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Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						6	6	7	7	/	0	1	Signature	

Paper Reference(s)

6677/01

Edexcel GCE

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 3 June 2015 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
8	
Total	

Materials required for examination	Items included with question papers
Mathematical Formulae (Pink)	Nil

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 or symbolic differentiation/integration, or have retrievable mathematical formulae stored in them.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initials and signature.
Check that you have the correct question paper.
Answer ALL the questions.
You must write your answer to each question in the space following the question.
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 for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
The marks for individual questions and the parts of questions are shown in round brackets: e.g. **(2)**.
There are 8 questions in this question paper. The total mark for this paper is 75.
There are 28 pages in this question paper. Any blank pages are indicated.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You should show sufficient working to make your methods clear to the Examiner.
Answers without working may not gain full credit.

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P 4 4 8 3 5 A 0 1 2 8

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PEARSON

1. Particle P of mass m and particle Q of mass km are moving in opposite directions on a smooth horizontal plane when they collide directly. Immediately before the collision the speed of P is $5u$ and the speed of Q is u. Immediately after the collision the speed of each particle is halved and the direction of motion of each particle is reversed.

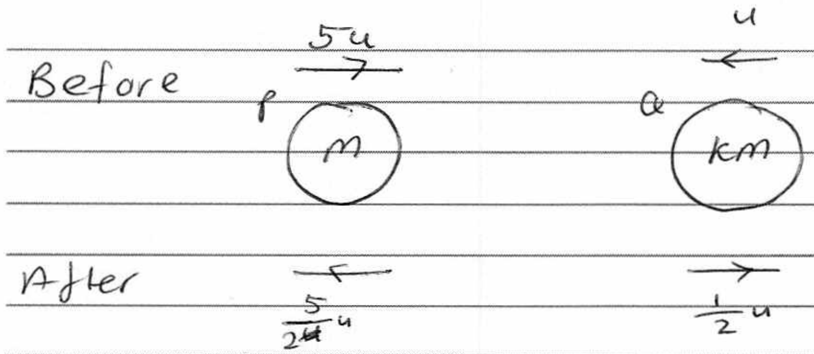
Find

(a) the value of k,

(3)

(b) the magnitude of the impulse exerted on P by Q in the collision.

(3)



a) $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$m(5u) + km(-u) = m(-\frac{5}{2}u) + km(\frac{1}{2}u)$

$5mu - kmu = -\frac{5}{2}mu + \frac{1}{2}kmu$

$5 - k = -5/2 + \frac{1}{2}k$

$\frac{15}{2} = \frac{3}{2}k$

~~$k = 5/3$~~

$k = 5$

b) $I = mv - mu$

$= m(-\frac{5}{2}u) - m(5u)$

$= -\frac{5}{2}mu - 5mu$

$= -\frac{15}{2}mu$ Ns

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2. A small stone is projected vertically upwards from a point O with a speed of 19.6 m s^{-1}.

Modelling the stone as a particle moving freely under gravity,

(a) find the greatest height above O reached by the stone,

(2)

(b) find the length of time for which the stone is more than 14.7 m above O.

(5)

a) $s = ?$

$u = 19.6$

$v = 0$

$a = -9.8$

$t =$

$v^2 = u^2 + 2as$

$0 = (19.6)^2 + 2(-9.8)s$

$s = 19.6 \text{ m}$

b) $s = 14.7$

$u = 19.6$

$v =$

$a = -9.8$

$t = ?$

$s = ut + \frac{1}{2}at^2$

$14.7 = 19.6t + \frac{1}{2}(-9.8)t^2$

$14.7 = 19.6t - 4.9t^2$

$4.9t^2 - 19.6t + 14.7 = 0$

$a = 4.9 \quad b = -19.6 \quad c = 14.7$

$$t = \frac{-(-19.6) \pm \sqrt{(-19.6)^2 - 4(4.9)(14.7)}}{2(4.9)}$$

$t = 3$ and $t = 1$

$3 - 1 = 2$

2 seconds

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3.

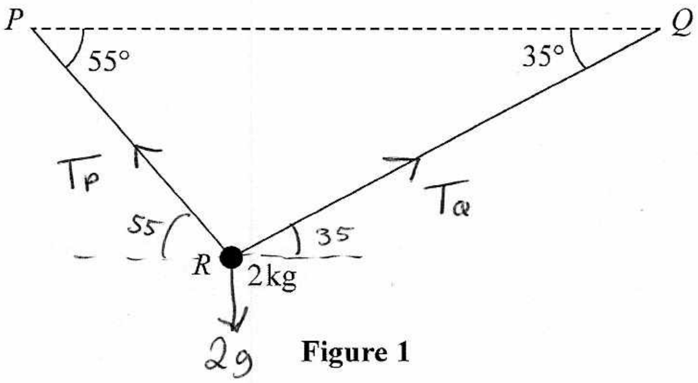

Figure 1

A particle of mass 2 kg is suspended from a horizontal ceiling by two light inextensible strings, *PR* and *QR*. The particle hangs at *R* in equilibrium, with the strings in a vertical plane. The string *PR* is inclined at 55° to the horizontal and the string *QR* is inclined at 35° to the horizontal, as shown in Figure 1.

Find

(i) the tension in the string *PR*,

(ii) the tension in the string *QR*.

(7)

$\leftarrow \; = \; \rightarrow$

$T_P \cos 55 = T_Q \cos 35$

$T_P = \dfrac{T_Q \cos 35}{\cos 55}$

$\uparrow \; = \; \downarrow$

$T_P \sin 55 + T_Q \sin 35 = 2g$

$\dfrac{T_Q \cos 35}{\cos 55} \sin 55 + T_Q \sin 35 = 2g$

$T_Q \left(\cos 35 \tan 55 + \sin 35\right) = 2g$

$T_Q = \underline{11.2 \text{ N } (3sf)}$

$T_P = \dfrac{11.2 \cos 35}{\cos 55}$

$= \underline{16.1 \text{ N } 3sf}$

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4.

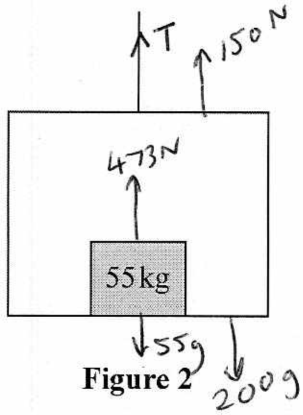

Figure 2

A lift of mass 200 kg is being lowered into a mineshaft by a vertical cable attached to the top of the lift. A crate of mass 55 kg is on the floor inside the lift, as shown in Figure 2. The lift descends vertically with constant acceleration. There is a constant upwards resistance of magnitude 150 N on the lift. The crate experiences a constant normal reaction of magnitude 473 N from the floor of the lift.

(a) Find the acceleration of the lift. **(3)**

(b) Find the magnitude of the force exerted on the lift by the cable. **(4)**

a) crate:

$55g - 473 = 55a$

$66 = 55a$

$a = 1.2 \text{ ms}^{-2}$

b) whole system:

$255g - T - 150 = 255(1.2)$

$2499 - T - 150 = 306$

$2499 - 150 - 306 = T$

$T = 2043 \text{ N}$

$= 2040 \text{ N}$ (3sf)

P 4 4 8 3 5 A 0 8 2 8

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5.

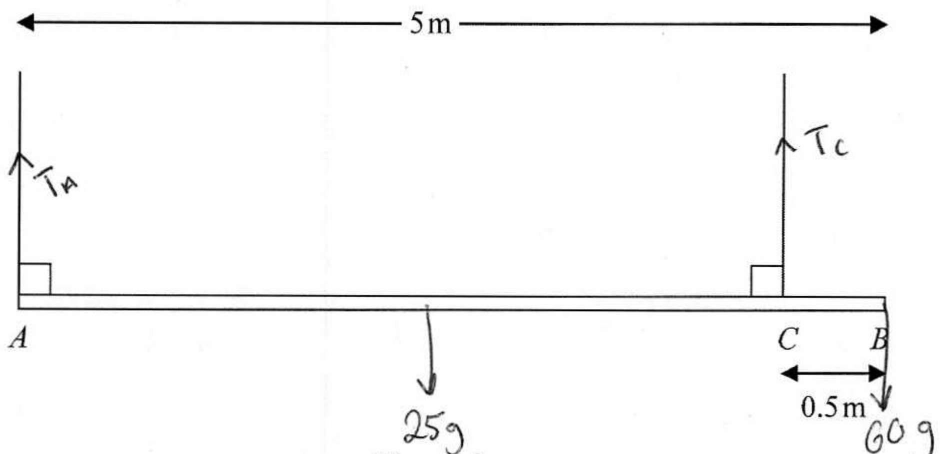

Figure 3

A beam AB has length 5 m and mass 25 kg. The beam is suspended in equilibrium in a horizontal position by two vertical ropes. One rope is attached to the beam at A and the other rope is attached to the point C on the beam where CB = 0.5 m, as shown in Figure 3. A particle P of mass 60 kg is attached to the beam at B and the beam remains in equilibrium in a horizontal position. The beam is modelled as a uniform rod and the ropes are modelled as light strings.

(a) Find

(i) the tension in the rope attached to the beam at A,

(ii) the tension in the rope attached to the beam at C.

(6)

Particle P is removed and replaced by a particle Q of mass M kg at B. Given that the beam remains in equilibrium in a horizontal position,

(b) find

(i) the greatest possible value of M,

(ii) the greatest possible tension in the rope attached to the beam at C.

(6)

ai) Taking moments about C:

$$0.5(60g) + 4.5T_A = 2(25g)$$
$$30g + 4.5T_A = 50g$$
$$4.5T_A = 20g$$
$$T_A = \frac{40}{9}g \text{ N} \quad (43.6\text{N } 3\text{sf})$$

P 4 4 8 3 5 A 0 1 2 2 8

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Question 5 continued

ii/ Forces up = forces down

$$\frac{40}{9}g + T_c = 85g$$

$$T_c = \frac{725}{9}g \text{ N} \qquad (789 \text{ N } 3\text{sf})$$

b i/

Beam on the point of tipping about C

$T_A = 0$

Taking moments about C:

$$0.5\,Mg = 2(25g)$$

$$0.5Mg = 50g$$

$$M = 100 \text{ kg}$$

ii Forces up = forces down

$$T_c = \cancel{125}\ 100g + 25g$$

$$= 125g$$

Leave blank

6. A particle P is moving with constant velocity. The position vector of P at time t seconds ($t \geqslant 0$) is $\mathbf{r}$ metres, relative to a fixed origin O, and is given by

$$\mathbf{r} = (2t - 3)\mathbf{i} + (4 - 5t)\mathbf{j}$$

(a) Find the initial position vector of P.

(1)

The particle P passes through the point with position vector $(3.4\mathbf{i} - 12\mathbf{j})$ m at time T seconds.

(b) Find the value of T.

(3)

(c) Find the speed of P.

(4)

6a) $-3i + 4j$ $\boxed{t=0}$

b/ i// $2t - 3 = 3.4$

$2t = 6.4$

$\underline{t = 3.2}$

c/ $r = \begin{pmatrix} -3 \\ 4 \end{pmatrix} + t\begin{pmatrix} 2 \\ -5 \end{pmatrix}$

$\sqrt{2^2 + 5^2} = \sqrt{29}$ ms^{-1}

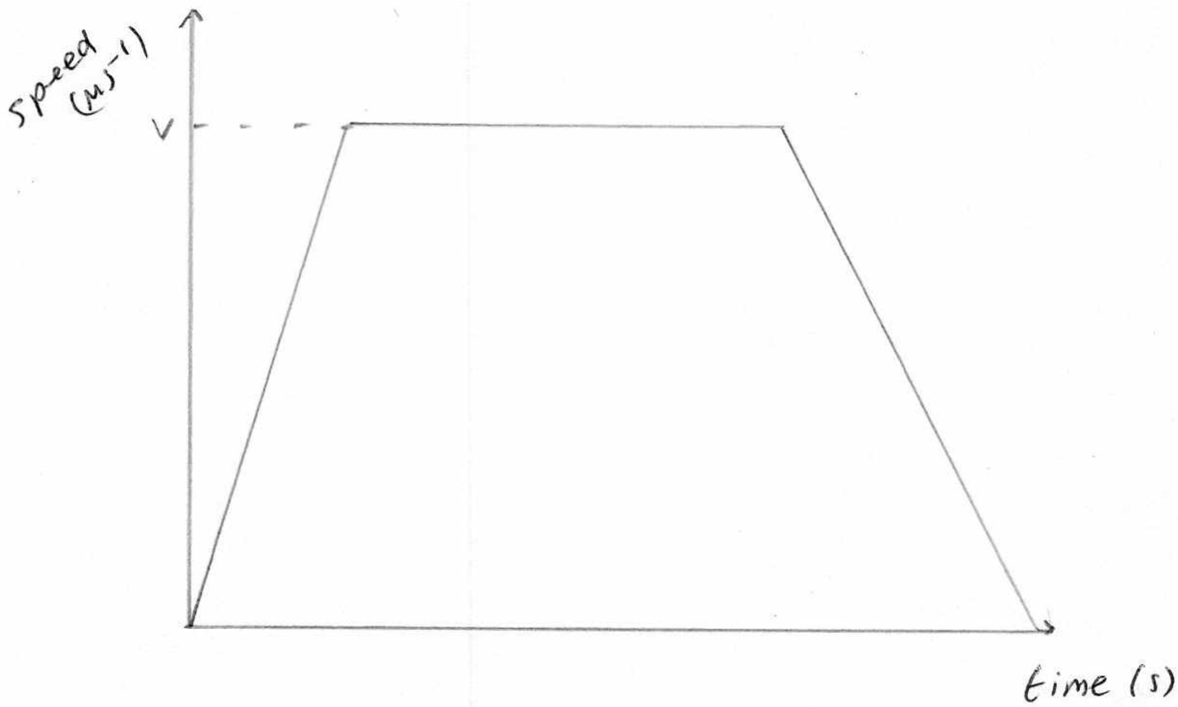
$= 5.39$ ms^{-1} (3sf)

Leave blank

7. A train travels along a straight horizontal track between two stations, A and B. The train starts from rest at A and moves with constant acceleration 0.5 m s^{-2} until it reaches a speed of $V \text{ m s}^{-1}$, ($V < 50$). The train then travels at this constant speed before it moves with constant deceleration 0.25 m s^{-2} until it comes to rest at B.

(a) Sketch in the space below a speed-time graph for the motion of the train between the two stations A and B.

(2)



The total time for the journey from A to B is 5 minutes.

(b) Find, in terms of V, the length of time, in seconds, for which the train is

(i) accelerating,

(ii) decelerating,

(iii) moving with constant speed.

(5)

Given that the distance between the two stations A and B is 6.3 km,

(c) find the value of V.

(6)

Leave blank

Question 7 continued

bi/ acceleration = $\frac{\text{velocity}}{\text{time}}$ (change in) (change in)

$0.5 = \frac{V}{t}$

$t = 2V$

ii/ $-0.25 = \frac{-V}{t}$

$t = 4V$

iii/ $300 - 6V$ $\boxed{\text{300 seconds total}}$

c/ Total distance = 6300m $\boxed{\text{Area}}$

$\left(\frac{300 + 300 - 6V}{2}\right)(v) = 6300$

$(300 - 3v)(v) = 6300$

$300v - 3v^2 = 6300$

$100v - v^2 = 2100$

$v^2 - 100v + 2100 = 0$

$(v - 30)(v - 70) = 0$

$v = 30 \quad v = 70$

v is less than 50

$\therefore \; V = 30 \text{ ms}^{-1}$

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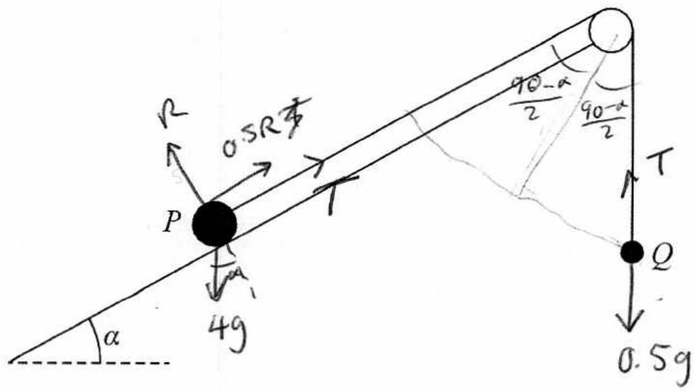
Turn over

8.



$\mu = 0.5$

Figure 4

Two particles P and Q have mass 4 kg and 0.5 kg respectively. The particles are attached to the ends of a light inextensible string. Particle P is held at rest on a fixed rough plane, which is inclined to the horizontal at an angle α where $\tan \alpha = \frac{4}{3}$. The coefficient of friction between P and the plane is 0.5. The string lies along the plane and passes over a small smooth light pulley which is fixed at the top of the plane. Particle Q hangs freely at rest vertically below the pulley. The string lies in the vertical plane which contains the pulley and a line of greatest slope of the inclined plane, as shown in Figure 4. Particle P is released from rest with the string taut and slides down the plane.

Given that Q has not hit the pulley, find

(a) the tension in the string during the motion, **(11)**

(b) the magnitude of the resultant force exerted by the string on the pulley. **(4)**

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

$P//$ $\quad R = 4g \cos \alpha$

$= \frac{12}{5} g$

$4g \sin \alpha - 0.5\left(\frac{12}{5} g\right) - T = 4a$

$\frac{16}{5} g - \frac{6}{5} g - T = 4a$

$2g - T = 4a \quad (1)$

$T - 0.5g$

$Q//$ $\quad \cancel{0.5g - T} = 0.5a$

$\cancel{4g - 8T = 4a} \quad (2)$

$8T - 4g = 4a$

Leave blank

Question 8 continued

$$2g - T = 8T - 4g$$

$$6g = 9T$$

$$\underline{\underline{T = \frac{2}{3}g \text{ N}}} \qquad (6.53 \text{ N } 3\text{sf})$$

b/

$$2T\cos\left(\frac{90-\alpha}{2}\right)$$

$$2\left(\frac{2}{3}g\right)\cos(18.4\ldots)$$

$$12.4 \text{ N } (3\text{sf})$$