OCR
RECOGNISING ACHIEVEMENT

GCE

Mathematics (MEI)

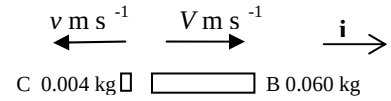
Advanced GCE

Unit **4762:** Mechanics 2

Mark Scheme for January 2011

Q 1		m a r k	notes
(i)	Let normal reaction be R		
	$\sin\alpha = \sqrt{1-0.8^2} = 0.6$	B1	Accept any form and implied
		M1	Use of $F_{max} = \mu R$
	$R = 2.5\times 9.8\times 0.8$	B1	Expression for R; may be implied
	$F_{max} = 0.85\times R = 16.66$	F1	FT their R
	Wt cpt down slope is $2.5 \times 9.8 \times 0.6 = 14.7$	B1	
	$16.66 > 14.7$ so at rest	E1	FT if their F and weight component show given result If g omitted, allow B1M1B0F1B0E1, so 4/6 [Award as follows for use of $\tan\alpha < \mu$: B1 $\tan\alpha = \frac{3}{4}$ E1 $\tan\alpha < \mu$ shown]
		6	
(ii)	Let the speeds down the plane be v_A and v_B . PCLM down the plane		
	$1.5\times 16 = 2.5v_A + 1.5v_B$	M1	PCLM
	so $5v_A + 3v_B = 48$	A1	Any form
	NEL +ve down the plane		
	$\frac{v_A - v_B}{0-16} = -0.4$	M1	NEL. Allow sign errors
	$v_A - v_B = 6.4$	A1	Any form
	$v_A = 8.4$ so 8.4 m s^{-1} down plane	E1	Condone direction not clear if +8.4 seen
	$v_B = 2$ so 2 m s^{-1} down plane	F1	Condone direction not clear if +2 seen. SC1 if 2 equations obtained and 8.4 substituted into one to obtain answer 2 (instead of E1F1)
		6	
(iii)	$1.5 \times (2 - 16)$ down plane	M1	Use of $m(\mathbf{v} - \mathbf{u})$ If impulse on A found, treat as MR unless final answer relates this to impulse on B
	$= -21$ N s down the plane	A1	± 21 N s
	so 21 Ns up the plane	A1	Direction explicitly commented on
		3	

Q 1		m a r k	notes
(iv)	**either**		
	$(2.5\times 9.8\times 0.6 - F_{max})\times t = 2.5(0-8.4)$	M1	Using Impulse-momentum (must use 8.4) . sufficient to consider one term on LHS
		B1	Either side correct
		A1	Allow only sign errors
	so t = 10.7142… 10.7 s (3 s. f.)	A1	cao
	or		
	Using N2L down the plane	M1	Using N2L ; sufficient to consider one force term
	a = – 0.784	A1	Allow sign errors
		M1	Using appropriate *suvat* must use a or-a found by use of N2L and u = 8.4
	using $v = u + at$, t = 10.7142… 10.7 s (3 s. f.)	A1	cao
	or		
	$0.5\times 2.5\times 8.4^2 + (14.7 - 16.66)x = 0$	M1	Use energy with 8.4, sufficient to consider one non-KE term
	x= 45	A1	
		M1	Using appropriate *suvat*
	T = 10.7142….. 10.7 (3 s. f.)	A1	cao
		4	
		19	

Q 2		mark	notes
(a)			
	Energy: $\frac{1}{2}\times 0.004\times v^2+\frac{1}{2}\times 0.060\times V^2=0.8$	M1	Use of KE in two terms in an equation.
	$v^2+15V^2=400$	A1	Any form
	PCLM in **i** direction: $0.06V-0.004v=0$	M1	PCLM. Accept sign errors.
	$v = 15V$	A1	Any form
	Solving	M1	Valid method for elimination of v or V from a linear and a quadratic
	$(15V)^2+15V^2=400$		
	so $V^2=\frac{400}{240}=\frac{5}{3}$ and $\mathbf{V}=\sqrt{\frac{5}{3}}\mathbf{i}$	A1	Accept 1.29099…**i** Accept no direction
	$\mathbf{v}=-15\sqrt{\frac{5}{3}}\mathbf{i}$ $(=-\sqrt{375}\mathbf{i})$	F1	Accept – 19.3649…**i** Accept no direction Second answer follows from first
		A1	(Relative) directions indicated - accept diagram. Both speeds correct.
		8	
(b) (i)	W is work done by resistances on car		
	$\frac{1}{2}\times 800\times\left(12^2-30^2\right)=-800\times 9.8\times 20+\mathrm{W}$	M1	Use of WE. Must have KE, W and GPE. Allow -*W*
		B1	Both KE terms. Accept sign error
		A1	All correct with *W* or -*W*
	W = – 145 600		
	so 145 600 J done by car against resistances	A1	cao
		4	

Q 2		m a r k	notes
(ii)	**either**		
	The slope is 18 × 25 = 450 m long	B1	
	$\frac{800\times 9.8\times 20+750\times 450}{25}$	M1	Use of P = (Work done) / (elapsed time) used for at least one work done term
		M1	WD is force × distance used for at least one force
		A1	Allow only sign errors both terms
	= 19 772 W	A1	cao.
	or		
	The angle of the slope is arcsin (1/22.5)	B1	
	$\left(800\times 9.8\times \frac{1}{22.5}+750\right)\times 18$	M1	Use of $P = Fv$ used for at least one term
		M1	Attempt at weight component
		A1	Allow only sign errors both terms
	= 19 772 W	A1	cao.
		5	
		17	

Q 3		m a r k	notes
(i)	Horizontal $X - 50 = 0$ Vertical: $R - Y - 45 = 0$	B1 B1 2	Any form Any form
(ii)	a. c. moments about A $1 \times R = 3 \times 45$ so $R = 135$ so $135 - Y - 45 = 0$ and $Y = 90$	 M1 E1 E1 3	 Clearly shown Shown
(iii)	In analysis below all internal forces are taken as tensions	B1 B1 2	Correct arrow pairs for all internal forces Correct labels

Q 3		m a r k	notes
(iv)		M1 M1 M1	Equilibrium attempted at a pin-joint Equilibrium attempted at a 2nd pin-joint Either Equilibrium equation for 2nd direction at a pin-joint or 3rd pin-joint considered
	At C $\uparrow \quad T_{CD}\cos 30 - 45 = 0$ so $T_{CD} = 30\sqrt{3}$ and force in CD is $30\sqrt{3}$ N (T) $\leftarrow \quad T_{BC} + T_{CD}\cos 60 = 0$ so $T_{BC} = -15\sqrt{3}$ and force in BC is $15\sqrt{3}$ N (C)	B1 A1 F1	At least 3 equations of resolution correct or follow through
	At D $\downarrow \quad T_{BD}\cos 30 + T_{CD}\cos 30 = 0$ so $T_{BD} = -30\sqrt{3}$ and force in BD is $30\sqrt{3}$ N (C)	 F1	
	$\leftarrow \quad T_{AD} + T_{BD}\cos 60 - T_{CD}\cos 60 - 50 = 0$ so $T_{AD} = 50 + 30\sqrt{3}$ and the force in AD is $50 + 30\sqrt{3}$ N (T)	 F1	
	At A $\downarrow \quad T_{AB}\cos 30 + 90 = 0$ so $T_{AB} = -60\sqrt{3}$ and the force in AB is $60\sqrt{3}$ N (C)	 F1	
		B1 10	At least 4 T/C correct
(v)	The equilibria at C depend only on the framework geometry and the 45 N. These are not changed so forces in CB and CD are not changed	 E1 E1 2	Resolve in two directions at *C* and obtain same results as in (iv) M1A1
		19	

Q 4		m a r k	notes
(i)	(2, 2.5)	B1 1	Condone writing as a vector
(ii)	By symmetry, $\bar{y} = 2.5$ For $\bar{x}$: $\left(5h + \frac{1}{2}\times 5\times 6\right)\bar{x} = 5h\times\left(-\frac{h}{2}\right) + \frac{1}{2}\times 5\times 6\times 2$ so $(5h+15)\bar{x} = -2.5h^2 + 30$ so $5(h+3)\bar{x} = 2.5(12-h^2)$ and $\bar{x} = \frac{12-h^2}{2(h+3)}$	B1 M1 A1 A1 A1 E1 6	Some justification needed These next 4 marks may be obtained from correct FT of their "2" from (i) 1st term RHS correct (allow sign error) Either other term correct All correct Clearly shown, including signs.
(iii)	Need $\bar{x} > 0$ So $\frac{12-h^2}{2(h+3)} > 0$ Hence $12 - h^2 > 0$ Since $h > 0$, $0 < h < 2\sqrt{3}$	M1 B1 A1 3	Allow $\bar{x} \geq 0$ or = 0 $2\sqrt{3}$ or $-2\sqrt{3}$ oe seen Accept only +ve root mentioned. WWW for signs Accept $h < 2\sqrt{3}$ as answer strict inequality for final A mark

Q 4		m a r k	notes
Q4 (iv)	**continued**		
	When $h = 3$, $\bar{x} = 0.25$	B1	Could be scored in (v)
	Let mag of vert force be T N a.c moments about axis thro' O		
	$T \times 6 - 15 \times 0.25 = 0$	M1	If moments about another point need all relevant forces. Allow sign errors. Condone use of $15g$
	so $T = 0.625$ so 0.625 N	A1 3	cao
(v)	Let magnitude of force be U N a.c. moments about axis thro' D		
	$U\cos30 \times 5 - 15 \times (3 + 0.25) = 0$	M1	Each term must be a moment. If moments about another point need all relevant forces. Condone use of $15g$.
		B1	moment of U ($5U\cos30$ or …) oe
		A1	$(3 + 0.25)$ oe
	$U = 11.25833\ldots$ so 11.3 N (3 s. f.)	A1 4	cao
		17	