MEEM 5990 **DESIGN OF EXPERIMENTS**
Assigned: 03/03/05 **Due: 03/17/05**

Take Home Midterm

1. An engineer suspects that the surface finish of a metal part is influenced by the feed rate and the depth of cut. She selects three feed rates and four depths of cut for an experimental investigation. The response of interest is the roughness average or R_a value (μin). Experimental trials are performed in a random order producing the following data:

Feed Rate (fpr)	Depth of Cut (μin)			
	0.02	0.04	0.06	0.08
0.005	24	21	21	26
	28	22	31	25
	31	18	22	24
0.010	118	89	114	118
	91	110	79	94
	97	113	83	111
0.015	223	201	239	227
	259	249	250	239
	247	228	227	218

a. Perform an appropriate analysis of variance and construct an ANOVA table.
b. Interpret the ANOVA (assume a significance level of $\alpha = 0.05$). What conclusions can be drawn from the experiment?
c. Using the method described in class, confirm the ANOVA results.
d. Calculate and interpret the model residuals.
e. If the model residuals so indicate, perform an appropriate variance stabilizing transformation on the data, and re-perform steps (a), (b), and (d).

2. Ordinarily, studying three variables at five levels each would require the examination of 5•5•5=125 unique tests conditions. A special type of designed experiment can be used to determine nearly the same information as the full experiment, but with one-fifth the number of tests. This design, the Latin Square Design, examines a specific group of tests from the complete set of tests. This problem considers a Latin Square Design. More information about Latin Square Designs is provided in the notes.

An experimenter is studying the effects of five different process layouts (A, B, C, D, and E) on the time it takes an operator to complete a given task. The experimenter is also concerned that the room temperature may influence the task time and thus considers five different room temperature levels for the trials. Five different operators (1-5) are selected to perform the task.

A Latin Square Design is performed to study the process, and the experiment conditions and responses are shown in the table below.

		Operator				
		1	2	3	4	5
Room Temperature (° F)	60	A 24	B 20	C 19	D 24	E 24
	65	B 17	C 24	D 30	E 27	A 36
	70	C 18	D 38	E 26	A 27	B 21
	75	D 26	E 31	A 26	B 23	C 22
	80	E 22	A 30	B 20	C 29	D 31

a. Perform an appropriate analysis of variance and construct an ANOVA table.
b. Interpret the ANOVA (assume a significance level of $\alpha = 0.05$). What conclusions can be drawn from the experiment?
c. Using the method described in class, confirm the ANOVA results.

3. Make up your own unreplicated two-way ANOVA example. Describe in detail the background for the experiment and the manner in which the experiment is performed. Which factors/variables will be fixed? Identify the variables that you will study and the levels that will be investigated. What response is of interest and how will it be measured? Describe the planned experiment (the complete conditions for all experimental trials) in detail. How does the plan reflect blocking and randomization considerations? Describe how the data is collected -- and present the data (try to use numbers that work out nicely). How do you plan to analyze the data obtained from the experiment? Show the ANOVA table for your example. Comment on the meaning of the ANOVA results.

4. Big John's BBQ Shack is investigating a new recipe for their world famous BBQ beef sandwiches. 12 BBQ experts are asked by the shack to taste a sample of the new and old BBQ recipe. Each sandwich that is tasted by a judge/expert is rated on a 50 point scale (a higher value is preferred). The data from the experiment is shown in the table below.

	Expert Judge											
	1	2	3	4	5	6	7	8	9	10	11	12
Old Recipe	44.0	40.4	44.8	46.0	45.3	40.0	46.0	45.5	45.4	42.8	43.2	42.2
New Recipe	48.0	46.1	45.6	45.7	46.8	47.7	44.2	46.0	47.9	46.3	44.6	43.8

a. Analyze the data in the table above using whatever method you deem appropriate.
b. Draw appropriate conclusions.

c. As discussed in class, a randomization distribution may be constructed by considering all possible sign combinations for the d values in a paired t-test -- and calculating d-bar for each combination. Using this concept, it is desired to prepare a randomization distribution for the data in the table above. Since there are 12 d values, there are a total of 2^{12}=4096 possible d-bar values. Prepare a histogram of all the possible d-bar values. What fraction of the possible d-bar values are greater than the d-bar value from the experiment? How does this fraction compare to the probability calculated above?
d. Big John prepares the BBQ beef every morning for that day's customers. Someone suggests that since a new batch of BBQ is prepared every day, this may impact the interpretation of the experiment. Comment.

5. Five chemicals are being considered in a process application. Of interest is the yield produced by the process. A number of trials are performed producing the results shown in the table below (the order in which the trials were performed is shown in parentheses).

Chemical A	Chemical B	Chemical C	Chemical D	Chemical E
84.8 (20)	86.7 (17)	76.9 (2)	77.6 (9)	86.1 (15)
77.8 (11)	88.4 (21)	81.1 (13)	84.5 (14)	85.0 (6)
76.8 (4)	84.2 (1)	81.7 (8)	81.4 (3)	89.3 (19)
76.4 (16)	86.7 (12)	81.3 (22)		87.6 (10)
79.2 (7)		77.3 (5)		
		81.7 (18)		

a. Perform an appropriate analysis of variance and construct an ANOVA table.
b. Interpret the ANOVA (assume a significance level of $\alpha = 0.05$). What conclusions can be drawn from the experiment?
c. Using the method described in class, confirm the ANOVA results.
d. Somone suggests that the process variability can be described with σ^2=3. Evaluate this claim.
e. Calculate and interpret the model residuals.

6. The etch uniformity of silicon wafers are of interest, and 20 "uniformity values" are collected from the process that performs the etch. The process data are shown below:

19.6	20.4	17.2	23.4	19.6
22.8	16.9	20.2	18.6	19.3
19.6	22.7	15.3	22.8	18.5
23.1	15.5	20.2	19.3	19.9

a. Assuming that $\sigma_y = 2$, use the data to construct a 95 percent confidence interval for the true mean, μ.
b. Issues are raised about the true level of process variability, i.e., someone suggests that maybe σ_y does not equal 2. Construct a 95 percent confidence interval for the true mean, μ, without using any assumption about the value for σ_y.
c. Assuming that the individuals are normally distributed, use your estimate of the sample variance to construct a 95 percent confidence interval for σ^2.

7. The President of Haavaad University has stated that people with blue eyes are better at math than people with brown eyes. The BEPA (Brown-Eyed People of America) are upset by this claim and decide to test it. They examine the Math SAT scores for 25 randomly selected students that are preparing to enter their Freshman Year of College. Additional information is solicited on each student -- in particular, eye color. Of the selected students, 5 individuals had neither blue nor brown colored eyes -- and their data were discarded. The Math SAT scores for the blue/brown eyed students are shown below.

Blue	530	614	629	663	572	591	609	568				
Brown	522	654	557	501	605	530	543	514	622	595	573	568

a. Analyze the data in the table above using whatever method you deem appropriate.
b. Draw appropriate conclusions.
c. There is some discussion about running a second experiment. Provide some suggestions on things that BEPA should consider for their next experiment.