Moments, levers and gears

Worked solutions

GCSE science calculations

This topic online

1 Jun tightens a bolt on his bike with a spanner. He pushes on the spanner with a force of 45 N at a perpendicular distance of 0.20 m from the centre of the bolt.

Calculate the moment of the force about the bolt. (2 marks)

Moment = force × distance

$M = 45 \times 0.20$

9.0 N m

2 A classroom door is 2.0 m tall and 0.85 m wide. Ms Bello pushes on the door handle with a force of 30 N at right angles to the door. The handle is 0.75 m from the hinges.

Calculate the moment of her push about the hinges. (2 marks)

Use the distance from the hinges to the handle, 0.75 m

Moment = force × distance

$M = 30 \times 0.75$

22.5 N m

3 A mechanic in a garage in Swindon uses a wrench to loosen a nut. She applies a force of 60 N at right angles to the wrench, 25 cm from the centre of the nut.

Calculate the moment of the force about the nut in N m. (3 marks)

1 m = 100 cm

$d = 25 \div 100 = 0.25$ m

Moment = force × distance

$M = 60 \times 0.25$

15 N m

4 A tower crane on a building site holds a load of steel beams. The weight of the load is 4.5 kN. The load hangs 12 m from the tower, measured horizontally.

Calculate the moment of the load about the tower in N m. (3 marks)

1 kN = 1000 N

$F = 4.5 \times 1000 = 4500$ N

Moment = force × distance

$M = 4500 \times 12$

54 000 N m

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5 A spanner is 30 cm long in total. Lucas grips the spanner so that his hand is 24 cm from the centre of the nut. He pushes at right angles to the spanner with a force of 50 N.

Calculate the moment of his push about the nut. (3 marks)

Use the distance from the nut to his hand (24 cm), not the length of the spanner

1 m = 100 cm

$d = 24 \div 100 = 0.24$ m

Moment = force x distance

$M = 50 \times 0.24$

12 N m

6 A moment of 18 N m is needed to undo a wheel nut on a go-kart. Isla uses a wheel brace and pushes at right angles to it, 0.40 m from the nut.

Calculate the smallest force Isla must apply. (2 marks)

Moment = force x distance

$18 = F \times 0.40$

Divide both sides by 0.40

$F = 18 \div 0.40$

45 N

7 Tomasz makes a hanging display for a school corridor. A light wooden rod hangs level from a string tied at its pivot point. A model of Saturn with a weight of 3.0 N hangs from the rod 0.36 m to the left of the pivot. A model of Jupiter with a weight of 4.0 N hangs to the right of the pivot.

Calculate how far from the pivot the model of Jupiter must hang for the rod to balance. (3 marks)

Balanced: clockwise moment = anticlockwise moment

Moment = force x distance

$M = 3.0 \times 0.36 = 1.08$ N m

$4.0 \times d = 1.08$

Divide both sides by 4.0

$d = 1.08 \div 4.0$

0.27 m

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8 A bottle top needs a moment of 6.0 N m to open it. Nadia uses an opener and pushes at right angles to it with a force of 40 N.

Calculate the distance from the bottle top to where Nadia pushes. Give your answer in cm. (3 marks)

Moment = force x distance

$6.0 = 40 \times d$

Divide both sides by 40

$d = 6.0 \div 40$

$d = 0.15$ m

1 m = 100 cm

$d = 0.15 \times 100$

15 cm

9 Chidi uses a long metal bar to lift the edge of a heavy paving slab. The bar rests on a brick, which acts as the pivot.

- Chidi pushes down with a force of 250 N, 1.2 m from the pivot.
- The other end of the bar is under the slab, 0.15 m from the pivot.

Calculate the upward force the bar exerts on the slab. (3 marks)

Moment = force x distance

$M = 250 \times 1.2 = 300$ N m

Balanced: the moment on the slab side is also 300 N m

$F \times 0.15 = 300$

Divide both sides by 0.15

$F = 300 \div 0.15$

2000 N

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10 In a model winch, a small gear drives a large gear. The teeth of the two gears push on each other with the same force.

- The small gear has a radius of 3.0 cm. A motor turns it with a moment of 0.90 N m.
- The large gear has a radius of 9.0 cm.

a. Calculate the force on the teeth of the small gear.

b. Calculate the moment of this force on the large gear. Show your working. (4 marks)

a)

1 m = 100 cm

$d = 3.0 \div 100 = 0.030$ m

Moment = force x distance

$0.90 = F \times 0.030$

Divide both sides by 0.030

$F = 0.90 \div 0.030$

30 N

b)

Same force on the teeth of the large gear

1 m = 100 cm

$d = 9.0 \div 100 = 0.090$ m

Moment = force x distance

$M = 30 \times 0.090$

2.7 N m

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11 In a Year 10 practical, a metre rule balances on a pivot at its 50 cm mark. Esther hangs a 200 g mass at the 20 cm mark.

Gravitational field strength = 9.8 N/kg

a. Calculate the moment of the 200 g mass about the pivot.

b. Esther balances the rule by hanging a 150 g mass on the other side of the pivot. Calculate the mark on the rule where she hangs it. Show your working.

(5 marks)

a)

The force is the weight, not the mass. 1 kg = 1000 g

$m = 200 \div 1000 = 0.200 \text{ kg}$

Weight = mass x gravitational field strength

$W = 0.200 \times 9.8 = 1.96 \text{ N}$

Distance from the pivot, not the reading on the rule

$d = 50 - 20 = 30 \text{ cm}$

1 m = 100 cm

$d = 30 \div 100 = 0.30 \text{ m}$

Moment = force x distance

$M = 1.96 \times 0.30$

0.588 N m

b)

1 kg = 1000 g

$m = 150 \div 1000 = 0.150 \text{ kg}$

Weight = mass x gravitational field strength

$W = 0.150 \times 9.8 = 1.47 \text{ N}$

Balanced: clockwise moment = anticlockwise moment

$1.47 \times d = 0.588$

Divide both sides by 1.47

$d = 0.588 \div 1.47$

$d = 0.40 \text{ m}$

$d = 0.40 \times 100 = 40 \text{ cm}$ from the pivot

The 150 g mass is on the other side of the pivot, so add 40 cm to the 50 cm mark

$\text{mark} = 50 + 40 = 90 \text{ cm}$

90 cm mark

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12 Mr Hussain (mass 80 kg) sits on a see-saw 0.90 m from the pivot. His son Bilal (mass 25 kg) sits on the other side, 2.0 m from the pivot. Each side of the see-saw is 2.4 m long.

Gravitational field strength = 9.8 N/kg

a. Calculate the moment of Mr Hussain's weight about the pivot.

b. Calculate the moment of Bilal's weight about the pivot.

c. Bilal says he can make the see-saw balance by moving further from the pivot. Is he right? Show your working.

(5 marks)

a)

The force is the weight. Weight = mass x gravitational field strength

$W = 80 \times 9.8 = 784\ N$

Moment = force x distance

$M = 784 \times 0.90$

705.6 N m

b)

$W = 25 \times 9.8 = 245\ N$

$M = 245 \times 2.0$

490 N m

c)

Balanced: Bilal's moment must be 705.6 N m

$245 \times d = 705.6$

$d = 705.6 \div 245$

$d = 2.88\ m$

2.88 m > 2.4 m, so he cannot sit that far out

No, he is not right

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