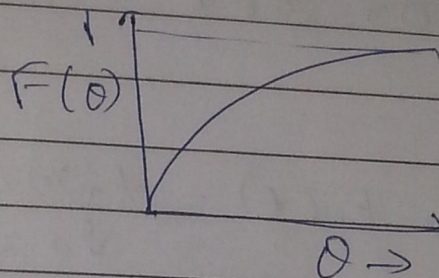
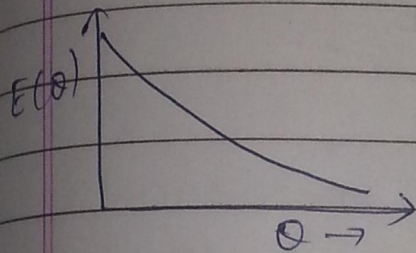


$$E(\theta) = \exp(-\theta) = \tau E(t)$$

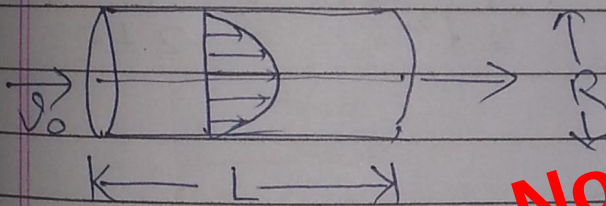
$$F(\theta) = \int_0^\infty E(\theta) d\theta = 1 - \exp(-\theta)$$



$$t_m = \tau$$

$$\sigma^2 = \tau^2 \Rightarrow \sigma = \tau$$

Laminar flow reactor $\rightarrow$



$$U = 2u_{avg} \left(1 - \frac{r^2}{R^2}\right), \quad u_{avg} = \frac{v_0}{\pi R^2}$$

Time that is spent by any fluid particle at 'r' $\rightarrow$

$$t(r) = \frac{L}{U(r)} = L \left(\frac{\pi R^2}{v_0} \cdot \frac{1}{2(1 - r^2/R^2)} \right)$$

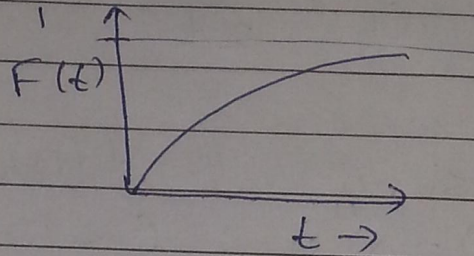
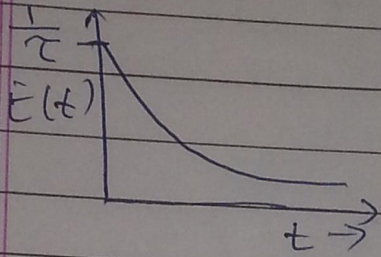
$$\Rightarrow t(r) = \frac{\tau}{2(1 - (r/R)^2)} \quad \text{--- (1)}$$

vol. flow rate b/w r and r+dr $\rightarrow$
 $dV = U(r) \cdot 2\pi r dr$

$\Rightarrow$ Fraction of total fluid through dr $\rightarrow$
 $\frac{dV}{V_0} = \frac{U(r) \cdot 2\pi r dr}{V_0} = E(t) dt$
 fraction whose res. time is b/w t & t+dt.

Teacher Signature

Diffⁿ CSTR operations: →
 a) Perfect (P) → ideal CSTR



As $\tau \uparrow \uparrow$, slope will decrease slowly.

b) Bypassing (BP) →

v_b → bypass vol. flow rates

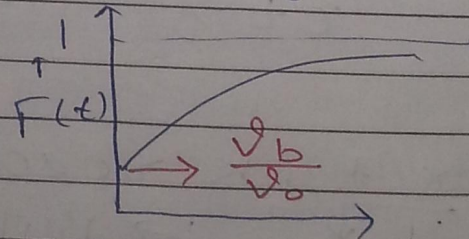
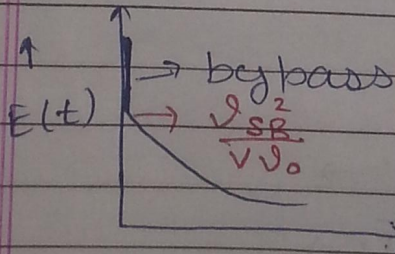
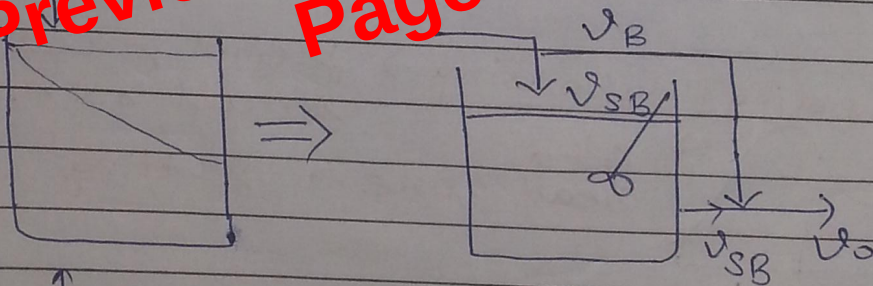
v_{sb} → enters system vol.

$$v_o = v_b + v_{sb}$$

→ Since, $v_{sb} < v_o \Rightarrow \tau_{sb} > \tau$

⇒ $C(t)$ or $E(t)$ decays slowly

$$E(t) = \frac{v_b}{v_o} \delta(t) + \frac{v_{sb}}{v_o} \left(\exp\left(-\frac{t}{\tau_{sb}}\right) \right)$$



c) Dead volume (DV) →

decays faster.

→ No bypassing

v_D → dead volume ($\tau_{sD} < \tau$)

v_{sD} → enters system vol.

Teacher Signature _____

$$\Rightarrow \frac{dC_A(d)}{dd} = -\delta_A + (C_A - C_{A0}) \frac{E(d)}{1-F(d)}$$

$$\text{or } \frac{dX}{dd} = \frac{\delta_A}{C_{A0}} + \frac{E(d)}{1-F(d)} \cdot X$$

To calculate X for max. mixedness model, integrate by starting from large d & move backward till $d=0$.
 → For $n > 1$, max. mixedness model gives lower bound on conversion.

Multiple Reactions: → $A+B \rightarrow \text{reactant}$
 Segregation Model

Each globule → diffn concn
 $\bar{C}_A = \int_0^\infty C_A(t) \cdot E(t) dt$

$\bar{C}_B = \int_0^\infty C_B(t) \cdot E(t) dt$ batch reactor.

$\frac{dC_A}{dt} = -\delta_A$ → no occ. simultaneously
 $\frac{dC_B}{dt} = -\delta_B = \sum_{i=1}^n \delta_{iB}$

Maximum mixedness model: →

$$\frac{dC_A}{dd} = -\sum_{i=1}^n \delta_{iA} + (C_A - C_{A0}) \frac{E(d)}{1-F(d)}$$

$$\frac{dC_B}{dd} = -\sum_{i=1}^n \delta_{iB} + (C_B - C_{B0}) \frac{E(d)}{1-F(d)}$$

If δ_{iA} is known, we can calculate C_A & C_B

→ Above model was zero-dimensional model, which give range of conversion for given E curve

Teacher Signature _____

$$\Rightarrow \frac{dC_A(d)}{dd} = -r_A + (C_A - C_{A0}) \frac{E(d)}{1-F(d)}$$

$$\text{or } \frac{dX}{dd} = \frac{r_A}{C_{A0}} + \frac{E(d)}{1-F(d)} \cdot X$$

To calculate X for max. mixedness model, integrate by starting from lagged & move backward till $d=0$.

→ For $n > 1$, max. mixedness model gives lower bound on conversion.

Multiple Reactions: → $A+B \rightarrow \text{product}$
Segregation Model

Each globule → different batch of A & B

$$\bar{C}_A = \int_0^\infty C_A(t) E(t) dt$$

→ Batch reactor.

$$\frac{dC_A}{dt} = -r_A = -\sum_{i=1}^q r_{iA}, \quad \frac{dC_B}{dt} = -r_B = -\sum_{i=1}^q r_{iB}$$

$q \rightarrow$ rxns occ. simultaneously

Maximum mixedness model: →

$$\frac{dC_A}{dd} = -\sum_{i=1}^q r_{iA} + (C_A - C_{A0}) \frac{E(d)}{1-F(d)}$$

$$\frac{dC_B}{dd} = -\sum_{i=1}^q r_{iB} + (C_B - C_{B0}) \frac{E(d)}{1-F(d)}$$

If r_{iA} is known, we can calculate C_A, C_B

→ Above model was zero-dimensional model, which give range of conversion for given E curve