Q- A ball is thrown straight up at a speed of 20m/s. On its way down, the ball is caught 5m above from where it was thrown.

a. How fast is the ball moving when it is caught?

b. How long is the ball in the air?

(a) Using equation of motion we can calculate the velocity as follow

Initial velocity u = 20 m/s (upward positive)

Final velocity v = ?

Acceleration g = -9.8 m/s^2 (downwards)

Displacement h = 5 m

$$v^2 = u^2 + 2gh$$

Gives $v^2 = (20)^2 + 2(-9.8) * 5 = 302$

Or $v = \sqrt{302} = 17.4\, m/s$

The question can also be solved using law of conservation of energy

Loss in KE = Gain in PE

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mgh$$

Or $v^2 - u^2 = 2gh$

Or $v^2 = 20^2 + 2 * (-9.8) * 5 = 400 - 98 = 302$

Gives $v_2 = \sqrt{302} = 17.4\, m/s$

(b) The time is given by

Using the equation

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

Or $5 = 20 * t + \frac{1}{2} * (-9.8) * t^2$

Or $9.8 * t^2 - 40t + 10 = 0$

This is a quadratic in t and will give two values of t (roots).

Or $t = \frac{40 \pm \sqrt{(40)^2 - 4*9.8*10}}{2*9.8} = 2.04 \pm 1.77$

Or t = 0.27 s or 3.81 s

The first value is the time to 5 m while going up and the second for coming down thus the total time for which the ball is in air will be t = **3.81 s**