Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M1

Advanced/Advanced Subsidiary

Friday 6 June 2014 – 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 small smooth balls A and B have mass 0.6 kg and 0.9 kg respectively. They are moving in a straight line towards each other in opposite directions on a smooth horizontal floor and collide directly. Immediately before the collision the speed of A is v m s^{-1} and the speed of B is 2 m s^{-1}. The speed of A is 2 m s^{-1} immediately after the collision and B is brought to rest by the collision.

Find

(a) the value of v,

(3)

(b) the magnitude of the impulse exerted on A by B in the collision.

(2)

Question Number	Scheme	Marks	Notes
1.			
(a)	$0.9\times 2-0.6v=0+0.6\times 2$	M1	Equation with all the terms – condone "0" missing. Terms must be of the form mv, but condone sign errors. Condone g present as a common factor.
		A1	Correct unsimplified equation
	$v=1$	A1 (3)	
(b)	$I=0.6(v+2)=1.8\text{ N s}$ or $I=0.9\times 2=1.8\text{ N s}$	M1	Change in momentum of A or of B. Condone sign slips and negative answer. No g.
		A1	1.8 only (or exact equivalent) From correct work only.
		(2)	
		[5]	
	Watch out for fortuitous answers in (b); $v=5$ from (a) used in (b) will score at most M1A0 in (b)		

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2. A ball is thrown vertically upwards with speed 20 m s^{-1} from a point A, which is h metres above the ground. The ball moves freely under gravity until it hits the ground 5 s later.

(a) Find the value of h.

(3)

A second ball is thrown vertically downwards with speed w m s^{-1} from A and moves freely under gravity until it hits the ground.

The first ball hits the ground with speed V m s^{-1} and the second ball hits the ground with speed $\frac{3}{4}V$ m s^{-1}.

(b) Find the value of w.

(5)

Question Number	Scheme	Marks	Notes
2 (a)	$h = -20\times 5 + \frac{1}{2}\times 9.8\times 25$	M1	Use of $s = ut + \frac{1}{2}at^2$ to find h. Must quote the correct formula and be using 20 & 5, but condone slips in substitution. Accept complete alternative solutions working via the maximum height. (max ht 20.4..., time to top 2.04...) Accept complete alternative methods using other *suvat* equations.
		A1	Correctly substituted equation(s) Condone use of a premature approximation.
	$h = 22.5$	A1 (3)	Final answer. Accept 22.5 or 23. Maximum 3sf. -22.5 is A0.
	NB Do not ignore subsequent working if they reach 22.5 and then move on to do further work.		
(b)	$V^2 = 20^2 + 2\times 9.8\times 22.5$ OR $V = -20 + (5\times 9.8)$	M1	First ball - use of *suvat* to find V or V^2 Follow their h.
	$(V^2 = 841)$ $= 29$	A1	Correct only (condone -29)
	$\left(\frac{3}{4}V\right)^2 = w^2 + 2\times 9.8\times 22.5$	M1	Second ball - *suvat* equation in V (or their V) to find w. Must be using the $\frac{3}{4}$.
	$w^2 = \frac{9}{16}\times 841 - 2\times 9.8\times 22.5$	A1ft	Correctly substituted equation with their V and their h.
	$w = 5.66$	A1	or 5.7. Answer correct to 2 s.f. or to 3 s.f.
		(5)	
		[8]	

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3. A particle P of mass 1.5 kg is placed at a point A on a rough plane which is inclined at 30° to the horizontal. The coefficient of friction between P and the plane is 0.6

(a) Show that P rests in equilibrium at A.

(5)

A horizontal force of magnitude X newtons is now applied to P, as shown in Figure 1. The force acts in a vertical plane containing a line of greatest slope of the inclined plane.

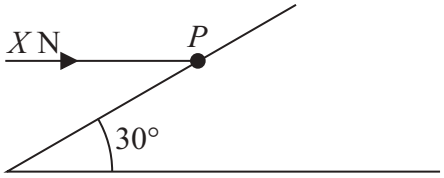


Figure 1

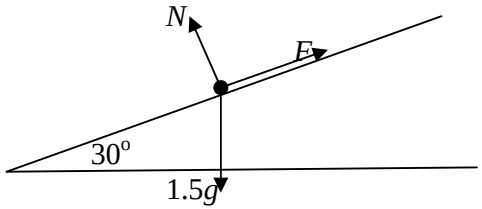
The particle is on the point of moving up the plane.

(b) Find

(i) the magnitude of the normal reaction of the plane on P,

(ii) the value of X.

(7)

Question Number	Scheme	Marks	Notes
3			
(a)	For equilibrium	M1	For resolution of forces parallel or perpendicular to the plane. Weight must be resolved. Condone sin/cos confusion.
	$R(\perp \text{ plane})\ N = 1.5g\cos 30$	A1	Correct equation for N (12.7)
	$R(\square \text{ plane})\ F = 1.5g\cos 60$	A1	Correct equation for F (7.35). Condone μR
	$\frac{F}{N} = \frac{\cos 60}{\cos 30} = 0.577... < 0.6$	M1	Use of $F_{max} = \mu N$ and compare with F, or find the value of their $\frac{F}{N}$ and compare with μ
	$\therefore$ equilibrium	A1 (5)	Reach **given conclusion** correctly. They must make some comment, however brief.
	ALT for first 3 marks:		
	Resolve vertically $N\cos 30 + F\cos 60 = 1.5g$	M1A1	
	Resolve horizontally $N\cos 60 = F\cos 30$	A1	
	ALT for last 2 marks:		
	$F_{max} = 0.6\times 12.73 = 7.63 > 7.35$	M1	
	$\therefore$ P is at rest	A1	
	Candidates who think that the diagram applies to (a) will score nothing in (a) but if they carry their results forward in to (b) then their work can score the marks available in (b).		If the candidate has given the equation of motion for the particle moving down the plane then A1 for $1.5g\sin 30 - \mu R = \pm 1.5a$ To score more they need to comment correctly on their answer: a = -0.19 impossible M1 Conclude that the particle cannot be moving. A1

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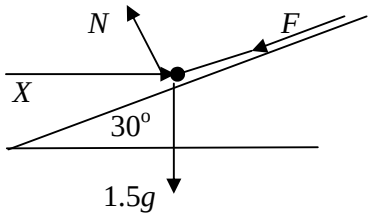
Question Number	Scheme	Marks	Notes
(b)			
	R(⊥ plane) $N = 1.5g\cos 30 + X\cos 60$	M1	Requires all 3 terms. Condone sin/cos confusion and sign errors.
	R(∥ plane) $X\cos 30 = 1.5g\cos 60 + F$	M1	Requires all 3 terms. Condone sin/cos confusion and sign errors.
		A1	Both equations correct unsimplified.
	$N = 1.5g\cos 30 + \dfrac{\cos 60}{\cos 30}(1.5g\cos 60 + 0.6N)$	DM1	Use $F = 0.6N$ to form an equation in N or in X. Dependent on the two previous M marks
	$N\left(1 - \dfrac{\cos 60}{\cos 30}\times 0.6\right) = 1.5g\cos 30 + \dfrac{\cos 60}{\cos 30}\times 1.5g\cos 60$		OR: $0.6(X\cos 60 + 1.5g\cos 30) + 1.5g\sin 30 = X\cos 30$
	(i) $N = 26$ or 26.0 (N)	A1	First value found correctly. (N or X)
	(ii) $X = (N - 1.5g\cos 30) \div \cos 60$	DM1	Substitute their N (or X) to find X (or N) Dependent on the previous M mark.
	$X = 26$ or 26.5	A1 (7) **[12]**	Second value found correctly.
Alt:	$N\cos 30 - F\cos 60 = 1.5g, \quad N\cos 30 - 0.6N\cos 60 = 1.5g$	M1,	Resolve vertically. Condone sin/cos confusion. Must have all terms.
		DM1	Use $F = 0.6N$
		A1	Correct unsimplified equation
	$N = \dfrac{1.5g}{\cos 30 - 0.6\cos 60} = 26$ or 26.0	A1	
	$X = F\cos 30 + N\cos 60, = N(0.6\cos 30 + \cos 60)$	M1,	Resolve horizontally. Follow their N. Must have all terms. Condone sin/cos confusion.
		DM1	Substitute for F and N
	$X = 26$ or 26.5	A1	

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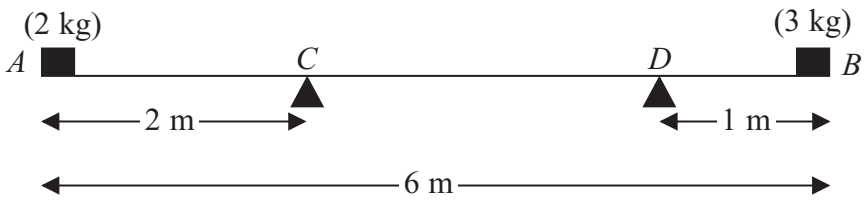

Figure 2

A plank AB, of length 6 m and mass 4 kg, rests in equilibrium horizontally on two supports at C and D, where $AC = 2$ m and $DB = 1$ m. A brick of mass 2 kg rests on the plank at A and a brick of mass 3 kg rests on the plank at B, as shown in Figure 2. The plank is modelled as a uniform rod and all bricks are modelled as particles.

(a) Find the magnitude of the reaction exerted on the plank

(i) by the support at C,

(ii) by the support at D.

(6)

The 3 kg brick is now removed and replaced with a brick of mass x kg at B. The plank remains horizontal and in equilibrium but the reactions on the plank at C and at D now have equal magnitude.

(b) Find the value of x.

(4)

Question Number	Scheme	Marks	Notes
4 (a)	(i) $\text{M}(D)\ 3R_C + 1\times 3g = 2\times 4g + 5\times 2g$	M1	e.g.Take moments about D – requires all 4 terms of the correct form, but condone sign errors. 1x need not be seen
		A1	Correct unsimplified equation
	$R_C = 5g$ or 49 N	A1	
	(ii) $\text{R}(\uparrow)\ R_C + R_D = 4g + 2g + 3g$	M1	e.g.Resolve vertically to form an equation in R_C and R_D, requires all 5 terms
		A1	Correct unsimplified equation
	$R_D = 4g$ or 39 or 39.2N	A1 (6)	
Alt	$\text{M}(A)\ 3\times 4g + 6\times 3g = 2R_C + 5R_D\ (= 30g)$	M1A1	Two equations – M1A1 for each
	$\text{M}(B)\ 3\times 4g + 6\times 2g = R_D + 4R_C\ (= 24g)$	M1A1	
	$\text{M}(C)\ 3R_D + 2\times 2g = 1\times 4g + 4\times 3g$		
	$\text{M(centre)}\ 3g\times 3 + R_C = 2R_D + 2g\times 3$		
	$R_C = 5g$ or 49 N, $R_D = 4g$ or 39 or 39.2N	A1,A1	Solve simultaneously for R_C and R_D
(b)	$\text{M}(D)\ 3R_C + xg = 8g + 10g \quad (3R_C = (18 - x)g)$	M1	First equation in x and R (or R_C and R_D) – correct terms required but condone sign slips.
	$\text{R}(\uparrow)\ R_C + R_D = 4g + 2g + xg$	M1	A second equation, correct terms required but condone sign slips.
	Alternatives: $\text{M}(B)\ 4R_C + R_D = 12g + 12g$		
	$\text{M}(A): 2R_C + 5R_D = 6xg + 3\times 4g$		
	$\text{M}(C): 2\times 2g + 3R_D = 4xg + 1\times 4g$		
	$2(18 - x)g = 3(6 + x)g$	DM1	Use $R_C = R_D$ and solve for x. (as far as x =…..) Dependent on the two previous M marks.
	$x = 3.6$	A1 (4) **[10]**	

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

A boy B is running in a field with constant velocity $(3\mathbf{i} - 2\mathbf{j})$ m s^{-1}. At time $t = 0$, B is at the point with position vector $10\mathbf{j}$ m.

Find

(a) the speed of B,

(2)

(b) the direction in which B is running, giving your answer as a bearing.

(3)

At time $t = 0$, a girl G is at the point with position vector $(4\mathbf{i} - 2\mathbf{j})$ m. The girl is running with constant velocity $\left(\frac{5}{3}\mathbf{i} + 2\mathbf{j}\right)$ m s^{-1} and meets B at the point P.

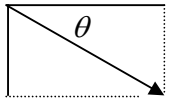
(c) Find

(i) the value of t when they meet,

(ii) the position vector of P.

(6)

P 4 3 0 6 8 A 0 1 4 2 8

Question Number	Scheme	Marks	Notes
5 (a)	Speed = $\sqrt{3^2+(-2)^2}$ or $\sqrt{3^2+2^2} = \sqrt{13}$ m s^{-1}	M1 A1(2)	Use Pythagoras Accept 3.6 or better Ignore their diagram if it does not support their working
(b)			
	$\tan\theta = \frac{2}{3}$, $\theta = 33.7$ OR $\tan\theta = \frac{3}{2}$, $\theta = 56.3$	M1	Find a relevant angle
	OR find another useful angle	A1	Their angle correct (seen or implied)
	Bearing = 124	A1 (3)	Correct bearing. Accept 124^o or awrt 124/124^o Accept N 124 E or S 56 E
(c)	$\mathbf{r}_B = 10\mathbf{j} + t(3\mathbf{i} - 2\mathbf{j})$	M1 A1	Find the position vector of B or G at time t Correct for B
	$\mathbf{r}_G = 4\mathbf{i} - 2\mathbf{j} + t\left(\frac{5}{3}\mathbf{i} + 2\mathbf{j}\right)$	A1	Correct for G
	$3t = 4 + \frac{5}{3}t$ OR $10 - 2t = -2 + 2t$	DM1	Compare coefficients of **i** or of **j** to form an equation in t.
	(i) $t = 3$ s	A1	Correct unambiguous conclusion.
	(ii) $\mathbf{r} = 10\mathbf{j} + 3(3\mathbf{i} - 2\mathbf{j}) = (9\mathbf{i} + 4\mathbf{j})$ m OR $\mathbf{r} = 4\mathbf{i} - 2\mathbf{j} + 3\left(\frac{5}{3}\mathbf{i} + 2\mathbf{j}\right) = (9\mathbf{i} + 4\mathbf{j})$ m	A1 (6)	Final answer. Accept with no units. Do not ignore subsequent working.
		[11]	

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6. A car starts from rest at a point A and moves along a straight horizontal road. The car moves with constant acceleration 1.5 m s^{-2} for the first 8 s. The car then moves with constant acceleration 0.8 m s^{-2} for the next 20 s. It then moves with constant speed for T seconds before slowing down with constant deceleration 2.8 m s^{-2} until it stops at a point B.

(a) Find the speed of the car 28 s after leaving A.

(3)

(b) Sketch, in the space provided, a speed–time graph to illustrate the motion of the car as it travels from A to B.

(2)

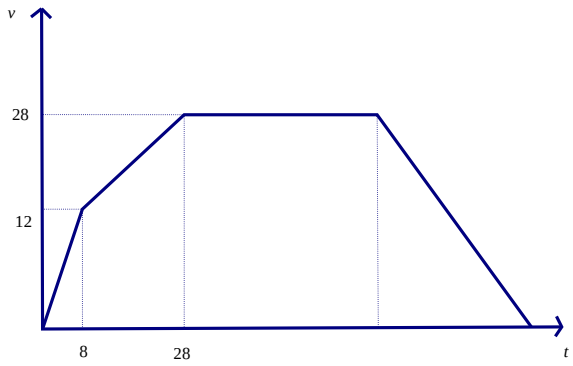
(c) Find the distance travelled by the car during the first 28 s of its journey from A.

(4)

The distance from A to B is 2 km.

(d) Find the value of T.

(4)

Question Number	Scheme	Marks	Notes
6(a)	$v_1 = 8\times1.5\ (=12)$	M1	Use of $v = u + at$ or equivalent for $t = 8$
	$v_2 = 12 + 0.8\times20$	M1	Follow their 12
	$v_2 = 28$ m s^{-1}	A1 (3)	
(b)		B1 B1ft (2)	shape nos: 8,28; 12,28 indicated. Follow their 12, 28
(c)	first 8 s: dist = $\frac{1}{2}\times8\times12\ \ (=48)$	M1 A1ft	Correct method for distance for the triangle (0-8) or the trapezium (8-28) Follow their 12
	next 20 s: dist = $\frac{1}{2}\times(12+28)\times20\ \ (=400)$	A1ft	Follow their 12, 28
	Total dist = 448 m	A1 (4)	Correct answer only (cao)
(d)	$0 = 28^2 - 2\times2.8s$	M1	Find area of right hand triangle or an expression in T for the trapezium (rectangle + triangle).
	$s = \frac{28^2}{2\times2.8}\ (=140)$	A1ft	Follow their 28
	$448 + 140 + 28T = 2000$	DM1	Form an equation in T for their 16, 448 and 140
	$T = \frac{2000-448-140}{28} = 50.4$	A1 (4)	Or better (50.42857...) Accept 50.
		[13]	

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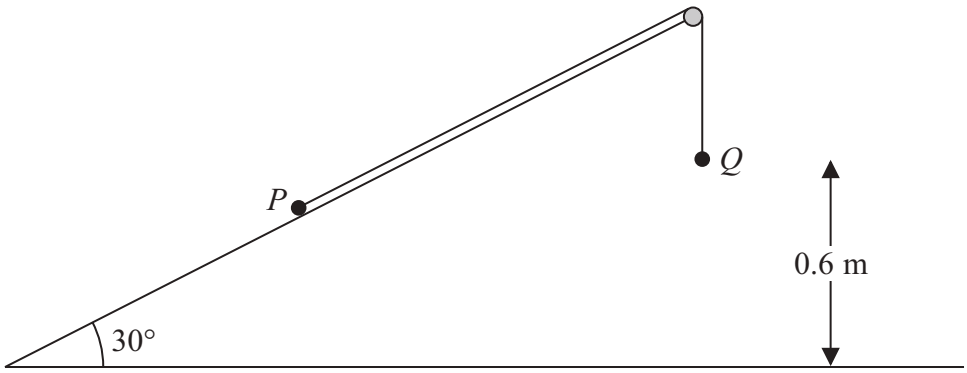


Figure 3

Two particles P and Q, of mass 2 kg and 3 kg respectively, are connected by a light inextensible string. Initially P is held at rest on a fixed smooth plane inclined at 30° to the horizontal. The string passes over a small smooth fixed pulley at the top of the plane. The particle Q hangs freely below the pulley and 0.6 m above the ground, as shown in Figure 3. The part of the string from P to the pulley is parallel to a line of greatest slope of the plane. The system is released from rest with the string taut.

For the motion before Q hits the ground,

(a) (i) show that the acceleration of Q is $\frac{2g}{5}$,

(ii) find the tension in the string.

(8)

On hitting the ground Q is immediately brought to rest by the impact.

(b) Find the speed of P at the instant when Q hits the ground.

(2)

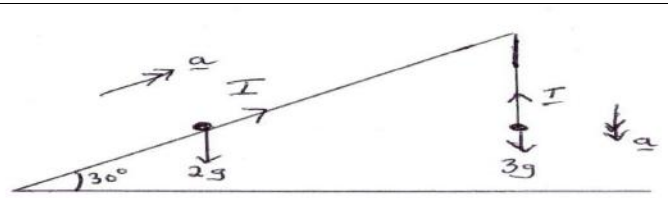
In its subsequent motion P does not reach the pulley.

(c) Find the total distance moved up the plane by P before it comes to instantaneous rest.

(4)

(d) Find the length of time between Q hitting the ground and P first coming to instantaneous rest.

(2)

Question Number	Scheme	Marks	Notes
7			
(a)	$3g - T = 3a$	M1	Eqn of motion for Q: must have the correct terms but condone sign errors
		A1	Correct equation
	$T - 2g\cos 60 = 2a$ $\quad (\ T - g = 2a\ )$	M1	Eqn of motion for P: must have the correct terms but condone sign errors. Weight must be resolved.
		A1	Correct equation
	Allow M1A1 for $3g - 2g\cos 60 = 5a$ in place of either of these two equations		
	$2g = 5a \quad a = \frac{2g}{5}$ $\quad *$	DM1	Use an exact method to solve for a (i.e. not the equation solver on their calculator). Dependent on the first 2 M marks or the M for the combined equation.
		A1	Given answer derived correctly from exact working.
	$T = 2\times\frac{2g}{5} + g = \frac{9g}{5}$	M1	Use given acceleration to solve for T.
		A1 (8)	accept 18 or 17.6
(b)	$v^2 = 2\times\frac{2g}{5}\times 0.6 = \frac{2.4g}{5}$	M1	Use the given acceleration to find the speed
	$v = \frac{2}{5}\sqrt{3g}$ oe involving g	A1 (2)	Accept 2.2 or 2.17

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Question Number	Scheme	Marks	Notes
(c)	String slack: accel of P (up plane) = $-g\cos 60 = -\frac{1}{2}g$	B1	
	$0 = \frac{2.4g}{5} - gs$	M1	Use of $v^2 = u^2 + 2as$ or equivalent for their acceleration $\neq \frac{2g}{5}$
	$s = \frac{2.4g}{5} \times \frac{1}{g} = \frac{2.4}{5} = 0.48$	A1	
	Total dist = 1.08 m	A1ft (4)	0.6 + their 0.48
(d)	$0 = \frac{2}{5}\sqrt{3g} - \frac{g}{2}t \quad (0 = 2.17 - 4.9t)$	M1	Use of $v = u + at$ or equivalent with their acceleration $\neq \frac{2g}{5}$ to find t.
	$t = \frac{4\sqrt{3g}}{5g} = 0.4426\ldots$		
	$= 0.44$ or 0.443	A1 (2)	only
		[16]	

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