Worksheet - Moments

Year: Year 13 · 21

Show your working.

Question 1

Question 1 – Calculating moments *(Section A · Skills practice)*

Calculate the moment of each force about the point O, stating whether it is clockwise or anticlockwise where this is given.

a. A force of 24 N acts at right angles to a spanner at a distance of 0.35 m from O. [1 mark]
b. A force of 40 N acts on a rod at an angle of 50° to the rod, at a point 0.6 m from O along the rod. [2 marks]
c. A force of 75 N has a moment of 30 N m about O. Find the perpendicular distance of its line of action from O. [1 mark]

Question 2

Question 2 – Balancing on a seesaw *(Section A · Skills practice)*

A uniform seesaw has its pivot at its centre. A child of mass 28 kg sits 1.8 m from the pivot.

a. At what distance from the pivot must a child of mass 36 kg sit on the other side to balance the seesaw? [3 marks]
b. A third child of mass 18 kg sits 0.5 m beyond the 36 kg child. Where must the 28 kg child sit now to keep balance? [3 marks]

Question 3

Question 3 – Reactions at the ends of a beam *(Section A · Skills practice)*

A uniform beam AB of length 5 m and mass 30 kg rests on supports at A and B. A load of mass 15 kg is placed on the beam 2 m from A.

a. Draw a force diagram. [2 marks]
b. By taking moments about A, find the reaction at B. [3 marks]
c. Find the reaction at A. [2 marks]

Question 4

Question 4 – A rod resting on two supports *(Section A · Skills practice)*

A uniform rod AB of length 8 m and mass 16 kg rests horizontally on supports at C

and D, where $AC = 1$ m and $BD = 2$ m.

a. Find CD. [1 mark]
b. Find the reactions at C and D. [5 marks]

Question 5

Question 5 – How far can she walk? *(Section A · Skills practice)*

A uniform plank of length 5 m and mass 20 kg rests on two supports, each 0.5 m from an end. A man of mass 50 kg walks along the plank towards one end.

a. Explain why the reaction at the far support is zero when the plank is about to tilt. [1 mark]
b. How far beyond the nearer support can he walk before the plank tilts? [3 marks]
c. Does this allow him to reach the end of the plank? [1 mark]

Question 6

Question 6 – A rod hanging from strings *(Section A · Skills practice)*

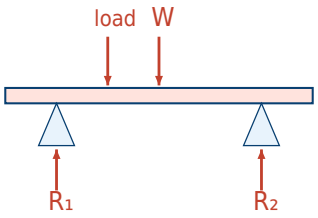
A uniform rod AB of length 1.5 m and mass 4 kg is suspended horizontally by two vertical strings attached at points 0.25 m from each end. A particle of mass 6 kg is attached to the rod at a point 0.4 m from A.

a. Find the tension in each string. [6 marks]

Question 7

Question 7 – The wheelbarrow *(Section B · Real-life practice)*

A gardener uses a wheelbarrow. The load of mass 45 kg acts 0.5 m horizontally from the axle of the wheel, and the gardener lifts the handles with a vertical force F at 1.3 m from the axle. The wheelbarrow itself is light.



a. Find F. [3 marks]
b. Find the force the ground exerts on the wheel. [2 marks]
c. The gardener moves the load 0.2 m closer to the wheel. Find the new force F and comment. [3 marks]

Question 8

Question 8 – The diving board *(Section B · Real-life practice)*

A uniform diving board AC of length 3 m and mass 24 kg is fixed at A by a bolt and rests on a support at B, where $AB = 0.8$ m. A diver of mass 60 kg stands at the free end C.

a. Show that the bolt must pull downwards on the board at A. [2 marks]
b. By taking moments about B, find the force exerted by the bolt at A. [4 marks]
c. Find the force exerted by the support at B. [2 marks]

Question 9

Question 9 – Walking across a plank *(Section B · Real-life practice)*

A uniform plank AB of length 6 m and mass 40 kg lies on two supports, at 1 m from A and at 1 m from B. A girl of mass 45 kg walks along the plank.

a. The girl stands 2 m from A. Find the reaction at each support. [5 marks]
b. Show that the plank cannot tilt, wherever she stands. [4 marks]

Question 10

Question 10 – A shelf bracket *(Section B · Real-life practice)*

A uniform shelf AB of length 2.4 m and mass 8 kg is hinged to a wall at A and supported horizontally by a light cable joining B to a point on the wall. The cable makes an angle of 50° with the shelf.

a. Show that the tension in the cable is 51.2 N, to 3 significant figures. [4 marks]
b. Find the horizontal and vertical components of the force exerted by the hinge on the shelf. [4 marks]

Question 11

Question 11 – The non-uniform plank *(Section B · Real-life practice)*

A plank of length 5 m and mass 20 kg balances horizontally about a pivot 1.8 m from end A when a child of mass 12 kg sits at A.

a. Find the distance of the centre of mass of the plank from A. [3 marks]
b. The child leaves and a child of mass 8 kg sits at B instead. Find the distance from A at which the pivot must now be placed for the plank to balance. [3 marks]

Question 12

Question 12 – The metre rule *(Section B · Real-life practice)*

A uniform metre rule has mass 120 g. It balances horizontally on a pivot placed at the 40 cm mark when a small mass m hangs at the 10 cm mark.

a. Find m. [3 marks]
b. The mass is moved to the 0 cm mark. Find the position of the pivot for balance. [3 marks]

Question 13

Question 13 – Lifting a girder *(Section B · Real-life practice)*

A uniform steel girder AB of length 8 m and mass 600 kg lies on rough horizontal ground. A crane lifts end B using a cable that makes 20° with the vertical. The girder is on the point of leaving the ground at B while end A stays on the ground.

a. Explain why the vertical component of the cable tension equals half the weight of the girder. [2 marks]
b. Find the tension in the cable. [3 marks]
c. Find the horizontal component of the cable tension, and state what force prevents the girder from sliding. [2 marks]

Question 14

Question 14 – The fishing rod *(Section B · Real-life practice)*

A uniform fishing rod of length 3 m and mass 0.8 kg is held horizontally by an angler. One hand is at the end A and the other is 0.3 m from A. A fish pulls vertically downwards with a force of 10 N at the far end B.

a. Find the vertical force exerted by the hand 0.3 m from A. [3 marks]
b. Find the vertical force exerted by the hand at A and state its direction. [3 marks]

Question 15

Question 15 – Scaffold plank *(Section C · Problem solving)*

A uniform scaffold plank AB of length 4.8 m and mass 30 kg rests horizontally on supports at C and D where $AC = 0.6$ m and $AD = 4.2$ m. A worker of mass 70 kg stands 1.0 m from A and a tool box of mass 20 kg rests 3.5 m from A.

Load	Mass (kg)	Distance from A (m)
Plank	30	2.4 (centre)
Worker	70	1.0
Tool box	20	3.5

a. Find the reactions at C and D. [5 marks]
b. The worker walks to end B. Find the new reactions and show that the plank does not tilt. [5 marks]

c. State two modelling assumptions. [2 marks]

Question 16

Question 16 – Hinge and cable *(Section C · Problem solving)*

A uniform rod AB of length 2 m and mass 10 kg is hinged to a vertical wall at A and held horizontally by a light cable from B to the wall which makes an angle of 40° with the rod. A mass of 8 kg hangs from the rod at a point 1.5 m from A.

a. Show that the tension in the cable is 168 N, to 3 significant figures. [4 marks]
b. Find the horizontal and vertical components of the force exerted on the rod by the hinge. [4 marks]
c. Find the magnitude and direction of the hinge force. [3 marks]
d. The cable is replaced by a longer one so that it makes 25° with the rod. Find the new tension and comment. [3 marks]

Question 17

Question 17 – Balancing a loaded rod *(Section C · Problem solving)*

A uniform rod of mass 6 kg and length 2 m carries four small masses, as shown in the table. The distances are measured from end A.

Mass (kg)	2	3	5	4
Distance from A (m)	0.2	0.6	1.1	1.8

a. Find the distance from A of the point at which the loaded rod balances. [4 marks]
b. The rod is placed on a pivot at that point. Find the reaction at the pivot. [1 mark]
c. The 4 kg mass is removed. Find how far the pivot must move, and in which direction, to balance. [4 marks]

Question 18

Question 18 – Weighing a plank on two scales *(Section C · Problem solving)*

A plank of length 4 m rests horizontally on two bathroom scales, one under each end. The scales read 180 N and 220 N, at A and B respectively. The plank is non-uniform.

a. Find the weight of the plank and the distance of its centre of mass from A. [4 marks]
b. A person of mass 70 kg now stands on the plank 1 m from A. Find the new reading on each scale. [5 marks]
c. The scales can each read up to 800 N. Find the greatest distance from A at which the person can stand without overloading scale B. [3 marks]

Question 19

Question 19 – Does the crate slide or tip? *(Section C · Problem solving)*

A uniform rectangular crate has width 0.6 m, height 1.2 m and mass 50 kg. It stands on a rough floor with coefficient of friction 0.4. A horizontal force P is applied at height 1.0 m above the floor, pushing the crate along the floor.

a. Find the force needed to make the crate slide. [3 marks]
b. Find the force needed to make the crate tip about its lower edge. [4 marks]
c. Which happens first? [1 mark]
d. At what height should the force be applied so that it is certain to slide rather than tip? [3 marks]

Question 20

Question 20 – Challenge: the tilting condition in general *(Section D · Challenge)*

A uniform plank of length $2L$ and mass M rests on two supports, each at a distance d from an end. A person of mass m walks towards one end.

a. Show that the plank tilts when the person is a distance $x = \dfrac{M(L-d)}{m}$ beyond the nearer support. [3 marks]
b. Hence show that the person can walk to the end without tilting if and only if $d > \dfrac{ML}{M+m}$. [3 marks]
c. Check your result with $M = 40$, $m = 45$, $L = 3$, $d = 1$. [2 marks]

Question 21

Question 21 – Challenge: the smallest tension *(Section D · Challenge)*

A uniform rod AB of weight W and length $2a$ is hinged at A and held horizontally by a light string attached at B making angle θ with the rod.

a. Show that the tension is $T = \dfrac{W}{2\sin\theta}$. [3 marks]
b. For which value of θ is the tension a minimum, and what is it? [2 marks]
c. The string can bear 80 N and $W = 100$ N. Find the smallest value of θ. [3 marks]