Faculty of Engineering and Applied Science
Engi 9605 – Water and Wastewater Treatment

Test 2, Open Book
Thursday, March 16, 2017, 10:30 – 11:45 p.m. Instructor: Dr. C. A. Coles

There are 2 questions worth a total of 40 marks. Only non-programmable scientific calculators without text or graphics storage are permitted. Accuracy and showing all work are important.

Name: ____________________________ Student ID: ________________________

1) Complete the design of horizontal flow rectangular sedimentation basins that are 5.4 m wide and have chain and flight sludge removal systems and tube settlers. The maximum flow, Q_{max} = 0.8 m^3/s, the overflow rate, V_0 = 140 m/d, and the temperature, T = 12°C. The hydraulic diameter of settling tubes is 65 mm, they are sloped at an angle of 60° with the horizontal, θ = 60°, have a height of 2.0 m, and the top of the settlers and to the top of the launders is 1.1 m.
   a) How many basins will satisfy the mean horizontal approach velocity, V_H? (4 marks)
   b) What is the basin length if the settlers occupy 75% of the surface area? (3 marks)
   c) Double check the overflow for the basin dimensions selected. (2 marks)
   d) Check that the Reynolds and Froude numbers are satisfied. (6 marks)
   e) How many effluent launders will satisfy the weir loading rate? (3 marks)
   (Total 18 marks)

W = 5.4 m $Q_{max} = 0.8\ m^3/s$ $\phi_{tubes} = 0.065\ m = 65\ mm$
$V_0 = 140\ m/d$ θ = 60°
T = 12°C h = 2.0 m
1.1 m = top settler to top launders.

a) $V_H = \dfrac{Q_{max}}{A_x} = \dfrac{0.8\ m^3/s}{(x \text{ basins})(5.4\ m)(2m + 1.1m)} = 0.01\ m/s$

x = 4.78 basins

use 5 basins.

b) $A_s = \dfrac{Q}{V_0} = \dfrac{0.8\ m^3/s \cdot 60 \times 60 \times 24\ s/d}{140\ m/d \cdot 1\ d} = 493.7\ m^2$

$L_{settlers} = \dfrac{493.7\ m^2}{(5 \text{ basins})(5.4\ m)} = 18.28 \approx 18.3\ m$

$L_{basin} = \dfrac{18.3\ m}{0.75} = 24.4\ m$

c) $V_0 = \frac{Q}{A_s} = \frac{0.8\ m^3/s \cdot 60 \times 60 \times 24\ s}{18.3 \times 5.4 m \quad d\ (5\ \text{basins})} = 1399 \simeq 1400\ m^3/d$. ①

d) $R_h = \frac{A_x}{P_w} = \frac{\pi r^2}{2\pi r} = \frac{r}{2} = \frac{(0.065/2)\,m}{2} = 0.01625 m$

$V_{fc} = \frac{Q}{A \sin\theta} = \frac{0.8\ m^3/s}{(5\ \text{basins})(5.4 m \times 18.3 m) \sin 60°} = 0.00187\ m/s$

$\sin 60° = 0.866$

$T = 12°C. \quad \nu = 1.236 \times 10^{-6}\ m^2/s$

$Re = \frac{V_{fc} R_h}{\nu} = \frac{(0.00187\ m/s)(0.01625\ m)}{1.236 \times 10^{-6}\ m/s} = 25.25 < 50$ O.K.

$Fr = \frac{V_{fc}^2}{g R_h} = \frac{(0.00187\ m/s)^2}{(9.81\ m/s^2)(0.01625)} = 0.0000184$

$= 1.84 \times 10^{-5} > 10^{-5}$

O.K.

e) WL: spacing ≤ 1.5 m on center

so need at least 3 launders.

$L_{launder} = L_{settler} = 18.3\ m.$

$WL = \frac{0.8\ m^3/s \cdot 60 \times 60 \times 24\ s/d}{(5\ \text{basins})\left(\frac{3\ \text{launders}}{\text{basin}}\right)(18.3\ m)\left(\frac{2\ \text{sides}}{\text{launder}}\right)} =$

$= 125.9\ \frac{m^3}{d \cdot m}$

$\leq 300\ m^3/d \cdot m$ O.K.

2) Water with an initial uniform suspended solids (SS) concentration of 250 mg/L is tested for settling in a settling column. The concentrations of SS in the collected samples, in mg/L, are recorded below for their respective depths and times.

a) Draw the 40%, 50%, 60% and 70% isoconcentration lines. (7 marks)

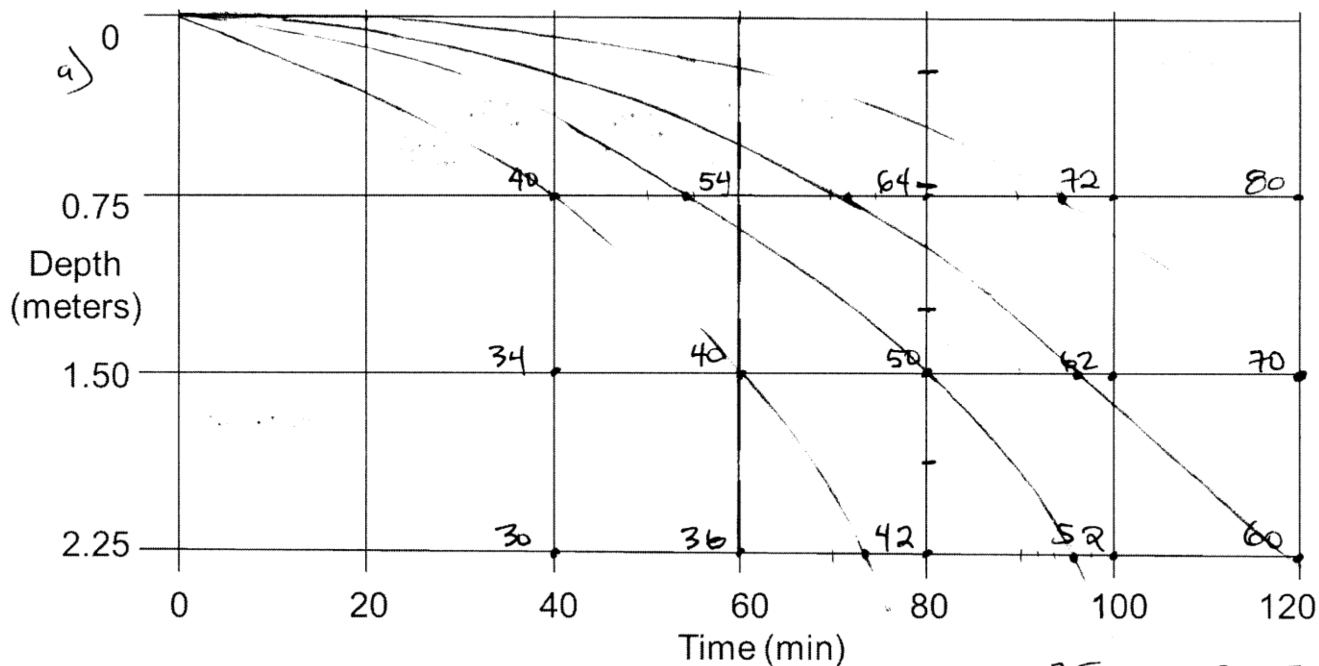
b) At 80 minutes detention find the theoretical SS removal in %, and V_0 in m/day. (10 marks)

c) What is the final theoretical concentration of SS in the effluent, in mg/L? (2 marks)

(Total 19 marks)

Time (min)	**0.75 m depth**		**1.50 m depth**		**2.25 m depth**	
40	150	40	165	34	175	30
60	115	54	150	40	160	36
80	90	64	125	50	145	42
100	70	72	95	62	120	52
120	50	80	75	70	100	60

a)



b) SS = 250 mg/L.

75 mm = 2.25 m.
vertical scale
1 mm = 0.03 m

$$R_{to} = 42\% + \frac{1.875}{2.25}(50-42) + \frac{1.23}{2.25}(60-50) + \frac{0.705}{2.25}(70-60) + \frac{0.225}{2.25}(100-70)$$

$$= 42 + 6.67 + 5.47 + 3.13 + 3$$

$$= 60.27\%.$$

$$V_0 = \frac{H}{t} = \frac{2.25\text{m}}{80\text{min}} \times \frac{60 \times 24\ \text{min}}{d}$$

$$= 40.5\ \text{m/d}.$$

c) $100 - 60.27 = 39.73\%$ removed.

$250(0.3973) = 99.3$ mg/L will remain in effluent.