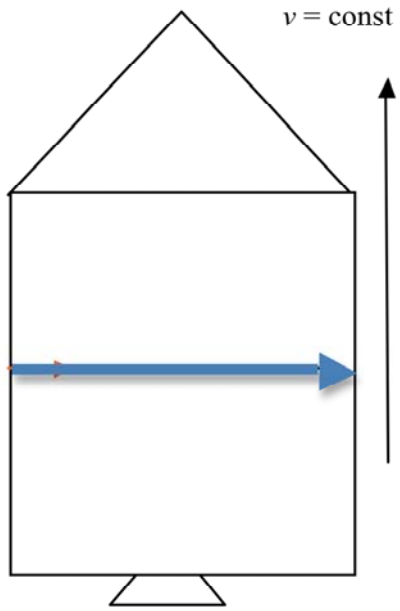
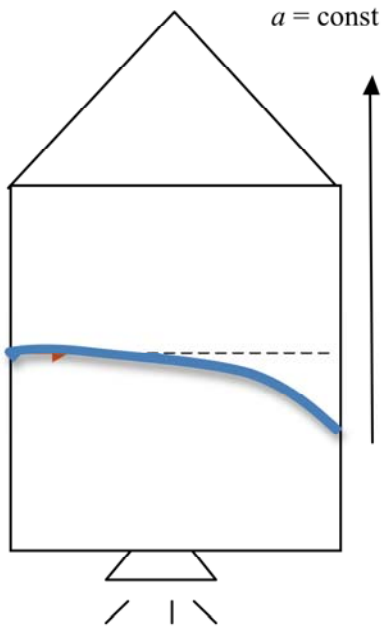
Mark scheme for Support Worksheet – Option H, Worksheet 3

1 See diagram below.



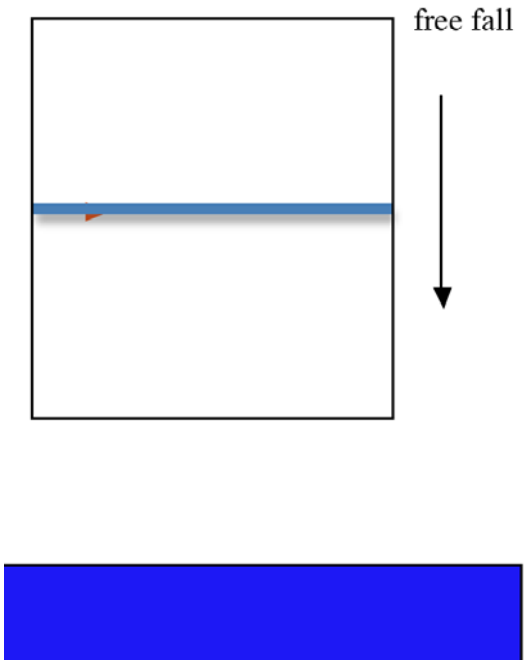
[1]

2 See diagram below.



[1]

3 See diagram below.



[1]

4 See diagram.

[1]

5 **a** Spacetime is where physical phenomena take place at specific places and specific times. [1]

b A geodesic is the path followed by an object upon which no forces act/it is a path of least length/it is the path followed by light rays in spacetime. [1]

6 A ray of light passing close to the Sun bends towards the Sun; this is because the Sun curves the spacetime around it; and light follows paths of least length in the curved spacetime, i.e. geodesics. [3]

7 The Sun curves the spacetime around it; no force acts on the planet and so the planet will follow the path of least length in the curved spacetime i.e. geodesics. [2]

8 $R_S = \frac{2GM}{c^2} = \frac{2 \times 6.67 \times 10^{-11} \times 4.0 \times 10^{36}}{(3.0 \times 10^8)^2} = 5.9 \times 10^9 \text{ m}$ [1]

9 The black hole constantly has mass fall into the hole; since $R_S = \frac{2GM}{c^2}$ the radius increases as the mass increases. [2]

10 $\frac{\Delta f}{f} = \frac{gH}{c^2} \Rightarrow \Delta f = \frac{fgH}{c^2}$; $\Delta f = \frac{4.0 \times 10^{14} \times 9.8 \times 58}{(3.0 \times 10^8)^2} = 2.5$ Hz [2]

11 $\Delta t = \frac{\Delta t_0}{\sqrt{1 - \frac{R_S}{r}}} = \frac{5.0}{\sqrt{1 - \frac{R_S}{1.5R_S}}}$; $\Delta t = 8.7$ s [2]