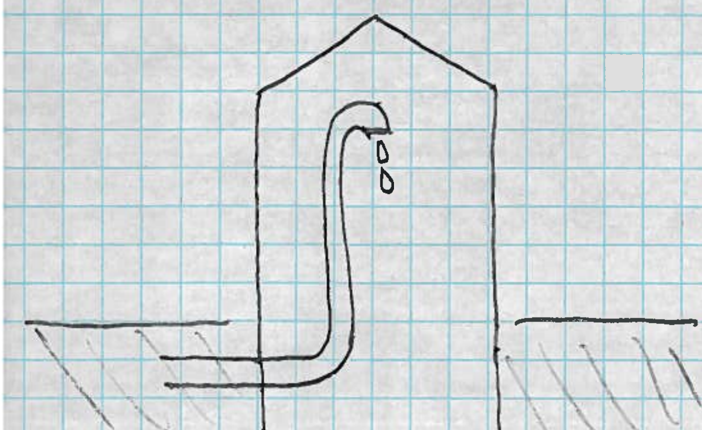
Bernoulli Problem #1, page 19.

A pipe of radius 2.5 cm carries water through the basement of a two-story home at speed 0.90 $\frac{m}{s}$ and gauge pressure 0.90 atm. Bathroom faucet on second floor, 8.2 m above basement, is turned on. What is speed of water coming out of faucet?



__If__ you read problem and imagine this picture, then the answer is very simple: if all water flowing into one single pipe flows out at the top, then the continuous fluid in the pipe must obey

$$(\text{Area}_1)(v_1) = (\text{Area}_2)(v_2)$$

where these are Areas of cross section of the pipe. There is only one radius of pipe mentioned ... so must conclude pipe has constant size

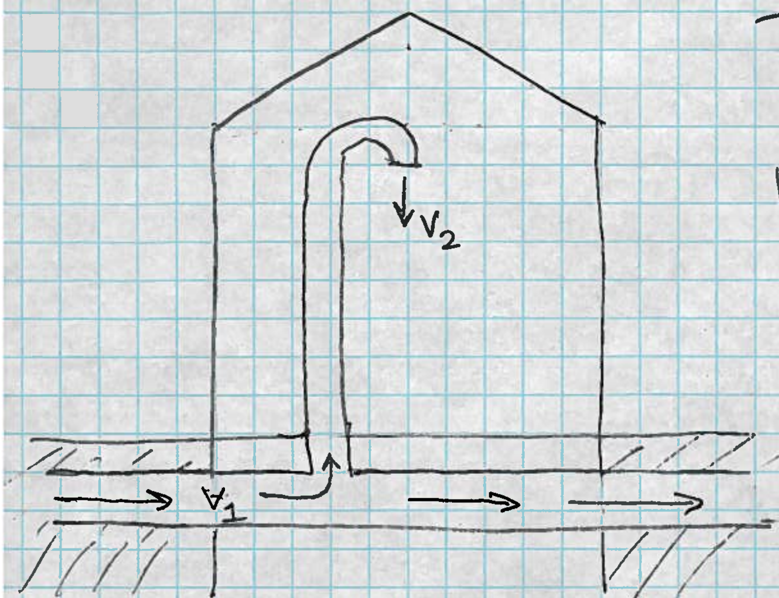
→ constant area

→ constant velocity

In this case, water flows __in__ at bottom $v_1 = 0.90 \frac{m}{s}$

__out__ at top $v_2 = 0.90 \frac{m}{s}$

But my picture is the wrong one — that was my mistake!



The correct picture is shown here: a big pipe carrying water at $v_1 = 0.90\ \frac{m}{s}$ has a smaller connecting pipe attached; <u>some</u> of the water from the big pipe enters the little pipe. <u>In</u> this case, the water splits – only some goes into little pipe. Since there is not a continuous, single flow, we don't know velocity of water in little pipe.

Here's what we do know.

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

$\rho = 1000\ \frac{kg}{m^3}$ fresh water

$v_1 = 0.90\ \frac{m}{s}$

$y_1 = 0\ m$ above basement

$y_2 = 8.2\ m$ above basement

$P_1 = 0.9\ atm$ gauge pressure = above air pressure

P_2 = air pressure, open to air

$$\rightarrow \quad P_1 - P_2 = 0.9\ atm = 9 \times 10^4\ \frac{N}{m^2}$$

We need to solve for v_2, velocity at faucet on 2^{nd} floor.

Rearrange

$$\frac{1}{2}\rho v_2^2 = \frac{1}{2}\rho v_1^2 + \rho g (y_1 - y_2) + (P_1 - P_2)$$

Now we can put in numbers

$$\frac{1}{2}\left(1000\ \frac{kg}{m^3}\right) V_2^2 = \frac{1}{2}\left(1000\ \frac{kg}{m^3}\right)\left(0.90\ \frac{m}{s}\right)^2$$

$$+ \left(1000\ \frac{kg}{m^3}\right)\left(9.8\ \frac{m}{s^2}\right)\left(0\,m - 8.2\,m\right)$$

$$+ \left(9 \times 10^4\ \frac{N}{m^2}\right)$$

$$\left(500\ \frac{kg}{m^3}\right) V_2^2 = 405\ \frac{kg}{m \cdot s^2} - 80{,}360\ \frac{kg}{m \cdot s^2} + 9 \times 10^4\ \frac{kg}{m \cdot s^2}$$

$$= 10{,}045\ \frac{kg}{m \cdot s^2}$$

$$V_2 = \sqrt{\frac{10{,}045\ \frac{kg}{m \cdot s^2}}{500\ \frac{kg}{m^3}}}$$

$$= 4.48\ \frac{m}{s}$$

but one input value, $P_1 = 0.9$ atm, given to 1 significant figure, so proper form is

$$\boxed{V_2 = 4\ \frac{m}{s}}$$