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 ***17/ENG06/001***

**1a** **ANSWERS**

1. The three conditions for a coutte flow are:
2. **Pressure gradient is constant**
3. **The flow is uniform**
4. **The flow is steady**
5. Four (4) conditions that can be used to determine the nature of flow are given by Reynolds experiment as:
6. **The diameter of the pipe(m)**
7. **The density of the fluid passing through the pipe(kg/m3)**
8. **The viscosity of the fluid(Ns/m2)**
9. **The velocity of the flow(m/s)**
10. The differences between aerofoil and hydrofoils are enlisted below:

|  |  |
| --- | --- |
| AEROFOIL | HYDROFOIL |
| 1. The aerofoil is a lifting device mainly used in gaseous fluids(air in particular)
 | The hydrofoil is a lifting device mainly utilized in liquid fluids( water) |
| 1. The aerofoil is mainly used for lifting of airplanes and jets.
 | The hydrofoil is mainly used to overcome drag and make machines move with a higher velocity in water. |

**QUESTION 1b SOLUTION**

Given: µ= 0.9 centipoise= 0.9 x 10-2 poise = 0.9 x 10-3 Ns/m2

 U= 1m/s

 b= 10mm=0.01m

 dp= 60KN/m2

 dx= 60m

therefore the pressure difference gradient is = $\frac{∂p}{∂x}$ = $\frac{-60000}{60}$= -1 x 103 N/m3

1. **Velocity distribution**= u = $\frac{U\_{y}}{b}-\frac{1}{2μ}\left(\frac{∂p}{∂x}\right)\left(by-y^{2}\right)$

 u =100y + 5555.56y – 555555.56y2

 u = (5.65556 x 103 )y – (5.556x 105 ) y2

1. **Discharge per unit width** = q= $\frac{Ub}{2}-\frac{b^{3}}{12μ}\left(\frac{∂p}{∂x}\right)$

 q = 0.005 + 0.09259 = 0.09759 m3/s/m

1. **Shear stress at upper plate** is @y=b,

 τ = $\frac{μU}{b}-\frac{1}{2}\left(\frac{∂p}{∂x}\right)\left(b-2y\right)$

 = τ = $\frac{μU}{b}-\frac{1}{2}\left(\frac{∂p}{∂x}\right)\left(-b\right)$

 τ = 0.09-5 = - 4.91 N/m2

**QUESTION 2 SOLUTION**

Given: µ= 0.9Ns/m2 b= 10mm=0.01m

 ρ= 1260kg/m3 P1= 250KN/m2

 U= -1.5m/s P2= 80KN/m2

$\frac{∂p}{∂x}$ = $\frac{-(P.1-P.2)}{Δx}$

But P.1= P1 + ρgz (piezometric)

 = 250000 + (1260) \*(9.81) \*(1)

 = 262.36KN/m2

And P.2= P2 + ρgz (piezometric)

 = 80000 + (1260)\*(9.81)\*(0)

 = 80KN/m2

$$Δx$$

1m

1m

Because the two plates are aligned at an angle of 45 degrees, the above diagram can be used to calculate the change in x

***By Pythagoras theorem,***

$Δx$ = $\sqrt{1^{2}+1^{2}}$ = $\sqrt{2}$ m

Therefore,

 $\frac{∂p}{∂x}$ = $\frac{-(P.1-P.2)}{Δx}$ = $\frac{-\left(262⋅36-80\right)}{\sqrt{2}}$ = -128.948KN/m3

1. ***Velocity distribution***= u = $\frac{U\_{y}}{b}-\frac{1}{2μ}\left(\frac{∂p}{∂x}\right)\left(by-y^{2}\right)$

 u = -150y + 716.38y – 71637.8$y^{2}$

 u = -(7.16378 x 104 )$y^{2}$ + 565.62y

1. ***Shear distribution***= τ = $\frac{μU}{b}-\frac{1}{2}\left(\frac{∂p}{∂x}\right)\left(b-2y\right)$

 τ = -135 + 644.74 – 128948y

 τ = 509.74 – (1.289 x 105 )y

1. **Maximum flow velocity**

At maximum flow velocity, $\frac{∂u}{∂y}=0$

0= -(1.4328 x 105 )y + 565.62

y= 3.9476 x 10-3 m

umax= -(7.16378 x 104 )$(3.9476 x 10-3 )^{2}$ + 565.62(3.9476 x 10-3)

umax= 1.12 m/s

1. Shear stress at upper plate is @y=b

Therefore, τ = 509.74 – (1.289 x 105 )y

 τ = 509.74 – (1.289 x 105 )( 0.01)

 τ = -779.26 N/m2