GCE

Mathematics

Advanced GCE **4730**

Mechanics 3

Mark Scheme for June 2010

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1	For included angle marked α or for $0.8(10.5 - 8.5\cos\alpha) = 4\cos\beta$ For opposite side marked 4/0.8 (or 4) or for $-0.8 \times 8.5\sin\alpha = 4\sin\beta$ $8.4^2 + 6.8^2 - 2 \times 8.4 \times 6.8\cos\alpha = 4^2$ $\alpha = 28.1^o$	M1 A1 A1 M1 A1ft A1 [6]	For triangle with two of its sides marked 0.8 x 10.5 and 0.8 x 8.5 (or 10.5 and 8.5) or for using I = Δmv in one direction. Allow B1 for omission of 0.8 Allow B1 for omission of 0.8 For using the cosine rule or for eliminating β ft 0.8 mis-used or not used
2(i)	$[100a = 2aV_B]$ Vertical component at B is 50 N Vertical component at C is 150 N	M1 A1 A1 [3]	For taking moments about A for AB
(ii)	$100(0.5a) + (\sqrt{3}\,a)F = 150a$ or $100a + 100(1.5a) = 150a + (\sqrt{3}\,a)F$ Frictional force is 57.7 N Direction is to the right	M1 A1ft A1 B1 [4]	For taking moments about B for BC (3 terms needed) or about A for the whole (4 terms needed)
3(i)	$u = 4$ $v = 2$	B1 B1 [2]	
(ii)	$mu = ma + mb$ (or $u = b - a$) $u = b - a$ (or $mu = ma + mb$) $a = 0$ and $b = 4\text{ms}^{-1}$ Speed of A is 2ms^{-1} and direction at 90^o to the wall Speed of B is 4ms^{-1} and direction parallel to the wall	M1 A1 B1 A1ft A1ft A1ft [6]	For using the principle of conservation of momentum or for using NEL with e = 1 ft incorrect u ft incorrect v ft incorrect u
4(i)	$[0.25\, dv/dt = 3/50 - t^2/2400]$ $v = 12t/50 - t^3/1800$ $[v(12) = 1.92]$ $[0.25\, dv/dt = t^2/2400 - 3/50 \rightarrow v = t^3/1800 - 12t/50 + C_2]$ $[1.92 = 0.96 - 2.88 + C_2]$ $v = t^3/1800 - 12t/50 + 3.84$ $v(24) = 5.76 = 3 \times v(12)$	M1 M1 A1 M1 M1 M1 A1 A1 [8]	For using Newton's second law (1st or 2nd stage) For attempting to integrate (1st stage) and using v(0) = 0 (may be implied by the absence of + C_1) For evaluating v when force is zero For using Newton's second law (2nd stage) and integrating For using v(12) = 1.92 AG

(ii)	Sketch has v(0) = 0 and slope decreasing (convex upwards) for 0 < t < 12 Sketch has slope increasing (concave upwards) for 12 < t < 24 Sketch has v(t) continuous, single valued and increasing (except possibly at t = 12) with v(24) seen to be > 2v(12)	B1 B1 B1 [3]	
5(i)	For using amplitude as a coefficient of a relevant trigonometric function. For using the value of ω as a coefficient of t in a relevant trigonometric function. $x_1 = 3\cos t$ and $x_2 = 4\cos 1.5t$	B1 B1 B1 [3]	
(ii)	Part distance is 20m [20 – (-3.62)] Distance travelled by P_2 is 23.6 m	M1 A1 M1 A1 [4]	For using distance travelled by P_2 for $0 < t < 5\pi/3$ is $5A_2$ For subtracting displacement of P_2 when t = 5.99 from part distance.
(iii)	$\dot{x}_1 = -3\sin t$; $\dot{x}_2 = -6\sin 1.5t$ $v_1 = 0.867$, $v_2 = -2.55$; opposite directions	M1 A1 M1 A1 [4]	For differentiating x_1 and x_2 For evaluating when t = 5.99 (must use radians)
	Alternative for (iii): $v_1^2 = 3^2 - 2.87^2$, $v_2^2 = 2.25[4^2 - (-3.62)^2]$ [$\pi < 5.99 < 2\pi \Rightarrow v_1 > 0$, $4\pi/3 < 5.99 < 2\pi \Rightarrow v_2 < 0$] $v_1 = 0.867$, $v_2 = -2.55$; opposite directions	M1 A1 M1 A1	For using $v^2 = n^2(a^2 - x^2)$ (must use radians to find values of x) For using the idea that v starts –ve and changes sign at intervals of T/2 s
6(i)	PE loss at lowest allowable point = 25W EE gain = $32000 \times 5^2/(2 \times 20)$ [25W = 20000] Value of W is 800	B1 M1 A1 M1 A1 [5]	For using $EE = \lambda x^2/(2L)$; may be scored in (i) or in (ii) For equating PE loss and EE gain and attempting to solve for W
(ii)	[800 = 32000x/20] $\frac{1}{2}(800/9.8)v^2 = 800 \times 20.5 - 32000 \times 0.5^2/(2 \times 20)$ Maximum speed is 19.9ms^{-1}	M1 M1 A1 A1 [4]	For using $W = \lambda x/L$ at max speed For using the principle of conservation of energy (3 terms required)
(iii)	$(800)\ddot{x}/g = 800 - 32000 \times 5/20$ Max. deceleration is 88.2 ms^{-2}	M1 A1 A1 [3]	For applying Newton's second law to jumper at lowest point (3 terms needed)

7(i)	[$\frac{1}{2}mv^2 - \frac{1}{2}m\,6^2 = mg(0.7)$] Speed of P before collision is $7.05ms^{-1}$ Coefficient of restitution is 0.695	M1 A1 B1ft [3]	For using the principle of conservation of energy for P (3 terms needed) ft 4.9 ÷ speed of P before collision
(ii)	[$\frac{1}{2}mv^2 = \frac{1}{2}m\,4.9^2 - mg0.7(1 - \cos\theta)$] $v^2 = 3.43(3 + 4\cos\theta)$ $T - mg\cos\theta = mv^2/0.7$ [$T - m9.8\cos\theta = m3.43(3 + 4\cos\theta)/0.7$] Tension is $14.7m(1 + 2\cos\theta)$N	M1 A1 M1 A1 M1 A1 [6]	For using the principle of conservation of energy for Q Accept any correct form For using Newton's second law radially with $a_r = v^2/r$ For substituting for v^2 AG
(iii)	$T = 0 \rightarrow \theta = 120°$ Radial acceleration is ($\pm$)4.9 ms^{-1} **or** transverse acceleration is ($\pm$)8.49 ms^{-1} Radial acceleration is ($\pm$)4.9 ms^{-1} **and** transverse acceleration is ($\pm$)8.49 ms^{-1}	B1 M1 A1 B1 [4]	For using $a_r = -g\cos\theta$ {or $3.43(3 + 4\cos\theta)/0.7$} or $a_t = -g\sin\theta$
			SR for candidates with a sin/cos mix in the work for M1 A1 B1 immediately above. (max. 1/3) Radial acceleration is ($\pm$)8.49 ms^{-1} **and** transverse acceleration is ($\pm$)4.9 ms^{-1} B1
(iv)	[$V^2 = 3.43\{3 + 4(-0.5)\}x0.5^2$ or $V^2 = (-g\cos120° \times 0.7) \times \cos^2 60°$] $V^2 = 0.8575$ [$mgH = \frac{1}{2}m(4.9^2 - 0.8575)$ or $mg(H - 1.05) = \frac{1}{2}m(3.43 - 0.8575)$] Greatest height is 1.18 m	M1 A1 M1 A1 [4]	For using $V = v(120°) \times \cos60°$ AG For using the principle of conservation of energy

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