Solution:

$u = \frac{3}{4}y - y2$, $\frac{du}{dy} = \frac{3}{4} - 2y$

At y = 0.15 m , $\frac{du}{dy} = \frac{3}{4} - 2 \times 0.15 = 0.45$

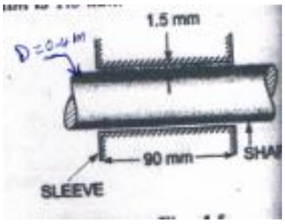
If $\mu = 8.5$ poise $= 0.85$ N .s / m^2

$\tau = \mu \frac{du}{dy} = 0.85 \times 0.45 = 0.3825$ N / m^2

Problem 1.13 /

The dynamic viscosity (μ) of an oil, used for lubrication between a shaft and sleeve is 6 poise. The shaft is of diameter 0.4 m and rotates (N) at 190 rpm. Calculate the power lost in a bearing for a sleeve length of 90 mm. The thickness of the oil film is 1.5 mm.

Solution:



$\mu = 6$ poise $= 0.6$ N.s / m^2

$u = r\,\omega = \frac{D}{2} \times \frac{2\pi N}{60} = \frac{\pi D N}{60} = \frac{\pi \times 0.4 \times 190}{60} = 3.98$ m/s

$\tau = \mu \frac{du}{dy} = 0.6 \frac{3.98}{1.5 \times 10^{-3}} = 1592$ N / m^2

$\tau = \frac{F}{A}$ (A is surface area)

$F = \tau A = \tau \times \pi D L = 1592 \times \pi \times 0.4 \times 90 \times 10^{-3} = 180.05$ N

$T = F \times \frac{D}{2}$ (T is Torque N.m)

$= 180.05 \times \frac{0.4}{2} = 36.01$ N.m

Power (lost) $= T\,\omega = 36.01 \times \frac{2\pi N}{60} =$ 716 48 watt.

Problem 1.14 /

The weight density (γ) of gas is 16 N/m^3 at 25°c and at an absolute pressure of 25 × 10^4 N/m^2. Determine the mass density (ρ) of gas and gas constant (R)?

Solution:

$T_{abs.}$ = 25 + 273 = 298° K

P = 0.25 × 10^6 = 25 × 10^4 N/m^2

γ = ρ g

$\rho = \frac{\gamma}{g} = \frac{16}{9.81} = 1.63\ kg/m^3$, $\frac{P}{\rho} = R\,T$, $R = \frac{p}{\rho\,T} = \frac{25\times10^4}{1.63\times298}$

= 532.5 N.m/kg.k

Problem 1.15 /

A cylinder of 0.6 m^3 in volume contains air at 50°c and P_1 is 30 × 10^4 N/m^2 absolute pressure. The air is compressed to 0.3 m^3. Find (1) pressure inside the cylinder, assuming isothermal process and (2) pressure and temperature, assuming adiabatic process. (Take 1.4).

Solution:

V_1 = 0.6 m^3 , T_1 = 50 +273 = 323° k, P_1 = 30× 10^4 N/m^2

V_2 = 0.3 m^3 , k = 1.4

(1) Isothermal process:

P V = constant

$P_1 V_1 = P_2 V_2$, $P_2 = \frac{p_1 V_1}{V_2} = \frac{30\times10^4\ \times0.6}{0.3}$ = 0.6 × 10^6 N/m^2

(2) Adiabatic process:

$P V^k$ = constant

$P_1 V_1^k = P_2 V_2^k$

$P_2 = P1\frac{V_1^k}{V_2^k} = 30\times10^4 \times \left(\frac{0.6}{0.3}\right)^{1,4} = 30\times10^4 \times 2^{1.4}$

$= 0.791\times10^6$ N / m^2

R T V^{k-1} = constant

T V^{k-1} = constant (R is constant)

$T_1 V_1^{k-1} = T_2 V_2^{k-1}$, $T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{1.4-1}$

$T_2 = 323 \left(\frac{0.6}{0.3}\right)^{0.4} = 323 \times 10^{0.4} = 426.2^o$ k

$T_2 = 426.2 - 273 = 153.2^o$c

<u>Problem 1.1</u>6 /

Determine the Bulk modulus of elasticity (K) of a liquid. If the pressure of the liquid increased from 70 N/cm^2 to 130 N/cm^2. The volume of the liquid decreases by 0.15 per cent (15%) .

<u>Solution</u>:

Increase of pressure (dP) = 130 - 70 = 60 N/cm^2

Decrease of Volume (dV) = 15 %

$K = \frac{dp}{\frac{dV}{V}} = \frac{60}{\frac{15}{100}} = 4 \times 10^4$ N / cm^2

<u>Problem 1.1</u>7 /

What is the Bulk modulus of elasticity of a liquid (K) which is compressed in a cylinder from a volume of 0.0125 m^3 at 80 × 10^4 N/m^2 pressure to a volume of 0.0124 m^3 at 150 × 10^4 N/m^2 pressure?

<u>Solution:</u>

d V = 0.0125 – 0.0124 = 0.0001 m^3

d P = 150 × 10^4– 80× 10^4 = 70 × 10^4 N/ m^2

$K = \frac{dP}{\frac{-dV}{V}} = \frac{70\times10^4}{\frac{0.0001}{0.0125}} = 70 \times 125 \times 10^4$ N/m^2

Problem 1.18 /

A surface tension of water in contact with air (σ) is 0.0725 N/m. The pressure inside a droplet of water is to be 0.02×10^4 N/m^2 greater than the outside pressure. Calculate the diameter of the droplet of water.

Solution:

$$P = 0.02 \times 10^4 \quad N/m^2$$

$$P = \frac{4\sigma}{d} \;,\quad d = \frac{4\sigma}{P} = \frac{4 \times 0.0725}{0.02 \times 10^4} = 0.00145 \text{ m} = 1.45 \text{ mm.}$$

Problem 1.19 /

Find the surface tension in a soap bubble (σ) of a 40 mm diameter, when the inside pressure is 2.5 N/m^2 above atmospheric pressure.

Solution:

$$P = \frac{8\sigma}{d} \quad , \quad \sigma = \frac{P\,d}{8} = \frac{2.5 \times 40 \times 10^{-3}}{8} = 0.0125 \text{ N/m}$$

Problem 1.20 /

The pressure outside the droplet of water of diameter 0.04 mm is 10.32 N/cm^2 (atmospheric pressure). Calculate the pressure within the droplet, if surface tension is given as 0.0725 N/m of water.

Solution:

$$P_{inside} = \frac{4\sigma}{d} = \frac{4 \times 0.0725}{0.04 \times 10^{-3}} = 7250 \text{ N/ m}^2 = 0.725 \text{ N / cm}^2$$

$$P_{outside} = P_{inside} + P_{atm.} = 0.725 + 10.32 = 11.045 \text{ N / cm}^2$$

Problem 1.21 /

Calculate the capillary effect in millimeter in a glass tube of 4 mm diameter, when immersed in (1) water, and (2) mercury. The values of the surface tension

of water and mercury are 0.073575 N/m and 0.51 N/m respectively. The angle of contact for mercury 1.30º.

Solution:

$$h = \frac{4\,\sigma\cos\theta}{\rho\,g\,d}$$

(1) For water rise, $h = \frac{4 \times 0.073575}{1000 \times 9.81 \times 4 \times 10^{-3}}$ **(Θ is zero)**

$$h = 7.51 \times 10^{-3}\ m = 7.51\ mm$$

(2) For mercury depression, $h = \frac{-4 \times 0.51 \times \cos 1.30^{o}}{13600 \times 9.81 \times 4 \times 10^{-3}}$

$$h = -2.46 \times 10^{-3}\ m = -2.46\ mm$$

Problem 1.22 /

Find the diameter of glass tube (capillary tube) that can be used to measure surface tension of water in contact with air as 0.073575 N/m.

Solution:

$$h = \frac{4\,\sigma}{\rho\,g\,d} \quad , \quad d = \frac{4\,\sigma}{\rho\,g\,h} = \frac{4 \times 0.073575}{1000 \times 9.81 \times 2 \times 10^{-3}}$$

$$= 0.015\ m = 1.5\ cm.$$