Statistics 101B - Spring 2020
Homework 5 (Due Tuesday May 26 at 5:00pm)

** Please upload your homework on CCLE. Please write your full name, student ID number, and section number on your homework.
Must be PDF.
NO late work will be accepted!**
You do not need to write the questions in your homework. Please show your work!

1. Problem 7.6
2. Problem 7.24

3. A 2^7 design is to be run in 8 blocks. We have the following 3 choices.

Choice 1: $B_1 = 123, B_2 = 4567, B_3 = 345,$

Choice 2: $B_1 = 1234, B_2 = 34, B_3 = 567,$

Choice 3: $B_1 = 1256, B_2 = 1234, B_3 = 1357,$

Give the blocking scheme for each choice, and find the best one from them.

Chapter 7 Problems

SS **7.1** Consider the experiment described in Problem 6.5. Analyze this experiment assuming that each replicate represents a block of a single production shift.

7.2 Consider the experiment described in Problem 6.9. Analyze this experiment assuming that each one of the four replicates represents a block.

SS **7.3** Consider the data from the first replicate of Problem 6.5. Suppose that these observations could not all be run using the same bar stock. Set up a design to run these observations in two blocks of four observations each with *ABC* confounded. Analyze the data.

7.4 Consider the data from the first replicate of Problem 6.5. Construct a design with two blocks of eight observations each with *ABCD* confounded. Analyze the data.

7.5 Repeat Problem 7.4 assuming that four blocks are required. Confound *ABD* and *ABC* (and consequently *CD*) with blocks.

SS **7.6** Using the data from the 2^5 design in Problem 6.24, construct and analyze a design in two blocks with *ABCDE* confounded with blocks.

SS **7.7** Repeat Problem 7.6 assuming that four blocks are necessary. Suggest a reasonable confounding scheme.

SS **7.8** Consider the data from the 2^5 design in Problem 6.24. Suppose that it was necessary to run this design in four blocks with *ACDE* and *BCD* (and consequently *ABE*) confounded. Analyze the data from this design.

SS **7.9** Consider the fill height deviation experiment in Problem 6.20. Suppose that each replicate was run on a separate day. Analyze the data assuming that days are blocks.

7.10 Consider the fill height deviation experiment in Problem 6.20. Suppose that only four runs could be made on each shift. Set up a design with *ABC* confounded in replicate I and *AC* confounded in replicate II. Analyze the data and comment on your findings.

SS **7.11** Consider the putting experiment in Problem 6.21. Analyze the data considering each replicate as a block.

7.12 The experiment in Problem 6.35 is a 2^5 factorial. Suppose that this design had been run in four blocks of eight runs each.

(a) Recommend a blocking scheme and set up the design.

(b) Analyze the data from this blocked design. Is blocking important?

7.13 Repeat Problem 7.12 using a design in two blocks.

7.14 The design in Problem 6.38 is a 2^3 factorial replicated twice. Suppose that each replicate was a block. Analyze all of the responses from this blocked design. Are the results comparable to those from Problem 6.38? Is the block effect large?

7.15 Consider the 2^6 design in eight blocks of eight runs each with *ABCD*, *ACE*, and *ABEF* as the independent effects chosen to be confounded with blocks. Generate the design. Find the other effects confounded with blocks.

7.16 Consider the 2^2 design in two blocks with *AB* confounded. Prove algebraically that $SS_{AB} = SS_{\text{Blocks}}$. SS

7.17 Consider the data in Example 7.2. Suppose that all the observations in block 2 are increased by 20. Analyze the data that would result. Estimate the block effect. Can you explain its magnitude? Do blocks now appear to be an important factor? Are any other effect estimates impacted by the change you made to the data?

7.18 Suppose that in Problem 6.5 we had confounded *ABC* in replicate I, *AB* in replicate II, and *BC* in replicate III. Calculate the factor effect estimates. Construct the analysis of variance table.

7.19 Repeat the analysis of Problem 6.5 assuming that *ABC* was confounded with blocks in each replicate.

7.20 Suppose that in Problem 6.11 *ABCD* was confounded in replicate I and *ABC* was confounded in replicate II. Perform the statistical analysis of this design.

7.21 Construct a 2^3 design with *ABC* confounded in the first two replicates and *BC* confounded in the third. Outline the analysis of variance and comment on the information obtained.

7.22 The block effect in a two-level design with two blocks can be calculated directly as the difference in the average response between the two blocks.

(a) True

(b) False

7.23 When constructing the 2^7 design confounded in eight blocks, three independent effects are chosen to generate the blocks, and there are a total of eight interactions confounded with blocks.

(a) True

(b) False

7.24 Consider the 2^5 factorial design in two blocks. If *ABCDE* is confounded with blocks, then which of the following runs is in the same block as run *acde*?

(a) *a* **(b)** *acd* **(c)** *bcd*

(d) *be* **(e)** *abe* **(f)** None of the above

7.25 The information on the interaction confounded with the block can always be separated from the block effect.

(a) True

(b) False

7.26 Consider the full 2^5 factorial design in Problem 6.42. Suppose that this experiment had been run in two blocks with *ABCDE* confounded with the blocks. Set up the blocked design and perform the analysis. Compare your results with the results obtained for the completely randomized design in Problem 6.42.

7.27 Suppose that you are designing an experiment for four factors and that due to material properties it is necessary to conduct the experiment in blocks. Material availability restricts you to the use of two blocks; however, each batch of material is only sufficient for six runs. So the standard 2^4 factorial in two blocks of eight runs each with *ABCD* confounded will not work. Recommend a design. Suggestion: this is a reasonable application for a *D*-optimal design. What type of design do you find in each block?

6.24 An experiment was run in a semiconductor fabrication plant in an effort to increase yield. Five factors, each at two levels, were studied. The factors (and levels) were A = aperture setting (small, large), B = exposure time (20% below nominal, 20% above nominal), C = development time (30 and 45 s), D = mask dimension (small, large), and E = etch time

SS

(14.5 and 15.5 min). The unreplicated 2^5 design shown below was run.

$(1) = 7$	$d = 8$	$e = 8$	$de = 6$
$a = 9$	$ad = 10$	$ae = 12$	$ade = 10$
$b = 34$	$bd = 32$	$be = 35$	$bde = 30$
$ab = 55$	$abd = 50$	$abe = 52$	$abde = 53$
$c = 16$	$cd = 18$	$ce = 15$	$cde = 15$
$ac = 20$	$acd = 21$	$ace = 22$	$acde = 20$
$bc = 40$	$bcd = 44$	$bce = 45$	$bcde = 41$
$abc = 60$	$abcd = 61$	$abce = 65$	$abcde = 63$

(a) Construct a normal probability plot of the effect estimates. Which effects appear to be large?

(b) Conduct an analysis of variance to confirm your findings for part (a).

(c) Write down the regression model relating yield to the significant process variables.

(d) Plot the residuals on normal probability paper. Is the plot satisfactory?

(e) Plot the residuals versus the predicted yields and versus each of the five factors. Comment on the plots.