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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	2	
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	own PDF	
8 Moments Beams and rods, tilting, non-uniform rods	10	82	own PDF	

[Full mark scheme](#)

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CHAPTER 4 • KEY SKILLS

4

Dynamics of a Particle Moving in a Straight Line

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

1 Force diagrams

Mark every force: weight mg , normal reaction R , tension T , thrust, resistance. Mass in kg, weight in newtons.

2 Newton's second law

Resultant force in the direction of the acceleration $= ma$. Put g in the weight, never in the ma term.

3 Vertical motion and lifts

Upwards: $T - mg = ma$. Decelerating upwards means a acts downwards. The floor pushes up on a passenger with force R .

4 Forces as vectors

$\mathbf{F}_1 + \mathbf{F}_2 + \dots = m\mathbf{a}$. Then

$|\mathbf{a}| = \sqrt{a_1^2 + a_2^2}$: give a magnitude when asked, not a vector.

5 Connected particles

Whole system for a (internal forces cancel), then one part for the tension or thrust. A towbar can push (thrust).

6 Pulleys

Light inextensible string and smooth pulley: same tension both sides, same acceleration. Force on the pulley: add the two tensions as vectors.

7 Newton's third law

B pushes on A with the same size force as A pushes on B , in the opposite direction.

8 When the motion changes

If a string breaks or goes slack, find the new acceleration. The final speed of one stage starts the next.

9 Modelling

Light: same tension throughout the string. Inextensible: same acceleration. Smooth pulley: no friction at the pulley.

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	10	10	12
1 Force diagrams			•	•	•	•	•			•
2 Newton's second law	•	•	•	•	•	•	•	•	•	•
3 Vertical motion and lifts				•	•	•	•			
4 Forces as vectors	•								•	
5 Connected particles			•	•			•	•		
6 Pulleys						•				•
7 Newton's third law			•				•			
8 When the motion changes					•	•	•	•		•
9 Modelling						•				•
Interleaved: constant acceleration and vertical motion (Chapter 2)		•	•		•	•		•		•
Interleaved: vectors, magnitude, direction (Chapter 3)	•								•	•
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 a separate force diagram for each particle. Write each equation of motion for one named particle (or the whole system) with its own mass in the ma term. After using $g = 9.8$, give answers to 2 or 3 s.f.



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

Three forces $(3\mathbf{i} - 2\mathbf{j})$ N, $(-\mathbf{i} + 5\mathbf{j})$ N and $(p\mathbf{i} + q\mathbf{j})$ N act on a particle P of mass 0.5 kg. The acceleration of P is $(8\mathbf{i} - 6\mathbf{j}) \text{ m s}^{-2}$

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

(3)

(b) Find the magnitude of the acceleration of P .

(1)

(c) Find the angle between the acceleration of P and the vector $\mathbf{i}$

(2)

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Question 1 continued

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(Total for Question 1 is 6 marks)



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(2)

Question 2 continued

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3. A car of mass 1200 kg is towing a trailer of mass 400 kg along a straight horizontal road using a light rigid horizontal towbar. The resistances to motion of the car and of the trailer are modelled as constant forces of magnitude 300 N and 100 N respectively. When the car and trailer are moving at 20 ms^{-1} , the driver applies the brakes, which produce a constant braking force of 3000 N on the car only.

(a) Find the deceleration of the car and trailer.

(2)

(b) Find the magnitude of the force in the towbar, stating whether it is a tension or a thrust.

(3)

(c) Find the distance travelled from the instant the brakes are applied until the car stops.

(1)

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Question 3 continued

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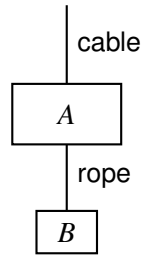


Figure 1

A crane lifts two crates vertically. Crate *A*, of mass 200 kg, is attached to the crane's cable. Crate *B*, of mass 50 kg, hangs below *A*, attached to it by a light inextensible rope, as shown in Figure 1. The crates are modelled as particles and air resistance is ignored. The crates are moving upwards and the tension in the cable is 2800 N.

- (a) Find the acceleration of the crates. (2)
- (b) Find the tension in the rope. (2)
- (c) Find the tension in the cable when the crates move upwards at constant speed. (1)
- Later, the crates are moving downwards and slowing down with deceleration 0.6 ms^{-2}
- (d) Find the tension in the rope. (1)



Question 4 continued

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5. A ball of mass 0.5 kg is projected vertically upwards with speed 18 m s^{-1} . The air resistance acting on the ball is modelled as a constant force of magnitude 1.1 N .

(a) Find the deceleration of the ball as it moves upwards. (2)

(b) Find the greatest height above the point of projection reached by the ball. (2)

(c) Find the speed of the ball when it returns to the point of projection. (2)

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Question 5 continued

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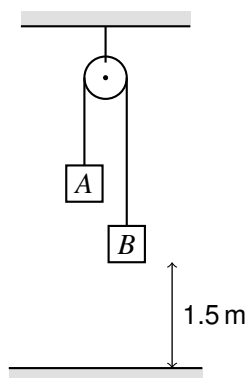


Figure 2

Two particles A and B , of mass 2 kg and 3 kg respectively, are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed in a horizontal ceiling. The particles hang with the string taut and the hanging parts of the string vertical. B is 1.5 m above horizontal ground, as shown in Figure 2. The system is released from rest. In the subsequent motion, A does not reach the pulley.

- (a) Find the acceleration of B and the tension in the string while both particles are moving. (5)
- (b) Find the speed of B at the instant it reaches the ground. (2)
- B does not rebound from the ground.
- (c) Find the greatest height of A above its initial position. (2)
- (d) State how you have used the fact that the string is inextensible. (1)



Question 6 continued

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Question 6 continued

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Figure 3

(a) Show that the acceleration of the lift is 1.2 ms^{-2} **(3)**

(b) Find the magnitude of the force exerted by B on A . **(2)**

(c) Find the magnitude of the force exerted by the floor of the lift on A . **(2)**

Later, the lift is moving upwards and decelerating at a constant rate, and the force exerted by the floor of the lift on A is 440 N .

(d) Find the deceleration of the lift and the tension in the cable. **(3)**

Question 7 continued

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Question 7 continued

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Question 8 continued

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Question 8 continued

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9. [In this question, $\mathbf{i}$ and $\mathbf{j}$ are horizontal unit vectors directed due east and due north respectively.]

A particle P of mass 2 kg moves on a smooth horizontal surface under the action of two forces $(4\mathbf{i} - 2\mathbf{j})\text{ N}$ and $(p\mathbf{i} + 6\mathbf{j})\text{ N}$, where p is a constant. The resultant of the two forces is parallel to the vector $(\mathbf{i} + 2\mathbf{j})$.

- (a) Find the value of p . (3)

- (b)** Find the magnitude of the acceleration of P . **(2)**

At time $t = 0$, P is moving with velocity $(3\mathbf{i} - 4\mathbf{j}) \text{ m s}^{-1}$

- (c)** Find the time at which P is moving due east, and its speed at this time. **(3)**

- (d)** Find the distance travelled by P from $t = 0$ to this time. **(2)**

Question 9 continued

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Question 9 continued

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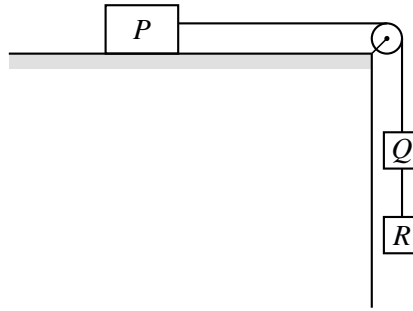


Figure 4

A particle P of mass 5 kg lies on a smooth horizontal table. It is attached to a light inextensible string which passes over a small smooth pulley at the edge of the table. The other end of the string is attached to a particle Q of mass 2 kg. A particle R of mass 3 kg hangs below Q , attached to Q by a second light inextensible string, as shown in Figure 4. The system is released from rest with both strings taut, and P does not reach the pulley.

- (a) Find the acceleration of P and the tension in the string between P and Q . (4)
- (b) Find the tension in the string between Q and R . (2)
- (c) Find the magnitude of the force exerted on the pulley by the string. (2)
- After 0.5 s the string between Q and R breaks.
- (d) Find the new acceleration of P . (2)
- (e) Find the distance that P moves in the 0.5 s after the string breaks. (2)



Question 10 continued

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TOTAL FOR CHAPTER 4 IS 82 MARKS

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