Answers to Chapter 0 Homework

1.a) $P = 1$ atm. $\quad V = (3.5)(4.2)(2.4) = 35.28\ m^3$

$W = mg = \rho V g$

$= 1.21 \frac{kg}{m^3} \times 35.28\ m^3 \times 9.8\ m/s^2 = 418\ \frac{kg \cdot m}{s^2} =$

$= 418\ N$

b) $F = P \cdot A = (1\ atm)\ \frac{1.01 \times 10^5\ N/m^2}{atm} \times (3.5)(4.2)$

uniform over the floor $= 1.5 \times 10^6\ N$

2. gauge pressure : $P_2 - P_0 = \Delta P = 9.3\ kPa$

$P_2 = P_1 + \rho g d \Rightarrow d = \frac{\Delta P}{\rho g} \Rightarrow$

$d = \frac{9300\ N/m^2}{998 \frac{kg}{m^3} \cdot 9.8 \frac{m}{s^2}} = 0.95 \frac{N/m^2}{N/m^3} = 0.95\ m$

($\frac{kg \cdot m}{s^2} = N$)

5. For maximum load $L \Leftrightarrow Mg = m_f g$

but $M = L + m_b + m_{He}$

$\Rightarrow (L + m_b + m_{He})\, g = m_{air}\, g$

$\Rightarrow L + 196 + \frac{4}{3}\pi R^3 \cdot \rho_{He} = \rho_{air} \cdot V_{air}$

$\Rightarrow L = (1.25 \cdot \frac{4}{3}\pi R^3) - 196 - \frac{4}{3}\pi R^3 \cdot \rho_{He}$

$= 1.25 \cdot \frac{4}{3}\pi (12)^3 - 196 - \frac{4}{3}\pi R^3 \cdot 0.16\ kg/m^3$

$= 9048 - 196 - 1158 = 7694\ kg$

6. $A_0 v_0 = n A v \Rightarrow n = \frac{A_0 v_0}{A v} = \frac{3 \times 30}{3 \times 10^{-7} \times 0.05} = 6 \times 10^9$ capillaries

7. equation (1) $\quad A_0 v_0 = A v \quad (1)$

$h = 45$ mm $\quad$ Since $a = g$ (free fall)

$A_0 = 1.2\ cm^2 \quad v^2 = v_0^2 + 2gh \quad (2)$

$A = 0.35\ cm \Rightarrow v_0^2 \frac{A_0^2}{A^2} = v_0^2 + 2gh$

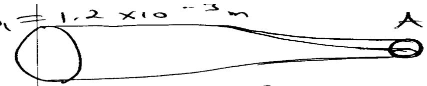
$\Rightarrow v_0^2 = \frac{2gh}{\frac{A_0^2}{A^2} - 1} = \sqrt{0.082}$

$\Rightarrow v_0 = 0.286\ m/s$

$\Rightarrow R_V = v_0 A_0 = 0.286 \times 1.2 \times 10^{-4} = 34 \times 10^{-6}\ m^3/s$

$= 34\ cm^3/s$

8. $A_1 = 1.2 \times 10^{-3} m$ $A_2 = \frac{A_1}{2}$



$\Delta P = P_1 - P_2 = 4120\ Pa$

$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$ (1)

$A_1 v_1 = A_2 v_2$ (2) $\Rightarrow 2v_1 = v_2$

$\Rightarrow P_1 - P_2 = \Delta P = 4120 = \frac{1}{2}\rho\,(v_2^2 - v_1^2)$

$\Rightarrow \frac{8240}{3\rho} = v_1^2 \Rightarrow v_1 = \sqrt{\frac{8240}{3\times 791}} = 1.86\ \frac{m}{s}$

$\Rightarrow R_v = v_1 A_1 = 1.86 \times 1.2 \times 10^{-3} = 2.23 \times 10^{-3}\ m^3/s$

12 $F = 42N$

$R = 1.1cm = 0.011m$

$A = \pi R^2$

$P = \frac{F}{A} = \frac{42}{\pi(0.011)^2}$

$\Rightarrow P = 110488\ \frac{N}{m^2} = 110488\ Pa$

13 $A = 3.4 \times 2.1 = 7.14 m^2$

$\Delta P = 1 - 0.96 = 0.04\ atm \times 1.013 \times 10^5\ \frac{N/m^2}{atm} = 4052\ Pa.$

$\Rightarrow F = \Delta P \cdot A = 4052\ \frac{N}{m^2} \cdot 7.14\ m^2 = 2.89 \times 10^4 N$

14 $d_1 = 1.08\ g/cm^3 = 1080\ Kg/m^3$

$d_{water} = 998\ Kg/m^3 = 0.998\ g/cm^3$ $\frac{1080 - 998}{1080} \times 100 = 0.076$

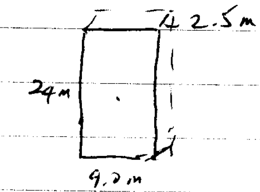
If $d_{water} = 1000\ Kg/m^3$ (at 50 atm) then the answer becomes 0.074.

Alternatively, the fish will fill its air sac with air. The

15 $V = 24 \times 9.0 \times 2.5 = 540\ m^3$ $\rho = 998\ Kg/m^3$

a) $\Rightarrow F = m \cdot g = \rho \cdot V \cdot g = 540 \times 998 \times 9.8 = 5.3 \times 10^6 N$

b) $F_{2\,short\,sides} = \frac{F_{bottom} \times 9 \times 2.5}{24 \times 9} =$



$2F = 0.552 \times 10^6 N$

$\Rightarrow F = 2.8 \times 10^5 N$

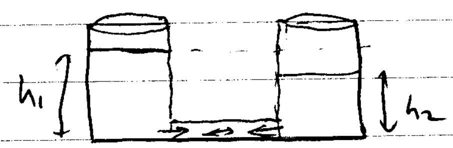
c) $F_{2\,longsides} = \frac{F_{bottom} \times 24 \times 2.5}{24 \times 9} = 1.47 \times 10^6 N$

$\Rightarrow F_{longside} = 7.4 \times 10^5 N$

d) no although $P = \frac{F}{A} = \frac{5.3 \times 10^6}{24 \times 9} = 24537\ Pa < 1atm$

but air is everywhere and therefore no net difference.

16 identical cylindrical vessels connected



upon establishing static equilibrium will be established at $\left(\frac{h_1 - h_2}{2}\right)$.

$\Rightarrow$ Work done by the gravitational force on the water

$W_g = mg\Delta h = \rho V g \Delta h = \rho g A \Delta h^2 = \rho g A \left(\frac{h_1 - h_2}{2}\right)^2$

$\Rightarrow W_g = \frac{1}{4} \rho g A (h_1 - h_2)^2$

17. $P_{sea\ level} = 1\ atm$

$d_{air} = 1.3\ Kg/m^3$

$P_1 = 0$

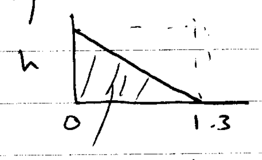
h

$P_0 = 1atm$ sea level

a) $\Rightarrow P_1 = P_0 + \rho g h \Rightarrow P_1\ (\text{no air}) = 0$

$\Rightarrow h = \frac{P_0}{\rho g} = \frac{1.013\times10^5}{1.3\times9.8} = 7.9\ Km$

b) the air density decreases linearly with height



$\Rightarrow P_0 = g\rho h$ The area under the curve expresses

$AUC = \frac{1}{2}\rho h$ the air density with height

$\Rightarrow P_0 = \frac{1}{2} g\rho h \Rightarrow h = \frac{2P_0}{g\rho} = 15.92\ km$

18. $d_i = 0.85\ m$ $= 3.80cm$ $= 53\ cm$ $\Rightarrow A_i = 11.34\ cm^2$ $A_o = 2206\ cm^2$

$\Delta P = \frac{F_i}{A_i} = \frac{F_o}{A_o}$ and $V = A_i d_i = A_o d_o$

$\Rightarrow d_o = \frac{A_i}{A_o} d_i = \frac{(11.34)(85)}{2206} = 0.44\ cm$

19. $\rho = 7870\ Kg/m^3$ $W_{app} = W_{act} - F_b$

$F_b = 200N$

a) $F_b = M_f \cdot g \Rightarrow M_f = 20.4\ Kg \Rightarrow V = \frac{20.4\ Kg}{\rho_{H_2O}} = \frac{20.4\ Kg}{998\ Kg/m^3} = 0.02\ m^3$

b) $m_{actual} = V \times \rho = 0.02 \times 7870 = 157.4\ Kg$

$\Rightarrow W_{actual} = 157.4\ Kg \times g = 1542\ N$

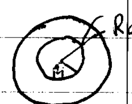
20. A block of wood floats
with $\frac{2}{3} V_f$ is submerged in fresh water
in oil $0.9V_f$ is submerged

because the wood floats $m_f g = mg \Rightarrow \rho_{medium} V_{submerged} = \rho_{body} V_{total\ body}$

a) $\rho_{H_2O} \times \frac{2}{3} V = \rho_{wood} V \Rightarrow \rho_{wood} = \frac{2 \times 998}{3} = 665\ Kg/m^3$

b) $\rho_{H_2O} \times \frac{2}{3} V = \rho_{oil} \times \frac{9}{10} V \Rightarrow \rho_{oil} = \frac{20}{27} \times \rho_{H_2O} = 739\ Kg/m^3$

21. hollow sphere $R_i = 8cm$ because it floats $m_f = m_s$



$R_0 = 9cm$

$\rho_{liquid} = 800\ Kg/m^3$

$\Rightarrow \rho_L \left(\left[\frac{V_0}{2} - \frac{V_i}{2} \right] + \frac{V_i}{2} \right) = m_s$ (sphere, water inside)

$\Rightarrow m_s = \frac{4}{3} \pi R_0^3 \frac{1}{2} \rho_L = \frac{4}{6} \pi (0.09)^3 \cdot 800 = 1.2\ Kg$

Also: $\rho_L \left(\frac{V_0}{2} - \frac{V_i}{2} + \frac{V_i}{2} \right) = \rho_s (V_0 - V_i)$

$\Rightarrow \rho_s = \frac{R_0^3 \rho_L}{2(R_0^3 - R_i^3)} = \frac{7.29 \times 10^{-4} \cdot 800}{2(2.17 \times 10^{-4})} = 1.68 \times 800 = 1344\ \frac{Kg}{m^3}$

22. $W_{actual} = 6000N$ $\quad W_{app} = W_{act} - F_b \Rightarrow F_b = 2000N$

$W_{app} = 4000N$ $\quad \vec{F}_b = m_f g \Rightarrow m_f = 204.1\ Kg$

$\rho_{Fe} = 7870\ \frac{Kg}{m^3}$

$\rho_{air} = 1.25\ \frac{Kg}{m^3} \Rightarrow \boxed{m_f = \rho_{H_2O} (V_{Fe} + V_{cav})}$ ① $\Rightarrow V_{Fe} = 0.2041 - V_{cav}$

$612.2 Kg = \frac{W_{actual}}{g} \Rightarrow m_{act} = m_{Fe} + m_{cav}$

$\Rightarrow m_{act} = 612.2\ Kg = \rho_{Fe} V_{Fe} + \rho_{air} V_{cav}$

$\Rightarrow \boxed{612.2\ Kg = 7870 V_{Fe} + 1.25 V_{cav}}$ ②

$\Rightarrow 612.2\ Kg = 7870 (0.2041 - V_{cav}) + 1.25 V_{cav} = 1606.3 - 7870 V_{cav} + 1.25 V_{cav}$

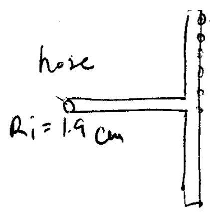
$\Rightarrow 994.1 = 7868.75\ V_{cav} \Rightarrow \boxed{V_{cav} = 0.126\ m^3}$

23. $R_i = 1.9$ cm

24 holes

$R = 0.13$ cm each

$V_1 = 0.91$ m/s



Using the equation of Continuity.

$V_1 A_1 = V_2 A_2$

$$\Rightarrow V_1 \pi R_1^2 = V_2 \times \pi R_2^2 \times 24$$

$$\Rightarrow V_2 = \frac{V_1}{24} \frac{R_1^2}{R_2^2} = \frac{0.91}{24}\left(\frac{1.9}{0.13}\right)^2 = 8.1 \text{ m/s}$$

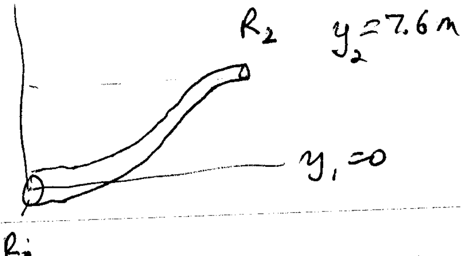
24. water pipe $R_1 = 2.5$ cm

$V_1 = 0.9$ m/s

$P_1 = 170$ KPa

$R_2 = 1.2$ cm

$y_2 = 7.6$ m



$$V_1 A_1 = V_2 A_2 \Rightarrow V_2 = \frac{V_1 A_1}{A_2} = \frac{0.9 \times \pi (2.5)^2}{\pi (1.2)^2} = 3.9 \frac{m}{s}$$

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g y_2$$

$$P_2 = P_1 + \frac{1}{2}\rho (V_1^2 - V_2^2) - \rho g y_2 =$$

$$= 1.7\times10^5 + 500(0.81 - 15.21) - 9800(7.6) \Rightarrow$$

$$P_2 = 1.7\times10^5 - 7200 - 74480 = 88320 \text{ Pa} \sim 88 \text{ KPa}$$

25.

$V_1 = 15$ m/s

$d_1 = 3$ cm

$d_2 = 5$ cm

$$R_V = 15 \frac{m}{s} \times \pi (0.015)^2 = 0.0106 \frac{m^3}{s}$$

$$\Rightarrow V_{10\,min} = R_V \times 600 \text{ sec} = 6.4 \text{ m}^3$$

b) $V_1 A_1 = V_2 A_2 \Rightarrow V_2 = \frac{V_1 A_1}{A_2} = 15\left(\frac{1.5}{2.5}\right)^2 = 5.4$ m/s

c) in the left section P_2.

$$\Rightarrow P_1 + \frac{1}{2}\rho V_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g y_2$$

$$\Rightarrow P_2 - P_1 = \Delta P = \frac{1}{2}\rho (V_1^2 - V_2^2) = 500(195.84) =$$

$$= 0.98 \times 10^5 \text{ Pa}$$