CIE 272

Civil Engineering Measurements

Exam #3

December 8, 2008

Directions:

1. Write your name on your exam book, NOW!
2. Read the questions carefully. Most errors on timed examinations are the result of not understanding what is being asked.
3. **DON'T PANIC!** Answer the easier questions first.

Good Luck!

1. (30 Points) The table below shows the change in the dissolved oxygen (DO) concentration in a river downstream from the point where wastewater is discharged into the river.

	Distance (km) x_i	**DO** (mg/L) y_i	$x_i \cdot y_i$	$(x_i - \bar{x})$	$(y_i - \bar{y})$	$(x_i - \bar{x})(y_i - \bar{y})$
	0.0	0.39	0.000	-10.289	0.123	-1.269
	3.1	0.37	1.147	-7.189	0.103	-0.743
	5.6	0.31	1.736	-4.689	0.043	-0.203
	8.8	0.28	2.464	-1.489	0.013	-0.020
	9.9	0.27	2.673	-0.389	0.003	-0.001
	12.8	0.25	3.200	2.511	-0.017	-0.042
	16.0	0.20	3.200	5.711	-0.067	-0.381
	17.2	0.17	2.924	6.911	-0.097	-0.668
	19.2	0.16	3.072	8.911	-0.107	-0.951
Sum	92.6	2.40	20.416	0.0	0.0	-4.277
Mean	10.3	0.27	2.268	0.0	0.0	-0.475
Std. Dev.	6.60	0.082	1.101	6.60	0.082	0.457
N	9	9	9	9	9	9

The regression equation for these data is:

$$[\text{DO (mg/L)}] = -0.0123 \times [\text{Distance (km)}] + 0.3931$$

a. (10) Use the regression equation to estimate the distance downstream at which the DO concentration equals 0.30 mg/L.

b. (10) What is the value of the regression residual at $\boldsymbol{x}$ = 12.8 km?

c. (10) Compute the correlation coefficient (r) between distance and DO concentration.

2. (35 Points) An "aquifer" is an underground water supply, usually a porous rock formation that can hold water. Wells drilled into aquifers are used for irrigation and drinking water in much of the western United States. The data in the table below show the withdrawal of water from an aquifer and the recharge, or return, of water to the aquifer for a 13-year period.

Year	Withdrawal (acre-ft)	Recharge (acre-ft)	Withdrawal – Recharge (acre-ft)
1	560	510	50
2	480	510	-30
3	525	500	25
4	560	510	50
5	555	493	62
6	535	500	35
7	495	490	5
8	555	520	35
9	560	500	60
10	555	525	30
11	540	485	55
12	550	530	20
13	525	500	25
Mean	538	506	32.5
Std. Dev.	25.9	13.5	25.3
N	13	13	13

a. (10) Estimate the 95% confidence interval for the recharge.

b. (15) If withdrawals exceed recharge over many years, the amount of water in the aquifer will decline. Test whether the mean withdrawal has exceeded the mean recharge in this 13-year period. Use $\alpha = 0.05$. If necessary, assume that the variances for withdrawal and recharge are *unequal*.

c. (10) Test whether the mean recharge for this aquifer is greater than 495 acre-ft. Use $\alpha = 0.05$.

[**Note for interest only**: It is desirable to establish the "sustainable withdrawal" from groundwater aquifers. This sustainable withdrawal is the amount that can be taken out without drawing down the aquifer in the long-term. This equals the long-term (i.e., the population) mean for the recharge. Your answer to part c of this question is an attempt to get at that value.]

3. (35 Points) The compressive strength of 15 samples of a polymer material used for strengthening concrete beams has been tested, with the results shown below, in increasing order. The units are N/mm^2.

50.80	52.50	53.60	54.10	54.50	55.20	55.80	56.50
56.80	57.10	57.40	59.30	59.80	60.30	60.60	

Mean	56.3	**Std. Dev.**	2.92

a. (15) In your exam book, draw a histogram for these data, using the following intervals:

50-52 52-54 54-56 56-58 58-60 60-62

Are the data approximately normally distributed?

b. (10) Find the 98% confidence interval for the compressive strength.

c. (10) Test the hypothesis that the mean compressive strength is less than 58 N/mm^2. Use $\alpha = 0.05$.

Extra Credit (10 Points)
(*Maximum Exam Score = 100)*

Consider the data in problem #2. You can see that the recharge to the aquifer is usually, but not always, at least 500 acre-ft.

a. (5) Estimate the probability that the recharge will be less than 500 acre-ft in three consecutive years.

b. (5) Estimate the probability that the recharge will be less than 500 exactly once in any three year period.