Please check the examination details below before entering your candidate information

Candidate surname StemUp Model Solution | Other names

Centre Number | Candidate Number

# Pearson Edexcel International Advanced Level

**Time** 1 hour 30 minutes

**Paper reference** **WME01/01**

# Mathematics

## International Advanced Subsidiary/Advanced Level
## Mechanics M1

**You must have:**
Mathematical Formulae and Statistical Tables (Yellow), calculator

Total Marks

**Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

### Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of $g$ is required, take $g = 9.8\,\text{m s}^{-2}$, and give your answer to either 2 significant figures or 3 significant figures.

### Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

### Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

*Turn over* ▶

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**1.** Two particles, $P$ and $Q$, are moving towards each other in opposite directions along the same straight line when they collide directly. Immediately before the collision the speed of $Q$ is $2u$. The mass of $Q$ is $3m$ and the magnitude of the impulse exerted by $P$ on $Q$ in the collision is $4mu$.

Find

(a) the speed of $Q$ immediately after the collision,

**(3)**

(b) the direction of motion of $Q$ immediately after the collision.

**(1)**

(a) Take the original direction of motion of Q as negative,
so the impulse exerted by P on Q (away from P) is positive.
Impulse on Q: $I = m(v - u)$
$4mu = 3m(v - (-2u))$
$4u = 3v + 6u \Rightarrow 3v = -2u$

$v = -\frac{2u}{3}$

Speed of Q immediately after the collision $= \frac{2}{3}u$

(b) v is negative, so Q is still moving in the same direction
as before the collision (its direction is unchanged).

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**Question 1 continued**

**Q1**

**(Total 4 marks)**

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**2.** A motorbike is moving with constant acceleration along a straight horizontal road.

The motorbike passes a point $P$ and 10 seconds later passes a point $Q$.

The speed of the motorbike as it passes $Q$ is $28\,\text{m s}^{-1}$

Given that $PQ = 220\,\text{m}$,

(a) find the acceleration of the motorbike,

**(3)**

(b) find the distance travelled by the motorbike during the fifth second after passing $P$

**(4)**

(a) P to Q: $s = 220,\ v = 28,\ t = 10$

$s = vt - \frac{1}{2}at^2$

$220 = 28 \times 10 - \frac{1}{2} \times a \times 10^2$

$220 = 280 - 50a \Rightarrow 50a = 60$

Acceleration $= 1.2\ \text{m s}^{-2}$

(b) Speed at P: $v = u + at \Rightarrow 28 = u + 1.2 \times 10 \Rightarrow u = 16$

Distance in first 5 s: $s_5 = 16 \times 5 + \frac{1}{2} \times 1.2 \times 5^2 = 80 + 15 = 95$

Distance in first 4 s: $s_4 = 16 \times 4 + \frac{1}{2} \times 1.2 \times 4^2 = 64 + 9.6 = 73.6$

Distance in the fifth second $= 95 - 73.6$

$= 21.4\ \text{m}$

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**Question 2 continued**

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**Question 2 continued**

**Q2**

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**3.** A tractor of mass 6 tonnes is dragging a large block of mass 2 tonnes along rough horizontal ground. The cable connecting the tractor to the block is horizontal and parallel to the direction of motion.

The cable is modelled as being light and inextensible.

The driving force of the tractor is 7400 N and the resistance to the motion of the tractor is 200 N. The resistance to the motion of the block is $R$ newtons, where $R$ is a constant.

Given that the tension in the cable is 6000 N and the tractor is accelerating,

(a) find the value of $R$.

**(6)**

(b) State how you have used the fact that the cable is modelled as being inextensible.

**(1)**

(a) Masses: tractor 6000 kg, block 2000 kg, tension $T = 6000$ N

N2L for the tractor (→):

$7400 - 200 - 6000 = 6000a$

$1200 = 6000a \Rightarrow a = 0.2 \text{ m s}^{-2}$

N2L for the block (→):

$6000 - R = 2000a$

$6000 - R = 2000 \times 0.2 = 400$

$R = 5600$

(b) Since the cable is inextensible, the tractor and the block both have the same acceleration (I used the same a in both equations).

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**Question 3 continued**

**Q3**

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**4.**

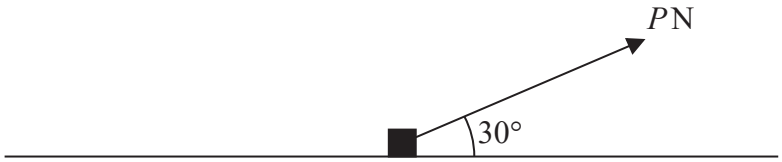



**Figure 1**

A small block of mass 5 kg lies at rest on a rough horizontal plane.

The coefficient of friction between the block and the plane is $\frac{3}{7}$

A force of magnitude $P$ newtons is applied to the block in a direction which makes an angle of 30° with the plane, as shown in Figure 1.

The block is modelled as a particle.

Given that $P = 14$

(a) find the magnitude of the frictional force exerted on the block by the plane and describe what happens to the block, justifying your answer.

**(6)**

The value of $P$ is now changed so that the block is on the point of slipping along the plane.

(b) Find the value of $P$

**(6)**

(a) Resolve vertically (↑):

$R + 14 \sin 30° = 5g$

$R = 49 - 7 = 42$ N

Maximum friction $F_{max} = \mu R = \frac{3}{7} \times 42 = 18$ N

Horizontal component of $P = 14 \cos 30° = 12.124...$ N

$12.1 < 18$, so the horizontal pull is less than the maximum friction.

Frictional force = 12.1 N (= $14 \cos 30°$), and the block remains at rest (friction has not reached its maximum value).

(b) On the point of slipping, so $F = \mu S$ where $S$ is the normal reaction.

Resolve vertically (↑): $P \sin 30° + S = 5g$

Resolve horizontally (→): $P \cos 30° = \frac{3}{7} S$

$S = 5g - P \sin 30° = 49 - \frac{P}{2}$

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**Question 4 continued**

$P \cos 30° = \frac{3}{7}\left(49 - \frac{P}{2}\right) = 21 - \frac{3P}{14}$

$P\left(\cos 30° + \frac{3}{14}\right) = 21$

$P = \frac{21}{1.080311...} = 19.439...$

$P = 19.4$

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**Question 4 continued**

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**Question 4 continued**

**Q4**

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**5.**

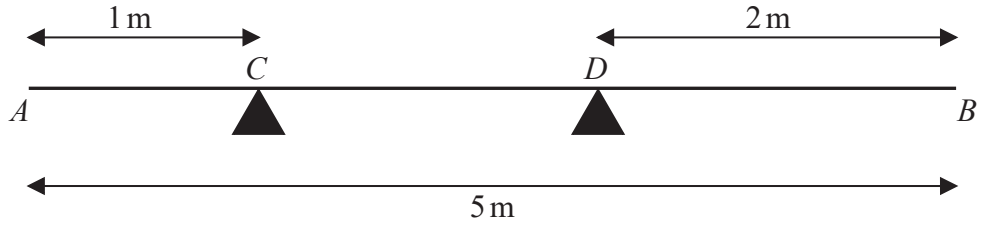



**Figure 2**

A uniform rod $AB$ has length 5 m and mass 5 kg. The rod rests in equilibrium in a horizontal position on two supports $C$ and $D$, where $AC = 1$ m and $DB = 2$ m, as shown in Figure 2.

A particle of mass 10 kg is placed on the rod at $A$ and a particle of mass $M$ kg is placed on the rod at $B$. The rod remains horizontal and in equilibrium.

(a) Find, in terms of $M$, the magnitude of the reaction on the rod at $C$.

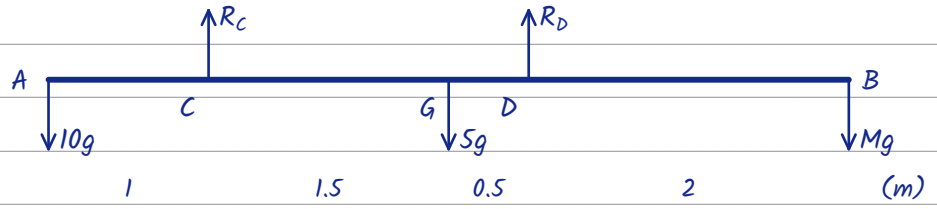
**(3)**

(b) Find, in terms of $M$, the magnitude of the reaction on the rod at $D$.

**(3)**

(c) Hence, or otherwise, find the range of possible values of $M$.

**(3)**




(a) Taking moments about D:

$R_C \times 2 + Mg \times 2 = 5g \times 0.5 + 10g \times 3$

$2R_C = 32.5g - 2Mg$

$R_C = (16.25 - M)g$ N $\quad (= 159 - 9.8M)$

(b) Taking moments about C:

$R_D \times 2 + 10g \times 1 = 5g \times 1.5 + Mg \times 4$

$2R_D = 4Mg - 2.5g$

$R_D = (2M - 1.25)g$ N $\quad (= 19.6M - 12.3)$

(c) For equilibrium both reactions must be non-negative.

$R_C \geqslant 0$: $\quad (16.25 - M)g \geqslant 0 \quad \Rightarrow \quad M \leqslant 16.25$

$R_D \geqslant 0$: $\quad (2M - 1.25)g \geqslant 0 \quad \Rightarrow \quad M \geqslant 0.625$

$0.625 \leqslant M \leqslant 16.25$

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**Question 5 continued**

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**Question 5 continued**

**Q5**

**(Total 9 marks)**

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**6.** A particle $P$ is moving with constant acceleration.

At time $t = 1$ second, $P$ has velocity $(-\mathbf{i} + 4\mathbf{j})\,\text{m s}^{-1}$

At time $t = 4$ seconds, $P$ has velocity $(5\mathbf{i} - 8\mathbf{j})\,\text{m s}^{-1}$

Find the speed of $P$ at time $t = 3.5$ seconds.

**(6)**

From $t = 1$ to $t = 4$ (3 seconds): $v = u + at$

$(5i - 8j) = (-i + 4j) + 3a$

$3a = 6i - 12j \Rightarrow a = (2i - 4j)\ m\ s^{-2}$

From $t = 1$ to $t = 3.5$ (2.5 seconds):

$v = (-i + 4j) + 2.5(2i - 4j)$

$v = (-i + 4j) + (5i - 10j) = (4i - 6j)\ m\ s^{-1}$

Speed $= \sqrt{(4^2 + (-6)^2)} = \sqrt{52} = 7.2111...$

Speed of $P$ at $t = 3.5$ s $= 7.21\ m\ s^{-1}$

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**Question 6 continued**

**Q6**

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**7.** Two small children, Ajaz and Beth, are running a 100 m race along a straight horizontal track.

They both start from rest, leaving the start line at the same time.

Ajaz accelerates at $0.8\,\text{m s}^{-2}$ up to a speed of $4\,\text{m s}^{-1}$ and then maintains this speed until he crosses the finish line.

Beth accelerates at $1\,\text{m s}^{-2}$ for $T$ seconds and then maintains a constant speed until she crosses the finish line.

Ajaz and Beth cross the finish line at the same time.

(a) Sketch, on the same axes, a speed-time graph for each child, from the instant when they leave the start line to the instant when they cross the finish line.

**(3)**

(b) Find the time taken by Ajaz to complete the race.

**(4)**

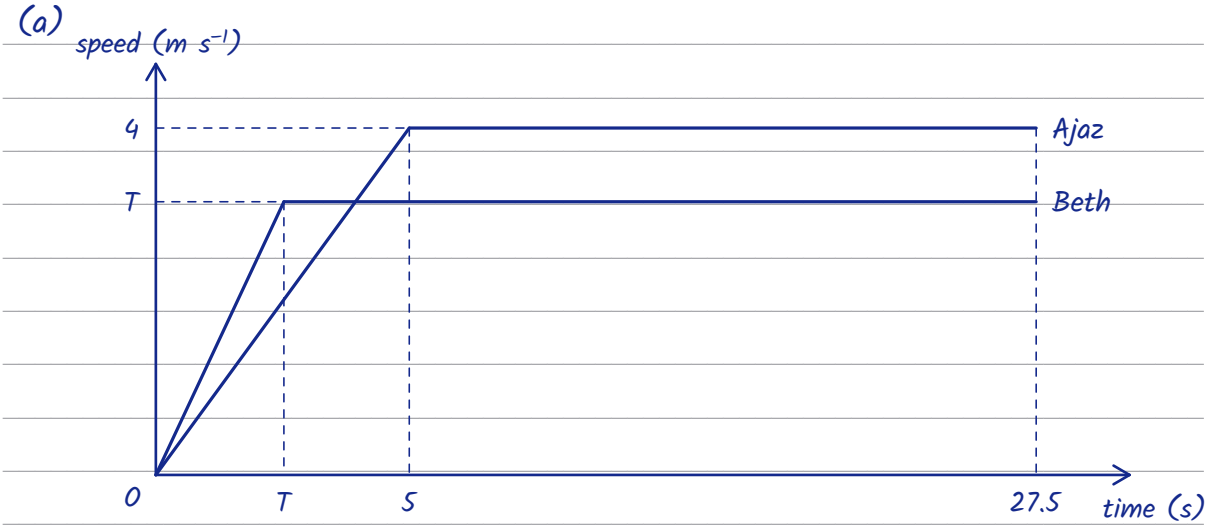
(c) Find the value of $T$

**(4)**

(d) Find the difference in the speeds of the two children as they cross the finish line.

**(2)**

(a)




(b) Time for Ajaz to reach 4 m s$^{-1}$ $= \frac{4}{0.8} = 5$ s

Distance = area under graph: $100 = \frac{1}{2} \times 5 \times 4 + 4(t - 5)$

$100 = 10 + 4t - 20 \Rightarrow 4t = 110$

$t = 27.5$ s

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**Question 7 continued**

(c) Beth reaches speed $1 \times T = T$ m s$^{-1}$ after T s, and finishes at 27.5 s.

$$100 = \frac{1}{2} \times T \times T + T(27.5 - T)$$

$$100 = \frac{1}{2} T^2 + 27.5T - T^2$$

$$T^2 - 55T + 200 = 0$$

$$T = \frac{55 \pm \sqrt{(55^2 - 4 \times 200)}}{2} = \frac{55 \pm \sqrt{2225}}{2}$$

$T = 3.915047...$ or $T = 51.08...$ (reject, since $T < 27.5$)

$T = 3.92$

(d) Ajaz finishes at 4 m s$^{-1}$; Beth finishes at $T = 3.915...$ m s$^{-1}$

Difference $= 4 - 3.915047... = 0.084952...$

Difference in speeds = 0.0850 m s$^{-1}$

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**Question 7 continued**

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**Question 7 continued**

**(Total 13 marks)**

**Q7**

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**8.** [*In this question,* **i** *and* **j** *are horizontal unit vectors directed due east and due north respectively and position vectors are given relative to a fixed origin O.*]

Two boats, $P$ and $Q$, are moving with constant velocities.

The velocity of $P$ is $15\mathbf{i}\,\text{m s}^{-1}$ and the velocity of $Q$ is $(20\mathbf{i} - 20\mathbf{j})\,\text{m s}^{-1}$

(a) Find the direction in which $Q$ is travelling, giving your answer as a bearing.

**(2)**

The boats are modelled as particles.

At time $t = 0$, $P$ is at the origin $O$ and $Q$ is at the point with position vector $200\mathbf{j}$ m.

At time $t$ seconds, the position vector of $P$ is $\mathbf{p}$ m and the position vector of $Q$ is $\mathbf{q}$ m.

(b) Show that

$$\overrightarrow{PQ} = [5t\mathbf{i} + (200 - 20t)\mathbf{j}]\,\text{m}$$

**(5)**

(c) Find the bearing of $P$ from $Q$ when $t = 10$

**(2)**

(d) Find the distance between $P$ and $Q$ when $Q$ is north east of $P$

**(5)**

(e) Find the times when $P$ and $Q$ are 200 m apart.

**(3)**

(a) Velocity of Q = 20i − 20j: 20 east and 20 south.

$\tan\theta = \frac{20}{20} = 1 \Rightarrow \theta = 45°$ south of east

Bearing = 090° + 45° = 135°

(b) $p = 0 + t(15i) \Rightarrow p = 15t\,i$

$q = 200j + t(20i - 20j)$

$PQ = q - p = 200j + t(20i - 20j) - 15t\,i$

$= 20t\,i - 15t\,i + (200 - 20t)j$

$PQ = [5t\,i + (200 - 20t)j]$ m as required

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**Question 8 continued**

(c) At $t = 10$: $PQ = 50i + (200 - 200)j = 50i$

So Q is due east of P, hence P is due west of Q.

Bearing of P from Q = 270°

(d) Q north east of P: i and j components of PQ are equal (and positive).

$5t = 200 - 20t \Rightarrow 25t = 200 \Rightarrow t = 8$

$PQ = (5 \times 8)i + (200 - 20 \times 8)j = 40i + 40j$

$|PQ| = \sqrt{(40^2 + 40^2)} = 40\sqrt{2} = 56.568...$

Distance = 56.6 m

(e) $|PQ| = 200$: $(5t)^2 + (200 - 20t)^2 = 200^2$

$25t^2 + 40000 - 8000t + 400t^2 = 40000$

$425t^2 - 8000t = 0 \Rightarrow t(425t - 8000) = 0$

$t = 0$ or $t = \frac{8000}{425} = \frac{320}{17} = 18.823...$

$t = 0$ s and $t = 18.8$ s

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**Question 8 continued**

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**Question 8 continued**

**Q8**

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**TOTAL FOR PAPER: 75 MARKS**

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