

Mathematics

Advanced GCE

Unit **4729**: Mechanics 2

Mark Scheme for June 2011

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1 i	$PE = 70 \times 3g$ $KE \text{ change} = 70 \times (2.1^2 - 1.4^2) / 2$ $PE \text{ change} + KE \text{ change}$ 2143.75 J	B1 B1 M1 A1 [4]	2058 85.75 Must include evaluation Accept 2140. Allow all values to be negative.
ii	$20(90 + T) = 2143.75$ $T = 17.1875 \text{ N}$	M1 A1ft A1 [3]	Work done = Energy change used $ft(cv(2143.75))$ accept 17.2
OR	$70g \cdot 0.15 - 90 - T = 70 \cdot (-0.06125)$ $T = 17.1875 \text{ N}$	M1 A1 A1 [3]	Use of $v^2 = u^2 + 2as$ to find a AND use of N2 law(4 terms) accept 17.2
2 i	$21000/25$ $0 = 21000/25 - 25k - 1250g \sin 2$ $k = 16.5$	B1 M1 A1 A1 [4]	Use of force = power/speed 3 terms $cv(21000/25)$
ii	$21000/v = 16.5v$ $v = 35.7 \text{ ms}^{-1}$	M1 A1ft A1 [3]	$ft \text{ on } cv(k)$
3 i	$-(8 \cos 30 / 3)(8^2 \sin 60 / 2)$ $+ (4)(8^2)$ $= (8^2 + 8^2 \sin 60 / 2)(x_G)$ $x_G = 2.09 \text{ cm}$	M1 A1 A1 A1 A1 [5]	Table of moments idea, may include g and/or density. -2.309×27.7
ii	$\tan \theta = (2.09/4)$ $\theta = 27.6^\circ$	M1 A1ft [2]	$ft \text{ } cv(x_G)$

4			
ia	If reversed $2.9 + 2 = e(3 + 1.5)$ $e > 1$ impossible	M1 A1 [2]	Award B1 if no explicit numerical justification
b	$2.9 - 2 = e(3 + 1.5)$ $e = 0.2$	M1 A1 [2]	May be seen in ia
ii	$3m - 0.2 \times 1.5 = 2m + 0.2 \times 2.9$ $m = 0.88$	M1 A1 A1 [3]	Conservation of momentum Accept with g included consistently Do not award if g used
iii	$0.68 = 0.2v + 0.2 \times 2.9$ $v = 0.5$ $e = 0.5/2.9$ $e = 0.172$	M1 A1 M1 A1 [4]	Impulse = change in momentum Separation speed not 2.9 Allow 5/29
5			
i	$x = (7\cos 30)t$ $y = (7\sin 30)t - gt^2/2$ $y = x \tan 30 - gx^2/(2 \times 7^2 \cos^2 30)$	B1 B1 M1 A1 [4]	Attempt to eliminate t $y = x/\sqrt{3} - 2x^2/15$ or $y = 0.577x - 0.133x^2$ aef
ii	$2x^2/15 - x/\sqrt{3} + 0.6 = 0$ or $9.8t^2 - 7t + 1.2 = 0$ $x = 1.73 \text{ m}$ or $\sqrt{3} \text{ m}$ $2.6(0) \text{ m}$ or $3\sqrt{3}/2 \text{ m}$	M1 M1 A1 A1 [4]	Create a 3 term Q.E. in x or t with $y = 0.6$ Solve 3 term Q.E. for x or t
iii	$v^2 = (7\sin 30)^2 - 2 \times 9.8 \times 0.6$ $v = 0.7 \text{ ms}^{-1}$ $\tan \theta = 0.7/(7\cos 30)$ $\theta = 6.59^\circ$ to horizontal or 83.4° to vertical	M1 A1 M1 A1 [4]	Using $v^2 = u^2 - 2gs$ with u a component of 7; can find t first from their x in (i), and then use $v = u + at$. Use component of 7
OR	Attempt to differentiate equation of trajectory $\tan 30 - gx/(7^2 \cos^2 30)$ Substitute $x = \sqrt{3}$ and equate to $\tan \theta$ $\theta = 6.59^\circ$ to horizontal or 83.4° to vertical	M1 A1 M1 A1 [4]	Allow $1/\sqrt{3} - 4x/15$ or $y' = 0.577 - 0.267x$

6 i	$R\sin 30 = 0.3g$ $R\cos 30 = 0.3\omega^2 \times 0.12$ $\omega = 11.9 \text{ rads}^{-1}$	M1 A1 M1 A1 A1 [5]	$R = 5.88$ or $0.6g$ accept $v^2/0.12$ for acceleration cao
ii	$S + R\cos 30 = 0.3 \times 2.1^2 / 0.2$ $R = 5.88$ $S = 1.52 \text{ N}$	M1 A1 B1ft A1 [4]	Resolve and use N2L on sphere Q, 3 terms needed ft $cv(R)$ from (i)
iii	$v_P = 11.9 \times 0.12$, or $h = 0.2/\tan 30$ or $0.12/\tan 30$ or $0.08/\tan 30$ $\pm(Q - P) =$ $0.5 \times 0.3(2.1^2 - (11.9 \times 0.12)^2)$ $+ (0.2/\tan 30 - 0.12/\tan 30) \times 0.3g$ $Q - P = \pm 0.763 \text{ J}$	B1 M1 A2ft A1 [5]	$cv(\omega)$ from (i) Attempt to calculate KE or PE for both particles KE difference (ft on $cv(\omega)$) or PE difference $Q - P = \pm(0.3556 + 0.4074)$
7 i	$F \times 0.8 =$ $0.6\cos 60 \times 550$ $F = 206.25$	M1 A1 A1 A1 [4]	Attempt at moments Accept 206, cao
ii	$T \times 2 \times 0.8/\tan 30$ $=$ $550 \times (0.8/\sin 30 - 0.6\cos 60)$ $T = 258$ $R = 550 - T\cos 30$ $F_r = T\sin 30$ $\mu = 129/326.6$ $\mu = 0.395$	M1* A1 M1* A1 A1 M1* A1 B1* M1dep* A1 [10]	Moment of T about P $T \times 2.77$ Moment of weight about P $550 \times (1.6 - 0.3)$ Accept to 2sf Resolving vertically, 3 terms needed Value for T not required Value for T not required; accept $<$ or \leq For correct use of $F = \mu R$, $R \neq 550$

<p>OR</p>	$T \times 0.8/\tan 30 + 550 \times 0.6\cos 60 = R \times 0.8/\cos 60$ $R = 550 - T\cos 30$ <p>Solve for T or R $T = 258$ or $R = 326.5625$ $F_r = T\sin 30$ $\mu = 129/326.6$ $\mu = 0.395$</p>	<p>M1* A2 M1* A1 M1 A1 B1* M1dep* A1 [10]</p>	<p>Moments about V, 3 terms needed A1 for two terms correct Resolving vertically, 3 terms needed</p> <p>Accept to 2sf Value for T not required; accept $<$ or \leq For correct use of $F = \mu R$, $R \neq 550$</p>
<p>OR</p>	$F_r \times 1.6\cos 30 + 550 \times (1.6\sin 30 + 0.6\sin 30) = R \times (1.6 + 1.6\sin 30)$ $R = 550 - T\cos 30$ $F_r = T\sin 30$ <p>Solving for at least one of R, F_r, or T Either $R = 326.5625$, or $F_r = 129(.0017008)$, or $T = 258$ $\mu = 129/326.6$ $\mu = 0.395$</p>	<p>M1* A2 M1* A1 B1* M1 A1 M1dep* A1 [10]</p>	<p>Moments about Q, 3 terms needed</p> <p>A1 for two terms correct Resolving vertically, 3 terms needed</p> <p>accept $<$ or \leq</p> <p>Only one needed. Accept to 2sf. For correct use of $F = \mu R$, $R \neq 550$</p>

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