1. A small circular hole 7.00 mm in diameter is cut in the side of a large water tank, 1.50 m below the water level in the tank. The top of the tank is open to the air. Calculate the volume of water discharged every 4.00 seconds. \( 1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} \)

Solution:

Start with Bernoulli’s equation:

\[
P_1 + \frac{1}{2} \rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2} \rho v_2^2 + \rho g y_2
\]

A couple important inferences you must make:

1. Both the top and the hole are open to the air, so \( P_1 = P_2 = 1 \text{ atm} \)
2. Assume that \( A_{\text{top}} \gg A_{\text{hole}} \) so, by \( A_1 v_1 = A_2 v_2 \), \( v_{\text{top}} = 0 \), so \( \frac{1}{2} \rho v_1^2 = 0 \)
3. Define \( y = 0 \) at the hole, so \( \rho g y_2 = 0 \).

These cause the equation to reduce:

\[
P_1 + \frac{1}{2} \rho v_1^2 = P_2 + \frac{1}{2} \rho v_2^2
\]

Known: \( \rho_{\text{water}} = 1000 \text{ kg/m}^3 \), \( y_1 = 1.50 \text{ m} \), \( d_{\text{hole}} = 7.00 \text{ mm} \), \( r_{\text{hole}} = 0.0035 \text{ m} \), \( A_{\text{hole}} = 3.849 \times 10^{-5} \text{ m}^2 \)

Plug in the relevant known values into your equation and solve for \( v_2 \):

\[
(2 \times 9.8 \times 1.5)^{(1/2)} = v_2 = 5.422 \text{ m/s}
\]

Remember \( A \times v = V/\text{s} \), so \( A_{\text{hole}} v_2 = \text{Volume/second} \). To find total volume multiply by 4.00 sec.

\[
3.849 \times 10^{-5} \times 5.422 \times 4 = 8.348 \times 10^{-4} \text{ m}^3
\]