

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 $v^2 = u^2 + 2as$: $625 = 25 + 240a$; $a = 600/240 = 2.5 \text{ m/s}^2$; equation chosen because s is given and t is not.

2.2 At the top $v = 0$: $0 = 144 - 2(9.8)s$; $s = 144/19.6 = 7.3 \text{ m}$.

2.3 $s = (u + v)t/2$; $v = u + at$; $s = ut + \frac{1}{2}at^2$; $v^2 = u^2 + 2as$.

2.4 $u_x = 20 \cos 40^\circ = 15.3 \text{ m/s}$; $u_y = 20 \sin 40^\circ = 12.9 \text{ m/s}$.

2.5 Any two: range reduced; time of flight reduced; trajectory steeper (non-parabolic); falling object reaches terminal speed.

3.1 $u_x = 18 \cos 35^\circ = 14.7 \text{ m/s}$, $u_y = 18 \sin 35^\circ = 10.3 \text{ m/s}$; time of flight $t = 2u_y/g = 20.6/9.8 = 2.11 \text{ s}$; max height $= u_y^2/2g = 106.6/19.6 = 5.44 \text{ m}$; range $= u_x t = 14.7 \times 2.11 = 31.0 \text{ m}$; assumption: no fluid resistance, so the two motions are independent.

3.2 Height: $s = \frac{1}{2}gt^2 = 4.9 \times 20.25 = 99 \text{ m}$; vertical impact component $= 9.8 \times 4.5 = 44.1 \text{ m/s}$; speed $= \sqrt{6^2 + 44.1^2} = 44.5 \text{ m/s}$.

3.3 Headwind reduces the horizontal velocity throughout: shorter range, steeper final descent, and (since the vertical motion is unchanged by a horizontal wind with no vertical drag) the same time of flight. A skydiver at terminal speed has drag equal and opposite to weight, so the resultant force – and the acceleration – is zero.