1.85 WATER AND WASTEWATER TREATMENT ENGINEERING
HOMEWORK 3 – DUE MARCH 3, 2005

Question 1 (6 points)

A wastewater was tested in a settling column test with the following results in terms of suspended sediment concentration:

At t = 30 minutes	
Depth below surface, h (cm)	Concentration remaining, c/c_0
38	0.23
118	0.81
198	0.94
278	0.97
358	0.98

At t = 60 minutes	
Depth below surface, h (cm)	Concentration remaining, c/c_0
34	0.05
114	0.46
194	0.73
274	0.86
354	0.92

At t = 90 minutes	
Depth below surface, h (cm)	Concentration remaining, c/c_0
32	0.03
112	0.23
192	0.52
272	0.70
352	0.83

a. What type of settling is indicated by these data? (2 points)

b. This particular wastewater is proposed to be treated in a rectangular sedimentation tank having a detention time of 2 hours and a depth of 4 meters. Estimate the percent of suspended sediments that will be removed. (2 points)

c. If the wastewater flow rate is 7,500 m^3/day, what needs to be the area and volume of the sedimentation tank? (2 points)

Question 2 (2 points)

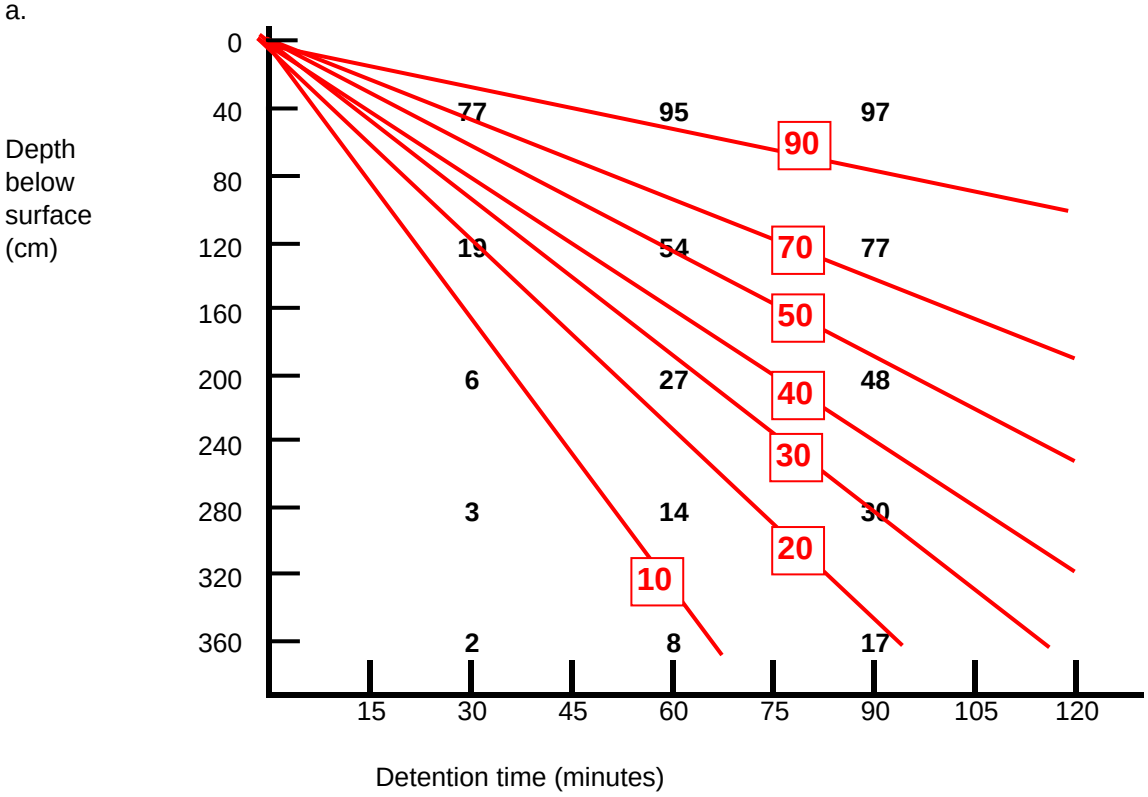
Viessman and Hammer Problem 10.15. Two rectangular clarifiers, each 30 ft. long, 15 ft. wide, and 10 ft. deep, settle 0.40 mgd following alum coagulation. The effluent channels have a total weir length of 60 ft. Calculate the detention time, horizontal velocity of flow, and rate of flow over the outlet weir in gpd per foot of weir length). Do these values meet the Recommended Standards for Water Works given in Section 10.13?

Question 3 (2 points)

Viessman and Hammer Problem 10.20. A rectangular sedimentation basin is to be designed for a flow of 1.0 mgd (million gallons per day) using a 2:1 length:width ratio, an overflow rate of 0.00077 fps (feet per second), and a detention time of 3.0 hr. What are the dimensions of the basin?

Solution to Homework 3, Question 1

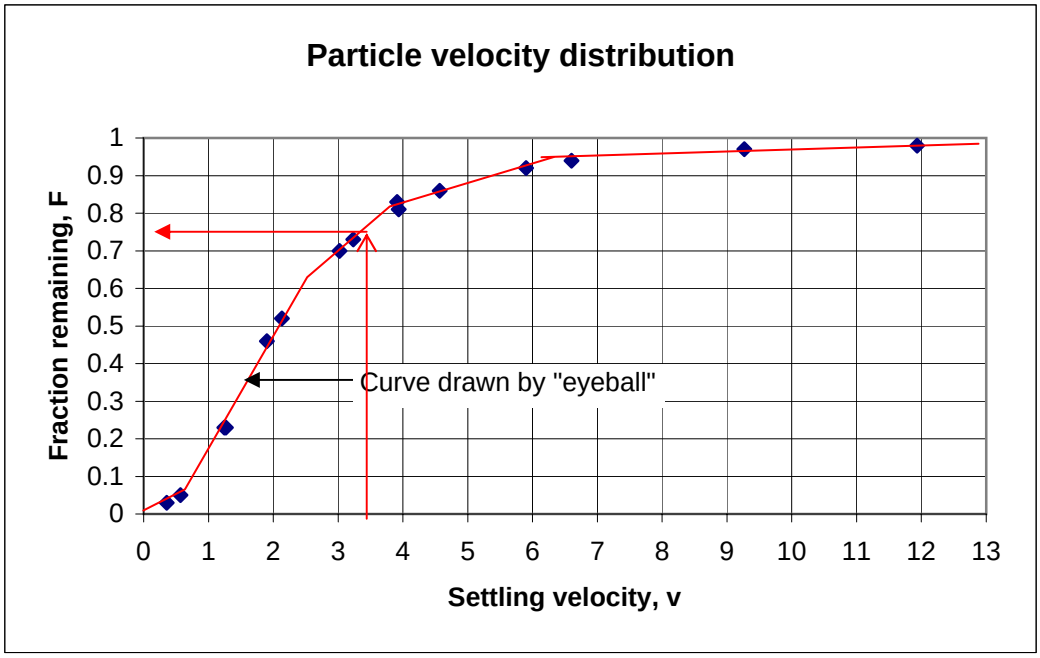
a.



Straight removal efficiency lines indicate discrete particle settling.

Solution to Homework 3, Question 1

Detention time (min)	Depth (cm)	Conc. remaining	Settling velocity (cm/min)
t	z	c/c_0	v
30	38	0.23	1.3
30	118	0.81	3.9
30	198	0.94	6.6
30	278	0.97	9.3
30	358	0.98	11.9
60	34	0.05	0.6
60	114	0.46	1.9
60	194	0.73	3.2
60	274	0.86	4.6
60	354	0.92	5.9
90	32	0.03	0.4
90	112	0.23	1.2
90	192	0.52	2.1
90	272	0.70	3.0
90	352	0.83	3.9



b. T_R = 2 hours hydraulic residence time

H = 4 m

$V_o = \frac{4\ m}{2\ hr} = 2\ m/hr$ overflow rate

$= 3.3\ cm/min$

Fraction settled is

$$(1 - F_o) + \int_0^{F_o} \frac{V}{V_o}\, dF$$

$F_o = 0.75$ for $V_o = 3.3$ from graph

Can approximate integral from graph of C/C_o vs V since it is pretty close to a triangle

$$\int_0^{F_o} \frac{V}{V_o}\, dF \simeq 0.38$$

Fraction removed $= (1 - 0.75) + 0.38$

$= 0.63$

c.

$$V_o = \frac{4\ m}{2\ hr} = 2\ \frac{m}{hr} = 48\ \frac{m}{d}$$

$$T_D = 2\ hr = \frac{\forall}{Q}$$

$$Q = 7500\ m^3/d \rightarrow \forall = T_D\, Q$$

$$= \frac{2}{24}\ day\ 7500\ \frac{m^3}{d}$$

$$= 625\ m^3$$

$$V_o = \frac{Q}{A_p} = 48\ m/d \rightarrow A_p = Q/V_o$$

$$= \frac{7500\ m^3/d}{48\ m/d}$$

$$= 156\ m^2$$

Perhaps 5 m x 30 m

Homework 3, Question 2

2 clarifiers $L = 30$ ft $W = 15$ ft $H = 10$ ft

$Q = 0.4$ mgd

$L_{weir} = 60$ ft

$$t_R = \frac{2\forall}{Q} = \frac{2 \cdot L \cdot W \cdot H}{Q} = \frac{2 \cdot 30 \cdot 15 \cdot 10 \text{ ft}^3}{0.4 \times 10^6 \frac{\text{gal}}{\text{day}} \frac{1}{7.48} \frac{\text{ft}^3}{\text{gal}}}$$

$$= 0.17 \text{ day} = 4.0 \text{ hour}$$

$$U = \frac{Q}{2 \cdot W \cdot H} = \frac{0.4 \times 10^6 \frac{\text{gal}}{\text{day}} \frac{1}{7.48} \frac{\text{ft}^3}{\text{gal}}}{2 \cdot 15 \cdot 10 \text{ ft}^2}$$

$$= 180 \text{ ft/day} = 0.12 \text{ ft/min}$$

Guideline is 0.5 ft/min → design is OK
(also OK when only one tank is in service and $U = 0.25$ ft/min)

$$\text{Weir loading} = \frac{Q}{L_{weir}} = \frac{0.4 \times 10^6 \frac{\text{gal}}{\text{day}}}{60 \text{ ft}}$$

$$= 6700 \text{ gpd/ft}$$

Guideline is 20,000 gpd/ft → design is OK

Homework 3, Question 3

Rectangular sedimentation basin

$Q = 1$ mgd

$L:W = 2:1$

$V_o = 0.00077$ ft/sec

$t_R = 3$ hour

$$t_R = \frac{\forall}{Q}$$

$$\forall = t_R Q = 3 \text{ hour } 10^6 \frac{\text{gal}}{\text{day}} \frac{1}{7.48} \frac{\text{ft}^3}{\text{gal}} \frac{1}{24} \frac{\text{day}}{\text{hr}}$$

$$= 17{,}000 \text{ ft}^3$$

$$V_o = \frac{Q}{A_p}$$

$$A_p = \frac{Q}{V_o} = \frac{10^6 \frac{\text{gal}}{\text{day}} \frac{1}{7.48} \frac{\text{ft}^3}{\text{gal}} \frac{1}{86400} \frac{\text{day}}{\text{sec}}}{0.00077 \frac{\text{ft}}{\text{sec}}}$$

$$= 2000 \text{ ft}^2$$

$L = 2W$ $\quad L \cdot W = 2000 \text{ ft}^2$

$2W^2 = 2000 \text{ ft}^2$ $\quad W = 32$ ft

$L = 64$ ft