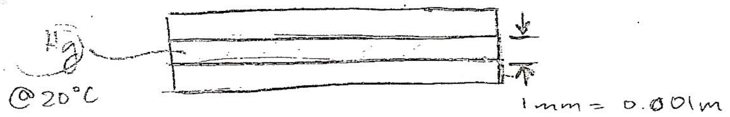
100

ENCE 3318
PRINCIPLES OF HYDRAULICS

TEST 1

25

1. Two large flat plates are separated by a thin mercury layer that is 1 mm thick and at a temperature of 20°C. A force is applied to the top plate such that a shear stress $\tau = 22.5$ N/m^2 is generated. How fast will the top plate move (<u>in m/s</u>) relative to the bottom plate after a constant velocity is attained? Assume that the velocity profile between the plates is linear.



$\tau = 22.5\ N/m^2$

$\mu = 1.5 \times 10^{-3}\ N \cdot s/m^2$ (Table A.4)

$\tau = \mu \frac{dv}{dy}$

$dv = v$

$22.5\ N/m^2 = \left(1.5 \times 10^{-3}\ \frac{N \cdot s}{m^2}\right) \frac{v}{0.001m}$

$v = \left(\frac{22.5\ N}{m^2}\right)\left(\frac{m^2}{1.5 \times 10^{-3}\ N \cdot s}\right)(0.001m)$

$v = 15\ m/s$ ✓

(Bulk Modulus)

2. What pressure increase must be applied to water to reduce its volume by ½ %? Give your answer in lbf/in^2. What depth (in feet) in sea water (γ=64.2 lbf/ft^3) is this equivalent to?

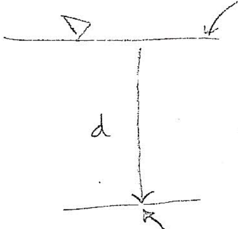
(25)

$$E = \frac{-\Delta p}{\left(\frac{\Delta V}{V}\right)}$$

Table A.5 → $E = 2.2 \times 10^9$ Pa $= 3.2 \times 10^5$ psi

$$\left(3.2 \times 10^5 \frac{lbf}{in^2}\right) = \frac{-\Delta p}{\left(-\frac{0.5}{100}\right)}$$

$\Delta p = 1600$ lbf/in^2 (increase)



$P_1 = 0$ (g)

$P_1 = 14.7$ psi (a)

$\gamma = 64.2$ lbf/ft^3

$P_2 = P_1 + \gamma d$ [going "-d" ... end result = "+"]

$$\left[1600 \frac{lbf}{in^2}\right]\left(\frac{144\ in^2}{ft^2}\right) = \left(64.21\ lbf/ft^3\right) d + \left[14.7 \frac{lbf}{in^2}\right]\left(\frac{144}{ft}\right)$$

ab

$d = 3555.26$ ft @ atm pressure

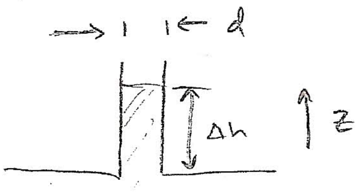
✓

(surface tension)

3. The capillary rise in medium sand is approximately 25 cm. If the medium sand can be modeled by a capillary tube (glass tube), what is its equivalent diameter?

(25)

$\Delta h = 0.25$ m



$\sigma = 0.073$ N/m

$\gamma_w = 9790$ N/m³ @ 20 °C

$$\Delta h = \frac{4\sigma}{\gamma d}$$

$$d = \frac{4\sigma}{\gamma \Delta h} = \frac{4(0.073\ \text{N/m})}{(9790\ \text{N/m}^3)(0.25\ \text{m})}$$

$$= 1.193 \times 10^{-4}\ \text{m}$$

$d = 0.12$ mm ✓

4.

(25)

600 mm = 0.60 m
300 mm = 0.30 m
150 mm = 0.15 m
100 mm = 0.10 m

■ Problem Statement

What is the absolute and gage pressure in drum *A* in Fig. 2.4 at position *a*?

$P = \left(\frac{14.7\ lbf}{in^2}\right)(6895) = 101356.5\ N/m^2$ (abs)

or

101.36 kPa (abs)

$P_1 = 14.7$ psi (a)

$P_1 = 0$ (g)

$P_a = N/m^2$

$\gamma_{Hg} = 133,000\ N/m^3$ @ 20°C

$S = \frac{\gamma_{fluid}}{\gamma_{water}}$

$\gamma_{fluid} = S(\gamma_{water})$

$\gamma_w = 9790\ N/m^3$ @ 20°C

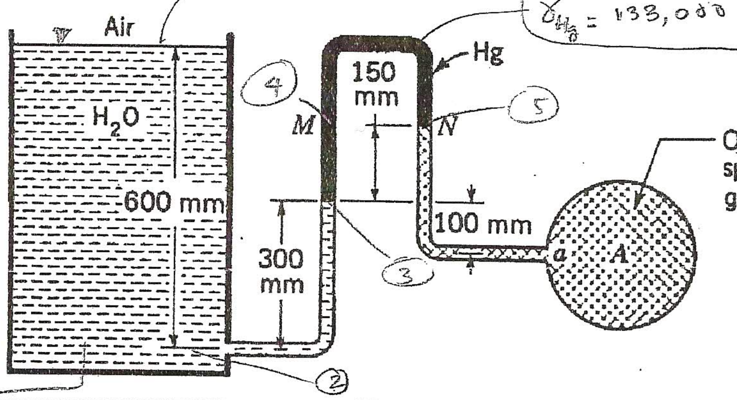


Figure 2.4
Inverted U-tube.

$P = -\gamma h$

Gage

$P_2 = P_1 + (.60m)(9790\ N/m^3)$ ($P_1 = 0$ (g))

$P_2 = 5874\ N/m^2$

$P_3 = P_2 - (.30m)(9790\ N/m^3)$

$= 5874 - 2937$

$P_3 = 2937\ N/m^2$

$P_4 = P_3 - (0.15\ m)(133,000\ N/m^3)$

$= 2937 - 19950$

$P_4 = -17013\ N/m^2$

$P_5 = P_4$

$P_a = P_5 + (.25\ m)(0.8)(9790\ N/m^3)$

$= -17013 + 1958$

$= -15055\ N/m^2$ (g)

$P_a = -15.055$ kPa (g) ✓

Absolute

$P_2 = P_1 + (.60m)(9790\ N/m^3)$

$= 101356.5 + 5874$

$P_2 = 107230.5\ N/m^2$

$P_3 = P_2 - (.30m)(9790\ N/m^3)$

$P_3 = 104293.5\ N/m^2$

$P_4 = P_3 - (0.15m)(133,000\ N/m^3)$

$P_4 = 84343.5\ N/m^2$

$P_5 = P_4$

$P_a = P_5 + (0.25m)(0.8)(9790\ N/m^3)$

$= 86301.5\ N/m^2$

$P_a = 86.302$ kPa (a) ✓