Homework #1

Ch 1: Nature of Fluids & Ch 2: Viscosity of Fluids and Pressure

MET 330 Virginia Beach Distance Learning WC2 and Campus

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CH 2 48, 58, 63, 76, 92, 107

Problem 48
The coin process requires a force of 18000 lb.
Hydraulic cylinder has as a diameter of 2.50 in
Compute oil pressure.

Given $F = 18000 lb$ $D = 2.50$ in $1 psi = 1 lb/in^2$

use pressure formula

$P = \frac{F}{A}$ Find A

cylinder
$A = \frac{\pi}{4} D^2$ $A = \frac{\pi}{4}(2.50 in)^2$ $A \approx 4.909 in^2$

$P = \frac{F}{A} = \frac{18000 lb}{4.909 in^2} = 3666.734569$ psi

$\boxed{P = 3666.7 \text{ psi}}$

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

Given mercury based on the bulk modulus
Mercury 68°F/20°C is 3.59 M psi / 24750 MPa
$E = 3.59 M psi$
Formula for bulk $= E = \frac{-\Delta p}{(\Delta V)/V}$

$\frac{(\Delta V)}{V} = \frac{1.00\%}{100} = 0.01$ (decrease in volume)
$= -0.01$

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Problem 58 cont.

Mercury $E = \frac{-\Delta p}{(\Delta V)/V}$ Find Δp $\Delta p = -(E)(\Delta V/V)$

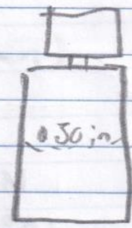
For PSI $\Delta p = -(3.59\,M_{psi} \times -0.01)$
$= \boxed{35900 \text{ psi}}$

MPa $\Delta p = -(24750\,MPa \times -0.01)$
$= \boxed{247.5\ MPa}$

Problem 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.

Given $D = 0.50$ in $\quad L = 42.0$



Hook law $= \frac{F}{\Delta L}$ $\quad$ Stiffness · Actuator

$$E = \frac{-p}{\left(\frac{\Delta V}{V}\right)} \qquad k_A = \frac{F}{\Delta L}$$

$E = 189000 \text{ lb/in}^2$

This problem requires equation plugged into other equation but first

Area of actuator

$$A = \frac{1}{4}\pi d^2 \Rightarrow \frac{1}{4}\pi(0.5 \text{ in})^2$$

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

Break down bulk modulus equation to match up to $= \frac{F}{\Delta L}$

Pressure $p = \frac{F}{A}$

Volume $= A \times L$ $\quad$ ΔVolume $= -A \times \Delta L$

Place in formula $\quad$ Stiffness

$$E = \frac{-\left(\frac{F}{A}\right)}{\frac{-A \times \Delta L}{A \times L}} = -\left(\frac{F}{\cancel{A}}\right) \times \frac{\Delta L}{-A\Delta L} = \frac{F}{\Delta L} = \frac{EA}{L}$$

$$= \frac{EA}{L} = \frac{189000 \text{ lb/in}^2 \times 0.1963 \text{ in}^2}{42.0 \text{ in}}$$

$$\boxed{\text{Stiffness} = 883.35 \text{ lb/in}}$$

Problem 76

In the US, 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

Given: Mass of man $m = \frac{w}{g}$

slugs $w = 1.0$ lbf

$g = 32.2\ ft/s^2$ $m = \frac{1.0\ lbf}{32.2\ ft/s^2}$

$m = 0.031\ lbf \cdot s^2/ft$ (mass of man)

$= 0.031$ slugs

kg Find mass of mass lbf → N

Given Weight of man ⇒ 1 lbf = 4.448 N

$g = 9.81\ m/s^2$

$m = \frac{w}{g} = \frac{(4.448\ N)}{9.81\ \frac{m}{s^2}} = 0.4534\ N \cdot \frac{s^2}{m}$

$= \boxed{0.4534\ kg}$

Weight of the meat

meat = 1 lbf

$= \boxed{4.448\ N}$

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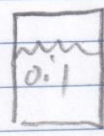
problem 927

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

Given
$D = 150$ mm of cylindrical container
Empty weight of container = 2.25 N
Depth of oil = 200 mm
weight + oil = 35.4N



The weight of the oil
$= 35.4\,N - 2.25\,N = 33.15\,N$

Vol of cylinder $V = \pi r^2 h$
$r = \frac{150\,mm}{2} = 75\,mm = 0.075\,m$ $h = 200\,mm = .200\,m$
$= (\pi)(0.075\,m)^2(.200\,m)$
$V = 3.534 \times 10^{-3}\,m^3$

Specific weight
$\gamma = \frac{w}{V} = \frac{\text{weight of oil}}{\text{volume}} = \frac{33.15\,N}{3.534 \times 10^{-3}\,m^3}$
$\gamma = 9380.3056$
$= 9380.31\,\frac{N}{m^3}$

match units to kN/m^3

Specific gravity $= \frac{\gamma_{oil}}{\gamma_{water @ 4°C}} = \frac{9380.31\,\frac{N}{m^3} \times 10^{3}}{9.81\,kN/m^3}$

$= \frac{9.380\,kN/m^3}{9.810\,kN/m^3} =$ $sg = 0.956167$

$\boxed{sg = 0.956}$

Problem 67 | 6

Alcohol has a specific gravity of 0.79.

Calculate its density both in $slugs/ft^3$ → g/cm^3

Given:

Specific gravity = $sg = 0.79$

Density

$\rho = (sg)(\rho_{water} @ 4°C)$

$= 0.79 \times 1.94\ slugs/ft^3$

$= \boxed{1.53\ slugs/ft^3}$

g/cm^3

$1\ slugs/ft^3 = 0.515\ g/cm$

$\rho = (1.53\ \cancel{slugs/ft^3})\dfrac{(0.515\ g/cm)}{(1\ \cancel{slugs/ft^3})}$

$\rho = 0.78795$

$\boxed{\rho = 0.79\ g/cm^3}$

CH2 17, 18, 27, 35, 8

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Problem 17

Give 4 examples of 4 Non-Newtonian fluids

- Thixotropic fluids like blood
- Solid particles that turn into liquid. These are electrorheological fluids.
- Toothpaste is another example. These are Bingham fluids.
- Dilatant fluids like corn starch

Problem 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 for the following fluids: Water at 40°C

Viscosity @ 40°C = $\boxed{6.5 \times 10^{-4}\ Pa \cdot s}$

(Based on Appendix D)

Problem 27

Use Appendix D to find Hydrogen at 40°F

Viscosity @ 40°F = $\boxed{1.7 \times 10^{-7}\ lbs \cdot s/ft^2}$

Problem 35

SAE 30 oil at 210°F Based on Appendix D

The viscosity @ 210°F

$= \boxed{2.2 \times 10^{-4}\ lb \cdot s/ft^2}$

Problem 61

In a falling ball viscometer, a steell ball 1.66 mm in diameter is allowed to fall freely in a heavy fuel oil having a specific gravity of 0.94. Steel weighs 77 kN/m³. If the ball is observed to fall 250 mm in 10.4s, calculate the viscosity of the oil.

FBD of the ball

Given

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

$Sg = 0.94$

(Steel ball) $Sg = \gamma = 77\ \text{kN/m}^3$

The fall travel 250 mm $t = 10.4\text{s}$

η = viscosity of oil

Kinematic Viscosity $\eta = \dfrac{F_d}{3\pi v D}$ $\quad W - F_b - F_d = 0$

$Sg = \dfrac{\text{specific weight oil}}{\text{specific weight water}} = 0.94 = \dfrac{\gamma_f}{9.81\ \text{kN/m}^3}$

Find oil

$\gamma_f = 0.94\,(9.81\ \text{kN/m}^3)$

$= 9.2214\ \text{kN/m}^3$

oil × volume of ball

$F_b = \gamma_f \left(\dfrac{\pi D^3}{6}\right) = 9.2214\ \text{kN/m}^3 \left(\dfrac{\pi(1.6\times10^{-3}\text{ m})^3}{6}\right)$

$\underline{F_b = 1.978 \times 10^{-8}\ \text{kN}}$

Find weight of ball

$W = \gamma V = 77\ \text{kN/m}^3 \left(\dfrac{\pi(1.6\times10^{-3}\text{ m})^3}{6}\right) =$ 2.1446 e-10

$\underline{= 1.651 \times 10^{-7}\ \text{kN}}$

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Go back to equation

$W - F_b - F_d = 0$

$(1.651 \times 10^{-7} kN) - (1.978 \times 10^{-8}) - F_d = 0$

$F_d = (1.651 \times 10^{-7} kN) - (1.978 \times 10^{-8} kN)$

$F_d = 1.453 \times 10^{-7} kN$

What is the velocity

$V = \frac{Distance}{time} = \frac{0.25 m}{10.4 s} = 0.024 m/s$

now use

$\eta = \frac{F_d}{3\pi V D} = \frac{1.453 \times 10^{-7} kN}{3\pi (0.024 m/s)(1.6 \times 10^{-3} m)}$

$\eta = 4.01479 \times 10^{-4} \frac{kN \cdot s}{m^2}$

$= 4.015 \times 10^{-4} \frac{kN \cdot s}{m^2}$

$\boxed{\eta = 4.015 \times 10^{-4} kPa \cdot s \text{ or } 0.4015 Pa \cdot s}$

Aaron Jackson

Homework 1 - ch 1: 48, 58, 63, 76, 92, 107
ch 2: 17, 18, 27, 35, 61

chapter 1

1.48 $P = \frac{F}{A}$

$P = \frac{15000\, lb}{4.90625\, in^2} = 3661.79\, lb/in^2$

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

$\frac{3.14 \cdot (2.5\, in^2)}{4} = 4.90625\, in^2$

1.58 $E = \frac{-\Delta p}{(\Delta V)/V}$

$\Delta p = -E[\Delta V/V] = [-3{,}590{,}000\, psi][-0.01] = 35900\, psi$
or 247.502 Mpa

1.63 Stiffness $= \frac{F}{\Delta L}$ $V = A \times L$ $\Delta V = A \cdot \Delta L$ $\boxed{882\, lb/in}$

F = Force
ΔL = displacement

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

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

F↑

$P = \frac{F}{A}$ $A = \frac{\pi d^2}{4}$ $\frac{\pi (0.50^2)}{4}$ $A = 0.196\, in^2$ $\frac{489000\, lb}{42}$

1.76 $w = mg$ $\quad m = \frac{lb \cdot s^2}{ft} = slug$ $\quad g = 32.2\ ft/s^2$

$m = \frac{w}{g}$ $\quad \frac{1\ lbf}{32.2\ ft/s^2}$

$\boxed{m = 0.031}$ $lbf \cdot s^2/ft$ or slug

$lbf = 4.448\ N$ $\quad 1N = = kg \cdot m/s^2$

$1\ lbf\ \frac{4.448\ N}{1\ lbf} = \boxed{4.448\ N}$

$m = \frac{4.448\ N}{9.81\ m/s} = 0.453\ N \cdot s^2/m$ $\quad \boxed{m = 0.453\ lb}$

1.92 $S_g = \frac{\gamma_o}{\gamma_w @ 4°C}$ $\quad \gamma_o = w/V$ $\quad D = 150\ mm = 0.15\ m$

$r = 75\ mm = 0.075\ m$

$\underline{2.25}$

$V = \pi r^2 h$

$200\ mm = 0.2\ m$ $\quad \begin{array}{r} 35.40N \\ -2.25N \\ \hline 33.15N \end{array}$ $\quad V = \pi (0.075)^2 (0.2)$

$V = 0.00353\ m^3$

$\gamma_{oil} = w_{oil} / V_{oil}$

$= 33.15/0.00353$ $\quad \gamma_{oil} = 9390.934\ N\ m^3$

$\frac{9390.934\ N \cdot m^3}{1000} = 957.28\ N/m^3$

1.(b) $S_g = 0.79$ $\quad S_g = \frac{\rho_s}{\rho_w @ 4°C}$

$\rho = S_g \cdot \rho_{water}$ @

$S_g \cdot \rho_{w @ 4°C} = \rho_s$

$0.79 \cdot 1.94$ slugs/ft³

$\rho = 1.53$ slugs/ft³

$1.53 \text{ slugs/ft}^3 \cdot \frac{0.515 \text{ g/cm}^3}{1 \text{ slugs/ft}^3} = 0.787 \text{ g/cm}^3$

Chapter 2

2.17 Pseudoplastic, Dilatant Fluids, Bingham Fluids, Thixotropic

2.16 W @ 40°C
Viscosity = 6.3×10^{-4} Pa·s

2.27 Hydrogen @ 40°F
Viscosity = 1.6×10^{-7} lb·s/ft²

2.35 SAE 30 oil at 210°F
Viscosity = 2.2×10^{-4} lb·s/ft²

2.6 $D = 1.6\,mm = 1.6 \times 10^{-3}\,m$ $sg = 0.94$ $\gamma = 77\,kN/m^3$

$$\eta = \frac{F_d}{3\pi v D}$$

$$\gamma = 0.94 \cdot 9.81\,kN/m^3 = 9.22\,kN/m^3$$

$$F_{ball} = 9.22\,\frac{\pi D^3}{6} = 9.22\,\frac{\pi \times 1.6 \times 10^{3}}{6} = 1.97 \times 10^{-9}\,kN$$

$$\text{Velocity} = \frac{D}{T} = \frac{0.25\,m}{10.45} = 0.024\,m/s$$

$$W = \gamma V \quad 77\,kN/m^3 \cdot 2.14 \times 10^{-9} = 1.6478 \times 10^{-7}\,kN$$

$$W - F_b - F_d = 0 \quad 1.6478 \times 10^{-7}\,kN - 1.97 \times 10^{-9}\,kN - F_d = 0$$

$$F_d = 1.45 \times 10^{-7}\,kN$$

$$\eta = \frac{1.45 \times 10^{-7}\,kN}{3\pi\,(0.024\,m/s)(1.6 \times 10^{-3}\,m)} = 4.0065 \times 10^{-4}\,kN \cdot s/m^2$$

$$\eta = 0.4006\,Pa \cdot s$$

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Homework 1.1

Chapter 1: 48, 58, 63, 76, 92, 107

Chapter 2: 17, 18, 27, 35, 61

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 18000 lb. The hydraulic cylinder has a diameter of 2.50 in. Compute the required oil pressure.

$P = \frac{F}{A}$ $\quad F = 18000\text{ lb}$ $\quad A = ?$ $\quad A = \frac{\pi}{4}(d)^2 \rightarrow A = \frac{\pi}{4}(2.5)^2$

$A = 4.9087\text{ in}^2$

$P = \frac{18000\text{ lb}}{4.9087\text{ in}^2} = \boxed{3666.96\text{ lb/in}^2 \text{ or psi}}$

1-58 Compute the pressure change required to cause a decrease in the volume of mercury by 1.00 percent. Express the result in Psi and MPa

$E = \frac{-\Delta P}{(\Delta V)/V}$ $\quad$ change in pressure $\Delta P = -E\left(\frac{\Delta V}{V}\right)$

mercury atm 20°C $\quad 3.59 \times 10^6$ psi $\quad$ 24,750 mPa

$\Delta P = -(3.59 \times 10^6\text{ psi})\left(-\frac{1.00}{100}\right) = \boxed{35,900\text{ Psi}}$

$\Delta P = -(24,750\text{ mPa})\left(\frac{1.00}{100}\right) = \boxed{247.5\text{ mPa}}$

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 0.50 in and a length of 42.0 in and that is filled with machine oil compute the stiffness in lb/in

$\text{stiffness} = \frac{F}{\Delta L}$ $\quad E = \frac{-P}{\Delta V/V}$ $\quad P = \frac{F}{A}$ $\quad V = A \times L$

$\Delta V = -A(\Delta L)$ $\quad E = \frac{-\left(\frac{F}{A}\right)}{\frac{-A(\Delta L)}{A \times L}} \rightarrow -\frac{F}{A} \times \frac{A \times L}{-A(\Delta L)} = \frac{FL}{A(\Delta L)} \rightarrow \frac{F}{\Delta L} = \frac{EA}{L}$

$A = \frac{\pi}{4}(d)^2 \rightarrow \frac{\pi}{4}(0.50)^2 = 0.196\text{ in}^2$ $\quad$ machine oil = 189,000 psi

$\frac{F}{\Delta L} = \frac{E \times A}{L} = \frac{(189,000\text{ lb/in}^2)(0.196\text{ in}^2)}{42\text{ in}} = \boxed{282\text{ lb/in}}$

Zach Hollifield

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, in kg and the weight in N.

$m = \frac{w}{g}$ $g = 32.2\ ft/s^2$

$m = \frac{1\ lbf}{32.2\ ft/s^2} = 0.031\ lbf \cdot s^2/ft$ $\boxed{m = 0.031\ slugs}$

$1\ lbf = 4.448\ N$ $w = 1\ lbf\left(\frac{4.448\ N}{1\ lbf}\right) = 4.448\ N$

$m = \frac{4.448\ N}{9.81\ m/s^2} = 0.453\ N \cdot s^2/m$ $\boxed{m = 0.453\ kg}$

$\boxed{w = 4.448\ N}$

1-92 A cylindrical container is 150 mm in diameter and weights 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.

$D = 150\ mm$ $r = \frac{150}{2} = 75\ mm\left(\frac{1\ m}{1000\ mm}\right) = 0.075\ m$ Empty $w = 2.25\ N$

Oil depth $= 200\ m\left(\frac{1\ m}{1000\ m}\right) = 0.2\ m$ w container with oil $= 35.4\ N$

Weight of oil $= (35.4 - 2.25\ N) = 33.15\ N\left(\frac{1\ kN}{1000\ N}\right) = 0.03315\ kN$

$V = \pi r^2 h \rightarrow (\pi)(0.075^2)(0.2) = 3.534 \times 10^{-3}\ m^3$ specific weight oil $\gamma_{oil} = \frac{W_{oil}}{V}$

$\gamma_{oil} = \frac{0.03315\ kN}{3.534 \times 10^{-3}\ m^3} = 9.38\ kN/m^3$ Specific Gravity $= \frac{\gamma_{oil}}{\gamma_{water} @ 4°C}$

$\gamma_{water} @ 4°C = 9.81\ kN/m^3$ $sg = \frac{9.38\ kN/m^3}{9.81\ kN/m^3}$ $\boxed{sg = 0.956\ kN/m^3}$

1-107 Alcohol has a specific gravity of 0.79. Calculate its density both in $slug/ft^3$ and g/cm^3.

$sg = 0.79$ $\rho = sg \times \rho_{water} @ 4°C$

$\rho = 0.79 \times 1.94\ slugs/ft^3$ $\boxed{\rho = 1.53\ slug/ft^3}$

$1\ slug/ft^3 = 0.515\ g/cm^3$

$\rho = 1.53\ slug/ft^3 \times \frac{0.515\ g/cm^3}{1\ slug/ft^3}$ $\boxed{\rho = 0.79\ g/cm^3}$

Zach Holliffeld

2-17 Give four examples of the types of fluids that are non-Newtonian.

$\boxed{\text{- Pseudoplastic - Dilatant Fluids - Bingham Fluids - Thixotropic}}$

Give the value of the viscosity

2-18 Water at 40°C

$\boxed{\text{viscosity} = 6.3 \times 10^{-4}\ Pa \cdot s}$

2-27 Hydrogen at 40° F

$\boxed{\text{viscosity} = 1.6 \times 10^{-7}\ lb \cdot s/ft^2}$

2-35 SAE 30 oil at 210° F

$\boxed{\text{viscosity} = 2.2 \times 10^{-4}\ lb \cdot s/ft^2}$

2-61 In a falling-ball viscometer, a steel ball 1.6mm in diameter is allowed to fall freely in a heavy fuel oil having a specific gravity of 0.94. Steel weighs 77 kN/m³. If the ball is observed to fall 250 mm in 10.4s, calculate oil viscosity

$D = 1.6mm = 1.6 \times 10^{-3} m \quad sg = 0.94 \quad \gamma = 77 KN/m^3$

$\eta = \frac{F_d}{3\pi v D} \quad \gamma = (0.94)(9.81) KN/m^3 = 9.22 KN/m^3$

$F_{boy} = 9.22\left(\frac{\pi D^3}{6}\right) = 9.22\left(\frac{\pi \times 1.6\times10^{-3}}{6}\right) = 1.97 \times 10^{-8} KN$

$\text{Velocity} = \frac{D}{T} = \frac{0.25m}{10.4s} = 0.024 m/s$

$W = \gamma V \rightarrow (77 kN/m^3)(2.14 \times 10^{-9}) = 1.6478 \times 10^{-7} KN$

$W - F_b - F_d = 0 \rightarrow (1.6478 \times 10^{-7} KN) - (1.97 \times 10^{-8} KN) - F_d = 0$

$F_d = 1.45 \times 10^{-7} KN$

$\eta = \frac{1.45 \times 10^{-7} KN}{3\pi (0.024 m/s)(1.6 \times 10^{-3} m)} = 4.0065 \times 10^{-4} KN \cdot S/m^2$

$\boxed{\eta = 0.4006\ Pa \cdot S}$