Homework #1

All problems are from the course textbook (Chapra).

1. Problem 14.1 (2 points)

Total: 2 points

14.1

Problem

The data in Table P14.1 were collected on Boulder Creek, CO, on 12/23/94. The slope at the sampling location is approximately 0.004. Use the data along with the appropriate formulas to determine:

(a) Cross-sectional area
(b) Mean depth
(c) Flow
(d) Mean velocity
(e) Longitudinal dispersion coefficient, and
(f) Distance needed to attain lateral mixing

Table P14.1

x (ft)	H (ft)	$U_{60\%}$ (fps)	$U_{20\%}$ (fps)	$U_{80\%}$ (fps)
0	0			
3	1.3	0.3		
6	1.25	0.35		
9	0.85	0.48		
12	1.2	0.46		
15	1.85	0.58		
18	1.85	0.66		
21	1.75	0.68		
24	1.9	0.67		
27	2.25		0.4	0.68
30	2.4		0.4	0.62
33	2.1		0.29	0.5
36	1.5	0.37		
39	1.0	0.25		
42	1.3	0.09		
45	1.2	0.13		
48	1.0	0.14		
51	0.8	0.08		
54	0			

SOLUTION:

Note: some of you used Simpson's Rule according to the text, which is fine. My personal preference is to do it empirically as shown below.

Using a spreadsheet, calculate cross-sectional area for each segment (assuming a simple rectangle of 3 ft width and height, H. Then determine flow by multiplying this area by the 60% height velocity or the average of the 20% and 80% height velocities.

Next sum these over all segments to get the totals.

x (ft)	H (ft)	$U_{60\%}$ (fps)	$U_{20\%}$ (fps)	$U_{80\%}$ (fps)	Axs (ft2)	Q (cfs)
0	0					
3	1.3	0.3			3.9	1.17
6	1.25	0.35			3.8	1.31
9	0.85	0.48			2.6	1.22
12	1.2	0.46			3.6	1.66
15	1.85	0.58			5.6	3.22
18	1.85	0.66			5.6	3.66
21	1.75	0.68			5.3	3.57
24	1.9	0.67			5.7	3.82
27	2.25		0.4	0.68	6.8	3.65
30	2.4		0.4	0.62	7.2	3.67
33	2.1		0.29	0.5	6.3	2.49
36	1.5	0.37			4.5	1.67
39	1	0.25			3.0	0.75
42	1.3	0.09			3.9	0.35
45	1.2	0.13			3.6	0.47
48	1	0.14			3.0	0.42
51	0.8	0.08			2.4	0.19
54	0					
				Total	76.5	33.29
				Mean depth (ft)	1.417	
				Mean velocity (ft/s)		0.4351

(a) Cross-sectional area

$76.5\ ft^2 = 7.11\ m^2$

(b) Mean depth

1.42 ft = 0.432 m

(c) Flow

33.29 cfs = 0.943 m^3/s

(d) Mean velocity

0.435 ft/sec = 0.133 m/s

(e) Longitudinal dispersion coefficient, and

$$U^* = \sqrt{gHS} = \sqrt{32.2*1.42*0.004} = 0.427 \text{ ft/sec} = 0.1302 \text{ m/sec}$$

$$E = 0.011\frac{U^2B^2}{HU^*} = 0.011\frac{0.435^2\ 54^2}{1.417*0.427} = \textbf{10.03 ft}^2\textbf{/sec = 0.93 m}^2\textbf{/sec}$$

(f) Distance needed to attain lateral mixing

$$E_{lat} = 0.6HU^* = 0.6*1.417*0.427 = 0.363 \text{ ft2/sec}$$

For a center discharge

$$L_m = 0.10U\frac{B^2}{E_{lat}} = \textbf{349 ft = 107 m}$$

For a side discharge

$$L_m = 0.40U\frac{B^2}{E_{lat}} = \textbf{1398 ft = 426 m}$$