RECOGNISING ACHIEVEMENT

GCE

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)		$3x_G = 2x0.3 + 1x0.6$ OR $3x_G = 2x0.3 + 0$ OR $3x_G = 4x0.3$ OR $3y_G = 1x0.3 + 1x0.6 + 0$ OR $3y_G = 4x0.3 - 1x0.3$ $x_G = 0.4$ (from AD) OR $x_G = 0.2$ (from BC) $y_G = 0.3$m from AB or CD $AG^2 = 0.4^2 + 0.3^2$ AG = 0.5 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 = 0.5x3 $v = 1.5\ ms^{-1}$	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 **AG**	M1 A1 A1 **[3]**	Tractive force x speed = power
	(ii)		$R = 4.8 \times 16^{3/2}$ $T - 4.8x16^{3/2} + 700gx1/15 = 700x0.3$ P = 59.9 x 16 P = 958 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)**		$T_A\cos30 + T_B\cos60 = 0.4g$ $2T\cos30 + T\cos60 = 0.4g$ $T_B = 1.76$ N $T_A = 3.51$ N	M1 A1 A1 A1 **[4]**	Resolves vertically, 3 terms T = 1.756. Watch for MR of Tcos30 + 2Tcos60 = 0.4g Accept 3.52
	(ii)		r = 0.5sin30 (= 0.25) $3.51\sin30 + 1.76\sin60 = 0.4\omega^2 0.5\sin30$ $\omega = 5.72$ 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 = 100cos20 x 30 WD = 2820 J	M1 A1 **[2]**	Product of 3 relevant elements. Angle could be 5, 25 or complements 2819.1...
	(ii)		PE = 25g x 30sin5 PE = 641	M1 A1 **[2]**	Product of weight and vertical height. Allow without g 640.6
	(iii)		 2819.1 = 640.6 + 30x70 + $25v^2/2$ v = 2.51 ms^{-1}	M1 A1ft A1 A1 **[4]**	4 term energy equation ft(cv 2820 and cv 641) cao
		OR	25a = 100cos20 -70 -25gsin5 a = 0.105 v^2 = 2 x 30 x 'a' v = 2.51	*M1 A1 dep*M1 A1 **[4]**	4 term equation Allow 0.1 here Or equivalent complete method cao

5	**(i)**		$x_H = 3x0.6/8$ $\pi(0.6^2x0.6)(0.6/2) - (0.6^3x2\pi/3)0.225$ $= \pi x0.6^3(1+2/3)x_G$ $x_G = 0.09$ m **AG**	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)**	 $mg(0.09\cos45) =$ $2(0.6+0.6\cos45+0.6\sin45)$ $m = 4.65$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)**		$0 = (14\sin30)^2 - 2gh$ $h = 2.5$ m	M1 A1 **[2]**	$h = (14\sin30)x1/1.4 - g(1/1.4)^2/2$ or use $(u^2\sin^2\theta)/2g$
	(ii)		 $0.4x15 = 0.4(14\cos30) + I$ $I = 1.15$	M1 A1 A1 **[3]**	Impulse = change in momentum Not 14 or 0 for horizontal speed before impulse aef
	(iii)		$v^2 = (14\sin30)^2 + 15^2$ $v = 16.6$ ms^{-1} $\tan\theta = 14\sin30/15$ OR $\tan\psi = 15/14\sin30$ $\theta = 25(.0)°$ OR $\psi = 65(.0)°$	M1 A1 M1 A1 **[4]**	Not $(14\sin30)^2 + (14\cos30)^2$ Allow $\sqrt{274}$ Correct trig to find an appropriate angle; not 14cos 30 for 15
	(iv)		$t = 14\sin30/g$ (= 1/1.4 = 0.7142..) $T = 1.43$ s $R = 14\cos30/1.4 + 15/1.4$ $R = 19.4$ m	M1 A1 M1A1 A1 **[5]**	Rise or fall time (not to be given in (i)) Accept 10/7 $(14^2\sin(2x30) + 16.6^2\sin(2x25))/2g$. 14 resolved, 15 not

7	**(i)**		$b + a = 1.8e$	M1	Uses restitution
				A1	$b - a = 1.8e$
				M1	Uses momentum
			$0.7b - 0.2a = 0.2 \times 1.8$	A1	$0.7b + 0.2a = 0.2 \times 1.8$, signs consistent with first eqn
				M1	Solves 2 simultaneous equations (eliminate a or b)
			$b = 0.4(1+e)$	A1	
			$a = 1.4e - 0.4$	A1	$a = 0.4 - 1.4e$
			$1.4e - 0.4 > 0.4 + 0.4e$	M1	Using a>b, correct signs in a essential
			$e > 0.8$	A1	
				[9]	
	OR	**Last 5 marks**	Using $a > b$	M1	correct signs in a essential
			$a > 0.72$	A1	
			$b > 0.72$	A1	
			$1.8e > 0.72 + 0.72$	M1	
			$e > 0.8$	A1	
	OR	**Last 5 marks**	Using $a = b$ to find a or b	M1	
			a (or b) = 0.9e and a (or b) = 0.72	A1	
			$e = 0.8$	A1	
			Convincing argument for correct inequality	M1	
			$e > 0.8$	A1	
	OR	**Last 5 marks**		M1	Solves 2 simultaneous equations (eliminate a or b)
			$a = 1.4e - 0.4$ or $b = 0.4(1+e)$	A1	aef or multiples thereof
			Using $a > b$	M1	correct signs in a essential
			$a > 0.9e$ or $b < 0.9e$	A1	aef or multiples thereof
			$e > 0.8$	A1	

	(ii)		c – (±0.25) = 1x0.75 c = 0.5, 1 0.75x0.7 = 0.25x0.7 + m (x1) *OR* 0.75x0.7 = -0.25x0.7 + 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* mx(0.75 ± 0.25) ± 0.7x0.25 = 0.75x0.7
	OR		½ x0.7x0.75^2 = ½ x0.7X0.25^2 + ½mc^2 0.7x 0.75 = 0.7x(+/-0.25) + mc Solving simultaneous equations m = 0.35 m = 1.4	B1 M1 A1 M1 A1 A1	½ may not be seen At least one momentum equation mc = 0.35 and 0.7
			Total	**[72]**	

[END]

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