

Mathematics

Advanced GCE

Unit **4729**: Mechanics 2

Mark Scheme for January 2011

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Question			Expected Answer	Mark	Rationale/Additional Guidance
1	(i)		$3x_G = 2 \times 0.3 + 1 \times 0.6$ OR $3x_G = 2 \times 0.3 + 0$ OR $3x_G = 4 \times 0.3$ OR $3y_G = 1 \times 0.3 + 1 \times 0.6 + 0$ OR $3y_G = 4 \times 0.3 - 1 \times 0.3$ $x_G = 0.4$ (from AD) OR $x_G = 0.2$ (from BC) $y_G = 0.3\text{m}$ from AB or CD $AG^2 = 0.4^2 + 0.3^2$ $AG = 0.5\text{ m}$	M1 A1 A1 M1 A1 [5]	Table of moments idea. M0 for reducing to 1D problem. Masses/weights may be included. Pythagoras with 2 appropriate distances. This may only be seen in (ii), allow M1A1 in this case.
	(ii)		$v = 0.5 \times 3$ $v = 1.5\text{ ms}^{-1}$	M1 A1 [2]	Allow use of candidate's 0.2, 0.4, 0.3, 0.5
2	(i)		$(k25^{3/2}) \times 25 = 15000$ $k = 4.8$ <div style="text-align: right;">AG</div>	M1 A1 A1 [3]	Tractive force x speed = power
	(ii)		$R = 4.8 \times 16^{3/2}$ $T - 4.8 \times 16^{3/2} + 700g \times 1/15 = 700 \times 0.3$ $P = 59.9 \times 16$ $P = 958\text{ W}$	B1 M1 A1 M1 A1 [5]	307.2 N2L, 4 terms to find tractive force (T) Allow cv(R), R not 600; (T = 59.866..) 16xTractive force

3	(i)		$T_A \cos 30 + T_B \cos 60 = 0.4g$ $2T \cos 30 + T \cos 60 = 0.4g$ $T_B = 1.76 \text{ N}$ $T_A = 3.51 \text{ N}$	M1 A1 A1 A1 [4]	Resolves vertically, 3 terms $T = 1.756$. Watch for MR of $T \cos 30 + 2T \cos 60 = 0.4g$ Accept 3.52
	(ii)		$r = 0.5 \sin 30 (= 0.25)$ $3.51 \sin 30 + 1.76 \sin 60 = 0.4 \omega^2 0.5 \sin 30$ $\omega = 5.72 \text{ rad s}^{-1}$	B1 M1 A1ft A1 [4]	N2L radial, 3 terms cv(1.76, 3.51, 0.25) Accept 5.73
4	(i)		$WD = 100 \cos 20 \times 30$ $WD = 2820 \text{ J}$	M1 A1 [2]	Product of 3 relevant elements. Angle could be 5, 25 or complements 2819.1...
	(ii)		$PE = 25g \times 30 \sin 5$ $PE = 641$	M1 A1 [2]	Product of weight and vertical height. Allow without g 640.6
	(iii)	OR	$2819.1 = 640.6$ $+ 30 \times 70 + 25v^2/2$ $v = 2.51 \text{ ms}^{-1}$ $25a = 100 \cos 20 - 70 - 25g \sin 5$ $a = 0.105$ $v^2 = 2 \times 30 \times 'a'$ $v = 2.51$	M1 A1ft A1 A1 [4] *M1 A1 dep*M1 A1 [4]	4 term energy equation ft(cv 2820 and cv 641) cao 4 term equation Allow 0.1 here Or equivalent complete method cao

5	(i)		$x_H = 3 \times 0.6/8$ $\pi(0.6^2 \times 0.6)(0.6/2) - (0.6^3 \times 2\pi/3)0.225$ $= \pi \times 0.6^3(1+2/3)x_G$ $x_G = 0.09 \text{ m}$	B1 M1 A1 A1 A1 [5]	CoM hemisphere ($x_H = 0.225$), may be implied Use of table of moments idea SC Volume of sphere used, max B1M1A1, moment equation fully correct for A1 (3/5) Accept -0.09
	(ii)	(a)	$mg(0.09\cos 45) =$ $2(0.6+0.6\cos 45+0.6\sin 45)$ $m = 4.65\text{kg}$	M1 A1 A1 A1 [4]	Attempt at moments (must resolve), allow without g $2(0.6+\sqrt{0.6^2+0.6^2})$ (4.6451...)
	(ii)	(b)	$2/4.6451g$ $\mu \geq 0.0439$	M1 A1 A1 [3]	Ratio force/weight cv(4.65) Correct inequality sign, accept 0.044
6	(i)		$0 = (14\sin 30)^2 - 2gh$ $h = 2.5 \text{ m}$	M1 A1 [2]	$h = (14\sin 30)x1/1.4 - g(1/1.4)^2/2$ or use $(u^2\sin^2\theta)/2g$
	(ii)		$0.4 \times 15 = 0.4(14\cos 30) + I$ $I = 1.15$	M1 A1 A1 [3]	Impulse = change in momentum Not 14 or 0 for horizontal speed before impulse aef
	(iii)		$v^2 = (14\sin 30)^2 + 15^2$ $v = 16.6 \text{ ms}^{-1}$ $\tan\theta = 14\sin 30/15$ OR $\tan\psi = 15/14\sin 30$ $\theta = 25(.0)^\circ$ OR $\psi = 65(.0)^\circ$	M1 A1 M1 A1 [4]	Not $(14\sin 30)^2 + (14\cos 30)^2$ Allow $\sqrt{274}$ Correct trig to find an appropriate angle; not $14\cos 30$ for 15
	(iv)		$t = 14\sin 30/g (= 1/1.4 = 0.7142..)$ $T = 1.43 \text{ s}$ $R = 14\cos 30/1.4 + 15/1.4$ $R = 19.4 \text{ m}$	M1 A1 M1A1 A1 [5]	Rise or fall time (not to be given in (i)) Accept 10/7 $(14^2\sin(2 \times 30) + 16.6^2\sin(2 \times 25))/2g$. 14 resolved, 15 not

	(ii)	$c - (\pm 0.25) = 1 \times 0.75$ $c = 0.5, 1$ $0.75 \times 0.7 = 0.25 \times 0.7 + m(x1)$ OR $0.75 \times 0.7 = -0.25 \times 0.7 + 0.5m$ $m = 0.35$ (from first equation) $m = 1.4$ (from second equation)	M1 A1A1 M1 A1 A1 [6]	Uses restitution with $e = 1$, either Or 0.75 ± 0.25 Uses momentum conservation with correct combination of sign and c value OR $m \times (0.75 \pm 0.25) \pm 0.7 \times 0.25 = 0.75 \times 0.7$
	OR	$\frac{1}{2} \times 0.7 \times 0.75^2 = \frac{1}{2} \times 0.7 \times 0.25^2 + \frac{1}{2} m c^2$ $0.7 \times 0.75 = 0.7 \times (\pm 0.25) + m c$ Solving simultaneous equations $m = 0.35$ $m = 1.4$	B1 M1 A1 M1 A1 A1	$\frac{1}{2}$ may not be seen At least one momentum equation $m c = 0.35$ and 0.7
		Total	[72]	

[END]

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