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Stone in Well

a) A boy with a stopwatch drops a stone in a well. If he hears the splash a time t after dropping the stone how deep, d, is the well?

Let time taken by stone to reach bottom $= x$.
Then $\Rightarrow d = \frac{1}{2}g(t - \frac{d}{v_w})^2$
$\Rightarrow d = \frac{1}{2}gt^2 - \frac{dtg}{v_w} + \frac{gd^2}{2v_w^2}$
$\Rightarrow 0 = \frac{1}{2d}gt^2 - \frac{tg}{v_w} + \frac{gd}{2v_w^2}$

Solving for d using matlab we get:

$$d = \frac{\pm(\sqrt{8gt^2v_w^4+4gt^2v_w^2-4g^2dtv_w+gd^2}-2gtv_w+gd)}{4v_w^2}$$

b) Consider the $v_w \gg gt$ limit of your solution for part (a) for both possible sign choices in front of the square root. What sign choice gives a reasonable answer and what is that answer? (Hint: Use the binomial expansion for the square root up to the second order term.)

$$\lim_{v_w \gg tg} d = \frac{1}{2}gt^2$$

d) What is the $g \to \infty$ limit of your answer to part (a)?

$$\lim_{g \to \infty} d = 0$$

e) If the boy assumed that sound travelled instantaneously what would he calculate the depth of the well to be?

$$d_{\text{inst.}} = \frac{1}{2}gt^2$$