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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	2	
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 6 • KEY SKILLS

6

Momentum and Impulse

Specification M1: Momentum and impulse • 10 questions • 81 marks • about 97 minutes

1 Momentum

Momentum = mv , in N s. It has a direction: choose a positive direction and give each velocity a sign.

2 Impulse

Impulse = change in momentum
 $= mv - mu$, measured in the direction of the impulse. For a constant force,
 $I = Ft$

3 Conservation of momentum

Total momentum before = total momentum after, when the only impulses are between the two particles.

4 Directions

Draw before and after diagrams. A negative answer for a velocity means the particle moves in the opposite direction.

5 Joining and jerks

Particles that coalesce, or are joined by a string that becomes taut, move with a common velocity afterwards.

6 Equal and opposite

The impulse on P equals the impulse on Q in size, in the opposite direction. Use the particle you know most about.

7 Magnitudes and units

A speed and the magnitude of an impulse are positive. Impulse in N s; no g in an impulse.

8 Before and after

Use suvat or $F = ma$ to find the speed just before a collision, then again for the motion after it.

9 Conditions

" P reverses direction" means its new velocity has the opposite sign: this gives an inequality, e.g. $k < 8$

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	11
1 Momentum	•	•	•	•	•	•	•	•	•	•
2 Impulse	•	•	•	•	•	•	•	•	•	•
3 Conservation of momentum	•		•	•		•	•	•	•	•
4 Directions	•	•	•		•		•		•	•
5 Joining and jerks	•			•				•	•	
6 Equal and opposite		•	•	•		•	•	•		•
7 Magnitudes and units	•	•	•	•		•		•	•	•
8 Before and after						•		•	•	•
9 Conditions					•		•			•
Interleaved: constant acceleration, two objects (Chapter 2)						•		•	•	•
Interleaved: $F = ma$ and friction (Chapters 4 and 5)		•				•		•		•
Interleaved: linear inequalities, algebra (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 before and after diagrams with arrows and a positive direction. Put the correct mass with each velocity. Give speeds and magnitudes of impulses as positive values, with units N s.



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1. Two railway trucks A and B , of masses 25 tonnes and 15 tonnes, move towards each other along a straight horizontal track. Immediately before they collide, A has speed 3 m s^{-1} and B has speed 1 m s^{-1} . In the collision the trucks join together.

(a) Find the speed of the trucks immediately after the collision, and state their direction of motion.

(3)

(b) Find the magnitude of the impulse exerted on B in the collision, stating the units of your answer.

(3)

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Question 1 continued

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(Total for Question 1 is 6 marks)



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2. A ball of mass 0.2 kg is moving horizontally with speed 12 m s^{-1} when it hits a vertical wall at right angles. It rebounds along the same line with speed 8 m s^{-1} . The ball is modelled as a particle.

(a) Find the magnitude of the impulse exerted on the ball by the wall.

(3)

The ball is in contact with the wall for 0.05 s .

(b) Find the magnitude of the average force exerted on the ball by the wall.

(2)

(c) State the magnitude and direction of the impulse exerted on the wall by the ball.

(1)

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Question 2 continued

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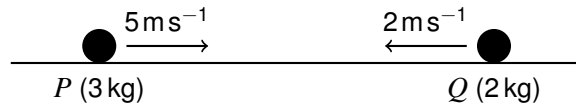


Figure 1

Two particles P and Q , of masses 3 kg and 2 kg , move towards each other along the same straight line on a smooth horizontal plane. Immediately before they collide, P has speed 5 ms^{-1} and Q has speed 2 ms^{-1} , as shown in Figure 1. Immediately after the collision, P moves with speed 1 ms^{-1} in the same direction as before.

- (a) Find the speed of Q immediately after the collision, and state its direction of motion. (3)
- (b) Find the magnitude of the impulse exerted on P in the collision. (2)
- (c) Write down the magnitude of the impulse exerted on Q , giving a reason. (1)



Question 3 continued

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4. Two particles A and B , of masses 2 kg and 3 kg , lie at rest on a smooth horizontal plane, connected by a light inextensible string which is slack. A is projected directly away from B with speed 6 ms^{-1} . When the string becomes taut, B is jerked into motion.
- (a) Explain why A and B move with the same speed immediately after the string becomes taut, and find this speed. (3)
- (b) Find the magnitude of the impulse exerted on B by the string. (2)
- (c) State how you have used the fact that the plane is smooth. (1)

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5. A particle P of mass $2m$ is moving in a straight line on a smooth horizontal surface with speed $3u$. It receives an impulse of magnitude λmu in the direction opposite to its motion.
- (a) Given that P then moves in the opposite direction with speed u , find the value of λ . (3)
- (b) Given instead that $\lambda = 4$, find the speed of P after the impulse and state its direction of motion. (2)
- (c) Find the range of values of λ for which the direction of motion of P is reversed. (1)

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Question 5 continued

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6. A particle A of mass 0.4 kg is projected with speed 6 ms^{-1} from a point O across a rough horizontal table, towards a particle B of mass 0.6 kg which is at rest 2 m from O . The coefficient of friction between each particle and the table is 0.25 . A collides directly with B . Immediately after the collision, A moves with speed 0.5 ms^{-1} in its original direction.

- (a) Find the speed of A immediately before the collision. (3)
- (b) Find the speed of B immediately after the collision. (2)
- (c) Find the magnitude of the impulse exerted on B in the collision. (2)
- (d) Find the distance between A and B when they have both come to rest. (3)



Question 6 continued

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Diagram showing three spheres A, B, and C on a horizontal surface. Sphere A has mass $2m$ and is moving to the right with velocity $4u$. Sphere B has mass m and is at rest. Sphere C has mass $3m$ and is at rest.

Three particles A , B and C , of masses $2m$, m and $3m$ respectively, lie in a straight line on a smooth horizontal surface, as shown in Figure 2. B and C are at rest. A is projected towards B with speed $4u$ and collides directly with B . Immediately after this collision, A moves with speed u in its original direction.

- (b)** Find, in terms of m and u , the magnitude of the impulse exerted on A . **(2)**

B then collides directly with C . Immediately after this collision, B moves with speed ku in its original direction.

- (d)** Find the range of values of k for which there are no further collisions between the particles. **(4)**

Question 7 continued

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Question 7 continued

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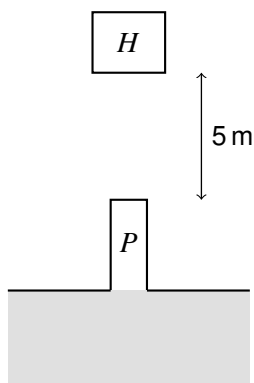


Figure 3

A pile driver consists of a hammer H of mass 400 kg which is released from rest 5 m above the top of a vertical pile P of mass 100 kg, as shown in Figure 3. The hammer falls freely and strikes the pile. Immediately after the impact, the hammer and the pile move downwards together. The ground exerts a constant resistance on the pile, and the pile is driven 0.2 m into the ground before coming to rest. The hammer and pile are modelled as particles.

- (a) Find the speed of the hammer immediately before it strikes the pile. (2)
- (b) Find the speed of the hammer and pile immediately after the impact. (2)
- (c) Find the magnitude of the impulse exerted on the pile by the hammer. (2)
- (d) Find the magnitude of the resistance exerted by the ground. (4)



Question 8 continued

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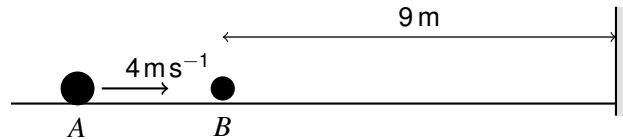


Figure 4

Two particles A and B , of masses 3 kg and 1 kg , lie on a smooth horizontal floor on a straight line perpendicular to a vertical wall. B is at rest, 9 m from the wall. A moves towards B with speed 4 m s^{-1} , as shown in Figure 4, and collides directly with B . Immediately after the collision, A moves towards the wall with speed 2 m s^{-1}

(a) Find the speed of B immediately after the collision.

(2)

B hits the wall and rebounds along the same line with speed 3 m s^{-1}

(b) Find the magnitude of the impulse exerted on B by the wall.

(2)

(c) Find the time between the two collisions of A and B , and the distance from the wall at which the second collision occurs.

(4)

In the second collision, A and B join together.

(d) Find their velocity immediately after the second collision.

(2)



Question 9 continued

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Question 9 continued

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10. Two particles P and Q , of masses $2m$ and km respectively, move towards each other along the same straight line on a smooth horizontal surface. Immediately before they collide, P has speed $3u$ and Q has speed u . In the collision the direction of motion of P is reversed and immediately afterwards P has speed u .

(a) Find, in terms of m and u , the magnitude of the impulse exerted on P , and explain why it does not depend on k . (2)

(b) Find, in terms of k and u , the velocity of Q immediately after the collision, taking the original direction of motion of P as positive. (3)

(c) Find the range of values of k for which the direction of motion of Q is reversed. (2)

Given that Q moves with speed $3u$ immediately after the collision,

(d) find the value of k . (2)

After the collision, Q moves onto a rough horizontal surface where the coefficient of friction between Q and the surface is 0.5.

(e) Find, in terms of u and g , the distance that Q travels on the rough surface before coming to rest. (2)



Question 10 continued

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TOTAL FOR CHAPTER 6 IS 81 MARKS

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