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Pearson Edexcel GCE

Centre Number | Candidate Number

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 14 June 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference **6677/01**

You must have:
Mathematical Formulae and Statistical Tables (Pink)

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.

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1. Three forces, $(15\mathbf{i} + \mathbf{j})$ N, $(5q\mathbf{i} - p\mathbf{j})$ N and $(-3p\mathbf{i} - q\mathbf{j})$ N, where p and q are constants, act on a particle. Given that the particle is in equilibrium, find the value of p and the value of q.

(6)

i// $15 + 5q - 3p = 0$

j// $1 - p - q = 0$

$(1-p) = q$

$15 + 5(1-p) - 3p = 0$

$15 + 5 - 5p - 3p = 0$

$20 - 8p = 0$

$20 = 8p$

$p = \frac{20}{8} = \frac{5}{2} = 2.5$

$q = 1 - (2.5)$

$= -1.5$

$p = 2.5 \quad q = -1.5$

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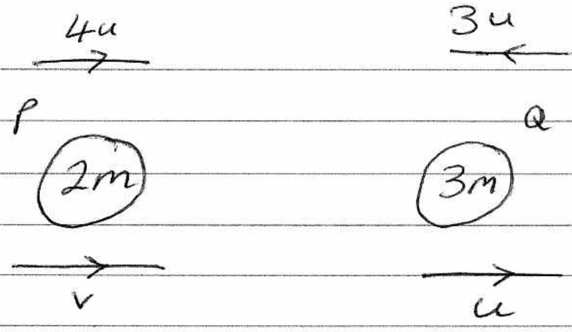
2. Two particles, P and Q, have masses $2m$ and $3m$ respectively. They are moving towards each other in opposite directions on a smooth horizontal plane when they collide directly. Immediately before they collide the speed of P is $4u$ and the speed of Q is $3u$. As a result of the collision, Q has its direction of motion reversed and is moving with speed u.

(a) Find the speed of P immediately after the collision.
(3)

(b) State whether or not the direction of motion of P has been reversed by the collision.
(1)

(c) Find the magnitude of the impulse exerted on P by Q in the collision.
(3)



$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

$2m(4u) + 3m(-3u) = 2m(v) + 3mu$

$8mu - 9mu = 2mv + 3mu$

$-mu = 2mv + 3mu$

$-4mu = 2mv$

$-4u = 2v$

$v = -2u$

Speed $= 2u$

b/ direction has been reversed.

c/ $I = mv - mu$

$= 2m(-2u) - 2m(4u)$

$= -4mu - 8mu$

$= -12mu$

Magnitude of Impulse $= 12mu$.

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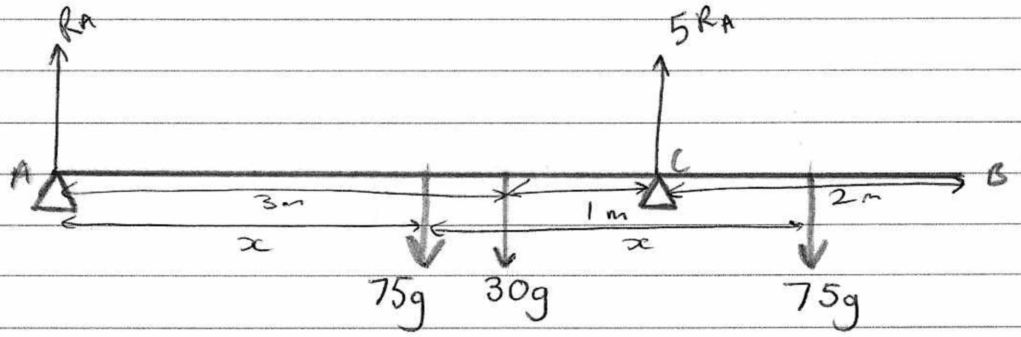
3. A plank AB has length 6 m and mass 30 kg. The point C is on the plank with $CB = 2$ m. The plank rests in equilibrium in a horizontal position on supports at A and C. Two people, each of mass 75 kg, stand on the plank. One person stands at the point P of the plank, where $AP = x$ metres, and the other person stands at the point Q of the plank, where $AQ = 2x$ metres. The plank remains horizontal and in equilibrium with the magnitude of the reaction at C five times the magnitude of the reaction at A. The plank is modelled as a uniform rod and each person is modelled as a particle.

(a) Find the value of x.

(7)

(b) State two ways in which you have used the assumptions made in modelling the plank as a uniform rod.

(2)



a) Forces up = Forces Down

$6R_A = 75g + 75g + 30g$
$6R_A = 180g$
$R_A = 30g$

Taking moments about A
Clockwise moments = Anti Clockwise moments.

$(75g)x + 75g(2x) + 30g(3) = 5(30g)(4)$

$75gx + 150gx + 90g = 600g$

$225gx = 510g$

$x = \frac{510}{225} = \frac{34}{15}$

b) Uniform → weight acts at centre Rod → does not bend.

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4.

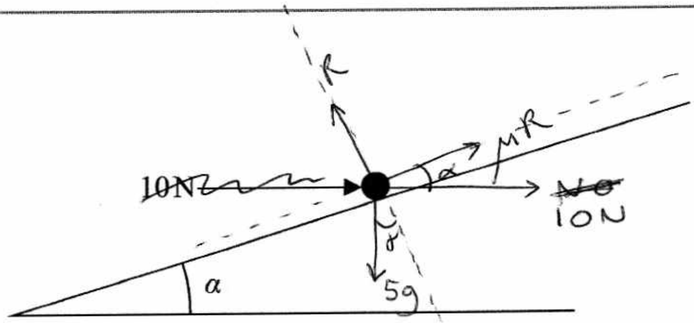
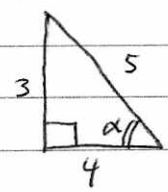


Figure 1

A particle P of mass 5 kg is held at rest in equilibrium on a rough inclined plane by a horizontal force of magnitude 10 N. The plane is inclined to the horizontal at an angle α where $\tan\alpha = \frac{3}{4}$, as shown in Figure 1. The line of action of the force lies in the vertical plane containing P and a line of greatest slope of the plane. The coefficient of friction between P and the plane is μ. Given that P is on the point of sliding down the plane, find the value of μ.

Friction takes max value.

(9)



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

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

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

perpendicular to the plane:

$R = 5g\cos\alpha + 10\sin\alpha$

$= 5g(4/5) + 10(3/5)$

$= 4g + 6$

parallel to the plane:

$5g\sin\alpha = 10\cos\alpha + \mu(4g+6)$

$5g(3/5) = 10(4/5) + \mu(4g+6)$

$3g = 8 + \mu(4g+6)$

$3g - 8 = \mu(4g+6)$

$\mu = \frac{3g-8}{4g+6}$

$= 0.47$ (2sf)

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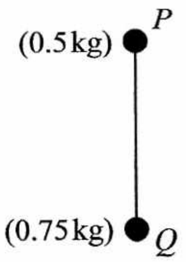

Figure 2

A vertical light rod PQ has a particle of mass 0.5 kg attached to it at P and a particle of mass 0.75 kg attached to it at Q, to form a system, as shown in Figure 2. The system is accelerated vertically upwards by a vertical force of magnitude 15 N applied to the particle at Q. Find the thrust in the rod.

(6)

whole system:

$F = ma$

$\frac{15 - 1.25g}{1.25} = \frac{1.25a}{1.25}$

$a = 12 - g \text{ ms}^{-2}$

Just P:

$F = ma$

$T - 0.5g = 0.5(12 - g)$

$T - 0.5g = 6 - 0.5g$

$T = 6\text{ N}$

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6. A cyclist is moving along a straight horizontal road and passes a point A. Five seconds later, at the instant when she is moving with speed 10 m s^{-1}, she passes the point B. She moves with constant acceleration from A to B.

Given that $AB = 40\text{m}$, find

(a) the acceleration of the cyclist as she moves from A to B,

(4)

(b) the time it takes her to travel from A to the midpoint of AB.

(5)

$s = 40$
u
$v = 10$
$a = ?$
$t = 5$

a) $s = vt - \frac{1}{2}at^2$

$40 = 10(5) - \frac{1}{2}a(5)^2$

$40 = 50 - \frac{25}{2}a$

$\frac{25}{2}a = 10$

$a = 0.8 \text{ ms}^{-2}$

b/ $s = 20$
$u = 6$
v
$a = 0.8$
$t = ?$

From original
$v = u + at$
$10 = u + 0.8(5)$
$u = 6$

$s = ut + \frac{1}{2}at^2$
$20 = 6t + \frac{1}{2}0.8t^2$
$20 = 6t + 0.4t^2$
$200 = 60t + 4t^2$
$50 = 15t + t^2$

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Question 6 continued

$t^2 + 15t - 50 = 0$

$a = 1 \quad b = 15 \quad c = -50$

$t = \dfrac{-(15) \pm \sqrt{(15)^2 - 4(1)(-50)}}{2(1)}$

$= 2.81 \ (3sf) \qquad -17.8 \ (3sf)$

t cannot be negative. $t = 2.81$ s.

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

Two ships, P and Q, are moving with constant velocities.
The velocity of P is $(9\mathbf{i} - 2\mathbf{j})\,\text{km h}^{-1}$ and the velocity of Q is $(4\mathbf{i} + 8\mathbf{j})\,\text{km h}^{-1}$

(a) Find the direction of motion of P, giving your answer as a bearing to the nearest degree.

(3)

When $t = 0$, the position vector of P is $(9\mathbf{i} + 10\mathbf{j})$ km and the position vector of Q is $(\mathbf{i} + 4\mathbf{j})$ km. At time t hours, the position vectors of P and Q are $\mathbf{p}$ km and $\mathbf{q}$ km respectively.

(b) Find an expression for

(i) $\mathbf{p}$ in terms of t,

(ii) $\mathbf{q}$ in terms of t.

(3)

(c) Hence show that, at time t hours,

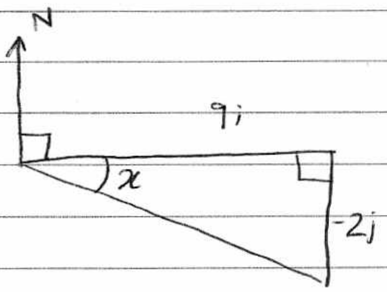
$$\overrightarrow{QP} = (8 + 5t)\mathbf{i} + (6 - 10t)\mathbf{j}$$

(2)

(d) Find the values of t when the ships are 10 km apart.

(6)

a)



$\tan(x) = \frac{2}{9}$

$x = \tan^{-1}\left(\frac{2}{9}\right)$

$= 12.52880771$

$90 + \text{Ans} = 103°$ (Nearest Degree)

b i) $9i + 10j + t(9i - 2j)$

ii) $i + 4j + t(4i + 8j)$

c) $\overrightarrow{QP} = p - q$

$= 9i + 10j + t(9i - 2j) - (i + 4j + t(4i + 8j))$

$= (9 + 9t)i + (10 - 2t)j - ((1 + 4t)i + (4 + 8t)j)$

$= (9 + 9t)i + (10 - 2t)j - (1 + 4t)i - (4 + 8t)j$

$= (8 - 5t)i + (6 - 10t)j$

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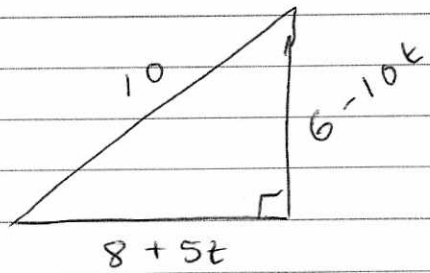
Question 7 continued

d/



$$(8+5t)^2 + (6-10t)^2 = 10^2$$

$$(8+5t)(8+5t) + (6-10t)(6-10t) = 100$$

$$64 + 40t + 40t + 25t^2 + 36 - 60t - 60t + 100t^2 = 100$$

$$125t^2 - 40t + 100 = 100$$

$$125t^2 - 40t = 0$$

$$5t(25t - 8) = 0$$

$$t = 0 \quad t = \frac{8}{25}$$

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8.

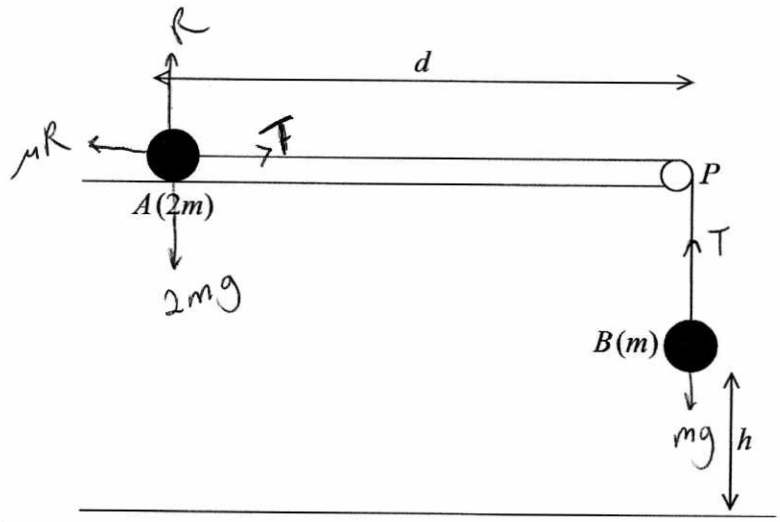

Figure 3

Two particles, A and B, have masses $2m$ and m respectively. The particles are attached to the ends of a light inextensible string. Particle A is held at rest on a fixed rough horizontal table at a distance d from a small smooth light pulley which is fixed at the edge of the table at the point P. The coefficient of friction between A and the table is μ, where $\mu < \frac{1}{2}$. The string is parallel to the table from A to P and passes over the pulley. Particle B hangs freely at rest vertically below P with the string taut and at a height h, $(h < d)$, above a horizontal floor, as shown in Figure 3. Particle A is released from rest with the string taut and slides along the table.

(a) (i) Write down an equation of motion for A.

(ii) Write down an equation of motion for B.

(4)

(b) Hence show that, until B hits the floor, the acceleration of A is $\frac{g}{3}(1 - 2\mu)$.

(3)

(c) Find, in terms of g, h and μ, the speed of A at the instant when B hits the floor.

(2)

After B hits the floor, A continues to slide along the table. Given that $\mu = \frac{1}{3}$ and that A comes to rest at P,

(d) find d in terms of h.

(5)

(e) Describe what would happen if $\mu = \frac{1}{2}$

(1)

ai/ $F = ma$ ii/ $F = ma$

$T - \mu(2mg) = 2ma$ $mg - T = ma$

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Question 8 continued

b/ $T = 2ma + \mu(2mg)$ $T = mg - ma$

$2ma + \mu(2mg) = mg - ma$

$2a + 2g\mu = g - a$

$3a + 2g\mu = g$

$3a = g - 2g\mu$

$3a = g(1 - 2\mu)$

$a = \frac{g}{3}(1 - 2\mu)$

c/ $s = h$
$u = 0$
$v = ?$
$a = \frac{g}{3}(1-2\mu)$
$t = ?$

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

$v^2 = (0)^2 + 2\left(\frac{g}{3}(1-2\mu)\right)h$

$v^2 = \frac{2gh}{3}(1-2\mu)$

$v = \sqrt{\frac{2gh}{3}(1-2\mu)}$

d/ $F = ma$

$-\mu(2mg) = 2ma$

$a = -\mu g$ $\mu = \frac{1}{3}$

$a = -\frac{1}{3}g$

$s = ?$
$u = \sqrt{\frac{2gh}{3}(1-\frac{2}{3})}$
$v = 0$
$a = -\frac{1}{3}g$
t

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

$0 = \frac{2gh}{3}(\frac{1}{3}) + 2(-\frac{1}{3}g)s$

$0 = \frac{2}{9}gh - \frac{2}{3}gs$

$\frac{2}{3}s = \frac{2}{9}h$

$s = \frac{1}{3}h$ $d = h + \frac{1}{3}h$
$= \frac{4}{3}h$

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Question 8 continued

e) If $\mu = \frac{1}{2}$ $a = \frac{g}{3}\left(1 - 2\left(\frac{1}{2}\right)\right)$

$= 0$

a would be 0.

The system would not move.

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