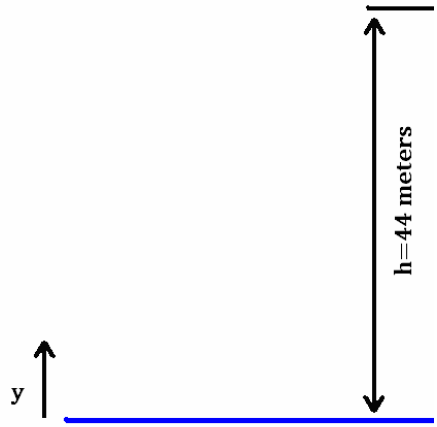
QUESTION:

A stone is dropped into the water from a bridge 44 meters high and another one is thrown vertically downward one second after the first stone is dropped. both stones strike the water at the same time. what is the second stone initial velocity?

SOLUTION:



Let's write the equation of 1st stone motion (its initial velocity is zero):

$$y = h - \frac{gt^2}{2}$$

The equation of the 2nd stone (considering that this stone has nonzero initial velocity υ_0, and it is thrown one second (t_0) later):

$$y = h - \upsilon_0(t - t_0) - \frac{g(t - t_0)^2}{2}$$

When both stones strike the water their y-coordinate is zero, and time $t = t_f$, hence

$$\begin{cases} 0 = h - \frac{gt_f^2}{2} \\ 0 = h - \upsilon_0(t_f - t_0) - \frac{g(t - t_0)^2}{2} \end{cases} \Rightarrow \begin{cases} t_f = \sqrt{\frac{2h}{g}} \\ 0 = h - \upsilon_0(\sqrt{\frac{2h}{g}} - t_0) - \frac{g}{2}(\sqrt{\frac{2h}{g}} - t_0)^2 \end{cases} \Rightarrow$$

$$\Rightarrow \upsilon_0(\sqrt{\frac{2h}{g}} - t_0) = h - \frac{g}{2}(\sqrt{\frac{2h}{g}} - t_0)^2$$

$$\upsilon_0 = \frac{h - \frac{g}{2}(\sqrt{\frac{2h}{g}} - t_0)^2}{\sqrt{\frac{2h}{g}} - t_0}$$

$$\upsilon_0 = \frac{h}{\sqrt{\frac{2h}{g}} - t_0} - \frac{g}{2}(\sqrt{\frac{2h}{g}} - t_0)$$

$$\upsilon_0 = 12.3 \ \frac{m}{s}$$

ANSWER: 12.3 m/s