Topic: Fluid Properties

1. If 6 m^3 of oil weighs 47 kN, calculate its specific weight, density, and specific gravity.

SPECIFIC WEIGHT

$$\gamma = \frac{W}{V} = \frac{47\ \text{kN}}{6\ \text{m}^3} = 7.833\ \text{kN/m}^3$$

DENSITY

$$\rho = \frac{\gamma}{g} = \frac{7833\ \text{N/m}^3}{9.81\ \text{m/s}^2} = 798\ \text{kg/m}^3$$

SPECIFIC GRAVITY

$$SG = \frac{\gamma_{OIL}}{\gamma_{WATER}} = \frac{7.833\ \text{kN/m}^3}{9.79\ \text{kN/m}^3} = 0.800$$

2. 10.0 L of an incompressible liquid exert a force of 20 N at the earth's surface. What force would 2.3 L of this liquid exert on the surface of the moon? The gravitational acceleration on the surface of the moon is 1.67 m/s^2.

   A. 0.39 N
   B. 0.78 N
   C. 3.4 N
   D. 4.6 N

INCOMPRESSIBLE → ρ IS CONSTANT

$$m = \frac{F}{g} = \frac{20\ \text{N}}{9.81\ \text{m/s}^2} = 2.04\ \text{kg}$$

$$\rho = \frac{m}{V} = \frac{2.04\ \text{kg}}{10\ \text{L}} = 0.204\ \text{kg/L}$$

FORCE OF 2.3L ON THE MOON:

$$F = ma = (0.204\ \text{kg/L})(2.3\ \text{L})(1.67\ \text{m/s}^2)$$

$$F = 0.784\ \text{N}$$ **B**

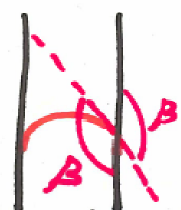
3. The viscosity of a fluid is

   A. the dimensionless ratio of the weight of a body to the weight of an equal volume of a substance taken as a standard.
   B. the weight of a unit volume of a substance.
   C. caused by surface tension and depends on the relative magnitudes of the cohesion of a liquid and the adhesion of the liquid to the walls of the containing vessel.
   D. that property which determines the amount of its resistance to a shearing force.

4. A capillary tube 5 millimeters in diameter has its end submerged in mercury. The capillary depression is 1 millimeter. If the angle made by the mercury (s.g. 13.57) and the tube wall is 140°, the surface tension of the mercury is most nearly:

   A. 0.22 N/m
   B. 2.22 N/m
   C. 4.44 N/m
   D. 26.00 N/m
   E. 49.59 N/m

$$\sigma = \frac{h\gamma d}{4\cos\beta}$$



$$\sigma = \frac{(0.001\,m)[(13.57)(9810\,N/m^3)](0.005\,m)}{4\cos 140°}$$

$\sigma = 0.22\,N/m$ A

5. A device measuring the pressure in a closed vessel registers a vacuum of 310 millimeters of mercury (s.g. 13.57) when the absolute atmospheric pressure is 100 kPa. Using the notion that 760 millimeters of mercury is equivalent to 101.3 kPa, the absolute pressure in the vessel is most nearly:

   A. 41.3 kPa
   B. 58.8 kPa
   C. 13.3 kPa
   D. –41.3 kPa
   E. –58.8 kPa

$P_{ABS} = P_{GAGE} + P_{ATM}$

$P_{ABS} = (-310\text{ mm Hg})\left(\frac{101.3\text{ kPa}}{760\text{mm Hg}}\right) + 100\text{kPa}$

$P_{ABS} = 58.8\text{ kPa}$ B

<u>Topic: Fluid Statics</u>

6. The gage pressure at a point 3 m below the surface of an open topped, water filled tank is most nearly:

   A. 681.25 kPa
   B. 358.54 kPa
   C. 187.20 kPa
   D. 98.10 kPa
   E. 29.43 kPa

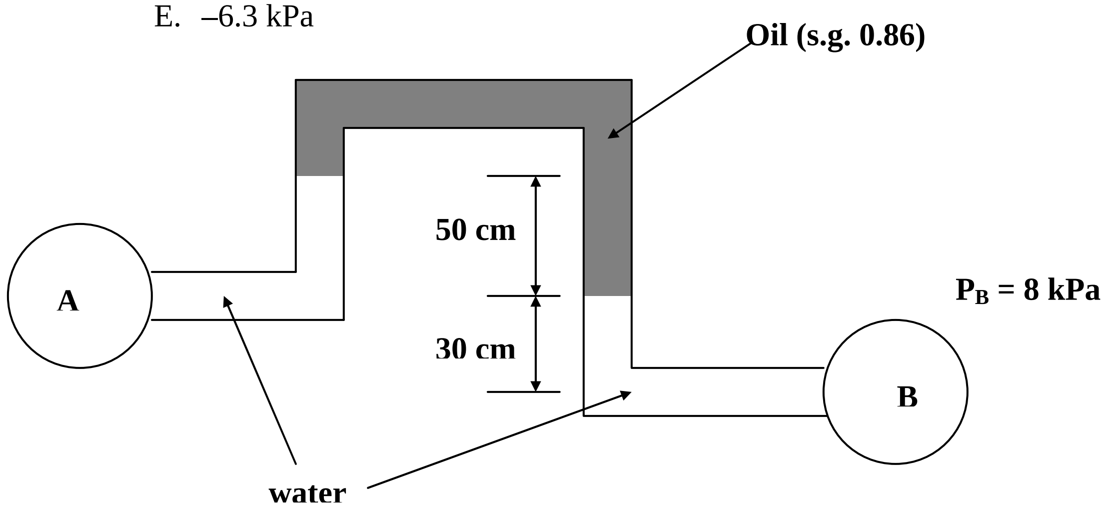
$\Delta P = \gamma h$ ← WATER PROPERTIES TABLE

$\Delta P = (9.81\text{ kN/m}^3)(3\text{m})$ [redacted]

$\Delta P = 29.43\text{ kPa}$ E

7. The pressure in pipe A shown below is most nearly:

   A. 6.3 kPa
   B. 5.8 kPa
   C. 4.2 kPa
   D. –5.8 kPa
   E. –6.3 kPa



STARTING @ KNOWN P_B:

$P_B - \gamma_w(0.30m) - \gamma_o(0.50m) + \gamma_w(0.80m) = P_A$

$8kPa + \gamma_w(0.20m) - \gamma_o(0.50m) = P_A$

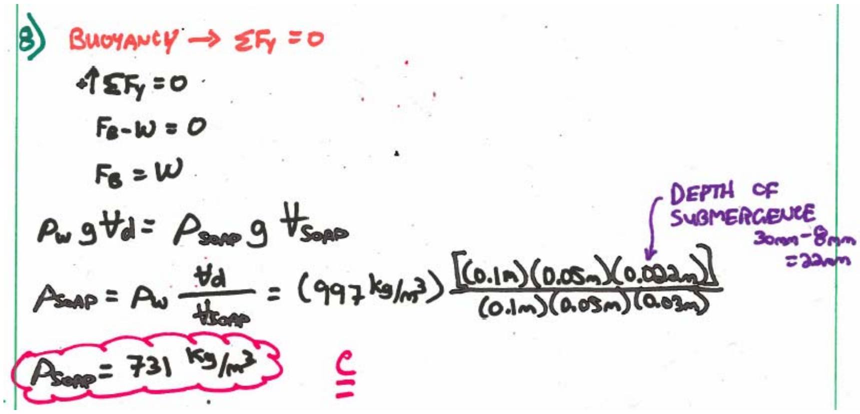
$8kPa + (9.81\ kN/m^3)(0.20m) - (0.86)(9.81\ kN/m^3)(0.5m) = P_A$

↑ WATER PROPERTIES TABLE ↑ SPECIFIC GRAVITY

$P_A = 5.76\ kPa$ B

8. A bar of soap with the dimensions 10 cm long, 5 cm wide, and 3 cm tall is floating in a basin of water with 8 mm extending above the surface. If the water density at the present temperature is 997 kg/m^3, the density of the soap is most nearly:

   A. 1510 kg/m^3
   B. 1359 kg/m^3
   C. 731 kg/m^3
   D. 135.9 kg/m^3
   E. 73.1 kg/m^3

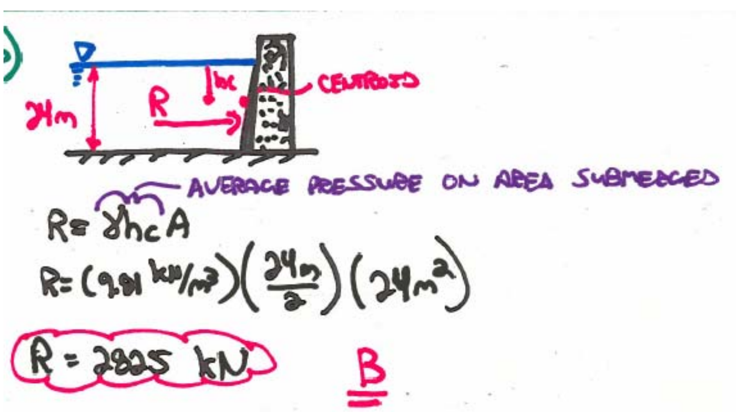


9. In a static liquid, the difference in pressure between two different elevations is:

    A. Equal to the difference in elevation multiplied by the fluid density.
    B. Equal to the difference in elevation multiplied by the specific weight of the fluid.
    C. Equal to the total depth of the fluid.
    D. The same in any direction.
    E. A function of time.

10. The force on a one-meter wide section of a dam holding back 24 m of water is most nearly:

    A. 17.97 kN
    B. 2,825 kN
    C. 3,532 kN
    D. 5,094 kN
    E. 5,660 kN



Topic: Fluid Dynamics

11. Laminar flow exists in a pipe. We know that

    A. The Reynolds Number is less than 2000.
    B. The velocity profile is linear.
    C. The shear stress distribution is linear.
    D. The pipe is smooth.

12. The hydraulic radius of a non-circular conduit is defined as

    A. The radius of an equivalent circular conduit.
    B. The ratio of the cross-sectional area of flow to the wetted perimeter.
    C. The ratio of the Reynolds Number to the roughness coefficient.
    D. The hydraulic diameter of an equivalent circular conduit.
    E. The ratio of the conduit area to its perimeter.

13. If the speed of an incompressible fluid is 4 m/s in a 240-mm-diameter pipe that enters a 160-mm-diameter pipe, what will the speed in the 160-mm-diameter pipe most nearly be?

    A. 16.0 m/s
    B. 10.7 m/s
    C. 9.00 m/s
    D. 4.00 m/s
    E. 2.00 m/s

USE CONTINUITY...

$$Q_1 = Q_2$$

$$A_1 v_1 = A_2 v_2$$

$$v_2 = v_1 \frac{A_1}{A_2} = (4.00\ \text{m/s}) \frac{\frac{\pi}{4}(240\ \text{mm})^2}{\frac{\pi}{4}(160\ \text{mm})^2}$$

$$v_2 = 9.00\ \text{m/s}$$

C

14. Water flows through a multi-sectional pipe placed horizontally on the ground. The velocity is 3.0 m/s at the entrance and 2.1 m/s at the exit. What is the pressure difference between these two points? Neglect friction.

    A. 0.2 kPa
    B. 110 kPa
    C. 28 kPa
    D. 2.3 kPa

NEGLECT FRICTION → BERNOULLI EQUATION

$$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g} \qquad z_1 = z_2 \text{ (PIPE ON LEVEL)}$$

$$\frac{P_1 - P_2}{\gamma} = \frac{V_2^2 - V_1^2}{2g}$$

$$P_1 - P_2 = \gamma\left[\frac{V_2^2 - V_1^2}{2g}\right] = (9.81\ kN/m^3)\left[\frac{(2.1\ m/s)^2 - (3.0\ m/s)^2}{2(9.81\ m/s^2)}\right]$$

$$P_1 - P_2 = -2.295\ kPa$$

$$P_2 - P_1 = 2.3\ kPa \qquad \underline{\underline{D}}$$

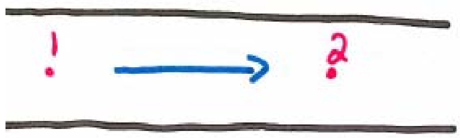
15. Select the false statement for the Bernoulli equation.

    A. It is valid for unsteady flow.
    B. It is valid along a streamline.
    C. It is valid in an inertial coordinate system.
    D. It is valid for inviscid flow.

16. If an incompressible flow is carried in a pipe where the elevation and cross-sectional area remains constant between two points a certain distance apart, the pressure drop in the pipe between the two points is considered due to:

    A. Atmospheric pressure
    B. Fluid density
    C. Velocity head change
    D. Friction
    E. Gravity

USE MECH. ENERGY EQ.:



$$\frac{P_1}{\gamma} + \cancel{z_1} + \cancel{\frac{V_1^2}{2g}} + \cancel{h_p} = \frac{P_2}{\gamma} + \cancel{z_2} + \cancel{\frac{V_2^2}{2g}} + \cancel{h_t} + h_L$$

$$h_L = \frac{P_1 - P_2}{\gamma}$$

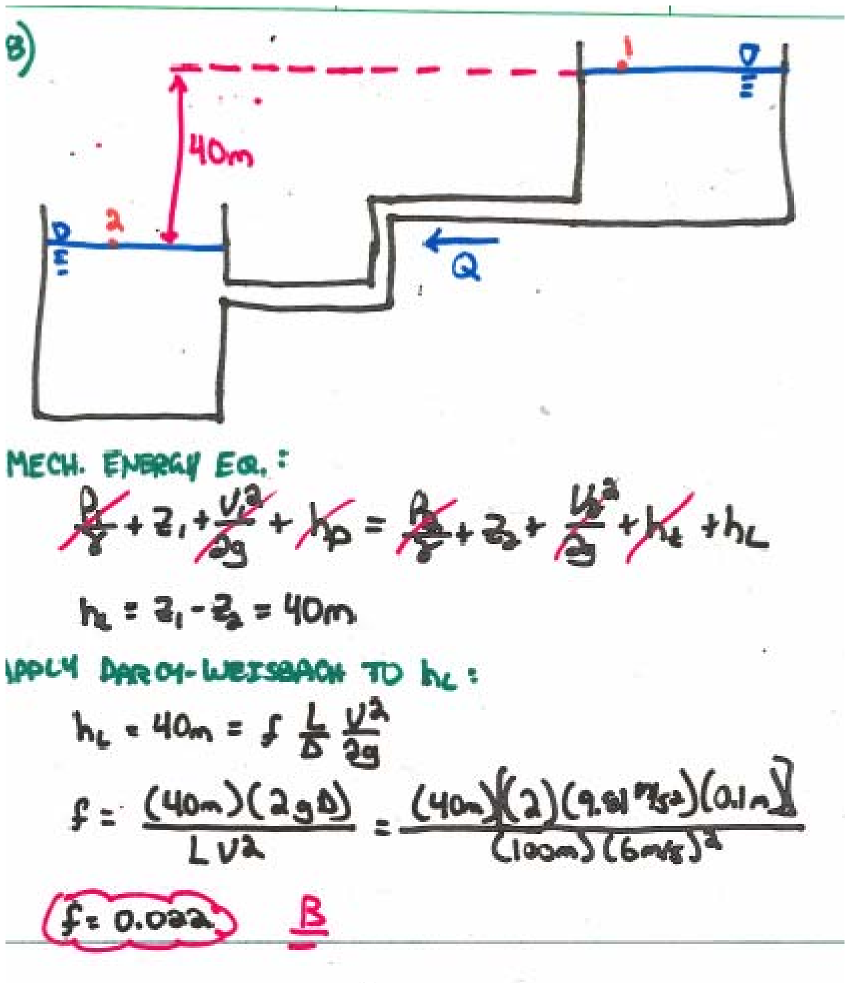
↑ FRICTION $\underline{\underline{D}}$

17. The Darcy-Weisbach friction factor (f) is a function of:

  A. The kinematic viscosity, velocity, and the Reynolds number.
  B. The flow rate, dynamic viscosity, and the roughness factor.
  C. The cross-sectional area and the wetted perimeter.
  D. The Reynolds number, the roughness factor, and pipe diameter.
  E. The average velocity, pipe length, pipe diameter, and gravity.

18. Water flows through a 10-cm-dia, 100-m-long pipe connecting two reservoirs with an elevation difference of 40 m. The average velocity is 6m/s. Neglecting minor losses, the friction factor is

  A. 0.020
  B. 0.022
  C. 0.024
  D. 0.026



19. The locus of elevations that water will rise in a series of pitot tubes is called

A. The hydraulic grade line.
B. The energy grade line.
C. The velocity head.
D. The elevation head.

Topic: Pumps and Turbines

Problems 20 and 21: A 2-m diameter, 200-m long, cast-iron pipe transports water from a reservoir with surface elevation 726 m to an 89% efficient turbine which has its outlet at 696 m. The turbine operates such that the flow rate is 6 m^3/s. Use kinematic viscosity $\nu = 10^{-6}$ m^2/s.

20. Approximate the losses up to the inlet of the turbine.

A. 20 m
B. 10 m
C. 2.5 m
D. 0.25 m

USE DARCY-WEISBACH EQ.:

$h_L = f \frac{L}{D} \frac{V^2}{2g}$

NEED V & f:

$V = \frac{Q}{A_t} = \frac{6\ m^3/s}{\frac{\pi}{4}(2m)^2} = 1.91\ m/s$

MOODY CHART TO FIND f...

$Re = \frac{VD}{\nu} = \frac{(1.91\ m/s)(2m)}{10^{-6}\ m^2/s} = 3.8 \times 10^6$

$\frac{\epsilon}{D} = \frac{2.5 \times 10^{-4}\ m}{2m} = 0.000125$

$f = 0.013$ (FROM MOODY CHART)

$h_L = (0.013) \frac{200m}{2m} \frac{(1.91\ m/s)^2}{2(9.81\ m/s^2)}$

$h_L \cong 0.25m$ D

21. What is the expected power output of the turbine?

A. 1550 kW
B. 960 kW
C. 270 kW
D. 43.2 kW

USE ENERGY EQ:

$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} + h_p = \frac{p_2}{\gamma} + z_2 + \frac{V_2^2}{2g} + h_t + h_L$

$P_1 = P_2 = P_{atm} = 0$ GAGE

$V_1 \lll V_2$

SOLVE FOR h_t:

$h_t = (z_1 - z_2) - \frac{V_2^2}{2g} - h_L$

$h_t = (726m - 696m) - \frac{(1.91\ m/s)^2}{2(9.81\ m/s^2)} - 0.25m$

$h_t = 29.6m$

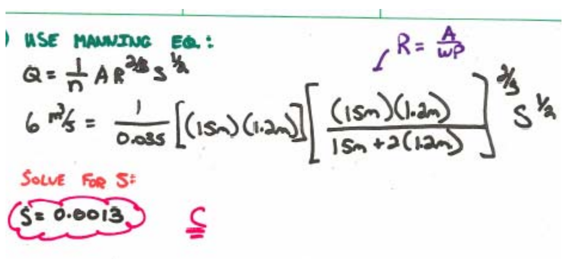
$\dot{W} = h_t \gamma Q \eta = (29.6m)(9.81\ kN/m^3)(6\ m^3/s)(0.89)$

$\dot{W} = 1550\ kW$ A

Topic: Pipe/Open Channel Flow

22. A 15-m-wide, 1.2-m deep river feeds a reservoir from above (Q = 6 m^3/s). Estimate the river's slope if the Manning *n* is 0.035.

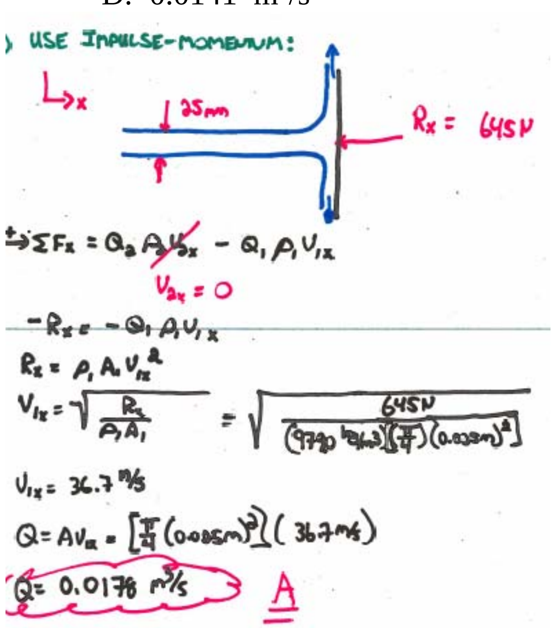
    A. 0.013
    B. 0.107
    C. 0.0013
    D. 0.00107



Topic: Momentum

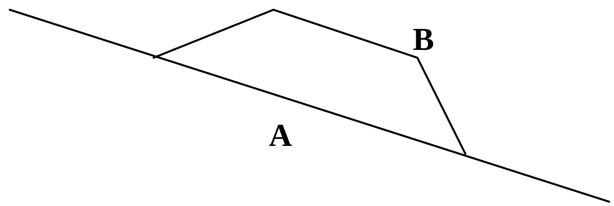
23. The force exerted by a 25-mm-diameter stream of water against a flat plate held normal to the stream's axis is 645 N. What is the flow?

    A. 0.0178 m^3/s
    B. 0.0056 m^3/s
    C. 0.7183 m^3/s
    D. 0.0141 m^3/s



Topic: Pipe Networks

24. The branched pipeline shown below has a flow in pipe A of 10 cubic feet per second. The following table gives the characteristics of each of the pipes.



	A	B
Diameter	16 in.	24 in.
Length	2,000 ft	3,000 ft
F	0.03	0.02
Area	1.3963 ft^2	3.142 ft^2

The flow in pipe B is most nearly:

A. 8.77 cfs
B. 21.60 cfs
C. 27.56 cfs
D. 77.94 cfs
E. 81.30 cfs

2-BRANCH PIPE NETWORK:

WE KNOW $h_{L_A} = h_{L_B}$ ... USE DARCY-WEISBACH

$$f_A \frac{L_A}{D_A}\frac{V_A^2}{2g} = f_B \frac{L_B}{D_B}\frac{V_B^2}{2g}$$

$$V_A = \frac{Q_A}{A_A} = \frac{10\ ft^3/s}{1.3963\ ft^2} = 7.16\ ft/s$$

$$(0.03)\frac{2000\ ft}{1.33\ ft}\frac{(7.16\ ft/s)^2}{2(32.2\ ft/s^2)} = (0.02)\frac{3000\ ft}{2\ ft}\frac{V_B^2}{2(32.2\ ft/s^2)}$$

SOLVE FOR V_B

$V_B = 8.77\ ft/s$

$Q_B = (8.77\ ft/s)(3.142\ ft^2)$

$Q_B = 27.56$ cfs

C