2) Velocity profile of a fluid over a plate is parabolic with vertex 20 cm from the plate. Where the velocity is 120 cm/s. Calculate the velocity and the shear stresses at a distance 0, 10, 20 cm from the plate, if the viscosity of fluid is 8.5 poise.

→ ∴ velocity profile is parabolic

$$u = Ay^2 + By + C \quad -(i)$$

$$\frac{du}{dy} = 2Ay + B \quad -(ii)$$

Now at $y = 0$, $u = 0$ ∴ $C = 0$ ∴ $u = Ay^2 + By \quad -(iii)$

at $y = 20$ cm, $u = 120$ cm/s and $\frac{du}{dy} = 0$

$$\Rightarrow \quad 120 = A(20)^2 + B \times 20$$

$$20A + B = 6 \quad -(iv)$$

from (ii):

$$0 = 40A + B \quad -(v)$$

from (v) & (iv)

∴ $B = 12$, $A = -3/10$

from (ii) $\frac{du}{dy} = -\frac{3}{5}y + 12 \quad -(vi)$

$\left(\frac{du}{dy}\right)_{y=0} = 12\,s^{-1}$, $\left(\frac{du}{dy}\right)_{y=10} = 6\,s^{-1}$, $\left(\frac{du}{dy}\right)_{y=20} = 0$

$\mu = 0.85$ N-s/m²

∴ shear stress, $\tau_{y=0} = 12 \times .85 = 10.20$ N/m²

$\tau_{y=10} = .85 \times 10 = 8.5$ N/m²

$\tau_{y=20} = .85 \times 0 = 0$ N/m²

4.) A space 25 mm wide between two large plane surfaces is filled with glycerine. What force is required to drag a very thin plate 0.75 m² in area between surfaces at a speed of 0.5 m/s,

i) if this plate remains equidistance from the two surface.

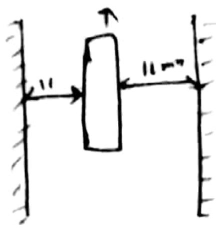
ii) If the plate is at a distance of 10 mm from the one of the surface.

Take $\mu = 0.785$ N-s/m²

→ distance bet. two surface = .025m
$\mu = 0.785$ N-s/m²
Velocity, $u = 0.5$ m/s
Relative velo. $du = 0.5$ m/s
(1)
Area, $A = 0.75 m^2$
$dy = 0.0125$ m
shear stress $= \mu \times \frac{du}{dy} = 0.785 \times \frac{0.5}{0.0125}$
$= 31.4$ N/m²
Force = shear stress × Area = 31.4×0.75
$= 23.55$ N
Total force, $F = 23.55 \times 2 = 47.1$ N

5.) A vertical gap 23.5mm wide of infinite extent contains oil of specific gravity 0.95 and viscosity 2.45 N-s/m². A metal plat of dimensions (1.5m X 1.5m X 1.5mm), weighing 49 N is to be lifted through the gap at a constant speed of 0.1 m/s. Estimate the force required to lift the plate. (Assume, the plate at middle position in gap).

→ middle gap = 23.5mm



Viscosity, $\mu = 2.45$ N-s/m²
specific gravity, $\rho = 0.95$
weight density of fluid = 0.95×1000
$= 829.5$ N/m³
Volume of plate = $1.5 \times 1.5 \times 0.0015$
$= 3.375 \times 10^{-3}$ m³

Thickness : 0.0015m
velocity : 0.1 m/s , weight = 49N
shear force on both side is same ,
$F_1 = F_2 = \mu \times \frac{du}{dy} \times \text{Area} = 2.45 \times \frac{.1}{0.011} \times 1.5 \times 1.5 = 50.11$ N
Total force, $F = 2 \times 50.11 = 100.22$ N

upward upthrust of liquid = weight of body

fluid displaced = volume of displaced fluid x weight density

$= 829.5 \times 3.375 \times 10^{-3} = 31.45 N$

Total force required = $100.22 + (49 - 31.45)$

$= 117.8 N$

7.) A 90N rectangular solid block slides down a 30° inclined plane. The plane is lubricated by 3 mm thick oil of viscosity 0.8 poise. If the contact area is $0.3 m^2$. estimate the terminal velocity of the block.

→ Data given:

weight, $w = 90N$

$\mu = .8 \ N\text{-}S/m^2$

area, $A = 0.3 m^2$

thickness of oil $dy = 0.003 m$

component of weight along slide = $W \sin 30 = 45N$

Thus the shear force F on the bottom of surface = 45N

Now, $F = \tau \times A$

$= \mu \times \frac{du}{dy} \times A \Rightarrow 45 = .8 \times \frac{du}{0.003} \times .3$

$du = 0.5625 m/s$

∴ Terminal velocity, $du = U = 0.5625 m/s$

8.) A 150mm diameter shaft motor at 1500 rpm in a 200mm long journal bearing diameter 150 mm. The uniform annular space between shaft and the bearing is filled with oil of dynamic viscosity 0.8 poise. Calculate the power required to rotate the shaf.

→ viscosity, $\mu = 0.08 \ N\text{-}s/m^2$

Tangential velocity of shaft, $v = r\omega = \frac{0.15}{2} \times 2\pi \times \frac{1500}{60}$

$= 11.78 m/s$

Change in velocity, $du = 11.78 m/s$

$dy = \frac{0.05m}{2}$

Shear force on shaft $= \mu \times \frac{du}{dy} \times A$

$= 0.08 \times \frac{11.78}{\frac{0.0005}{2}} \times \pi \times 0.15 \times 0.2$

$= 355.26 N$

$\therefore$ Power required $= F \times V$

$= F \times \omega \times r$

$= 4.185$ KW.

10.) A hydraulic ramp of 200 mm diameter and 1.2 m long moves with in a concentric cylindrical 200.2 mm diameter. The annular clearance is filled with oil of specific gravity 0.85 and Kinetic viscosity 400 mm²/s. What is the viscous force resisting the motion when the ramp moves at speed of 120 mm/s.

$dy = \frac{200.2 - 200}{2} = 1 \times 10^{-4} m$ $\quad \nu = 4 \times 10^{-4} m^2/s$

$\rho = 0.85 \times 10^3 \ Kg/m^2$

$du = 0.12 m/s$

$\mu = \nu \times \rho = 4 \times 10^{-4} \times .85 \times 10^3 = 0.34 \ N\text{-}s/m^2$

$\tau = \mu \frac{du}{dy} = .34 \times \frac{0.12}{1 \times 10^{-4}} = 408 \ N/m^2$

Shear force, $F = \tau \times A$

Now Area, $A = \pi D L = \pi \times \frac{200}{1000} \times 1.2$

$= 0.754 m^2$

$F = 408 \times .754 = 307.6 N$

$\therefore$ Viscous force, $F = 307.6 N$