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

Paper Reference(s)

6677/01

Edexcel GCE

Jono Sols

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 16 May 2012 – Morning

Time: 1 hour 30 minutes

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
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Total	

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Materials required for examination
Mathematical Formulae (Pink)

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 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}.
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 7 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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1. Two particles A and B, of mass $5m$ kg and $2m$ kg respectively, are moving in opposite directions along the same straight horizontal line. The particles collide directly. Immediately before the collision, the speeds of A and B are 3 m s^{-1} and 4 m s^{-1} respectively. The direction of motion of A is unchanged by the collision. Immediately after the collision, the speed of A is 0.8 m s^{-1}.

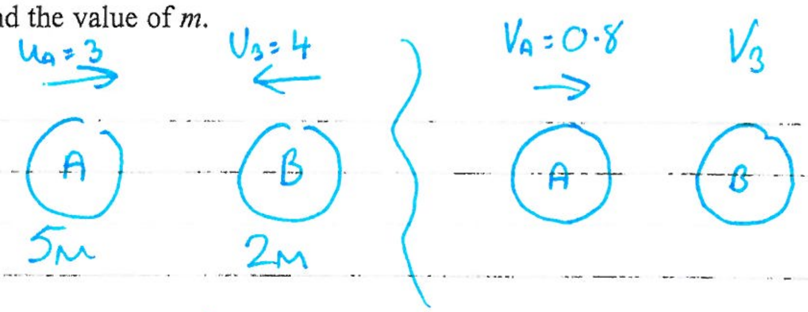
(a) Find the speed of B immediately after the collision.

(3)

In the collision, the magnitude of the impulse exerted on A by B is 3.3 N s.

(b) Find the value of m.

(3)



(a) $(5m \times 3) + (2m \times {}^{-}4) = (5m \times 0.8) + 2mV_B$

$15\cancel{m} - 8\cancel{m} = 4\cancel{m} + 2\cancel{m}V_B$

$7 = 4 + 2V_B$

$V_B = \frac{3}{2} = 1.5 \text{ ms}^{-1} \rightarrow$

(b) Impulse = change in momentum

$-3.3 = 5m(0.8 - 3)$

$-3.3 = -11m$

$m = 0.3$ kg.

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2.

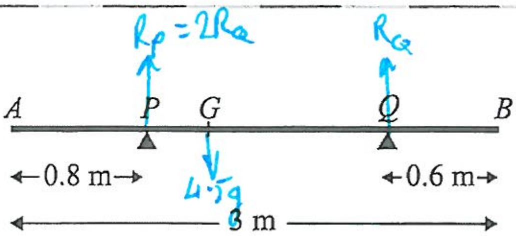

Figure 1

A non-uniform rod AB has length 3 m and mass 4.5 kg. The rod rests in equilibrium, in a horizontal position, on two smooth supports at P and at Q, where $AP = 0.8$ m and $QB = 0.6$ m, as shown in Figure 1. The centre of mass of the rod is at G. Given that the magnitude of the reaction of the support at P on the rod is twice the magnitude of the reaction of the support at Q on the rod, find

(a) the magnitude of the reaction of the support at Q on the rod,

(3)

(b) the distance AG.

(4)

(a) $\sum F_y = 0$ $\quad R_P + R_Q - 4.5g = 0$

$2R_Q + R_Q = 4.5g$

$3R_Q = 4.5g$

$R_Q = 1.5g$ N

(b) $\curvearrowright_A$ $\quad (0.8 \times 3g) + (AG \times {}^{-}4.5g) + (2.4 \times 1.5g) = 0$

$2.4\cancel{g} - 4.5\cancel{g}AG + 3.6\cancel{g} = 0$

$4.5AG = 6$

$AG = \frac{4}{3}$ m.

3.

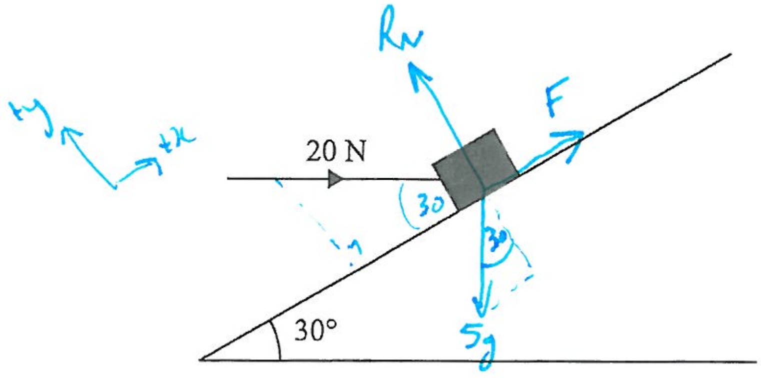

Figure 2

A box of mass 5 kg lies on a rough plane inclined at 30° to the horizontal. The box is held in equilibrium by a horizontal force of magnitude 20 N, as shown in Figure 2. The force acts in a vertical plane containing a line of greatest slope of the inclined plane.
The box is in equilibrium and on the point of moving down the plane. The box is modelled as a particle.

Find

(a) the magnitude of the normal reaction of the plane on the box,

(4)

(b) the coefficient of friction between the box and the plane.

(5)

(a) $\Sigma F_y = 0 \qquad R_N - 5g\cos 30 - 20\sin 30 = 0$

$$R_n = \frac{\sqrt{3}g}{2} + 10$$

(b) $\Sigma F_{\cancel{x}} = 0 \qquad F + 20\cos 30 - 5g\sin 30 = 0$

$$F = \frac{5g}{2} - 10\sqrt{3}$$

Now $\mu = \frac{F}{R_n} = \frac{2.5g - 10\sqrt{3}}{4.9\sqrt{3} + 10} = 0.388$

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4. A car is moving on a straight horizontal road. At time $t = 0$, the car is moving with speed 20 m s^{-1} and is at the point A. The car maintains the speed of 20 m s^{-1} for 25 s. The car then moves with constant deceleration 0.4 m s^{-2}, reducing its speed from 20 m s^{-1} to 8 m s^{-1}. The car then moves with constant speed 8 m s^{-1} for 60 s. The car then moves with constant acceleration until it is moving with speed 20 m s^{-1} at the point B.

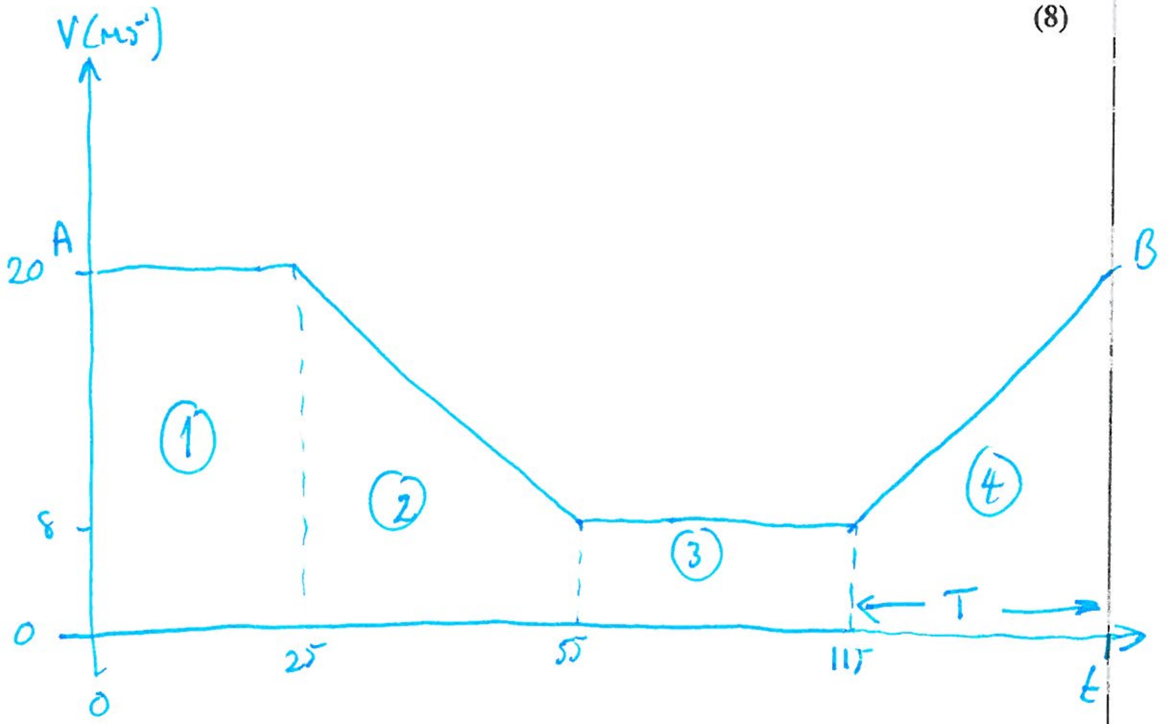
(a) Sketch a speed-time graph to represent the motion of the car from A to B.
(3)

(b) Find the time for which the car is decelerating.
(2)

Given that the distance from A to B is 1960 m,

(c) find the time taken for the car to move from A to B.
(8)

(a)



(b) time of deceleration : $u=20$ $v=8$ $a=-0.4$ $t=?$

$v=u+at$

$8=20-0.4t$

$0.4t=12$

$t=30$ sec

(c) distance = Area ① + ② + ③ + ④

$1960 = \frac{1}{2}(25\times20) + \frac{1}{2}(20+8)\times30 + (60\times8) + \frac{1}{2}(8+20)T$

$1960 = 500 + 420 + 480 + 14T$

$14T = 560 \Rightarrow T=40$ ∴ Journey time $= 115+40 = 155$ sec.

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5. A particle P is projected vertically upwards from a point A with speed u m s^{-1}. The point A is 17.5 m above horizontal ground. The particle P moves freely under gravity until it reaches the ground with speed 28 m s^{-1}.

(a) Show that $u = 21$

(3)

At time t seconds after projection, P is 19 m above A.

(b) Find the possible values of t.

(5)

The ground is soft and, after P reaches the ground, P sinks vertically downwards into the ground before coming to rest. The mass of P is 4 kg and the ground is assumed to exert a constant resistive force of magnitude 5000 N on P.

(c) Find the vertical distance that P sinks into the ground before coming to rest.

(4)

(a) $u\uparrow$ $s = 17.5\downarrow$ $a = 9.8\downarrow$ $V = 28\downarrow$
$= -u\downarrow$

Using $V^2 = u^2 + 2as$

$28^2 = (-u)^2 + 2\times 9.8\times 17.5$

$28^2 - 343 = u^2$

$u^2 = 441$
$u = 21$ ms^{-1} As required

(b) $u = 21\uparrow$ $a = 9.8\downarrow$ $s = 19\uparrow$ $t = ?$
$= -9.8\uparrow$

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

$19 = 21t + \frac{1}{2}\times -9.8t^2$

$4.9t^2 - 21t + 19 = 0$

$t = 1.3$ sec or ~~3~~ 3.0 sec

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Question 5 continued

(C) N2L: $-5000 = 4a$

$a = -1250 \text{ ms}^{-2}$

Now $u = 28$ $v = 0$ $a = -1250$ $s = ?$

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

$0^2 = 28^2 + 2 \times -1250 s$

$2500 s = 28^2$

$s = 0.3136 \text{m}$

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

A ship S is moving with constant velocity $(-12\mathbf{i} + 7.5\mathbf{j})$ km h^{-1}.

(a) Find the direction in which S is moving, giving your answer as a bearing. **(3)**

At time t hours after noon, the position vector of S is **s** km. When $t = 0$, $\mathbf{s} = 40\mathbf{i} - 6\mathbf{j}$.

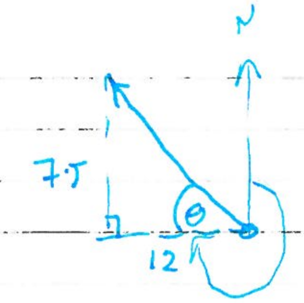
(b) Write down **s** in terms of t. **(2)**

A fixed beacon B is at the point with position vector $(7\mathbf{i} + 12.5\mathbf{j})$ km.

(c) Find the distance of S from B when $t = 3$ **(4)**

(d) Find the distance of S from B when S is due north of B. **(4)**

(a)



$\theta = \tan^{-1}\left(\frac{7.5}{12}\right) = 32^\circ$

$\therefore$ S travelling on bearing $32 + 270 = 302^\circ$

(b) $S_t = \begin{pmatrix} 40 \\ -6 \end{pmatrix} + t\begin{pmatrix} -12 \\ 7.5 \end{pmatrix} = \begin{pmatrix} 40 - 12t \\ 7.5t - 6 \end{pmatrix}$

(c) @ $t = 3$ $\quad S = \begin{pmatrix} 40 \\ -6 \end{pmatrix} + 3\begin{pmatrix} -12 \\ 7.5 \end{pmatrix} = \begin{pmatrix} 4 \\ 16.5 \end{pmatrix}$

$\vec{SB} = -\vec{OS} + \vec{OB} = -\begin{pmatrix} 4 \\ 16.5 \end{pmatrix} + \begin{pmatrix} 40 \\ -6 \end{pmatrix} = \begin{pmatrix} 36 \\ -22.5 \end{pmatrix}$

$|\vec{SB}| = \sqrt{36^2 + (-22.5)^2} = 42.5$ km

(d) when S is due north of B, their i components will be the same

$\therefore \quad 40 - 12t = 7$

$t = \frac{33}{12}$

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Question 6 continued

at this point j component of S will be $7.5\left(\frac{33}{12}\right) - 6 = 14.6$

So distance between S+B will be $14.6 - 12.5 = 2.1$ km.

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7.

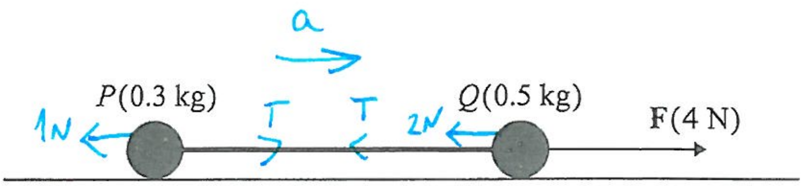

Figure 3

Two particles P and Q, of mass 0.3 kg and 0.5 kg respectively, are joined by a light horizontal rod. The system of the particles and the rod is at rest on a horizontal plane. At time $t = 0$, a constant force **F** of magnitude 4 N is applied to Q in the direction PQ, as shown in Figure 3. The system moves under the action of this force until $t = 6$ s. During the motion, the resistance to the motion of P has constant magnitude 1 N and the resistance to the motion of Q has constant magnitude 2 N.

Find

(a) the acceleration of the particles as the system moves under the action of **F**,

(3)

(b) the speed of the particles at $t = 6$ s,

(2)

(c) the tension in the rod as the system moves under the action of **F**.

(3)

At $t = 6$ s, **F** is removed and the system decelerates to rest. The resistances to motion are unchanged. Find

(d) the distance moved by P as the system decelerates,

(4)

(e) the thrust in the rod as the system decelerates.

(3)

(a) N2L on whole system: $4 - 3 = 0.8a$

$1 = 0.8a$

$a = 1.25\ \text{ms}^{-2}$

(b) $u = 0$ $v = ?$ $a = 1.25$ $t = 6$ $\quad v = u + at$

$v = 0 + 1.25 \times 6 = 7.5\ \text{ms}^{-1}$

(c) N2L on P: $T - 1 = 0.3a$

$T = 0.3 \times 1.25 + 1 = 4.75\text{N}$

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Question 7 continued

(d) change in accel: $-3 = 0.8a$

$a = -3.75N$

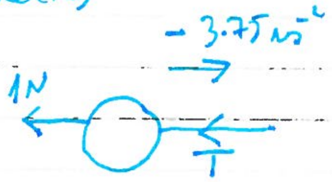
$u = 7.5 \quad v = 0 \quad a = -3.75 \quad s = ?$

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

$0 = 7.5^2 - 2 \times 3.75s$

$s = 7.5$ metres

(e) N2L on P



$-T - 1 = 0.3 \times -3.75$

$1.125 - 1 = T$

$T = 0.125N.$

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