



eClassroom

A-LEVEL MATHEMATICS • MECHANICS 1

Moments

Worksheet

Pearson Edexcel International A Level (WME01) & A Level (9MA0) • Calculator and statistical tables allowed: take $g = 9.8 \text{ m s}^{-2}$ and give answers to 2 or 3 s.f.

Free Moments worksheet for A-Level and International A-Level Maths, with full worked solutions



Tap a section to jump straight to it

By the end of this worksheet you can: find moments and resultant moments • solve beams on supports and ropes • find centres of mass of rods • use the point of tilting • *Stretch:* reactions as functions of position, ranges of safe positions, and models such as levers and steelyards.

Which questions are for me?

CORE The methods every A-level student must secure. Start here.

STRETCH Beams, planks and rods that must not turn: reactions, tensions, centres of mass and the point of tilting.

Every section has both, clearly labelled. Questions get harder as you go, and every skill in Sections A to D is needed in Section E.

Track your progress

Section	B	C	D	E
Core marks	23	10	13	15
Stretch marks	16	14	17	10
My score				

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A**Worked examples & Your turn**

Read each example carefully. Cover it up, then answer the question beside it using the same method.

CORE*Secure the method***Worked example A1: the moment of a force**

Find the moment about P of a 12 N force acting at right angles to a rod, 0.5 m from P

Moment = force $\times$ perpendicular distance

6 N m

Your turn A1

Find the moment about P of a 40 N force acting at right angles to a rod, 0.35 m from P

Worked example A2: resultant moment

About a point O , a 10 N force acts clockwise at 2 m and a 6 N force anticlockwise at 3 m. Find the resultant moment.

Clockwise positive: $20 - 18$

2 N m clockwise

Your turn A2

About a point O , an 8 N force acts clockwise at 2.5 m and a 5 N force anticlockwise at 3 m. Find the resultant moment.

Worked example A3: two supports

A uniform 4 m rod of weight 30 N rests on supports at its ends A and B , with 20 N hung 1 m from A . Find both reactions.

Moments about A , then resolve

$$4R_B = 30(2) + 20(1)$$

$R_B = 20 \text{ N}, R_A = 30 \text{ N}$

Your turn A3

A uniform 6 m rod of weight 60 N rests on supports at its ends A and B , with 40 N hung 2 m from A . Find both reactions.



STRETCH

Worked example A4: tilting

A uniform 3 m rod AB of weight 50 N rests on supports at A and at C , 2 m from A . Find the weight at B that makes it about to tilt.

About to tilt about C : $R_A = 0$

$$50(0.5) = W(1)$$

25 N

Your turn A4

A uniform 5 m rod AB of weight 80 N rests on supports at A and at C , 3.5 m from A . Find the weight at B that makes it about to tilt.

Worked example A5: a non-uniform rod

A non-uniform 2 m rod of weight 30 N rests on supports at its ends; $R_A = 18$ N. Find the centre of mass.

$R_B = 12$; moments about A : $12(2) = 30x$

0.8 m from A

Your turn A5

A non-uniform 3 m rod of weight 40 N rests on supports at its ends; $R_A = 25$ N. Find the centre of mass.

Worked example A6: particles on a light rod

A light rod has 2 kg at $x = 0$, 3 kg at $x = 1$ m and 5 kg at $x = 2$ m. Find the centre of mass.

$$\bar{x} = \frac{\sum mx}{\sum m}$$

$$\frac{0 + 3 + 10}{10}$$

1.3 m

Your turn A6

A light rod has 1 kg at $x = 0$, 4 kg at $x = 0.5$ m and 3 kg at $x = 1.5$ m. Find the centre of mass.

Worked example A7: ropes

A uniform 5 m beam of weight 120 N hangs from ropes at A and at D , 1 m from B . Find both tensions.

Moments about A : $4T_D = 120(2.5)$

$T_D = 75$ N, $T_A = 45$ N

Your turn A7

A uniform 6 m beam of weight 90 N hangs from ropes at A and at D , 1.5 m from B . Find both tensions.



B**Fluency**

Each question is a designed sequence. From one part to the next, ask yourself: what changed, and what did it do to the answer?

CORE*Secure the method*

- B1** A uniform 5 m plank of weight 400 N rests on supports at its ends A and B . A 600 N cart is x m from A
- (a) Find R_B in terms of x (b) Find R_A in terms of x
- (c) Find x when $R_A = R_B$ (d) Find x when $R_A = 2R_B$
- [4 marks]
- B2** A uniform 4 m board of weight 300 N hangs from ropes at its ends A and B . A 700 N painter stands 1 m from A
- (a) Find T_B (b) Find T_A
- (c) Where must he stand for equal tensions? (d) Find T_A when he stands at B
- [4 marks]
- B3** A non-uniform 4 m pole AB of weight 150 N has its centre of mass 1.6 m from A . It is carried horizontally by two people.
- (a) People at A and B : find the force at B (b) Find the force at A
- (c) The person at B moves 1 m in: find their force (d) Find the force at A now
- [4 marks]
- B4** A uniform 6 m plank of weight 240 N rests on supports at A and at C , 4 m from A . A 360 N child walks from C towards B
- (a) How far beyond C before it tilts? (b) How far is the child from A then?
- (c) Find the reaction at C then (d) How far beyond C for a 480 N child?
- [4 marks]



CORE

continued: centres of mass

- B5** A light 2 m rod AB carries 4 kg at A , 1 kg 1.2 m from A and 3 kg at B
- (a) Find the distance of the centre of mass from A
- (b) State where a single support must be placed for balance.
- (c) Find the reaction at that support. [3 marks]
- B6** A non-uniform 3 m rod of weight 90 N rests on supports at its ends A and B , with $R_A = 60$ N
- (a) Find R_B
- (b) Find the centre of mass from A
- (c) 30 N is hung at B : find R_B
- (d) Find R_A now [4 marks]

STRETCH

- B7** A non-uniform 1 m rod of weight 6 N, centre of mass 0.3 m from A , pivots at C , 0.35 m from A . A load L N hangs at A ; a 4 N weight slides on CB , d m from C
- (a) Find d for balance with no load
- (b) Find d when $L = 5$
- (c) Find the greatest load it can weigh
- (d) Find the force on the pivot when $L = 5$ [4 marks]
- B8** A light 1.5 m bar rests on a pivot 0.2 m from end A . A 900 N load presses down at A
- (a) Find the force at B to lift it
- (b) Find the force on the pivot
- (c) The pivot moves to 0.15 m from A : find the force
- (d) The bar is uniform, weight 20 N (pivot 0.2 m): find the force [4 marks]
- B9** A non-uniform 4 m beam hangs from ropes at its ends A and B , with $T_A = 120$ N and $T_B = 80$ N
- (a) Find the weight
- (b) Find the centre of mass from A
- (c) 100 N is hung at B : find T_B
- (d) Find T_A now [4 marks]
- B10** A uniform 6 m beam of weight 300 N rests on supports C and D , 1 m from A and 1 m from B . A 200 N load is x m from A
- (a) Find both reactions if $R_C = 2R_D$
- (b) Find x then
- (c) Find x for equal reactions
- (d) Find R_D with the load at A [4 marks]



C**Reasoning**

Show your working and explain your thinking. A correct answer without a reason does not score full marks.

CORE*Secure the method*

- C1** A 40 N weight hangs 1.5 m from end A of a rod resting on a support at C , where $AC = 0.5$ m. Ama writes its moment about C as 40×1.5
Explain her error, and find the moment. [2 marks]
- C2** A rod of weight 50 N rests on two supports. Ben writes its moment about one support as $50g \times 1.2$
Explain his error. [2 marks]
- C3** A beam rests on supports at C and D and is about to tilt about D . Cal writes $R_D = 0$
Explain his error. [3 marks]
- C4** A non-uniform plank of length 4 m is used in a question. Dee takes its weight to act 2 m from each end.
Explain her error. [3 marks]

STRETCH

- C5** In part (a) a beam hangs from ropes with $T_A = 65$ N. In part (b) a load is added. Eli uses $T_A = 65$ N again in part (b)
Explain his error. [3 marks]
- C6** A beam of weight 200 N is “modelled as a rod”. Faye says this means the beam is light.
Explain her error, and state what the rod model does assume. [3 marks]
- C7** A uniform beam hangs from two ropes that are not at its ends. Gus says the tensions must be equal because the beam is horizontal.
Explain why he is wrong. [3 marks]
- C8** A uniform beam AB of length l and weight W rests on supports at A and B . A load L is placed x from A
- (a) Show that $R_B = \frac{W}{2} + \frac{Lx}{l}$ and find R_A (3)
- (b) Hence explain how R_B changes as the load moves towards B (2)
- [5 marks]



D**Problem solving**

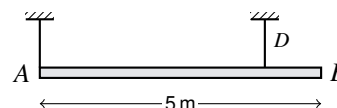
You decide the method. Read the whole question first, and show every step.

CORE

Secure the method

- D1** A uniform plank AB has length 5 m and weight 40 N. It hangs in equilibrium in a horizontal position from two light vertical ropes, one attached at A and the other attached at a point D on the plank. The tension in the rope at D is 25 N

Find the distance AD and the tension in the rope at A



[3 marks]

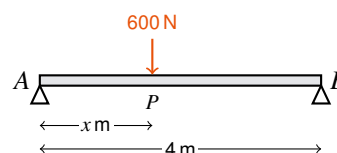
- D2** A non-uniform plank AB of length 4 m and weight 200 N has its centre of mass 1.5 m from A . It rests horizontally on supports at A and B . A person of weight 600 N stands on the plank at P , where $AP = x$ m

(a) Show that the reaction at B is $(75 + 150x)$ N

(2)

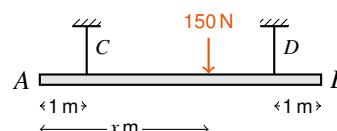
(b) Find x when the reaction at A is three times the reaction at B

(2)



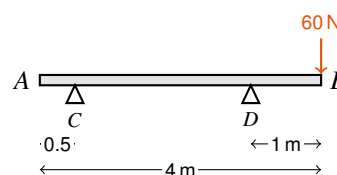
[4 marks]

- D3** A uniform beam AB of length 6 m and weight 300 N hangs horizontally from two vertical ropes attached at C and D , where $AC = 1$ m and $DB = 1$ m. A load of 150 N hangs from the beam x m from A . The tension in the rope at D is twice the tension in the rope at C
- Find the value of x



[3 marks]

- D4** A uniform shelf AB of length 4 m and weight 100 N rests horizontally on two brackets at C and D , where $AC = 0.5$ m and $DB = 1$ m. A box of weight 60 N is placed on the shelf at the end B
- Find the reactions at C and D



[3 marks]



STRETCH

- D5** A non-uniform rod AB of length 2 m and weight W newtons hangs from a single vertical string. When the string is attached at a point 0.8 m from A , the rod hangs horizontally in equilibrium with nothing attached. When the string is attached at the midpoint M of the rod, the rod hangs horizontally only when a 3 N weight is hung at A

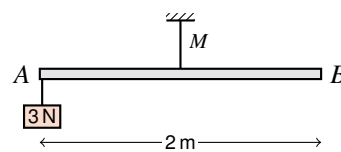
(a) Write down the distance of the centre of mass from A

(1)

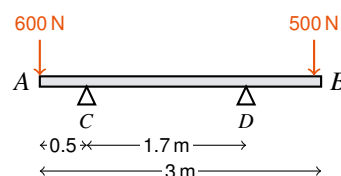
(b) Find the value of W

(3)

[4 marks]



- D6** A uniform bench AB of length 3 m and weight 150 N rests horizontally on trestles at C and D , where $AC = 0.5$ m and $CD = 1.7$ m. A person of weight 600 N sits at A , and a second person of weight 500 N sits on the bench so that the reactions at C and D are equal. Find the distance of the second person from A



[4 marks]

- D7** A wheelbarrow is modelled as a rod AB of length 1.5 m, with the wheel at A and the handles at B . The wheelbarrow has weight 150 N acting 0.7 m from A and carries a load of weight 400 N acting 0.5 m from A . A gardener holds it horizontally by a vertical force F at B

(a) Find F

(2)

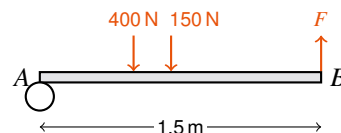
(b) Find the force on the wheel.

(1)

(c) Find F if the load is moved to 0.3 m from A

(1)

[4 marks]



- D8** A non-uniform beam AB of length 6 m and weight 300 N rests horizontally on supports at C and D , where $AC = 1$ m and $DB = 1.5$ m. The reaction at D is twice the reaction at C

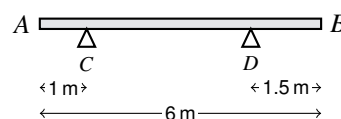
(a) Find the distance of the centre of mass from A

(3)

(b) A child of weight 400 N stands at A . Find the reaction at D

(2)

[5 marks]



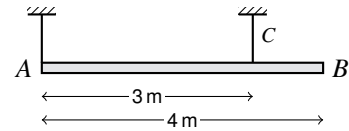
E**Exam practice**

Full-size exam questions in the style of WME01. Write your answers in the spaces, and show every step.

CORE

Exam questions for everyone

- E1** A uniform beam AB has length 4 m and mass 20 kg. The beam hangs in equilibrium in a horizontal position from two light vertical ropes. One rope is attached at A and the other rope is attached at the point C on the beam, where $AC = 3$ m. The beam is modelled as a uniform rod, and the ropes are modelled as light inextensible strings.



- (a) Using the model, find the tension in each rope.

(3)

A load of mass 15 kg is now attached to the beam at B . The load is modelled as a particle, and the beam remains horizontal and in equilibrium.

- (b) Using the model, find the new tension in the rope at C

(2)

The load at B is removed and replaced by a different load of mass M kg, also attached at B . The beam is now on the point of turning about C

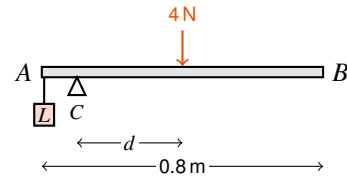
- (c) Using the model, find the value of M , explaining how you have used the fact that the beam is on the point of turning.

(2)

(Total for Question E1 is 7 marks)



- E2** A steelyard is a device for weighing loads. It is modelled as a non-uniform rod AB of length 0.8 m and weight 10 N, whose centre of mass is 0.05 m from A . The rod is pivoted at C , where $AC = 0.1$ m, and a load of weight L newtons hangs from A . A weight of 4 N can slide along CB ; when the rod rests horizontally in equilibrium, this weight is d m from C . The load and the sliding weight are modelled as particles.



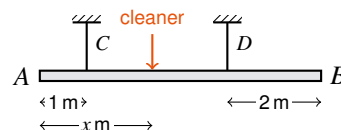
- (a) Using the model, find the value of d when there is no load at A (2)
- (b) Show that $d = 0.025L + 0.125$ (2)
- (c) Find the greatest load that the steelyard can weigh, given that the sliding weight must stay on CB (2)
- (d) Find the magnitude of the force exerted on the rod by the pivot when the greatest load is weighed. (2)

(Total for Question E2 is 8 marks)



STRETCH

- E3** A window cleaner stands on a platform AB of length 6 m and mass 40 kg, which hangs horizontally from two vertical cables attached at C and D , where $AC = 1$ m and $DB = 2$ m. The window cleaner has mass 80 kg and stands at a point P , where $AP = x$ m. Each cable will break if its tension exceeds 900 N. The platform is modelled as a uniform rod and the window cleaner as a particle.



- (a) Show that the tension in the cable at C is $\frac{1}{3}(360 - 80x)g$ newtons.

(3)

- (b) Find the tension in the cable at D in terms of x and g

(1)

- (c) Using the model, find the range of values of x for which the platform remains horizontal, neither cable becomes slack, and neither cable breaks.

(4)

- (d) State how you have used the assumption that the platform is uniform, and give one other modelling assumption you have made.

(2)

(Total for Question E3 is 10 marks)

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