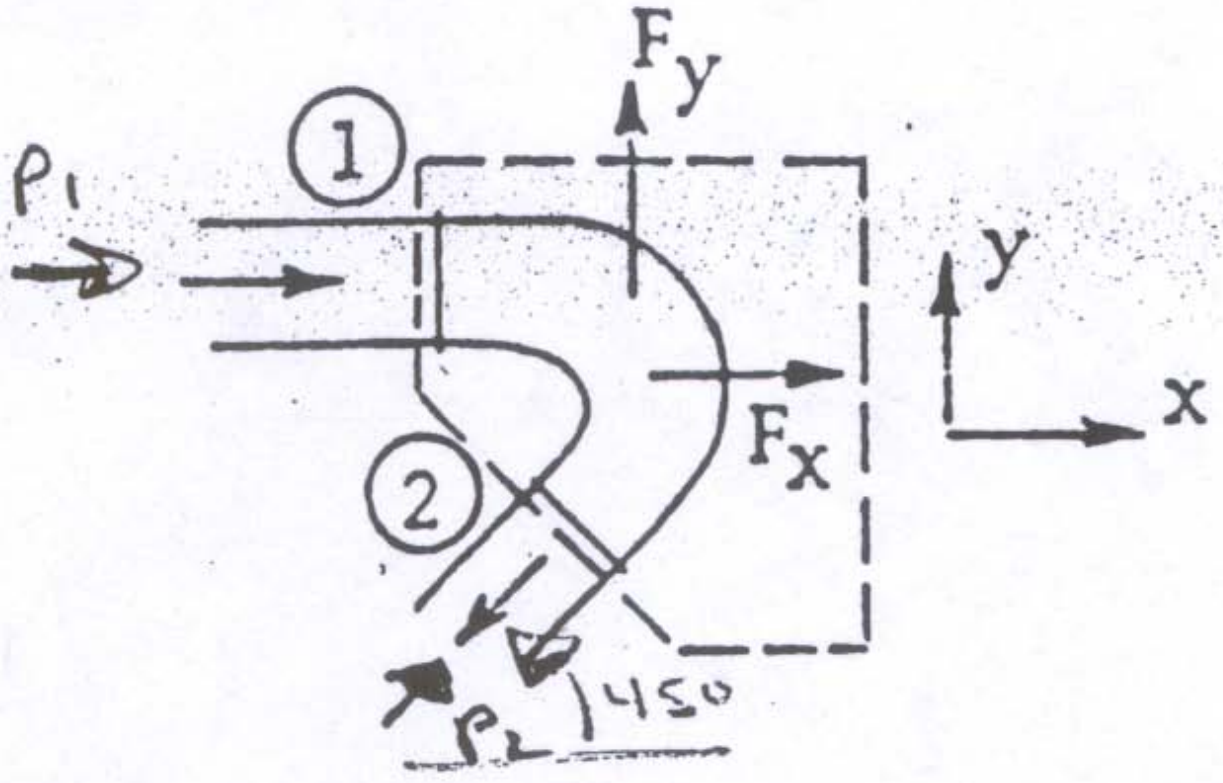
6.47 A pipe 1 ft in diameter bends through an angle of 135°. The velocity of flow of gasoline (S = 0.8) is 15 ft/s, and the pressure is 10 psi in the bend. What external force is required to hold the bend against the action of the gasoline? Neglect the gravitational force.



$$\Sigma \underline{F} = \frac{d}{dt}\int_{CV} \rho \underline{V}\, d\forall + \int_{CS} \rho \underline{V} V_R \cdot d\underline{A}$$

6.47

$$\Sigma F_x = \rho V_{1x}(-V_1 A_1) + \rho V_{2x}(V_2 A_2)$$

$$p_1 A_1 + p_2 A_2 \cos 45^\circ + F_x = \rho Q (V_{2x} - V_{1x})$$

$p_1 = p_2 = p = 10$ psi $\rho = 1.94$ slug/ft^3

$$V_1 A_1 = V_2 A_2 = Q = 15 \times \pi r^2 = 11.78 \text{ cfs}$$
$$A_1 = A_2 \Rightarrow V_1 = V_2 = V$$

$$F_x = -pA(1+\cos 45^\circ) + \rho Q(-V\cos 45^\circ - V)$$
$$= -pA(1+\cos 45^\circ) - \rho Q V(\cos 45^\circ + 1)$$
$$= -\overbrace{10 \times 144}^{psf} \times \pi \times .5^2 (1+\cos 45^\circ) - .8 \times 1.94 \times 11.78 \times 15(\cos 45^\circ + 1)$$
$$= -2,399 \text{ lbf}$$

force required to hold bend in place

$$\Sigma F_y = p_2 A_2 \sin 45^\circ + F_y = \rho Q (V_{2y} - V_{1y})$$

$$F_y = -pA \sin 45^\circ + \rho Q(-V \sin 45^\circ)$$

$$= -10 \times 144 \times \pi \times .5^2 \sin 45^\circ - .8 \times 1.94 \times 11.78 \times 15 \sin 45^\circ$$

$$= -994 \text{ lbf}$$