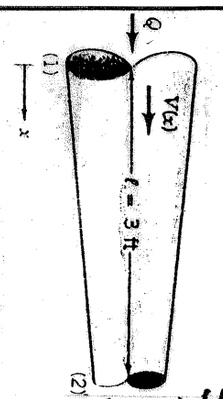
3.2

3.2 Repeat Problem 3.1 if the pipe is vertical with the flow down.



(a) $-\gamma \sin\theta - \frac{\partial p}{\partial s} = \rho V \frac{\partial V}{\partial s}$ with $\theta = -90°$ and $V = 10(1+x)\ \frac{ft}{s}$

$\frac{\partial p}{\partial s} = -\rho V \frac{\partial V}{\partial s} + \gamma$ or $\frac{\partial p}{\partial x} = -\rho V \frac{\partial V}{\partial x} + \gamma = -\rho(10(1+x))(10) + \gamma$

Thus, $\frac{\partial p}{\partial x} = -1.94 \frac{slugs}{ft^3}(10\frac{ft}{s})^2(1+x) + 62.4 \frac{lb}{ft^3}$, with x in feet

$= \underline{\underline{-194(1+x) + 62.4 \frac{lb}{ft^3}}}$

(b)(i) $\frac{dp}{dx} = -194(1+x) + 62.4$ so that $\int_{p_1=50psi}^{p_2} dp = \int_{x_1=0}^{x_2=3} [-194(1+x) + 62.4]\, dx$

or $p_2 = 50psi - 194\left(3 + \frac{3^2}{2}\right)\frac{lb}{ft^2}\left(\frac{1\,ft^2}{144\,in.^2}\right) + 62.4(3)\frac{lb}{ft^2}\left(\frac{1\,ft^2}{144\,in.^2}\right)$

$= 50 - 10.1 + 1.3 = \underline{\underline{41.2\,psi}}$

(ii) $p_1 + \frac{1}{2}\rho V_1^2 + \gamma z_1 = p_2 + \frac{1}{2}\rho V_2^2 + \gamma z_2$ or with $z_1 = 0$, $z_2 = -3\,ft$

and $V_1 = 10(1+0) = 10\frac{ft}{s}$, $V_2 = 10(1+3) = 40\frac{ft}{s}$

$p_2 = p_1 + \frac{1}{2}\rho(V_1^2 - V_2^2) - \gamma z_2$

$= 50psi + \frac{1}{2}(1.94\frac{slug}{ft^3})(10^2 - 40^2) - 62.4\frac{lb}{ft^3}(-3\,ft)$

$= \underline{\underline{41.2\,psi}}$