| Question Number | Scheme | Marks |
|---|---|---|
| **7(a)** | Conservation of Energy: | M1 |
| | $\frac{1}{2}m\times 12^2 = \frac{1}{2}m\times 8^2 + mgh$ | A1<br>A1 |
| | ($h$ =) 4.1 (m) | A1 |
| | | (4) |
| **7(b)** | Vertical distance: | M1 |
| | $"4.1" = 12\sin\alpha\times 1.5 - \frac{g}{2}\times 1.5^2$ | A1ft |
| | $\alpha = 57°$ | A1 |
| | | (3) |
| **7(c)** | Equation in $\alpha$ and $\beta$ only | M1 |
| | Eg. Horizontally:<br>$12\cos\alpha = 8\cos\beta$ | Eg. Vertical and horizontal components:<br>$\tan\beta = \frac{12\sin\alpha - 1.5g}{12\cos\alpha}\left(= -0.709....\right)$ | A1ft |
| | $\beta = 35°$ | A1 |
| | | (3) |
| **7(d)** | Max height, $T$ | Times when $v$ = 8 | Times when $h$ = 4.08 | M1 |
| | $2(1.5 - T)$ | $T_2 - T_1$ | $T_2 - T_1$ | dM1 |
| | $T = \frac{12\sin\alpha}{g}$ | $0 = 8\sin\beta\, T - \frac{1}{2}gT^2$ | $4.08 = 12\sin\alpha\, T - \frac{1}{2}gT^2$ | A1ft |
| | 0.94 (s) | A1 |
| | | (4) |
| | | **(14 marks)** |

| Notes | |
|---|---|
| (a) M1 | Energy equation with correct number of terms and dimensionally correct including mass. M0 if no energy equation used or for incorrect energy formulae. |
| A1 | Unsimplified equation with at most one error. |
| A1 | Correct unsimplified equation. |
| A1 | 4.1 or 4.08 only (2 or 3sf) |
| (b) M1 | Complete method to find an equation in sin $\alpha$ only, using their $h$.<br>This equation could be obtained by getting two equations in $\alpha$ and $\beta$, which don't require $h$, and eliminating $\beta$ |
| A1ft | Correct equation, ft their $h$ if used. ($\sin\alpha = 0.839$) |
| A1 | 57° or 57.1° (or 1.0 or 0.996 radians) [57.06178257…] |
| (c) M1 | A method to reach an equation in $\alpha$ and $\beta$ only.<br>E.g. Equating horizontal speed in terms of $\alpha$ and $\beta$<br>or finding the vertical velocity components at $B$, $v_V$, and then using<br>$\tan\beta = \frac{\lvert v_V\rvert}{12\cos\alpha}$ or $\sin\beta = \frac{\lvert v_V\rvert}{8}$. |
| A1ft | A correct equation in $\alpha$ (need not be substituted) and $\beta$, ft their $h$ and $\alpha$ |
| A1 | 35° or 35.4° (or 0.617 or 0.62 radians) [35.35311389…] |

| | |
|---|---|
| **N.B.** | $v_V$ can be found in a number of ways [$v_V$ = 4.628911565…]<br>$v = u + at$ : $v_V = 12\sin\alpha - 1.5g$<br>$v^2 = u^2 + 2as$ : $v_V = \sqrt{(12\sin\alpha)^2 - 2g \times \text{their } h}$<br>$s = vt - \frac{1}{2}at^2$ : $h = 1.5v_V + \frac{1}{2}g \times 1.5^2 \Rightarrow v_V = \frac{h - \frac{1}{2}g \times 1.5^2}{1.5} = \frac{2h}{3} - \frac{3g}{4}$<br>$s = \left(\frac{u+v}{2}\right)t$ : $h = \left(\frac{12\sin\alpha + v_V}{2}\right) \times 1.5 \Rightarrow v_V = \frac{4}{h} - 12\sin\alpha$ |
| (d) M1 | Method to find an appropriate time(s), *T*, that could be used to find the required time:<br>E.g.time to maximum height, times to height 4.08, times to speed being 8.<br>M0 for total flight time unless they go on to use appropriately. |
| dM1 | A correct overall method to use their *T* to find the required time. |
| A1ft | Correct equation for their *T*, ft their *h*, $\alpha$, $\beta$ |
| A1 | 0.94 or 0.945 obtained from correct working. [0.9446758295…] |