

Mathematics

Advanced GCE 4729

Mechanics 2

Mark Scheme for June 2010

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1	$v^2 = 2 \times 9.8 \times 10$ $v = 14 \text{ m s}^{-1}$ speed = $\sqrt{7^2 + 14^2}$ 15.7 or $7\sqrt{5} \text{ m s}^{-1}$ $\tan^{-1}(14/7)$ or $\tan^{-1}(7/14)$ 63.4° to the horizontal	M1 A1 M1 A1 M1 A1 6	Using $v^2 = u^2 + 2as$ with $u = 0$ Method to find speed using their “v” Method to find angle using their “v” 26.6° to vertical 6
2 (i)	$(6 \sin \Pi/2) \div (\Pi/2)$ 3.82	M1 A1 2	Use of correct formula AG
	(ii)	M1 A1 A1 M1 A1 5	Method to find centre of mass Attempt to find the required angle 7
3 (i)	$D = 128\,000/80 (= 1600)$ $k(80)^2 = 128\,000/80$ $k = 1/4$ $R = 900 \text{ N}$	B1 M1 A1 A1 B1 5	Driving force = resistance FT on their k ($R = 3600k$)
	(ii)	B1 B1 M1 A1 4	4 terms required 9
4 (i)	$4T \cos 20^\circ = 5 \times g \times 2.5$ $T = 32.6 \text{ N}$	M1 A1 A1 3	Using moments; allow sin/cos mix Allow with omission of g
	(ii)	M1 A1 M1 A1 M1 A1 A1 A1 7	allow sin/cos mix FT their T FT their T, but not from omission of g $X \neq 0, Y \neq 0$ or 31.2° to left of vertical 10

5 (i)	$T\cos 45^\circ + R\sin 45^\circ = mg$ $T\sin 45^\circ - R\cos 45^\circ = m\sin 45^\circ \omega^2$ $2T = \sqrt{2}mg + ml\omega^2$ $T = m/2(\sqrt{2}g + l\omega^2)$	*M1 A1 *M1 A1 Dep*M1 A1 6	3 terms 3 terms; $a = r\omega^2$ Method to eliminate R AG www
	(ii) $R = 0$ $2R = \sqrt{2}mg - ml\omega^2$ or $T\cos 45^\circ = mg$ or $T = ml\omega^2$ Solve to find ω $\omega = 4.16 \text{ rad s}^{-1}$	B1 B1 M1 A1 4	may be implied 10
6 (i)	$2mu = 2mv + 3mv$ $v = 2/5 u$	M1 A1 A1 3	Conservation of momentum Must be $v =$
	(ii) $e = (3v - v) / u$ $e = 4/5$	M1 A1 2	Using restitution AG
	(iii) Initial K.E. = $9mv^2 / 2 = 18mu^2 / 25$ Final K.E. = $9mv^2 / 8 = 9mu^2 / 50$ $\frac{1}{2} m (V)^2 = \text{Final K.E.}$ $V = 3u / 5$	B1 FT B1 FT M1 A1 4	FT on their v from (i) FT on their v from (i) AG
	(iv) $4mu / 5 - 3mu / 5 = 2mx + my$ $u / 5 = 2x + y$ $e = 4/5 = (y - x) / u$ $4u = 5y - 5x$ solving 2 relevant equations $x = -u/5$ $y = 3u/5$ $y = 3u/5$ away from wall (x) + towards wall (y)	M1 A1 FT M1 FT A1 M1 A1 A1 A1 8	Conservation of momentum FT on their v from (i); aef Using restitution FT on their v from (i); aef both 17

<p>7 (i)</p> <p>Or last 4 marks of (i)</p>	<p>$R = 0.2 \times 9.8 \times \cos 30^\circ (= 1.70)$ $F = 0.1 \times 9.8 \times \cos 30^\circ (= 0.849)$ FT</p> <p>$\frac{1}{2} \times 0.2 \times 11^2 - \frac{1}{2} \times 0.2 v^2 =$ $0.2 \times 9.8 \times 5 \sin 30 + 5 \times 0.849$ $v = 5.44 \text{ m s}^{-1}$</p> <p>$F + 0.2g \sin 30 = \pm 0.2a$ $a = \pm 9.1$ $v^2 = 11^2 + 2 \times a \times 5$ $v = 5.44 \text{ m s}^{-1}$</p>	<p>B1 B1 M1 A1 A1 A1 6 M1 A1 M1 A1</p>	<p>FT on their R, but not $R = 0.2g$ Use of conservation of energy</p> <p>AG</p> <p>Use of N2L, 3 terms</p> <p>Complete method to find v</p>
<p>(ii)</p> <p>Or first 5 marks of (ii)</p>	<p>$t = 5 \cos 30^\circ / 5.44 \cos 30^\circ$ $t = 0.919 \text{ s}$ $u = 5.44 \sin 30^\circ (= 2.72)$ $s = 2.72 \times 0.919 - 4.9 \times 0.919^2$ $s = -1.6$ (or better) Ht drop to C = $5 \sin 30^\circ = 2.5 \text{ m}$ Ball does not hit the roof</p> <p>$y = x \tan \theta - gx^2 \sec^2 \theta / 2V^2$ substitute values $V = 5.44 \quad \theta = 30^\circ \quad x = 5 \cos 30^\circ$ $y = 2.5 - 9.8 \times 25 \times 3 / 4 \times 4 / 3 / (2 \times 5.44^2)$ $y = -1.6$ (or better)</p>	<p>M1 A1 B1 M1 A1 B1 A1 7 B1 M1 A1 A1 A1</p>	<p>time to lateral position over C</p> <p>Ht dropped</p> <p>13</p> <p>all 3 correct</p>
<p>OR (ii)</p>	<p>$u = 5.44 \sin 30^\circ (= 2.72)$ $-2.5 = 5.44 \sin 30 t - 4.9 t^2$</p> <p>$t = 1.04$ $x = 5.44 \cos 30 \times 1.04 = 4.9$ (or better) Horizontal distance from B to C = $5 \cos 30 = 4.3$ (or better) Ball does not hit the roof</p>	<p>B1 M1 A1 A1 A1 B1 A1 7</p>	<p>aef time to position level with AC</p>
<p>OR (ii)</p>	<p>$y = x \tan \theta - gx^2 \sec^2 \theta / 2V^2$ substitute values $-2.5 = 0.577x - 0.221x^2$ Attempt to solve quadratic for x $x = 4.9$ (or better) Horizontal distance from B to C = $5 \cos 30 = 4.3$ (or better) Ball does not hit the roof</p>	<p>B1 M1 A1 M1 A1 B1 A1 7</p>	<p>aef</p>
<p>OR (ii)</p>	<p>$u = 5.44 \sin 30^\circ = 2.72$ $-2.5 = 5.44 \sin 30 t - 4.9 t^2$</p> <p>$t = 1.0$ (or better) $T = 5 \cos 30^\circ / 5.44 \cos 30^\circ$ $T = 0.92$ (or better) Ball does not hit the roof</p>	<p>B1 M1 A1 A1 M1 A1 A1 7</p>	<p>aef time to position level with AC time to lateral position over C</p>

OR (ii)	Attempt at equation of trajectory $y = 0.577x - 0.221x^2$ $y = -0.577x$ Solving their quadratic and linear equations to get at least x or y $x = 5.2$ (or better) or $y = -3.0$ (or better) Horizontal distance from B to C = $5\cos 30 = 4.3$ (or better) Or Ht drop to C = $5\sin 30^\circ = 2.5$ Ball does not hit the roof	M1 A1 B1 M1 A1 B1 A1 7	Equation of BC Must be the one needed for comparison
OR (ii)	Attempt at equation of trajectory $y = 0.577x - 0.221x^2$ $y = -0.577x$ Solving their quadratic and linear equations $x = 5.2$ (or better) and $y = -3.0$ (or better) Distance = 6.0 (or better) Ball does not hit the roof	M1 A1 B1 M1 A1 B1 A1 7	Distance from B to point of intersection

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