

5.4 Moments, levers and gears

Name: _____ Class: _____ Date: _____

Total: 22 marks

KEY WORDS moment

Objective

Calculate moments with $M = Fd$ (perpendicular distance), balance moments, and explain levers and gears. Physics only. Original questions for spec statement 4.5.4.

1 Key knowledge and worked examples

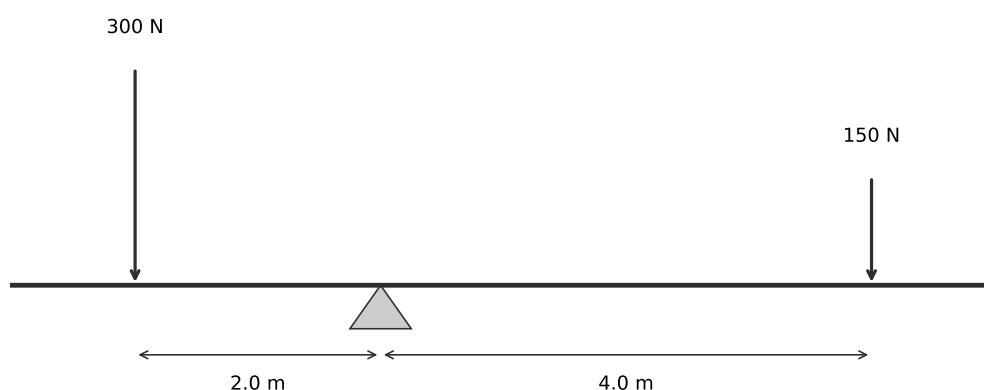
A force can make an object **rotate** about a pivot. The turning effect is the **moment** :

$$M = Fd$$

- M in $\text{N} \cdot \text{m}$; F in N ; d = **perpendicular distance from the pivot to the line of action** of the force, in m .

Balanced object: total clockwise moment = total anticlockwise moment.

$$\text{Balanced: } 300 \text{ N} \times 2.0 \text{ m} = 150 \text{ N} \times 4.0 \text{ m}$$



$$F_1 d_1 = F_2 d_2 \text{ about the pivot.}$$

Levers and gears transmit the rotational effect of a force:

- a **lever**: a small force far from the pivot balances a large force close to it (the moments balance about the pivot);

- **gears:** teeth mesh so turning one gear turns another; a smaller driver gear spinning fast turns a larger gear slowly with a bigger moment (and vice versa).

Worked example. A 300 N load sits 2.0 m left of a pivot; a person pushes down 4.0 m right of it.

- Balance: clockwise = anticlockwise.

$$F_R d_R = F_L d_L$$

$$F_R = \frac{F_L d_L}{d_R} = \frac{300 \text{ N} \times 2.0 \text{ m}}{4.0 \text{ m}} = \mathbf{150 \text{ N}}$$

- Half the force, twice the distance – that is the lever’s trade.

2 Practice

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

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

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]

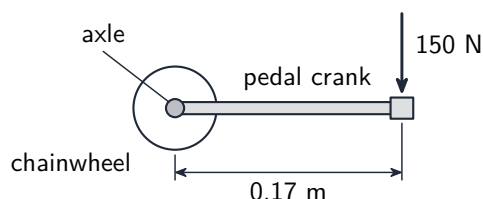
3 Exam-style questions

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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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]