1.85 WATER AND WASTEWATER TREATMENT ENGINEERING
HOMEWORK 3

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)

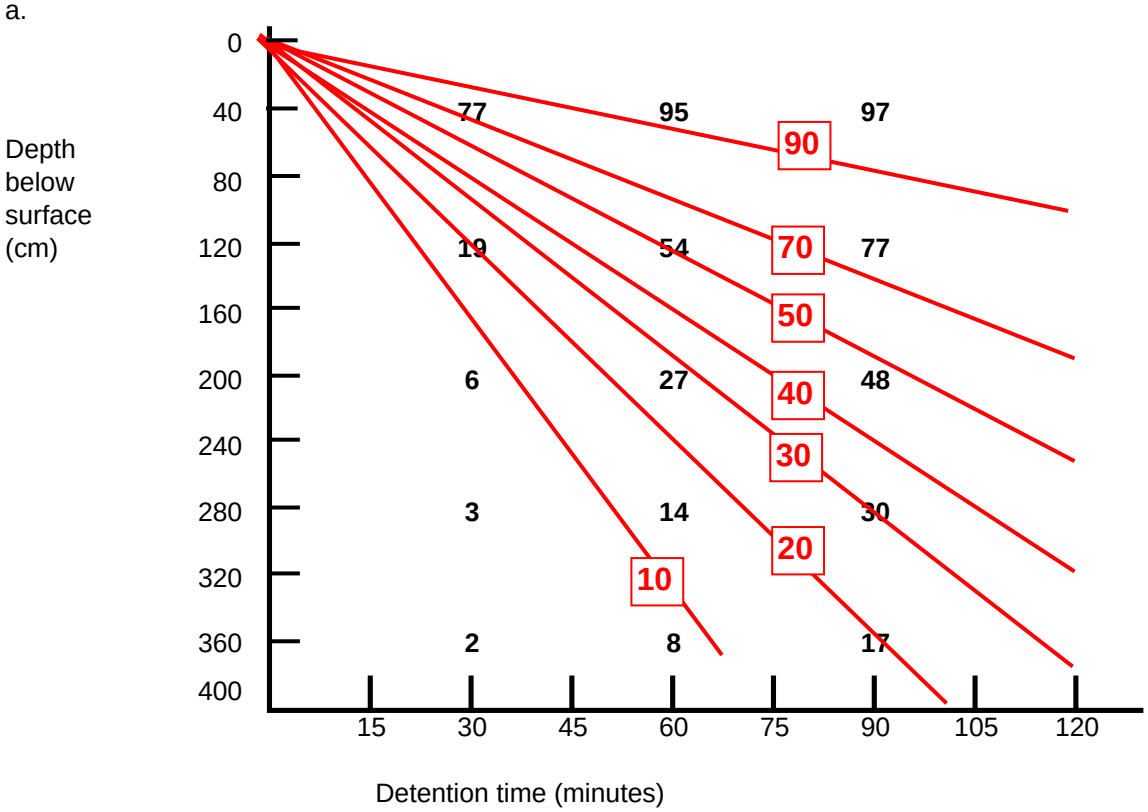
The city of Hong Kong has a dual water-supply system that provides freshwater for drinking and bathing, and salt water for flushing toilets. At the Hong Kong wastewater treatment plant, as in most other wastewater treatment plants, wastewater is passed through a primary clarifier to settle out suspended solids. The Hong Kong plant achieves greater removal in their primary clarifier than most plants elsewhere in the world. Why?

Question 3 (2 points)

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

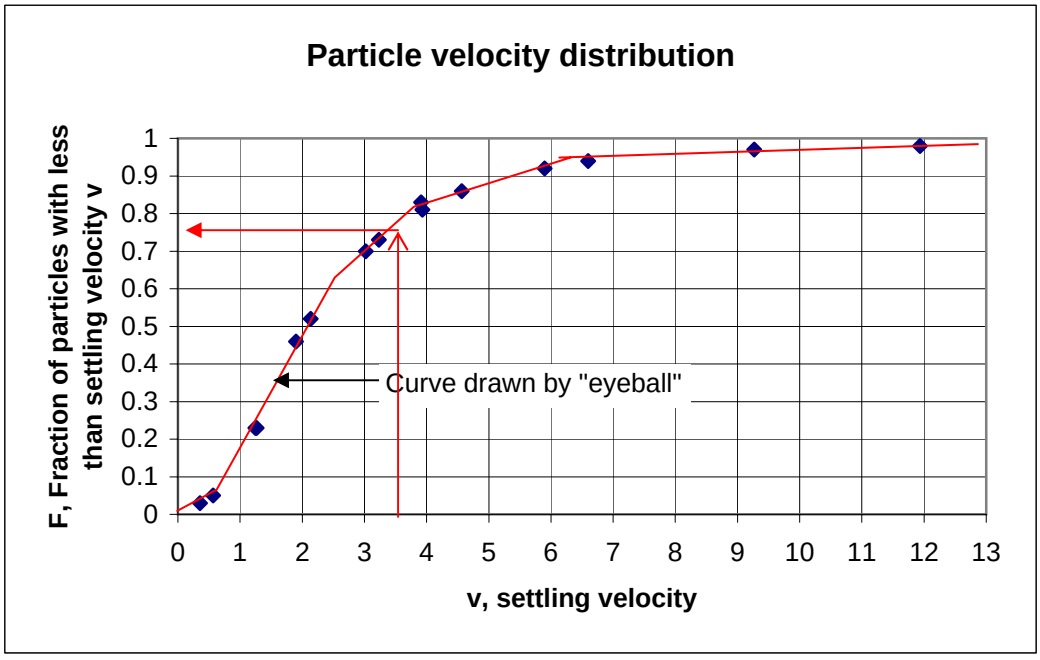
a.



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



Solution to Homework 3, Question 1

Fraction removed from Equation 9.30, pg. 230, of Reynolds and Richards

$1 - F_0 =$ 1 - 0.75 0.25

v	F	v - ave	ΔF	v ΔF
3.3	0.76			
3.0	0.70	3.2	0.06	0.19
2.5	0.64	2.8	0.06	0.17
2.0	0.49	2.3	0.15	0.34
1.5	0.34	1.8	0.15	0.26
1.0	0.18	1.3	0.16	0.20
0.5	0.04	0.8	0.14	0.11
0.0	0.00	0.3	0.04	0.01

Sum	1.27

Sum/v_0	0.38

Fraction removed = 0.25 + 0.38
Fraction removed = 0.63

Alternative calculation using graph and formula from Lecture 6, page 18

R	h	Δh	Rave	$\Delta h/h_n$ * Rave
100	0			
90	100	100	95	23.8
70	190	90	80	18.0
50	230	40	60	6.0
40	325	95	45	10.7
30	370	45	35	3.9
26	400	30	28	2.1
			Sum	64.5

Percent removed = 64.5 %

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

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

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

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Question 2 (2 points)

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Answer

The sea water increases the electrical conduct ivity of the water and thereby acts as a coagulant, enhancing the efficiency of sedimentation process.

Question 3 (2 points)

A rectangular sedimentation basin is to be designed for a flow of 1.0 mg d (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?

Answer

$$\text{Overflow rate} = 0.00077 \frac{ft}{sec} \times 7.48 \frac{gal}{ft^3} \times 86400 \frac{sec}{day}$$

$$= 500 \frac{gpd}{ft^2}$$

$$\frac{Q}{A} = 500 \frac{gpd}{ft^2} = \frac{1{,}000{,}000 \ gpd}{2W \cdot W \quad ft^2}$$

$$2W^2 = 10^6 \rightarrow W = 32 \text{ ft} \quad L = 2W = 64 \text{ ft}$$