Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M1

Advanced/Advanced Subsidiary

Wednesday 14 June 2017 – Morning
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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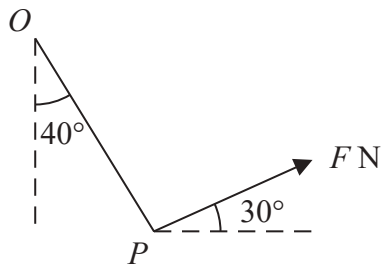


Figure 1

A particle P of weight 5 N is attached to one end of a light string. The other end of the string is attached to a fixed point O. A force of magnitude F newtons is applied to P. The line of action of the force is inclined to the horizontal at 30° and lies in the same vertical plane as the string. The particle P is in equilibrium with the string making an angle of 40° with the downward vertical, as shown in Figure 1.

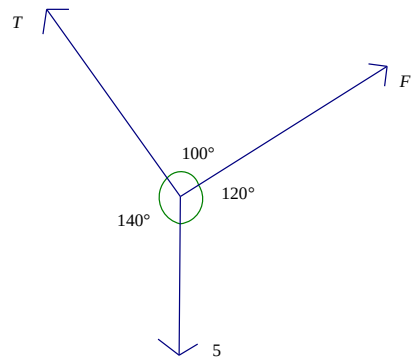
Find

(i) the tension in the string,

(ii) the value of F.

(7)

June 2017 Standardisation
WME01 Mechanics M1
Mark Scheme

Question	Scheme	Marks	Notes
1.	Vertically: $T\cos 40 + F\cos 60 = 5$	M1	First equation seen for resolution of forces. No missing/additional terms Condone sin/cos confusion and sign error(s) 5*g* in place of 5 is an accuracy error *T* must link with 40 or 50 and *F* with 60 or 30
		A1	Correct equation
	Horizontally: $T\cos 50 = F\cos 30$	M1	Second equation seen for resolution of forces No missing/additional terms Condone sin/cos confusion and sign error(s) 5*g* in place of 5 is an accuracy error *T* must link with 40 or 50 and *F* with 60 or 30
		A1	Correct equation
	Perpendicular to line of *F*: $T\cos 10 = 5\cos 30$		
	Perpendicular to line of *T*: $F\cos 10 = 5\cos 50$		
	Solve for T or F	dM1	Dependent on using equation(s) that scored M mark(s)
	$T = 4.3969..$ N = 4.4 N (or better)	A1	One correct
	$F = 3.263....$ = 3.3 N(or better)	A1	Both correct
		[7]	
1 alt			Solution using Lami's theorem Or a triangle of forces
	$\frac{5}{\sin 100} = \frac{F}{\sin 140} = \frac{T}{\sin 120}$	M1	One pair including $\frac{5}{\sin 100}$ or $\frac{5}{\sin 80}$ Incorrect pairing of forces and angles is M0
		A1	Two fractions correct
		M1	Second pair of fractions
		A1	All correct
	Solve for T or F	dM1	Dependent on using equation(s) that scored M mark(s)
	$T = 4.3969..$ N = 4.4 N (or better)	A1	One correct
	$F = 3.263....$ = 3.3 N(or better)	A1	Both correct

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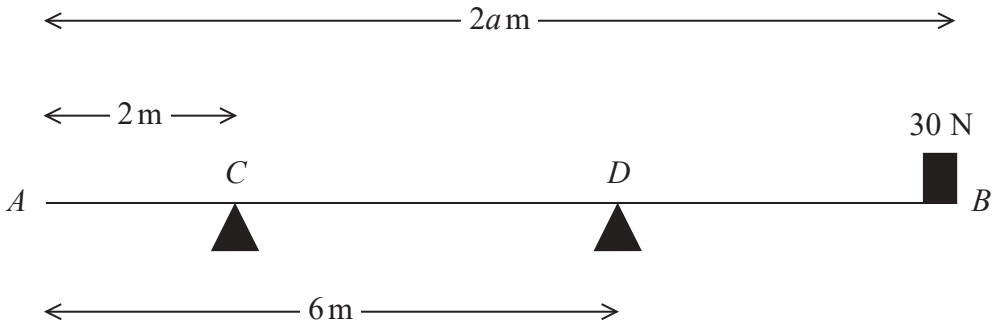

Figure 2

A wooden beam AB has weight 140 N and length $2a$ metres. The beam rests horizontally in equilibrium on two supports at C and D, where $AC = 2$ m and $AD = 6$ m. A block of weight 30 N is placed on the beam at B and the beam remains horizontal and in equilibrium, as shown in Figure 2. The reaction on the beam at D has magnitude 120 N. The block is modelled as a particle and the beam is modelled as a uniform rod.

(a) Find the value of a.

(4)

The support at D is now moved to a point E on the beam and the beam remains horizontal and in equilibrium with the block at B. The magnitude of the reaction on the beam at C is now equal to the magnitude of the reaction on the beam at E.

(b) Find the distance AE.

(5)

Question	Scheme	Marks	Notes
2.(a)	M(C) $140(a-2)+30(2a-2)=120$ x 4 M(G) $50(a-2)+30a=120(6-a)$ M(D) $4\times50+30(2a-6)=140(6-a)$ M(B) $140a=120(a-6)+50(2a-2)$ M(A) $50\times2+120\times6=140a+30\times2a$	M1	Moments or alternative complete method to form an equation in a only. Dimensionally correct. Condone sign error(s) No missing/additional terms Condone a common factor of g
		A1	At most one error
	$(200a=820)$	A1	Correct unsimplified equation in a
	$a=4.1$	A1	
		(4)	
(b)	$(\uparrow),\ (2R=170 \Rightarrow) R=85$	B1	Or a correct second moments equation in their a to achieve 2 equations in 2 unknowns
	M(A) $85\times2+85\times x = 140\times a+30\times2a$ M(C) $85(x-2)=140\times(a-2)+(2a-2)\times30$ M(G) $85\times(a-2)+30\times a=85(x-a)$ M(E) $30(2a-x)+85(x-2)=140(x-a)$ M(B) $85\times(2a-2)+85(2a-x)=140\times a$	M1	Moments equation with equal reactions in a or their a. Dimensionally correct. No missing/additional terms. Condone sign error(s) Accept alternative complete method to form an equation in a different horizontal distance to E Condone incorrect R, $R\neq120, R\neq50$ Condone a common factor of g
		A1ft	At most one error Follow their a and their $R\neq120, R\neq50$
		A1ft	Correct unsimplified equation in AE Follow their a and their $R\neq120, R\neq50$
	$AE=\frac{130}{17}$ m (7.6 m or better)	A1	
			If they find a different x, e.g. $CE=5.6$ and go no further, they score 4/5.
		(5)	
		[9]	
			A candidate who has a common factor of g throughout can score 8/9

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3. Two particles, P and Q, have masses 0.5 kg and m kg respectively. They are moving in opposite directions towards each other along the same straight line on a smooth horizontal plane and collide directly. Immediately before the collision the speed of P is $4\,\text{m s}^{-1}$ and the speed of Q is $2\,\text{m s}^{-1}$. The magnitude of the impulse exerted on P by Q in the collision is 4.2 N s. As a result of the collision the direction of motion of P is reversed.

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

(3)

The speed of Q immediately after the collision is $1\,\text{m s}^{-1}$.

(b) Find the two possible values of m.

(4)

Question	Scheme	Marks	Notes
3.(a)	$4.2 = 0.5(v - -4)$	M1	Impulse/ momentum equation Must be using $I = \pm(mv - mu)$ Inclusion of g is M0
		A1	Correct unsimplified equation
	$v = 4.4 \text{ ms}^{-1}$	A1	Must be positive - the question asks for the speed.
		(3)	
(b)	$2 - 2m = -\frac{1}{2}v \pm m$	M1	Conservation of momentum. No missing/additional terms. Condone sign errors. Dimensionally correct. Follow their v Condone a common factor of g throughout
		A1ft	Correct equation for one solution. Follow their v
		A1ft	Correct unsimplified equation(s) for both possible solutions. Follow their v
	$m = 1.4$ or 4.2	A1	Need both
		OR	
	$4.2 = m(\pm 1 - -2)$	M1	Impulse on Q. Dimensionally correct. Condone sign errors
		A1	Correct equation for one solution
		A1	Correct unsimplified equation for both possible solutions
	$m = 1.4$ or 4.2	A1	Need both
		(4)	
		[7]	

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4. A small ball of mass 0.2 kg is moving vertically downwards when it hits a horizontal floor. Immediately before hitting the floor the ball has speed $10\,\text{m s}^{-1}$. Immediately after hitting the floor the ball rebounds vertically with speed $7\,\text{m s}^{-1}$.

(a) Find the magnitude of the impulse exerted by the floor on the ball.

(2)

By modelling the motion of the ball as that of a particle moving freely under gravity,

(b) find the maximum height above the floor reached by the ball after it has rebounded from the floor,

(2)

(c) find the time between the instant when the ball first hits the floor and the instant when the ball is first 1 m above the floor and moving upwards.

(4)

Question	Scheme	Marks	Notes
4(a)	$I = 0.2(7--10)$	M1	Impulse momentum equation. Dimensionally correct. Must be using $\pm(mv-mu)$
	$= 3.4$ N s	A1	
		(2)	
(b)	$0 = 7^2 - 2gH$	M1	Complete method to find max ht Must be using 7 ($u = 10$ is M0)
	$H = 2.5$ m	A1	Must be positive
		(2)	
(c)	$1 = 7t - 4.9t^2$	M1	Complete method to form an equation in t (using 7)
	$4.9t^2 - 7t + 1 = 0$	A1	Or equivalent
	$t = \dfrac{7 \pm \sqrt{49 - 19.6}}{9.8}$	dM1	Solve for t (sight of either root $\Rightarrow$ M1) Dependent on previous M1
	$= 0.16$ s or 0.161 s	A1	Final answer (do not ISW) Max 3 s.f.
		(4)	
(c) alt	$v^2 = 49 - 2g$	M1	Find speed when 1 m up and use of *suvat* to find t
	$v = \sqrt{\dfrac{147}{5}} = 7 - gt$	A1	or equivalent
		dM1	Solve for t Dependent on previous M1
	$t = 0.16$ s or 0.161 s	A1	Final answer (do not ISW) Max 3 s.f.
		(4)	
		[8]	

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5. Two trains, P and Q, move on horizontal parallel straight tracks. Initially both are at rest in a station and level with each other. At time $t = 0$, P starts off and moves with constant acceleration for 10 s up to a speed of $25\,\text{m s}^{-1}$ and then moves at a constant speed of $25\,\text{m s}^{-1}$. At time $t = 20$, where t is measured in seconds, train Q starts to move in the same direction as P. Train Q accelerates with the same initial constant acceleration as P, up to a speed of $40\,\text{m s}^{-1}$ and then moves at a constant speed of $40\,\text{m s}^{-1}$. Train Q overtakes P at time $t = T$, after both trains have reached their constant speeds.

(a) Sketch, on the same axes, the speed-time graphs of both trains for $0 \leqslant t \leqslant T$.

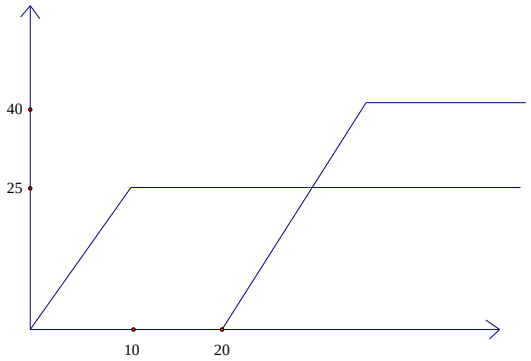
(3)

(b) Find the value of t at the instant when both trains are moving at the same speed.

(2)

(c) Find the value of T.

(8)

Question	Scheme	Marks	Notes
5. (a)		B1 B1 B1	One graph correct shape Both graphs correct shape, on same sketch and intersecting (with different start times) Figs 10,20,25,40 shown (with 20 as the second start time) Ignore all vertical lines
		(3)	
(b)	20 + 10	M1	Complete method
	= 30	A1	
		(2)	
(c)	$\frac{40}{t_1 - 20} = \frac{25}{10}$	M1	Complete method to find time when Q reaches 40 m s^{-1}
		A1	Correct unsimplified equation
	$\Rightarrow t_1 = 36$	A1	
Or:	Time to reach 40 m s^{-1} is $\frac{40}{2.5}(=16)$ (M1A1)		
	Time from start $= \frac{40}{2.5} + 20 = 36$ (A1)		(seen or implied)
		M1	Find distance travelled by either train at $t = T$
	$\frac{(T + T - 10)}{2} \times 25$	A1	One correct
	$\frac{(T - 20 + T - 36)}{2} \times 40$	A1ft	Both correct. Follow their 36
	Equate and solve for T	dM1	
	$T = 66\frac{1}{3}$	A1	Accept 66 or better
		(8)	
		13	

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6. [*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively.*]

A particle P moves with constant acceleration $(-2\mathbf{i} + 3\mathbf{j})\,\text{m s}^{-2}$. At time t seconds, the velocity of P is $\mathbf{v}\,\text{m s}^{-1}$. When $t = 0$, $\mathbf{v} = 10\mathbf{i} + 4\mathbf{j}$.

(a) Find the direction of motion of P when $t = 6$, giving your answer as a bearing to the nearest degree.

(5)

(b) Find the value of t when P is moving north east.

(4)

Question	Scheme	Marks	Notes
6. (a)	$\mathbf{v} = (10\mathbf{i} + 4\mathbf{j}) + 6(-2\mathbf{i} + 3\mathbf{j})$	M1	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ with $t = 6$
	$= -2\mathbf{i} + 22\mathbf{j}$	A1	
	$\tan\theta = \pm\frac{22}{2}$ or $\tan\theta = \pm\frac{2}{22}$	M1	Correct use of trig to find a relevant angle for their **v**
	$\theta = 85^\circ$ or $5°$	A1	Seen or implied
	bearing is 355°	A1	
		(5)	
(b)	$\mathbf{v} = (10\mathbf{i} + 4\mathbf{j}) + t(-2\mathbf{i} + 3\mathbf{j})$	M1	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$
	$\left(= (10 - 2t)\mathbf{i} + (4 + 3t)\mathbf{j})\right)$	A1	Correct unsimplified
	$(10 - 2t) = (4 + 3t)$	DM1	Equate coefficients to give equation in t only
	$t = 1.2$	A1	
		(4)	
		[9]	

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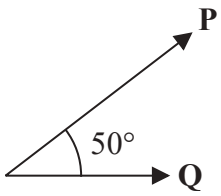

Figure 3

Two forces, **P** and **Q**, act on a particle. The force **P** has magnitude 8 N and the force **Q** has magnitude 5 N. The angle between the directions of **P** and **Q** is 50°, as shown in Figure 3. The resultant of **P** and **Q** is the force **R**.

(a) Find, to 3 significant figures, the magnitude of **R**.

(4)

(b) Find, to the nearest degree, the size of the angle between the direction of **P** and the direction of **R**.

(4)

Question	Scheme	Marks	Notes
7(a)	$\|\mathbf{R}\|^2 = 8^2 + 5^2 - 2 \times 8 \times 5\cos 130^o$	M1	Use of cosine rule
		A1	At most one error e.g. 50 in place of 130
		A1	Correct unsimplified.
	$\|\mathbf{R}\| = 11.9$ N (3 SF)	A1	12 or better
		(4)	
7a alt	$\|\mathbf{R}\|^2 = (5 + 8\cos 50°)^2 + (8\sin 50°)^2$	M1	Use of Pythagoras (with usual rules for resolved components)
	$(= 10.14^2 + 6.13^2)$	A1	At most one error
		A1	Correct unsimplified.
	$\|\mathbf{R}\| = 11.9$ N (3 SF)	A1	
		(4)	
(b)	$\frac{\sin\theta}{5} = \frac{\sin 130}{11.85}$	M1	Independent M1. Use of sine rule or cosine rule with their $\|\mathbf{R}\|$
		A1ft	Follow their $\|\mathbf{R}\|$
	$\sin\theta = \frac{\sin 130}{11.85}$	DM1	Solve for θ
	$\theta = 19^o$	A1	
		(4)	
7balt	$\tan\alpha = \frac{8\sin 50°}{5 + 8\cos 50°}$	M1	Independent M1 Correct use of trig to find direction of **R** Or use cosine rule to find α
	$(\alpha = 31.1...°)$	A1ft	Correct unsimplified. Follow their components
	$\theta = 50° - \alpha$	DM1	Use their α to solve for θ
	$\theta = 19^o$	A1	
			Alternatively, find $\beta = 58.8....$ and use $\theta = \beta - 40$
		(4)	
		[8]	

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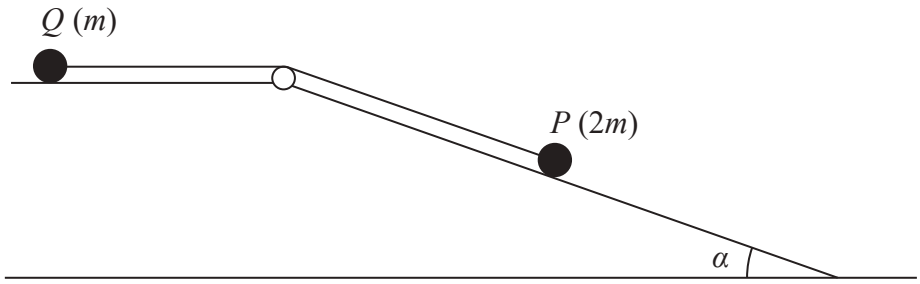

Figure 4

Two particles, P and Q, with masses $2m$ and m respectively, are attached to the ends of a light inextensible string. The string passes over a small smooth pulley which is fixed at the edge of a rough horizontal table. Particle Q is held at rest on the table and particle P is on the surface of a smooth inclined plane. The top of the plane coincides with the edge of the table. The plane is inclined to the horizontal at an angle α, where $\tan \alpha = \frac{3}{4}$, as shown in Figure 4. The string lies in a vertical plane containing the pulley and a line of greatest slope of the plane. The coefficient of friction between Q and the table is $\frac{1}{2}$. Particle Q is released from rest with the string taut and P begins to slide down the plane.

(a) By writing down an equation of motion for each particle,

(i) find the initial acceleration of the system,

(ii) find the tension in the string.

(10)

Suppose now that the coefficient of friction between Q and the table is μ and when Q is released it remains at rest.

(b) Find the smallest possible value of μ.

(4)

Question	Scheme	Marks	Notes
8. (a)			
	$R = mg$	B1	Resolve vertically at Q
	$F = \frac{1}{2}R$	B1	Use of $F = \mu R$
	$T - F = ma$	M1	Equation of motion for Q No missing/additional terms Condone sign error(s)
		A1	
	$2mg\sin\alpha - T = 2ma$	M1	Equation of motion for P No missing/additional terms Condone sign error(s) and sin/cos confusion
		A1	
(i)		dM1	Solve for a or T Dependent on 2 correct equations (one of which could be for the whole system)
	$a = \frac{7g}{30} = 2.3$ or $2.29\ \text{ms}^{-2}$	A1	a or T correct
(ii)	$T = \frac{7mg}{30} + \frac{mg}{2}$	dM1	Solve for second unknown Dependent on 2 correct equations (one of which could be for the whole system)
	$= \frac{11mg}{15}$	A1 (10)	Both correct Accept $T = 7.2m$ or better
(b)	$a = 0 \Rightarrow 2mg\sin\alpha - T = 0$	M1	Use equation of motion of P to find T.
	$\Rightarrow T = \frac{6mg}{5}$	A1	$(11.76m)$
	$\mu mg \geq \frac{6mg}{5}$	dM1	For Q, $T \leq \mu R$. Dependent on preceding M Condone use of $T = \mu R$
	Least value is 1.2	A1 (4)	
(b) alt	$2mg\sin\alpha - \mu R = 0$	M1A1	Using the combined equation
	$\frac{6}{5}mg = \mu mg$	M1	Substitute for trig and R and solve
	Least value is 1.2	A1 (4)	
		[14]	