Fundamental Fluid Concepts

Name: **Key** Date: _____

Question 1

Determine the weight of the liquid

volume of liquid : 16 ft^3
density : 1.22 slug / ft^3

$\gamma = \rho g = (1.22 \text{ slug} / ft^3)(32.2 \text{ ft} / s^2) = 39.284 \text{ lb} / ft^3$

$w = \gamma v = (39.284 \text{ lb} / ft^3)(16 \text{ ft}^3) = 628.544 \text{ lb} \approx 629 \text{ lb}$

Question 2

Determine the weight of the air

absolute pressure : 680 kPa
temperature : 70°C
volume : 1.35 m^3
$R = 286.9 \text{ J} / \text{kg} \cdot \text{K}$

$p = \rho RT$

$680(10^3) \text{ N} / m^2 = \rho(286.9 \text{ J} / \text{kg} \cdot \text{K})(70° + 273)\text{K}$

$\rho = 6.910 \text{ kg} / m^3$

$w = \rho g v = (6.910 \text{ kg} / m^3)(9.81 \text{ m} / s^2)(1.35 \text{ m}^3) = 91.5 \text{ N}$

Question 3

Determine the absolute pressure

volume : 0.35 m^3
40 kg of nitrogen
$R = 296.8 \text{ J} / \text{kg} \cdot \text{K}$
temperature : 40°C

$\rho = m / v = (40 \text{ kg}) / (0.35 \text{ m}^3) = 114.29 \text{ kg} / m^3$

$p = \rho RT$

$p = (114.29 \text{ kg} / m^3)(296.8 \text{ J} / \text{kg} \cdot \text{K})(40° + 273)\text{K} = 10.62 (10^6) \text{ Pa} = 10.6 \text{ MPa}$

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Question 4

Determine the density and specific gravity of the mercury

specific weight : 133 kN / m^3
temperature : 20°C

$\gamma = \rho g$

$133\ (10^3)\ N / m^3 = \rho_{Hg}(9.81\ m / s^2)$

$\rho_{Hg} = 13{,}558\ kg / m^3 = 13.6\ Mg / m^3$

$S_{Hg} = \rho_{Hg} / \rho_w = (13{,}558\ kg / m^3) / (1{,}000\ kg / m^3) = 13.6$

Question 5

Determine the weight of the oil

volume : $5.0535(10^6)\ ft^3$

specific gravity : 0.940

standard specific weight : 62.4 lb / ft^3

$\gamma_o = S_o\gamma_w = 0.940(62.4\ lb / ft^3) = 58.656\ lb / ft^3$

$w_o = \gamma_o v_o = (58.656\ lb / ft^3)(5.0535(10^6)\ ft^3) = 296.41\ (10^6)\ lb \approx 296\ (10^6)\ lb$

Question 6

Determine the depth of the swimming pool at 35°C

area of pool : 36 m^2

5°C , $(\rho_w)_1 = 1000\ kg / m^3$

35°C , $(\rho_w)_2 = 994\ kg / m^3$

5°C , depth 3.03 m

$(\rho_w)_1 = m / v_1$

$1000\ kg / m^3 = (m) / (36\ m^2)(3.03\ m)$

$m = 109.08\ (10^3)\ kg$

$(\rho_w)_2 = m / v_2$

$994\ kg / m^3 = 109.08\ (10^3)\ kg / (36\ m^2)(h)$

$h = 3.048\ m = 3.05\ m$

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Question 7

Determine the mass of air that must be removed to maintain the same pressure at 30°C

temperature : 15°C
pressure : 210 kPa
tank volume : 5 m^3
$R = 286.9\ J / kg \cdot K$

$p_1 = \rho_1 R T_1$

$210(10^3)\ N / m^2 = \rho_1(286.9\ J / kg \cdot K)(15° + 273)\ K$

$\rho_1 = 2.5415\ kg / m^3$

$m_1 = \rho_1 v = (2.5415\ kg / m^3)(5\ m^3) = 12.7075\ kg$

$p_2 = \rho_2 R T_2$

$210(10^3)\ N / m^2 = \rho_2(286.9\ J / kg \cdot K)(30° + 273)\ K$

$\rho_1 = 2.4157\ kg / m^3$

$m_2 = \rho_2 v = (2.4157\ kg / m^3)(5\ m^3) = 12.0785\ kg$

$\Delta m = m_1 - m_2 = 12.7075\ kg - 12.0785\ kg = 0.629\ kg$

Question 8

Determine the specific weight of the mixture at standard temperature and pressure

gasoline mixed with 8 ft^3 of kerosene
mixture volume : 12 ft^3
$\rho_g = 1.41\ slug / ft^3$
$\rho_k = 1.58\ slug / ft^3$

$v_g = 12\ ft^3 - 8\ ft^3 = 4\ ft^3$

$w_m = \rho_g g v_g + \rho_k g v_k = (1.41\ slug / ft^3)(32.2\ ft / s^2)(4\ ft^3) + (1.58\ slug / ft^3)(32.2\ ft / s^2)(8\ ft^3) = 588.62\ lb$

$\gamma_m = w_m / v_m = 588.62\ lb / 12\ ft^3 = 49.1\ lb / ft^3$

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Question 9

Determine the approximate bulk modulus

pressure : 650 psi
specific weight increases from 310 lb / ft³ to 312 lb / ft³

$$E_v = \frac{650\ \text{lb / in}^2}{\left(\frac{(312\ \text{lb / ft}^3 - 310\ \text{lb / ft}^3)}{310\ \text{lb / ft}^3}\right)} = 100.75\ (10^3)\ \text{psi} \approx 101\ (10^3)\ \text{psi}$$

OR

$$E_v = \frac{650\ \text{lb / in}^2}{\ln\left(\frac{312\ \text{lb / ft}^3}{310\ \text{lb / ft}^3}\right)} = 101.07\ (10^3)\ \text{psi} \approx 101\ (10^3)\ \text{psi}$$

Question 10

Determine if the fluid is Newtonian or non-Newtonian

τ_1 : 0.14 N / m²
$(du / dy)_1$: 13.63 s^{-1}
τ_2 : 0.48 N / m²
$(du / dy)_2$:153 s^{-1}

$\tau_1 = \mu_1(du / dy)_1$

$0.14\ \text{N / m}^2 = \mu_1(13.63\ s^{-1})$

$\mu_1 = 0.01027\ \text{N} \cdot \text{s / m}^2$

$\tau_2 = \mu_2(du / dy)_2$

$0.48\ \text{N / m}^2 = \mu_2(153\ s^{-1})$

$\mu_2 = 0.003137\ \text{N} \cdot \text{s / m}^2$

$\mu_1 \neq \mu_2$ the fluid is non-Newtonian