Tony Jones	ODU MET 330 Fluid Mechanics	Topic: Ch. 1 Section 1-11

The definition of Pressure

48. A coining press is used to produce commemorative coins with the likenesses of all the U.S. presidents. The coining process requires a force of 18 000 lb. The hydraulic cylinder has a diameter of 2.50 in. Compute the required oil pressure.

$$P = \frac{F}{A} = \frac{18000}{\frac{\pi r^2}{4}} = \frac{18000}{\frac{\pi (25)^2}{4}} = \frac{18000 \text{lb}}{4.91 \text{in}^2}$$

Bulk Modulus

$$P = 3666.93 \text{ lb/in}^2$$

58. Compute the pressure change required to cause a decrease in the volume of mercury by 1.00 percent. Express the result in both psi and MPa.

$$\Delta P = -E(\Delta V/V) = -3.59 \times 10^6 \frac{\text{lb}}{\text{in}^2} \cdot (-0.01)$$

$$\Delta P = 35900 \text{ lb/in}^2$$

$$\Delta P = -24750 \text{MP}(-0.01) = 2475 \text{ MPa}$$

63. A measure of the stiffness of a linear actuator system is the amount of force required to cause a certain linear deflection. For an actuator that has an inside diameter of 0.50 in and a length of 42.0 in and that is filled with machine oil, compute the stiffness in lb/in.

Ans. 884 lb/in

Conversion: 1kN = 224.80894 lbf

$$d = 0.50 \text{in}$$

$$\text{Stiffness} = \frac{\text{force}}{\Delta L} = \frac{AE}{\Delta L}$$

$$A = \frac{1}{4}\pi d^2$$

$$A = \frac{1}{4}\pi (0.5)^2$$

$$= \frac{(189000 \frac{\text{lb}}{\text{in}^2})(0.1963 \text{in}^2)}{42 \text{in}}$$

$$A = 0.1963 \text{in}^2$$

$$E = 189000 \text{ PSI}$$

$$\text{Stiffness} = 883.4 \frac{\text{lb}}{\text{in}}$$

$$\Delta L = 42 \text{in}$$

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Force and Mass

76. In the United States, hamburger and other meats are sold by the pound. Assuming that this is 1.00-lb force, compute the mass in slugs, the mass in kg, and the weight in N.

Conversion $F = mg$ $g = 32.2 \frac{ft}{sec^2}$

$1 \text{ slug} = 14.594 \text{ kg}$ $m = \frac{F}{g} = \frac{1.00 \text{ lb}}{32.2 \frac{ft}{sec^2}} = 0.0311 \frac{lb}{\frac{ft}{sec^2}}$ or Slug

$m = 0.0311 \text{ slug} \cdot 14.594 \frac{kg}{slug} = 0.453 \text{ kg}$

Density, Specific Weight, and Specific Gravity

92. A cylindrical container is 150 mm in diameter and weighs 2.25 N when empty. When filled to a depth of 200 mm with a certain oil, it weighs 35.4 N. Calculate the specific gravity of the oil.

Given:
→ Container
dia = 150 mm
$w_e = 2.25 N$
depth = 200 mm
$w_{oil} = 35.4 N$
→ Find = Sg?

$W_{oil} = 35.4 - 2.25 = 33.15 N$

$V_o = A d = \left(\frac{\pi d^2}{4}\right) = \frac{\pi (150)^2}{4} = 3.53 \times 10^{-3} m^3$

$\gamma_o = \frac{W}{V} = \frac{33.15 N}{3.53 \times 10^{-3} m^3} = 9.38 \times 10^3 \frac{N}{m^3}$

$Sg = \frac{\gamma_o}{\gamma_w} = \frac{9.38 \times 10^3 \frac{N}{m^3}}{9.81 \times 10^3 \frac{N}{m^3}} = 0.956$

107. Alcohol has a specific gravity of 0.79. Calculate its density both in slug/ft^3 and g/cm^3.

ans. 1.53 slug/ft^3; 0.79 g/cm^3

$Sg = 0.79$

$\rho = ?$

$\rho = (0.79)\left(1.94 \frac{slug}{ft^3}\right)$

$\rho = 1.53 \frac{slug}{ft^3}$

$\rho = (0.79)\left(1 \frac{g}{cm^3}\right)$

$\rho = 0.79 \frac{g}{cm^3}$

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17. Give four examples of the types of fluids that are non-Newtonian.

Corn Starch, Nail Polish, Whipped Cream, Latex Paint

Appendix D: Gives dynamic viscosity for a variety of fluids as a function of temperature. Using this appendix, give the value of the viscosity for the following fluids:

18. Water at 40 °C.

$2.25 \times 10^{-4} \frac{lb\text{-}s}{ft^2}$

25. Hydrogen at 40 °F

$1.90 \times 10^{-7} \frac{lb\text{-}s}{ft^2}$

35. SAE 30 oil at 210 °F

$3.75 \times 10^{-5} \frac{lb\text{-}s}{ft^2}$

61. In a falling-ball viscometer, a steel ball 1.6 mm in diameter is allowed to fall freely in a heavy fuel oil having a specific gravity of 0.94. Steel weighs 77kN/m3. If the ball is observed to fall 250 mm in 10.4 s, calculate the viscosity of the oil.

Given:

Steel ball

$Dia = 1.6mm = 1.6 \times 10^{-3} m$

$sg_{oil} = 0.94$

$W_{st} = 77 \frac{kN}{m^3}$

$d = 250mm = 250 \times 10^{-3} m$

$t = 10.4 sec$

Find Density (ρ) of Steel Ball

$\rho = \frac{(77 \frac{kN}{m^3})(1000 \frac{N}{kN})}{9.81 \frac{m}{sec^2}}$

$\rho = 7849.14 \frac{kg}{m^3}$

Stoke's Law

$f = 6\pi r \eta v$

$v = \frac{d}{t} = \frac{250 \times 10^{-3} m}{10.4 sec} = 0.024 \frac{m}{sec}$

$\eta = \frac{g d^2}{18 v} \cdot (\rho_{steel} - \rho_{oil})$

$\eta = \frac{(9.81 \frac{m}{sec^2})(1.60 \times 10^{-3} m)^2}{18 (0.024 \frac{m}{sec})} \cdot (7849.14 \frac{kg}{m^3} - 940 \frac{kg}{m^3})$

$\eta = (5.81 \times 10^{-5})(6909.13 \frac{kg}{m^3})$

$\eta = \underline{0.402}$ Viscosity of oil

$\rho_{oil} = (0.94) 1000 \frac{kg}{m^3}$

$\rho = 940 \frac{kg}{m^3}$