Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M1

Advanced/Advanced Subsidiary

Tuesday 25 October 2016 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
WME01/01

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

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.

Turn over ▶

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1. Two particles, P and Q, have masses $2m$ and $3m$ respectively. They are moving towards each other, in opposite directions, along the same straight line, on a smooth horizontal plane. The particles collide. Immediately before they collide the speed of P is $2u$ and the speed of Q is u. In the collision the magnitude of the impulse exerted on P by Q is $5mu$.

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

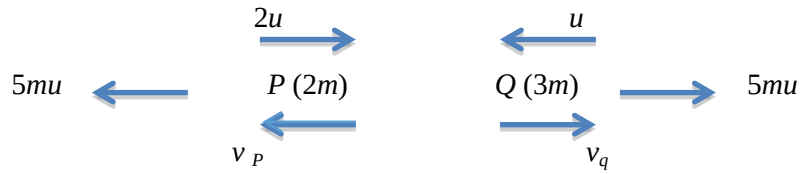
(3)

(b) State whether the direction of motion of P has been reversed by the collision.

(1)

(c) Find the speed of Q immediately after the collision.

(3)

Question Number	Scheme	Marks
1.(a)	 $5mu = 2m(v_P - -2u)$ $v_P = \frac{1}{2}u$	M1 A1 A1 (3)
(b)	Reversed	B1 (1)
(c)	$5mu = 3m(v_Q - -u)$ $v_Q = \frac{2}{3}u$ **OR** $2m2u - 3mu = -2m\frac{1}{2}u + 3m\ v_Q$ $v_Q = \frac{2}{3}u$	M1 A1 A1 (3) **OR** M1 A1 A1 (3) **7**
	Notes	
1.(a)	First M1 for a complete method to find v_P (M0 for CLM only, with 2 unknowns) for use of $5mu$ = change in momentum of P (must have $2m$ in both terms) (M0 if *clearly* adding momenta) but condone sign errors. First A1 for a correct equation in v_P only. Second A1 for ½ u (A0 if –ve)	
1.(b)	B1 for reversed – only allow if ½ u or - ½ u has been correctly obtained in (a). Allow: '(Yes) it has' but NOT just 'Yes' nor 'has been changed' nor just "opposite"	
1.(c)	First M1 for a complete method to find v_Q (M0 for CLM only, with 2 unknowns) for use of $5mu$ = change in momentum of Q (must have $3m$ in both terms) (M0 if *clearly* adding momenta) but condone sign errors. First A1 for a correct equation in v_Q only. Second A1 for $\frac{2}{3}u$ or $0.67u$ or better (A0 if –ve) **OR** First M1 for a complete method to find v_Q for use of CLM with correct no. of terms and their v_P (M0 for CLM only, with 2 unknowns) but condone sign errors. First A1 for a correct equation in v_Q only. Second A1 for $\frac{2}{3}u$ or $0.67u$ or better (A0 if –ve) **N.B.** They may find v_Q first i.e. do (c) first, then use CLM in (a).	

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2. [*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane.*]

Three forces, $(-10\mathbf{i} + a\mathbf{j})$ N, $(b\mathbf{i} - 5\mathbf{j})$ N and $(2a\mathbf{i} + 7\mathbf{j})$ N, where a and b are constants, act on a particle P of mass 3 kg. The acceleration of P is $(3\mathbf{i} + 4\mathbf{j})$ m s^{-2}

(a) Find the value of a and the value of b.

(5)

At time $t = 0$ seconds the speed of P is u m s^{-1} and at time $t = 4$ seconds the velocity of P is $(20\mathbf{i} + 20\mathbf{j})$ m s^{-1}

(b) Find the value of u.

(4)

Question Number	Scheme	Marks
2(a)	$(-10\mathbf{i}+a\mathbf{j})+(b\mathbf{i}-5\mathbf{j})+(2a\mathbf{i}+7\mathbf{j}) = 3(3\mathbf{i}+4\mathbf{j})$ $a-5+7=12 \Rightarrow a=10$ $-10+b+2a=9 \Rightarrow b=-1$	M1 M1 A1 M1 A1 (5)
(b)	$20\mathbf{i}+20\mathbf{j}=\mathbf{u}+4(3\mathbf{i}+4\mathbf{j})$ $\mathbf{u}=(8\mathbf{i}+4\mathbf{j})$ $u=\sqrt{8^2+4^2}=\sqrt{80}=8.9$ (or better)	M1 A1 M1 A1 **(**4) **9**
	Notes	
2(a)	First M1 for applying **F** = *m***a**; need all terms but allow slips and allow *m* instead of 3 Second M1 (independent but M0 if they have **0** instead of *m***a**) for equating *coefficients* of **j** First A1 for $a = 10$ Third M1 (independent but M0 if they have **0** instead of *m***a**) for equating *coefficients* of **i** Second A1 for $b = -1$	
(b)	First M1 for applying **v** = **u** + *t***a**; need all terms and must be vector **u** First A1 for 8**i** + 4**j** Second M1 (independent) for finding magnitude of their vector **u** Second A1 for √80 or 8.9 or better	

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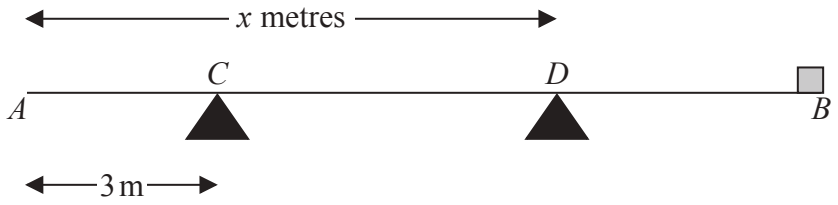
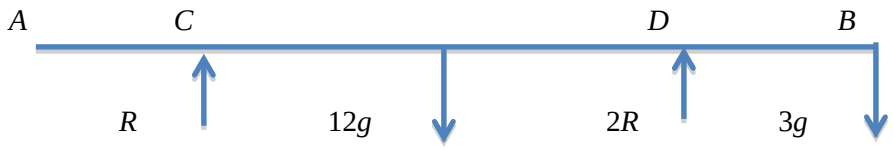


Figure 1

A plank AB has length 8 m and mass 12 kg. The plank rests on two supports. One support is at C, where $AC = 3$ m and the other support is at D, where $AD = x$ metres. A block of mass 3 kg is placed on the plank at B, as shown in Figure 1. The plank rests in equilibrium in a horizontal position. The magnitude of the force exerted on the plank by the support at D is twice the magnitude of the force exerted on the plank by the support at C. The plank is modelled as a uniform rod and the block is modelled as a particle.

Find the value of x.

(7)

Question Number	Scheme	Marks
3.	 $(\uparrow)$ $R+2R=12g+3g$ $M(A)$, $2Rx+3R=12g.4+3g.8$ $x=5.7$	M1 A2 M1 A2 A1 **7**
	Notes	
	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 $S = 2R$) only or R and x only or S and x only. (-1 each error , A1A0 or A0A0) Second M1 for either a vertical resolution (with correct of terms) or 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 $S = 2R$) only or R and x only or S and x only. (-1 each error, A1A0 or A0A0) Fifth A1 for $x = 5.7$ oe **N.B. On ePen, first 3 marks are for a vertical resolution, if it appears, second 3 marks are for a moments equation.** **If no vertical resolution, award marks as they appear for the (two) moments equation(s).** **(i)** In a moments equation, if R and $2R$ (or S and $0.5S$) 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, treat as 1 error. **(iv)** Full marks possible if all g's omitted. **(v)** For inconsistent omission of g, penalise each omission. $M(B),\ R\times 5+S(8-x)=12g\times 4$ $M(C),\ S(x-3)=12g\times 1+3g\times 5$ $M(D),\ R(x-3)+3g(8-x)=12g(x-4)$ **N.B. If they use a different variable, other than *x, for a length, with it clearly marked on the diagram,* they can score all the marks for any moments equation.**	

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4. [*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*]

A particle P is moving with velocity $(\mathbf{i} - 2\mathbf{j})$ km h^{-1}. At time $t = 0$ hours, the position vector of P is $(-5\mathbf{i} + 9\mathbf{j})$ km. At time t hours, the position vector of P is $\mathbf{p}$ km.

(a) Find an expression for $\mathbf{p}$ in terms of t.

(2)

The point A has position vector $(3\mathbf{i} + 2\mathbf{j})$ km.

(b) Find the position vector of P when P is due west of A.

(4)

Another particle Q is moving with velocity $\left[(2b - 1)\mathbf{i} + (5 - 2b)\mathbf{j}\right]$ km h^{-1} where b is a constant.

Given that the particles are moving along parallel lines,

(c) find the value of b.

(4)

Question Number	Scheme	Marks
4.(a)	$\mathbf{p} = (-5\mathbf{i} + 9\mathbf{j}) + t(\mathbf{i} - 2\mathbf{j})$	M1 A1 (2)
(b)	$2 = 9 - 2t$ $t = 3.5$ $\mathbf{p} = (-5\mathbf{i} + 9\mathbf{j}) + 3.5(\mathbf{i} - 2\mathbf{j}) = (-1.5\mathbf{i} + 2\mathbf{j})$	M1 A1 M1 A1 (4)
(c)	$\frac{2b-1}{5-2b} = \frac{1}{-2}$ $b = -1.5$	M1 A1 **DM1** A1 (4) **10**
	Notes	
4.(a)	M1 for clear attempt at $\mathbf{p} = (-5\mathbf{i} + 9\mathbf{j}) + t(\mathbf{i} - 2\mathbf{j})$ (allow slips but must be ' + ') A1 if correct	
(b)	First M1 for equating the **j** *component* of their **p** to 2 First A1 for $t = 3.5$ Second M1 (independent) for substituting their t value into their **p** Second A1 for (-1.5**i** + 2**j**)	
(c)	First M1 for $\frac{2b-1}{5-2b} = \pm\frac{1}{2}$ or $\frac{2b-1}{5-2b} = \pm\frac{2}{1}$ (must be in b only but allow slips) First A1 for a correct equation in b only Second M1 (dependent on first M1) for solving for b Second A1 for b = -1.5	

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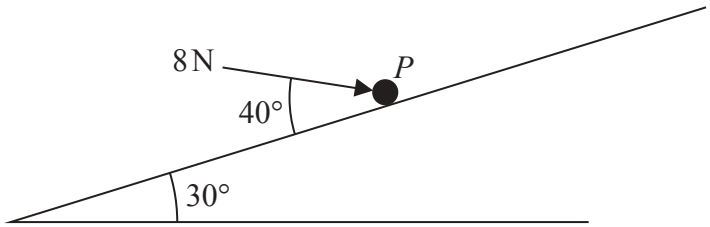

Figure 2

A particle P of mass 0.5 kg is at rest on a rough plane which is inclined to the horizontal at 30°. The particle is held in equilibrium by a force of magnitude 8 N, acting at an angle of 40° to the plane, as shown in Figure 2. 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 up the plane, find the value of μ.

(9)

Question Number	Scheme	Marks
5(a)	(□), $R = 8\cos 50^o + 0.5g\cos 30^o$ (□), $F = 8\cos 40^o - 0.5g\sin 30^o$ $F = \mu R$ $\mu = 0.39$ or 0.392	M1 A2 M1 A2 B1 **DM1** A1 **9**
	Notes	
	First M1 for resolving perpendicular to the plane with usual rules and 8 must be used with 40^o or 50^o and 0.5(g) must be used with 30^o or 60^o First A1 and second A1 for a correct equation – 1 each error (A1A0 or A0A0) Second M1 for resolving parallel to the plane with usual rules and 8 must be used with 40^o or 50^o and 0.5(g) must be used with 30^o or 60^o Third A1 and fourth A1 for a correct equation – 1 each error (A1A0 or A0A0) B1 for $F = \mu R$ seen Third M1 dependent on both previous M marks for solving for μ Fifth A1 for 0.39 or 0.392 **N.B. If they resolve in any other directions e.g. horizontally or vertically, apply similar rules to the above for the M mark in each case.**	

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6. Two cars A and B are moving in the same direction along a straight horizontal road. Car A is moving with uniform acceleration $0.4\,\text{m s}^{-2}$ and car B is moving with uniform acceleration $0.5\,\text{m s}^{-2}$. At the instant when B is 200 m behind A, the speed of A is $35\,\text{m s}^{-1}$ and the speed of B is $44\,\text{m s}^{-1}$. Find the speed of B when it overtakes A.

(9)

Question Number	Scheme	Marks
6.	$s_A = 35t + \frac{1}{2}0.4t^2; s_B = 44t + \frac{1}{2}0.5t^2$ $44t + \frac{1}{2}0.5t^2 = 200 + 35t + \frac{1}{2}0.4t^2$ $\frac{1}{20}t^2 + 9t - 200 = 0$ $(t-20)(t+200) = 0$ $t = 20$ $v = 44 + \frac{1}{2}.20 = 54 \text{ ms}^{-1}$	M1 A1 A1 M1 A1 M1 A1 **DM1** A1 **9**
	Notes	
	First M1 for use of $s = ut + \frac{1}{2}at^2$ for either *A* or *B* First A1 for a correct equation for *A* Second A1 for a correct equation for *B* Second M1 for producing a quadratic in *t* only from their s_A = their $s_B \pm 200$ Third A1 for a correct '3 term = 0' equation Third M1 (can be implied by one correct answer) for attempt to solve their quadratic (M0 if linear). Must include 200, must be 3 terms and must have come from using both distance expressions. Fourth A1 for $t = 20$ Fourth M1 dependent on third M1 for correctly using their *t* value to find *v* Fifth A1 for 54 **N.B. SC for trial and error to find *t* ; can score max M1A1A1M1A0M0A0M1A1 6/9**	

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7. A train moves on a straight horizontal track between two stations A and B. The train starts from rest at A and moves with constant acceleration $1\,\text{m s}^{-2}$ until it reaches a speed of $V\,\text{m s}^{-1}$. The train maintains this speed of $V\,\text{m s}^{-1}$ for the next T seconds before slowing down with constant deceleration $0.5\,\text{m s}^{-2}$, coming to rest at B. The journey from A to B takes 180 s and the distance between the stations is 4800 m.

(a) Sketch a speed-time graph for the motion of the train from A to B.

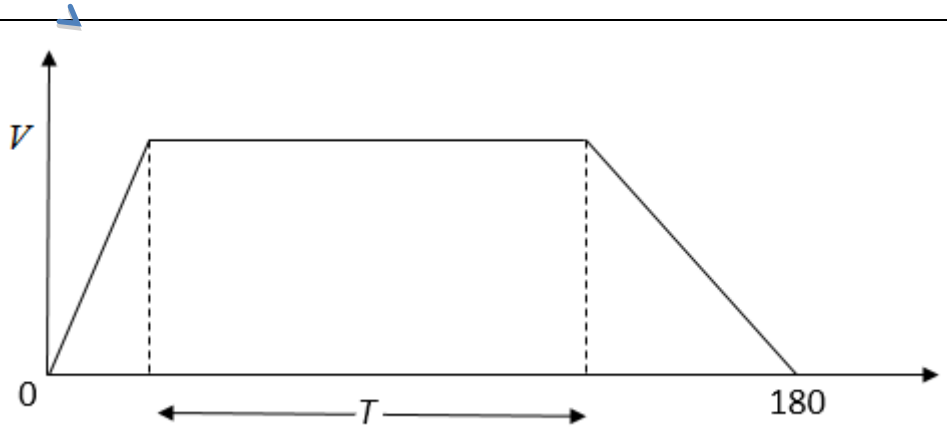
(2)

(b) Show that $T = 180 - 3V$.

(2)

(c) Find the value of V.

(7)

Question Number	Scheme	Marks
7.(a)		B1 shape B1 figs. (V,T,180) (2)
(b)	Time accelerating = $V/1 = V$ Time decelerating = $V/0.5 = 2V$ Time at constant speed, $T = 180 - (2V + V)$ $T = 180 - 3V$ **Printed answer**	M1 A1 (2)
(c)	$\frac{1}{2}(180+180-3V)V = 4800$ $V^2 - 120V + 3200 = 0$ $(V-40)(V-80) = 0$ $V = 40$ or 80 or both, since $(180 - 3 \times 80) < 0$	M1 A1 A1 A1 **DM**1 A1, M1 (7) **11**
	Notes	
7.(a)	First B1 for a trapezium, starting at the origin and finishing on the t-axis. Second B1 for V, T with delineators or marked on the top of the trapezium or oe and 180 correctly positioned.	
(b)	M1 for both Time accelerating = $V/1 = V$ and Time decelerating = $V/0.5 = 2V$ M0 if no working for the $2V$ as it's a 'Show that' or if they use $V/-0.5$ and fudge the –ve sign A1 for $T = 180 - (2V + V) = 180 - 3V$ **Printed answer**	

(c)	First M1 for attempt at using area under graph = 4800, with appropriate terms, to produce an equation in V only; must have used $\frac{1}{2}$ somewhere. (M0 if one *suvat* formula used) First A1 and second A1 for a correct equation (A1A0 one error) Third A1 for a correct quadratic expression = 0 Second M1 dependent on first M1 for solving their quadratic (can be implied by 1 correct answer) Fourth A1 for $V = 40$ or $V = 80$ or both Third M1 for a correct reason for rejecting $V = 80$. (only available if both correct values have been obtained) Allow: "Since $T > 0$, $V = 40$" oe	

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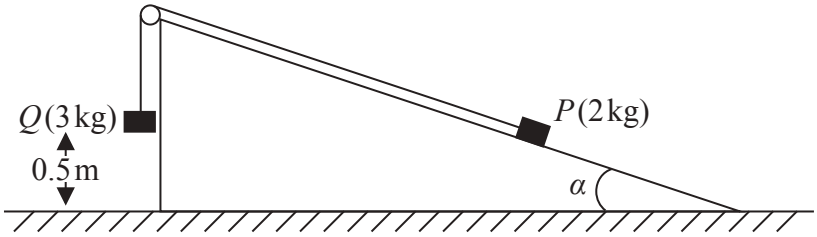

Figure 3

Two particles P and Q have masses 2 kg and 3 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a smooth light pulley which is fixed at the top of a rough plane. The plane is inclined to horizontal ground at an angle α, where $\tan \alpha = \frac{3}{4}$. Initially P is held at rest on the inclined plane with the part of the string from P to the pulley parallel to a line of greatest slope of the plane. The particle Q hangs freely below the pulley at a height of 0.5 m above the ground, as shown in Figure 3. The coefficient of friction between P and the plane is μ. The system is released from rest, with the string taut, and Q strikes the ground before P reaches the pulley. The speed of Q at the instant when it strikes the ground is 1.4 m s^{-1}.

(a) For the motion before Q strikes the ground, find the tension in the string.

(5)

(b) Find the value of μ.

(8)

Question Number	Scheme	Marks
8(a)	$1.4^2 = 2a \times 0.5 \Rightarrow a = 1.96 \text{ ms}^{-2}$ $3g - T = 3a \text{ or } -3a$ $T = 23.5 \text{ N or } 24 \text{ N}$	M1 A1 M1 A1 A1 (5)
(b)	$F = \mu R$ $R = 2g\cos\alpha$ $T - 2g\sin\alpha - F = 2a \text{ or } -2a$ $\mu = 0.5$	B1 M1 A1 M1 A1 A1 **DM**1 A1 (8) **13**
	Notes	
8(a)	First M1 for using one or more *suvat* formulae to produce an equation in *a* only First A1 for 1.96 (or -1.96 but only if correctly used in the second equation, in which case they *could* score 5/5) Second M1 for resolving vertically for *Q* (correct no. of terms but condone sign errors) Second A1 for a correct equation provided *a* used consistently in their two equations (but *a* does not need to be substituted) **N.B.** If they haven't found a value for *a*, the A1 can be scored for either 3*a* or – 3*a* in the equation of motion. Third A1 for 23.5 or 24	
(b)	B1 for $F = \mu R$ seen First M1 for resolving perpendicular to the plane (correct no. of terms with 2*g* resolved) First A1 for a correct equation (M1A0 for $R = mg\cos\alpha$) Second M1 for resolving parallel to the plane (correct no. of terms with 2*g* resolved but condone sign errors) Second A1 and third A1 for a correct equation (A1A0 for one error) N.B. Neither *T* nor *F* nor *a* needs to be substituted. Third M1 dependent on both previous M marks, for solving for μ(a *numerical* value) Fourth A1 for μ= 0.5 (A0 for 0.499)	