

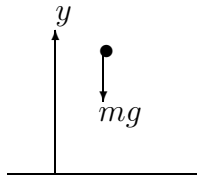
### Question

A particle is thrown vertically upwards from the surface of the earth with a speed  $1\text{ms}^{-1}$ .

(You may assume the gravitational field is constant with  $g = 9,8\text{ms}^{-2}$ )

- (i) How long does it take for it to return to earth?
- (ii) What is its maximum height?
- (iii) What is its maximum speed?

### Answer



Newton's 2nd Law:  $m\ddot{y} = -mg \Rightarrow \ddot{y} = -g$

Therefore  $y = vt - \frac{1}{2}gt^2$

Initially  $\dot{y} = v = 1\text{ms}^{-1}$

- (i) The particle returns to the ground when  $y = 0$ .

$$\begin{aligned} vt - \frac{1}{2}gt^2 = 0 & \Rightarrow t(v - \frac{1}{2}gt) = 0 \\ & \Rightarrow t = 0 \quad \text{or} \quad v - \frac{1}{2}gt = 0 \\ & \qquad \qquad \qquad \frac{1}{2}gt = v \\ & \qquad \qquad \qquad t = \frac{2v}{g} \\ & \qquad \qquad \qquad t = \frac{2 \times 1}{9.8} \\ & \qquad \qquad \qquad \approx 0.2s \end{aligned}$$

(since  $v = 1$ , and  $g = 9.8$ )

- (ii) The maximum height occurs when there is no upward speed.

$$\text{Thus } \dot{y} = v - gt = 0 \Rightarrow t = \frac{v}{g} = \frac{1}{9.8}s$$

- (iii) The maximum speed occurs at  $y = 0$ , and is therefore  $1\text{ms}^{-1}$