Write your name here

Surname	Other names

Pearson Edexcel International Advanced Level

Centre Number	Candidate Number

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 6 June 2018 – 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

June 2018

Leave blank

1. Particle P has mass $3m$ and particle Q has mass m. The particles are moving towards each other in opposite directions along the same straight line on a smooth horizontal plane. The particles collide directly. Immediately before the collision the speed of P is u and the speed of Q is $3u$. In the collision, the magnitude of the impulse exerted by Q on P is $5mu$.

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

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

(6)

P Q

$3m$ m

$\rightarrow$ u $\leftarrow$ $3u$

$\leftarrow v_1$ $\rightarrow v_2$

$5mu = 3m(v_1 + u)$

$3v_1 + 3u = 5u$

$3v_1 = 2u$

$v_1 = \frac{2}{3}u$

$5mu = m(v_2 + 3u)$

$5u = v_2 + 3u$

$v_2 = 2u$

alt

Law of conservation of momentum

$3mu - 3mu = -3mv_1 + mv_2$

$0 = -3mv_1 + mv_2$

$3v_1 + v_2 = 0$

$3\left(-\frac{2}{3}u\right) + 2u = 0$

$\therefore$ speed of P is $\frac{2}{3}u\,ms^{-1}$

speed of Q $2u\,ms^{-1}$

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

2.

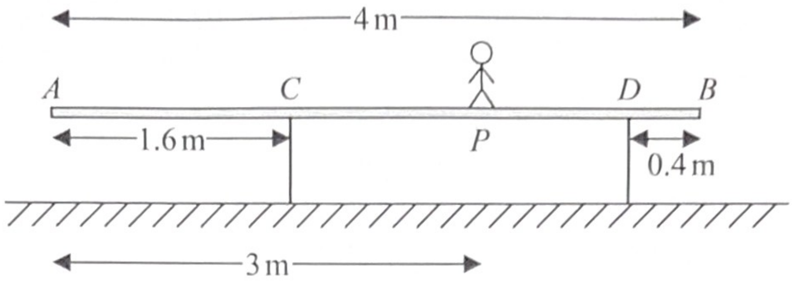


Figure 1

A uniform wooden beam AB, of mass 20 kg and length 4 m, rests in equilibrium in a horizontal position on two supports. One support is at C, where $AC = 1.6$ m, and the other support is at D, where $DB = 0.4$ m. A boy of mass 60 kg stands on the beam at the point P, where $AP = 3$ m, as shown in Figure 1. The beam remains in equilibrium in a horizontal position.

By modelling the boy as a particle and the beam as a uniform rod,

(a) (i) find, in terms of g, the magnitude of the force exerted on the beam by the support at C,

(ii) find, in terms of g, the magnitude of the force exerted on the beam by the support at D.

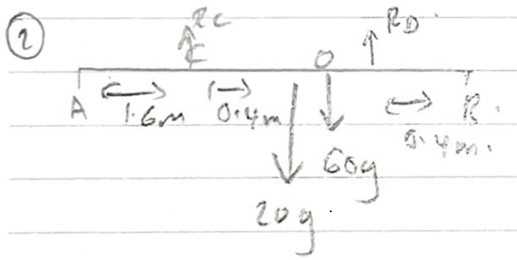
(6)

The boy now starts to walk slowly along the beam towards the end A.

(b) Find the greatest distance he can walk from P without the beam tilting.

(4)

2



$R_C + R_D = 80g$

$R_D = 80g - R_C$

M(A)

$1.6R_C + 3.6R_D = 2(20g) + 3(60g)$

$1.6R_C + 3.6R_D = 220g$

$1.6R_C + 288g - 3.6R_C = 220g$

$68g = 2R_C$

$R_C = \underline{34g}$

$R_D = 80g - 34g$

$= 46g$

Leave blank

Question 2 continued

(b) When it starts tilting

$R_D = 0.$

$R_C = 80g$

$M(A)$

$1.6 R_C = 2(20g) + x(60g)$

$128g = 40g + x(60g)$

$x = \frac{22}{15}$ m from A

$3 - \frac{22}{15} = \frac{23}{15}$

$\therefore$ he can walk a distance less than or equal to $\frac{23}{15}$ m

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

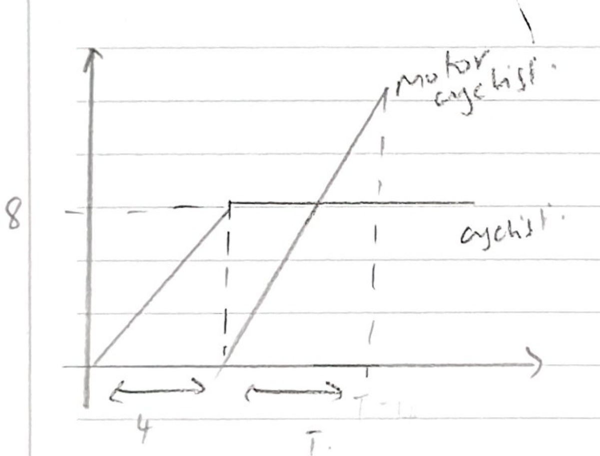
3. A cyclist starts from rest at the point O on a straight horizontal road. The cyclist moves along the road with constant acceleration $2\,\mathrm{m\,s^{-2}}$ for 4 seconds and then continues to move along the road at constant speed. At the instant when the cyclist stops accelerating, a motorcyclist starts from rest at the point O and moves along the road with constant acceleration $4\,\mathrm{m\,s^{-2}}$ in the same direction as the cyclist. The motorcyclist has been moving for T seconds when she overtakes the cyclist.

(a) Sketch, on the same axes, a speed-time graph for the motion of the cyclist and a speed-time graph for the motion of the motorcyclist, to the time when the motorcyclist overtakes the cyclist.

(4)

(b) Find, giving your answer to 1 decimal place, the value of T.

(6)



(b) Area under trapezium

s
$u = 0$
$v = ?$
$a = 2$
$t = 4$

$\frac{v}{2} = 4$

$v = 8$

$\frac{1}{2} \times 8 \times 4 = 16\text{m}.$

$8 \times T = 8T.$

Area under triangle.

$\frac{1}{2} \times T \times h =$

s
$u = 0$
$v = ?$
$a = 4$
$t = T$

$\frac{v}{4} = T$

$v = 4T.$

$\frac{1}{2} \times 4T \times T = 2T^2.$

$2T^2 = 16 + 8T.$

$T^2 - 4T - 8 = 0.$

$\frac{4 \pm \sqrt{4^2 - 4(-8)}}{2 \times 1}$

$T = 5.5$

Leave blank

4. A rough plane is inclined at an angle α to the horizontal, where $\tan\alpha = \frac{3}{4}$. A particle of mass 2 kg is projected with speed $6\,\mathrm{m\,s^{-1}}$ from a point O on the plane, up a line of greatest slope of the plane. The coefficient of friction between the particle and the plane is 0.25

(a) Find the magnitude of the frictional force acting on the particle as it moves up the plane. **(3)**

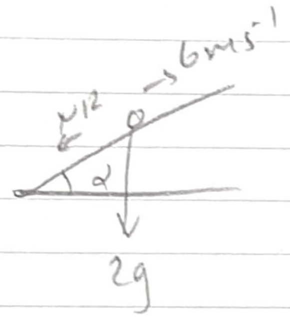
The particle comes to instantaneous rest at the point A.

(b) Find the distance OA. **(5)**

The particle now moves down the plane from A.

(c) Find the speed of P as it passes through O. **(5)**

(a)



$\tan\alpha = \frac{3}{4}$

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

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

$2g\cos\alpha = R.$

$0.25 \times 2g \times \frac{4}{5} = \mu R$

$F = \frac{2}{5}g.$

(b) $s = ?$
$u = 6$
$v = 0$
$a = -4/5g.$
t

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

$a = \frac{-4}{5}g.$

$0 = 6^2 + 2\left(\frac{-4}{5}g\right)s$

$s = \underline{2.30\,\mathrm{m}}$

(c) $s = 2.3$
$u = 0$
$v = ?$
$a = 2g/5$
t

$2g\sin\alpha - \frac{2}{5}g = 2a.$

$a = 2g/5.$

$v^2 = 2\left(\frac{2g}{5}\right)(2.3)$

$v = \underline{3\sqrt{2}\,\mathrm{ms^{-2}}}$

Leave blank

5. [*In this question* **i** *and* **j** *are perpendicular horizontal unit vectors and position vectors are given relative to a fixed origin O.*]

A particle P is moving in a straight line with constant velocity. At 9 am, the position vector of P is $(7\mathbf{i} + 5\mathbf{j})$ km and at 9.20 am, the position vector of P is $6\mathbf{i}$ km. At time t hours after 9 am, the position vector of P is $\mathbf{r}_p$ km.

(a) Find, in km h^{-1}, the speed of P.
(4)

(b) Show that $\mathbf{r}_p = (7 - 3t)\,\mathbf{i} + (5 - 15t)\,\mathbf{j}$.
(2)

(c) Find the value of t when $\mathbf{r}_p$ is parallel to $16\mathbf{i} + 5\mathbf{j}$.
(4)

The position vector of another particle Q, at time t hours after 9 am, is $\mathbf{r}_Q$ km, where $\mathbf{r}_Q = (5 + 2t)\,\mathbf{i} + (-3 + 5t)\,\mathbf{j}$

(d) Show that P and Q will collide and find the position vector of the point of collision.
(5)

(5) $v_0 = \begin{pmatrix} 7 \\ 5 \end{pmatrix}$

$r = \begin{pmatrix} 6 \\ 0 \end{pmatrix}$.

$\dfrac{disp}{t} = vel$

$r = r_0 + vt$.

$\begin{pmatrix} 6 \\ 0 \end{pmatrix} = \begin{pmatrix} 7 \\ 5 \end{pmatrix} + v\begin{pmatrix} 1/3 \end{pmatrix}$

$3\begin{pmatrix} -1 \\ -5 \end{pmatrix} = v$.

$v = \begin{pmatrix} -3 \\ -15 \end{pmatrix}$

$\sqrt{3^2 + 15^2}$

$= 3\sqrt{26}\ kmh^{-1}$

(b) $r_p = \begin{pmatrix} 7 \\ 5 \end{pmatrix} + t\begin{pmatrix} -3 \\ -15 \end{pmatrix}$

$r_p = \begin{pmatrix} 7 - 3t \\ 7 - 15t \end{pmatrix}$.

$\therefore r_p = (7 - 3t)i + (5 - 15t)j$.

(c) $7 - 3t = k \cdot 16$.

$5 - 15t = 5 \cdot k$.

$\dfrac{7 - 3t}{16} \times 5 = 5 - 15t$.

$\dfrac{7 - 3t}{16} = 1 - 3t$.

$7 - 3t = 16 - 48t$.

$t = 1/5\ hr$.

Leave blank

Question 5 continued

(d) $v_q = \begin{pmatrix} 5+2t \\ -3+5t \end{pmatrix}$

$7 - 3t = 5 + 2t$.

$t = 2/5$.

$5 - 15t = -3 + 5t$.

$t = 2/5$.

∴ Both values of t are the same ∴ they will collide

$\begin{pmatrix} 7 - 3(0.4) \\ 5 - 15(0.4) \end{pmatrix}$

$= 5.8i - j$.

Leave blank

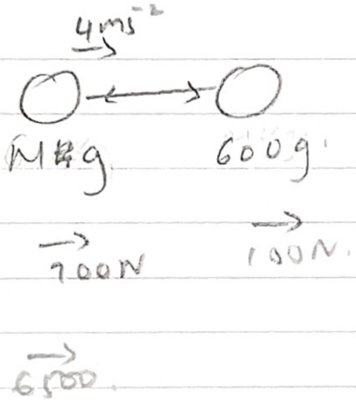
6. A car pulls a trailer along a straight horizontal road using a light inextensible towbar. The mass of the car is M kg, the mass of the trailer is 600 kg and the towbar is horizontal and parallel to the direction of motion. There is a resistance to motion of magnitude 200 N acting on the car and a resistance to motion of magnitude 100 N acting on the trailer. The driver of the car spots a hazard ahead. Instantly he reduces the force produced by the engine of the car to zero and applies the brakes of the car. The brakes produce a braking force on the car of magnitude 6500 N and the car and the trailer have a constant deceleration of magnitude $4\,\text{m s}^{-2}$

Given that the resistances to motion on the car and trailer are unchanged and that the car comes to rest after travelling 40.5 m from the point where the brakes were applied, find

(a) the thrust in the towbar while the car is braking, **(3)**

(b) the value of M, **(3)**

(c) the time it takes for the car to stop after the brakes are applied. **(3)**



(a) $-T-100=+600\times-4$

$-T=-2300$

$T=2300\text{N}$

(b) $-6500-300=(M+600)\times-4$

~~6500~~

$1700=M+600$

$M=1100\text{kg}$

(c) $s=40.5$

u

$v=0$

$a=-4$

$t=?$

$40.5=\frac{-1}{2}(-4)(t)^2$

$t=4.5\text{s}$

Leave blank

7.

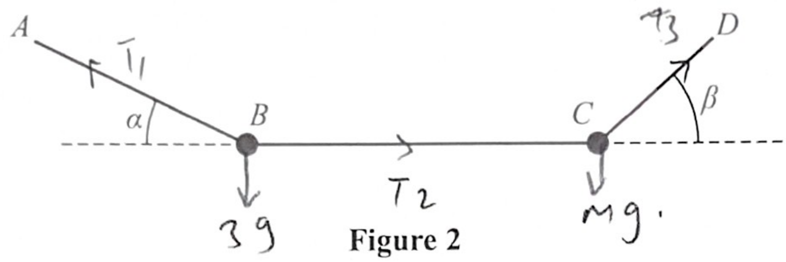


Figure 2

A washing line *ABCD* is fixed at the points *A* and *D*. There are two heavy items of clothing hanging on the washing line, one fixed at *B* and the other fixed at *C*. The washing line is modelled as a light inextensible string, the item at *B* is modelled as a particle of mass 3 kg and the item at *C* is modelled as a particle of mass *M* kg. The section *AB* makes an angle α with the horizontal, where $\tan\alpha = \frac{3}{4}$, the section *BC* is horizontal and the section *CD* makes an angle β with the horizontal, where $\tan\beta = \frac{12}{5}$, as shown in Figure 2. The system is in equilibrium.

(a) Find the tension in *AB*. **(4)**

(b) Find the tension in *BC*. **(3)**

(c) Find the value of *M*. **(5)**

$\tan\alpha = \frac{3}{4}$, $\sin\alpha = \frac{3}{5}$

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

$\tan\alpha = \frac{12}{5}$ $\sin\beta = \frac{12}{13}$.

$\cos\beta = \frac{5}{13}$.

$T_1 \sin\alpha = 3g$

$T_1 = \frac{3g}{0.6}$

$T_1 = 5g$.

(b) $T_2 = T_1 \cos\alpha$.

$T_2 = 5g \times \frac{4}{5} = 4g$.

(c) $T_3 \cos\beta = 4g$.

$T_3 = \frac{4g}{5/13}$.

$T_3 = \frac{52}{5} g$

$T_3 \sin\beta = mg$.

$\frac{52}{5} g \times \frac{12}{13} = mg$.

$M = 9.6$ kg.