HOMEWORK # 1

$\boxed{\#1.48}$ 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 inches. Compute the oil pressure.

$\boxed{\text{SOLUTION}}$

Force = F = 18,000 lb

Diam. = ϕ = 2.50 in

$\therefore$ Area = A = $\frac{\pi d^2}{4} = \frac{\pi (2.5 in)^2}{4} = 4.91\ in^2$

$P = F/A = \frac{18{,}000\ lb}{4.91\ in^2} = 3666.93\ psi = P$

$\boxed{\#1.58}$ 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.

$\boxed{\text{SOLUTION}}$

volume decreases by 1% = -0.01

Use Bulk Modulus formula to solve for change in pressure

$\rightarrow E = \frac{-\Delta P}{\Delta V/V}$

$\rightarrow$ E in book is 3,590,000 psi & 24,750 MPa

$\rightarrow \Delta V/V = -0.01$

$\rightarrow \Delta P = -E \times (\Delta V/V) = \cancel{-}(3{,}590{,}000 psi)(\cancel{-}0.01)$

$\rightarrow \Delta P = 35{,}900\ psi$

$\rightarrow \frac{35{,}900\ psi}{} \Big| \frac{1\ \cancel{atm}}{14.7\ psi} \Big| \frac{.101 \times 325\ MPa}{1\ \cancel{atm}}$

$\rightarrow 247.45\ MPa = \Delta P$

$\boxed{\Delta P = 35{,}900 psi \ \& \ 247.45 MPa}$

#1.63 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 0.5 in and a length of 42.0 in and that is filled with machine oil, compute the stiffness in lb/in.

SOLUTION

The formolas we will use:

$\rightarrow E = \dfrac{-\Delta P}{\Delta V / V}$ $\qquad \rightarrow V = A \cdot L$

$\rightarrow P = \dfrac{F}{A}$ $\qquad \rightarrow \Delta V = -A(\Delta L)$

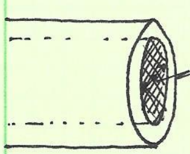
Now substitute pressure, volume, and change in volume into the Bulk Modulus equation:

$$\rightarrow E = \frac{-(F/A)}{\dfrac{(-A(\Delta L))}{(A \cdot L)}} = \left(\frac{\cancel{-}F}{\cancel{A}}\right)\left(\frac{\cancel{A} \cdot L}{\cancel{-}A(\Delta L)}\right) = \frac{F \cdot L}{A \cdot \Delta L} = E$$

$$\rightarrow \frac{F}{\Delta L} = \frac{E \cdot A}{L}$$

we know to derive to this equation so our final units will be in lb/in.

Now calculate the cross-sectional area of the system



$$A = \frac{\pi d^2}{4} = \frac{\pi (0.5in)^2}{4} = \frac{\pi (0.5)^2}{4} = 0.196in^2$$

$E = 189{,}000 psi \ (lb/in^2)$

$A = 0.196 in^2$

$L = 42 in$

$$\rightarrow F/\Delta L = \frac{(189{,}000\, lb/\cancel{in^2})(0.196\cancel{in^2})}{42 in} =$$

$$F/\Delta L = 882\, lb/in$$

#1.76 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.

SOLUTION

Convert 1.00 lb to Newtons:

$$\rightarrow \frac{1.00\,\cancel{lb}}{} \left| \frac{1\,N}{0.2248\,\cancel{lb}} \right. = 4.448\,N$$

Compute masses:

$\rightarrow F = m \cdot a$

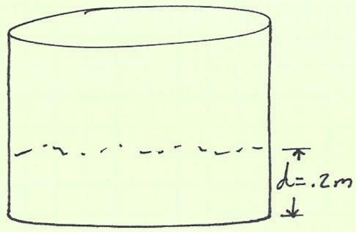
$$\frac{1.00\,lb}{32.2\,ft/s^2} = m = 0.031056\ slugs$$

$\rightarrow F = m \cdot a$

$$\frac{4.448\,N}{9.81\,m/s^2} = m = 0.453415\ kg$$

lb-f = 1.00 lb
N = 4.448 N
kg = 0.453415 kg
slug = 0.031056 slugs

#1.92 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.



Find weight oil $= \Delta N = 35.4N - 2.25N$

$\Delta N = 33.15N$

$F = m \cdot a \qquad m_{oil} = F/a = 33.15N / 9.81 m/s^2$

$m_{oil} = 3.38\,kg$

$$\rho_{oil} = \frac{m}{V} = \frac{3.38\,kg}{\left(\frac{\pi(.15m)^2}{4}\right)(.2m)} = 956.344\,kg/m^3$$

$$s.g. = \frac{\rho_{oil}}{\rho_{water @ 4^\circ C}} = \frac{956.344\,\cancel{kg/m^3}}{1000\,\cancel{kg/m^3}} = 0.956 = s.g.$$

#2.17 Give 4 examples of the types of fluids that are non-Newtonian.

SOLUTION

"Non-Newtonian fluids change their viscosity or flow behavior under stress. If you apply a force to such fluids (say you hit, shake, or jump on them), the sudden application of stress can cause them to get thicker and act like a solid, or in some cases it results in the opposite behavior and they may get runnier than they were before. Remove the stress (let them sit still or only move them slowly) and they will return to their earlier state."

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- Oobleck (a cornstarch/water mixture)
- ketchup
- Quicksand
- Custard

#2.18 Appendix D gives dynamic viscosity for a variety of fluids as a function of temperature. Using this appendix, give the value of the viscosity of water @ 40°C.

SOLUTION

According to graph in Appendix D:

$\rightarrow H_2O @ 40°C = 6.5 \times 10^{-4}\ N\cdot s/m^2$ = Dynamic Viscosity

#2.27 As above ↑

SOLUTION → Hydrogen @ 40°F = $2.8 \times 10^{-7}\ lb\cdot s/ft^2$ = Dynamic Viscosity

#2.35 As above ↑

SOLUTION → SAE 30 @ 210°F = $2.3 \times 10^{-4}\ lb\cdot s/ft^2$ = Dynamic Viscosity

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

SOLUTION

Gravity of oil = 0.94 | Ball ϕ = 0.0016m | Ball weight = 77 kN/m³ |

Time taken = 10.4s | Height = 0.25m | Viscosity formula ⇒ $\eta = \frac{Fd}{3\pi v\phi}$

→ We need the ~~drag~~ buyant force to find its terminal velocity

→ $F_b = \gamma_f V$ specific weight, volume of ball

→ $\underset{s.g.}{=} 0.94 = \frac{\gamma_f}{\gamma_w} = \frac{\gamma_f}{9.81\ kN/m^3}$

$\gamma_f = 9.22\ kN/m^3$ (plug into buyant formula)

→ $F_b = (9.22\ kN/m^3)\left(\frac{\pi D^3}{6}\right) = (9.22\ kN/\cancel{m^3})(2.14466 \times 10^{-9}\ \cancel{m^3})$

$F_b = 1.977 \times 10^{-8}$

→ Now we can find velocity

→ $v = \frac{d}{t} = \frac{.25m}{10.4s} = 0.024038\ m/s$

→ density of steel ball $= \frac{W \cdot 1000}{g} = \frac{(77\ kN/m^3)(1000)}{9.81\ m/s^2} = 7849.13\ kg/m^3$

→ density of oil = $0.94 \times 1000\ kg/m^3 = 940\ kg/m^3$

$\rho_{steel\ ball} - \rho_{oil} = 7849.13 - 940 = 6909.13\ kg/m^3$

$$\eta = \frac{(9.81)(0.0016)^2}{18\,(0.024)}(6909.13\ kg/m^3)$$

$\eta = 0.4016\ Pa \cdot s$