

35. We denote h as the height of a step and w as the width. To hit step n , the ball must fall a distance nh and travel horizontally a distance between $(n-1)w$ and nw . We take the origin of a coordinate system to be at the point where the ball leaves the top of the stairway, and we choose the y axis to be positive in the upward direction. The coordinates of the ball at time t are given by $x = v_{0x}t$ and $y = -\frac{1}{2}gt^2$ (since $v_{0y} = 0$). We equate y to $-nh$ and solve for the time to reach the level of step n :

$$t = \sqrt{\frac{2nh}{g}}.$$

The x coordinate then is

$$x = v_{0x}\sqrt{\frac{2nh}{g}} = (1.52 \text{ m/s})\sqrt{\frac{2n(0.203 \text{ m})}{9.8 \text{ m/s}^2}} = (0.309 \text{ m})\sqrt{n}.$$

The method is to try values of n until we find one for which x/w is less than n but greater than $n-1$. For $n = 1$, $x = 0.309 \text{ m}$ and $x/w = 1.52$, which is greater than n . For $n = 2$, $x = 0.437 \text{ m}$ and $x/w = 2.15$, which is also greater than n . For $n = 3$, $x = 0.535 \text{ m}$ and $x/w = 2.64$. Now, this is less than n and greater than $n-1$, so the ball hits the third step.