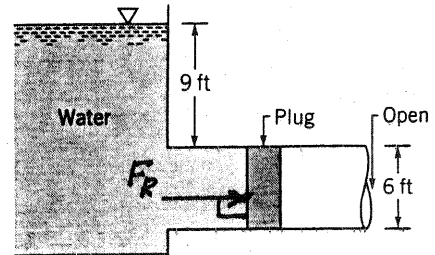2.51 A large, open tank contains water and is connected to a 6-ft diameter conduit as shown in Fig. P2.51 . A circular plug is used to seal the conduit. Determine the magnitude, direction, and location of the force of the water on the plug.

■ FIGURE P2.51

$$F_R = \gamma h_c A = \left(62.4 \frac{lb}{ft^3}\right)(12\,ft)\left(\frac{\pi}{4}\right)(6\,ft)^2 = \underline{\underline{21,200\,lb}}$$

$$y_R = \frac{I_{xc}}{y_c A} + y_c \qquad \text{where} \qquad I_{xc} = \frac{\pi\,(3ft)^4}{4} = 63.6\,ft^4$$

Thus,

$$y_R = \frac{\frac{\pi}{4}(3ft)^4}{(12\,ft)\,\pi\,(3ft)^2} + 12\,ft = \underline{\underline{12.19\,ft}}$$

The force of 21,200 lb acts 12.19 ft below the water surface and is perpendicular to the plug surface as shown.