

Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

5 Newton's laws of motion

Exercise B, Question 21

Question:

A ball is thrown vertically upwards from ground level. Throughout its motion it is acted on by gravity and a resistance force of constant magnitude.

The ball reaches a maximum height of 1.5 metres after 0.5 seconds.

(a) Find:

(i) the initial speed of the ball,

(ii) its acceleration as it is moving upwards.

The mass of the ball is 0.2 kg.

(b) Show that the magnitude of the resistance force is 0.44 N.

(c) Find the acceleration of the ball as it falls back to the ground.

(d) Find the total time that the ball is in the air. [A]

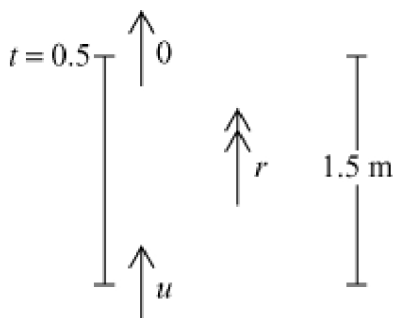
Solution:

$$s = \frac{(u+v)}{2} t \uparrow$$

$$(a) (i) \quad 1.5 = \frac{(u+0)}{2} \times 0.5$$

$$\therefore \frac{1.5 \times 2}{0.5} = u$$

$$\therefore u = 6 \text{ m s}^{-1}$$



$$v = u + at, \uparrow$$

$$0 = 6 + (-r) \times 0.5$$

$$(ii) \therefore 0.5r = 6$$

$$\text{so } r = \frac{6}{0.5} = 12 \text{ m s}^{-2}$$

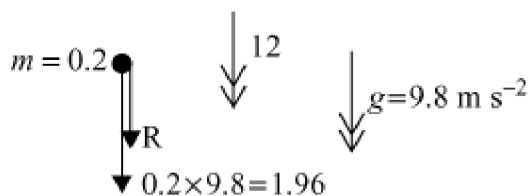
i.e. a retardation of 12 m s^{-2}

(b) Newton's 2nd Law, \downarrow

$$R + 0.2 \times 9.8 = 0.2 \times 12$$

$$\therefore R = 0.2 \times 12 - 0.2 \times 9.8$$

$$R = 0.44 \text{ N is the resistive force}$$

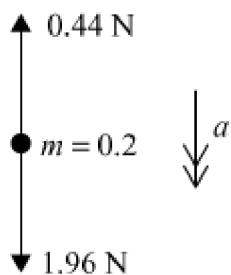


(c) Newton's 2nd Law, \downarrow

$$1.96 - 0.44 = 0.2a$$

$$\therefore \frac{1.52}{0.2} = a$$

$$a = 7.6 \text{ m s}^{-2}$$



$$\text{on way down, } s = ut + \frac{1}{2}at^2$$

$$1.5 = 0 \times t_2 + \frac{1}{2} \times 7.6 \times t_2^2$$

$$(d) \text{ so } t_2^2 = \frac{1.5 \times 2}{7.6}$$

$$\therefore t_2 = 0.62828\dots$$

$$\therefore \text{total time in air} = 0.5 + 0.62828\dots$$

$$= 1.1282\dots$$

$$= 1.13 \text{ seconds (3 s.f.)}$$