Dimensionless number

Dimensionless numbers are those which are obtained by dividing the inertia force by viscous force, gravity force, pressure force or surface tension force or elastic force.

1 Reynold's Number :-

it is the ratio of inertia force of flowing fluid and the viscous force

F_i (inertia force) = mass × Acceleration

$= \rho \times \text{volume} \times \frac{\text{velocity}}{\text{time}}$

$= \rho \times AV \times V$

$= \rho AV^2$

viscous force = Shear Stress × Area

$= \tau \times A$

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

$= \mu \cdot \frac{V}{L} \cdot A$

$$Re = \frac{\rho V L}{\mu} = \frac{V \times L}{\nu}$$

for pipe flow, the linear dimension L is taken as dia d

$$Re = \frac{\rho V d}{\mu}$$

Froude's Number →

$$\sqrt{\frac{\text{inertia force}}{\text{gravity force}}}$$

$$F_r = \sqrt{\frac{\rho A V^2}{\rho A L g}} = \sqrt{\frac{V^2}{Lg}}$$

$$F_r = \frac{V}{\sqrt{Lg}}$$

$$\left\{ \begin{aligned} F_g &= \rho \times V \times g \\ &= \rho \times L^2 \times L \times g \\ &= \rho \times A \times L \times g \end{aligned} \right\}$$

~~Euler's~~ weber's Number (Eu)

~~note~~ $$Eu = \sqrt{\frac{\text{inertia force}}{\text{Surface tension force}}}$$

$$F_i = \rho A V^2$$

F_s = Surface tension force = Surface tension/L × Length
= $\sigma \times L$

$$W_e = \sqrt{\frac{\rho A V^2}{\sigma \times L}} = \sqrt{\frac{\rho \times L^2 \times V^2}{\sigma \times L}} = \frac{V}{\sqrt{\sigma/\rho L}}$$

$$We = \frac{V}{\sqrt{\frac{\sigma}{\rho L}}}$$

Euler's ~~Weber's~~ number :-

$$\sqrt{\frac{\text{inertia force}}{\text{Pressure force}}}$$

$F_i = \rho A V^2$

$F_p = p \times A$

$$E_u = \sqrt{\frac{\rho A V^2}{p \times A}} = \sqrt{\frac{V^2}{p/\rho}}$$

$$E_u = \frac{V}{\sqrt{\frac{p}{\rho}}}$$

Mach's Number (M) →

$$M = \sqrt{\frac{\text{inertia force}}{\text{Elastic force}}}$$

$F_i = \rho A V^2$

F_e = Elastic force = Elastic Stress × Area

$= K \times A \quad = K \times L^2$

$$M = \sqrt{\frac{\rho A V^2}{K \times L^2}} = \frac{V}{\sqrt{K/\rho}} \qquad \sqrt{\frac{K}{\rho}} = C$$

$$M = \frac{V}{C}$$