Model Answer
Dr. Ramez A. Elra

Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number

Candidate Number

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 14 June 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference
WME01/01

You must have:
Mathematical Formulae and Statistical Tables (Blue)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. 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). Coloured pencils and highlighter pens must not be used.
- **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 $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- 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.

Turn over

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Pearson

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1.

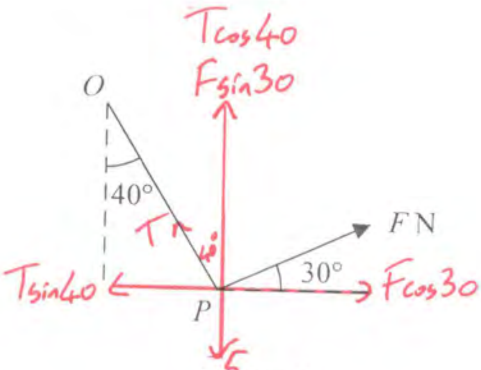

Figure 1

A particle P of weight 5 N is attached to one end of a light string. The other end of the string is attached to a fixed point O. A force of magnitude F newtons is applied to P. The line of action of the force is inclined to the horizontal at 30° and lies in the same vertical plane as the string. The particle P is in equilibrium with the string making an angle of 40° with the downward vertical, as shown in Figure 1.

Find

(i) the tension in the string,

(ii) the value of F.

(7)

$\leftrightarrow \quad T\sin 40 = F\cos 30$

$T = \dfrac{F\cos 30}{\sin 40}$

$\updownarrow \quad T\cos 40 + F\sin 30 = 5$

$\dfrac{F\cos 30\cos 40}{\sin 40} + F\sin 30 = 5$

$F = \dfrac{5}{\dfrac{\cos 30\cos 40}{\sin 40} + \sin 30} \simeq 3.26N$

$T = 4.39692\ldots \simeq 4.40N$

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2.

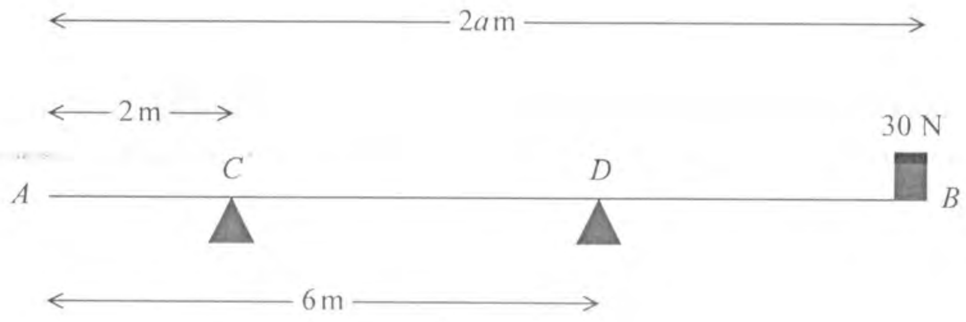


Figure 2

A wooden beam AB has weight 140 N and length $2a$ metres. The beam rests horizontally in equilibrium on two supports at C and D, where $AC = 2$ m and $AD = 6$ m. A block of weight 30 N is placed on the beam at B and the beam remains horizontal and in equilibrium, as shown in Figure 2. The reaction on the beam at D has magnitude 120 N. The block is modelled as a particle and the beam is modelled as a uniform rod.

(a) Find the value of a.

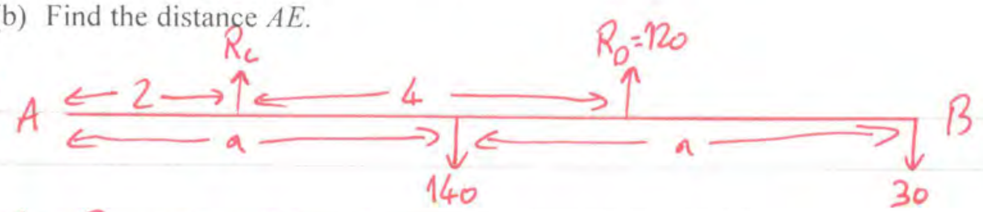
(4)

The support at D is now moved to a point E on the beam and the beam remains horizontal and in equilibrium with the block at B. The magnitude of the reaction on the beam at C is now equal to the magnitude of the reaction on the beam at E.

(b) Find the distance AE.

(5)

(a)



$\updownarrow$ $R_c + 120 = 140 + 30$

$R_c = 50\,N$

$M(A)$ $50(2) + 120(6) = 140(a) + 30(2a)$

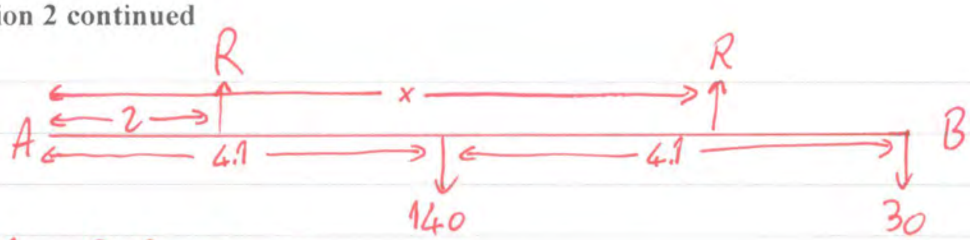
$820 = 140a + 60a$

$200a = 820$

$\boxed{a = 4.1\,m}$

Question 2 continued

(b)



$\updownarrow \quad R + R = 140 + 30$

$R = 85N$

$M(A) \quad 85(2) + 85(x) = 140(4.1) + 30(8.2)$

$170 + 85x = 574 + 246$

$85x = 650$

$x = \frac{130}{17} \simeq \boxed{7.65m}$

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3. Two particles, P and Q, have masses 0.5 kg and m kg respectively. They are moving in opposite directions towards each other along the same straight line on a smooth horizontal plane and collide directly. Immediately before the collision the speed of P is $4\,\text{m s}^{-1}$ and the speed of Q is $2\,\text{m s}^{-1}$. The magnitude of the impulse exerted on P by Q in the collision is 4.2 N s. As a result of the collision the direction of motion of P is reversed.

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

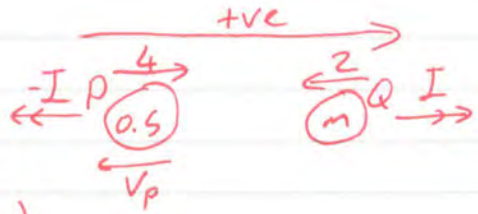
(3)

The speed of Q immediately after the collision is $1\,\text{m s}^{-1}$.

(b) Find the two possible values of m.

(4)

(a)



$I = m(v-u)$

$-4.2 = 0.5(-V_p - 4)$

$-8.4 = -V_p - 4$

$\boxed{V_p = 4.4\,\text{ms}^{-1}}$

(b) Option 1

$4.2 = m(-1 - -2)$

$\boxed{m = 4.2\,\text{Kg}}$

Option 2

$4.2 = m(1 - -2)$

$\boxed{m = 1.4\,\text{Kg}}$

4. A small ball of mass 0.2 kg is moving vertically downwards when it hits a horizontal floor. Immediately before hitting the floor the ball has speed $10\,\text{m s}^{-1}$. Immediately after hitting the floor the ball rebounds vertically with speed $7\,\text{m s}^{-1}$.

(a) Find the magnitude of the impulse exerted by the floor on the ball. **(2)**

By modelling the motion of the ball as that of a particle moving freely under gravity,

(b) find the maximum height above the floor reached by the ball after it has rebounded from the floor, **(2)**

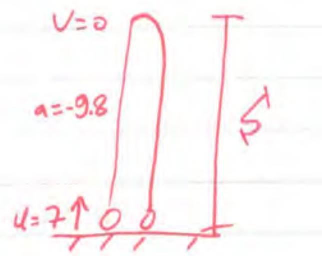
(c) find the time between the instant when the ball first hits the floor and the instant when the ball is first 1 m above the floor and moving upwards. **(4)**

(a) $10\downarrow$ 0.2 $\uparrow 7$ $\uparrow$ +ve

$I = m(v-u)$

$I = 0.2(7 - -10)$

$\boxed{I = 3.4\,Ns}$

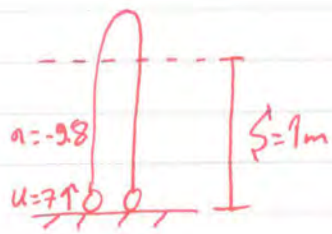


(b) $V^2 = U^2 + 2aS$

$0 = 7^2 + 2(-9.8)S$

$19.6S = 49$

$\boxed{S = 2.5m}$



(c) $S = ut + \frac{1}{2}at^2$

$1 = 7t + \frac{1}{2}(-9.8)t^2$

$1 = 7t - 4.9t^2 \quad (\times 10)$

$49t^2 - 70t + 10 = 0$

$t = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$t = \dfrac{-(-70) \pm \sqrt{(-70)^2 - 4(49)(10)}}{2(49)}$

$t = \dfrac{70 \pm \sqrt{2940}}{98}$

$t = \dfrac{5 + \sqrt{15}}{7} \simeq 1.27s$ $\quad$ $t = \dfrac{5 - \sqrt{15}}{7} \simeq \boxed{0.16s}$

Second time moving downwards $\quad$ First time moving upwards

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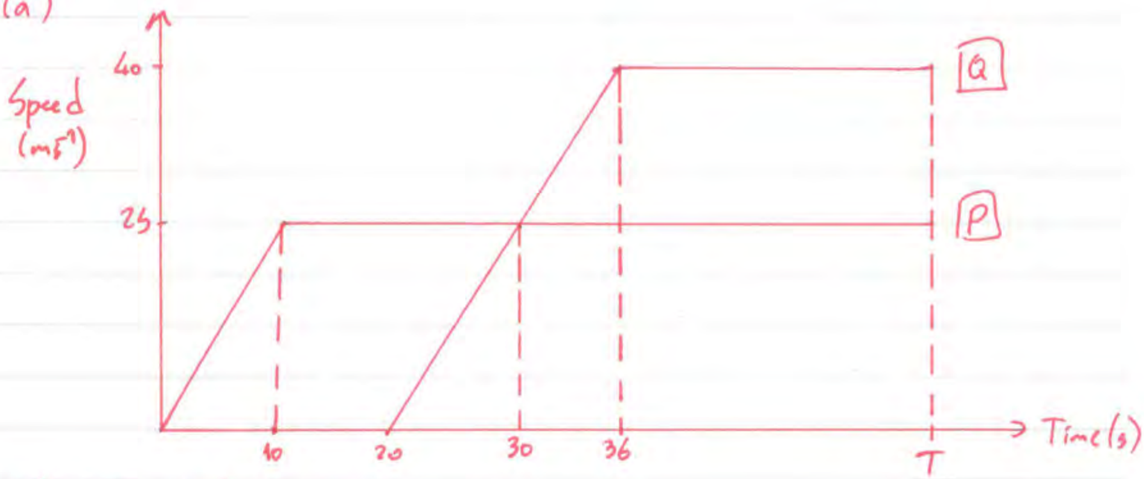
5. Two trains, P and Q, move on horizontal parallel straight tracks. Initially both are at rest in a station and level with each other. At time $t = 0$, P starts off and moves with constant acceleration for 10 s up to a speed of $25\,\text{m s}^{-1}$ and then moves at a constant speed of $25\,\text{m s}^{-1}$. At time $t = 20$, where t is measured in seconds, train Q starts to move in the same direction as P. Train Q accelerates with the same initial constant acceleration as P, up to a speed of $40\,\text{m s}^{-1}$ and then moves at a constant speed of $40\,\text{m s}^{-1}$. Train Q overtakes P at time $t = T$, after both trains have reached their constant speeds.

(a) Sketch, on the same axes, the speed-time graphs of both trains for $0 \leqslant t \leqslant T$.
(3)

(b) Find the value of t at the instant when both trains are moving at the same speed.
(2)

(c) Find the value of T.
(8)

(a)



(b) ∵ Train P & Train Q have the same acc.
∴ Train Q will take 10 seconds to reach $25\,ms^{-1}$

$\boxed{t = 30\,s}$

(c) Train P $\quad V = U + at$

$25 = 0 + 10a$

$a = 2.5\,ms^{-2}$

Train Q $\quad V = U + at$

$40 = 0 + 2.5t$

$t = 16$

Distance travelled by P = Distance travelled by Q

$$\tfrac{1}{2}(T + T - 10)(25) = \tfrac{1}{2}(T - 20 + T - 36)(40)$$
$$(2T - 10)(25) = (2T - 56)(40)$$
$$50T - 250 = 80T - 2240$$
$$30T = 1990$$
$$\boxed{T = \frac{199}{3} \simeq 66.3\,s}$$

P 5 0 7 1 4 A 0 1 6 2 8

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6. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively.*]

A particle P moves with constant acceleration $(-2\mathbf{i} + 3\mathbf{j})\,\mathrm{m\,s^{-2}}$. At time t seconds, the velocity of P is $\mathbf{v}\,\mathrm{m\,s^{-1}}$. When $t = 0$, $\mathbf{v} = 10\mathbf{i} + 4\mathbf{j}$.

(a) Find the direction of motion of P when $t = 6$, giving your answer as a bearing to the nearest degree.
(5)

(b) Find the value of t when P is moving north east.
(4)

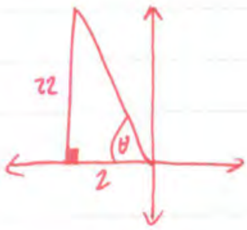
(a) $V = U + at$

$V = \begin{pmatrix}10\\4\end{pmatrix} + \begin{pmatrix}-2\\3\end{pmatrix}6$

$V = \begin{pmatrix}-2\\22\end{pmatrix} = -2i + 22j$

$\tan\theta = \left(\frac{22}{2}\right) \quad \theta \simeq 85°$

Bearing $= 270° + 85° = \boxed{355°}$



(b) $V = U + at$

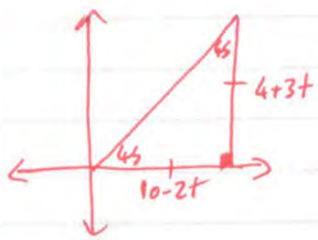
$V = \begin{pmatrix}10\\4\end{pmatrix} + \begin{pmatrix}-2\\3\end{pmatrix}t$

$V = \begin{pmatrix}10-2t\\4+3t\end{pmatrix}$

$10 - 2t = 4 + 3t$

$5t = 6$

$\boxed{t = 1.2s}$



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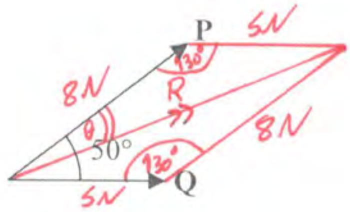

Figure 3

Two forces, **P** and **Q**, act on a particle. The force **P** has magnitude 8 N and the force **Q** has magnitude 5 N. The angle between the directions of **P** and **Q** is 50°, as shown in Figure 3. The resultant of **P** and **Q** is the force **R**.

(a) Find, to 3 significant figures, the magnitude of **R**.

(4)

(b) Find, to the nearest degree, the size of the angle between the direction of **P** and the direction of **R**.

(4)

(a) $R = \sqrt{5^2 + 8^2 - 2(5)(8)\cos 130^\circ}$

$\boxed{R \simeq 11.9N}$

(b) $\frac{5}{\sin\theta} = \frac{R}{\sin 130}$

$\sin\theta = \frac{5\sin 130}{R} = 0.323....$

$\theta = 18.858...^\circ \simeq \boxed{19^\circ}$

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8.

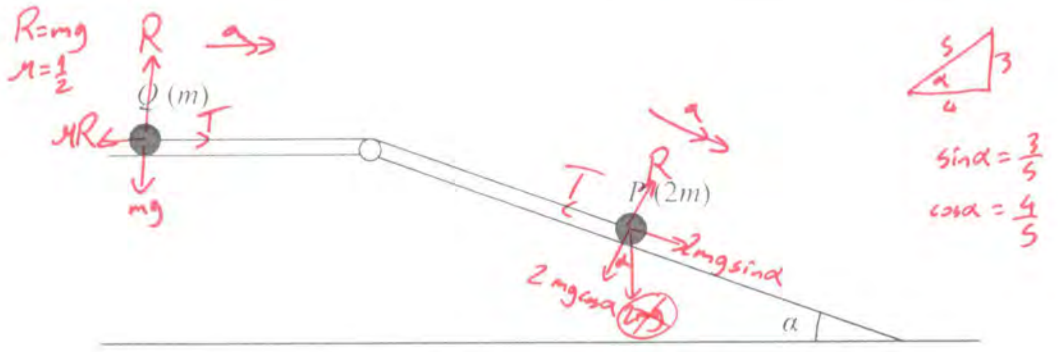

Figure 4

Two particles, P and Q, with masses $2m$ and m respectively, are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the edge of a rough horizontal table. Particle Q is held at rest on the table and particle P is on the surface of a smooth inclined plane. The top of the plane coincides with the edge of the table. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$, as shown in Figure 4. The string lies in a vertical plane containing the pulley and a line of greatest slope of the plane. The coefficient of friction between Q and the table is $\frac{1}{2}$. Particle Q is released from rest with the string taut and P begins to slide down the plane.

(a) By writing down an equation of motion for each particle,

(i) find the initial acceleration of the system,

(ii) find the tension in the string.

(10)

Suppose now that the coefficient of friction between Q and the table is μ and when Q is released it remains at rest.

(b) Find the smallest possible value of μ.

(4)

(a) $2mg\sin\alpha - \cancel{T} = 2ma$

$\oplus\ \cancel{T} - \mu R = ma$

$2mg\sin\alpha - \mu R = 3ma$

$2\cancel{m}g(\frac{3}{5}) - \frac{1}{2}(\cancel{m}g) = 3\cancel{m}a$

$\frac{6}{5}g - \frac{1}{2}g = 3a$

$\boxed{a = \frac{7}{30}g \ \text{ms}^{-2}}$

$T - \frac{1}{2}mg = m(\frac{7}{30}g)$

$\boxed{T = \frac{11}{15}mg\ N}$

(b) At rest $(a=0)$

$2mg\sin\alpha = T = \mu R$

$2\cancel{m}g(\frac{3}{5}) = \mu \cancel{m}g$

$\boxed{\mu = 1.2}$