UNIT - III

Dynamics of fluid flow

→ The velocity and acceleration at a point in a fluid flow. without taking in to consideration the forces causing to flow

→ The chapter includes to study of force causing fluid flow; the dynamics of fluid flow is the study of fluid motion with the force

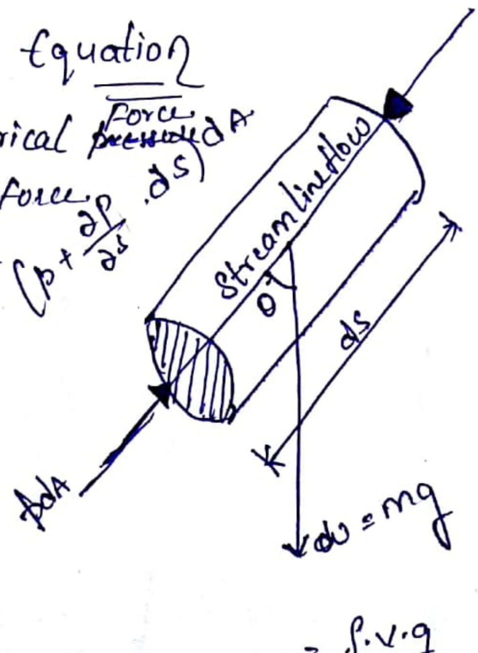
→ The dynamic behaviour of fluid flow is analysed by the Newton's second law of motion, which relation relates the acceleration with the force

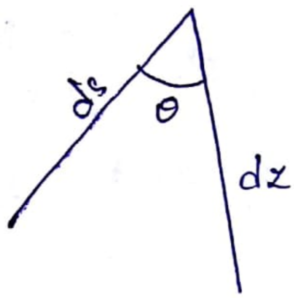
$\rho = \frac{m}{v}$

$\rho \cdot v = m$

Eluer's Equation

1. Geomentrical Force dA
2. pressure Force
3. and some External forces





$\cos\theta = \frac{dz}{ds}$

$= \rho \cdot v \cdot g$

$w = \rho \cdot dA ds \cdot g$

$F = m \cdot a$

$p\,dA - \left(p + \frac{\partial p}{\partial s} \cdot ds\right) dA - \rho\, dA\, ds \cdot g \cos\theta = ma$

$$a = \frac{dv}{dt}$$

$$= \frac{dv}{dt} + \frac{dv}{ds}\frac{ds}{dt}$$

$\therefore \frac{dv}{dt} = 0$

$\frac{ds}{dt} = v$

$$a = v \cdot \frac{dv}{ds}$$

$\left(p + \frac{\partial p}{\partial s} \cdot ds\right) dA$

$p\,dA - \left(p + \frac{\partial p}{\partial s} \cdot ds\right) dA - \rho\, dA\, ds \cdot g\cos\theta = \rho\, dA\, ds \cdot v \frac{dv}{ds}$

$p\,dA - p\,dA - \frac{\partial p}{\partial s}\, ds\, dA - \rho\, dA\, ds\, g\, \frac{\partial z}{\partial s} = \rho\, dA\, ds \cdot v \frac{dv}{ds}$

$$= \frac{-\frac{\partial p}{\partial s}\, ds\, dA - \rho\, dA\, ds\, g \frac{dz}{ds}}{\rho\, dA\, ds} = v \frac{dv}{ds}$$

dividing $\rho\, dA\, ds$ on both side

$$= \frac{-\frac{\partial p}{\partial s}\, ds\, dA}{\rho\, dA\, ds} - \frac{\rho\, dA\, ds}{\rho\, dA\, ds} \cdot g \frac{dz}{ds} = v \cdot \frac{dv}{ds}$$

$$= -\frac{\partial p}{\partial s} \frac{1}{\rho} - g \frac{\partial z}{\partial s} = v \cdot \frac{\partial v}{\partial s}$$

$$= -\frac{\partial p}{\rho} - g\, \partial z = v \cdot dv$$

$$\frac{dp}{\rho} + g\, dz + v \cdot dv = 0$$

z - datum line

the height of the fluid from level of the surface

$\frac{\partial p}{\rho} + g\,dz + v\,dv = 0$

Bernoulli's Equation :-

pressure head

kinetic Energy head and

datum line head :

Bernoulli's Equation is derived from Euler's Equation by Applying integral

$$\left[\frac{dp}{\rho} + g \cdot dz + v \cdot dv = 0\right]$$

$$\int \frac{dp}{\rho} + \int g \cdot dz + \int v \cdot dv = \text{constant}$$

$$\frac{1}{\rho} \int dp + g \int dz + \int v \cdot dv = \text{constant}$$

$$\frac{1}{\rho} \cdot p + g \cdot z + \frac{v^2}{2} = \text{constant}$$

$$\frac{p}{\rho} + g \cdot z + \frac{v^2}{2} = \text{constant}$$

dividing 'g' on both sides

$$\boxed{\frac{p}{\rho g} + z + \frac{v^2}{2g} = \text{constant}}$$

z - datum line → The height of the liquid level of the surface

Problem :-

1. Water is flowing through a pipe of 5cms in diameter under a pressure of 29.43 N/cm^2 (guage pressure) and with a mean velocity 2m/sec Find the total head (or) ~~total energy~~ per unit weight of water at a cross section which is 5m above the dattum line

Sol:- given:-

diameter (d) = 5cm → $\frac{5}{100}$ = 0.05m

pressure (p) = 29.43 N/cm^2 → $29.43 \times 10^4\ N/m^2$

velocity (v) = 2m/sec

above the dattum line (z) = 5m

$1(cm)^2 = (10^{-2}m)^2$
$10^{-4}m^2$

acceleration (g) = 9.81

pressure head = $\frac{p}{\rho g} = \frac{29.43 \times 10^4}{1000 \times 9.81} = \frac{294,300}{9,810}$

= 30 M

Kinetic head = $\frac{v^2}{2g} = \frac{2 \times 2}{2 \times 9.81}$ = 0.2 M

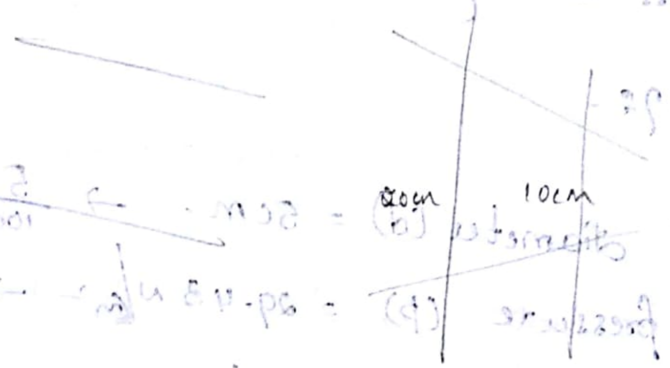
Total head = k.h + p.h + d.h

= 0.2 + 30 + 5

Th = 35.2 M.

2. A pipe through which water is flowing is having the diameter 20cm and 10 cm at the cross section ① & ② respectively the velocity of water at sec ① the velocity of water at section at 4.0 m/sec section ① & ② and the rate of discharge (Q)

Sol:- given:-



$d_1 = 20cm = \frac{20}{100} = 0.02 m$

$d_2 = 10cm = \frac{10}{100} = 0.10 m$

velocity $(v_1) = 4 m/sec$

velocity $(v_2) = ?$

rate of discharge $(Q) = ?$

$Q = A_1 V_1 = A_2 V_2$

$V_2 = \frac{A_1 V_1}{A_2}$

$A_1 = \pi/4 (d)^2$

$= \frac{3.14}{4} (0.2)^2$

$= 0.0314$

$V_2 = \frac{(0.0314)(4)}{0.0078}$

$V_2 = 16.10 m$

$A_2 = \pi/4 (d_2)^2$

Rate of discharge (Q) = $A_1 \times V_1$

$= 0.0314 \times 4$

$= 0.1256\,m$

$= \frac{3.14}{4}(0.10)^2 = 0.0078$

Rate of discharge (Q) = $A_2 \times V_2$

$= 0.0078 \times 16.10$

$= 0.12558\,m$