Example (1.2)

Determine the specific gravity of a fluid having viscosity of (4.0 c.poise) and kinematic viscosity of (3.6 c.stoke)

Solution

$$\mu = 4.0\ c.p\ \frac{poise}{100\ c.p} = 0.04\ poise = 0.04\ \frac{g}{cm.sec}$$

$$\boldsymbol{\nu} = 3.6\ c.stoke\ \frac{stoke}{100\ c.stoke} = 0.036\ stoke = 0.036\ \frac{\mathrm{cm}^2}{\mathrm{sec}}$$

$$\rho\ = \frac{\mu}{\boldsymbol{\nu}} = \frac{0.04\ \frac{g}{cm.sec}}{0.036\ \frac{\mathrm{cm}^2}{\mathrm{sec}}} = 1.1111\ \ \frac{g}{cm} \qquad ,\boldsymbol{SG_{liq}} = \frac{\rho_{liq}}{\rho_{water}} = \frac{1111.1\ \frac{\mathrm{kg}}{\mathrm{m}^3}}{1000\ (\frac{kg}{m^3})} = 1.1111$$

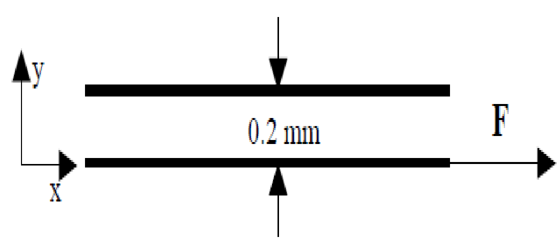
Example (1.3)

A flat plate of area $2x10^4$ cm^2 is pulled with a speed of 0.5 m/s relative to another plate located at a distance of 0.2 mm from it. If the fluid separated the two plates has a viscosity of (1.0 poise), find the force required to maintain the speed.

Solution

$$\mu = 1\ \mathrm{poise} = 1\ \frac{\mathrm{g}}{\mathrm{cm.sec}} * \frac{\mathrm{kg}}{1000\mathrm{g}} * \frac{100\mathrm{cm}}{\mathrm{m}} = 0.1\ \mathrm{pa.sec}$$

$$\frac{\mathrm{du}}{\mathrm{dy}} = \frac{0.5\ \mathrm{m/s}}{0.2 * 10^{-3}\mathrm{m}} = 2500\ \mathrm{s}^{-1}$$



$$\tau = \mu\ \frac{\mathrm{du}}{\mathrm{dy}} = 0.1\mathrm{pa.s} * 2500\mathrm{s}^{-1}\ = 250\mathrm{pa}$$

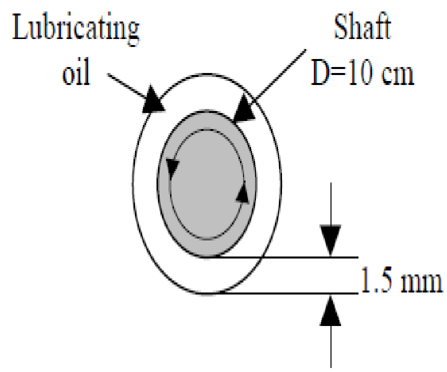
$$\mathrm{F} = \tau\ \mathrm{A} = 250\mathrm{pa} * 2\mathrm{m}^2 = 500\mathrm{N}$$

Example (1.4)

A shaft of diameter 10 cm having a clearance of 1.5 mm rotates at 180 rpm in a bearing which is lubricated by an oil of viscosity 100 c.p. Find the intensity of shear of the lubricating oil if the length of the bearing is 20 cm and find the torque.

Solution:

The linear velocity of rotating is



$$u = \pi DN = \frac{\pi(0.1m)(180rpm)}{60\ s/min} = 0.9425m/s$$

$$\mu = 100\ c.p = 1\ \frac{g}{cm.sec} * \frac{kg}{1000g} * \frac{100cm}{m}$$
$$= 0.1pa.sec$$

$$\tau = \mu\ \frac{du}{dy} = 0.1pa.s * \frac{\frac{0.9425m}{s}}{0.0015m} = 62.83pa$$

$$F = \tau\ A = 62.83pa * \pi DL = 62.83pa * \pi(0.1)(0.2)m^2 = 3.95N$$

The torque is equivalent to rotating moment

T=FR =F (D/2) =3.95N*(0.1/2)m=0.1975J

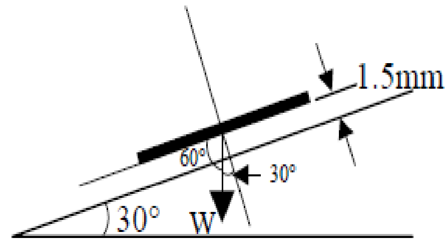
Example (1.5)

A plate of size 60 cm x 60 cm slides over a plane inclined to the horizontal at an angle of 30°. It is separated from the plane with a film of oil of thickness 1.5 mm. The plate weighs 25kg and slides down with a velocity of 0.25 m/s. Calculate the dynamic viscosity of oil used as lubricant. What would be its kinematic viscosity if the specific gravity of oil is(0.95)

Solution:

Component of W along the plane =W cos(60) =W sin(30)

= 25 (0.5) = 12.5 kg



F = 12.5 kg (9.81 m/s^2) =122.625 N

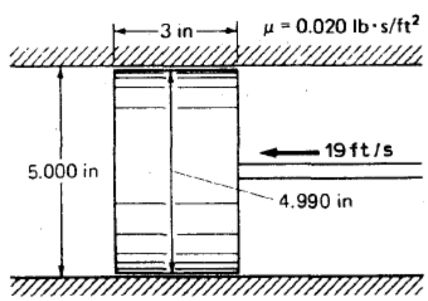
τ = F/A = 122.625 N/(0.6 x0.6) m^2 = 340.625 Pa

$$\mu = \frac{\tau}{\frac{du}{dy}} = \frac{340.625\ \text{pa}}{\frac{0.25\ \text{m/s}}{0.0015\ \text{m}}} = 2.044\ \text{pa.s} = 20.44\ \text{poise}$$

$$\nu = \frac{\mu}{\rho} = \frac{2.044\ \text{pa.s}}{950\ \text{kg/m}^3} = \frac{0.00215\text{m}^2}{\text{s}} = 21.5\ \ \text{stoke}$$

Example (1.6)

A piston is moving through a cylinder at speed of 19 ft/s as shown in figure below the film of oil separating the piston from cylinder has the a viscosity of 0.02 Ib.s/ft^2. What is the force required to maintain the motion.



Solution:

$$\tau = \mu\,\frac{du}{dr} = 0.02\ \text{Ib.s/ft}^2 * \frac{19\,\frac{\text{ft}}{\text{s}}}{\frac{5-4.99}{2}\ ft}\,(12) = 912\ \text{Ib/ft}^2$$

$$\text{F} = \tau\ \text{A} = 912 * \pi\text{DL} = \frac{912\ \text{Ib}}{\text{ft}^2} * \left[\pi\left(\frac{5}{12}\right)\left(\frac{3}{12}\right)\text{ft}^2\right] = 298\ \text{Ib}$$

<u>Example (1.7)</u>

Liquid benzene is flowing through a 30m long section of a 10 cm diameter copper tube at a rate of 5 m/s. Determine the flow rate of benzene, the mass flow rate, and the mass flux. The density of liquid benzene is ρ = 883 kg/m3.

$$\boldsymbol{A} \;=\; \frac{\pi}{4}\,(0.1)^2 = 0.000785\,m^2$$

$$\boldsymbol{Q} = \boldsymbol{uA} \;= 5 * \;0.000785 \;= 0.0393\,m^3/s$$

$$\boldsymbol{\dot{m} = Q\rho = 0.0393 * 883 = 34.657\ kg/s}$$

$$\boldsymbol{G} = \frac{\boldsymbol{\dot{m}}}{\boldsymbol{A}} = \quad \frac{34.657}{0.00785} \;= 4415\ kg/m^2.s$$