

Paper Reference(s)

6677

Edexcel GCE

Mechanics M1

Advanced Subsidiary

Friday 20 January 2012 – Afternoon

Time: 1 hour 30 minutes

Materials required for examination

Mathematical Formulae (Pink or Green)

Items included with question papers

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, differentiation and integration, or have retrievable mathematical formulas stored in them.

Instructions to Candidates

In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M1), the paper reference (6677), your surname, other name and signature.

Whenever a numerical value of g is required, take $g = 9.8 \text{ m s}^{-2}$.

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.

There are 8 questions in this question paper.

The total mark for this paper is 75.

Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.

You must show sufficient working to make your methods clear to the Examiner.

Answers without working may not gain full credit.

1. A railway truck P , of mass m kg, is moving along a straight horizontal track with speed 15 m s^{-1} . Truck P collides with a truck Q of mass 3000 kg , which is at rest on the same track. Immediately after the collision the speed of P is 3 m s^{-1} and the speed of Q is 9 m s^{-1} . The direction of motion of P is reversed by the collision.

Modelling the trucks as particles, find

(a) the magnitude of the impulse exerted by P on Q , (2)

(b) the value of m . (3)

2. A car of mass 1000 kg is towing a caravan of mass 750 kg along a straight horizontal road. The caravan is connected to the car by a tow-bar which is parallel to the direction of motion of the car and the caravan. The tow-bar is modelled as a light rod. The engine of the car provides a constant driving force of 3200 N . The resistances to the motion of the car and the caravan are modelled as constant forces of magnitude 800 newtons and $R \text{ newtons}$ respectively.

Given that the acceleration of the car and the caravan is 0.88 m s^{-2} ,

(a) show that $R = 860$, (3)

(b) find the tension in the tow-bar. (3)

3. Three forces \mathbf{F}_1 , \mathbf{F}_2 and \mathbf{F}_3 acting on a particle P are given by

$$\mathbf{F}_1 = (7\mathbf{i} - 9\mathbf{j}) \text{ N}$$

$$\mathbf{F}_2 = (5\mathbf{i} + 6\mathbf{j}) \text{ N}$$

$$\mathbf{F}_3 = (p\mathbf{i} + q\mathbf{j}) \text{ N}$$

where p and q are constants.

Given that P is in equilibrium,

(a) find the value of p and the value of q . (3)

The force \mathbf{F}_3 is now removed. The resultant of \mathbf{F}_1 and \mathbf{F}_2 is \mathbf{R} . Find

(b) the magnitude of \mathbf{R} , (2)

(c) the angle, to the nearest degree, that the direction of \mathbf{R} makes with \mathbf{j} . (3)

4.

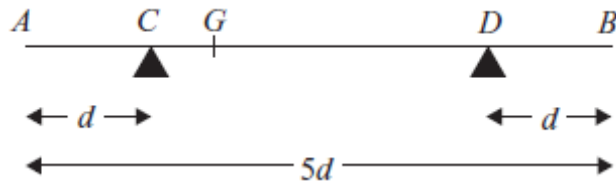


Figure 1

A non-uniform rod AB , of mass m and length $5d$, rests horizontally in equilibrium on two supports at C and D , where $AC = DB = d$, as shown in Figure 1. The centre of mass of the rod is at the point G . A particle of mass $\frac{5}{2}m$ is placed on the rod at B and the rod is on the point of tipping about D .

(a) Show that $GD = \frac{5}{2}d$. (4)

The particle is moved from B to the mid-point of the rod and the rod remains in equilibrium.

(b) Find the magnitude of the normal reaction between the support at D and the rod. (5)

5. A stone is projected vertically upwards from a point A with speed $u \text{ m s}^{-1}$. After projection the stone moves freely under gravity until it returns to A . The time between the instant that the stone is projected and the instant that it returns to A is $3\frac{4}{7}$ seconds.

Modelling the stone as a particle,

(a) show that $u = 17\frac{1}{2}$, (3)

(b) find the greatest height above A reached by the stone, (2)

(c) find the length of time for which the stone is at least $6\frac{3}{5}$ m above A . (6)

6. A car moves along a straight horizontal road from a point A to a point B , where $AB = 885$ m. The car accelerates from rest at A to a speed of 15 m s^{-1} at a constant rate $a \text{ m s}^{-2}$.

The time for which the car accelerates is $\frac{1}{3}T$ seconds. The car maintains the speed of 15 m s^{-1} for T seconds. The car then decelerates at a constant rate of 2.5 m s^{-2} , stopping at B .

- (a) Find the time for which the car decelerates. (2)
- (b) Sketch a speed-time graph for the motion of the car. (2)
- (c) Find the value of T . (4)
- (d) Find the value of a . (2)
- (e) Sketch an acceleration-time graph for the motion of the car. (3)
-

7. [In this question, the unit vectors \mathbf{i} and \mathbf{j} are due east and due north respectively. Position vectors are relative to a fixed origin O .]

A boat P is moving with constant velocity $(-4\mathbf{i} + 8\mathbf{j}) \text{ km h}^{-1}$.

- (a) Calculate the speed of P . (2)

When $t = 0$, the boat P has position vector $(2\mathbf{i} - 8\mathbf{j}) \text{ km}$. At time t hours, the position vector of P is $\mathbf{p} \text{ km}$.

- (b) Write down \mathbf{p} in terms of t . (1)

A second boat Q is also moving with constant velocity. At time t hours, the position vector of Q is $\mathbf{q} \text{ km}$, where

$$\mathbf{q} = 18\mathbf{i} + 12\mathbf{j} - t(6\mathbf{i} + 8\mathbf{j}).$$

Find

- (c) the value of t when P is due west of Q , (3)

- (d) the distance between P and Q when P is due west of Q . (3)
-

8.

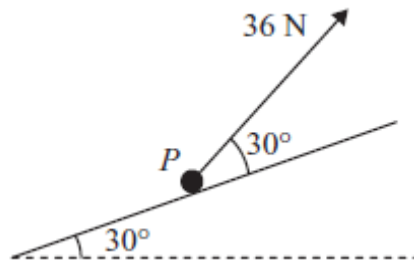


Figure 2

A particle P of mass 4 kg is moving up a fixed rough plane at a constant speed of 16 m s^{-1} under the action of a force of magnitude 36 N . The plane is inclined at 30° to the horizontal. The force acts in the vertical plane containing the line of greatest slope of the plane through P , and acts at 30° to the inclined plane, as shown in Figure 2. The coefficient of friction between P and the plane is μ . Find

(a) the magnitude of the normal reaction between P and the plane, (4)

(b) the value of μ . (5)

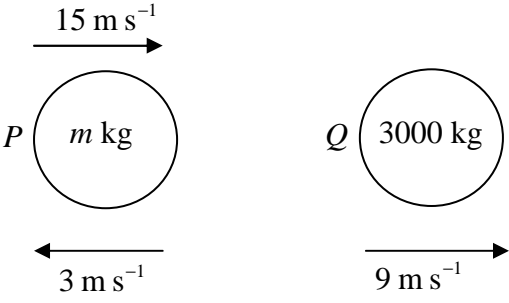
The force of magnitude 36 N is removed.

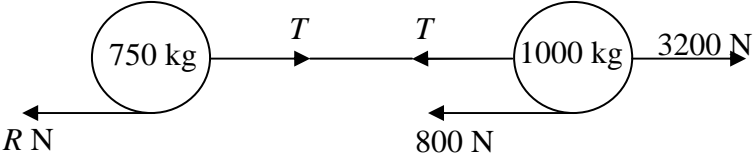
(c) Find the distance that P travels between the instant when the force is removed and the instant when it comes to rest. (5)

TOTAL FOR PAPER: 75 MARKS

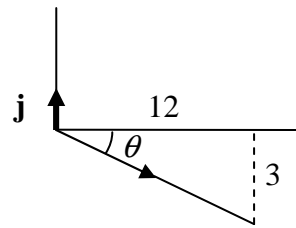
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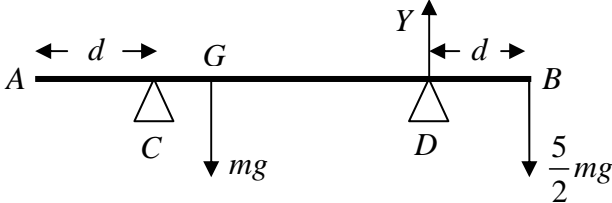
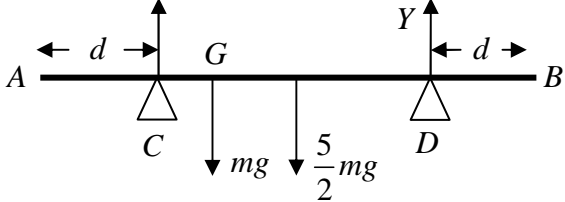
January 2012
6677 Mechanics M1
Mark Scheme

Question Number	Scheme	Marks
<p>1 (a)</p>	 <p style="text-align: center;">For Q $I = 3000 \times 9 = 27\,000$ (N s)</p>	<p>M1 A1 (2)</p>
<p>(b)</p>	<p>Conservation of linear momentum $15m = -3m + 3000 \times 9$ Leading to $m = 1500$</p>	<p>M1 A1 A1 (3) 5</p>
	<p><i>Alternative to (b)</i> For P $27\,000 = m(15 - (-3))$ Leading to $m = 1500$</p>	<p>M1 A1 A1 (3)</p>

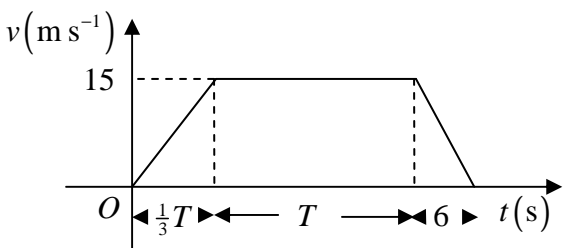
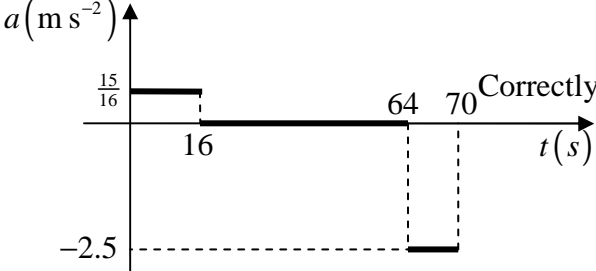
Question Number	Scheme	Marks
<p>2 (a)</p>	 <p>For the whole system $R \rightarrow \quad 3200 - 800 - R = 1750 \times 0.88$ Leading to $R = 860 \text{ *}$</p> <p>(b) For the caravan $R \rightarrow \quad T - 860 = 750 \times 0.88$ Leading to $T = 1520 \text{ (N)}$</p>	<p>M1 A1 A1 (3)</p> <p>M1 A1 A1 (3) 6</p>
	<p><i>Alternative for (b)</i> For the car $R \rightarrow \quad 3200 - 800 - T = 1000 \times 0.88$ Leading to $T = 1520 \text{ (N)}$</p>	<p>M1 A1 A1 (3)</p>

Question Number	Scheme	Marks
3 (a)	$7 + 5 + p = 0 \quad \text{or} \quad -9 + 6 + q = 0$ $p = -12$ $q = 3$	M1 A1 A1 (3)
3 (b)	$\mathbf{R} = 12\mathbf{i} - 3\mathbf{j}$ $ \mathbf{R} = \sqrt{(12^2 + (-3)^2)} = \sqrt{153} \text{ or } 3\sqrt{17} \text{ or } 12.4 \text{ or better (N)}$	M1 A1 (2)
3 (c)	$\tan \theta = \frac{3}{12}$ $\theta = 14.03^\circ \dots$ <p>Angle with \mathbf{j} is 104°, to the nearest degree cao</p>	M1 A1 A1 (3) 8

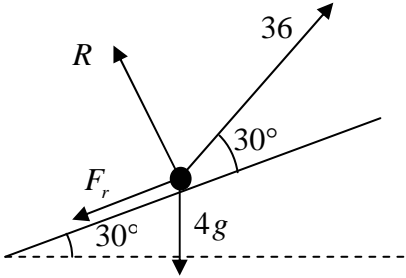


Question Number	Scheme	Marks
4 (a)	 <p>M(D) $mg \times GD = \frac{5}{2} mg \times d$</p> <p>$GD = \frac{5}{2} d$ *</p>	<p>M1 A1</p> <p>DM1 A1</p> <p>(4)</p>
(b)	 <p>M(C) $mg \times \frac{d}{2} + \frac{5}{2} mg \times \frac{3}{2} d = Y \times 3d$</p> <p>Leading to $Y = \frac{17}{12} mg$</p>	<p>M1 A2(1, 0)</p> <p>DM1 A1</p> <p>(5)</p> <p>9</p>

Question Number	Scheme	Marks
5 (a)	$v = u + at(\uparrow) \Rightarrow 0 = u - g\left(\frac{25}{14}\right)$ $u = 17 \frac{1}{2} *$	M1 M(A)1 A1 (3)
(b)	$v^2 = u^2 + 2as(\uparrow) \Rightarrow 0^2 = 17.5^2 - 2gs$ $s = 15.6 \text{ (m) or } 16 \text{ (m)}$	M1 A1 (2)
(c)	$s = ut + \frac{1}{2}at^2(\uparrow) \Rightarrow 6.6 = 17.5t - \frac{1}{2}gt^2$ $4.9t^2 - 17.5t + 6.6 = 0$ $t = \frac{17.5 \pm \sqrt{(17.5^2 - 129.36)}}{9.8} = \frac{17.5 \pm 13.3}{9.8}$ $t = 3.142.. (22/7) \text{ or } 0.428...(3/7)$ $T = t_2 - t_1 = 2.71 \text{ (2.7)}$ OR $v^2 = u^2 + 2as(\uparrow) \Rightarrow v^2 = 17.5^2 - 2gx6.6$ $v = \pm 13.3$ $v = u + at(\uparrow) \Rightarrow \pm 13.3 = 17.5 - gt$ $t = \frac{17.5 \pm 13.3}{9.8}$ $= 3.14.. (22/7) \text{ or } 0.428..(3/7)$ $T = 3.14.. - 0.428.. = 2.71 \text{ or } 2.7$ OR $v^2 = u^2 + 2as(\uparrow) \Rightarrow v^2 = 17.5^2 - 2gx6.6 \text{ or } 0^2 = u^2 - 2gx(15.625 - 6.6)$ $v = 13.3 \qquad u = 13.3$ $v = u + at(\uparrow) \Rightarrow 0 = 13.3 - gt$ $t = \frac{13.3}{g}$ $T = 2 \times \frac{13.3}{g} = 2.7 \text{ or } 2.71$	M1 A1 DM1 A1 DM1 A1 (6) M1A1 DM1 A1 DM1 A1 (6) M1 A1 DM1 A1 DM1 A1 (6)
		11

Question Number	Scheme	Marks
6 (a)	$v = u + at \Rightarrow 0 = 15 - 2.5t$ $t = 6 \text{ (s)}$	M1 A1 (2)
(b)		Shape 15, T B1 B1 (2)
(c)	$\frac{1}{2} 15 \left(\frac{4}{3} T + 6 + T \right) = 885$ $\frac{7}{3} T = 118 - 6$ $T = 112 \times \frac{3}{7} = 48$	ft their 6 M1 A1ft M1 A1 (4)
(d)	$a = \frac{15}{\frac{1}{3} T} = \frac{15}{16}, 0.9375, 0.938, 0.94$	M1 A1 (2)
(e)		3 horizontal lines B1 B1 B1 Correctly placed; no cts vert line -2.5, ft their $\frac{15}{16}$ (3) 13

Question Number	Scheme	Marks
7 (a)	$\sqrt{((-4)^2 + 8^2)} = \sqrt{80} \text{ (km h}^{-1}\text{)}$ accept exact equivalents or 8.9 or better	M1 A1 (2)
(b)	$\mathbf{p} = (2\mathbf{i} - 8\mathbf{j}) + t(-4\mathbf{i} + 8\mathbf{j})$	B1 (1)
(c)	Equating j components $-8 + 8t = 12 - 8t$ $t = \frac{5}{4} \text{ oe}$	M1 A1 A1 (3)
(d)	Using their t from (c) to find the i -cpts of p and q and subtract them $10\frac{1}{2} - (-3) = 13\frac{1}{2} \text{ (km)}$	M1 A1 ft A1 (3) 9

Question Number	Scheme	Marks
8 (a)	 $R + 36 \sin 30^\circ = 4g \cos 30^\circ$ $R \approx 15.9, 16$	M1 A1 M1 A1 (4)
(b)	Use of $F_r = \mu R$ $36 \cos 30^\circ = F + 4g \sin 30^\circ$ $\mu = \frac{36 \cos 30^\circ - 4g \sin 30^\circ}{R} \approx 0.726$ 0.73	B1 M1 A1 M1 A1 (5)
(c)	After force is removed $R = 4g \cos 30^\circ$ $-\mu 4g \cos 30^\circ - 4g \sin 30^\circ = 4a$ $a = (-)11.06 \dots$ $v^2 = u^2 + 2as \Rightarrow 0^2 = 16^2 - 2 \times 11.06 \dots \times s$ $s = \frac{16^2}{2 \times 11.06 \dots} \approx 11.6 \text{ (m)}$ 12	B1 M1 A1 M1 A1 (5) 14