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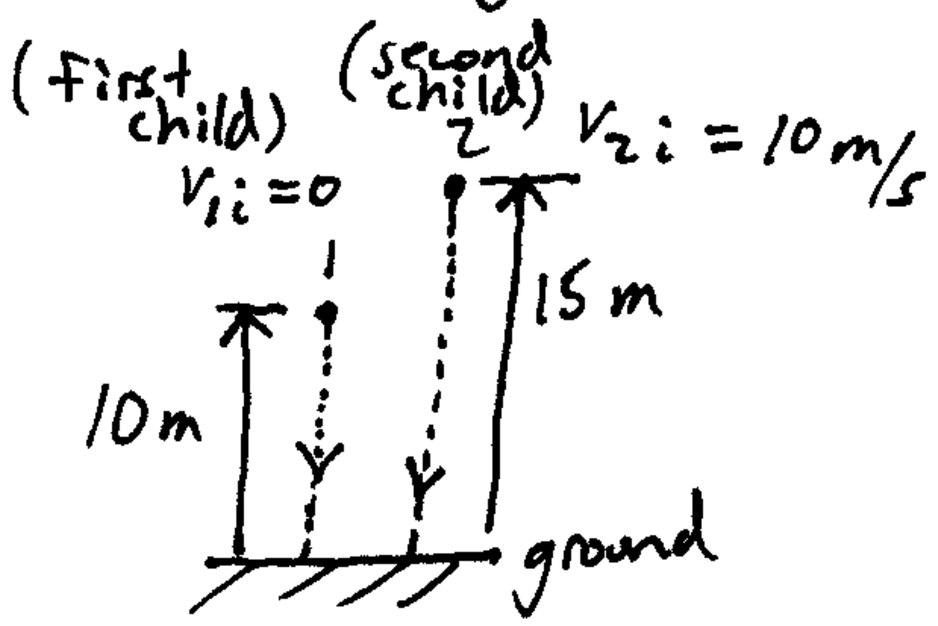
Jan. 23, 2020

This is a 1-D problem involving free-fall acceleration.

A game is played by two children, in which one child, at a height of 10 m above the ground, drops a rock with no initial speed. The second child also drops a rock, from a height of 15 m above the ground. The second child drops the rock t_r seconds after the first child drops the rock, with an initial downward speed of 10 m/s. What is the value of t_r so that both rocks hit the ground at the same time?



Solution:

- Assumptions:
  - air resistance is negligible
  - 1-D motion

For the first child, use the kinematic equation:

$$d_1 = v_{1i}t + \frac{1}{2}gt^2 \quad (1)$$

$d_1 = 10\ m$ (rock displacement)

$v_{1i} = 0$ (released from rest)

$g = 9.8\ m/s^2$

$t = ?$ (Falling time of first child's rock)

For the second child, use the kinematic equation:

$$d_2 = v_{2i}(t - t_r) + \frac{1}{2}g(t - t_r)^2 \quad (2)$$

$d_2 = 15\,m$ (rock displacement)

$v_{2i} = 10\,m/s$ (initial downward speed)

$g = 9.8\,m/s^2$

$t = ?$ (falling time of first child's rock, same as in equation (1))

In equation (2), $(t - t_r)$ is used because the second child drops the rock t_r seconds after the first child. $(t - t_r)$ is the falling time of second child's rock

Substitute known values in equation (1):

$10 = 4.9t^2 \Rightarrow t = 1.428s$ (falling time for first child's rock)

Substitute known values in equation (2):

$$15 = 10(t - t_r) + 4.9(t - t_r)^2$$

Substitute $t = 1.428s$ into the above equation and solve for t_r:

$$15 = 10(1.428 - t_r) + 4.9(1.428 - t_r)^2$$

Simplify: $15 = 14.28 - 10t_r + 10 - 14t_r + 4.9t_r^2$

$$\Rightarrow 4.9t_r^2 - 24t_r + 9.28 = 0$$

$t_r = 4.47s$ (not valid since $> t$) or $t_r = \underline{0.423\,s}$ (answer)