Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | Candidate Number

Wednesday 24 October 2018

Morning (Time: 1 hour 30 minutes) | Paper Reference **WME01/01**

Mechanics M1

Advanced/Advanced Subsidiary

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 ▶

Pearson

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1. A particle P of mass 0.8 kg is moving along a straight horizontal line on a smooth hoizontal surface with speed $4\,\mathrm{m\,s^{-1}}$. A second particle Q of mass 2 kg is moving, in the opposite direction to P, along the same straight line with speed $2\,\mathrm{m\,s^{-1}}$. The particles collide directly. Immediately after the collision the direction of motion of each particle is reversed and the speed of P is $2.5\,\mathrm{m\,s^{-1}}$.

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

(3)

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

(3)

(1) (P) (Q).

$4\,\mathrm{ms^{-1}}$ $\longrightarrow$ $\quad$ $\longleftarrow$ $2\,\mathrm{ms^{-1}}$

0·8 kg $\quad$ 2 kg.

$\longleftarrow$ $2{\cdot}5\,\mathrm{ms^{-1}}$ $\quad$ $\longrightarrow$ x.

$R(\rightarrow)$.

$0{\cdot}8(4) + 2(-2) = 0{\cdot}8(-2{\cdot}5) + 2(x)$

$3{\cdot}2 - 4 = -2 + 2x$.

$1{\cdot}2 = 2x$.

$x = 0{\cdot}6\,\mathrm{ms^{-1}}$

(b) $0{\cdot}8(2{\cdot}5 + 4)$

$= \underline{5{\cdot}2\,\mathrm{Ns}}$

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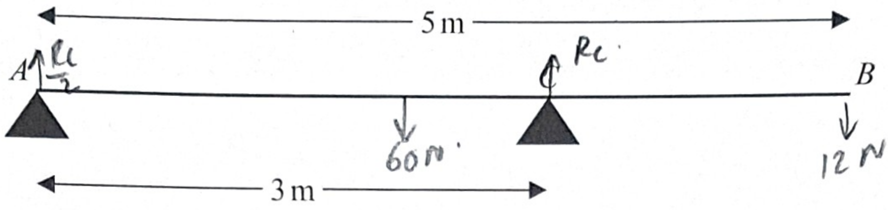

Figure 1

A non-uniform plank AB has weight 60 N and length 5 m. The plank rests horizontally in equilibrium on two smooth supports at A and C, where $AC = 3$ m, as shown in Figure 1. A parcel of weight 12 N is placed on the plank at B and the plank remains horizontal and in equilibrium. The magnitude of the reaction of the support at A on the plank is half the magnitude of the reaction of the support at C on the plank.

By modelling the plank as a non-uniform rod and the parcel as a particle,

(a) find the distance of the centre of mass of the plank from A.

(6)

(b) State briefly how you have used the modelling assumption

(i) that the parcel is a particle,

(ii) that the plank is a rod.

(2)

(a) $72 = \frac{3}{2} Rc$ (Balancing forces)

$Rc = 48N$

M(A)

$60x + 12(5) = 3(48)$

$x = 1.4m$

b i) The weight of the particle only acts on one point ie. only acts at point B.

(ii) → The plank remains straight ie it doesn't bend.

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3. At time $t = 0$, a stone is thrown vertically upwards with speed $19.6\,\mathrm{m\,s^{-1}}$ from a point A which is h metres above horizontal ground. At time $t = 3$ s, another stone is released from rest from a point B which is also h metres above the same horizontal ground. Both stones hit the ground at time $t = T$ seconds. The motion of each stone is modelled as that of a particle moving freely under gravity.

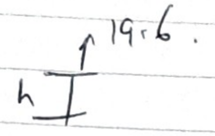
Find

(i) the value of T,

(ii) the value of h.

(7)

3



Stone A

$s = -h$
$u = 19.6$
$v =$
$a = -9.8$
$t = T$.

$-h = 19.6T - 4.9T^2$.

Stone B $\downarrow$ +ve.

$s = h$
$u = 0$
v
$a = 9.8$
$t = T-3$

$h = 4.9(T-3)^2$ -- ②.

combining eqns ① and ②

$-4.9(T-3)^2 = 19.6T - 4.9T^2$.

$(T-3)^2 = -4T + T^2$

$T^2 - 6T + 9 = 4T + T^2$

$2T = 9$.

$T = \frac{9}{2}$.

$h = 4.9(4.5-3)^2$

$h = 11.025\,\mathrm{m}$

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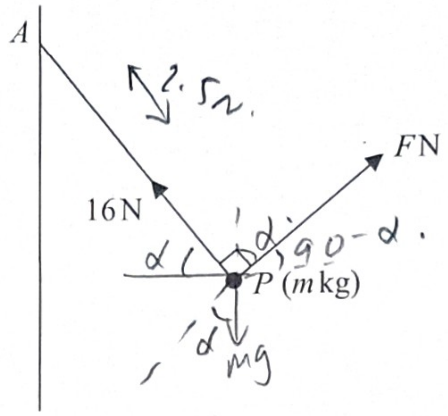


Figure 2

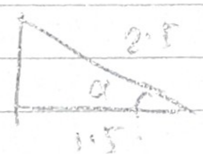
A particle P of mass m kg is attached to one end of a light inextensible string of length 2.5 m. The other end of the string is attached to a fixed point A on a vertical wall. The tension in the string is 16 N. The particle is held in equilibrium by a force of magnitude F newtons, acting in the vertical plane which is perpendicular to the wall and contains the string. This force acts in a direction perpendicular to the string, as shown in Figure 2.

Given that the horizontal distance of P from the wall is 1.5 m, find

(i) the value of F,

(ii) the value of m.

(7)



$\cos\alpha = \frac{1.5}{2.5}$

$\cos\alpha = \frac{3}{5}$

$\sin\alpha = \frac{4}{5}$

$16\cos\alpha = F\sin\alpha.$

$\frac{16}{F} = \tan\alpha.$

$\frac{16}{F} = \frac{4}{3}$ $\quad F = 12N$

(ii) $m(A)$

$mg\cos\alpha = 12$

$mg = \frac{12}{0.6}$

$mg = 20$

$m = \frac{100}{49}.$

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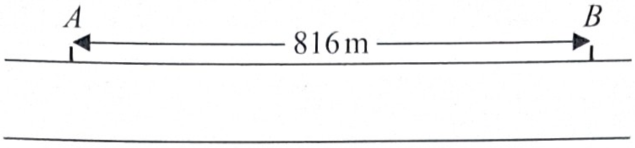


Figure 3

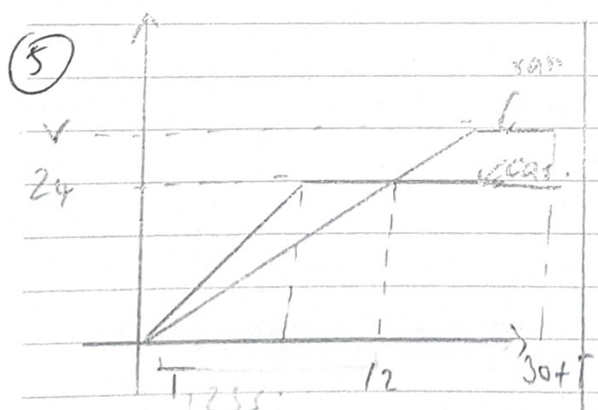
Two posts, A and B, are fixed at the side of a straight horizontal road and are 816 m apart, as shown in Figure 3. A car and a van are at rest side by side on the road and level with A. The car and the van start to move at the same time in the direction AB. The car accelerates from rest with constant acceleration until it reaches a speed of $24\,\text{m s}^{-1}$. The car then moves at a constant speed of $24\,\text{m s}^{-1}$. The van accelerates from rest with constant acceleration for 12 s until it reaches a speed of $V\,\text{m s}^{-1}$. The van then moves at a constant speed of $V\,\text{m s}^{-1}$. When the car has been moving at $24\,\text{m s}^{-1}$ for 30 s, the van draws level with the car at B, and each vehicle has then travelled a distance of 816 m.

(a) Sketch, on the same diagram, a speed-time graph for the motion of each vehicle from A to B.
(3)

(b) Find the time for which the car is accelerating.
(3)

(c) Find the value of V.
(3)

5



(c) $\left(\frac{1}{2} \times 12 \times V\right) + (26 \times V) = 816.$

$\underline{\underline{V = 25.5\,\text{ms}^{-1}}}$

(b) $s = 96$

$u = 0$

$v = 24$

a

$t = ?$

$96 = \left(\frac{0+24}{2}\right) t.$

$t = 8.$

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

6. The point A on a horizontal playground has position vector $(3\mathbf{i} - 2\mathbf{j})$ m. At time $t = 0$, a girl kicks a ball from A. The ball moves horizontally along the playground with constant velocity $(4\mathbf{i} + 5\mathbf{j})\,\text{m s}^{-1}$.

Modelling the ball as a particle, find

(a) the speed of the ball, **(2)**

(b) the position vector of the ball at time t seconds. **(2)**

The point B on the playground has position vector $(\mathbf{i} + 6\mathbf{j})$ m. At time $t = T$ seconds, the ball is due east of B.

(c) Find the value of T. **(2)**

A boy is running due east with constant speed $v\,\text{m s}^{-1}$. At the instant when the girl kicks the ball from A, the boy is at B.

Given that the boy intercepts the ball,

(d) find the value of v. **(5)**

(a) $\begin{pmatrix}4\\5\end{pmatrix}$ $\sqrt{4^2+5^2}$

$= 6.4\,\text{ms}^{-1}$

(b) $r = r_0 + vt$.

$\begin{pmatrix}3\\-2\end{pmatrix} + \begin{pmatrix}4\\5\end{pmatrix}t$

$r = (3+4t)i + (5t-2)j$.

(c) $6 = 5t-2$.

$t = \frac{8}{5}$.

(d) $\begin{pmatrix}v\\0\end{pmatrix} \rightarrow$ velocity of boy.

$r = r_0 + vt$.

$\begin{pmatrix}1\\6\end{pmatrix} + \begin{pmatrix}v\\0\end{pmatrix}t$

$r_Q = \begin{pmatrix}1+vt\\6\end{pmatrix}$

$6 = 5t-2$

$5t = 8$ $\quad t = 8/5$.

$1 + \frac{8}{5}v = 3 + 4\left(\frac{8}{5}\right)$ $\quad \therefore v = \frac{21}{4}\,\text{ms}^{-1}$

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7. A truck of mass 1600 kg is towing a car of mass 960 kg along a straight horizontal road. The truck and the car are joined by a light rigid tow bar. The tow bar is horizontal and is parallel to the direction of motion. The truck and the car experience constant resistances to motion of magnitude 640 N and R newtons respectively. The truck's engine produces a constant driving force of magnitude 2100 N. The magnitude of the acceleration of the truck and the car is $0.4\,\mathrm{m\,s^{-2}}$.

(a) Show that $R = 436$

(3)

(b) Find the tension in the tow bar.

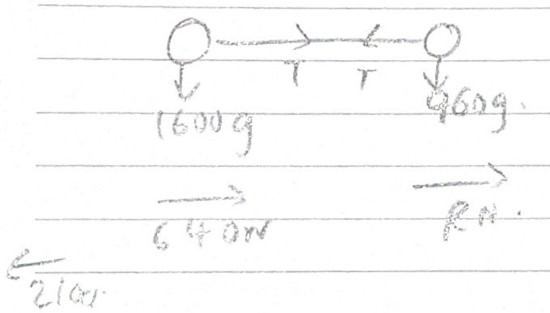
(3)

The two vehicles come to a hill inclined at an angle α to the horizontal where $\sin\alpha = \frac{1}{15}$.

The truck and the car move down a line of greatest slope of the hill with the tow bar parallel to the direction of motion. The truck's engine produces a constant driving force of magnitude 2100 N. The magnitudes of the resistances to motion on the truck and the car are 640 N and 436 N respectively.

(c) Find the magnitude of the acceleration of the truck and the car as they move down the hill.

(4)



For the whole system.

$2100 - 640 - R = 2560 \times 0.4$

$-R = -436,$

$R = 436$ as req.

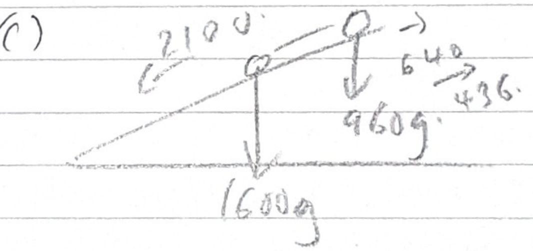
(b) For truck.

~~$2100 - 640 - R$~~ =

$2100 - 640 - T = 1600 \times 0.4$

$T = \underline{\underline{820N}}$

(c)



For whole system

R(↙).

$2100 + \frac{1600g}{15} + \frac{960g}{15} = 640 - 436$

$= 2560 \times a$

$a = \frac{79}{75}\ \mathrm{ms^{-2}}$

$= 1.05\ \mathrm{ms^{-2}}$

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8.

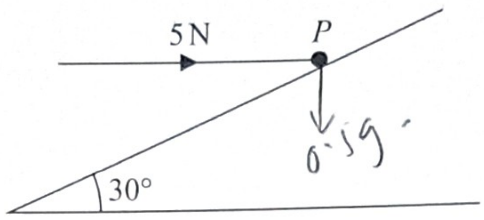

Figure 4

A rough plane is inclined at 30° to the horizontal. A particle P of mass 0.5 kg is held at rest on the plane by a horizontal force of magnitude 5 N, as shown in Figure 4. The force acts in a vertical plane containing a line of greatest slope of the inclined plane. The particle is on the point of moving up the plane.

(a) Find the magnitude of the normal reaction of the plane on P.
(4)

(b) Find the coefficient of friction between P and the plane.
(5)

The force of magnitude 5 N is now removed and P accelerates from rest down the plane.

(c) Find the speed of P after it has travelled 3 m down the plane.
(8)

(a) $0.5g\cos 30 = \frac{49\sqrt{3}}{20}$

$\frac{49\sqrt{3}}{20} + 5\cos 60$

$= 6.74N$

(b) $5\cos 30 - \frac{0.5g}{2} - \mu(6.74) = 0$

$\mu = 0.279$

(c) $0.5g\cos 60 - 0.279R = 0.5a$

$R = 0.5g\cos 30$

$a = 2.53 ms^{-2}$

$v^2 = 2 \times 2.533 \times 3$

$v^2 = 295.$

$v = 3.9ms^{-1}$

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