| | | | |
|---|---|---|---|
| 7a | Horizontal distance | M1 | Correct use of *suvat* |
| | $x = u\cos\alpha\, t$ | A1 | Correct equation |
| | Vertical distance | M1 | Correct use of *suvat* |
| | $y = u\sin\alpha\, t - \frac{1}{2}gt^2$ | A1 | Correct equation. Correct signs. Condone if not using "y" |
| | $t = \frac{x}{u\cos\alpha} \Rightarrow$<br>$y = u\sin\alpha.\frac{x}{u\cos\alpha} - \frac{g}{2}\left(\frac{x}{u\cos\alpha}\right)^2$<br>$\left(= x\tan\alpha - \frac{gx^2}{2u^2}\sec^2\alpha\right)$ | DM1 | Dependent on the first 2 M marks. Substitute for $t$ to obtain $y$ in terms of $x$ and $\alpha$ |
| | $y = x\tan\alpha - \frac{gx^2}{2u^2}\left(1+\tan^2\alpha\right)$ * | A1* | Obtain **given answer** from correct working (final step needs to be explained).<br>Allow if $\sec^2\alpha$ seen.<br>Must be "y" here |
| | | [6] | |
| | | | |
| 7b | $u = 20, x = 10, y > 2 \Rightarrow$<br>$2 = 10\tan\theta - \frac{100g}{800}\left(1+\tan^2\theta\right)$<br>$\left(\frac{g}{8}\tan^2\theta - 10\tan\theta + \left(2+\frac{g}{8}\right) = 0\right)$ | M1 | Use given values to form quadratic in $\tan\theta$ or equivalent equation in one trig function.<br>Allow working with =, < or > 2 |
| | Critical values:<br>$\theta° = 18.6°$ or $\theta° = 82.7°$ | A1 | One correct value to 2 sf or better |
| | Range: $18.6 < \theta < 82.7$ | A1 | Accept < or $\leqslant$<br>$\left(19 \leq \theta \leq 82 \text{ or } 83\right)$ max 3 sf |
| | | [3] | |
| | | | |
| 7c | $y = 10\tan 40° - \frac{9.8\times 100}{2\times 400}\left(1+\tan^2 40°\right)$ | M1 | Use given formula to find vertical height |
| | $y = 6.3(03...)\,(\text{m})$ | A1 | Can be implied by correctly substituted formula |
| | Conservation of energy | DM1 | Dependent on the first M1.<br>Need all 3 terms. Dimensionally correct. Condone sign errors. |
| | $\frac{1}{2}mv^2 = \frac{1}{2}m\times 400 - mgy$ | A1ft | Correct unsimplified equation in $y$ or their $y$ |
| | $v = 17 \quad (16.6)\left(\text{m s}^{-1}\right)$ | A1 | 2sf or 3sf only |
| | | [5] | |
| | | | |
| 7c alt | $20\cos 40°\, t = 10$ , $t = \frac{1}{2\cos 40°} = 0.653....$<br>$\updownarrow v_V = 20\sin 40° - gt$ | M1 | Complete method using *suvat* to vertical component of speed e.g. by finding time taken then use of $v = u - gt$ or finding vertical distance and using *suvat* |
| | $= 6.5 \quad (6.459...)$ | A1 | 6.5 or better (not final answer so allow > 3sf or a correct unsimplified expression) |
| | $v^2 = \left(v_H\right)^2 + \left(v_V\right)^2$ | DM1 | Correct use of Pythagoras |

| | | | |
|---|---|---|---|
| | | | Dependent on preceding M mark |
| | $\leftrightarrow v_H = 20\cos 40° \left(= 15.3....\right)$ | A1 | Horizontal component of speed seen or implied |
| | $v = 17 \quad (16.6)\left(\text{m s}^{-1}\right)$ | A1 | 2sf or 3sf only |
| | | [5] | |
| | | | |
| 7d | $0 = x\tan 40° - \dfrac{9.8x^2}{800}\left(1 + \tan^2 40°\right)$ | M1 | Complete method to solve for $x$. |
| | $x = 40\,(40.2)\,(\text{m})$ | A1 | 2sf or 3sf only |
| | | [2] | |
| | | | |
| 7d Alt1 | $y = 0 \Rightarrow t = \dfrac{40\sin 40°}{g}\left(= 2.623...\right)$<br>$x = 20\cos 40° \times t$ | M1 | Complete method to solve for $x$. |
| | $x = 40\,(40.2)\,(\text{m})$ | A1 | 2sf or 3sf only |
| | | [2] | |
| | | | |
| 7d Alt2 | $\text{Range} = \dfrac{20^2 \sin 80°}{g}$ | M1 | Complete method to solve for $x$. |
| | $= 40\,(40.2)\,(\text{m})$ | A1 | 2sf or 3sf only |
| | | [2] | |
| | | | |
| | | (16) | |
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