CEN 212 FLUID MECHANICS

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MOMENTUM BALANCE

- SHELL MOMENTUM BALANCES and VELOCITY DISTRIBUTIONS IN LAMINAR FLOW

In order to obtain a velocity profile in flow systems, a momentum balance shall be made on a volume element, in which momentum enters and leaves the system by;

a. Convection: from flow of the bulk fluid

b. Molecular transport: as a result of velocity gradients (viscous action)

MOMENTUM BALANCE

Rate of momentum in by convective transport - Rate of momentum out by convective transport + Rate of momentum in by molecular transport

- Rate of momentum out by molecular transport + Sum of forces acting on the system

= Rate of momentum accumulation

$\tau . S$

$m.V$

Pressure force

Gravitational force

= O under steady state

MOMENTUM BALANCE

- In order to set up and solve viscous problems

a. A momentum balance over a thin shell should be written.

b. The differential equation for the momentum flux should be written.

c. Newton’s Law of Viscosity should be inserted to obtain a diferential equation for the velocity

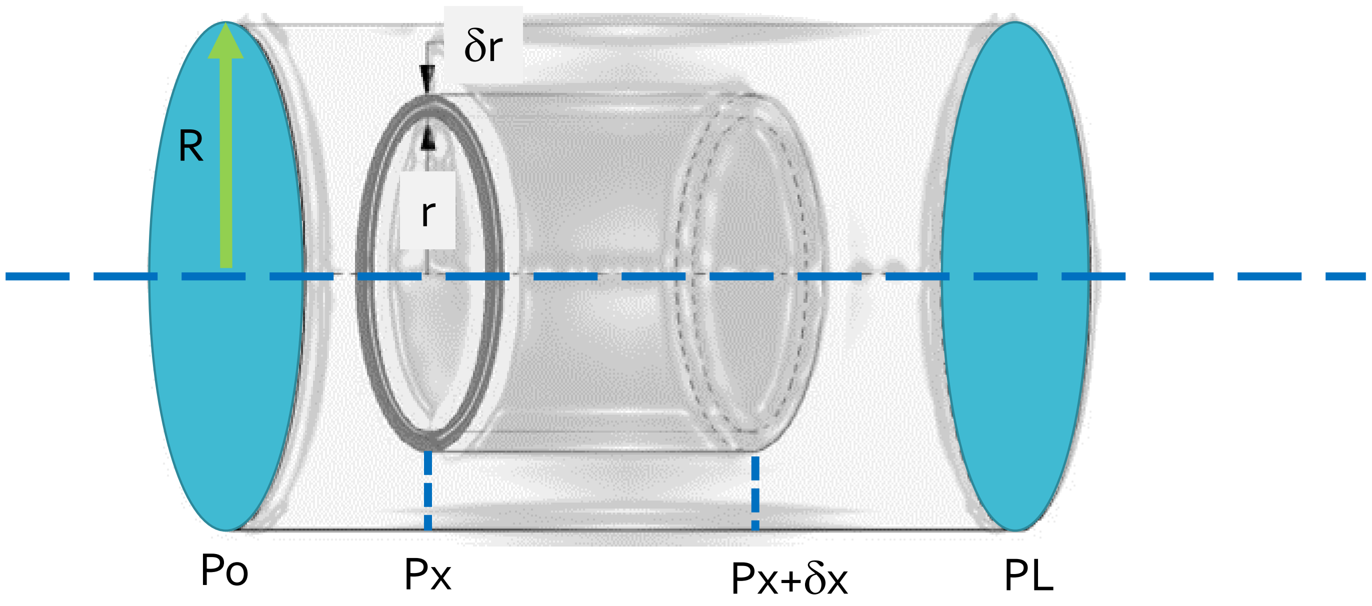
d. This equation should be solved by using boundary conditions.

MOMENTUM BALANCE

- Boundary conditions are statements about the velocity or stress at the boundaries of the system. The most commonly used boundary conditions are:

a. At solid-liquid interface, te velocity of the fluid equals the velocity of the solid surface tangential to the fluid.
b. At liquid-liquid interface, momentum transport nad velocity perpendicular to the interface is constant.
c. At gas-liquid interface momentum transport is taken to be zero.

MOMENTUM BALANCE



Assumptions:

a. One-dimensional laminar flow
b. Newtonian fluid
c. End-effects are ignored
d. Steady-state

MOMENTUM BALANCE

- Total momentum balance equation:
- $\tau rx.2\pi r\Delta x\Big|_{r} - \tau rx.2\pi r\Delta x\Big|_{r+\Delta r} + \rho V_x^2.2\pi r\Delta r\Big|_{x} \rho V_x^2.2\pi r\Delta r\Big|_{x+\Delta x} +$

$$P2\pi r\Delta r\Big|_{x} - P2\pi r\Delta r\Big|_{x+\Delta x} = 0$$

MOMENTUM BALANCE

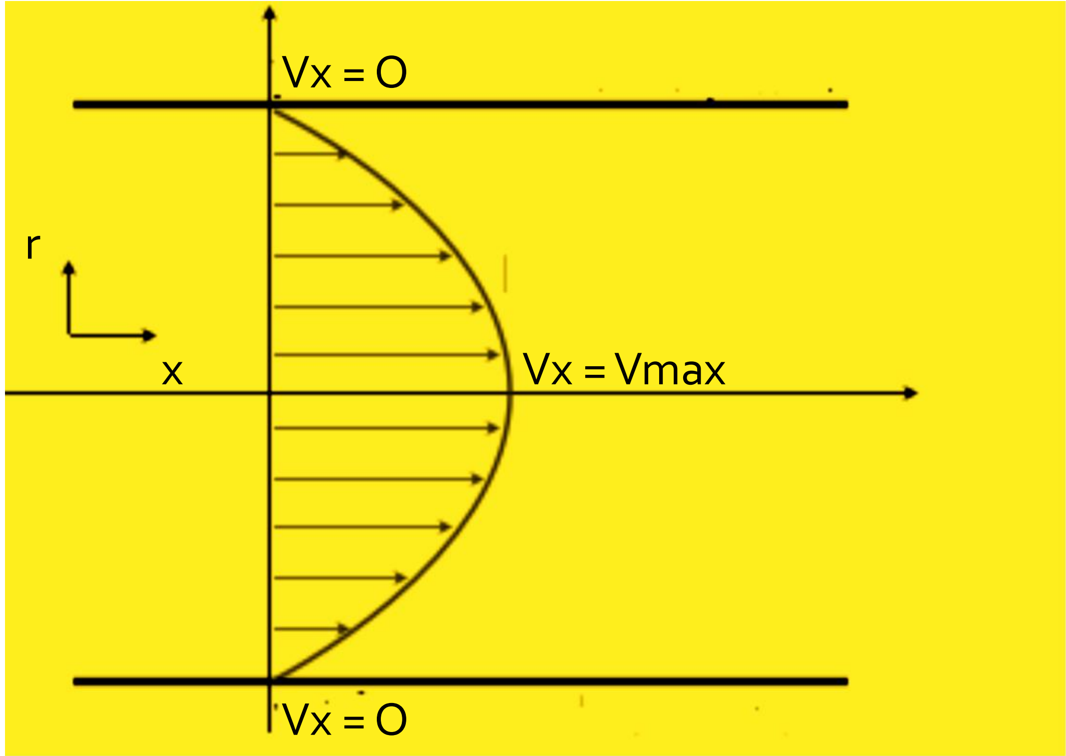
$$Vx = \frac{\Delta P}{\mu L}\frac{r^2}{4} + c1lnr + C2$$

Boundary conditions are:

1. r=R Vx=O
2. R=O Vx=Vmax

MOMENTUM BALANCE

- $Vx = \frac{(Po - PL)}{4\mu L} . R^2 (1 - (\frac{r}{R})^2)$



MOMENTUM BALANCE

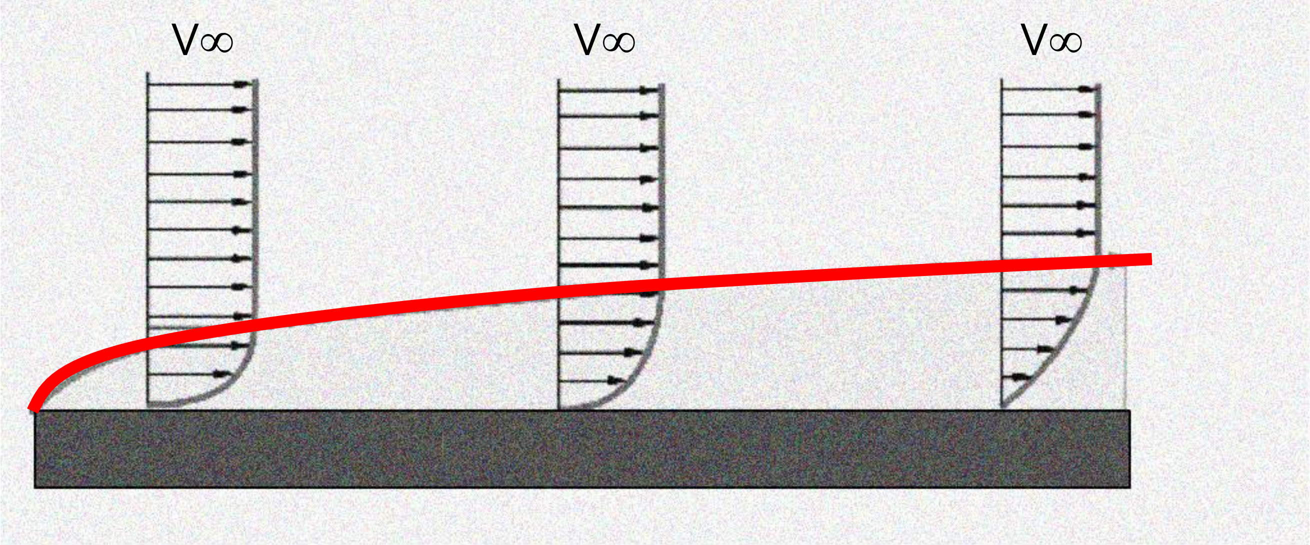
HAGEN-POISEUILLE EQUATION;

$$Vx = \frac{(Po - PL)D^2}{32\ \mu L}$$

gives the pressure drop because of friction in laminar flow through a horizontal pipe. One of its uses is in the experimental measurement of viscosity

BOUNDARY LAYERS

- A Boundary Layer is defined as that part of a moving fluid in which the fluid motion is influenced by the presence of a solid boundary.



BOUNDARY LAYERS