HW2 Answer template

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Problem 1

(a) 1 Bar = 100,000 Pa

1 Psi = 6894.8 Pa

$\therefore$ $500000 \cancel{Pa} \times \frac{1 \text{ Psi}}{6894.8 \cancel{Pa}} = 72.5$

$\boxed{72.5 \text{ Psi}}$

(b) 1 Psi = 6894.8 Pa

$\therefore$ $110 \cancel{Psi} \times \frac{6894.8 \text{ Pa}}{1 \cancel{Psi}} = 758428 \text{ Pa}$

$\boxed{7.58 \times 10^5 \text{ Pa}}$

(c) 1 torr = 133.32 Pa

1 atm = 1.0133×10^5 Pa

$\therefore$ $520 \cancel{torr} \times \frac{133.32 \cancel{Pa}}{1 \cancel{torr}} \times \frac{1 \text{ atm}}{1.0133 \times 10^5 \cancel{Pa}} = 0.684$

$\boxed{0.684 \text{ atm}}$

(d) 1 fsw = 12 isw = 0.030643 bar

1 bar = 100,000 Pa

1 atm = 1.0133×10^5 Pa

$\therefore$ $1 \cancel{atm} \cdot \frac{1.0133 \times 10^5 \cancel{Pa}}{1 \cancel{atm}} \times \frac{1 \cancel{bar}}{100,000 \cancel{Pa}} \cdot \frac{12 \text{ isw}}{0.030643 \cancel{bar}}$

$\boxed{397. \text{ isw}}$

(e) 1 lbf/ft² = 47.880 Pa

1 mmHg = 1.3332×10^2 Pa

$2000 \cancel{lbf/ft^2} \cdot \frac{47.88 \cancel{Pa}}{1 \cancel{lbf/ft^2}} \cdot \frac{1 \text{ mmHg}}{1.3332 \times 10^2 \cancel{Pa}}$

$\boxed{718. \text{ mmHg}}$

Problem 2

(a)

$q = vA = \frac{L}{t} \cdot L^2 = \frac{L^3}{t}$

$C_v, G_f \Rightarrow$ No Dimension

$P = \frac{m}{Lt^2}$; $\frac{L^3}{t} = N_1 \sqrt{\frac{\frac{m}{Lt^2}}{x}}$

$\frac{L^3}{t} = \left[\frac{\sqrt{L}\, L^3}{\sqrt{m}}\right] \frac{\sqrt{m}}{\sqrt{L}\, t}$

$\boxed{\frac{L^{3.5}}{\sqrt{M}}}$

(b)

If $N_1 = \frac{L^{3.5}}{\sqrt{M}}$

SI for L: m

SI for M: kg

$\therefore$ Units N_1: $\frac{m^{3.5}}{\sqrt{kg}}$

then convert to match

$\boxed{\frac{m^{3.5}}{\sqrt{kg}}}$

(c)

$\frac{gal}{min} = 1.0 \frac{m^3 \sqrt{m}}{\sqrt{kg}} \cdot \frac{\sqrt{slug} \cdot \sqrt{ft}}{sec \cdot in}$

$= 1.0 \frac{m^3 \sqrt{m}}{\sqrt{kg}} \cdot \frac{\sqrt{slug}}{sec} \cdot \frac{12}{\sqrt{ft}}$

1 gal = $3.78 \times 10^{-3}\ m^3$

$1 \sqrt{ft} = 0.552 \sqrt{m}$

$1 \sqrt{slug} = 3.82 \sqrt{kg}$

$\frac{gal}{min} = \frac{3.78 \times 10^{-3}\ m^3 \cdot 0.552 \sqrt{m}}{3.82 \sqrt{kg}} \cdot \sqrt{slug} \cdot \frac{12}{\sqrt{ft}} \cdot \frac{60}{sec} = 0.393 \frac{m^{3.5}}{\sqrt{kg}} \cdot psi$

$\boxed{0.393 \frac{m^{3.5}}{\sqrt{kg}}}$

(d)

X: No Dimensions

$\rightarrow \frac{P_1 - P_2}{P_1} = \frac{\frac{m}{Lt^2} - \frac{m}{Lt^2}}{\frac{m}{Lt^2}} \rightarrow \frac{\cancel{\frac{m}{Lt^2}}}{\cancel{\frac{m}{Lt^2}}}$

$\boxed{\text{Dimensionless}}$

(e)

$\frac{L^3}{t} = \left[\frac{t\sqrt{T}\, L^4}{m}\right] \frac{m}{Lt^2} \cdot \frac{1}{\sqrt{T}}$

$\boxed{\frac{t\sqrt{T}\, L^4}{m}}$

Problem 3

$$\Delta P = \frac{8 \mu Q L}{\pi R^4} \longrightarrow \mu = \frac{\Delta P \pi R^4}{8 Q L}$$

$$\boxed{\mu = 3.95 \times 10^{-2} \frac{kg}{m s}}$$

$$= \frac{58 PSi \cdot 6.89 \times 10^3 \frac{Pa}{PSi} \cdot \pi \cdot (0.002\ m)^4}{8 \cdot 0.9 \frac{m^3}{hr} \cdot \frac{1 hr}{3600 sec} \cdot 10\ in \cdot \frac{2.54 \times 10^{-2} m}{in}} = 0.0395 \frac{kg}{m s}$$

$$Re = \frac{\rho v L}{\mu} \qquad \rho = 1000 \frac{kg}{m^3} \qquad v = \frac{Q}{A} = \frac{Q}{\pi R^2}$$

$$L = 0.002\ m \qquad \mu = 3.95 \times 10^{-2} \frac{kg}{m \cdot s}$$

$$Re = \frac{1000 \frac{\cancel{kg}}{\cancel{m^3}} \cdot 0.9 \frac{\cancel{m^3}}{\cancel{hr}} \cdot \frac{1 \cancel{hr}}{3600 \cancel{sec}} \cdot \frac{1}{\pi (0.002\ \cancel{m})^{\cancel{2}}} \cdot 0.002\ \cancel{m}}{3.95 \times 10^{-2} \frac{\cancel{kg}}{\cancel{m} \cdot \cancel{s}}}$$

$$Re = 1007.31$$

$$\boxed{1.01 \times 10^3}$$

Problem 4

(a)

Newtonian → linear ∴

$n = 1$

(b)

$n > 1$

(c)

$n < 1$

(d)

$\tau = C\left(\frac{dv}{dy}\right)^n \Big]_{n=1} \rightarrow \frac{1200\ \text{Pa}}{0.4\ \frac{N\cdot s}{m^2}} = \frac{\Delta v}{\Delta y}$

$\Delta y = 0.001\ m \qquad \therefore \Delta v = \frac{1200\ \text{Pa}}{0.4\ \frac{N\cdot s}{m^2}} \cdot \Delta y$

$3.00\ \frac{m}{sec}$

(e)

$n = 1.2$

$\frac{dv}{dy} = \sqrt[1.2]{\tau/C} \Rightarrow \Delta y\left(\frac{\tau}{C}\right)^{1/1.2}$

$0.790\ \frac{m}{sec}$

(f) $n = 0.8$

$\Delta v = \Delta y\left(\frac{\tau}{C}\right)^{1/0.8}$

$22.2\ \frac{m}{sec}$

$P_2 - P_1 = -\rho g h$

Problem 5
What is h_1?

$P_{2\,water} = 101325 \text{ Pa} - 997 \frac{kg}{m^3} \cdot 9.8 \frac{m}{s^2} \cdot 0.27 m$

$= 98687 \text{ Pa}$

$P_{2\,merc} = 101325 \text{ Pa} - 13600 \frac{kg}{m^3} \cdot 9.8 \frac{m}{s^2} \cdot 0.08$

$= 90663 \text{ Pa}$

$\boxed{6.0 \text{ cm}}$

$$h_1 = \frac{P_{2\,merc} - P_{2\,water}}{-\rho_{merc} \cdot g} = \frac{90663 - 98687}{-13600 \cdot 9.8} = 0.06 \text{ m}$$

What is h_2?

$\boxed{52.4 \text{ cm}}$

$P_{2\,merc} = 90663 \text{ Pa}$

$P_{1\,merc} = P_{2\,merc} + \rho g h$

$= 90663 + 13600 \cdot 9.8 \cdot 0.05 = 97327 \text{ Pa}$

$$h_2 = \frac{P_{1\,merc} - P_{atm}}{-\rho g} = \frac{97327 - 90663}{-0.00078 \cdot 9.8} = 0.524 \text{ m}$$

$$\rho = \frac{SG}{997} = 0.00078 \frac{kg}{m^3}$$

Problem 6

(a)

$P_A - \rho_M g(0.17) + \rho_A g(0.14) + \rho_w g(0.18) - \rho_w g(0.98)$
$= 101325 \text{ Pa}$

$\boxed{1{,}32 \times 10^2 \text{ kPa}}$

$h = 1.2\text{ m} \cos(35°) = 0.98$

$\rho_m = 13600 \frac{kg}{m^3}$ $\quad g = 9.8 \frac{m}{s^2}$ $\quad \therefore P_A = 101325 + 30472$

$\rho_A = 1.18 \frac{kg}{m^3}$

$\rho_w = 997 \frac{kg}{m^3}$

(b)

$\boxed{1.33 \text{ m}}$

$101325 = 135000 - \rho_m g(0.17) + \rho_A g(0.14) + \rho_w g(0.18) - \rho_w g \underline{h}$

$101325 = 114102.7 - \rho g h \rightarrow h = \frac{12777}{977 \cdot 9.8} = 1.33 \text{ m}$

Problem 7

(a) The molecules in a fluid can flow around each other so it will always move

False

(b)

$\bar{P}: \frac{kg}{m^2 s^3} \rightarrow \frac{M}{L^2 t^3}$

$Q: \frac{L^3}{t}$

$P: \frac{kg}{m s^2} \rightarrow \frac{M}{L t^2}$

$\frac{M}{L^2 t^3} = \left[\frac{1}{L^4}\right] \frac{ML^3}{t^3}$

$QP = \frac{L^{3}}{t} \frac{M}{\cancel{L} t^2} = \frac{L^2 M}{t^3} \frac{L}{t} = \frac{L^3 M}{t^4} \neq \frac{M}{L^2 t^3}$

False

$C (=) \frac{1}{L^4}$

(c)

$\cancel{\Delta P = \rho g h = 997 \frac{kg}{m^3} \cdot 9.8 \frac{m}{s^2} \cdot 1m}$

$\cancel{9770.6\ Pa = 9.77\ kPa}$

False

$\Delta P = \rho g h = 997 \frac{kg}{m^3} \cdot 9.8 \frac{m}{s^2} \cdot 1\,m = 9770.6\ Pa = 9.77\ kPa$