Edexcel International A Level (IAL) Physics

Your notes

Moments

Contents

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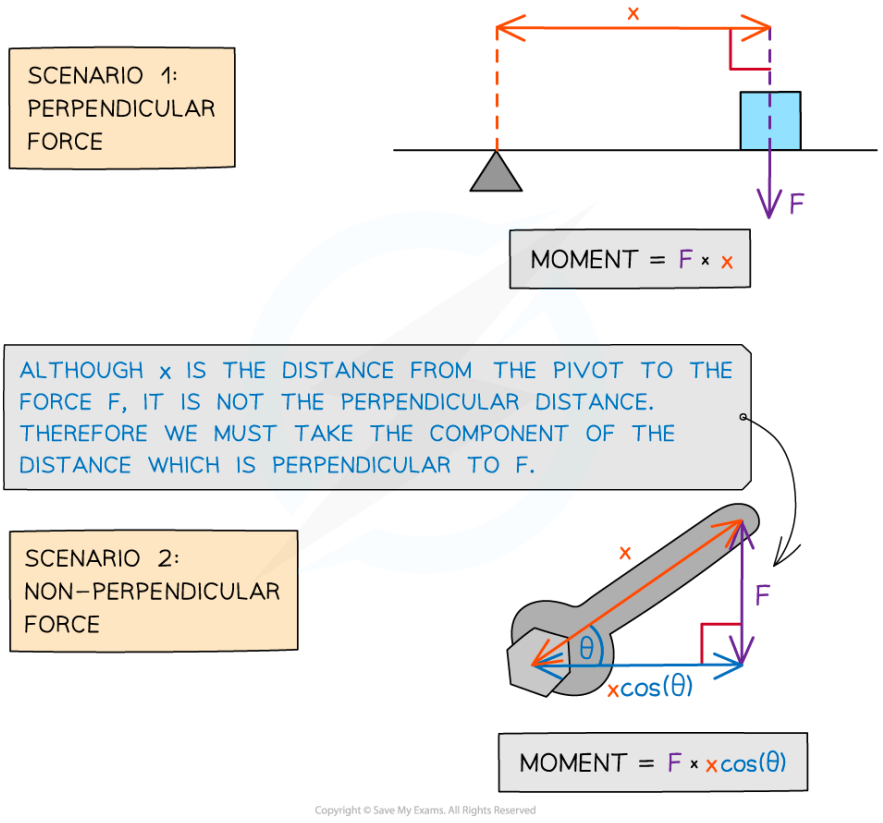
Calculating the Moment of a Force

- A moment is the **turning effect of a force**
- Moments occur when forces cause objects to **rotate** about some pivot
- The moment of a force is given by

Moment (**N m**) = Force (**N**) × perpendicular distance from the pivot (**m**)

- The SI unit for the moment is Newton metres (**N m**). This may also be Newton centimetres (**N cm**) depending on the units given for the distance



The force might not always be perpendicular to the distance

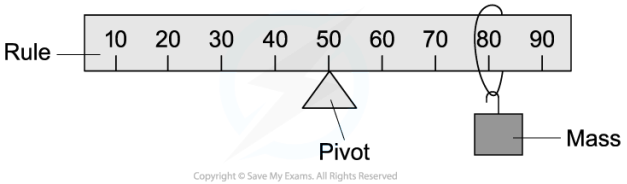
- An example of moments in everyday life is opening a door
- The door handle is placed on the other side of the door to the hinge (the pivot) to **maximise** the distance for a given force and therefore provides a greater moment (turning force)
  - This makes it easier to push or pull

Worked Example

A uniform metre rule is pivoted at the 50 cm mark.

A 0.5 kg weight is suspended at the 80 cm mark, causing the rule to rotate about the pivot.

Assuming the weight of the rule is negligible, what is the turning moment about the pivot?



Answer:

STEP 1

MOMENT = FORCE × PERPENDICULAR DISTANCE FROM THE PIVOT

STEP 2

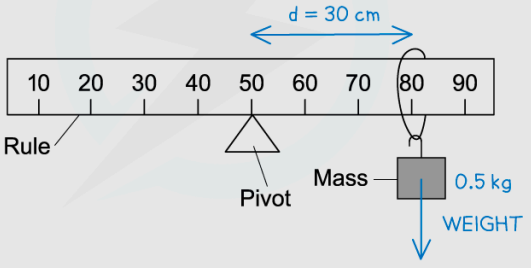
IDENTIFY THE FORCE REQUIRED

THE ONLY FORCE IS THE WEIGHT OF THE MASS ACTING DOWNWARDS

WEIGHT = mg = 0.5 × 9.81 = 4.905 N = 5 N

STEP 3

IDENTIFY THE PERPENDICULAR DISTANCE FROM THE RULE: 80 cm − 50 cm = 30 cm



STEP 4

SUBSTITUTE VALUES INTO MOMENT EQUATION

MOMENT = 5 N × 30 cm = 150 Ncm

Examiner Tips and Tricks

If not already given, drawing all the forces on an object in the diagram will help you see which ones are perpendicular to the distance from the pivot. Not all the forces will

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provide a turning effect and it is not unusual for a question to provide more forces than required to throw you off!

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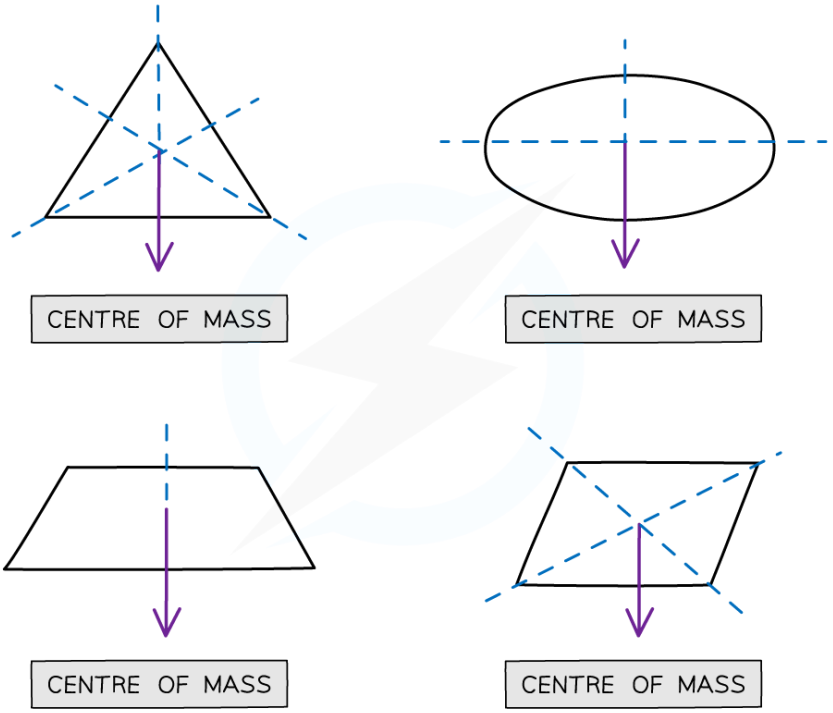
Centre of Gravity

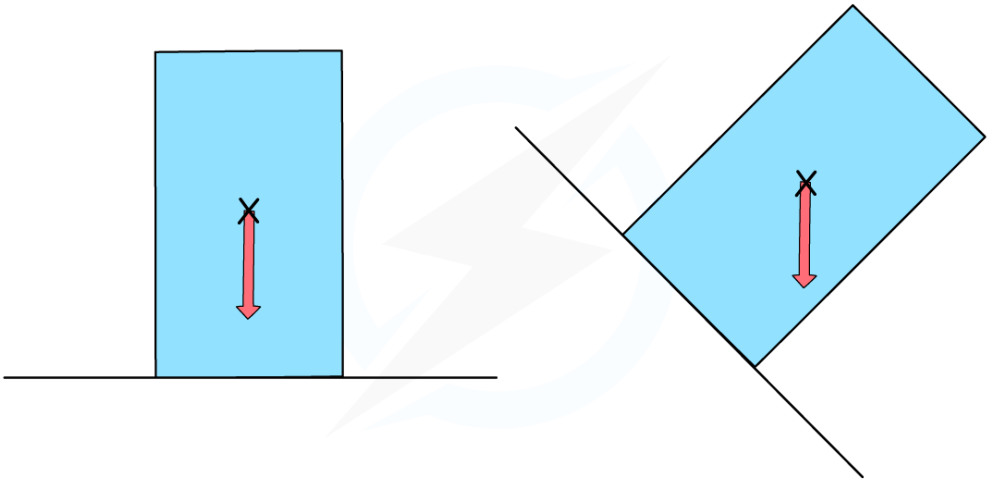
- The centre of gravity (sometimes called the centre of mass) of an object is **the point through which all the weight can be considered to act**
- The position of the centre of gravity of uniform regular solid is at its centre
  - For example, for a person standing upright, their centre of gravity is roughly in the middle of the body behind the navel, and for a sphere, it is at the centre
- For symmetrical objects with uniform density, the centre of gravity is located at the **point of symmetry**



The centre of mass of a shape can be found by symmetry

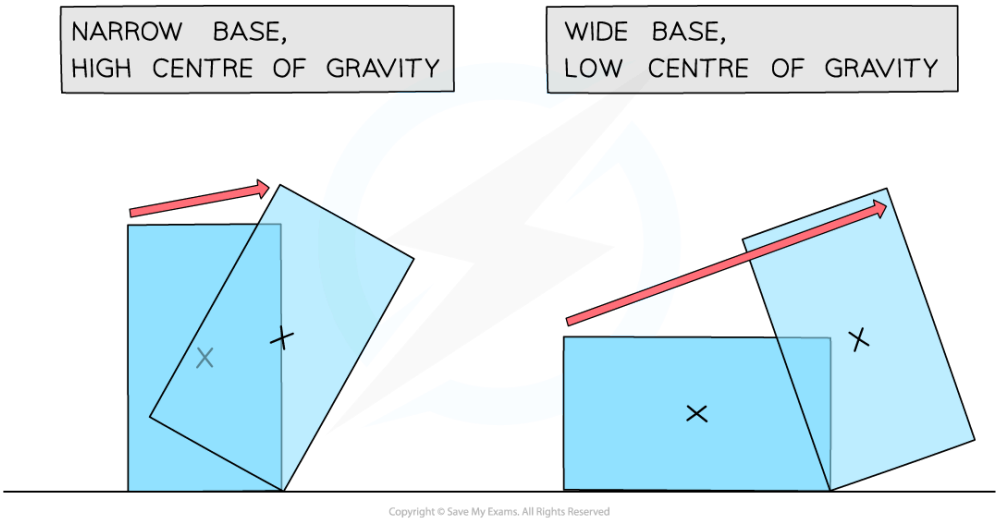
Stability

- The position of the centre of gravity of an object affects its stability
- An object is stable when its centre of gravity lies above its base



The object on the right will topple, as its centre of gravity is no longer over its base

- The **wider** base an object has, the **lower** its centre of gravity and it is more **stable**
- The **narrower** base an object has, the **higher** its centre of gravity and the object is more likely to topple over if pushed



The most stable objects have wide bases and low centres of mass

The Principle of Moments

- The principle of moments states:

  For a system to be in equilibrium, the sum of clockwise moments about a point must be equal to the sum of the anticlockwise moments (about the same point)

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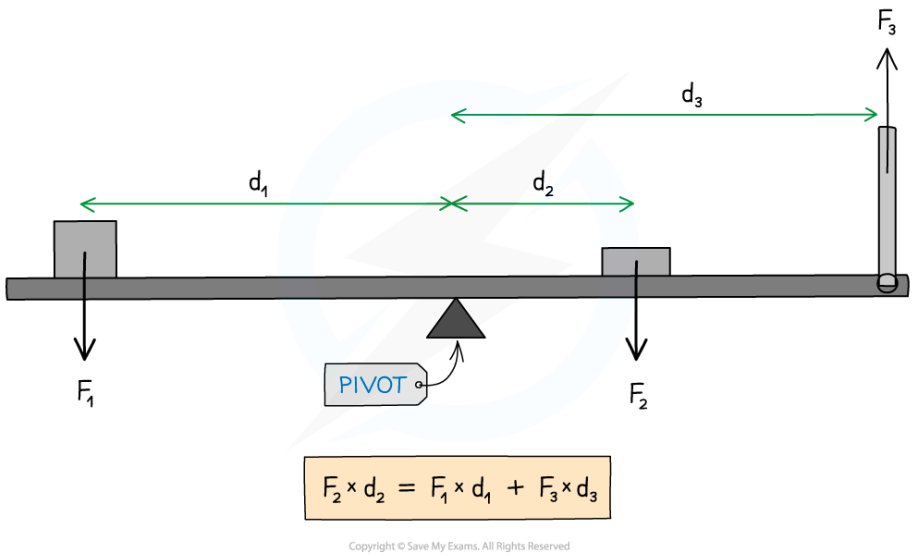


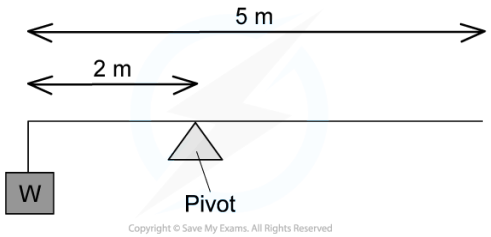
Diagram showing the moments acting on a balanced beam

- In the above diagram:
  - Force F_2 is supplying a clockwise moment;
  - Forces F_1 and F_3 are supplying anticlockwise moments
- Hence: $F_2 \times d_2 = (F_1 \times d_1) + (F_3 \times d_3)$

Worked Example

A uniform beam of weight 40 N is 5 m long and is supported by a pivot situated 2 m from one end.

When a load of weight W is hung from that end, the beam is in equilibrium, as shown in the diagram.



What is the value of W?

A. 10 N

B. 50 N

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C. 25 N

D. 30 N

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ANSWER: A

STEP 1

PRINCIPLE OF MOMENTS STATES THAT

CLOCKWISE MOMENTS = ANTICLOCKWISE MOMENTS

STEP 2

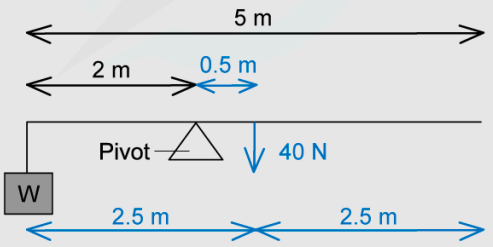
CALCULATE THE CLOCKWISE MOMENT

SINCE THE BEAM IS UNIFORM, ITS WEIGHT WILL ACT AT ITS CENTRE OF GRAVITY (THE MIDDLE)

THIS IS $5 \div 2 = 2.5$ m FROM THE END

SINCE THE PIVOT IS 2m FROM THE END, THIS FORCE IS 0.5 m FROM THE PIVOT

CLOCKWISE MOMENT = $40 \text{ N} \times 0.5 \text{ m} = 20 \text{ Nm}$



STEP 3

CALCULATE THE ANTICLOCKWISE MOMENT

ANTICLOCKWISE MOMENT = $W \times 2m$

STEP 4

EQUATE BOTH THESE MOMENTS

$20 \text{ Nm} = W \times 2m$

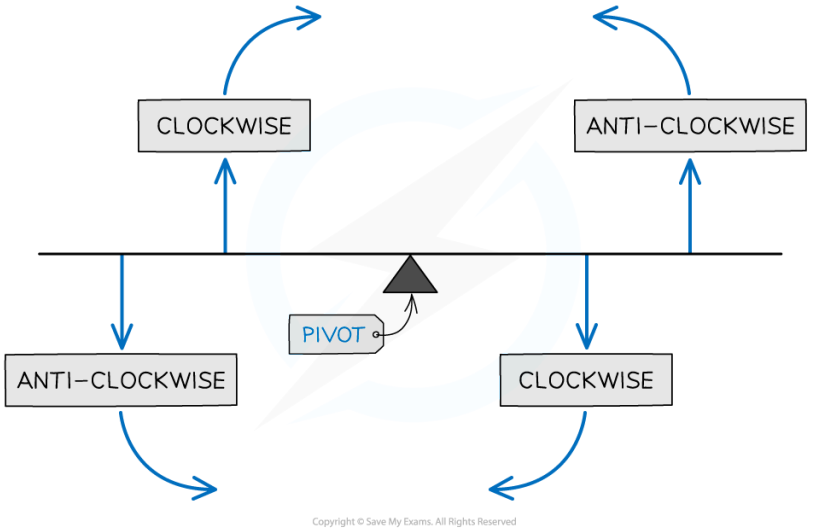
STEP 5

REARRANGE FOR W

$$W = \frac{20 \text{ Nm}}{2m} = 10 \text{ N}$$

Examiner Tips and Tricks

Make sure that all the distances are in the same units and you're considering the correct forces as clockwise or anticlockwise, as seen in the diagram below



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