ENR211 STATISTICS FOR ENGINEERS

Problem Set 4

ANOVA

- 1. A manufacturing plant produces ball bearings. 1000 samples from a batch were tested where 95% passed a stress test. In another batch, 89% passed the test, where the sample size was also the same. The standard errors wrere 0.68% and 1.3%, respectively. Is the difference due to chance variations?
- 2. A geography test was given to a simple random sample of 250 high-school students in a certain large school district. One question involved an outline map of Europe, with the countries identified only by number. The students were asked to pick out Great Britain and France. As it turned out, 65.6% could find France, compared to 70.4% for Great Britain. Is the difference statistically significant? Or can this be determined from the information given?
- 3. A study was done to compare the performances of engine bearings made of different compounds (Mc-Cool 1979). Ten bearings of each type were tested. The following table gives the times until failure (in units of millions of cycles):

Type I	Type II
3.03	3.19
5.53	4.26
5.60	4.47
9.30	4.53
9.92	4.67
12.51	4.69
12.95	12.78
15.21	6.79
16.04	9.37
16.84	12.75

Use normal theory to test the hypothesis that there is no difference between the two types of bearings.

4. An experiment was done to measure the effects of ozone, a component of smog. A group of 22 seventyday-old rats were kept in an environment containing ozone for 7 days, and their weight gains were recorded. Another group of 23 rats of a similar age were kept in an ozone-free environment for a similar time, and their weight gains were recorded. The data (in grams) are given below. Analyze the data to determine the effect of ozone. Write a summary of your conclusions.

Controls	Ozone	
41.0	10.1	
38.4	6.1	
24.9	20.4	
25.9	7.3	
21.9	14.3	
13.1	15.5	
27.3	-9.9	
28.5	6.8	
16.9	28.2	
-17.2	9.6	
15.4	6.6	
27.4	12.1	
19.2	15.7	
22.4	26.0	
17.7	39.9	
29.4	-15.9	
21.4	-14.7	
22.7	44.1	
26.0	-9.0	
26.6	-9.0	

[This problem is from Doksum and Sievers (1976), who provide an interesting analysis.]

5. Proteinuria, the presence of excess protein in urine, is a symptom of renal (kidney) distress among diabetics. Taguma et al. (1985) studied the effects of captopril for treating proteinuria in diabetics. Urinary protein was measured for 12 patients before and after eight weeks of captopril therapy. The amounts of urinary protein (in g/24 hrs) before and after therapy are shown in the following table. What can you conclude about the effect of captopril?

Before	After	
24.6	10.1	
17.0	5.7	
16.0	5.6	
10.4	3.4	
8.2	6.5	
7.9	0.7	
8.2	6.5	
7.9	0.7	
5.8	6.1	
5.4	4.7	
5.1	2.0	
4.7	2.9	

6. During each of four experiments on the use of carbon tetrachloride as a worm killer, ten rats were infested with larvae (Armitage 1983). Eight days later, five rats were treated with carbon tetrachloride; the other five were kept as controls. After two more days, all the rats were killed and the numbers of worms were counted. The table below gives the counts of worms for the four control groups. Significant differences, although not expected, might be attributable to changes in experimental conditions. A finding of significant differences could result in more carefully controlled experimentation and thus greater precision in later work. Use the F test to test whether there are significant differences among the four groups.

Group I	Group II	Group III	Group IV
279	378	172	381
338	275	335	346
334	412	335	340
198	265	282	471
303	286	250	318

7. Samples of each of three types of stopwatches were tested. The following table gives thousands of cycles (on-off-restart) survived until some part of the mechanism failed (Natrella 1963). Test whether there is a significant difference among the types.

Type I	Type II	Type III
1.7	13.6	13.4
1.9	19.8	20.9
6.1	25.2	25.1
12.5	46.2	29.7
16.5	46.2	46.9

8. Paint used for marking lanes on highways must be very durable. In one trial, paint from four different suppliers, labeled GS, FD, L, and ZK, were tested on six different highway sites, denoted 1, 2, 3, 4, 5, 6. After a considerable length of time, which included different levels of traffic and weather, the average wear for the samples at the six sites was as follows:

Table 1: Average Wear for Paint Suppliers at Six Sites

Sites	GS	FD	L	ZK
1	69	59	55	70
2	83	65	65	75
3	74	64	59	74
4	61	52	59	62
5	78	71	67	74
6	69	64	58	74

Perform ANOVA Analysis.