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This is a 1-D problem involving Free-Fall acceleration, in which an object is released from rest.

A building is under construction, and a construction worker is standing on top of a 130 m high elevator shaft. The worker accidentally drops his hammer down the shaft.

(a) At what speed does the hammer hit the ground?

(b) How much time passes between when the hammer is dropped and when it hits the ground?

(c) What fraction of the total airborne time does the hammer spend in the top 75% of the falling distance?

Solution:

Assumptions: - Hammer motion is purely vertical
- Air resistance is negligible

(a) Use the Kinematic equation: $v_2^2 = v_1^2 + 2gd$ (1-D equation)

↓+ (sign convention)

$v_1 = 0$ (starts falling from rest)
$g = 9.8\ m/s^2$ (down direction)
$d = 130\ m$ (displacement)

$v_2 = ?$ (final speed)

substitute:

$$v_2^2 = 2(9.8)(130)$$

$$v_2 = \sqrt{2(9.8)(130)}$$

$$v_2 = 50.5 \text{ m/s} \text{ (answer)}$$

(b) Use the kinematic equation:

$$d = v_1 t + \frac{1}{2} g t^2$$

$t = ?$ (falling time)

substitute:

$$130 = 0 + \frac{1}{2}(9.8)t^2$$

$$t = 5.15 \text{ s} \text{ (answer)}$$

(c) Use the same equation as in (b), but change d to $0.75 \times 130 = 97.5$ m.

substitute:

$$97.5 = 0 + \frac{1}{2}(9.8)t^2$$

$$t = 4.46 \text{ s}$$

$$\text{Fraction} = \frac{4.46}{5.15} = 0.866 \rightarrow 87\% \text{ (answer)}$$