

for steady flow  $\frac{\partial \rho}{\partial t} = 0$

$$\rho \left( \frac{u_r}{r} + \frac{\partial u_r}{\partial r} \right) + \rho \cdot \frac{\partial u_\theta}{\partial \theta} \cdot \frac{1}{r} = 0$$

$$= \frac{u_r}{r} + \frac{\partial u_r}{\partial r} + \frac{1}{r} \cdot \frac{\partial u_\theta}{\partial \theta} = 0$$

$$= u_r + r \cdot \frac{\partial u_r}{\partial r} + \frac{\partial u_\theta}{\partial \theta} = 0$$

$$= \frac{\partial (r \cdot u_r)}{\partial r} + \frac{\partial (u_\theta)}{\partial \theta} = 0$$

$$\Rightarrow \frac{\partial (r u_r)}{\partial r} = u_r + \frac{\partial u_r}{\partial r} \cdot r$$

This is the continuity eq<sup>n</sup> in polar coordinate in two dim<sup>n</sup> flow

\* Velocity Potential function :- It is defined as the scalar function of space and time such that its ~~gives the -ve derivative~~ derivative of w.r.t ~~time~~ any direction gives the velocity in that direction. It is denoted by  $\phi$ .  $\phi = f(x, y, z)$

$$u = - \frac{\partial \phi}{\partial x}$$

$$v = - \frac{\partial \phi}{\partial y}$$

$$w = - \frac{\partial \phi}{\partial z}$$

for Polar coordinates

$$u_r = \frac{\partial \phi}{\partial r}$$

$$u_\theta = \frac{1}{r} \cdot \frac{\partial \phi}{\partial \theta}$$

Laplace Eq<sup>n</sup> for steady flow

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} + \frac{\partial^2 \phi}{\partial z^2} = 0$$