

Mark Scheme (Results)

January 2021

Pearson Edexcel International Advanced Level In Mechanics M2 (WME02/01)

Overtion		Manta	
Question Number	Scheme	Marks	
1	$(\mathbf{I} =)1.5\{v\mathbf{i} - (4\mathbf{i} + 6\mathbf{j})\}$	M1	Use of $\mathbf{I} = m\mathbf{v} - m\mathbf{u}$. Must be using $v\mathbf{i}$. Condone \mathbf{u} , \mathbf{v} confusion. Ignore the left hand side
	$=1.5\{(v-4)\mathbf{i}-6\mathbf{j}\}$	A1	Or equivalent seen or implied Condone subtraction the wrong way round. Ignore the left hand side
	$\Rightarrow 15^2 = 1.5^2 \left\{ \left(v - 4 \right)^2 + 6^2 \right\}$	M1	Use of modulus. Allow for $p^2 + q^2 = 100$
	$(100 = (v-4)^2 + 36)$ $(v^2 - 8v - 48 = 0)$	A1	Correct unsimplified equation in <i>v</i>
	$\left(v^2 - 8v - 48 = 0\right)$	A1	Correct simplified equation in <i>v</i> seen or implied.
	$\Rightarrow v = 12$	A1	One correct value
	or $v = -4$	A1	Both correct values
1 alt1		[7]	
	15 Vi17 15 m		
	Initial momentum = $(6\mathbf{i} + 9\mathbf{j})$ Ns	M1	Impulse momentum triangle. Accept $\sqrt{117}$ Ns
	$\cos \alpha = \frac{6}{\sqrt{117}} \left(= \frac{2}{\sqrt{13}} \right)$	A1	Or equivalent
	$m^2 + 117 - 2m\sqrt{117}\cos\alpha = 225$	M1	Use of cosine formula (final momentum <i>m</i>)
	$m^2 - 12m - 108 = 0$	A1	Or equivalent
	$\Rightarrow m = -6 \text{ or } m = 18$	A1	_
	$\Rightarrow v = 12$	A1	One correct value
	or $v = -4$	A1	Both correct values
		[7]	
1alt2	Initial momentum = $(6\mathbf{i} + 9\mathbf{j})$ Ns	M1	Impulse momentum triangle. Accept $\sqrt{117}$ Ns
	$\sin \alpha = \frac{3}{\sqrt{13}}$	A1	Or equivalent
	$\frac{15}{\sin \alpha} = \frac{\sqrt{117}}{\sin \theta}$	M1	Use of sine formula
	$\Rightarrow \sin \theta = \frac{3}{5}$, $\theta = 36.9^{\circ}$ or $\theta = 143.1^{\circ}$	A1	
	$\frac{m}{\sin 86.8} = \frac{15}{\sin \alpha} \text{ or } \frac{m}{\sin 19.4} = \frac{15}{\sin (180 - \alpha)}$	A1	Correct equation in m
	$\Rightarrow v = 12$	A1	One correct value
	or $v = -4$	A1	Both correct values
		[7]	

Question Number	Scheme	Marks	Notes
2.	G G G G G G G G G G		
	Centre of mass of triangle is at G , where $AG = 8a$	B1	Or equivalent. Seen or implied e.g. $\frac{2}{3} \times 5a \cos \theta \left(= \frac{40a}{13} \right)$ from AB
	$\sin\theta = \frac{5}{13}$	B1	Or equivalent. Any correct trig ratio for an angle in the triangle. Seen or implied
	$M(A): 13aF = W \times 8a \times \frac{5}{13}$	M1	Dimensionally correct with resolved component of their 8 <i>a</i> Condone sin/cos confusion. If <i>g</i> appears, mark as an accuracy error
		A1	Correct substituted equation (any form)
	$F = \frac{40W}{169} \left(N \right)$	A1	0.24W or better
		[5]	

Question Number	Scheme	Marks	Notes
3.	Use of $P = 15F_1$ or $P = 10F_2$	M1	Seen or implied
	$F_1 - R = 600 \times 0.2$	M1	Equation of motion. Needs all terms. Condone sign errors. Inclusion of <i>g</i> is an accuracy error
	$\frac{P}{15} - R = 120$	A1	Correct equation in <i>P</i> and their <i>R</i>
	Up the slope: $F_2 - R - 600g \sin \theta = 0$	M1	Equation of motion. Needs all terms and $F_2 \neq F_1$. Condone sign errors. Condone sin/cos confusion. Omission of g is an accuracy error
		A1	Unsimplified equation in P or F_2 with at most 1 error
	$\frac{P}{10} - R - 30g = 0$	A1	Correct equation in <i>P</i> and their same <i>R</i>
	$\frac{P}{15} - \frac{P}{10} + 30g = 120$	DM1	Solve for <i>P</i> . Dependent on the 2 preceding M marks
	P = 5220 (5200)	A1	Correct max 3 s.f.
		[8]	

Question Number	Scheme	Marks	Notes
4	$6m \times 3a + 4m \times 4a + 5m \times 2a = 15m \times y$	M1	Moments about a horizontal axis. Terms dimensionally consistent. Condone slip with <i>a</i> Needs all terms. Condone sign errors
	(44ma = 15my)	A1	Correct unsimplified
	$y = \frac{44a}{15} \text{ from } B$	A1	Or equivalent. Correct for their axis $\frac{46a}{15}$ from $A \frac{16a}{15}$ from $E(CD)$
	$5m \times \frac{3a}{2} + 4m \times a = 15mx$	M1	Moments about a vertical axis Terms dimensionally consistent. Condone slip with <i>a</i> Needs all terms. Condone sign errors
	$\left(\frac{23ma}{2} = 15mx\right)$	A1	Correct unsimplified
	$x = \frac{23a}{30} \text{ from } E(AB)$	A1	Or equivalent. Correct for their axis $\frac{67a}{30}$ from C
	$\tan \theta = \frac{\frac{23}{30}}{\frac{44}{15}}$ $= \frac{23}{88} (= 0.261)$ $\theta = 14.64 \approx 15^{\circ}$	M1	Find a relevant angle using distances measured from <i>B</i> (Allow for $\tan \theta = \frac{88}{23}$)
	$=\frac{23}{88}(=0.261)$	A1ft	Correct for their distances from B . $\left(\frac{\text{horizontal}}{\text{vertical}}\right)$
	<i>θ</i> = 14.64 ≃ 15°	A1	From correct working. The question asks for the answer to the nearest degree.
		[9]	
	SR1: If a candidate has not used <i>a</i> in their working available: M1A0A0 M1A1A1 M1A1A1 SR2: If a candidate has a in their working, but no marks available are M1A1A0 M1A1A	ot as part of	
	marks available are M1A1A0 M1A1A0 M1A1A	X 1	

Question Number	Scheme	Marks	Notes
5(a)	$5T^2 - 12T + 15 = T^2 + 8T - 10$	M1	Parallel to i + j
	$\Rightarrow 4T^2 - 20T + 25 = 0$	A1	Correct quadratic in T
	$\Rightarrow T = \frac{5}{2}$	A1	
		[3]	
5(b)	$\mathbf{a} = (10t - 12)\mathbf{i} + (2t + 8)\mathbf{j}$	M1	Correct differentiation (at least 2 powers going down by one)
	$=18\mathbf{i}+14\mathbf{j}$	A1	
	$\left \mathbf{a}\right = \sqrt{18^2 + 14^2}$	DM1	Use of Pythagoras to find magnitude. Dependent on preceding M1
	$=\sqrt{520} = 22.8 \text{ (m s}^{-2})$	A1	23 or better e.g. $2\sqrt{130}$
		[4]	
5(c)	$\mathbf{s} = \left(\frac{5}{3}t^3 - 6t^2 + 15t\right)\mathbf{i} + \left(\frac{1}{3}t^3 + 4t^2 - 10t\right)\mathbf{j}$	M1	Integrate (at least 2 powers going up by one)
		A1	At most one error
		A1	All correct
	= $(45-54+45)\mathbf{i}+(9+36-30)\mathbf{j}$		
	$=36\mathbf{i}+15\mathbf{j} \ (\mathrm{m})$	A1	
		[4]	
		[11]	

Question Number	Scheme	Marks	Notes
ба	$ \begin{array}{c} R \\ 70g \\ \hline \end{array} $ $ \longrightarrow F$		
	M(A): $3 \times 30g \times \frac{1}{2} + 70g \times 2 \times \frac{1}{2} = N \times \frac{6\sqrt{3}}{2}$	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion and sign errors. Allow with sin/cos 60°
	$\left(45g + 70g = 3\sqrt{3}N\right)$	A1	Correct unsimplified
	$\updownarrow: R = 100g ,$	B1	B0 if they have $F_B \neq 0$
	$\iff F = N = 217 \text{ (N)} \left(\frac{115g}{3\sqrt{3}} \right)$	B1	Solve for <i>F</i> (216.891 seen or implied)
			NB Either of these B marks could be earned for a second moments equation
	$\sqrt{(100g)^2 + 217^2}$	DM1	Use of Pythagoras with <i>their R, F</i> Dependent on the preceding M mark
	=1000 (N)	A1	
Alt6a	M(B): $ \frac{30g \times 3\cos 60^{\circ} + 70g \times 4\cos 60^{\circ}}{= R \times 6\cos 60^{\circ} - F \times 6\sin 60^{\circ}} $ M(base wall) $ 3R = \frac{3}{2}.30g + 2.70g + 3\sqrt{3}N $	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion and sign errors. Allow with sin/cos 60°
	$\left(45g + 140g = 3R - 3\sqrt{3}F\right)$	A1	
	$\updownarrow: R = 100g ,$	B1	
	$3\sqrt{3}F = 115g \ , F = \frac{115g}{3\sqrt{3}}$	B1	Solve for <i>F</i> 216.891
	$\sqrt{(100g)^2 + 217^2}$	DM1	Use of Pythagoras with their R, F
	=1000 (N)	A1	
		[6]	
6b	$F = 0.4 \times 100g (= 392)$	M1	Use of $F = \mu R$ with their value for R
	M(A): $F \times 3\sqrt{3} = 70g \times \frac{x}{2} + 30g \times \frac{3}{2}$	M1	$(F \neq 217)$ Allow for moments about <i>B</i> to find distance from the top
	$40g \times 3\sqrt{3} = 35gx + 45g$	A1	Equation in <i>x</i> (distance from ground) only
	(AD =) x = 4.65 (m)	A1	4.7 or better (4.65274)
6с	e.g. The ladder does not bend The ladder meets the wall/floor at a point The weight acts at a single point	[4] B1	With no incorrect statement(s) seen

[*] [*-]

Question			Notes
Number	Scheme	Marks	Notes
7a	Equation for conservation of energy.	M1	Need all terms. Condone sign errors
	$\frac{1}{2} \times m \times 144 + m \times g \times 20 = \frac{1}{2} mv^2$	A1	Correct unsimplified equation with at most
	$2^{m \times 144 + m \times g \times 20} = 2^{mv}$		one error
	22 22 2	A1	Correct equation (with or without <i>m</i>)
	v = 23 or 23.2	A1	Max 3 s.f.
7b	$12\cos\theta\times5=40$	[4] M1	Horizontal motion
70	$12\cos\theta \times 3 = 40$	IVII	Condone sine/cosine confusion
	(minimum=) $12\cos\theta = 8 \text{ (m s}^{-1})$	A1	Final answer : do not ignore subsequent working
		[2]	
7c	Speed = $10 \Rightarrow \text{Vertical component} = 6 \text{ (m s}^{-1})$	B1ft	Follow their horizontal component
	$(\pm)6 = 12\sin\theta - gt$	M1	Vertical speed
	$=12\times\frac{\sqrt{5}}{3}-gt$	A1	Correct equation for one value of <i>t</i> or for the time interval.
	(t = 0.30 and t = 1.52)		Correct trig value seen or implied
	Time = $1.52 0.30 = 1.22$ (s)	A1	Correct interval
	Required time = $5-1.22$ (s)	M1	Find required time – follow their 1.22
	= 3.78 (s)	A1	Or 3.8. Max 3 s.f.
		[6]	
	Alternatives for M1A1A1	~ -	
	Use of $v = u + at$	(M1)	
	-6 = 6 - gt	(A1)	Or find time to top and double it
	$t = \frac{12}{g}$	(A1)	
	Vertical speed: $6 = 12 \sin \theta - gt_1$	(M1)	
	$-6 = 12\sin\theta - gt_2$	(A1)	
	$12 = g(t_2 - t_1), t_2 - t_1 = \frac{12}{g}$	(A1)	
	Alternatives for B1M1A1A1		
	ht above A $\frac{22}{g}$	(B1)	Using energy 2.24 seen or implied e.g. by 22.24
	Use of $s = ut + \frac{1}{2}at^2$	(M1)	$20 + \frac{22}{g}$ used with $12\sin\theta$ is M0
	$\frac{22}{g} = 12\sin\theta t - \frac{1}{2}gt^2$	(A1)	
	Time = $1.52 0.30 = 1.22$ (s)	(A1)	Correct interval
	Speed 10, angle to horizontal $\alpha \Rightarrow 10\cos\alpha = 8$	(B1)	
	Time to top: $0 = 10\sin \alpha - gt$	(M1)	
	$10 \times 0.6 = gt$	(A1)	

То	otal time $=\frac{12}{g}$	(A1)	
	0	[11]	

Question Number	Scheme	Marks	Notes
8a	$ \begin{array}{cccc} v & \longrightarrow & & & & & & & \\ A & & & & & & & \\ \hline A & & & & & & & \\ \hline A & & & & & & & \\ \hline A & & & & & & & \\ \hline A & & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & & & \\ \hline A & & & & \\ A & & & & \\ \hline A & & & & \\ A & & & & \\ \hline A & & & & \\ \hline A & & & & \\ A & & & & \\ \hline A & & & & \\ A & & & & \\ \hline A & & & & \\ A & & & & \\ A & & & & \\ \hline A & & & & \\ A &$		
	Impulse on A: $8mu = 3mv - 3m \times \frac{u}{3}$	M1	Terms dimensionally correct. Must be subtracting. Condone sign errors. Must be combining correct mass and speed
	v = 3u	A1	
			Terms dimensionally correct. Condone sign errors
	Impulse on <i>B</i> : $8mu = 4mu + 4mw$	M1	Or use CLM: $9mu - 4mw = 3m\frac{u}{3} + 4mu$ Must be combining correct mass and
			speed
	w = u	A1	**
	Impact law: $u - \frac{u}{3} = e(3u + u)$ $e = \frac{1}{6}$	M1	Used the right way round. Condone sign errors
	$e = \frac{1}{6}$	A1	
	Award first 4 marks in order on the scheme. in place of whichever impulse equation is no		r CLM equation, if used, should be given
	Watch out for sign errors in the equations If they have $3mv + 4mw$ in the equation for a "correct" answer. The sign error in the CI double sign error is $4/6$		
		[6]	
8b	Gap when <i>B</i> hits wall = $\frac{2d}{3}$	B1	Or find distances from the first impact: $s_A = \frac{d}{3} + \frac{u}{3}t$ and $s_B = d - \frac{u}{4}t$
	Speed of rebound from wall $=\frac{u}{4}$	B1	Allow + / -
	Time to close gap = $\frac{\frac{2d}{3}}{\frac{u}{3} + \frac{u}{4}}$	M1	
	$=\frac{8d}{7u}$	A1	
	Distance from wall = $\frac{8d}{7u} \times \frac{u}{4}$	DM1	Dependent on the preceding M1
	$=\frac{2d}{7}$	A1 [6]	
8balt	Time for $A \frac{d-x}{u/3} \left(= \frac{3d-3x}{u} \right)$	B1	
	Speed of rebound from wall $=\frac{u}{4}$	B1	

Time for $B = \frac{d}{u} + \frac{x}{\frac{u}{4}}$	M1	
$\left(=\frac{d+4x}{u}\right)$	A1	
3d - 3x = d + 4x	DM1	Solve for <i>x</i> Dependent on the preceding M1
$x = \frac{2d}{7}$	A1 [6]	
	[12]	