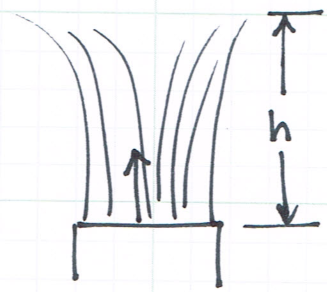
 Name: SOLUTION

CE 3305 Engineering Fluid Mechanics
Exercise Set 10
Spring 2014

1. Problem 4.49, pg 157
2. Problem 4.51, pg 157
3. Problem 4.55, pg 159

4.49) A water jet issues vertically from a nozzle, as shown. The water velocity as it exits the nozzle is 18 m/s. Calculate how high h the jet will rise.

SKETCH:



KNOWN:

$V = 18\,m/s$

UNKNOWN:

$h = ?$

GOVERNING EQN:

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$

SOLUTION

$$\cancelto{0}{\frac{P_1}{\gamma}} + \frac{V_1^2}{2g} + z_1 = \cancelto{0}{\frac{P_2}{\gamma}} + \cancelto{V_2=0}{\frac{V_2^2}{2g}} + z_2$$

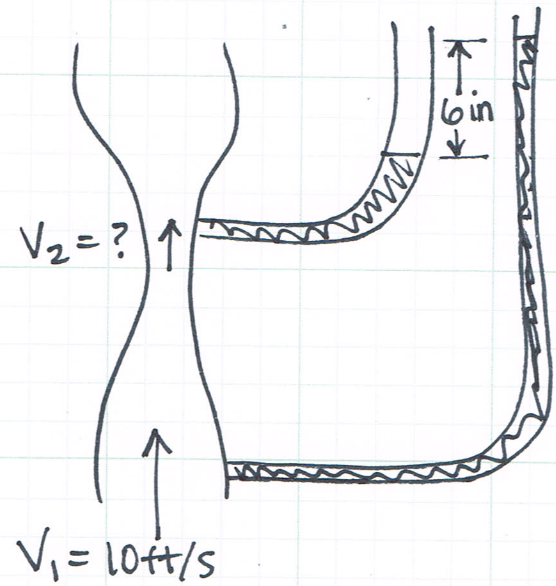
$$0 + \frac{(18\,m/s)^2}{2(9.81\,m/s^2)} + z_1 = 0 + 0 + z_2$$

$$z_2 - z_1 = h = \frac{324\,m^2/s^2}{19.62\,m/s^2}$$

$$\boxed{h = 16.5\,m}$$

4.51) Water flows through a vertical contraction (venturi) section. Piezometers are attached to the upstream pipe and minimum area section as shown. The velocity in the pipe is 10 ft/s. The difference in elevation between the two water levels in the piezometers is 6 inches. The water temperature is 68°F. What is the velocity (ft/s) at the minimum area?

SKETCH:



KNOWN:

$V_1 = 10\,ft/s$
$\Delta z = 6\,inch$
$T = 68°F$

UNKNOWN:

V_2

GOVERNING EQN:

$$P_1 + \gamma z_1 + \rho\frac{V_1^2}{2} = P_2 + \gamma z_2 + \rho\frac{V_2^2}{2}$$

SOLUTION:

$$\rho\frac{V_2^2}{2} = \rho\frac{V_1^2}{2} + (p_1 + \gamma z_1) - (P_2 + \gamma z_2)$$

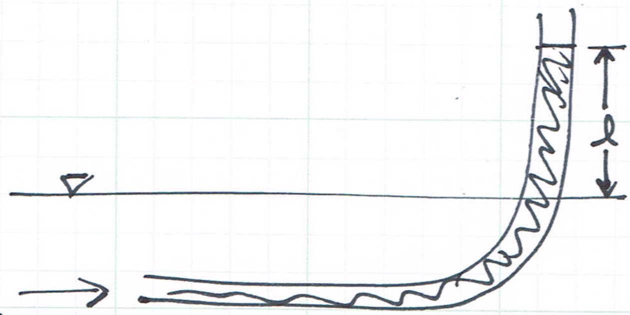
$$(P_1 + \gamma z_1) - (P_2 + \gamma z_2) = \gamma \Delta h$$

$$\therefore V_2 = \sqrt{V_1^2 + \left(\frac{2\gamma\Delta h}{\rho}\right)} = \sqrt{V_1^2 + 2g\Delta h}$$

$$V_2 = \sqrt{(10\,ft/s)^2 + 2(32.2\,ft/s^2)(0.5\,ft)} = 11.49\,ft/s \Rightarrow \boxed{V_2 = 11.5\,\frac{ft}{s}}$$

4.55) A glass tube is inserted into a flowing stream of water with one opening directed upstream and the other end vertical. If the water velocity is 5m/s, how high will the water rise in the vertical leg relative to the level of the water surface of the stream?

SKETCH:



5m/s ~~4m/s~~

KNOWN:

V = 5 m/s
90° bend

UNKNOWN:

Rise in vertical leg, ℓ

GOVERNING EQN:

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2$$

SOLUTION:

Between stagnation point and water surface in tube

$$\frac{P_s}{\gamma} = h + d$$

Between free stream ~~ad~~ and stagnation point

$$\frac{P_s}{\gamma} = d + \frac{V^2}{2g}$$

$$h + d = d + \frac{V^2}{2g}$$

$$h = \frac{V^2}{2g} = \frac{(5\,m/s)^2}{2(9.81\,m/s^2)} = \boxed{1.27\,m = h}$$