Exercise walk-through

5.4
Moments, levers and gears – physics only (4.5.4)

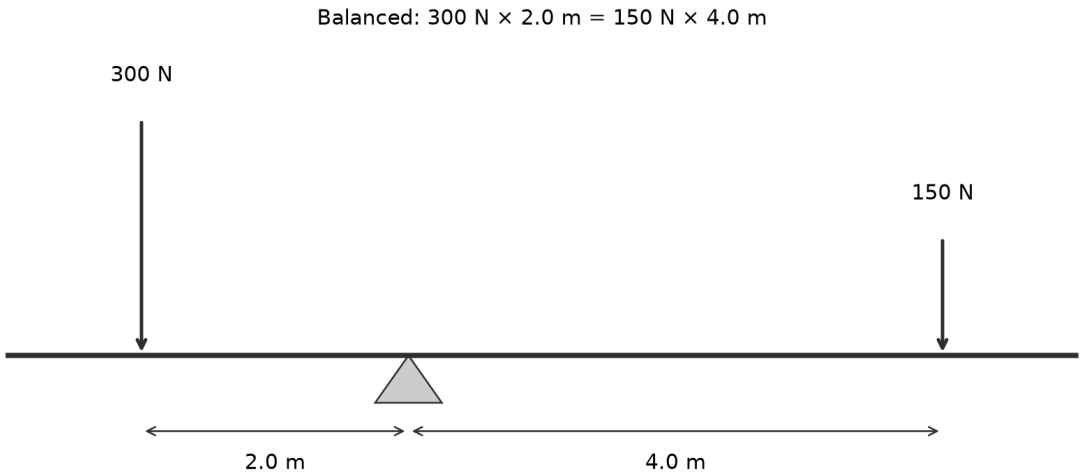
AQA · GCSE · Physics

Moments, levers and gears (physics only)

- A force can make an object turn about a pivot.
- The turning effect is called the **moment** :
- M is the **moment** in newton-metres (N m), F is the force in N, and d is the perpendicular distance from the pivot to the line of action of the force, in m.
- If an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment.

$$M = Fd$$

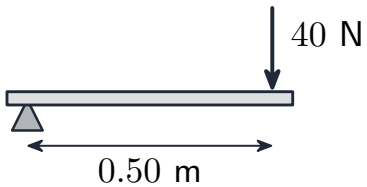
Figure: Moments, levers and gears (physics only)



- A balanced beam: 300 N at 2.0 m balances 150 N at 4.0 m.
- Match each part of the diagram to the text.

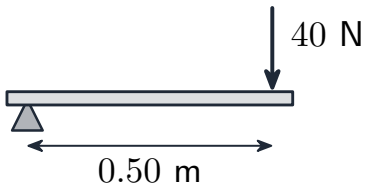
Exercise 2.1

2.1 A 40 N force acts 0.50 m from a pivot. Calculate the moment. [2]



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2.1

$$M = Fd = 40 \times 0.50 = \mathbf{20}\ \text{N} \cdot \text{m}$$

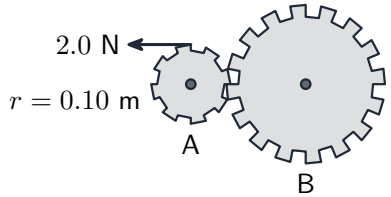
(substitution 1, answer with unit 1)

Exercise 2.2

2.2 State the balance condition for an object that does not rotate about a pivot. [1]

balanced: no rotation

2.3 A child applies a tangential force of 2.0 N at the rim of gear A, of radius 0.10 m. Gear A meshes with gear B of twice the radius. Calculate the input moment and state the output moment and relative rotation rate for ideal gears. [3]

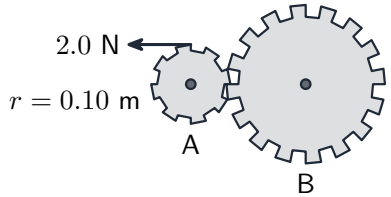


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2.2 Total clockwise moment about the pivot = total anticlockwise moment.

2.3 Moment $= 2.0 \times 0.10 = 0.20$ N · m. A gear of twice the radius turns with twice the moment at half the rate – the ideal meshed gears transmit the same tangential contact force and turn in opposite directions.

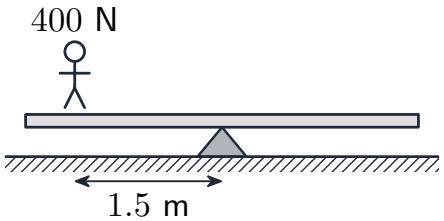
Exercise 3.1

3.1 A see-saw balances. A 400 N child sits 1.5 m left of the pivot.

(a) Calculate the anticlockwise moment. [2]

(b) A 600 N child sits right of the pivot. Calculate their distance for balance. [2]

(c) The 400 N child moves 0.5 m further from the pivot. State and explain which way the see-saw tips. [2]



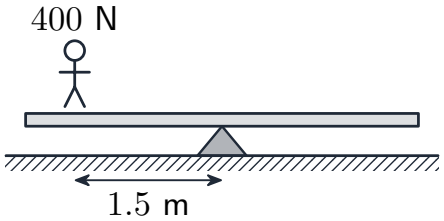
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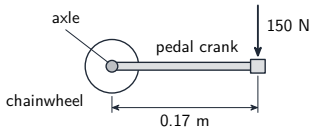
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3.1 (a) $M = 400 \times 1.5 = \mathbf{600}$ N · m anticlockwise (C1, A1). (b) Balance: $600 \times d = 600$ so $d = \mathbf{1.0}$ m (C1, A1). (c) It tips further left / down on the 400 N side: the left moment grows to $400 \times 2.0 = 800$ N · m against 600 N · m right – unbalanced anticlockwise.

Exercise 3.2

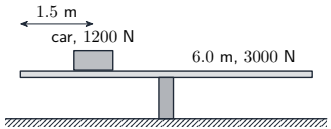
3.2 A bicycle's pedal crank is 0.17 m long; the rider pushes down with 150 N perpendicular to the crank.



(a) Calculate the moment about the axle. [2]

(b) The chain transfers this turning effect to the rear wheel's gear. Explain how gears transmit rotational effects and why a lower gear helps on a hill. [3]

3.3 A uniform 6.0 m bridge of weight 3000 N rests on a support at its centre; a 1200 N car stands 1.5 m from the left end.



(a) Explain why the bridge's own weight acts at its centre. [1]

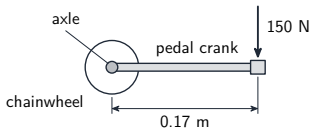
(b) Taking moments about the centre support, calculate the extra support force needed at the left end 3.0 m away. [3]

(c) State one assumption in your calculation. [1]

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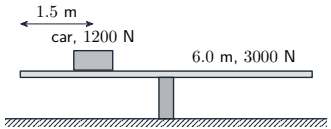
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3.2 (a) Force perpendicular to the crank, so d = crank length.

$$M = Fd = 150 \times 0.17 = 25.5 \approx \mathbf{26}\ \text{N} \cdot \text{m}\ (2\ \text{s.f.})$$

(C1, A1) (b) The chain exerts a tangential force on the rear gear's teeth, producing a

Full solution on next slide

Full solution 3.2

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(C1, A1) (b) The chain exerts a tangential force on the rear gear's teeth, producing a moment about its axle; a lower (larger) rear gear multiplies the moment at the wheel; more moment at lower rotation rate suits climbing, where the rider needs force rather than speed.

3.3 (a) A uniform object's weight acts at its centre of mass, the midpoint. (b) The car's moment about the centre: $1200 \times (3.0 - 1.5) = 1800\ \text{N} \cdot \text{m}$ anticlockwise (C1). The left support at 3.0 m must supply 1800 N · m clockwise (C1):

$$F = \frac{M}{d} = \frac{1800}{3.0} = \mathbf{600}\ \text{N}$$

(c) The car acts as a point load at its stated position / the bridge is uniform / the support is at the centre (any one, B1).