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INTERNATIONAL A LEVEL MATHEMATICS • MECHANICS 1

# Mechanics 1

Exam Questions by Topic

Pearson Edexcel International Advanced Level (WME01/01) • Calculator allowed • Take  $g = 9.8 \text{ m s}^{-2}$

Multi-step exam questions at the difficulty of the real WME01 paper, with a full mark scheme

| Chapters (tap a chapter to jump to it)                                                                                  | Qs | Marks | Page           | My score |
|-------------------------------------------------------------------------------------------------------------------------|----|-------|----------------|----------|
| <b>1 Mathematical Models in Mechanics</b><br>Not examined on its own: modelling ideas are tested within Chapters 2 to 8 | —  | —     | Not applicable |          |
| <b>2 Constant Acceleration</b><br>Motion graphs, the suvat formulae, vertical motion under gravity                      | 10 | 82    | own PDF        |          |
| <b>3 Vectors in Mechanics</b><br>Resultants, velocity and position vectors, $\mathbf{r} = \mathbf{r}_0 + \mathbf{v}t$   | 10 | 81    | own PDF        |          |
| <b>4 Dynamics of a Particle Moving in a Straight Line</b><br>$F = ma$ , connected particles, pulleys, lifts             | 10 | 82    | own PDF        |          |
| <b>5 Forces and Friction</b><br>Resolving forces, friction, inclined planes                                             | 10 | 86    | own PDF        |          |
| <b>6 Momentum and Impulse</b><br>Conservation of momentum, impulse                                                      | 10 | 81    | own PDF        |          |
| <b>7 Statics of a Particle</b><br>Equilibrium, limiting friction                                                        | 10 | 82    | own PDF        |          |
| <b>8 Moments</b><br>Beams and rods, tilting, non-uniform rods                                                           | 10 | 82    | 2              |          |

[Full mark scheme](#)

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## CHAPTER 8 • KEY SKILLS

## 8

## Moments

Specification M1: Moments • 10 questions • 82 marks • about 98 minutes

**1 Moment of a force**

Moment = force  $\times$  perpendicular distance from the point, in N m. State clockwise or anticlockwise.

**2 Resultant moment**

Add the moments about one point, counting clockwise as positive (or anticlockwise). Zero resultant moment means no turning.

**3 Equilibrium**

Resolve vertically and take moments about one point, or take moments about two points. Choose a point where an unknown force acts.

**4 Uniform or not**

A uniform rod's weight acts at its midpoint. For a non-uniform rod, let the centre of mass be  $x$  m from one end.

**5 Tilting**

On the point of tilting about  $D$ : the reaction at the other support (or the tension in the other rope) is zero. Take moments about  $D$ .

**6 Ranges**

For no tilting, both reactions must be  $\geq 0$ : each tilting case gives one end of the range of positions.

**7 Relationships**

" $R_C = 2R_D$ " or "the tensions are equal": write the forces in one unknown before taking moments.

**8 Weights and masses**

A mass  $m$  kg has weight  $mg$  N. If a weight is given in newtons, do not multiply by  $g$  again.

**9 Modelling**

Rod: rigid, stays straight. Uniform: weight at the middle. Particle: weight acts at a single point.

**Skills map** every skill above is tested at least once; interleaved skills come from GCSE or other chapters

| Skill                                                  | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
|--------------------------------------------------------|----|----|----|----|----|----|----|----|----|-----|
| Marks                                                  | 6  | 6  | 6  | 6  | 6  | 10 | 10 | 11 | 10 | 11  |
| 1 Moment of a force                                    | •  | •  | •  | •  | •  | •  | •  | •  | •  | •   |
| 2 Resultant moment                                     |    |    |    |    | •  |    |    |    | •  | •   |
| 3 Equilibrium                                          | •  | •  | •  |    |    | •  | •  | •  | •  | •   |
| 4 Uniform or not                                       | •  |    |    | •  |    |    |    | •  |    | •   |
| 5 Tilting                                              |    |    | •  | •  |    | •  | •  | •  |    |     |
| 6 Ranges                                               |    |    |    |    |    | •  | •  |    |    | •   |
| 7 Relationships                                        |    | •  |    |    |    |    |    | •  |    |     |
| 8 Weights and masses                                   |    |    |    | •  |    |    |    |    |    | •   |
| 9 Modelling                                            | •  | •  |    |    |    |    | •  |    | •  |     |
| Interleaved: forming and solving linear equations (P1) |    |    |    |    | •  |    |    | •  | •  |     |
| Interleaved: linear inequalities (P1)                  |    |    |    |    |    | •  | •  |    |    | •   |
| Interleaved: simultaneous equations (P1)               |    | •  |    | •  |    |    |    | •  |    | •   |

**Exam difficulty.** Questions 1 to 5 check each skill on its own. Questions 6 to 10 are multi-step questions built like the last questions on a real WME01 paper, where one part leads into the next and skills from different topics are combined.

**Must learn.** Draw the rod with every force and every distance marked. Take moments about the point where the force you do not want acts. Each moments equation must be dimensionally correct: force  $\times$  distance in every term.



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A horizontal beam is shown with a pin support at point A and a roller support at point C. The distance between the supports is indicated as 1 m.

### Figure 1

(a) Find the magnitude of the reaction on the plank at  $C$ . (3)

**(b)** Find the magnitude of the reaction on the plank at  $A$ . **(2)**

**(c)** State how you have used the fact that the plank is uniform. **(1)**

## Question 1 continued

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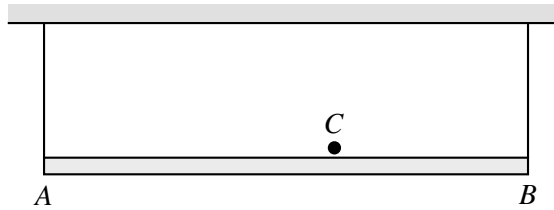


Figure 2

A uniform beam  $AB$ , of length 4 m and mass 30 kg, hangs in equilibrium in a horizontal position from two vertical ropes attached to the beam at  $A$  and at  $B$ . A load of mass 20 kg is attached to the beam at the point  $C$ , as shown in Figure 2. The tension in the rope at  $B$  is 1.5 times the tension in the rope at  $A$ . The load is modelled as a particle and the ropes as light inextensible strings.

(a) Find the tension in each rope.

(3)

(b) Find the distance  $AC$ .

(2)

(c) State how you have used the modelling assumption that the beam is a rod.

(1)



## Question 2 continued

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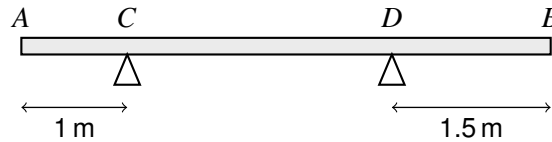


Figure 3

A uniform rod  $AB$  has length 5 m and mass 20 kg. It rests horizontally on two supports at  $C$  and  $D$ , where  $AC = 1$  m and  $DB = 1.5$  m, as shown in Figure 3. A particle of mass  $m$  kg is placed on the rod at  $B$  and the rod remains in equilibrium.

(a) Find the greatest possible value of  $m$ .

(3)

(b) Given instead that  $m = 10$ , find the reactions at  $C$  and at  $D$ .

(3)



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## Question 3 continued

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When a vertical force of magnitude 30 N is applied downwards at  $A$ , the rod is on the point of tilting about  $C$ . When instead a vertical force of magnitude 50 N is applied downwards at  $B$ , the rod is on the point of tilting about  $D$ .

**(6)**

## Question 4 continued

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5. A light rod  $AB$  has length 3 m. Particles of mass 2 kg, 5 kg and 3 kg are attached to the rod at  $A$ , at the point  $C$  where  $AC = 1$  m, and at  $B$  respectively.

(a) Find the distance from  $A$  of the point at which the rod can be supported so that it rests horizontally in equilibrium.

(3)

(b) The rod is suspended from this point by a single vertical string. Find the tension in the string.

(1)

A further particle of mass 1 kg is attached to the rod at  $A$ .

(c) Find how far, and in which direction, the string must be moved for the rod to rest horizontally.

(2)

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## Question 5 continued

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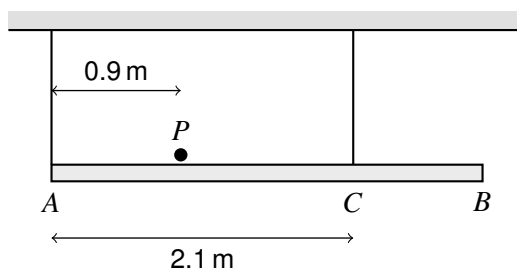


Figure 5

A uniform beam  $AB$ , of length 3 m and mass 60 kg, is held in a horizontal position by two vertical cables, one attached at  $A$  and the other at the point  $C$  on the beam, where  $AC = 2.1$  m. A particle  $P$  of mass 40 kg is attached to the beam 0.9 m from  $A$ , as shown in Figure 5.

(a) Show that the tension in the cable at  $C$  is 588 N. (3)

(b) Find the tension in the cable at  $A$ . (1)

The cable at  $C$  will break if the tension in it exceeds 800 N.

(c) Find the greatest distance from  $A$  at which  $P$  can be attached without the cable at  $C$  breaking. (3)

$P$  is removed, and a particle of mass  $M$  kg is attached to the beam at  $B$ . The beam is now on the point of tilting about  $C$ .

(d) Find the value of  $M$ . (3)



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## Question 6 continued

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## Question 7 continued

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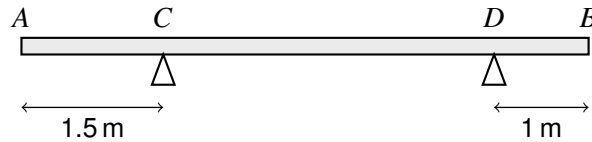


Figure 7

A non-uniform rod  $AB$  has length 6 m and mass 18 kg. It rests horizontally on two supports at  $C$  and  $D$ , where  $AC = 1.5$  m and  $DB = 1$  m, as shown in Figure 7. The reaction on the rod at  $C$  is twice the reaction on the rod at  $D$ .

(a) Find the distance of the centre of mass of the rod from  $A$ . (5)

(b) Find the greatest mass of a particle that can be placed on the rod at  $B$  without the rod tilting. (3)

The support at  $D$  is removed and replaced by a support at the point  $E$ . A particle of mass 5 kg is placed on the rod at  $A$ , and the reactions at  $C$  and  $E$  are now equal.

(c) Find the distance  $AE$ . (3)



## Question 8 continued

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## Question 8 continued

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A horizontal beam is shown with points A, C, and B marked. A fulcrum is located at point C. A dimension line below the beam indicates the distance from A to C is 2.5 m.

### Figure 8

**(d)** Give two criticisms of the model. **(2)**

## Question 9 continued

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**Question 9 continued**

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Diagram of a beam AB of length 4 m. A bolt is at A, and a roller support is at C, which is 1 m from A. The distance from C to B is 3 m.

## Question 10 continued

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**TOTAL FOR CHAPTER 8 IS 82 MARKS**

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