CIE 272

Civil Engineering Measurements

Exam #3
December 12, 2003

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.

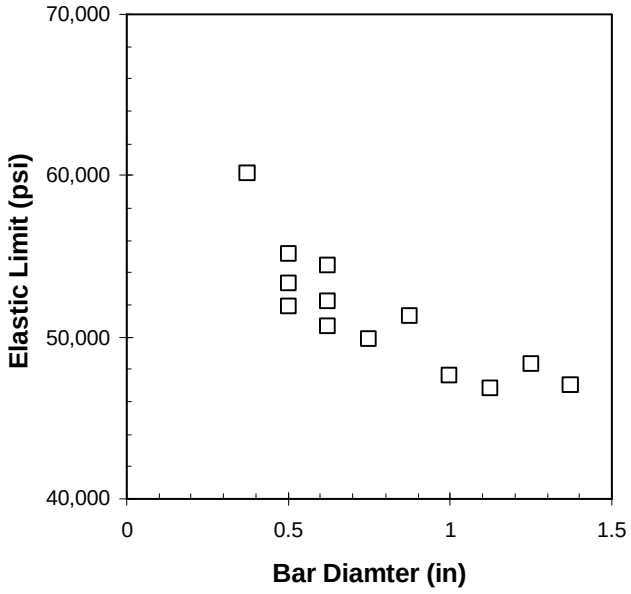
Good Luck!

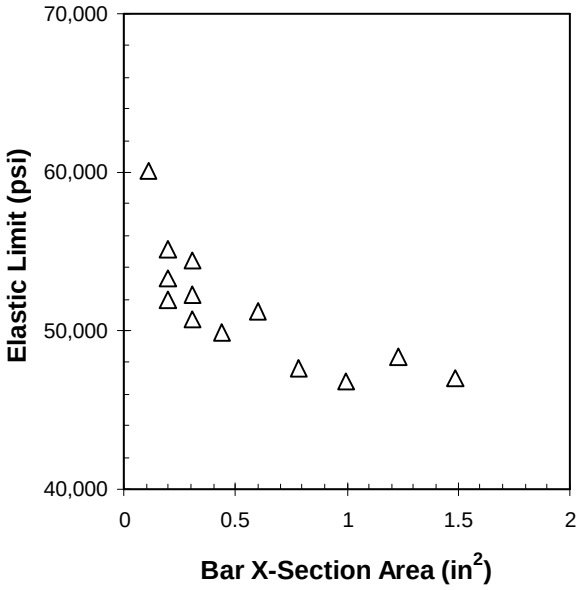
1. **(20 Points)** The "elastic limit" of steel is the pressure at which the steel begins to fail. The "ultimate strength" is the pressure at which the steel actually breaks. In principle, a batch of steel should have the same properties regardless of how it is used. Testing of steel reinforcing bars, however, indicates that the elastic limit and ultimate strength are related to the size of the bars. The data in the table below show the results of testing 13 steel reinforcing bars of different sizes. The bar number equals the diameter in eighths of an inch.

Bar Size Number	Elastic Limit (psi) x_i	Ultimate Strength (psi) y_i	$x_i - \bar{x}$	$y_i - \bar{y}$	$(x_i - \bar{x})(y_i - \bar{y})$
3	60,100	95,420	8,672	14,476	125,543,220
4	55,120	89,360	3692	8,416	31,076,040
4	51,930	81,470	502	526	264,333
4	53,299	84,520	1,871	3,576	6,692,490
5	54,400	82,150	2,972	1,206	3,585,017
5	50,690	78,230	-738	-2,714	2,001,622
5	52,219	78,031	791	-2,913	-2,305,467
6	49,850	79,740	-1,578	-1,204	1,899,235
7	51,240	83,400	-188	2,456	-460,608
8	47,600	73,390	-3,828	-7,554	28,912,931
9	46,810	71,080	-4,618	-9,864	45,547,044
10	48,300	76,980	-3,128	-3,964	12,397,322
11	47,000	78,500	-4,428	-2,444	10,820,563
Sum	668,558	1,052,271	0	0	265,973,745
Mean	51,428	80,944	0	0	20,459,519
Std. Dev.	3,769	6,418	3,769	6,418	34,805,707

a. **(10)** Compute the correlation between the elastic limit and the ultimate strength. Would you describe the relationship between the elastic limit and the ultimate strength as "strong" or "weak"?

b. **(10)** The bar size could be expressed as the diameter of the bar or as the cross-sectional area. Shown below are graphs of the relationships between elastic limit and bar diameter or bar cross-sectional area.





You would like to use linear regression to develop a relationship between bar size and the elastic limit. Would it be best to use bar diameter or cross-sectional area as the measure of bar size? **Explain your answer.**

2. **(30 Points)** Traffic lights were installed at twelve troublesome intersections in London, England. The data in the table below show the number of accidents at each intersection in the two years before and after the traffic lights were installed:

	Intersection													Std.
	1	2	3	4	5	6	7	8	9	10	11	12	Mean	Dev.
Before	27	4	18	20	17	12	18	24	18	19	3	8	15.7	7.48
After	20	9	14	14	16	3	13	4	9	11	3	6	10.2	5.47
Change	-7	+5	-4	-6	-1	-9	-5	-20	-9	-8	0	-2	-5.5	6.17

a. **(10)** Would it be appropriate to use a paired t-test with these data? **Explain your answer.**

b. **(10)** Test whether it is reasonable to assume that the "before" and "after" data have equal variances. Use α=0.05

c. **(10)** Regardless of your answers to parts *a* and *b*, use the two-sample t-test (assuming equal variances) to test whether the installation of traffic lights has significantly reduced the number of accidents at these intersections. Use α=0.01.

3. **(25 Points)** An engineer is planning to collect soil samples and test them for their shear strength. She wishes to test the hypotheses:

H_1: Mean strength > 850 psi

H_0: Mean strength = 850 psi

The test is to be carried out at the 95% significance level, and the population variance is unknown.

a. (5) What is the appropriate test statistic for this test? Give the formula.

b. (10) State the decision rule for the test, including the numerical value of *z* or *t* to which the test statistic should be compared, if the engineer collects 21 soil samples.

c. (10) Based on some old data, the engineer believes that the mean shear strength will be about 1000 psi, and the standard deviation will be about 300 psi. Estimate the number of samples that the engineer should collect in order to conclude that the mean strength is greater than 850 psi at the α=0.05 significance level.

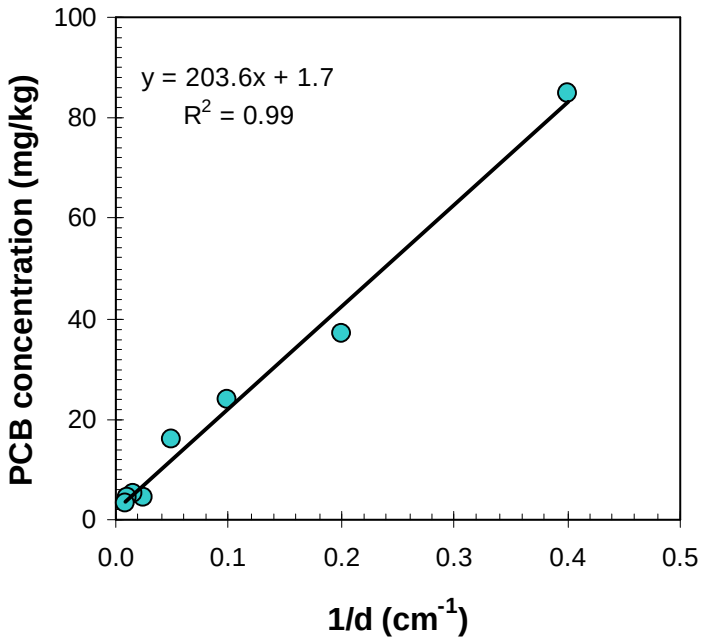
4. **(25 Points)** When a pollutant is spilled onto soil, its concentration typically decreases as you go down in the soil. A simple model for the relationship between concentration and depth is:

$$C = \frac{A}{d} + C_{\infty} \qquad [1]$$

where: C = concentration (mg/kg)
d = depth in soil (cm)
A, C_8 = constants estimated by regression analysis

Soils were collected at a site where PCB contamination is believed to have occurred. The data are shown in the table below. A plot of the PCB concentration versus the inverse of the depth is also shown, along with the regression equation.

Depth (cm)	PCB Concentration (mg/kg)
2.5	85
5	40
10	22
20	11
40	6.1
60	5
90	4.3
120	3



a. **(10)** Determine the values of the constants A and C_8 that should be used in equation [1].

b. **(10)** What are the units of A and C_8 ?

c. **(5)** The total mass of PCBs in the soil, in g m^{-2}, can be calculated by integrating equation [1] with respect to depth (d), and multiplying by 0.015 (for unit conversions). Compute the mass of PCBs between 2.5 and 150 cm in this soil.