Write your name here

Surname	Other names

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 $g = 9.8 \text{ m s}^{-2}$, 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.

Turn over ▶

Pearson

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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)

Question Number	Scheme	Marks
1	$(15\mathbf{i}+\mathbf{j})+(5q\mathbf{i}-p\mathbf{j})+(-3p\mathbf{i}-q\mathbf{j})=\mathbf{0}$	M1
	$3p-5q=15$ $p+q=1$	M1 A1
	$p=2.5 \quad q=-1.5$	M1 A1 A1
		6
	Notes	
	First M1 for equating the sum of the three forces to zero (can be implied by subsequent working) Second M1 for equating the sum of the **i** components to zero AND the sum of the **j** components to zero oe to produce TWO equations, each one being in *p* and *q* ONLY. First A1 for TWO correct equations (in any form) **N.B.** It is possible to obtain TWO equations by using $\lambda(3p-5q-15)=\mu(p+q-1)$ with TWO different pairs of values for λ and μ, with one pair not a multiple of the other e.g $\lambda=1$, $\mu=1$ AND $\lambda=1$, $\mu=2$. Third M1(independent) for attempt (either by substitution or elimination) to produce an equation in either *p* ONLY or *q* ONLY. Second A1 for $p=2.5$ (any equivalent form, fractions do not need to be in lowest terms) Third A1 for $q=-1.5$ (any equivalent form, fractions do not need to be in lowest terms)	

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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.

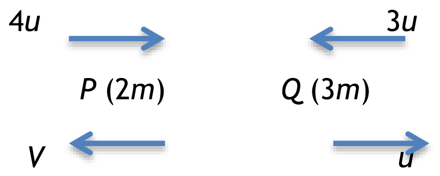
(3)

(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)

Question Number	Scheme	Marks
2(a)	 $8mu - 9mu = -2mV + 3mu$ $V = 2u$	M1 A1 A1 (3)
(b)	(Has been) reversed	B1 (1)
(c)	For Q: $I = 3m(u - -3u)$ $= 12mu$ OR: For P: $I = 2m(2u - -4u)$ $= 12mu$	M1 A1 A1 (3) **OR** M1 A1 A1 (3) **7**
	Notes	
(a)	M1 for CLM with correct no. of terms, all dimensionally correct, to give an equation in m, u and their V only. Condone consistent g's or cancelled m's. First A1 for a correct equation (they may have + $2mV$) Second A1 for $2u$ (must be positive since speed is required)	
(b)	B1 for '(has been) reversed'. <u>Only available if a correct velocity has been correctly obtained in part (a).</u> B0 for 'changed' ,'direction has changed' , 'yes'	
(c)	M1 for using Impulse = change in momentum of Q (must have $3m$ in both terms) (M0 if *clearly* adding momenta or if g is included) but condone sign errors. First A1 for $3m(u - -3u)$ or $-3m(u - -3u)$ Second A1 for $12mu$ (must be positive since magnitude required) **OR** M1 for using Impulse = change in momentum of P (must have $2m$ in both terms) (M0 if *clearly* adding momenta) but condone sign errors. First A1 for $2m(2u - -4u)$ or $-2m(2u - -4u)$ Second A1 for $12mu$ (must be positive since magnitude required) N.B. Allow use of $I = 3m(u - v)$ or $I = 2m(u - v)$ since only magnitude required	

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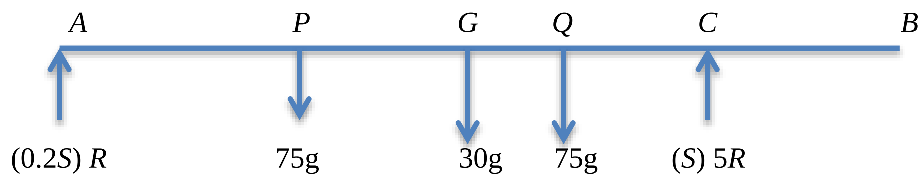
3. A plank AB has length 6 m and mass 30 kg. The point C is on the plank with CB = 2 m. The plank rests in equilibrium in a horizontal position on supports at A and C. Two people, each of mass 75 kg, stand on the plank. One person stands at the point P of the plank, where $AP = x$ metres, and the other 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)

Question Number	Scheme	Marks
3(a)	 $(-)\ R+5R=75g+30g+75g$ $M(A)\quad 75gx+75g2x+30g\times 3=5R\times 4$ $x=\frac{34}{15}=2.3$ or better (N.B. Or another Moments Equation)	M1 A2 M1 A2 A1 (M1 A2) (7)
(b)	uniform – mass is or acts at midpoint of plank; centre of mass is at middle of plank; weight acts at the middle of the plank, centre of gravity is at midpoint rod - plank does not bend, remains straight, is inflexible, is rigid	B1 B1 (2) **9**
	Notes	
(a)	First M1 for either a vertical resolution (with correct of terms) or a moments equation (all terms dim correct and correct no. of terms) First A1 and Second A1 for a correct equation in *R* (or *S* where *S* = 5*R*) only or *R* and *x* only or *S* and *x* only. (- 1 each error , A1A0 or A0A0) Second M1 for a moments equation (all terms dim correct and correct no. of terms) Third A1 and Fourth A1 for a correct equation in *R* (or *S* where *S* = 5*R*) only or *R* and *x* only or *S* and *x* only. (- 1 each error, A1A0 or A0A0) Fifth A1 for $x = {}^{34}/_{15}$ oe or 2.3 (or better) **(i)** In a moments equation, if *R* and 5*R* (or *S* and 0.2*S*) are interchanged, treat as 1 error. **(ii)** Ignore diagram if it helps the candidate. **(iii)** If an equation is correct but contains both *R* and *S, or S = 5R is never used*, treat as 1 error. **(iv)** Full marks possible if all *g*'s omitted. **(v)** For inconsistent omission of *g*, penalise each omission. $M(B),\ R\times 6+5R\times 2=75g(6-x)+75g(6-2x)+30g\times 3$ $M(C),\ 75g(4-x)+75g(4-2x)+30g\times 1=R\times 4$ $M(G),\ 75g(3-x)+5R\times 1=R\times 3+75g(2x-3)$ $M(P),\ Rx+30g(3-x)+75gx=5R(4-x)$ $M(Q),\ 75gx+30g(2x-3)+5R(4-2x)=R\times 2x$	
(b)	First B1 for first correct answer seen. Second B1 for the other answer, but only award this second mark if no extras given.	

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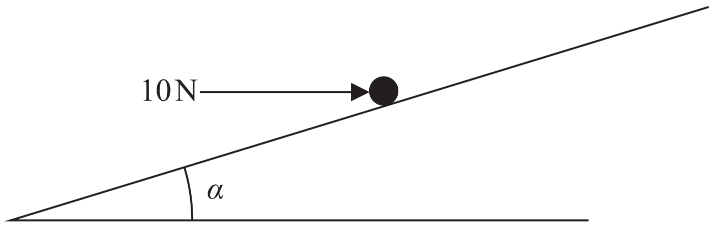

Figure 1

A particle P of mass 5kg is held at rest in equilibrium on a rough inclined plane by a horizontal force of magnitude 10N. 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.

(9)

Question Number	Scheme	Marks
4	$F = mR$ $(\nwarrow)$, $R = 10\sin a + 5g\cos a$ (45.2) $(\nearrow)$, $F = 5g\sin a - 10\cos a$ (21.4) $m = \dfrac{g\sin a - 2\cos a}{2\sin a + g\cos a} = 0.47$ or 0.473	B1 M1 A2 M1 A2 M1 A1 **9**
	Notes	
	B1 for $F = mR$ seen or implied First M1 for resolving perpendicular to the plane with usual rules First and second A1's for a correct equation. A1A0 if one error. Second M1 for resolving parallel to the plane with usual rules Third and fourth A1's for a correct equation. A1A0 if one error. If m is used instead of 5, penalise once in each equation. Third M1 <u>independent</u> for eliminating R to produce an equation in μ only. Does not need to be $\mu = \ldots$. Fifth A1 for 0.47 or 0.473.	

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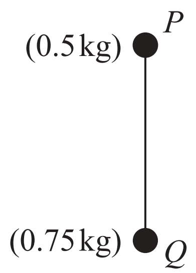

Figure 2

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)

Question Number	Scheme	Marks
5	$T - 0.5g = 0.5a$ $15 - T - 0.75g = 0.75a$ $(\text{OR: } 15 - 0.5g - 0.75g = 1.25a)$ $(a = 2.2 \text{ m s}^{-2})$ $T = 6 \text{ N}$	M1 A1 M1 A1 M1 A1 **6**
	Notes	
	First M1 for an equation of motion for either *P* or *Q* with usual rules i.e. correct no. of terms, dimensionally correct but condone sign errors First A1 for a correct equation (allow *T* replaced by – *T* and/or *a* replaced by –*a*) Second M1 for another equation of motion (for either *P* or *Q* or whole system) with usual rules as above Second A1 for a correct equation (allow *T* consistently replaced by – *T* and/or *a* consistently replaced by –*a*) Third M1 for solving two THREE term equations of **motion** for *T* Third A1 for 6 (N). Must be positive but allow a change from – 6 to 6, if they have consistently used -*T* instead of *T*.	

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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 $AB = 40$ 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)

Question Number	Scheme	Marks
6(a)	$s = vt - \frac{1}{2}at^2$ $40 = 10 \times 5 - \frac{1}{2}a5^2$ $a = 0.8$	M1 A2 A1 (4)
(b)	Finding u (= 6) $s = ut + \frac{1}{2}at^2$ (A to M) $20 = 6t + \frac{1}{2}0.8t^2$ $t = \frac{-15 \pm \sqrt{225+200}}{2}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM**1 A1 (5)
	Alternative :	
	Finding v ($= \sqrt{68}$) $s = vt - \frac{1}{2}at^2$ (A to M) $20 = \sqrt{68}t - \frac{1}{2}0.8t^2$ $t = \frac{\sqrt{68} \pm \sqrt{68-32}}{0.8}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM1** A1 (5)
	Alternative : $s = vt_1 - \frac{1}{2}at_1^2$ (M to B) $20 = 10t_1 - \frac{1}{2}0.8t_1^2$ $t_1 = \frac{10 \pm \sqrt{100-32}}{0.8}$ $= 2.192$ $t = 5 - t_1 = 2.8$ or 2.81 or better	M2 A1 **DM**1 A1 (5) **9**

	Notes	
6(a)	First M1 for a complete method to produce a value for *a*. They may use two (or more equations) and solve for *a*.(see possible equations) A2 if all correct, A1A0 for one error Third A1 for 0.8 (m s^{-2}) Possible equations: $40 = 5u + \frac{1}{2}a.5^2$ $10^2 = u^2 + 2a.40$ $10 = u + 5a$ $40 = \frac{(u+10)}{2}.5$	
6(b)	First M1 for attempt to find a value for u (This may have been done in part (a) but MUST be used in (b)) Second M1 for a complete method (may involve 2 or more *suvat* equations) for finding an equation in t *only* First A1 for a correct equation Third M1, **dependent** on previous M, for solving their equation for t Second A1 for 2.8 (s) or better or $\frac{5(2\sqrt{17}-6)}{4}$; $\frac{40}{6+2\sqrt{17}}$	

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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 $(9\mathbf{i} - 2\mathbf{j})$ km h^{-1} and the velocity of Q is $(4\mathbf{i} + 8\mathbf{j})$ 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)

Question Number	Scheme	Marks
7(a)	$\tan\theta = \frac{2}{9}$ $\theta = 12.5^\circ$ bearing 103°	M1 A1 A1 (3)
(b) **(i)** **(ii)**	$\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$ $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$	M1 A1 A1 (3)
(c)	$\overrightarrow{QP} = (8 + 5t)\mathbf{i} + (6 - 10t)\mathbf{j}$	M1 A1 (2)
(d)	$D^2 = (8+5t)^2 + (6-10t)^2$ $= 125t^2 - 40t + 100$ $100 = 125t^2 - 40t + 100$ $0 = 5t(25t - 8)$ $t = 0$ or 0.32	M1 A1 M1 M1 A1 A1 (6) **14**
	Notes	
7(a)	M1 for $\tan\theta = \pm\frac{2}{9}$ or $\pm\frac{9}{2}$ or use $\sin\theta$ or $\cos\theta$	
	First A1 for $\theta = \pm 13^\circ$ or $\pm 77^\circ$ or $\pm 12.5^\circ$ or $\pm 77.5^\circ$ or better	
	Second A1 for 103°	
7(b)	M1 for clear attempt at $\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$ or $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$ (Allow slips but must be a '+' sign and **r** + *t* **v**)	
(i)	First A1 for $\mathbf{p} = (9\mathbf{i} + 10\mathbf{j}) + t(9\mathbf{i} - 2\mathbf{j})$oe	
(ii)	Second A1 for $\mathbf{q} = (\mathbf{i} + 4\mathbf{j}) + t(4\mathbf{i} + 8\mathbf{j})$oe	
7(c)	M1 for **p** – **q** or **q** – **p** with their **p** and **q** substituted A1 for correct answer $\overrightarrow{QP} = (8 + 5t)\mathbf{i} + (6 - 10t)\mathbf{j}$ (don't need $\overrightarrow{QP}$ but on R.H.S must be **identical** coefficients of **i** and **j** but allow column vectors)	
7(d)	First M1 for attempt to find QP or QP^2 in terms of *t only*, using correct formula First A1 for a correct expression (with or without √) $125t^2 - 40t + 100$ Second M1 for √ (3 term quadratic) = 10 or (3 term quadratic) =100. Third M1 for quadratic expression = 0 and attempt to solve (e.g. factorising or using formula) Second A1 for $t = 0$ (if they divide by *t* and lose this value but get 0.32, M1A0A1) Third A1 for $t = 0.32$ oe	

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8.

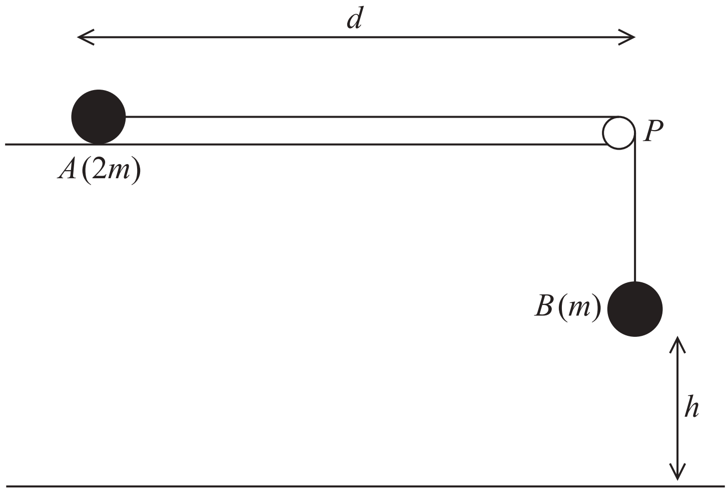

Figure 3

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)

Question Number	Scheme	Marks
8(a) **(i)** **(ii)**	For A : $T - F = 2ma$ For B : $mg - T = ma$	M1 A1 M1 A1 (4)
(b)	$R = 2mg$ $mg(1-2\mu) = 3ma$ $\frac{g}{3}(1-2\mu) = a$	B1 M1 A1 (3)
(c)	$v^2 = \frac{2gh}{3}(1-2\mu)$ $v = \sqrt{\frac{2gh}{3}(1-2\mu)}$	M1 A1 (2)
(d)	$-\mu R = 2ma'$ $0^2 = \text{their } u^2 - 2a's$ $0 = \frac{2gh}{3}(1-\frac{2}{3}) - 2(\frac{1}{3}g)s$ (or $s = (d-h)$) $s = \frac{1}{3}h$ $d = \frac{1}{3}h + h = \frac{4}{3}h$	M1 M1 A1 (A1) A1 A1 (5)
(e)	A (or B) would not move; **OR** A (or B) would remain in (limiting) equilibrium; **OR** the system would remain in (limiting) equilibrium	B1 (1) **15**

	Notes	
8(a)(i) **(ii)**	First M1 for equation of motion for A with usual rules First A1 for a correct equation (allow $-T$ instead of T) Second M1 for equation of motion for B with usual rules Second A1 for a correct equation (allow consistent $-T$ instead of T)	
8(b)	B1 for $R = 2mg$ M1 for using $F = \mu R$ and eliminating to give equation in a and μ only. A1 for PRINTED ANSWER (Must be identical to printed answer)	
8(c)	M1 for using $v^2 = u^2 + 2as$ or any other complete method to find the speed of A A1 for correct answer in any form	
8(d)	First M1 for equation of motion for A with $T = 0$ and $F = \mu R$ e.g. $\mu R = 2ma'$(must be $2m$) Second M1 for using $v^2 = u^2 + 2as$ with their u^2 from (c), $v = 0$ and a **new** a (does **not** need to be substituted) First A1 for a correct equation in s, g and h with $\mu = \frac{1}{3}$ Second A1 for $s = \frac{1}{3} h$ Third A1 for $d = \frac{4}{3} h$ **ALTERNATIVE** using work-energy principle: M2 for $\mu Rs = \frac{1}{2}2mu^2$ (their u^2 from (c)) (M1 if they use m) First A1 for $\frac{1}{3}2mgs = \frac{1}{2}2m\frac{2gh}{3}(1-\frac{2}{3})$ Second A1 for $s = \frac{1}{3} h$ Third A1 for $d = \frac{4}{3} h$	
8(e)	B1 for any one of the alternatives listed above.	