RECOGNISING ACHIEVEMENT

GCE

Mathematics

Advanced GCE

Unit **4730:** Mechanics 3

Mark Scheme for January 2011

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1 i	(-)15cosα = (0 –) 0.5x22 or 15sinβ = 0.5x22 Impulse makes angle 42.8^o (0.748 rads) with negative x-axis	M1 A1 A1 [3]	M1 for using I = Δ(mv) in 'x' direction or for sketching Δ reflecting **I** = m(**v** – **u**) AEF, but angle must be clear
ii	15sinα = 0.5v or 15cosβ = 0.5v or $(0.5v)^2 = 15^2 - 11^2$ Correct explicit expression for v Speed is 20.4 ms^{-1}	M1 A1 A1 [3]	For using I = Δ(mv) in 'y' direction or using sketched Δ

2	½ (m)(v^2 - 6^2) = -(m)g x 0.5 in (i) or ½ (m)(v^2 – 6^2) = -(m)g x 1 in (ii) v^2 = 26.2 in (i) and 16.4 in (ii) T = 0.4v^2/0.5 in (i) or T + 0.4g = 0.4v^2/0.5 Tension is 21.0N in (i) (20.96) 9.2N in (ii)	M1 A1 M1 A1 A1 A1 [6]	For using the principle of conservation of energy in (i) or (ii) soi For using Newton's second law with a = v^2/L. M1 for either attempt, A1 for both right

3 i	2.8*V* = 1.4x72 Vertical component at *P* is 36 N	M1 A1 [2]	For taking moments about *Q* for *PQ* or for using symmetry
ii	36 + *N* = 72 + 54 Normal component at *R* is 90 N	M1 A1 [2]	For resolving forces vertically on both rods AG
iii	1.44F = 1.2x90 – 0.8x54 or 72x1.4 + 54x3.6 + 1.44F = 90x4 with not more than 1 error in either case Equation correct and leading to F = 45 For using F = μR Coefficient is 0.5	M1 A1 A1 M1 A1 [5]	For taking moments about *Q* for *QR* or about *P* for the whole structure (all terms needed)

4 i	$0.4(7\times0.6) - 0.3\times2.8 = 0.4a + 0.3b$ $0.7(7\times0.6 + 2.8) = b - a$ Speed of *B* is $4ms^{-1}$	M1 A1 M1 A1 M1 A1 [6]	For using the principle of conservation of momentum For using $e(\Delta u) = \Delta v$ For eliminating a from equations
ii	a = (-)0.9 Component perp. to l.o.c. is 5.6 $\tan\alpha = 5.6/0.9$ $\alpha = 80.9°$ Angle turned through is 46.0° (0.803^c)	B1 B1 M1 A1 A1ft [5]	For attempting to find α - the angle between the direction of motion of A after collision and the l.o.c. to the left, or $90° - \alpha$ $126.9° - \alpha$

5 i	$2.45e/0.5 = 0.05g$ ($e = 0.1$) Distance from O is 0.5 + 0.1 = 0.6m	M1 A1 A1 [3]	For using $T = \lambda e/L$ and resolving forces vertically accept use of 0.1 to show both sides equal to 0.49 AG
ii	$mg - T = m\ddot{x}$ $0.05g - 2.45(0.1 + x)/0.5 = 0.05\ddot{x}$ $\ddot{x} = -98x$	M1 A1 A1 [3]	For using Newton's second law with 3 terms AG
iii	$a = 0.075$ $n = 7\sqrt{2}$ oe $x = 0.075\cos(7\sqrt{2}\,t)$ $x(0.2) = -0.0298$ $v = -0.075(7\sqrt{2})\sin(7\sqrt{2}\,t)$ $v(0.2) = -0.681$ ➔ velocity is $0.681ms^{-1}$ upwards	B1 B1 M1 A1 M1 A1ft A1 [7]	 accept 9.90 For using $x = a\cos nt$ oe For differentiating $x = a\cos nt$ and using it ft incorrect *a* and/or *n* If from $v^2 = n^2(a^2 - x^2)$ the direction must be clearly established

6 i	$112e/4 = 3.5 \times 9.8 \times \frac{40}{49}$	M1	For using $mg\sin\theta$ and $\lambda e/L$
		A1	
	$V^2 = 2\times8\times(4 + 1)$	M1	For using $s = 4 + e$ and $a = 8$ in $v^2 = 2as$, or by energy
	$V^2 = 80$	A1	
	$0.5\sqrt{80} = (0.5 + 3.5)u$	M1	For using the principle of conservation of momentum
	Initial speed of combined particles is $\frac{1}{2}\sqrt{5}$ ms^{-1}	A1	
		[6]	AG
ii		M1	For using EE = $\lambda x^2/2L$
	Gain in EE = $(112/(2\times4))\{(X + 1)^2 - 1^2\}$	A1	
	Loss of KE = ½ (0.5 + 3.5) x 5/4	B1	
	Loss of PE = $(0.5 + 3.5) \times 9.8 \times \frac{40}{49}X$	B1	
			For using the principle of conservation of energy
	$14(X^2 + 2X) = 2.5 + 32X$	M1	
	$28X^2 - 8X - 5 = 0$	A1	AG
		[6]	
OR	$T - mg\sin\theta = -ma$	M1	For use of $F = ma$
	$\frac{112(x+1)}{4} - 4g\frac{40}{49} = -4a$	A1	allow one sign slip for A1
	$\int (7x-1)\,dx = -\int v\,dv \ (+c)$	M1	Using $a = v\frac{dv}{dx}$ and integrating
	$\frac{7x^2}{2} - x = -\frac{v^2}{2} + c$	A1	
	$c = \frac{5}{8}$	A1	
	$28X^2 - 8X - 5 = 0$	A1	AG Convincingly
		[6]	

7 i	$0.2g - v^2/2000 = 0.2v(dv/dx)$ $\left(\frac{400v}{3920 - v^2}\right)\frac{dv}{dx} = 1.$	M1 A1 [2]	For using Newton's second law with $a = v(dv/dx)$ AG Convincing, with no slips.
ii	$-200 \ln(3920 - v^2) = x + (A)$ $-200 \ln(3920) = A$ $x = 200 \ln\left(\frac{3920}{3920 - v^2}\right)$ $e^{x/200} = 3920/(3920 - v^2)$ $v^2 = 3920(1 - e^{-x/200})$ $0 < e^{-x/200} \Rightarrow v^2 < 3920$	M1 A1 M1 A1 M1 A1 B1 [7]	For separating variables and integrating For using v(0) = 0 For using inverse ln process AG Convincingly – dep on correct answer
iii	Using $0.2g - v^2/2000 = 0.2a$ $v = 40$ Gain in KE = ½ 0.2x1600 (=160J) $x = 200 \ln\left(\frac{3920}{3920 - 1600}\right)$ (= 104.90) 0.2g x (104.9) – 160 Work done is 45.6 J	M1 A1 B1ft B1ft M1 A1 [6]	 For using WD = loss of PE – gain in KE
OR	Using $0.2g - v^2/2000 = 0.2a$ $v = 40$ $x = 200 \ln\left(\frac{3920}{3920 - 1600}\right)$ (= 104.90...) WD = $\int \frac{v^2}{2000} dx + c$ = $\int \frac{3920}{2000}(1 - e^{-x/200})\, dx$ = $3920/2000(x + 200e^{(-x/200)} - 392$ Work done is 45.6 J	M1 A1 B1ft M1 A1 A1 [6]	 Use of WD = $\int F dx$ and subst for v^2

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