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

[Full mark scheme](#)

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CHAPTER 7 • KEY SKILLS

7

Statics of a Particle

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

1 Equilibrium

The resultant force is zero: resolve in two perpendicular directions and set each total to 0. No ma term.

2 Choosing directions

Resolve perpendicular to a force you do not need, so it does not appear. On a plane: parallel and perpendicular to it.

3 Strings

The tension acts along the string, away from the particle. Over a smooth pulley the tension is the same on both sides.

4 Triangle of forces

Three forces in equilibrium form a closed triangle: the sine rule gives

$$\frac{T_1}{\sin A} = \frac{T_2}{\sin B} = \frac{W}{\sin C}$$

5 Forces in components

Equilibrium: the $\mathbf{i}$ (east) parts add to 0 and the $\mathbf{j}$ (north) parts add to 0.

Removing one force leaves a resultant equal and opposite to it.

6 Friction at rest

$F \leq \mu R$: friction takes whatever value is needed, up to μR . $F = \mu R$ only when on the point of slipping.

7 Limiting cases

About to slip down: friction acts up the plane; about to slip up: friction acts down. Each case gives one end of a range.

8 Inequalities

"Remains at rest" gives $F \leq \mu R$, so $\mu \geq \frac{F}{R}$. Keep the inequality the right way round.

9 Normal reaction

R acts perpendicular to the surface and may be reduced (or reversed, for a ring on a rod) by a pull.

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 Equilibrium	•	•	•	•	•	•	•	•	•	•
2 Choosing directions	•			•	•	•		•		•
3 Strings	•					•	•			•
4 Triangle of forces	•						•			
5 Forces in components		•		•						
6 Friction at rest			•		•	•		•	•	•
7 Limiting cases					•	•		•	•	•
8 Inequalities			•						•	•
9 Normal reaction			•			•		•	•	
Interleaved: $F = ma$ and friction in motion (Chapters 4 and 5)		•				•				•
Interleaved: vectors and exact trigonometry (Chapter 3, P1)		•	•		•	•	•	•		•
Interleaved: linear inequalities (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 every force, including R and friction, with friction opposing the direction in which the particle would move. Find R from the perpendicular resolution, including every force with a component in that direction.



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A diagram showing a weight suspended from a horizontal ceiling by two strings. The left string is labeled AC and makes an angle of 30° with a dashed horizontal line. The right string is labeled BC and makes an angle of 45° with the same dashed horizontal line. The ceiling is represented by a thick horizontal line at the top. The weight is represented by a black dot at point C .

A particle C of mass 4 kg hangs in equilibrium, supported by two light inextensible strings AC and BC attached to fixed points A and B on a horizontal ceiling. The strings AC and BC are inclined to the horizontal at 30° and 45° respectively, as shown in Figure 1.

(6)

Question 1 continued

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(Total for Question 1 is 6 marks)



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2. [In this question, $\mathbf{i}$ and $\mathbf{j}$ are perpendicular horizontal unit vectors.]

A particle P of mass 2 kg rests on a smooth horizontal surface. Three horizontal forces $(3\mathbf{i} - 4\mathbf{j})\text{ N}$, $(p\mathbf{i} + 2\mathbf{j})\text{ N}$ and $(-5\mathbf{i} + q\mathbf{j})\text{ N}$ act on P , and P is in equilibrium.

- (a) Find the value of p and the value of q .

(2)

The force $(-5\mathbf{i} + q\mathbf{j})\text{ N}$ is now removed.

- (b) Find the magnitude of the acceleration of P and the angle its direction makes with $\mathbf{i}$.

(4)

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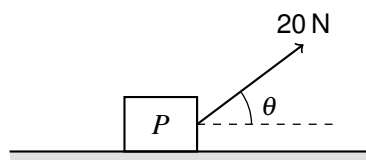


Figure 2

A particle P of weight 40 N lies at rest on a rough horizontal surface. A force of magnitude 20 N is applied to P at an angle θ above the horizontal, where $\tan \theta = \frac{3}{4}$, as shown in Figure 2. The coefficient of friction between P and the surface is μ . The particle remains at rest.

- (a) Find the magnitude of the normal reaction on P . (2)
- (b) Show that $\mu \geq \frac{4}{7}$. (3)
- (c) Describe the equilibrium of P when $\mu = \frac{4}{7}$. (1)



Question 3 continued

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- (2)**

Question 4 continued

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5. A particle of mass 2 kg rests on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{7}{24}$. The particle is on the point of slipping down the plane.

(a) Show that the coefficient of friction between the particle and the plane is $\frac{7}{24}$

(2)

A force acting up the plane along a line of greatest slope is now applied to the particle.

(b) Find the least magnitude of this force that will make the particle move up the plane.

(3)

(c) State the direction of the friction force in part (b), giving a reason.

(1)

Question 5 continued

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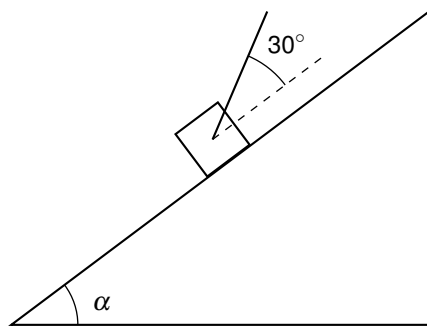


Figure 3

A box of mass m rests on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$. A light string is attached to the box and is held so that it makes an angle of 30° with the plane, above a line of greatest slope, as shown in Figure 3. The tension in the string is $\frac{1}{2}mg$ and the box is on the point of slipping down the plane. The box is modelled as a particle.

(a) Find, in terms of m and g , the normal reaction on the box. (3)

(b) Show that the coefficient of friction between the box and the plane is $\frac{12 - 5\sqrt{3}}{11}$. (4)

The string is now cut.

(c) Show that the box slides down the plane, and find its acceleration. (3)



Question 6 continued

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Question 6 continued

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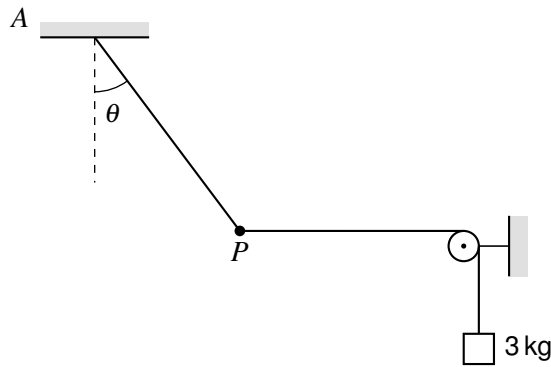


Figure 4

A particle P of mass 4 kg is attached to one end of a light inextensible string whose other end is fixed at the point A . A second light inextensible string is attached to P , passes over a small smooth fixed pulley and carries a particle of mass 3 kg hanging freely. P hangs in equilibrium with the second string horizontal between P and the pulley and with AP inclined at an angle θ to the vertical, as shown in Figure 4.

- (a) Find the value of θ and the tension in AP .

(5)

The 3 kg particle is replaced by a particle of mass M kg, and P hangs in equilibrium with AP inclined at 45° to the vertical and the second string still horizontal.

- (b) Find the value of M .

(2)

- (c) State how you have used the fact that the pulley is smooth.

(1)

- (d) For the original 3 kg particle, find the magnitude of the force exerted on the pulley by the string.

(2)



Question 7 continued

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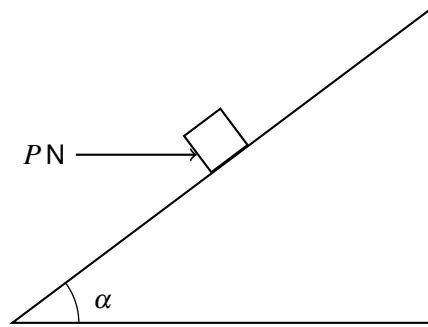


Figure 5

A particle of mass 2 kg is held at rest on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{3}{4}$, by a horizontal force of magnitude P newtons, as shown in Figure 5. The line of action of the force lies in a vertical plane containing a line of greatest slope. The coefficient of friction between the particle and the plane is 0.25.

- (a) Find the least possible value of P . (5)
- (b) Find the greatest possible value of P . (4)
- (c) Given that $P = 15$, find the magnitude and direction of the friction force acting on the particle. (2)



Question 8 continued

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Question 8 continued

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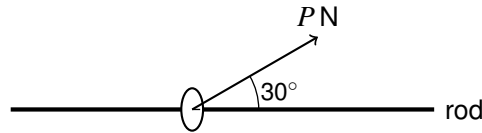


Figure 6

A small ring of mass 0.4 kg is threaded on a fixed rough horizontal rod. A force of magnitude P newtons is applied to the ring at an angle of 30° above the horizontal, as shown in Figure 6, in the vertical plane containing the rod. The coefficient of friction between the ring and the rod is 0.5 . The ring is modelled as a particle.

- (a) Given that $P = 1.5$, show that the ring remains at rest, and find the friction force acting on it. (4)
- (b) Find the greatest value of P for which the ring remains at rest. (4)
- (c) Explain why, for large values of P , the normal reaction on the ring acts downwards, and why this does not allow the ring to stay at rest. (2)



Question 9 continued

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Question 9 continued

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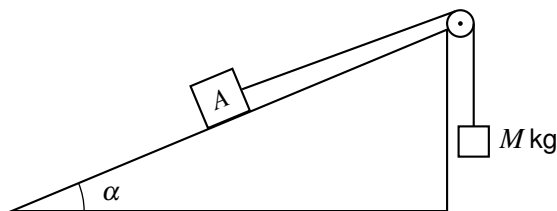


Figure 7

A particle A of mass 5 kg lies on a rough plane inclined at an angle α to the horizontal, where $\tan \alpha = \frac{5}{12}$. It is attached to a light inextensible string which passes over a small smooth pulley at the top of the plane and carries a particle of mass $M\text{ kg}$ hanging freely, as shown in Figure 7. The part of the string from A to the pulley lies along a line of greatest slope. The coefficient of friction between A and the plane is 0.2 . The system is in equilibrium.

(a) Show that the least possible value of M is 1 . (4)

(b) Find the greatest possible value of M . (3)

(c) Find the value of M for which there is no friction acting on A . (1)

The hanging particle is replaced by one of mass 4 kg and the system is released from rest.

(d) Find the acceleration of A . (3)



Question 10 continued

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TOTAL FOR CHAPTER 7 IS 82 MARKS

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