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 23 January 2013 – 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	
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}.
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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PEARSON

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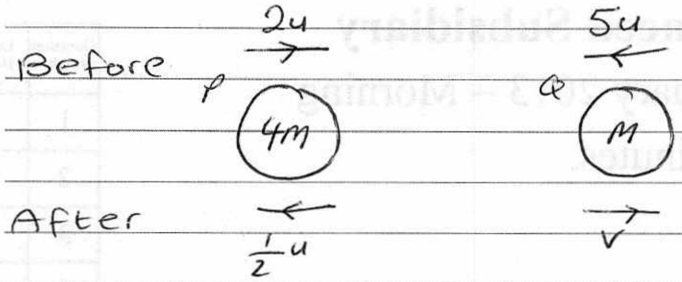
1. Two particles P and Q have masses $4m$ and m respectively. The particles are moving towards each other on a smooth horizontal plane and collide directly. The speeds of P and Q immediately before the collision are $2u$ and $5u$ respectively. Immediately after the collision, the speed of P is $\frac{1}{2}u$ and its direction of motion is reversed.

(a) Find the speed and direction of motion of Q after the collision.

(4)

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

(3)



$M_1U_1 + M_2U_2 = M_1V_1 + M_2V_2$

$4m(2u) + m(-5u) = 4m(-\frac{1}{2}u) + mv$

$8mu - 5mu = -2mu + mv$

$5mu = mv$

$\underline{\underline{v = 5u}}$

the direction of Q is reversed.

b/ $I = |mv - mu|$

$= |4m(-\frac{1}{2}u) - 4m(2u)|$

$= |-2mu - 8mu|$

$= |-10mu|$

$= 10mu$

2. A steel girder AB, of mass 200 kg and length 12 m, rests horizontally in equilibrium on two smooth supports at C and at D, where $AC = 2$ m and $DB = 2$ m. A man of mass 80 kg stands on the girder at the point P, where $AP = 4$ m, as shown in Figure 1.

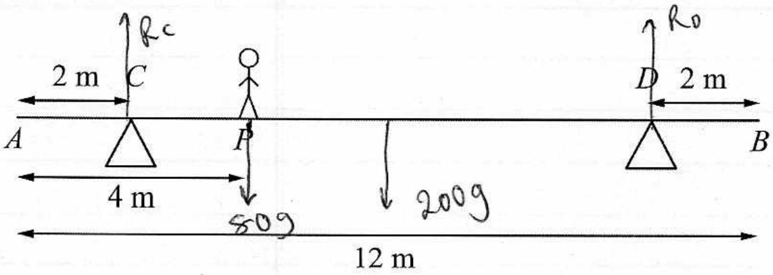


Figure 1

The man is modelled as a particle and the girder is modelled as a uniform rod.

(a) Find the magnitude of the reaction on the girder at the support at C.

(3)

The support at D is now moved to the point X on the girder, where $XB = x$ metres. The man remains on the girder at P, as shown in Figure 2.

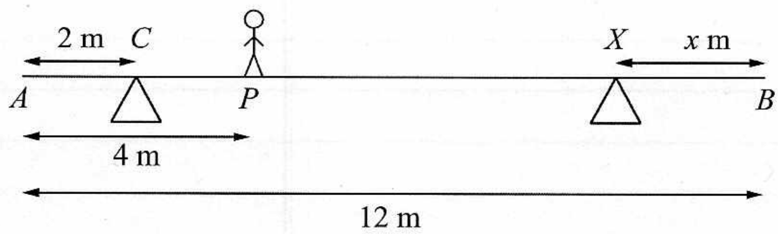


Figure 2

Given that the magnitudes of the reactions at the two supports are now equal and that the girder again rests horizontally in equilibrium, find

(b) the magnitude of the reaction at the support at X,

(2)

(c) the value of x.

(4)

a/ Taking moments about D.

$8R_c = 4(200g) + 6(80g)$

$8R_c = 1280g$

$R_c = 160g$

P 4 1 4 8 1 A 0 4 2 8

Leave blank

Question 2 continued

b/ Forces up = Forces down

$2R = 80g + 200g$

$\underline{\underline{R = 140g}}$

c/ Taking moments about B:

$x(140g) + 10(140g) = 6(200g) + 8(80g)$

$x(140g) \quad 1400g = 1200g + 640g$

$x(140g) = 440g$

$\underline{\underline{x = \frac{22}{7} m}}$

Leave blank

3. A particle P of mass 2 kg is attached to one end of a light string, the other end of which is attached to a fixed point O. The particle is held in equilibrium, with OP at 30° to the downward vertical, by a force of magnitude F newtons. The force acts in the same vertical plane as the string and acts at an angle of 30° to the horizontal, as shown in Figure 3.

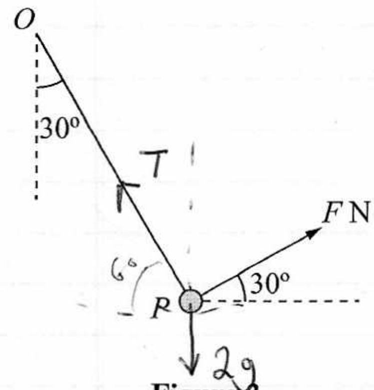


Figure 3

Find

(i) the value of F,

(ii) the tension in the string.

(8)

Resolving →

$T \cos 60 = F \cos 30$

$\frac{1}{2}T = \frac{\sqrt{3}}{2}F$

Resolving ↑

$T \sin 60 + F \sin 30 = 2g$

$\frac{\sqrt{3}}{2}T + \frac{1}{2}F = 2g$ (2)

$T = \sqrt{3}F$ (1)

$\frac{\sqrt{3}}{2}(\sqrt{3}F) + \frac{1}{2}F = 2g$

$2F = 2g$

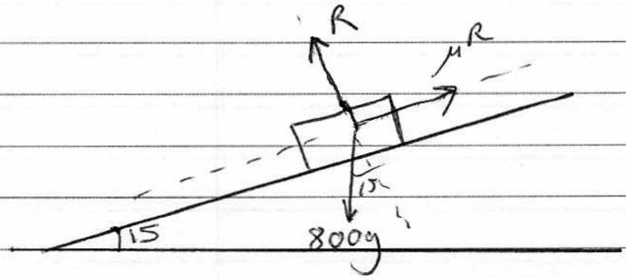
$F = \underline{\underline{g}}$

$T = \underline{\underline{\sqrt{3}\,g}}$

Leave blank

4. A lifeboat slides down a straight ramp inclined at an angle of 15° to the horizontal. The lifeboat has mass 800 kg and the length of the ramp is 50 m. The lifeboat is released from rest at the top of the ramp and is moving with a speed of 12.6 m s^{-1} when it reaches the end of the ramp. By modelling the lifeboat as a particle and the ramp as a rough inclined plane, find the coefficient of friction between the lifeboat and the ramp.

(9)



Resolving ↑

$R = 800g \cos 15$

$= 7573\ldots$ N

$s = 50$ $\quad$ $v^2 = u^2 + 2as$

$u = 0$

$v = 12.6$ $\quad$ $(12.6)^2 = 2(a)(50)$

$a = ?$ $\quad$ $a = 1.5876$ ms^{-2}

$F = ma$

$800g \sin 15 - \mu(\text{"}7573\text{"}) = 800(\text{"}1.5876\text{"})$

$\mu = \underline{0.10}$ (2sf)

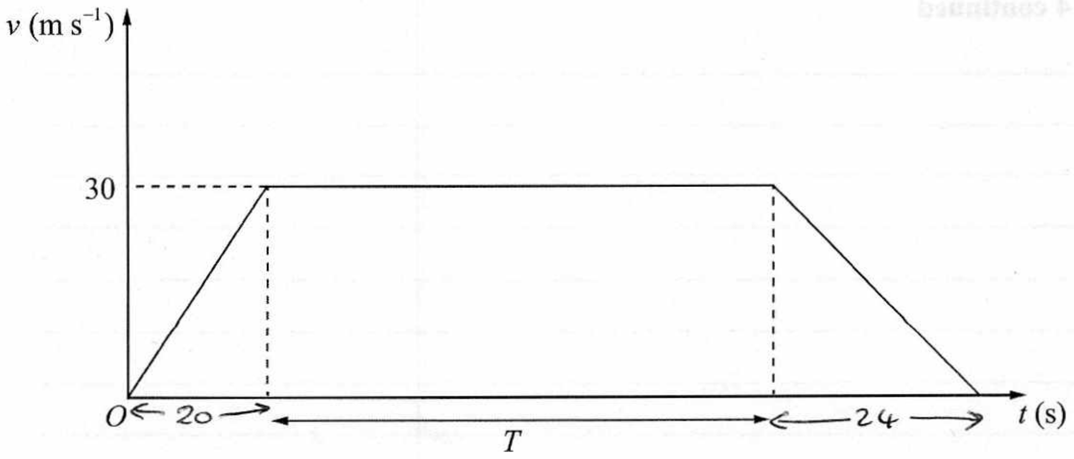
5. 

Figure 4

1500 m

The velocity-time graph in Figure 4 represents the journey of a train P travelling along a straight horizontal track between two stations which are 1.5 km apart. The train P leaves the first station, accelerating uniformly from rest for 300 m until it reaches a speed of 30 m s^{-1}. The train then maintains this speed for T seconds before decelerating uniformly at 1.25 m s^{-2}, coming to rest at the next station.

(a) Find the acceleration of P during the first 300 m of its journey. **(2)**

(b) Find the value of T. **(5)**

A second train Q completes the same journey in the same total time. The train leaves the first station, accelerating uniformly from rest until it reaches a speed of V m s^{-1} and then immediately decelerates uniformly until it comes to rest at the next station.

(c) Sketch on the diagram above, a velocity-time graph which represents the journey of train Q. **(2)**

(d) Find the value of V. **(6)**

a) $a = \cancel{\frac{v-u}{t}}$

$= \cancel{30}$

$s = 300$

$u = 0$

$v = 30$

$a =$

t

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

$(30)^2 = 2(a)(300)$

$a = 1.5 \text{ ms}^{-2}$

$v = u + at$

$30 = 1.5t$

$t = 20$

P 4 1 4 8 1 A 0 1 6 2 8

Question 5 continued

Leave blank

b/ For deceleration $s=$
$u = 30$
$v = 0$
$a = -1.25$
$t = ?$

$v = u + at$
$0 = 30 + (-1.25)t$
$t = 24$

Area under graph = distance

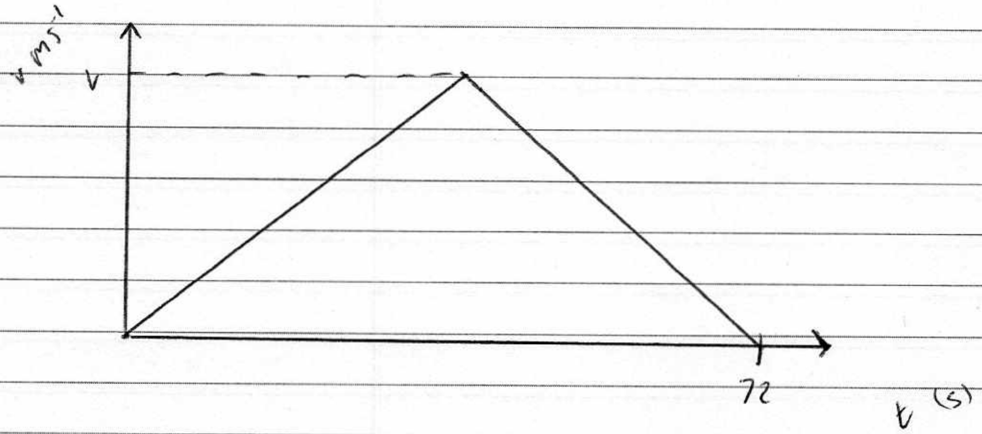
$$\frac{20 + T + 24 + T}{2} \times 30 = 1500$$

$$\frac{2T + 44}{2} \times 30 = 1500$$

$$T + 22 = 50$$

$$T = 28 \text{ seconds}$$

c/



$$\tfrac{1}{2}(72)(V) = 1500$$

$$V = \frac{125}{3}\ ms^{-1}$$

Leave blank

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 sets sail at 9 am from a port P and moves with constant velocity. The position vector of P is $(4\mathbf{i} - 8\mathbf{j})$ km. At 9.30 am the ship is at the point with position vector $(\mathbf{i} - 4\mathbf{j})$ km.

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

(4)

(b) Show that the position vector $\mathbf{r}$ km of the ship, t hours after 9 am, is given by $\mathbf{r} = (4 - 6t)\mathbf{i} + (8t - 8)\mathbf{j}$.

(2)

At 10 am, a passenger on the ship observes that a lighthouse L is due west of the ship. At 10.30 am, the passenger observes that L is now south-west of the ship.

(c) Find the position vector of L.

(5)

a) $v = \dfrac{(i - 4j) - (4i - 8j)}{0.5}$ $\left[\text{speed} = \dfrac{\text{distance}}{\text{time}}\right]$

$= \dfrac{-3i + 4j}{0.5}$

$= -6i + 8j$

Speed $= \sqrt{6^2 + 8^2} = \underline{10 \text{ km h}^{-1}}$

b) $r = (4i - 8j) + t(-6i + 8j)$

$= (4 - 6t)i + (-8 + 8t)j$

$= (4 - 6t)i + (8t - 8)j$

c) when $t = 1$ $r = -2i$

Due west (js are the same) $\underline{j = 0}$

when $t = 1.5$ $r = -5i + 4j$

South west so $r - L$ is parallel to $-i - j$

Leave blank

Question 6 continued

Let $l = ki$

$r - l = (-5 - k)i + 4j$

parallel to $-i - j$:

$(5-k)i + 4j = x(-i - j)$

~~i//~~ $j//$ $4 = -x$

$x = -4$

$i//$ $-5 - k = 4$

$-k = 9$

$k = -9$

$l = -9i$

Leave blank

7.

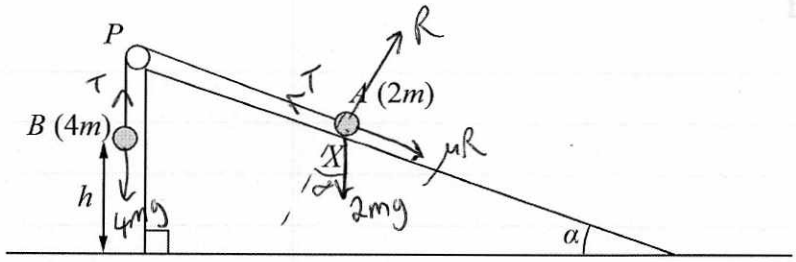


Figure 5

Figure 5 shows two particles A and B, of mass $2m$ and $4m$ respectively, connected by a light inextensible string. Initially A is held at rest on a rough inclined plane which is fixed to horizontal ground. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$. The coefficient of friction between A and the plane is $\frac{1}{4}$. The string passes over a small smooth pulley P which is fixed at the top of the plane. The part of the string from A to P is parallel to a line of greatest slope of the plane and B hangs vertically below P. The system is released from rest with the string taut, with A at the point X and with B at a height h above the ground.

For the motion until B hits the ground,

(a) give a reason why the magnitudes of the accelerations of the two particles are the same,

(1)

(b) write down an equation of motion for each particle,

(4)

(c) find the acceleration of each particle.

(5)

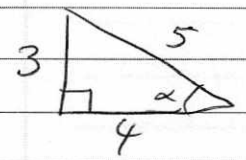
Particle B does not rebound when it hits the ground and A continues moving up the plane towards P. Given that A comes to rest at the point Y, without reaching P,

(d) find the distance XY in terms of h.

(6)

$\tan\alpha = 3/4$

$\sin\alpha = 3/5$



$\cos\alpha = 4/5$

a) They are connected by a light inextensible string

~~and~~

~~It is a smooth pulley~~

P 4 1 4 8 1 A 0 2 4 2 8

Question 7 continued

b/ $F = ma$

B: $4mg - T = 4ma$

A: $T - \mu R - 2mg \sin\alpha = 2ma$

$$\boxed{\begin{aligned} R &= 2mg\cos\alpha \\ &= 2mg(4/5) \\ &= \tfrac{8}{5}mg \end{aligned}}$$

$\mu = \frac{1}{4}$

$T - \frac{1}{4}\left(\frac{8}{5}mg\right) - 2mg\,(3/5) = 2ma$

$T - \frac{2}{5}mg - \frac{6}{5}mg = 2ma$

$\underline{T - \frac{8}{5}mg = 2ma}$

c/ $T = 4mg - 4ma$ (1)

$T = 2ma + \frac{8}{5}mg$ (2)

$4\cancel{m}g - 4\cancel{m}a = 2\cancel{m}a + \frac{8}{5}\cancel{m}g$

$4g - 4a = 2a + \frac{8}{5}g$

$\frac{12}{5}g = 6a$

$\underline{\underline{a = \frac{2}{5}g \text{ ms}^{-2}}}$

d/ $s = h$

$u = 0$ [First motion before B hits ground]

$v = ?$

$a = \frac{2}{5}g$

$t =$

Question 7 continued

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

$v^2 = 2(\frac{2}{5}g)h$

$v^2 = \frac{4}{5}gh$

$v = \sqrt{\frac{4}{5}gh}$

Second Motion : $F = ma$

$-2mg\sin\alpha - \mu R = 2ma$

$-\frac{6}{5}mg - \frac{2}{5}mg = 2ma$

$-\frac{8}{5}\cancel{m}g = 2\cancel{m}a$

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

$s = ?$
$u = \sqrt{\frac{4}{5}gh}$
$v = 0$
$a = -4/5g$
$t =$

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

$0 = \frac{4}{5}gh + 2(-\frac{4}{5}g)s$

$-\frac{4}{5}\cancel{g}h = -\frac{8}{5}\cancel{g}s$

$s = \frac{1}{2}h$ (After B hits ground)

$\frac{1}{2}h + h = \frac{3}{2}h$ (+ original h for first motion)