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•18 *Snorkeling by humans and elephants.* When a person snorkels, the lungs are connected directly to the atmosphere through the snorkel tube and thus are at atmospheric pressure. In atmospheres, what is the difference Δp between this internal air pressure and the water pressure against the body if the length of the snorkel tube is (a) 20 cm (standard situation) and (b) 4.0 m (probably lethal situation)? In the latter, the pressure difference causes blood vessels on the walls of the lungs to rupture, releasing blood into the lungs. As depicted in Fig. 14-34, an elephant can safely snorkel through its trunk while swimming with its lungs 4.0 m below the water surface because the membrane around its lungs contains connective tissue that holds and protects the blood vessels, preventing rupturing.

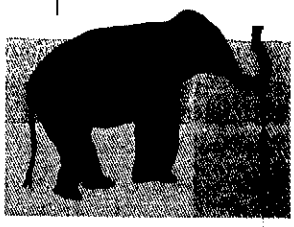
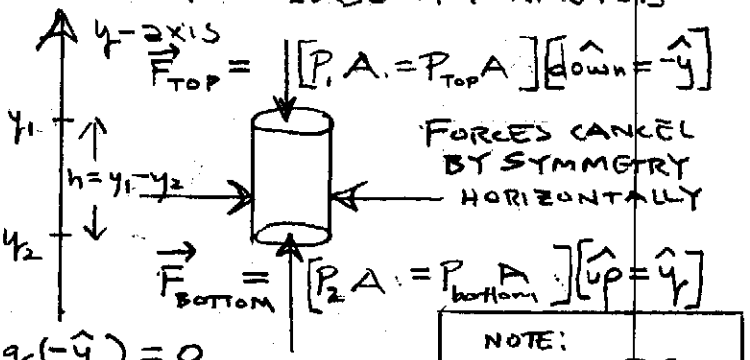


FIG. 14-34 Problem 18.

THE PRESSURE AT A CERTAIN DEPTH CAN BE DETERMINED BY CONSIDERING THE EQUILIBRIUM OF A PARCEL OF FLUID — CHOOSE A CYLINDRICAL PARCEL FOR EASE OF ANALYSIS



NOTE:
F_{TOP} = WEIGHT OF OVERLYING FLUID BEARING DOWN ON CYLINDER
F_{BOTTOM} = REACTION FORCE OF WEIGHT OF OVERLYING FLUID BEARING DOWN ON WHAT IS BELOW

$$\vec{F}^{NET}_{CYL\ OF\ FLUID} = P_1 A(-\hat{y}) + P_2 A(\hat{y}) + m_F g(-\hat{y}) \equiv 0$$

WHERE MASS OF THE FLUID = $m_F = \rho V = \rho A h = \rho A(y_1 - y_2)$

$$\vec{F}^{NET}_{ON\ FLUID} \equiv 0 \Rightarrow (P_2 - P_1)A = \rho A h g$$
$$\Rightarrow (P_2 - P_1) = \rho g (y_1 - y_2)$$

OR $P_2 = P_1 + \rho g(y_1 - y_2)$ OR $P_b = P_t + \rho g h$ (h = DIFFERENTIAL DEPTH)

IF y_1 = TOP LEVEL OF FLUID = FLUID'S SURFACE WHERE THERE IS THE AMBIENT ATMOSPERIC PRESSURE = $P_1 = P_{AIR} = P_0$ THAT WE "GAUGE" OR MEASURE EVERYTHING RELATIVE TO.

$y_2 = y_1 - h$: - DEPTH BELOW REFERENCE LEVEL

$P_2 = P_1 + \rho g(y_1 - y_2) \Rightarrow P_b = P_T + \rho g h \Rightarrow P_{ABSOLUTE} = P_0 + \rho g h = P_{REFERENCE} + P_{GAUGE}$

NOTE: THIS IS <u>HYDROSTATIC PRESSURE</u> BECAUSE IT IS DUE TO FLUID AT REST.

NOTE: ATMOSPHERIC PRESSURE WHICH WE USUALLY MEASURE GAUGE PRESSURE RELATIVE TO = 1 ATM $\approx 10\ N/cm^2 \Rightarrow 10 \frac{N}{cm^2}\left(100\,cm\right)^2 = 10^4\,cm^2 = 1\,m^2$

$= 1.01 \times 10^5\ N/m^2$ NOTE: 10 N ≈ WEIGHT OF 1 kg ON EARTH'S SURFACE

Δp = DIFFERENCE BETWEEN AIR PRESSURE = P_0 = "INTERNAL PRESSURE WHEN USING A SNORKEL" & ABSOLUTE PRESSURE AT DEPTH h IN THE WATER

$= (\rho_0 + \rho g h) - \rho_0 = \rho g h = P_{GAUGE}$

a) $= \left(\frac{1000\ kg}{m^3} = \frac{1\ METRIC\ TON}{m^3}\right)\left(9.80\ \frac{m}{s^2}\right) h = 9800h\ (\approx 10^4 h)$

$= 9800(h = 0.30) = 2{,}940\ N/m^2$

b) $= 9800(h = 4.0\,m) = 39{,}200\ N/m^2$