Exam 3
Due Thursday July 23rd, 2020 at 11:59pm

Instructions:

- Please turn in the final copy of your Exam 1 into your shared dropbox folder: "1 Turned-in Exams".
  - Name your file: "Lastname Firstname Exam3"
  - Please only turn in a single pdf
- Your answers must be written in your own words, extracting what you need from your software output to support your narrative.
- Please do not copy and paste R output.
- Any graphs/figures must be in the section where they help answer a question with an explanation.
- You may attach code and output to your assignment as an Appendix. The appendix may be looked at if something is not clear in your writing.

Problem 1. Cracked Springs

(4 points) Box and Bisgaard (1987) described an experiment to reduce the percentage of cracked springs produced by a particular manufacturing process. Three factors are investigated: temperature of the quenching oil, carbon content of the steel, and temperature of the steel before quenching. A 2^3 design was used; the design and response data, percentage of noncracked springs, are given in the Table below. Show that the "one-factor-at-a-time" approach can miss the optimal settings obtained from analyzing the factorial effects. Assume that any nonzero estimated effects are significant. Hint: First assume oil temperature is the important factor (fix C=0.5 and S =1450), followed by percentage of carbon (fix S = 1450), and finally the steel temperature.

Oil Temperature (°F)	Percentage of Carbon	Steel Temperature (°F)	Percentage of Non-cracked Springs
70	0.50	1450	67
70	0.50	1600	79
70	0.70	1450	61
70	0.70	1600	75
120	0.50	1450	59
120	0.50	1600	90
120	0.70	1450	52
120	0.70	1600	87

Problem 2. Task Efficiency Experiment

A 2^3 experiment was performed by an industrial engineer and the results are given in the following Table. Half of the experiment was done on one day and the remaining half on the next day.

(a) (4 points) Compute the main effect of task.

(b) (2 points) Use a half-normal plot to detect significant factorial effects. Compare your findings with those based on IER version of Lenth's method at an appropriate α level.

(c) (2 points) With the timing mechanism operating properly, the standard deviation of the readings of average response time is known to be about 1 ($\sigma = 1$). Subsequent to carrying out this experiment, however, it was discovered that the timing device, although it had been operating properly on the first day, had not been operating properly on the second day. On that second day, the standard deviation was $\sigma = 4$. Given this information, what is the variance of the main effect of task computed in part (a)? Hint: See Lecture #5 for the variance of the factorial effect.

Setup	Flasher Type	Inertia of Lever	Task	Avg. Response Time (secs)	Randomized Order
1	A	Low	Y	11	1
2	B	Low	Y	12	4
3	A	High	Y	10	5
4	B	High	Y	11	3
5	A	Low	Z	16	2
6	B	Low	Z	14	6
7	A	High	Z	15	7
8	B	High	Z	19	8

Note: Flash A (low) and Flash B (high); Task Y (low) and Task Z (high); Randomized order is the order in which the experiments were performed.

Problem 3. Blocking

Suppose a 2^7 design is arranged in 8 blocks with generators $B_1 = 123, B_2 = 456, B_3 = 167$.

(a) (4 points) Find all the interactions that are confounded with block effects and use these to compute the $g_i(b)$ for $i \geq 2$ and determine the order of estimability.

(b) (2 points) An alternative scheme is the one given in Table 4A.1 (page 207 of WH) with $k = 7$ and $q = 3$. Compute the $g_i(b)$ for $i \geq 2$ and determine the order of estimability for the second scheme.

(c) (2 points) Compare the two schemes and show the clear advantages of the second scheme.

Hint: Page 197 of WH - "In general, a blocking scheme is said to have *estimability of order e* if the lowest order interactions confounded with block effects are of order $e+1$ ... estimability of order e ensures that all factorial effects of order e are estimable in the blocking scheme."

Problem 4. Resolution

(a) (4 points) What is the resolution of each of the fractional factorial designs below? Which design do you prefer? Justify your answers.

(i) 2^{6-2} with $5 = 1234$ and $6 = 124$,

(ii) 2^{6-2} with $5 = 123$ and $6 = 124$,

(b) (2 points) For the design in (*ii*), if we further know that any two-factor interaction involving 6 (i.e., 16, 26, 36, 46, 56) is negligible, which two-factor interactions are estimable under the usual assumptions that three-factor and higher interactions are negligible?

(c) (2 points) Under the same assumptions as in (b), find a scheme to arrange the design in (*ii*) in two blocks of size 8. Explain why your choice is the best.

Problem 5. Design Choice

(6 points) An experimenter who wishes to use a 2^{8-2} design can only do 16 runs in a day and would like to include “day” as a blocking variable. What design would you recommend? Why? Give the treatment generators and the block generators for your design and the collection of clear effects.