Free Fall

(1) A ball is thrown upward with an initial velocity of 10.0 m/s from the top of a 50.0 m tall building.

(a) With what velocity will the ball strike the ground?

Ans- Given: $y = -50.0\,m$ (displacement), $v_0 = +10.0\,m/s$

Find (a) & (b) v

The y in the kinetic equations stands for displacement from the launch point, not distance. When the ball strikes the ground, it will displace $-50.0\,m$, or $50\,m$ below the launch point.

(a) $v^2 = v_0^2 - 2gy = (+10.0\,m/s)^2 - 2(9.80\,m/s^2)(-50.0\,m)$

$= 1.08 \times 10^3\,m^2/s^2$

So, $v = \sqrt{1.08 \times 10^3\,m^2/s^2} = \pm 32.9\,m/s$

The positive answer is discarded since the ball is falling when it lands (moving downward)

Therefore $v = -32.9\,m/s$

(b) From $v = v_0 - gt$, we have

$$t = \frac{v_0 - v}{g} = \frac{(+10.0\,m/s - (-32.9\,m/s)}{9.80\,m/s^2} = \frac{42.9\,m/s}{9.80\,m/s^2}$$

$= 4.38\,s$

(2) A stone is dropped freely in the river from a bridge it takes 5s to touch the water surface in the river. Calculate:

(i) the height of the bridge from the water level

Ans- Given

$u = 0 m/s$

$t = 5 sec$

distance travelled - height of bridge = hm

So,

$s = ut + \frac{1}{2}at^2$

$= \frac{1}{2} \times 9.8 \times 5 \times 5$

$= 122.5 m$

(ii) the distance covered by stone in the last second ($g = 9.8 m/s^2$)

Ans- Distance covered in 4 sec

$= \frac{1}{2} \times 9.8 \times 16$

$= 78.4 m$

distance covered in last sec.

= distance covered in 5s - distance covered in 4 sec

$= 122.5 - 78.4$

$= 44.1 m$

3. A tennis ball is struck with a racket, giving it straight upward at 22 meters per second. After how much time will it be falling at 15 meters per second?

Ans- Case 1 :-

Given,

$u = 22 m/s$, $v = 0$, $g = -9.8$

To find t_1

$\rightarrow u = u + gt_1$

$\Rightarrow 0 = 22 + (-9.8) \times t_1$

$\Rightarrow 0 = 22 - 9.8 \times t_1$

$\Rightarrow 9.8 t_1 = 22$

$\Rightarrow t_1 = 2.24$ sec

Case-2 :-

Given,

$u = 0$, $v = 15 m/s$, $g = 9.8$

To find t_2

$\rightarrow v = u + gt_2$

$\rightarrow 15 = 0 + 9.8 t_2$

$\Rightarrow 15 = 9.8 t_2$

$\Rightarrow t_2 = 1.53$ sec.

So, $t = t_1 + t_2 = (2.24 + 1.53)$ secs $= 3.77 = 3.8$ secs.