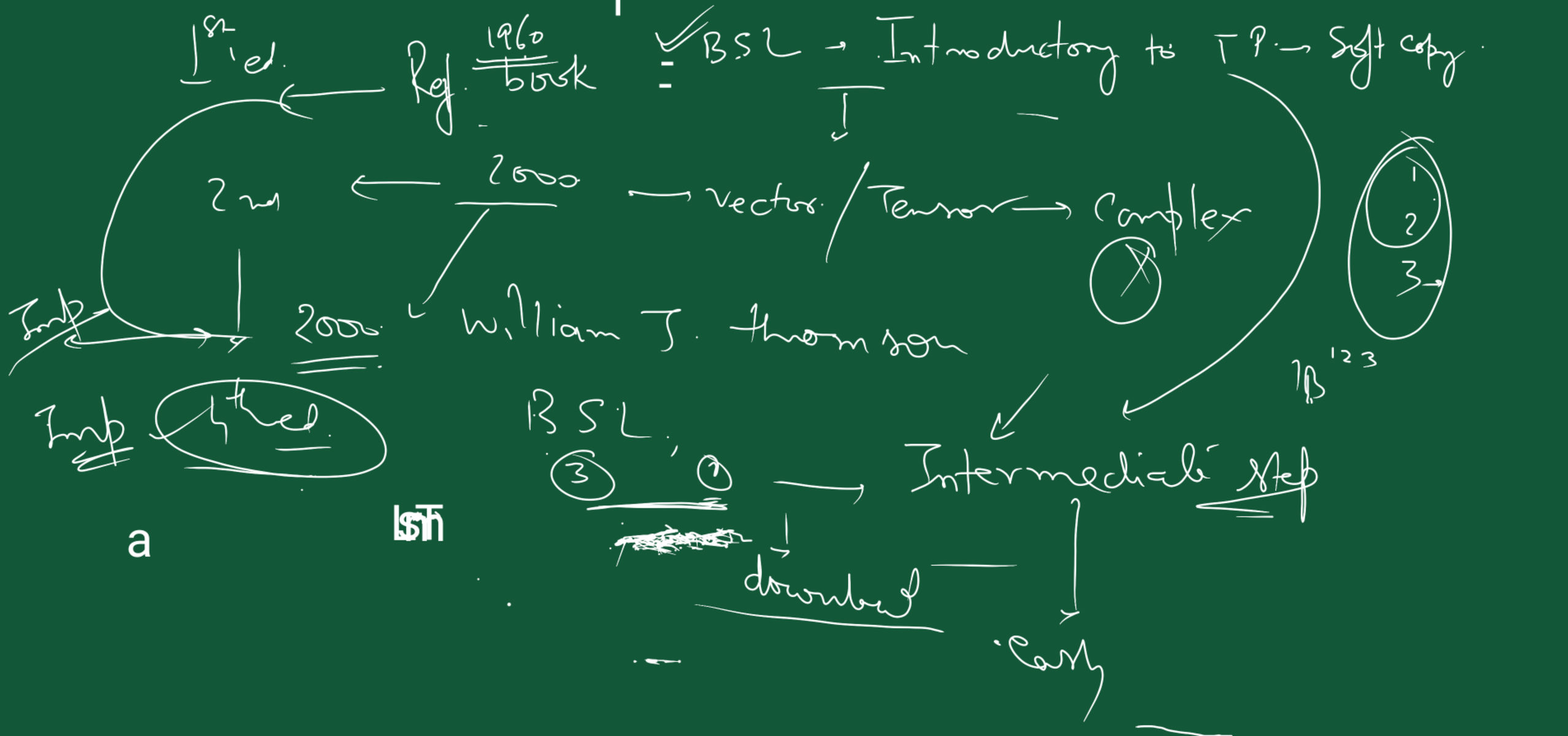
Transport Phenomena



Phenomenological law

↓

Fundamental law ⟶ Molecular level

① Mass → Fick law = $J = -D \frac{dC}{dx}$ (flux)

② Energy — Fourier law → $q_x = -k \frac{dT}{dx}$ (flux)

③ Momentum — Newton's law $\tau = -\mu \frac{dv}{dx}$ (flux)

trans. Analogy

Analogy

Application

Profile of any one

eg, T, C, v

$$\text{Flux} = \frac{\text{Driving force (gradient)}}{\text{Resistance}} = \frac{1}{\text{Conductance}}$$

$$q_x = \frac{\frac{dT}{dx}}{\frac{1}{k}} = k\frac{dT}{dx}$$

$\frac{dT}{dx}$ → unit-

$\frac{1}{k}$ → unit

True Analogy → unit- wise it should be same

$J = D\frac{dC}{dz}$ → Conc → $\frac{mol}{V}$

dz → dist

diffusivity → $\frac{m^2}{s}$

$q = \frac{k}{\rho C_p}\frac{d(\rho C_p T)}{dx}$

Thermal diffusivity = $\frac{k}{\rho C_p}$ → $\frac{m^2}{s}$

$\frac{d(\rho C_p T)}{dx}$

$\frac{m C_p T}{V} = \rho C_p T$ → unit of energy

$= \alpha\frac{d\rho C_p T}{dx}$

$\tau = \frac{\mu}{\rho}\frac{d(\rho v)}{dx}$

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

momentum flux → $\tau = \nu\frac{d(\rho v)}{dx}$ → $\frac{m}{s}$

Fluid Mechanics

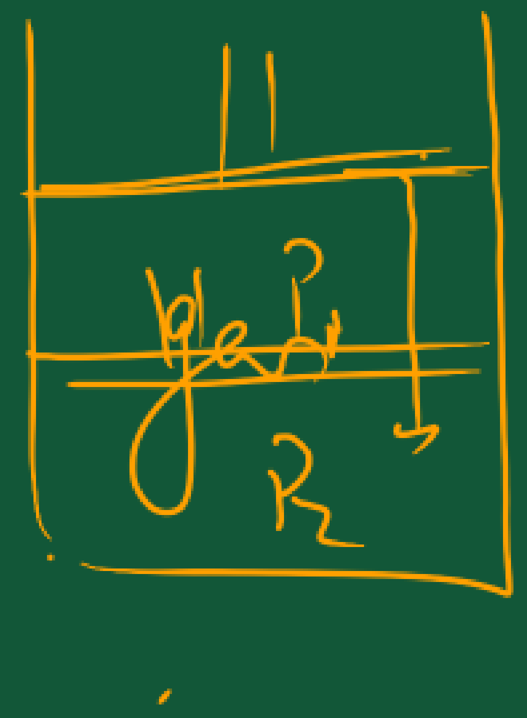
Classification of fluid

Ideal fluid

fluid   X   l

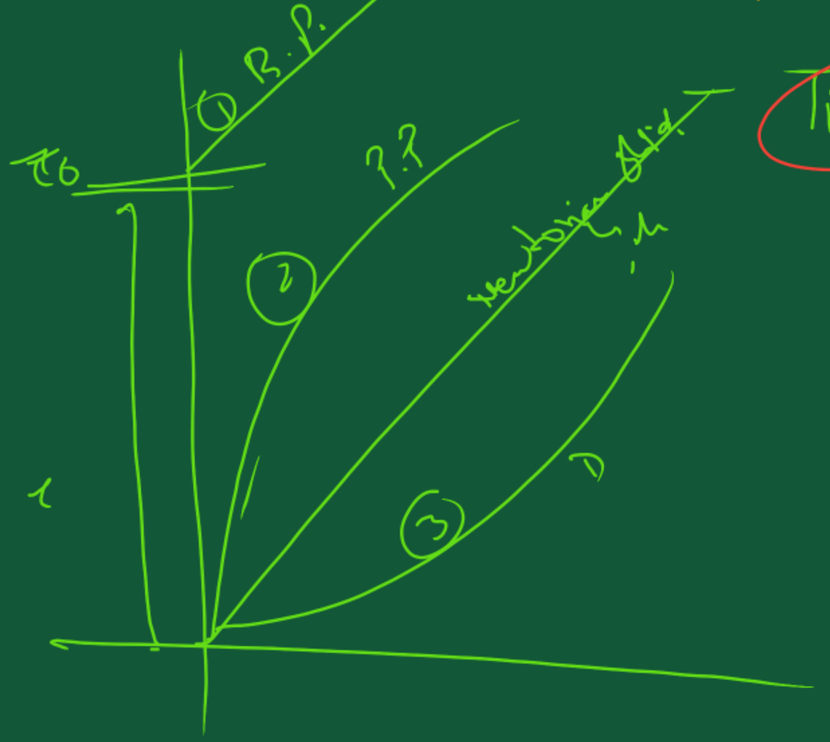
liq

- Incompressible
- No viscosity
- No surface tension



- Compressible fluid
- Incompressible fluid - Ideal
- Newtonian fluid
  - Kerosene, alcohol, Benzene
- Non-Newtonian fluid

Non Newtonian fluid



Time independent. Ex-?

① – Bingham plastic → Shear Stress is independent

② – Pseudo Plastic → Shear thining.

③ – Dialatent – Shear thicking

Time dependent

- Thixotropic → Paint $\tau \uparrow$ $\mu \downarrow$
- Rheopectic → Gypsum $\tau \uparrow$ $\mu \uparrow$

$\frac{dv}{dx}$

M
E
M

Transport- Comes in three section.

Analysis
- Micro → Molecular level / Transport — Molecule level / Molecule → Viscous force
- Intermediate → Convective transport- — Bulk. level. / Inertial force
- Macro → Macroscopic — Bulk body → gravity

$\frac{d\tau}{dx}$

τ_1 τ_2

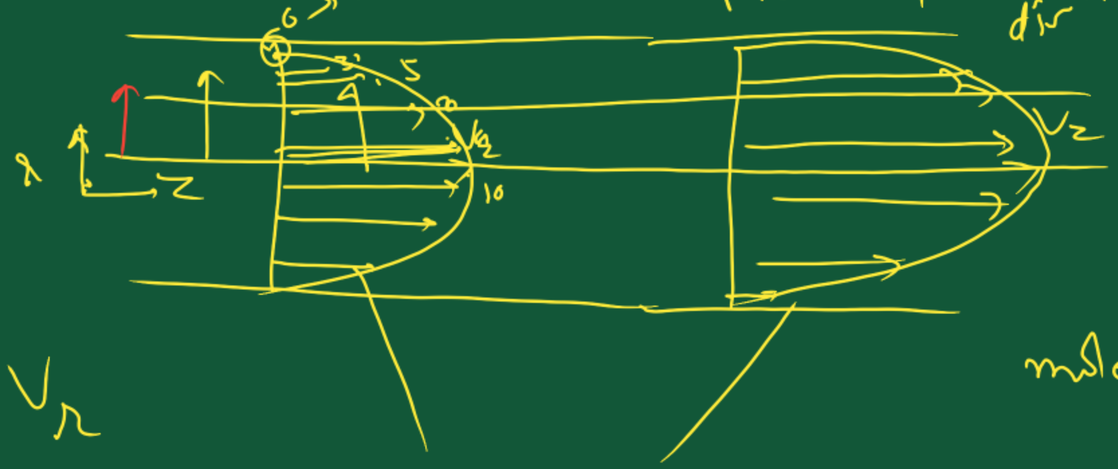
mg

x, y, z

Viscous force > Inertial force

$\therefore$

Distinction b/w Convective and Molecular Momentum Transport



Same profile

V_z

Fully developed flow

Molecular Transport

z - dir

V_z is const

$\frac{dV_z}{dz} = 0$

Molecular Mom = 0

V_z is const. w.r.to z

Convection flow ⇒ ✓

r dir^n

V_z is varying with r.

$\frac{dV_z}{dr} \neq 0$

molecular momentum = ✓

Convective momentum ✗