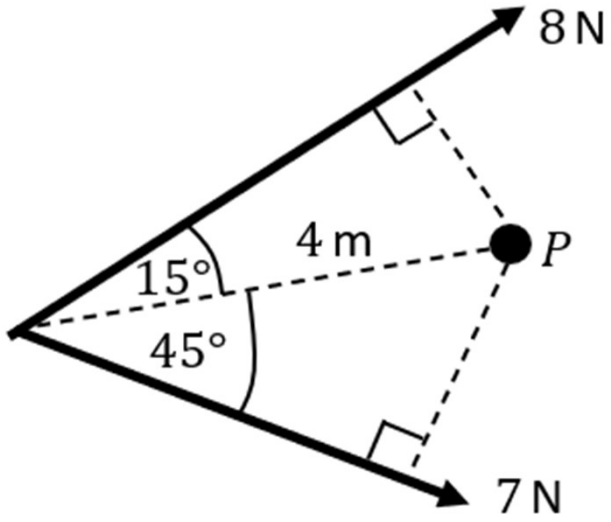
Worked Example

The rod is light. Calculate the resultant moment acting about P.



Worked Example

The rod is light. Calculate the resultant moment acting about P



T.74: Ex 4B Qs 3+, P.34: 4.2 Qs 3+

4.3) Equilibrium

Forces AND moments are balanced

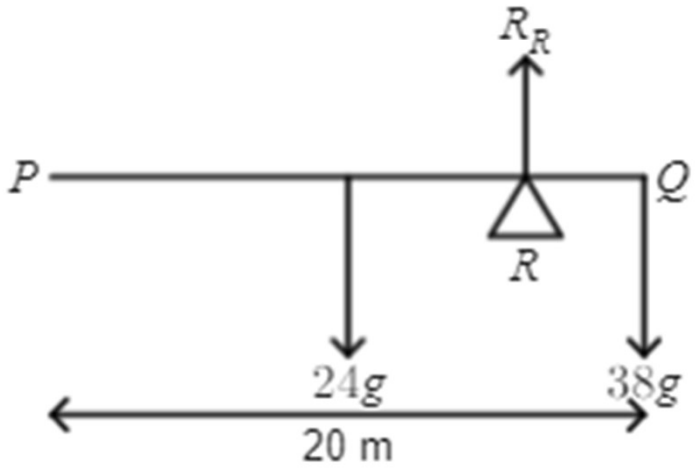
- Resultant force = 0
- Anticlockwise moments = clockwise moments *about any point*

Notes

646f: Determine the distance of a support from a point on a uniform roc when the rod is in equilibrium.

A uniform beam PQ of mass 24 kg and length 20 m rests i equilibrium on a single support R.

An object of mass 38 kg is attached to the beam at Q

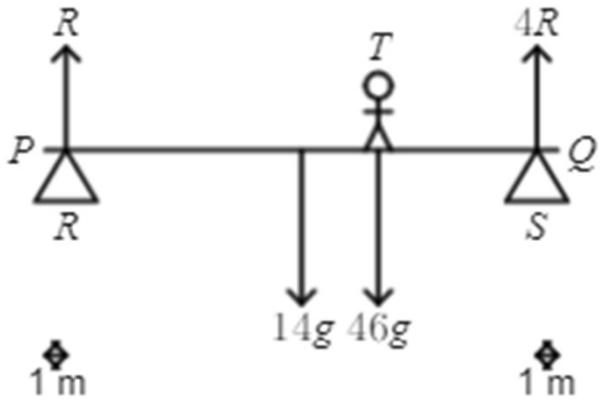


Find the distance PR.

646g: Determine a distance on a uniform rod when reaction forces are connected.

A uniform beam PQ of mass 14 kg and length 25 m rests in equilibrium on supports at R and S with $PR = 1$ m and $QS = 1$ m.

When a man of mass 46 kg stands on the beam at T, the magnitude of the reaction at S is 4 times the magnitude of the reaction at R.

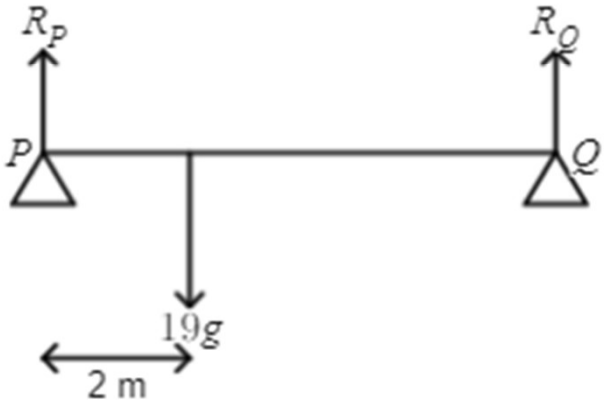


Find the distance PT.

Worked Example

646h: Determine the reaction forces on a non-uniform rod resting on two supports.

A non-uniform beam PQ of mass 19 kg and length 7 m rests in equilibrium on supports at P and Q.
The centre of mass is 2 m away from P.



Find the force exerted by each of the supports.

T.78: Ex 4C Qs 1-2, P.36: 4.3 Qs 1-2

Worked Example

A uniform beam AB, of mass 20 kg and length 10m, rests horizontally on supports at C and D, where $AC = DB = 2$ m.
When a man of mass 60kg stands on the beam at E the magnitude of the reaction at D is three times the magnitude of the reaction at C.
By modelling the beam as a rod and the man as a particle, find the distance AE.

T.78: Ex 4C Qs 3-5, P.36: 4.3 Q3

Worked Example

A uniform rod AB has length $5\ m$ and mass $20\ kg$.
The rod is in equilibrium in a horizontal position, resting on two smooth supports at C and D, where $AC = 0.4$ metres and $DB = x$ metres.
Given that the magnitude of the reaction on the rod at D is three times the magnitude of the reaction on the rod at C, find the value of x

T.78: Ex 4C Qs 6+, P.36: 4.3 Qs4+

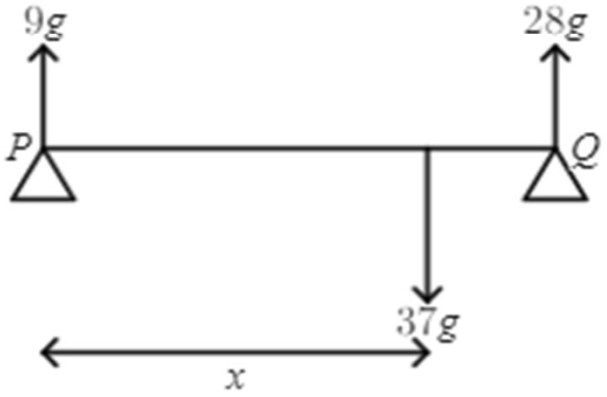
4.4) Centres of mass

Notes

Worked Example

646i: Determine the centre of mass of a non-uniform rod resting on two supports.

A non-uniform beam PQ of mass 37 kg and length 12 m rests in equilibrium on supports at P and Q.
The reactions at these supports are $9g$ N and $28g$ N respectively.

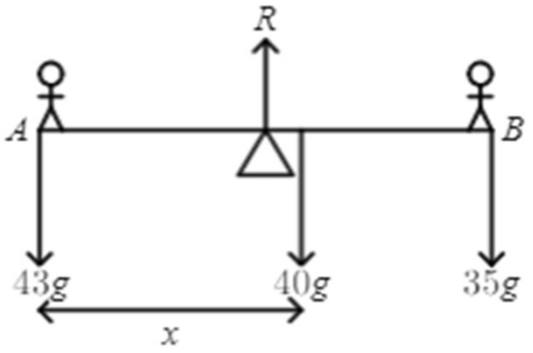


Find the distance of the centre of mass of the beam from P.

Worked Example

646j: Determine the centre of mass of a non-uniform rod resting on a single support.

A non-uniform beam AB of mass 40 kg and length 19 m is pivoted at the midpoint of the rod. The plank is in equilibrium in a horizontal position when a child of mass 43 kg sits at A and a child of mass 35 kg sits at B.



Find the distance of the centre of mass of the rod from A.

T.81 Ex 4D Qs 1-2, P.38: 4.4 Qs 1-2

Worked Example

Sam and Tamsin are sitting on a non-uniform plan AB of mass 45kg and length 2m.
The plank is pivoted at M, the midpoint of AB.
The centre of mass of AB is at C where AC is 0.8. Sam has mass 70 kg.
Tamsin has mass 50 kg and sits at A.
Where must Sam sit for the plank to be horizontal?

T.81 Ex 4D Qs 3-4, P.38: 4.4 Q 3

Worked Example

A non-uniform rod AB is $6\ m$ long and has weight $40\ N$.
It is in a horizontal position resting on supports at points C and D, where $AC = 0.5\ m$ and $AD = 5\ m$.
The magnitude of the reaction at C is four times the magnitude of the reaction at D.
Find the distance of the centre of mass of the rod from A

T.81 Ex 4D Qs 5+, P.38: 4.4 Qs 4+

4.5) Tilting

Notes

Worked Example

A uniform beam beam AB, of mass 54kg and length 8m, rests horizontally on supports C and D where $AC = 2$ m and $CD = 7$ m.
When an object is placed at A, the beam is on the point of tilting about C.
Determine the mass of the object.

Worked Example

A non-uniform rod AB, of length 5 m and weight 80 N, is suspended from a pair of light cables attached to C and D where $AC = 2$ m and $BD = 1$ m.
When a weight of 50 N is hung from A the rod is on the point of rotating.
Find the distance of the centre of mass of the rod from A.

T.84 Ex 4E Qs 1-3, P.39: 4.5 Qs 1-3

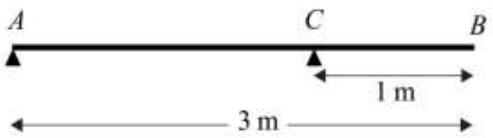
Worked Example

A beam AB has length $25\ m$. The beam rests horizontally in equilibrium on two smooth supports at the points P and Q, where $AP = 4\ m$ and $QB = 5\ m$.
When an adult of mass $60\ kg$ stands on the beam at A, the beam remains in equilibrium and is on the point of tilting about P.
When the same child stands on the beam at B, the beam remains in equilibrium and is on the point of tilting about Q.
The child is modelled as a particle and the beam is modelled as a non-uniform rod.

a) Find the mass of the beam
b) Find the distance of the centre of mass of the beam from A

[EdExcel Mechanics 1 June 2005]

6. **Figure 3**



A uniform beam AB has mass 12 kg and length 3 m. The beam rests in equilibrium in a horizontal position, resting on two smooth supports. One support is at the end A, the other at a point C on the beam, where $BC = 1$ m, as shown in Figure 3. The beam is modelled as a uniform rod.

(a) Find the reaction on the beam at C.

(3)

A woman of mass 48 kg stands on the beam at the point D. The beam remains in equilibrium. The reactions on the beam at A and C are now equal.

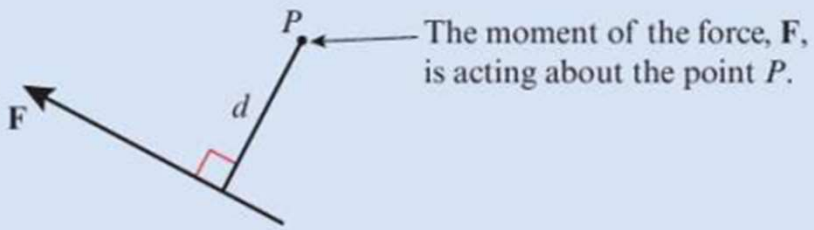
(b) Find the distance AD.

(7)

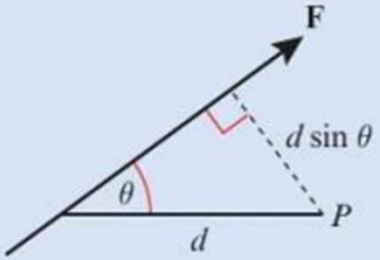
Summary of Key Points

Summary of key points

1 Moment of **F** about $P = |\mathbf{F}| \times d$ clockwise



2 Moment of **F** about $P = |\mathbf{F}| \times d\sin\theta$ clockwise



3 The sum of the moments acting on a body is called the resultant moment.

4 When a rigid body is in equilibrium the resultant force in any direction is 0 N and the resultant moment about any point is 0 N m.

5 When a rigid body is on the point of tilting about a pivot, the reaction at any other support (or the tension in any other wire or string) is zero.

T.85 mixed Ex, P.41 BSG