P2.90 The tank in Fig. P2.90 is 120 cm long into the paper. Determine the horizontal and vertical hydrostatic forces on the quarter-circle panel AB. The fluid is water at 20°C. Neglect atmospheric pressure.

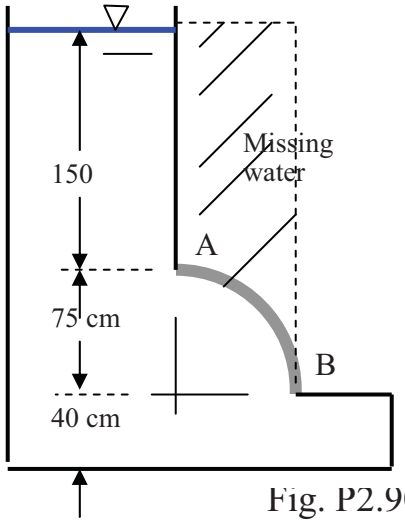

Fig. P2.90

Solution: For water at 20°C, take $\gamma = 9790$ N/m^3.

The vertical force on AB is the weight of the missing water above AB – see the dashed lines in Fig. P2.90. Calculate this as a rectangle plus a square-minus-a-quarter-circle:

$$\text{Missing water} = (1.5m)(0.75m)(1.2m) + (1-\pi/4)(0.75m)^2 = 2.16 + 0.145 = 2.305\,m^3$$

$$F_V = \gamma\upsilon = (9790\,N/m^3)(2.305\,m^3) = \mathbf{22{,}600\,N} \quad (\textit{vertical force})$$

The horizontal force is calculated from the vertical projection of panel AB:

$$F_H = p_{CG}\,h\,A_{projection} = (9790\frac{N}{m^3})(1.5 + \frac{0.75}{2}m)(0.75m)(1.2m) = \mathbf{16{,}500\,N} \quad (\textit{horizontal force})$$

2.91 The hemispherical dome in Fig. P2.91 weighs 30 kN and is filled with water and attached to the floor by six equally-spaced bolts. What is the force in each bolt required to hold the dome down?

Solution: Assuming no leakage, the hydrostatic force required equals the *weight of missing water*, that is, the water in a 4-m-diameter cylinder, 6 m high, minus the hemisphere and the small pipe:

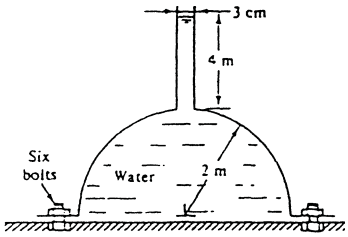

Fig. P2.91

$$F_{total} = W_{2\text{-m-cylinder}} - W_{2\text{-m-hemisphere}} - W_{3\text{-cm-pipe}}$$
$$= (9790)\pi(2)^2(6) - (9790)(2\pi/3)(2)^3 - (9790)(\pi/4)(0.03)^2(4)$$
$$= 738149 - 164033 - 28 = 574088 \text{ N}$$

The dome material helps with 30 kN of weight, thus the bolts must supply 574088–30000 or 544088 N. The force in each of 6 bolts is 544088/6 or $F_{bolt} \approx$ **90700 N** *Ans*.

2.92 A 4-m-diameter water tank consists of two half-cylinders, each weighing 4.5 kN/m, bolted together as in Fig. P2.92. If the end caps are neglected, compute the force in each bolt.

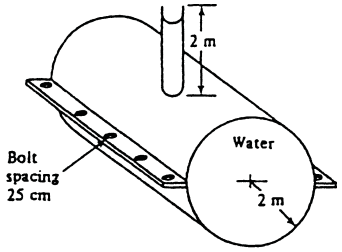

Fig. P2.92

Solution: Consider a 25-cm width of upper cylinder, as at right. The water pressure in the bolt plane is

$$p_1 = \gamma h = (9790)(4) = 39160 \text{ Pa}$$