



Mathematics Paper 2

Structured Questions

Model Paper 2025

Time Allowed: 1 hour 15 minutes

Total Marks: 50

You must answer on the question paper.

You must bring a soft pencil (preferably type B or HB), a clean eraser, and a dark blue or black pen. You will also need geometrical instruments.

Calculators are allowed.

Before attempting the paper, write your name, candidate number, centre name, and centre number clearly in the designated spaces.

Instructions for Candidates

- Answer all questions.
 - Write your answer to each question in the space provided.
 - Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
 - You must show all necessary working clearly.
 - Do not use an erasable pen or correction fluid.
 - Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.
 - Avoid writing over any barcodes printed on the paper.
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Information for Candidates

- This paper consists of a total of **50 marks**.
 - The number of marks assigned for every question or its parts is indicated within brackets [].
 - A formula sheet will be provided with this paper.
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Please read all questions carefully and follow the instructions exactly to ensure your responses are properly evaluated.

1

A car of mass 1000 kg starts from rest on a straight horizontal road. The engine produces a constant driving force of 2400N and the resistive forces total 400N.

(a) Write the equation of resultant force and find the acceleration.

Resultant Force =

a = [3]

(b) Find the speed after 10 s.

v = [2]

(c) The driver now brakes uniformly to rest over 50 m. Find the braking force.

F = [2]

(d) Explain one reason why modelling the resistive force as constant may be unrealistic.

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[2]

2

A crate of mass 25kg slides down a rough slope inclined at 25° to the horizontal. The coefficient of friction is 0.3.

(a) Draw a labelled force diagram.

[2]

(b) Find the frictional force.

$$F = \dots\dots\dots [2]$$

(c) Use Newton's Second Law to find the downward acceleration of the crate.

$$a = \dots\dots\dots [3]$$

(d) If the crate starts from rest and moves 10 m, find its speed at the bottom.

$$v = \dots\dots\dots [2]$$

(e) Explain how changing the surface material would affect the model.

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[1]

3

A small motor lifts a 12 kg load vertically from rest to a height of 5 m in 4 s , overcoming gravity and frictional resistance of 15 N .

(a) Calculate the work done against gravity.

Work done = [2]

(b) Find the total work done by the motor.

Total Work done = [2]

(c) Find the average power output of the motor.

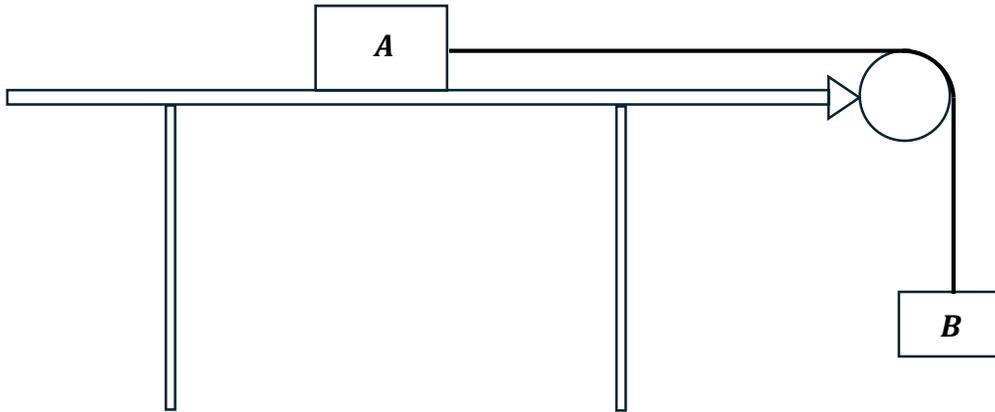
Average Power Output =[2]

(d) Manufacturer claims motor is 85% efficient. Estimate the electrical energy supplied in 4 s.

Input Energy = [2]

4

Two blocks A (3 kg) and B (2 kg) are connected by a light inextensible string over a smooth pulley. A rests on a smooth horizontal table; B hangs vertically.



(a) Draw forces on each block on the diagram above.

[2]

(b) Find the acceleration of the system.

$a = \dots\dots\dots$ [3]

(c) Find the tension in the string.

$$T = \dots\dots\dots [2]$$

(d) Discuss one assumption made about the pulley or string and how relaxing it would affect the result.

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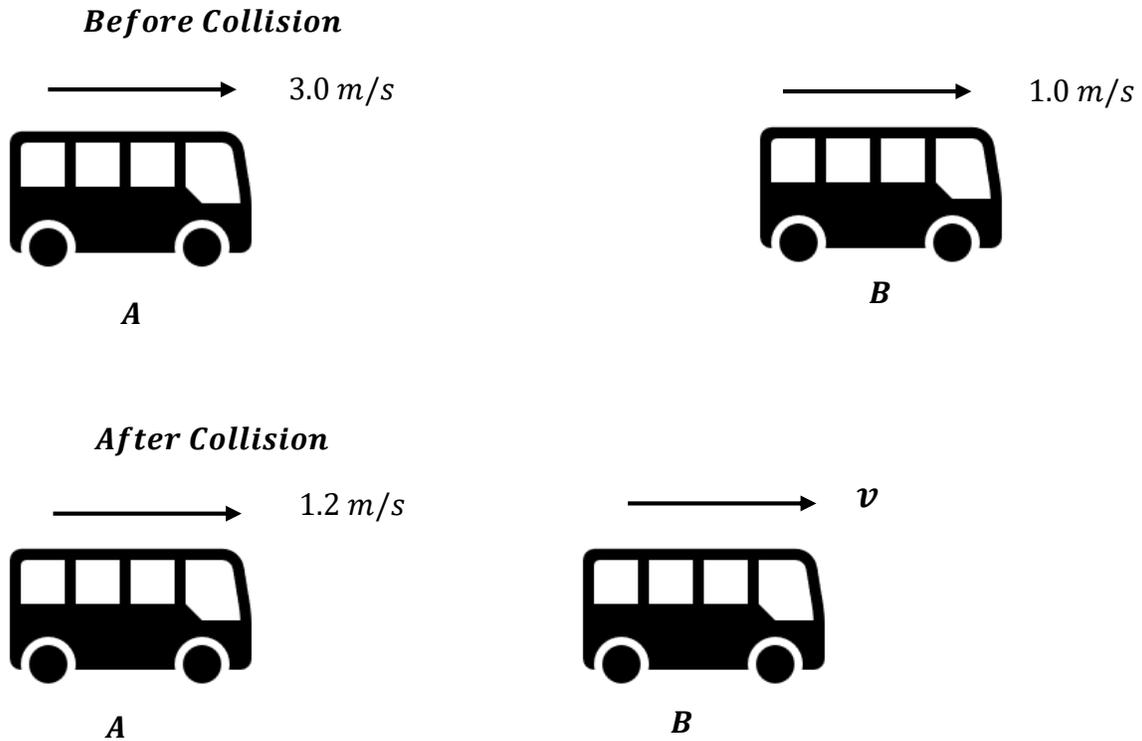
[3]

5

Two trolleys collide on a smooth horizontal track.

Before collision, trolley A (2 kg) was moving at 3.0 m/s and trolley B (3 kg) at 1.0 m/s in the same direction.

After the collision, trolley A moves at 1.2 m/s.



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

$v = \dots\dots\dots$ [3]

(b) Find the coefficient of restitution e .

$e = \dots\dots\dots$ [2]

(c) Explain what would happen if the collision were perfectly inelastic.

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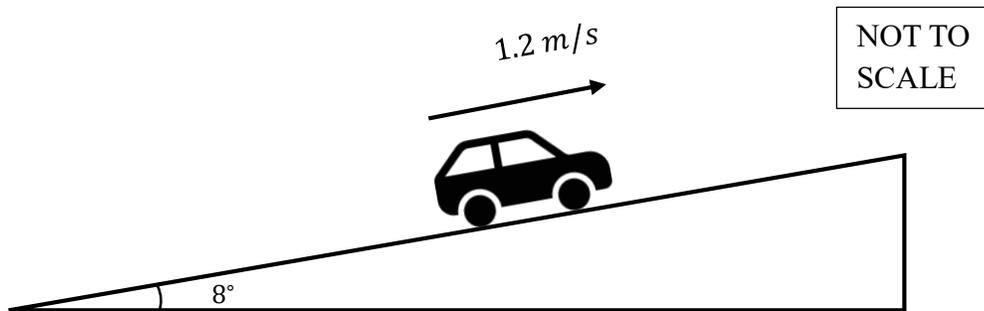
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[1]

6

A 900 kg car travels up a hill inclined at 8° . When the engine is switched off the initial speed was 12.0 m/s and resistive forces add up to 600 N .



(a) Find the distance S the car travels up the hill before coming to rest.

Distance= [3]

- (b) The car travels up the hill with decreasing speed until it comes to rest.
Find the time t it takes for the car to reach at rest.

$t = \dots\dots\dots$ [2]

- (c) State and explain one simplification made in this model and how it affects the stopping distance.

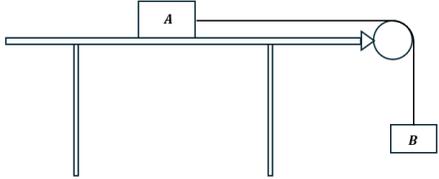
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[2]

Model Paper 2 Marking Scheme

Question	Solution	Notes
Q1	A car of mass 1000 kg starts from rest on a straight horizontal road. The engine produces a constant driving force of 2400 N and the resistive forces total 400 N.	
(a) Write the equation of resultant force and find the acceleration.	Resultant force = $2400 - 400 = 2000\text{N}$. Using $F = ma$ $\Rightarrow 2000 = 1000a$ $\Rightarrow a = 2.0\text{m s}^{-2}$.	M1 for resultant forces set-up A1 for substitution of forces A1 for correct value of a with its correct unit
(b) Find the speed after 10 s.	$v = u + at$ $v = 0 + 2(10) = 20\text{m/s}$	M1 for correct use of equation of motion A1 for correct value of v with its correct unit
(c) The driver now brakes uniformly to rest over 50 m. Find the braking force.	$v^2 = u^2 + 2as$ $0 = 20^2 + 2a(50)$ $a = -4\text{m s}^{-2}$. $F = ma$ $F = 1000(-4) = -4000\text{N}$. Braking force = 4000 N (opposing motion).	M1 for correct use of equation of motion A1 for correct value of F with its correct unit
(d) Explain one reason why modelling the resistive force as constant may be unrealistic.	In reality, air resistance increases with speed; as the car accelerates, the resistive force would rise, reducing the actual acceleration and increasing the braking distance.	E1 for identifying variable resistance. E1 for explaining consequence on motion.
Q2	A crate of mass 25kg slides down a rough slope inclined at 25° to the horizontal. The coefficient of friction is 0.3.	
(a) Draw a labelled force diagram.	Diagram shows: – Weight $W = mg$ vertically down. – Normal reaction R perpendicular to plane. – Friction F up the plane. – Component of weight $mg\sin 25^\circ$ down the plane	B1 for all four forces shown B1 for all correct directions and labels
(b) Find the frictional force.	$R = mg\cos 25^\circ$ $= 25 \times 9.8 \times 0.906 = 222\text{N}$ $F = \mu R = 0.3 \times 222 = 66.6\text{N}$.	M1 for equating R to the horizontal component of weight A1 for correct value of F

	(c) Use Newton's Second Law to find the downward acceleration of the crate.	Down-slope: $mg\sin 25^\circ - F = ma.$ $25(9.8\sin 25^\circ - 2.664) = 25a.$ $a = 9.8(0.423) - 2.664 \approx 1.47\text{m s}^{-2}$	M1 for resolving along the slope M1 for substitution of forces A1 for correct value of acceleration
	(d) If the crate starts from rest and moves 10 m, find its speed at the bottom.	$v^2 = u^2 + 2as$ $= 0 + 2(1.47)(10)$ $\Rightarrow v = \sqrt{29.4} = 5.42\text{m s}^{-1}$	M1 for correct use of equation of motion A1 for correct value of speed
	(e) Explain how changing the surface material would affect the model.	A rougher surface increases μ , reducing acceleration; a smoother one reduces μ , increasing acceleration.	E1 for correct qualitative link between μ and acceleration.
Q3	A small motor lifts a 12 kg load vertically from rest to a height of 5 m in 4 s, overcoming gravity and frictional resistance of 15 N.		
	(a) Calculate the work done against gravity.	Work against gravity = mgh $= 12 \times 9.8 \times 5 = 588 \text{ J}.$	M1 for using the formula for gravitational potential energy (or work done against gravity) A1 for the correct value of energy
	(b) Find the total work done by the motor.	Work against friction = $F_{\text{fric}} \times s$ $= 15 \times 5 = 75 \text{ J}.$ Total work = $588 + 75 = 663 \text{ J}$	M1 for computing frictional work and add to work done against gravity A1 for correct value of total work
	(c) Find the average power output of the motor.	Power $P = \frac{\text{Work done}}{\text{time}}$ $= \frac{663}{4} = 165.75 \text{ W}$ (or 166 W to 3 s.f.)	M1 for correct use of the formula A1 for the correct value of power
	(d) Manufacturer claims motor is 85% efficient. Estimate the electrical energy supplied in 4 s.	Efficiency = $\frac{\text{Useful output energy}}{\text{Input Energy}}$ Input energy = $\frac{663}{0.85} = 780 \text{ J}$	M1 for correctly using efficiency formula A1 for correct value of input energy
Q4	Two blocks A(3 kg) and B(2 kg) are connected by a light inextensible string over a smooth pulley. A rests on a smooth horizontal table; B hangs vertically.		

			
(a) Draw the forces on each block.		<p>Diagram for <i>A</i>: tension T to the right. (No friction, normal R up, weight $3g$ down). Diagram for <i>B</i>: tension T upward, weight $2g$ downward.</p>	<p>B1 for correct forces shown on <i>A</i> B1 for correct forces shown on <i>B</i></p>
(b) Find the acceleration of the system.		<p>Let acceleration of <i>B</i> downward be a (so <i>A</i> accelerates right with a). Equations: For <i>A</i>: $T = m_A a = 3a$. For <i>B</i>: $m_B g - T = m_B a \Rightarrow 2g - T = 2a$. Substitute $T = 3a$: $2g - 3a = 2a \Rightarrow 2g = 5a$. So $a = \frac{2g}{5} = \frac{19.6}{5} = 3.92 \text{ ms}^{-2}$</p>	<p>M1 for correct use of Newton's law of motion M1 for eliminating T and solving algebraically A1 for correct value of a</p>
(c) Find the tension in the string.		<p>Use $T = m_A a = 3 \times 3.92 = 11.76 \text{ N}$. (Or use $T = m_B (g - a) = 2(9.8 - 3.92) = 11.76 \text{ N}$.)</p>	<p>M1 for using the right equation of T A1 for correct value of T</p>
(d) Discuss one assumption made about the pulley or string and how relaxing it would affect the result.		<p>Example answer: assume the pulley is smooth and massless \rightarrow tensions either side equal and no rotational inertia. If pulley has non-negligible mass or friction at axle, tensions differ and some energy goes into rotating the pulley (or overcome friction). Result: acceleration would be less (since effective inertia increases) and tensions on the two sides would not be equal.</p>	<p>B1 for identifying an assumption E1 for explaining its effect E1 for explaining the consequence</p>
Q5	<p>Two trolleys collide on a smooth horizontal track. Before collision, trolley A (2 kg) was moving at 3.0 m/s and trolley B (3 kg) at 1.0 m/s in the same direction. After the collision, trolley A moves at 1.2 m/s.</p>		

	(a) Find the speed of B after the collision.	Total momentum before = total after. Before: $2 \times 3.0 + 3 \times 1.0 = 6.0 + 3.0 = 9.0 \text{ kgm/s}$. After: $2 \times 1.2 + 3 \times v'_B$ $= 2.4 + 3v'_B$. So $9.0 = 2.4 + 3v'_B \Rightarrow 3v'_B = 6.6$ $\Rightarrow v'_B = 2.2\text{m/s}$	M1 for using law of conservation of momentum M1 for correct substitution into the equation A1 for correct final value of velocity
	(b) Find the coefficient of restitution e .	Relative speed of approach = $u_A - u_B = 3.0 - 1.0 = 2\text{m/s}$ Relative speed of separation = $v'_B - v'_A = 2.2 - 1.2 = 1\text{m/s}$ $e = \frac{\text{separation}}{\text{approach}} = \frac{1.0}{2.0} = 0.50$	M1 for correct substitution in the formula for coefficient of restitution A1 for correct value of e
	(c) Explain what would happen if the collision were perfectly inelastic.	In a perfectly inelastic collision, the two trolleys stick together after impact; they move with a common speed found from total momentum. Kinetic energy would be reduced (maximum loss compatible with momentum).	E1 for the correct explanation (explained equivalently)
Q6	A 900 kg car travels up a hill inclined at 8° . When the engine is switched off the initial speed was 12.0 m/s and resistive forces add up to 600 N .		
	(a) Find the distance S the car travels up the hill before coming to rest.	Use work–energy: Initial kinetic energy = work done against gravity + work done against resistive forces. $\frac{1}{2} mu^2 = (mg)(S)(\sin\theta) + F_{res} S$ Solve for S : $S = \frac{\frac{1}{2} mu^2}{mg \sin \theta + F_{res}}$ $\frac{1}{2} mu^2 = 0.5 \times 900 \times 12^2 = 64800$ $\sin 8^\circ \approx 0.139173$. $mg \sin \theta = 900 \times 9.8 \times \sin 8^\circ \approx 1227.51 \text{ N}$ $Denominator = 1227.51 + 600 = 1827.51 \text{ N}$ $S = \frac{64800}{1827.51} \approx 35.46 \text{ m}$ Answer: $S \approx 35.5 \text{ m}$ (to s.f.)	M1 for writing the correct energy-work equation equating KE to works M1 for correct substitution of numerical values for KE and denominator A1 for correct numerical value of distance

<p>(b) The car travels up the hill with decreasing speed until it comes to rest. Find the time t it takes for the car to reach at rest.</p>	<p>Weight component down slope: $mg\sin 8^\circ = 900 \times 9.8 \times \sin 8^\circ$ $= 1227 \text{ N}$ Total retarding force = $1227 + 600$ $= 1827 \text{ N}$ Deceleration: $a = \frac{1827}{900} = 2.03 \text{ m/s}^2$ Time to stop: $t = \frac{u}{a} = \frac{12}{2.03} = 5.9 \text{ s}$</p>	<p>M1 for correct total retarding force and correct deceleration and correct use of first equation of motion afterwards A1 for correct value of t</p>
<p>(c) State and explain one simplification made in this model and how it affects the stopping distance.</p>	<p>Possible answer (sample):</p> <ul style="list-style-type: none"> • The resistive force (600 N) is assumed constant, independent of speed. • In reality, air resistance increases with speed, so the actual retarding force is greater at higher speeds and smaller at lower speeds. • Therefore, this assumption causes the model to overestimate the stopping distance. 	<p>E2 for assuming uniform acceleration while the resultant acceleration varies with air resistance</p>