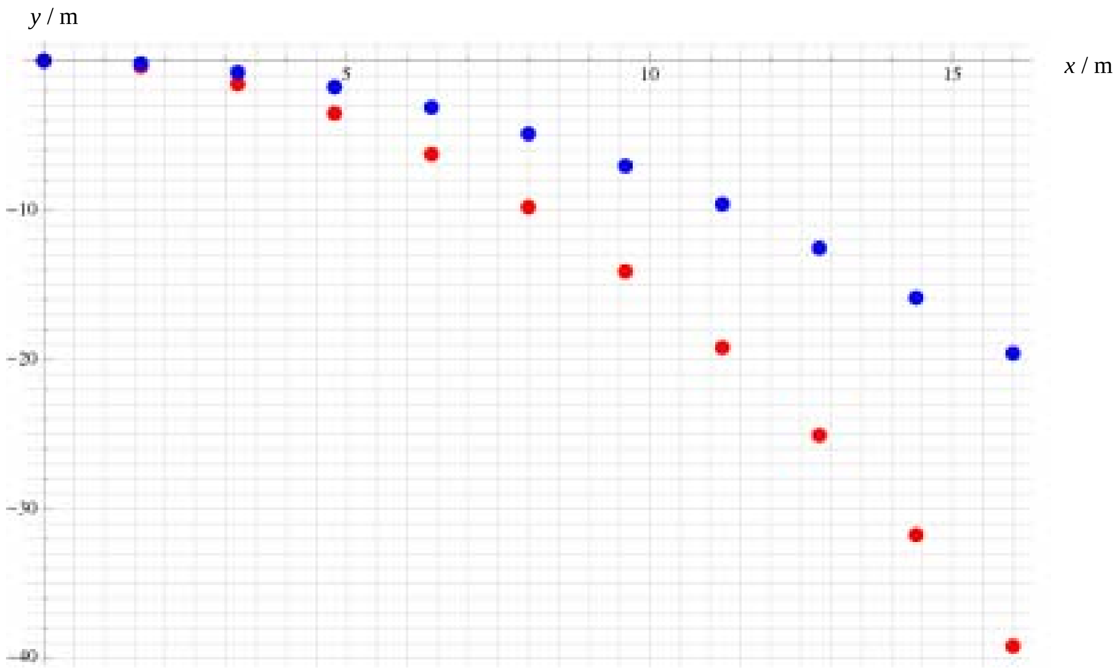
Mark scheme for Extension Worksheet – Topic 2, Worksheet 4

1 **a** The object covered 16 m in 2.0 s so the initial velocity horizontally is $8.0\ \mathrm{m\,s^{-1}}$. [1]

b The horizontal distance travelled will be double than before; but the vertical distance fallen will be the same. [2]

c See diagram in red: equal horizontal distances travelled; increasingly larger vertical distances.



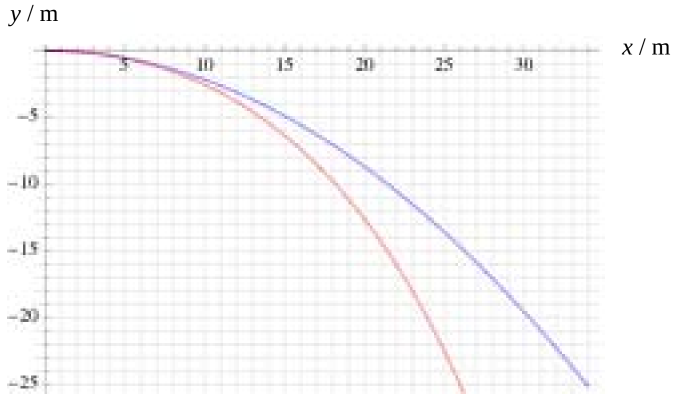
[2]

2 **a** The ball will hit the sea when: $-25 = -\frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{50}{9.8}} = 2.259\ \mathrm{s}$; hence

$v_x = 15\ \mathrm{m\,s^{-1}}$ and $v_y = 0 - gt = -9.8 \times 2.259 = -22.14\ \mathrm{m\,s^{-1}}$; hence

$\theta = \arctan\frac{-22.14}{15} = -55.88 \approx -59^\circ$ [3]

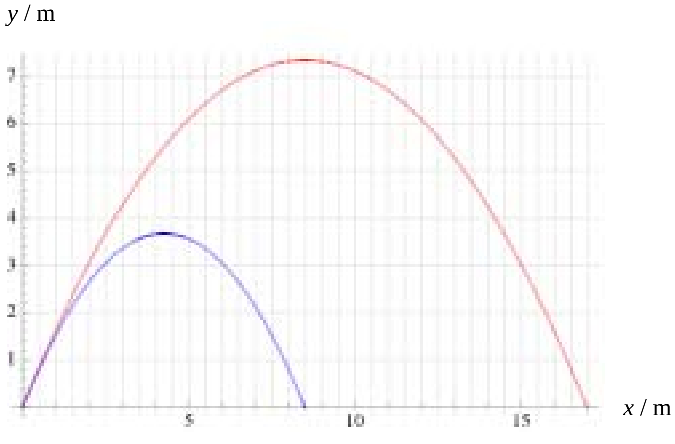
b A possible path is shown in red (blue is the path without air resistance). Projectile has less range; path is not parabolic; becomes steeper.



[3]

3 The key point is that with half the value of g the time of flight will be twice as long; and hence both the range and the maximum height will double. [2]

The graph shows one possibility with the red curve corresponding to half the value of *g*.



4 After time *t* the vertical displacement of the ball is given by $y = vt\sin\theta - \frac{1}{2}gt^2$ and the horizontal displacement is $x = vt\cos\theta$. Hence $t = \frac{x}{v\cos\theta} = \frac{35}{v\frac{\sqrt{3}}{2}} = \frac{70}{v\sqrt{3}}$; and

$$2 = v\frac{70}{v\sqrt{3}} \times \frac{1}{2} - \frac{1}{2} \times 9.8 \times \left(\frac{70}{v\sqrt{3}}\right)^2$$; the last equation becomes

$$2 = 20.207 - \frac{8003}{v^2} \Rightarrow \frac{8003}{v^2} = 18.207 \Rightarrow v = 20.966 \approx 21 \text{ m s}^{-1}$$ [3]

5 **a** The ball covers 24 m in 2.0 s so $u_x = \frac{24}{2.0} = 12\ \text{m s}^{-1}$ [1]

b $\theta = \arctan\frac{u_y}{u_x} = \arctan\frac{32}{12}$; $\theta = 69^\circ$ [2]

c The vertical velocity component becomes zero at 2.0 s so $0 = 32 - g \times 2.0$; hence $g = 16\ \text{m s}^{-2}$ [2]

d From the graph the vertical displacement at $t = 3.6$ s and at $t = 3.8$ s is 11.5 m and 6.1 m respectively; hence $\bar{v}_y = \frac{\Delta y}{\Delta t} = \frac{6.1 - 11.5}{0.20} = -27\ \text{m s}^{-1}$ [2]