

HL Paper 3

- a. Outline what is meant by a black hole. [2]
- b. An observer views a distant spacecraft that is 23.0 km from the centre of a black hole. The spacecraft contains a clock that ticks once every second and the ticks can be detected by the distant observer. In 2.00 minutes the observer counts 112 ticks of the clock. [3]
- Determine the mass of the black hole.

Markscheme

- a. region of space with extreme/very large curvature of spacetime
such that light cannot escape the region **OR** escape speed within region is $> c$
Do not allow "large" or omission of degree of curvature.
- b. time for 1 second spacecraft tick in observer frame = 1.07s

$$1.07 = \frac{1.00}{\sqrt{1 - \frac{R_S}{2.3 \times 10^4}}} \quad \text{OR} \quad R_S = 2.96 \times 10^3 \text{m}$$

$$M = \ll \frac{c^2 \times 2.96 \times 10^3}{2 \times 6.67 \times 10^{-11}} = \gg 2.0 \times 10^{30} \text{kg}$$

Examiners report

- a. [N/A]
b. [N/A]