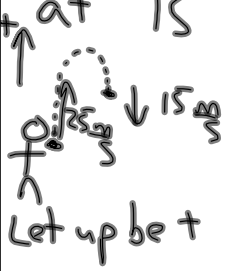


Acceleration Example:

A ball is thrown up at  $25 \frac{m}{s}$ . How long is it in the air before it's moving down at  $15 \frac{m}{s}$ ?



Let up be +

$$a = \frac{v_f - v_i}{t}$$

$$a = -9.8 \frac{m}{s^2}$$

$$v_f = -15 \frac{m}{s}$$

$$v_i = 25 \frac{m}{s}$$

$$t = \frac{v_f - v_i}{a} = \frac{(-15) - (25)}{(-9.8)} = \frac{-40}{-9.8}$$

What is the displacement at this point?

$$v_{av} = \frac{d}{t}$$

$$v_{av} = \frac{v_i + v_f}{2}$$

$$t = \frac{-40}{-9.8}$$

**t = 4.1 s**

Sep 18-1:38 PM

Deriving Kinematic equations:

$$v_{av} = \frac{d}{t} \quad v_{av} = \frac{v_i + v_f}{2}$$

$$\frac{d}{t} = \frac{v_i + v_f}{2}$$

$$d = \left(\frac{v_i + v_f}{2}\right)t$$

$$d = \left(\frac{v_i + (v_i + at)}{2}\right)t$$

$$= \left(\frac{2v_i + at}{2}\right)t$$

$$= \frac{2v_i t + at^2}{2}$$

$$= \frac{2v_i t}{2} + \frac{at^2}{2}$$

$$d = v_i t + \frac{1}{2}at^2$$

$$a = \frac{v_f - v_i}{t}$$

Rearrange

$$at = v_f - v_i$$

$$v_i + at = v_f$$

$$v_i = v_f - at$$

$$d = \left(\frac{(v_f - at) + v_f}{2}\right)t$$

$$d = v_f t - \frac{1}{2}at^2$$

Solve (2) for t

$$t = \frac{v_f - v_i}{a}$$

$$d = \left(\frac{v_i + v_f}{2}\right) \left(\frac{v_f - v_i}{a}\right)$$

$$= \frac{(v_i + v_f)(v_f - v_i)}{2a}$$

$$= \frac{v_f^2 - v_i^2}{2a}$$

$$d = \frac{v_f^2 - v_i^2}{2a}$$

$$2ad = v_f^2 - v_i^2$$

$$v_f^2 = v_i^2 + 2ad$$

From last example

$$v_i = 25 \frac{m}{s}$$

$$v_f = -15 \frac{m}{s}$$

$$a = -9.8 \frac{m}{s^2}$$

$$d = ?$$

$$d = \frac{v_f^2 - v_i^2}{2a}$$

$$= \frac{(-15)^2 - (25)^2}{2(-9.8)}$$

$$= \frac{225 - 625}{-19.6}$$

$$= \frac{-400}{-19.6}$$

$$= 20.4$$

Sep 18-2:10 PM

Example:

An observant physics student notices a rat falling from the top of their school. She determined that it took 0.15 s for the rat to pass the second storey window, which is 1.9 m off the ground, and 2.6 m from the top of the school.

a) How tall is the window?  
 b) What speed did the rat have when it landed?

Sep 19-12:58 PM

Diagram: A vertical line representing a building. The top is labeled '2.6 m'. A window is shown with a height 'h' and a distance of '1.9 m' from the ground.

Section 1 (from top):  
 $\downarrow +$   
 $V_i = 0$   
 $a = 9.8 \frac{m}{s^2}$   
 $d = 2.6 \text{ m}$   
 $V_f = ?$   
 $t = ?$

Section 2 (window):  
 $t = 0.15 \text{ s}$   
 $a = 9.8 \frac{m}{s^2}$   
 $V_i = ?$   
 $V_f = ?$   
 $d = h$

Section 3 (from window to ground):  
 $d = 1.9 \text{ m}$   
 $a = 9.8 \frac{m}{s^2}$   
 $t = ?$   
 $V_i = ?$   
 $V_f = ?$

Section 1 calculations:  
 $V_f^2 = V_i^2 + 2ad$   
 $= 0 + 2(9.8)(2.6)$   
 $= 50.96$   
 $V_f = 7.14 \frac{m}{s}$

Section 2 calculations:  
 $d = V_i t + \frac{1}{2} a t^2$   
 $h = (7.14)(0.15) + \frac{1}{2}(9.8)(0.15)^2$   
 $= 1.071 + 0.110$   
 $= 1.181 \text{ m}$   
 ∴ the window is 1.18 m high

Section 3 calculations:  
 $d = 2.6 + 1.181 + 1.9 = 5.681 \text{ m}$   
 $V_i = 0$   
 $a = 9.8 \frac{m}{s^2}$   
 $V_f = ?$   
 $V_f^2 = V_i^2 + 2ad$   
 $= 0 + 2(9.8)(5.681)$   
 $= 111.3$   
 $V_f = 10.6 \frac{m}{s}$

Sep 19-1:04 PM