10 Dec
1030–1130

Prof. Shankar
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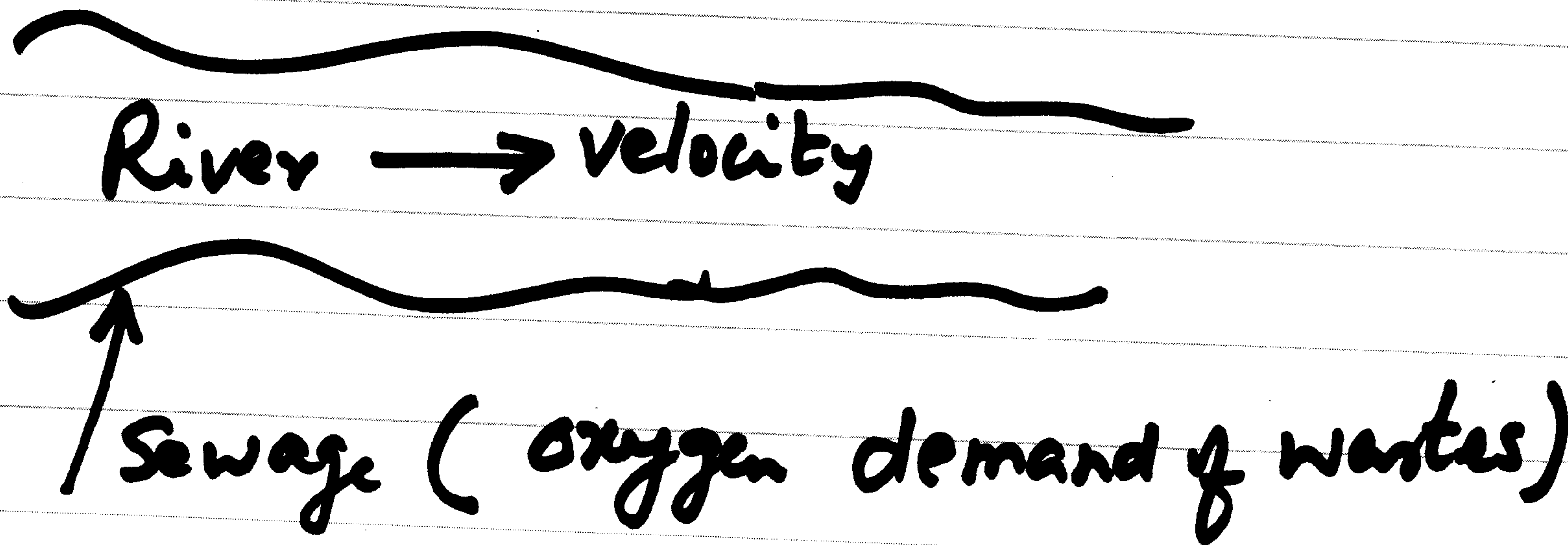
Advanced Reaction Engineering

Practice Problems in Env Reaction Engg

Oxygen Sag in River Systems


River → velocity
Sewage (oxygen demand of wastes)

$$I/p - O/p + Gen = \cancel{Acc}$$

Steady state

$$(vAC)_x - (vAC)_{x+\Delta x} + k_2(C_s - C)A\Delta x$$

$$- k_1 A \Delta x S + (r_p - r_{sp} - r_3)A\Delta x = 0.$$

$-p$

$$-v\frac{dc}{dx} + k_2(c_s - c) - k_1 s - \beta = 0$$

S: pollution load $S = S_0 e^{-k_1 \tau}$

τ: residence time of pollution load

ψ: $c_s - c$ oxygen sag.

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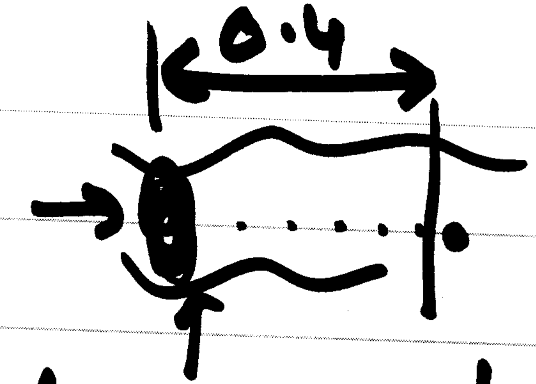


$\psi = C_s - C$

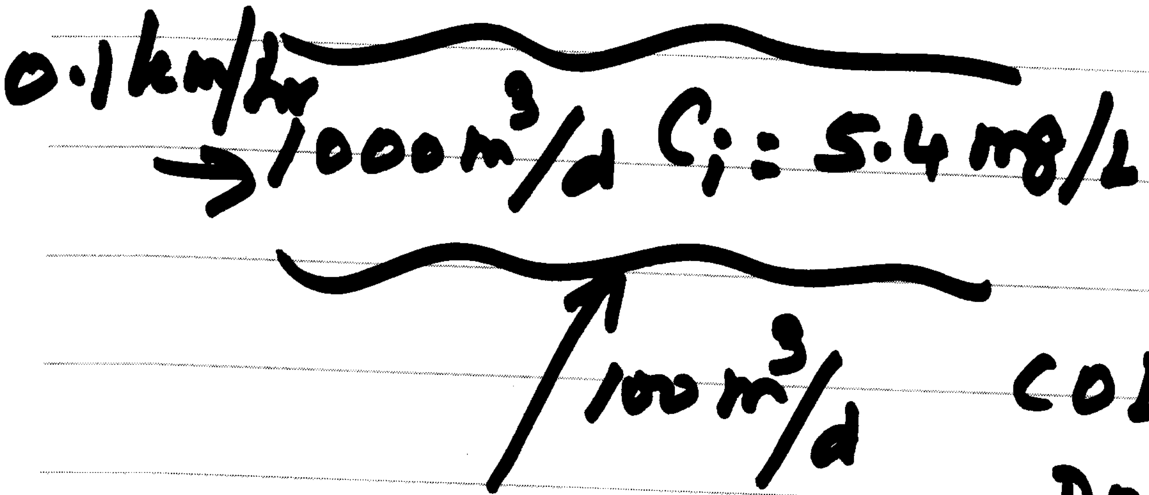
$$\psi = \frac{k_1 S_0}{(k_2 - k_1)}\left(e^{-k_1\tau} - e^{-k_2\tau}\right) + \frac{\beta}{k_2}\left(1 - e^{-k_2\tau}\right) + \psi_i e^{-k_2\tau}.$$

k_1: pollution Removal Rate Constant

k_2: Re aeration Rate Constant

ψ_i : $(C_s - C_i)$: initial deficit

$C_s = 6\ mg/L$; 90% Sat



$k_1 = 0.3/d$

$k_2 = .7/d$

COD = 500 mg/L

DO = 0.0

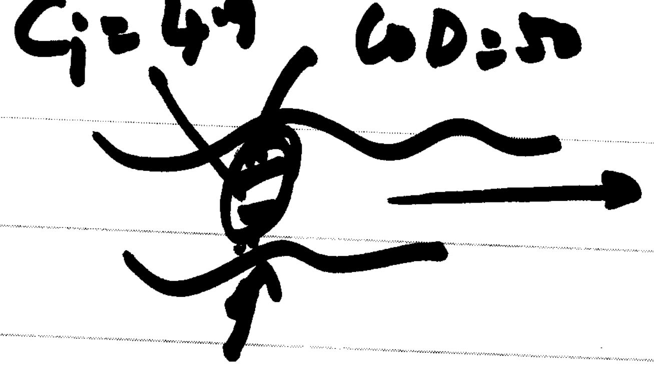
$k_2 = \frac{0.7}{d}$.

(1) Max Sag

(2) where max Sag occurs

(3) where Downstream DO reaches 90% sat

(4) What is the COD where max Sag occurs.



DO in River

$$\frac{(0.9)(0.6)1000 + 100(0)}{(1000 + 100)} = 4.9\ mg/L$$

COD in river.

$$\frac{(500)(100) + (1000)(5\ mg/L)}{(1100)} = 50\ \frac{mg}{L}$$

$\psi_i = C_s - C_i = (0.9)6 - 4.9$

$= 0.5$ mg/L

$C = 0$ $\psi_1 = 5.4$ mg/L

$5.4 =$ What is τ.

Solving $\tau = 0.4$ days

Oxygen level in river $= 0$ @ $\tau = 0.4d$

$d = (0.1)(0.4) \times 24$

$= 0$ km

$\underline{\underline{0.96}}$

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$$S = S_0 \, e^{-k_1 \tau}$$

$$(50) \exp\{-0.3 \quad 0.04\}$$

$$= 44 \text{ mg/L}$$

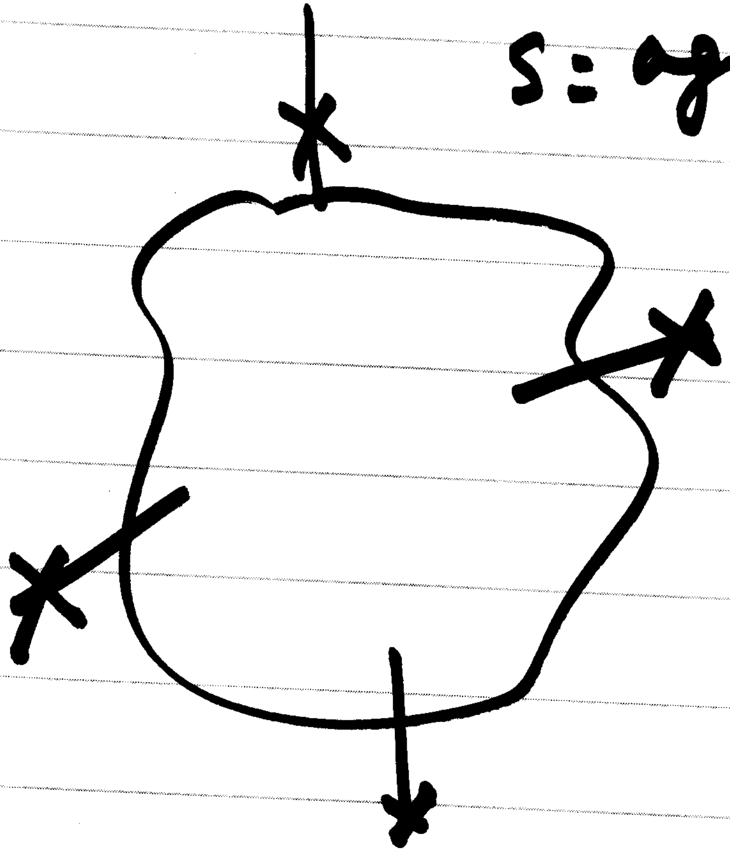
τ ? when $S = 5$ mg/L

$$(5) = (50) \exp(-0.3 \, \tau)$$

$\tau = 7.67$ days $\Rightarrow$ $\underline{\underline{18}}$ KM

what Do at
$\tau = 7.67$ days

Advanced Reaction Engineering
Practice Problems in Population Balance Modelling



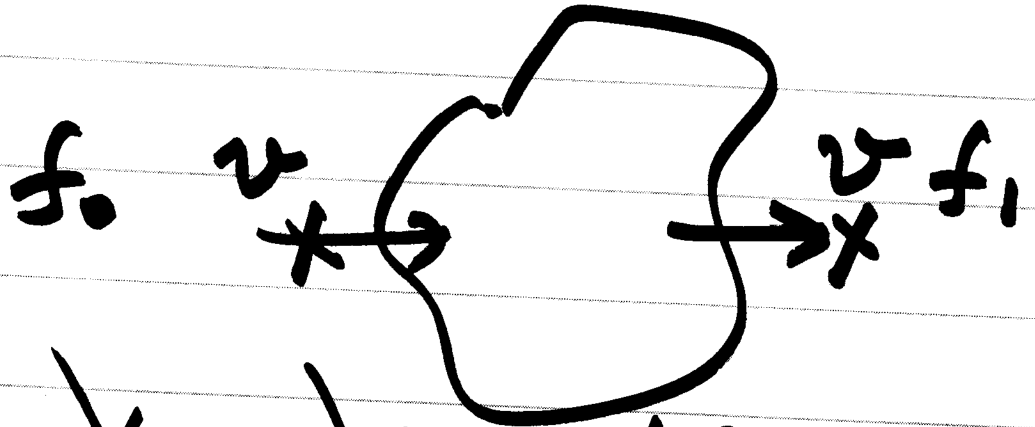
s = age of animal

$$B = \beta' \delta(s-0)$$

$$D(s) = \alpha' s$$

β and α constants

I/P − O/P + Gen = Acc.



$$\cancel{I/R} - \cancel{O/P} + (\text{Gen} - \text{Death}) = \cancel{Acc}$$

$$\cancel{f_0} - \cancel{f_1} - \frac{d}{ds}(f_1 r_1 V) = 0$$

$$+ \beta' \delta (s-0) + \alpha' s = 0$$

(B) (D)

3

$$\beta' \delta(s) - \alpha' s = \frac{d}{ds}(\sigma, \tau, V) = 0$$

τ_1 = Rate of change of property.

(age) $s = t$

$$\tau_1 = \frac{d}{dt}(\,s\,) = 1$$

(t)

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$$\gamma_1 = 1$$

$$\beta' \delta(s-0) - \alpha' s - \frac{d}{ds}(1 \cdot V \cdot f_1) = 0$$

$$\beta' \delta(s) - \alpha' s - \frac{d}{ds}(V f_1) = 0$$

(β/V) and (α/V) contants $= \frac{\beta'}{V} = \beta$

$\alpha'/V = \alpha.$

$$\boxed{\beta\, \delta(s) - \alpha s - \frac{d}{ds} f_1}$$

$$\boxed{\beta\,\delta(s-0) - \alpha s - \frac{d}{ds}(s f_1) = 0}$$

$f_1(s)$ age distribution in forest

I) Solve homogeneous eqn.

$$-\frac{d f_1}{ds} - \alpha s = 0 \Rightarrow f_1(s) = -\frac{\alpha s^2}{2} + C$$

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To find constant of integration

Take Balance $\left[(S-ds), S \right]$ $S \to 0$ $ds \to 0$

$\cancel{A/R} - \cancel{O/P} + Gen + B - D = 0$

$dt \; \left(f_1 \cancel{r_1} V \right)_{S-ds} - \left(f_1 (r_1 \cancel{V}) \right)_S + \beta \delta (s-0) \, ds \, V$

$S \to 0$

$ds \to 0$

$- \left(\alpha S \cancel{ds} V \right) = 0.$

$f_1(0) = \beta$

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$$f_1(s) = -\alpha \frac{s^2}{2} + C$$

$$f_1(0) = \beta \Rightarrow C = \beta$$

$$f_1(s) = -\alpha \frac{s^2}{2} + \beta$$

$$\int_{\text{all ages}} f_1 \, ds = 1 \Rightarrow$$

$f_1(s) = -\alpha \frac{s^2}{2} + \beta.$

Integrating over all normalized ages assuming $s \in (0, 1)$

$$1 = \left[-\alpha \frac{s^3}{6} + \beta s \right]_0^1$$

$$1 = \beta - \frac{\alpha}{6} \quad \text{or} \quad \boxed{\beta = \frac{(6 - \alpha)}{6}.}$$