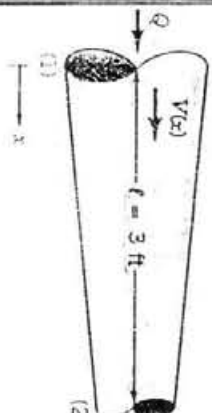


## 3.4

3.4 Repeat Problem 3.3 if the pipe is vertical with the flow down.



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

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

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

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

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

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

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

$$(ii) \quad p_1 + \frac{1}{2} \rho V_1^2 + \gamma Z_1 = p_2 + \frac{1}{2} \rho V_2^2 + \gamma Z_2 \quad \text{or with } Z_1 = 0, Z_2 = -3 \text{ ft}$$

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

$$p_2 = p_1 + \frac{1}{2} \rho (V_1^2 - V_2^2) - \gamma Z_2$$

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

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