Engineering Statistics II, HW 7

Due beginning of class Monday, Nov. 3

Instructions: Remember: problems are to be placed in correct order from front to back in your hw and your pages are to be stapled together. Be sure to provide copies of all relevant Minitab text output and graphics.

0: Be sure to have read the *Regression ANOVA handout*, sections 14.1-14.3 and 14.5 in your book, and the Sleeper DOE handout.

1: In this problem you will analyze data from an experiment investigating the ultimate tensile strength of drilled 6 inch by 2 inch aluminum strips. A hole of diameter .149 in., .185 in., or .221 in. was centered either .5 in or 1.0 in. from the edge and 3.0 in. from each end of 18 strips. Ultimate axial stress was then measured for each on an MTS machine. The tensile strength (in pounds) obtained in this 3 by 2 balanced factorial experiment are given in the following table (and provided in a data set on the course website):

		Placement	
		1 (.5 in.)	2 (1.0 in)
Size	1 (.149 in.)	5728, 5664, 5524	5689, 5891, 5611
	2 (.185 in.)	5508, 5620, 5375	5579, 5557, 5778
	3 (.221 in.)	5469, 5440, 5460	5621, 5664, 5523

i. Is this a factorial experiment? Why or why not?

ii. Is this experiment replicated? If so, then how many replications are there?

iii. Analyze this experiment using Minitab's *Generalized Linear Model* routine. Be sure to have it compute the residuals and the predicted values (`FITS`).

iii. Check the regression assumptions. Do you feel the regression assumptions are met?

iv. Although some of the assumptions may be somewhat violated, one statistician feels these are not serious enough to invalidate hypothesis tests. Test the main and interaction effects at $\alpha = 0.10$. What do you conclude?

v. Create main effect and interaction plots using `Stat -> ANOVA -> General Linear Model -> Factorial Plots` and include these in your hw. Do you see evidence of interaction in the interaction plot? What is the practical implication of interaction if you wish to maximize or minimize a response variable? What values for size and placement would you use to maximize ultimate tensile strength?

2. Consider the following data from a two-factor experiment with two levels (low=-1, high=1) for each factor:

		B	
		-1	1
A	-1	280, 290	300, 310
	1	230, 235	260, 240

i. Note that this is a 2^k factorial experiment. What is k? Is the experiment replicated and, if so, how many replications are there? Is the experiment balanced? Why or why not?

ii. Manually compute the main effects estimates for A and B and the estimate of the interaction effect.

ii. Manually estimate the coefficients for the regression model

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1 x_2 + \epsilon$$

in which x_1 is -1 if A = -1 and +1 if A = +1 and x_2 is defined similarly in terms of B. Note that $\hat{\beta}_0$ is just the average of all eight response variable values. (Hint: recall the simple relationship between an effect estimate and the corresponding regression coefficient.)

iii. Enter the data into Minitab and use Minitab's regression procedure to verify your calculations in part ii. Be sure to include the resulting output in your hw.

iv. Assume all regression assumptions are met so that the coefficient t-tests are reliable. Refine your model by dropping terms whose coefficients are not significant at $\alpha = 0.10$. What is your resulting model?

v. Referring to your Minitab output from part iii, answer the following questions:

1. What are the values of the sums of squares SST, SSR, and SSE?
2. Why does SSR, the regression sum of squares, have 3 degrees of freedom?
3. Give the null and alternative hypotheses corresponding to the F statistic in the regression ANOVA table. What is the value of the F statistic, the corresponding p-value, and your conclusion?
4. What is the R^2 value for the regression model and how does it relate to the sums of squares in the ANOVA table? What does R^2 tell us about the explanatory power of a regression model?

3: (Real Data) CD's and, more recently, DVD's look like they're going the way of VHS, cassette tapes and LP's. This is very bad news for Sony DADC in Terre Haute, Sony's flagship facility for producing CD's and DVD, including blueray DVD's. Nonetheless, consider the following experiment to minimize a CD/DVD electronic response called "jitter," a measure of how well the CD can be read by a CD-ROM device. A 2^3 design with two replicates was used. The three factors are

Factor	Low level	High level
Laser power	90%	110%
Developing time	20 sec.	30 sec.
Linear velocity	1.20	1.30

Note that "linear velocity" is a measure of the speed with which the laser travels while it etches pits in the photosensitive material. Here are the runs and jitter values in standard order:

Run	A	B	C	rep1	rep2
1	-	-	-	34	40
2	+	-	-	26	29
3	-	+	-	33	35
4	+	+	-	21	22
5	-	-	+	24	23
6	+	-	+	23	22
7	-	+	+	19	18
8	+	+	+	18	18

Analyze the data using Minitab's DOE routines as follows. Be sure to include all relevant output in your hw.

i. Fit the full model containing all terms.

ii. Assuming all assumptions are adequately met (you will NOT check them in this problem), refine your full model by refitting a reduced model with insignificant terms dropped. Use $\alpha = 0.10$ for your t-tests. Write out your reduced model in terms of the coded variables using your coefficient estimates.

iii. To increase the speed with which discs are manufactured, the company wants use to use the high value (1.3) for linear velocity and the low value (20 sec.) for developing time. Given these settings, what value of laser power minimizes "jitter?" What is the mean value of jitter predicted by your model for these values of laser power, linear velocity, and development time?

iv. Convert your model in part ii from coded variables x_1, x_2, and x_3, to one expressed in the "natural" variables laser power, linear velocity, and development time.