CEE 3500 – Civil and Environmental Engineering Fluid Mechanics – Fall 2005
Assignment No. 2

[1]. (Problem 2.1, page 41). If the specific weight of a gas is 12.40 N/m^3, what is its specific volume in m^3/kg?

[2]. (Problem 2.6, page 41). At a depth of 4 miles in the ocean the pressure is 9520 psi. Assume that the specific weight at the surface is 64.00 lb/ft^3 and that the average volume modulus is 320,000 psi for that pressure range. (a) What will be the change in specific volume at that depth? (b) What will be the specific volume at that depth? (c) What will be the specific weight at that depth? (d) What is the percentage change in the specific weight?

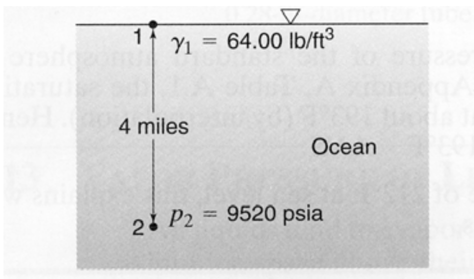


Figure P2.6

[2]. (Problem 2.7, page 42). Water at 68°F is in a long, rigid cylinder of inside diameter 0.600 in. A plunger applies pressure to the water. If, with zero force, the initial length of the water column is 25.00 in, what will its length be if a force of 420 lb is applied to the plunger. Assume no leakage and no friction.

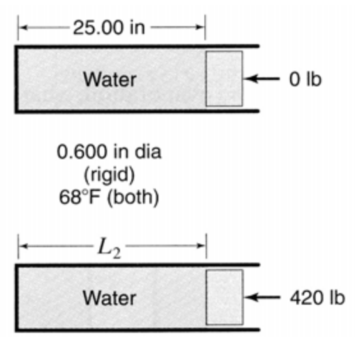


Figure P2.7

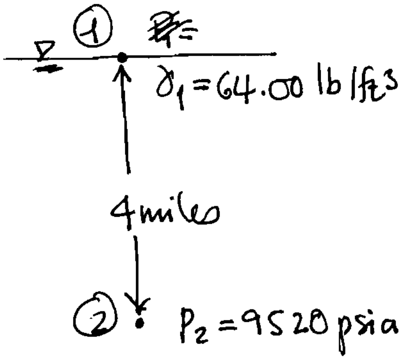
Assignment 2 – solutions

2.1 – $\gamma = 12.40\ N/m^3$, $v = ?\ (m^3/kg)$, use $g = 9.81\ m/s^2$

$$v = \frac{1}{\rho} \quad \text{and} \quad \gamma = \rho g \Rightarrow \rho = \frac{\gamma}{g} \quad \text{and} \quad v = \frac{1}{\rho} = \frac{1}{\gamma/g} = \frac{g}{\gamma}$$

$$v = \frac{9.81\ m/s^2}{12.40\ N/m^3} = \frac{9.81}{12.40}\ \frac{m}{s^2} \cdot \frac{m^3}{N} = 0.7911\ \frac{m^{\cancel{4}\,3}}{\cancel{s^2}\cdot kg \cdot \cancel{m}/\cancel{s^2}} = \underline{\underline{0.7911\ \frac{m^3}{kg}}}$$

2.6



$E_v = 320\,000$ psia, $g = 32.2\ ft/s^2$

(a) $\Delta v = ?$ (b) $v_2 = ?$

(c) $\gamma_2 = ?$ (d) $\Delta v / v_1 = ?\ (\%)$

(e) $\Delta\gamma/\gamma_1 = ?$

$p_2 = 9520$ psia $\Rightarrow$ use $p_1 = 14.7$ psia, $\Delta p = p_2 - p_1 = 9505.3$ psia

(ok, to use $\Delta p = 9520$ psia)

Given $\gamma_1 = 64\ lb/ft^3$, $\rho_1 = \frac{\gamma_1}{g} = \frac{64\ lb/ft^3}{32.2\ ft/s^2} = 1.99\ \frac{slug}{ft^3}$, $v_1 = \frac{1}{\rho} = 0.503\ \frac{ft^3}{slug}$

From the definition of $E_v = -\frac{\Delta p}{\Delta v / v_1} = -\frac{9505.3\ psia}{\Delta v / 0.503\ ft^3/slug} = 320\,000$ psia

$$\frac{\Delta v}{v_1} = -\frac{\Delta p}{E_v} \Rightarrow \Delta v = -\frac{\Delta p}{E_v} v_1 = -\frac{9505.3\ psia}{320\,000\ psia} \times 0.503\ \frac{ft^3}{slug}$$

(a) $\boxed{\Delta v = -0.015\ ft^3/slug}$

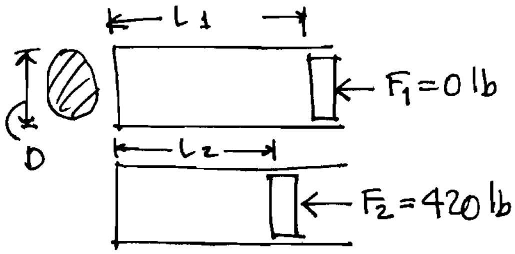
(b) $\boxed{v_2 = v_1 + \Delta v = 0.503\ \frac{ft^3}{slug} + \left(-0.015\ \frac{ft^3}{slug}\right) = 0.488\ ft^3/slug.}$

(c) $\boxed{\gamma_2 = \rho_2 g = \frac{1}{v_2} g = \frac{g}{v_2} = \frac{32.2\ ft/s^2}{0.488\ ft^3/slug} = 65.98\ lb/ft^3 \approx 66\ lb/ft^3}$

(d) $\boxed{\frac{|\Delta v|}{v_1} \cdot 100\% = \frac{0.015\ ft^3/slug}{0.503\ ft^3/slug} * 100 = 2.98\% \approx 3\%}$

(e) $\boxed{\frac{\Delta\gamma}{\gamma_1} \cdot 100\% = \frac{\gamma_2 - \gamma_1}{\gamma_1} \cdot 100\% = \frac{65.98 - 64.00}{64.00} \times 100\% = 3.09\%}$

$\boxed{2.7}$ Water at 68°F, $D = 0.600\,in$, $L_1 = 25.00\,in$, $F_1 = 0$
$L_2 = ?$, $F_2 = 420\,lb$



Area, $A = \frac{\pi D^2}{4} = \frac{\pi \times (0.600/12\,ft)^2}{4} = 1.96 \times 10^{-3}\,ft^2$

ALTERNATIVELY
$A = \frac{\pi \times (0.6\,in)^2}{4}$
$A = 0.2827\,in^2$

volumes, $V_1 = A L_1$
$V_2 = A L_2$

pressures, $p_1 = \frac{F_1}{A} = \frac{0}{A} = 0$

$p_2 = \frac{F_2}{A} = \frac{420\,lb}{0.2827\,in^2} = 1485.45\,psi$ (close to 1500 psi), $\Delta p = p_2 - \cancelto{0}{p_1} = p_2 = 1485.45\,psi$

From Table 2.1, at $T = 68°F$ and $p \simeq 1500\,psia$, $E_v = 330\,000\,psi$

From the definition of the bulk modulus of elasticity, $E_v = -\frac{\Delta p}{\Delta V / V_1}$

$\frac{\Delta V}{V_1} = -\frac{\Delta p}{E_v} \Rightarrow \Delta V = -\frac{\Delta p}{E_v} \cdot V_1$, but also $\Delta V = V_2 - V_1$, thus

$V_2 - V_1 = -\frac{\Delta p}{E_v} \cdot V_1 \Rightarrow V_2 = -\frac{\Delta p}{E_v} \cdot V_1 + V_1 = V_1 \left(1 - \frac{\Delta p}{E_v}\right)$

with $V_2 = A L_2$ and $V_1 = A L_1$, we have $\cancel{A} L_2 = \cancel{A} L_1 \left(1 - \frac{\Delta p}{E_v}\right)$

$\Rightarrow L_2 = L_1 \left(1 - \frac{\Delta p}{E_v}\right) = 25.00\,in \left(1 - \frac{1485.45\,psi}{330\,000\,psi}\right)$

$L_2 = 25.00\,in \times (1 - 0.0045) = 25.00\,in \times 0.9955$

$$\boxed{L_2 = 24.89\,in}$$