

Mathematics (MEI)

Advanced GCE 4762

Mechanics 2

Mark Scheme for June 2010

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Q 1	mark	sub	
(i) For P $200 \times 5 + 250 = 200v_p$ $v_p = 6.25$ so $6.25\mathbf{i} \text{ m s}^{-1}$ For Q $250 \times 5 - 250 = 250v_Q$ $v_Q = 4$ so $4\mathbf{i} \text{ m s}^{-1}$	M1 E1 M1 A1	Award for I-M Accept no \mathbf{i} and no units Must have impulse in opposite sense Must indicate direction. Accept no units.	4
(ii) \mathbf{i} direction positive PCLM: $2250 = 200 \times 4.5 + 250w_Q$ $w_Q = 5.4$ so $5.4\mathbf{i} \text{ m s}^{-1}$ NEL: $\frac{w_Q - 4.5}{4 - 6.25} = -e$ $e = 0.4$	M1 F1 E1 M1 A1 A1	PCLM used. Allow error in LHS FT from (i) Any form. FT only from (i) NEL . Allow sign errors Signs correct. FT only from (i) cao	6
(iii) \mathbf{i} direction positive Suppose absolute vel of object is $-V\mathbf{i}$ $200 \times 4.5 = -20V + 180 \times 5.5$ $V = 4.5$ speed of separation is $5.5 + 4.5 = 10 \text{ m s}^{-1}$	M1 B1 A1 A1 F1	Applying PCLM. All terms present. Allow sign errors. Correct masses All correct (including signs) FT their V .	5
(iv) $180 \times 5.5 + 250 \times 5.4 = 430W$ $W = 5.4418\dots$ so $5.44 \mathbf{i} \text{ m s}^{-1}$ (3 s. f.)	M1 A1	Using correct masses and velocities cao	2
			17

Q 2	mark	sub
(i) $20\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix} = 15\begin{pmatrix} 20 \\ 0 \end{pmatrix} + 3\begin{pmatrix} 0 \\ 100 \end{pmatrix} + 2\begin{pmatrix} 25 \\ 200 \end{pmatrix}$ $\bar{x} = 17.5$ $\bar{y} = 35$	M1 B1 A1 A1 A1	Method to obtain at least 1 coordinate '100' or '25' correct Either one RHS term correct or one component of two RHS terms correct 5
(ii) $25\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix} = \begin{pmatrix} 350 \\ 700 \end{pmatrix} + 5\begin{pmatrix} 40 \\ 200 \end{pmatrix}$ so $\bar{x} = 22$, $\bar{y} = 68$	M1 E1	Using (i) or starting again Clearly shown. 2
(iii) We need the edge that the \bar{x} position is nearest $\bar{x} = 22$; distances are 22 to PQ, 18 to SR 15 to QR so edge QR	M1 B1 B1 A1	This may be implied One distance correct All distances correct 4
(iv) Moments about RS In sense xOy $T \sin 50 \times 200 - T \cos 50 \times 40$ $-20g \times (40 - 17.5) = 0$ $T = 34.5889\dots$ so 34.6 N (3 s. f.)	M1 B1 M1 A1 B1 A1 A1	Moments about RS attempted Use of weight not mass below. FT mass from here Attempt to find moment of T about RS, including attempt at resolution. May try to find perp dist from G to line of action of the force. 40 - 17.5 All correct allowing sign errors cao (except for use of mass) 7
		18

Q 3	mark	sub
(i) a.c. moments about A $1 \times T - 2 \times 300 = 0$ so $T = 600$ Resolving $\rightarrow X = 0$ $\uparrow T - Y = 300$ so $Y = 300$	E1 B1 M1 A1	Justified 4
(ii) Diagram <i>The working below sets all internal forces as tensions; candidates need not do this.</i>	B1 B1	All external forces marked consistent with (i) All internal forces with arrows and labels 2
(iii) Let angle DAB be θ . $\cos \theta = \frac{1}{2}$, $\sin \theta = \frac{\sqrt{3}}{2}$ A $\uparrow -300 - T_{AB} \sin \theta = 0$ so $T_{AB} = -200\sqrt{3}$ so force is $200\sqrt{3}$ (C) A $\rightarrow T_{AD} + T_{AB} \cos \theta = 0$ so $T_{AD} = 100\sqrt{3}$ so force is $100\sqrt{3}$ (T) C $\uparrow T_{CD} \sin \theta - 300 = 0$ so $T_{CD} = 200\sqrt{3}$ so force is $200\sqrt{3}$ (T) C $\leftarrow T_{BC} + T_{CD} \cos \theta = 0$ so $T_{BC} = -100\sqrt{3}$ so force is $100\sqrt{3}$ (C) B $\uparrow T_{AB} \sin \theta + T_{BD} = 0$ so $T_{BD} = 300$ so force is 300 (T)	B1 M1 M1 A1 F1 F1 F1 F1 F1 F1	Or equivalent seen Attempt at equilibrium at pin-joints 1 equilib correct, allowing sign errors All T/C consistent with their calculations and diagrams 9
(iv) AD, AB, BC, CD 300 N, X and Y not changed. Equilibrium equations at A and C are not altered B $\uparrow T_{AB} \sin \theta + T'_{BD} + 600 = 0$ so $T'_{BD} = -300$ so force is 300 (C)	B1 E1 M1 A1	C not needed. [If 300 N (C) given WWW, award SC1 (NB it must be made clear that this is a compression)] 4
		19

Q 4		mark		sub
(i)	Let friction be F N and normal reaction R N $F_{\max} = 58 \cos 35$ $R = 16g + 58 \sin 35$ $F_{\max} = \mu R$ so $\mu = 0.249968\dots$ about 0.25	B1 M1 A1 M1 E1	Need not be explicit Both terms required.	5
(ii)	WD is $70 \cos 35 \times 3 = 210 \cos 35$ so $172.0219\dots = 172$ J (3 s. f.) Average power is WD/time so $34.4043\dots = 34.4$ W (3 s. f.)	M1 A1 M1 A1	Use of $WD = Fd$. Accept $\cos 35$ omitted. cao	4
(iii)	Using the constant acceleration result $s = \frac{1}{2}(u+v)t$ with $s = 3$, $u = 0$, $v = 1.5$ and $t = 5$ we see that $3 \neq \frac{1}{2}(0+1.5) \times 5 = 3.75$	M1 E1	Attempt to substitute in <i>suvat</i> (sequence) Conclusion clear	2
(iv)	$172.0219\dots$ $= \frac{1}{2} \times 16 \times 1.5^2$ $+ 0.25 \times (16g + 70 \sin 35) \times 3$ + WD so WD by S is $6.30916\dots$ so 6.31 J (3 s. f.)	M1 M1 A1 M1 A1 A1 A1	Using W-E equn, allow 1 missing term KE term attempted correct Attempt at using new F in $F_{\max} = \mu R$ All correct cao	7
				18

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