Question 1 (Coutte flow)

- One of the plates must be stationary while the order tends to infinity.
- the flow must be laminar between the plates
- acceleration and pressure gradient are <u>zero</u>.

Question 1 (determination of the nature of flow)

- through the determination of it's Reynold's number
- presence of local acceleration
- ~~obe~~ whether the flow is rotational
-

Aerofoil	Hydrofoil
- Applies to air as medium in conserned	Applies to liquids (water) as medium in concern.

Question 1

$\mu = 0.9$ Centipoise

$b = 10mm = 0.01m$

$y = ?$

$U = 1 ms^{-1}$

$dx = 6mm$

$dp = 60 KN/m^2 = 60 \times 10^3 N/m^2$

(i) Velocity distribution

$$U = \frac{Uy}{b} - \left[\frac{1}{2\mu}\left(\frac{dp}{dx}\right)(by - y^2)\right]$$

$$U = \frac{1 \times y}{0.01} - \left[\frac{1}{2\times(0.9\times10^{-3})} \cdot \left(-\frac{60\times10^3 Nm^{-3}}{60m}\right) \cdot \left(0.01y - y^2\right)\right]$$

$$= 100y - [0.556\times10^3 \times -10^3 \times (0.01y - y^2)]$$

$$= 100y - [-5560y + (5.56\times10^5 y^2)]$$

$$= 5660y + (5.56y^2 \times 10^5)$$

$=$ ~~...~~ $+$ ~~...~~

(ii) Flow Rate $q = \frac{Ub}{2} - \frac{b^3}{12\mu}\left(\frac{dp}{dx}\right)$

$$= \frac{1\times0.01}{2} - \left[\frac{(0.01)^3}{12(0.9\times10^{-3})} \cdot \left(-\frac{60\times10^3}{60}\right)\right]$$

$$= 0.005 - [9.259\times10^{-5} \times -10^3]$$

$$= 0.005 + 9.259\times10^{-2}$$

$$= 0.005 + 0.0926$$

$$= 0.0976 m^3/s$$

(iii) Shear Stress distribution where $y = b$

$$= \frac{\mu U}{b} - \left[\frac{1}{2}\left(\frac{dp}{dx}\right) \cdot (b - 2y)\right]$$

$$= \frac{0.9(10^{-3})}{0.01} - \left[\frac{1}{2}\left[-10^3\right] \cdot (0.01 - 2y)\right]$$

$$= 0.09 - [0.5 \times -10^3 \times (0.01 - 2y)]$$

$$= 0.09 - [-5 + 10^3 y]$$

$$= 5.09 - 1000y = -4.91 Nm^{-2}$$

Question 2

17/eng06/013

$\mu = 0.9 Ns/m^2$

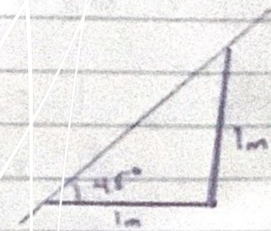
$\rho = 1260 Kg/m^3$

$U = -1.5 ms^{-1}$

$b = 0.01m$

$P_1 = 250kNm^{-2}$

$P_2 = 80kNm^{-2}$



$\sin 45° = 1/x$

$x = 1/\sin 45°$

$x = \sqrt{2}$

Solution

$P_1' = P_1 + \rho g h$

$= 250 \times 10^3 + (1260 \times 9.81 \times 1)$

$= 262.6 \times 10^3 Nm^{-2}$

$P_2' = P_2 + \rho g h$

$= 80 \times 10^3 + (1260 \times 9.81 \times 0)$

$= 80 \times 10^3$

$\delta p = 262.6 \times 10^3 - 80 \times 10^3$

$= 182.6 \times 10^3 Nm^{-2}$

Flow in downslope while Upper plate Moves UpSlope

$-\frac{\delta p}{\delta x} = \left(\frac{182.6 \times 10^3}{\sqrt{2}}\right)$

$\frac{\delta p}{\delta x} = -128.95 \times 10^3 Nm^{-3}$

(i) Velocity distribution

$$U = \frac{Uy}{b} - \left[\frac{1}{2\mu} \cdot \left(\frac{\delta p}{\delta x}\right) \cdot (by - y^2)\right]$$

$$= \frac{-1.5}{0.01} y - \left[\frac{1}{2(0.9)} \cdot \left(-128.95 \times 10^3\right)(0.01y - y^2)\right]$$

$$= -150y - [0.556 \cdot (-128.95 \times 10^3)(0.01y - y^2)]$$

$$= -150y - [-716.96y - 7.17 \times 10^4 y^2]$$

$$= -150y + 716.96y + 7.17 \times 10^4 y^2$$

$$= +566.96y + (7.17 \times 10^4)y^2$$

(ii) Stress (shear) distribution

$\tau =$ ~~...~~

where $U = 566y + 7.17 \times 10^4 y^2$

$$\frac{du}{dy} = 566 + 1.43 \times 10^5 y$$

$$\tau = \mu \left(\frac{du}{dy} \right)$$

$$\tau = 0.9(566 + 1.43 \times 10^5 y)$$

$$\tau = 509.4 + 1.287 \times 10^5 y$$

(iii) Max Velocity

U_{max} occurs at $du/dy = 0$

Substituting back into the previous equation

$$0 = 566.4 + 1.43 \times 10^5 (y)$$

$$y = -\frac{566.4}{1.43 \times 10^5}$$

$$y = -3.958 \times 10^{-3} m$$

Therefore

$$U_{max} = 566.96(y) + (7.17 \times 10^4)(y^2)$$

$$= -2.24 + 1.12$$

$$= -1.12 ms^{-1}$$

In the opposite direction of flow

(iii)

$$\tau = 509.4 + 1.287 \times 10^5 (-3.958 \times 10^{-3})$$

$$= 509.4 + (-509.39)$$

$$= 0.01 Nm^{-2}$$