

5.7 Problems

5.1. The following output was obtained from a computer program that performed a two-factor ANOVA on a factorial experiment.

Two-way ANOVA: y versus A, B					
Source	DF	SS	MS	F	P
A	1	0.322			
B	—	80.554	40.2771	4.59	—
Interaction	—	—	—	—	—
Error	12	105.327	8.7773		
Total	17	231.551			

- Fill in the blanks in the ANOVA table. You can use bounds on the P -values.
- How many levels were used for factor B?
- How many replicates of the experiment were performed?
- What conclusions would you draw about this experiment?

5.2. The following output was obtained from a computer program that performed a two-factor ANOVA on a factorial experiment.

Two-way ANOVA: y versus A, B					
Source	DF	SS	MS	F	P
A	1		0.0002	—	—
B	—	180.378	—	—	—
Interaction	3	8.479	—	—	0.932
Error	8	158.797	—	—	—
Total	15	347.653	—	—	—

- Fill in the blanks in the ANOVA table. You can use bounds on the P -values.
 - How many levels were used for factor B?
 - How many replicates of the experiment were performed?
 - What conclusions would you draw about this experiment?
- 5.3. The yield of a chemical process is being studied. The two most important variables are thought to be the pressure and the temperature. Three levels of each factor are selected, and a factorial experiment with two replicates is performed. The yield data are as follows:

Temperature (°C)	Pressure (psig)		
	200	215	230
150	90.4	90.7	90.2
	90.2	90.6	90.4
160	90.1	90.5	89.9
	90.3	90.6	90.1
170	90.5	90.8	90.4
	90.7	90.9	90.1

- Analyze the data and draw conclusions. Use $\alpha = 0.05$.
- Prepare appropriate residual plots and comment on the model's adequacy.
- Under what conditions would you operate this process?

5.4. An engineer suspects that the surface finish of a metal part is influenced by the feed rate and the depth of cut. He selects three feed rates and four depths of cut. He then conducts a factorial experiment and obtains the following data:

Feed Rate (in/min)	Depth of Cut (in)			
	0.15	0.18	0.20	0.25
0.20	74	79	82	99
	64	68	88	104
	60	73	92	96
	92	98	99	104
0.25	86	104	108	110
	88	88	95	99
	99	104	108	114
	98	99	110	111
0.30	102	95	99	107

- Analyze the data and draw conclusions. Use $\alpha = 0.05$.
 - Prepare appropriate residual plots and comment on the model's adequacy.
 - Obtain point estimates of the mean surface finish at each feed rate.
 - Find the P -values for the tests in part (a).
- 5.5. For the data in Problem 5.4, compute a 95 percent confidence interval estimate of the mean difference in response for feed rates of 0.20 and 0.25 in/min.
- 5.6. An article in *Industrial Quality Control* (1956, pp. 5–8) describes an experiment to investigate the effect of the type of glass and the type of phosphor on the brightness of a television tube. The response variable is the current necessary (in microamps) to obtain a specified brightness level. The data are as follows:

Glass Type	Phosphor Type		
	1	2	3
1	280	300	290
	290	310	285
	285	295	290
	230	260	220
2	235	240	225
	240	235	230

- (a) Is there any indication that either factor influences brightness? Use $\alpha = 0.05$.
 (b) Do the two factors interact? Use $\alpha = 0.05$.
 (c) Analyze the residuals from this experiment.

5.7. Johnson and Leone (*Statistics and Experimental Design in Engineering and the Physical Sciences*, Wiley, 1977) describe an experiment to investigate warping of copper plates. The two factors studied were the temperature and the copper content of the plates. The response variable was a measure of the amount of warping. The data were as follows:

Temperature (°C)	Copper Content (%)			
	40	60	80	100
50	17, 20	16, 21	24, 22	28, 27
75	12, 9	18, 13	17, 12	27, 31
100	16, 12	18, 21	25, 23	30, 23
125	21, 17	23, 21	23, 22	29, 31

- (a) Is there any indication that either factor affects the amount of warping? Is there any interaction between the factors? Use $\alpha = 0.05$.
 (b) Analyze the residuals from this experiment.
 (c) Plot the average warping at each level of copper content and compare them to an appropriately scaled t distribution. Describe the differences in the effects of the different levels of copper content on warping. If low warping is desirable, what level of copper content would you specify?
 (d) Suppose that temperature cannot be easily controlled in the environment in which the copper plates are to be used. Does this change your answer for part (c)?

5.8. The factors that influence the breaking strength of a synthetic fiber are being studied. Four production machines and three operators are chosen and a factorial experiment is run using fiber from the same production batch. The results are as follows:

Operator	Machine			
	1	2	3	4
1	109	110	108	110
	110	115	109	108
2	110	110	111	114
	112	111	109	112
3	116	112	114	120
	114	115	119	117

- (a) Analyze the data and draw conclusions. Use $\alpha = 0.05$.
 (b) Prepare appropriate residual plots and comment on the model's adequacy.

5.9. A mechanical engineer is studying the thrust force developed by a drill press. He suspects that the drilling speed and the feed rate of the material are the most important factors. He selects four feed rates and uses a high and low drill speed chosen to represent the extreme operating conditions. He obtains the following results. Analyze the data and draw conclusions. Use $\alpha = 0.05$.

Drill Speed	Feed Rate			
	0.015	0.030	0.045	0.060
125	2.70	2.45	2.60	2.75
	2.78	2.49	2.72	2.86
200	2.83	2.85	2.86	2.94
	2.86	2.80	2.87	2.88

5.10. An experiment is conducted to study the influence of operating temperature and three types of faceplate glass in the light output of an oscilloscope tube. The following data are collected:

Glass Type	Temperature		
	100	125	150
1	580	1090	1392
	568	1087	1380
	570	1085	1386
2	550	1070	1328
	530	1035	1312
	579	1000	1299
3	546	1045	867
	575	1053	904
	599	1066	889

- (a) Use $\alpha = 0.05$ in the analysis. Is there a significant interaction effect? Does glass type or temperature affect the response? What conclusions can you draw?
 (b) Fit an appropriate model relating light output to glass type and temperature.
 (c) Analyze the residuals from this experiment. Comment on the adequacy of the models you have considered.

5.11. Consider the experiment in Problem 5.3. Fit an appropriate model to the response data. Use this model to provide guidance concerning operating conditions for the process.

5.12. Use Tukey's test to determine which levels of the pressure factor are significantly different for the data in Problem 5.3.

5.13. An experiment was conducted to determine whether either firing temperature or furnace position affects the baked density of a carbon anode. The data are shown below:

Position	Temperature (°C)		
	800	825	850
1	570	1063	565
	565	1080	510
	583	1043	590
	528	988	526
2	547	1026	538
	521	1004	532

Suppose we assume that no interaction exists. Write down the statistical model. Conduct the analysis of variance and test hypotheses on the main effects. What conclusions can be drawn? Comment on the model's adequacy.

5.14. Derive the expected mean squares for a two-factor analysis of variance with one observation per cell, assuming that both factors are fixed.

5.15. Consider the following data from a two-factor factorial experiment. Analyze the data and draw conclusions. Perform a test for nonadditivity. Use $\alpha = 0.05$.

Row Factor	Column Factor			
	1	2	3	4
1	36	39	36	32
2	18	20	22	20
3	30	37	33	34

5.16. The shear strength of an adhesive is thought to be affected by the application pressure and temperature. A factorial experiment is performed in which both factors are assumed to be fixed. Analyze the data and draw conclusions. Perform a test for nonadditivity.

Pressure (lb/in ²)	Temperature (°F)		
	250	260	270
120	9.60	11.28	9.00
130	9.69	10.10	9.57
140	8.43	11.01	9.03
150	9.98	10.44	9.80

5.17. Consider the three-factor model

$$y_{ijk} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\tau\gamma)_{ik} + (\beta\gamma)_{jk} + \epsilon_{ijk} \begin{cases} i = 1, 2, \dots, a \\ j = 1, 2, \dots, b \\ k = 1, 2, \dots, c \end{cases}$$

Notice that there is only one replicate. Assuming all the factors are fixed, write down the analysis of variance table, including the expected mean squares. What would you use as the "experimental error" to test hypotheses?

5.18. The percentage of hardwood concentration in raw pulp, the vat pressure, and the cooking time of the pulp are being investigated for their effects on the strength of paper. Three levels of hardwood concentration, three levels of pressure, and two cooking times are selected. A factorial experiment with two replicates is conducted, and the following data are obtained:

Percentage of Hardwood Concentration	Cooking Time 3.0 Hours		
	Pressure		
	400	500	650
2	196.6	197.7	199.8
	196.0	196.0	199.4
4	198.5	196.0	198.4
	197.2	196.9	197.6
8	197.5	195.6	197.4
	196.6	196.2	198.1

Percentage of Hardwood Concentration	Cooking Time 4.0 Hours		
	Pressure		
	400	500	650
2	198.4	199.6	200.6
	198.6	200.4	200.9
4	197.5	198.7	199.6
	198.1	198.0	199.0
8	197.6	197.0	198.5
	198.4	197.8	199.8

- Analyze the data and draw conclusions. Use $\alpha = 0.05$.
- Prepare appropriate residual plots and comment on the model's adequacy.
- Under what set of conditions would you operate this process? Why?

5.19. The quality control department of a fabric finishing plant is studying the effect of several factors on the dyeing of cotton-synthetic cloth used to manufacture men's shirts. Three operators, three cycle times, and two temperatures were selected, and three small specimens of cloth were dyed under each set of conditions. The finished cloth was compared to a standard, and a numerical score was assigned. The results are as follows. Analyze the data and draw conclusions. Comment on the model's adequacy.


Cycle Time	Temperature					
	300°C			350°C		
	Operator			Operator		
	1	2	3	1	2	3
40	23	27	31	24	38	34
	24	28	32	23	36	36
	25	26	29	28	35	39
	36	34	33	37	34	34
50	35	38	34	39	38	36
	36	39	35	35	36	31
	28	35	26	26	36	28
60	24	35	27	29	37	26
	27	34	25	25	34	24


5.20. In Problem 5.3, suppose that we wish to reject the null hypothesis with a high probability if the difference in the true mean yield at any two pressures is as great as 0.5. If a reasonable prior estimate of the standard deviation of yield is 0.1, how many replicates should be run?

5.21. The yield of a chemical process is being studied. The two factors of interest are temperature and pressure. Three levels of each factor are selected; however, only nine runs can be made in one day. The experimenter runs a complete replicate of the design on each day. The data are shown in the following table. Analyze the data, assuming that the days are blocks.

Temperature	Day 1 Pressure			Day 2 Pressure		
	250	260	270	250	260	270
Low	86.3	84.0	85.8	86.1	85.2	87.3
Medium	88.5	87.3	89.0	89.4	89.9	90.3
High	89.1	90.2	91.3	91.7	93.2	93.7

5.22. Consider the data in Problem 5.7. Analyze the data, assuming that replicates are blocks.

 **5.23.** Consider the data in Problem 5.8. Analyze the data, assuming that replicates are blocks.

 **5.24.** An article in the *Journal of Testing and Evaluation* (Vol. 16, no. 2, pp. 508–515) investigated the effects of cyclic loading and environmental conditions on fatigue crack growth at a constant 22 MPa stress for a particular material. The data from this experiment are shown below (the response is crack growth rate):

Frequency	Environment		
	Air	H ₂ O	Salt H ₂ O
10	2.29	2.06	1.90
	2.47	2.05	1.93

1	2.48	2.23	1.75
	2.12	2.03	2.06
	2.65	3.20	3.10
	2.68	3.18	3.24
	2.06	3.96	3.98
	2.38	3.64	3.24
	2.24	11.00	9.96
	2.71	11.00	10.01
0.1	2.81	9.06	9.36
	2.08	11.30	10.40

(a) Analyze the data from this experiment (use $\alpha = 0.05$).

(b) Analyze the residuals.

(c) Repeat the analyses from parts (a) and (b) using $\ln(y)$ as the response. Comment on the results.

5.25. An article in the *IEEE Transactions on Electron Devices* (Nov. 1986, pp. 1754) describes a study on polysilicon doping. The experiment shown below is a variation of their study. The response variable is base current.

Polysilicon Doping (ions)	Anneal Temperature (°C)		
	900	950	1000
1×10^{20}	4.60	10.15	11.01
	4.40	10.20	10.58
2×10^{20}	3.20	9.38	10.81
	3.50	10.02	10.60

(a) Is there evidence (with $\alpha = 0.05$) indicating that either polysilicon doping level or anneal temperature affects base current?

(b) Prepare graphical displays to assist in interpreting this experiment.

(c) Analyze the residuals and comment on model adequacy.

(d) Is the model

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{22} x_2^2 + \beta_{12} x_1 x_2 + \epsilon$$

supported by this experiment (x_1 = doping level, x_2 = temperature)? Estimate the parameters in this model and plot the response surface.

5.26. An experiment was conducted to study the life (in hours) of two different brands of batteries in three different devices (radio, camera, and portable DVD player). A completely randomized two-factor factorial experiment was conducted and the following data resulted.

Brand of Battery	Device		
	Radio	Camera	DVD Player
A	8.6	7.9	5.4
	8.2	8.4	5.7
B	9.4	8.5	5.8
	8.8	8.9	5.9

(a) Analyze the data and draw conclusions, using $\alpha = 0.05$.

(b) Investigate model adequacy by plotting the residuals.

(c) Which brand of batteries would you recommend?

5.27. I have recently purchased new golf clubs, which I believe will significantly improve my game. Below are the scores of three rounds of golf played at three different golf courses with the old and the new clubs.

Clubs	Course		
	Ahwatukee	Karsten	Foothills
Old	90	91	88
	87	93	86
	86	90	90
New	88	90	86
	87	91	85
	85	88	88

(a) Conduct an analysis of variance. Using $\alpha = 0.05$, what conclusions can you draw?

(b) Investigate model adequacy by plotting the residuals.

5.28. A manufacturer of laundry products is investigating the performance of a newly formulated stain remover. The new formulation is compared to the original formulation with respect to its ability to remove a standard tomato-like stain in a test article of cotton cloth using a factorial experiment. The other factors in the experiment are the number of times the test article is washed (1 or 2) and whether or not a detergent booster is used. The response variable is the stain shade after washing (12 is the darkest, 0 is the lightest). The data are shown in the following table.

Formulation	Number of Washings		Number of Washings	
	1		2	
	Booster		Booster	
	Yes	No	Yes	No
New	6, 5	6, 5	3, 2	4, 1
Original	10, 9	11, 11	10, 9	9, 10

(a) Conduct an analysis of variance. Using $\alpha = 0.05$, what conclusions can you draw?

(b) Investigate model adequacy by plotting the residuals.

5.29. Bone anchors are used by orthopedic surgeons in repairing torn rotator cuffs (a common shoulder tendon injury among baseball players). The bone anchor is a threaded insert that is screwed into a hole that has been drilled into the shoulder bone near the site of the torn tendon. The torn tendon is then sutured to the anchor. In a successful operation, the tendon is stabilized and reattaches itself to the bone. However, bone anchors can pull out if they are subjected to high loads. An experiment was performed to study the force required to pull out the anchor for three anchor types and two different foam densities (the foam simulates the natural variability found in real bone). Two replicates of the experiment were performed. The experimental design and the pullout force response data are as follows.

Anchor Type	Foam Density	
	Low	High
A	190, 200	241, 255
B	185, 190	230, 237
C	210, 205	256, 260

(a) Analyze the data from this experiment.

(b) Investigate model adequacy by constructing appropriate residual plots.

(c) What conclusions can you draw?

5.30. An experiment was performed to investigate the keyboard feel on a computer (crisp or mushy) and the size of the keys (small, medium, or large). The response variable is typing speed. Three replicates of the experiment were performed. The experimental design and the data are as follow.

Key Size	Keyboard Feel	
	Mushy	Crisp
Small	31, 33, 35	36, 40, 41
Medium	36, 35, 33	40, 41, 42
Large	37, 34, 33	38, 36, 39

(a) Analyze the data from this experiment.

(b) Investigate model adequacy by constructing appropriate residual plots.

(c) What conclusions can you draw?

5.31. An article in *Quality Progress* (May 2011, pp. 42–48) describes the use of factorial experiments to improve a silver powder production process. This product is used in conductive pastes to manufacture a wide variety of products ranging from silicon wafers to elastic membrane switches. Powder density (g/cm³) and surface area (cm²/g) are the two critical

characteristics of this product. The experiments involved three factors—reaction temperature, ammonium percent, and stirring rate. Each of these factors had two levels and the design was replicated twice. The design is shown below.

Ammonium (%)	Stir Rate (RPM)	Temperature (°C)	Density	Surface Area
2	100	8	14.68	0.40
2	100	8	15.18	0.43
30	100	8	15.12	0.42
30	100	8	17.48	0.41
2	150	8	7.54	0.69
2	150	8	6.66	0.67
30	150	8	12.46	0.52
30	150	8	12.62	0.36
2	100	40	10.95	0.58
2	100	40	17.68	0.43
30	100	40	12.65	0.57
30	100	40	15.96	0.54
2	150	40	8.03	0.68
2	150	40	8.84	0.75
30	150	40	14.96	0.41
30	150	40	14.96	0.41

- Analyze the density response. Are any interactions significant? Draw appropriate conclusions about the effects of the significant factors on the response.
- Prepare appropriate residual plots and comment on model adequacy.
- Construct contour plots to aid in practical interpretation of the density response.
- Analyze the surface area response. Are any interactions significant? Draw appropriate conclusions about the effects of the significant factors on the response.
- Prepare appropriate residual plots and comment on model adequacy.
- Construct contour plots to aid in practical interpretation of the surface area response.

5.32. Continuation of Problem 5.31. Suppose that the specifications require that surface area must be between 0.3 and 0.6 cm²/g and that density must be less than 14 g/cm³. Find a set of operating conditions that will result in a product that meets these requirements.

5.33. An article in *Biotechnology Progress* (2001, Vol. 17, pp. 366–368) described an experiment to investigate nisin extraction in aqueous two-phase solutions. A two-factor factorial experiment was conducted using factors A = concentration of PEG and B = concentration of Na₂SO₄. Data similar to that reported in the paper are shown below.

A	B	Extraction (%)
13	11	62.9
13	11	65.4
15	11	76.1
15	11	72.3
13	13	87.5
13	13	84.2
15	13	102.3
15	13	105.6

- Analyze the extraction response. Draw appropriate conclusions about the effects of the significant factors on the response.
- Prepare appropriate residual plots and comment on model adequacy.
- Construct contour plots to aid in practical interpretation of the density response.

5.34. Reconsider the experiment in Problem 5.4. Suppose that this experiment had been conducted in three blocks, with each replicate a block. Assume that the observations in the data table are given in order, that is, the first observation in each cell comes from the first replicate, and so on. Reanalyze the data as a factorial experiment in blocks and estimate the variance component for blocks. Does it appear that blocking was useful in this experiment?

5.35. Reconsider the experiment in Problem 5.6. Suppose that this experiment had been conducted in three blocks, with each replicate a block. Assume that the observations in the data table are given in order, that is, the first observation in each cell comes from the first replicate, and so on. Reanalyze the data as a factorial experiment in blocks and estimate the variance component for blocks. Does it appear that blocking was useful in this experiment?

5.36. Reconsider the experiment in Problem 5.8. Suppose that this experiment had been conducted in two blocks, with each replicate a block. Assume that the observations in the data table are given in order, that is, the first observation in each cell comes from the first replicate, and so on. Reanalyze the data as a factorial experiment in blocks and estimate the variance component for blocks. Does it appear that blocking was useful in this experiment?

5.37. Reconsider the three-factor factorial experiment in Problem 5.18. Suppose that this experiment had been conducted in two blocks, with each replicate a block. Assume that the observations in the data table are given in order, that is, the first observation in each cell comes from the first replicate, and so on. Reanalyze the data as a factorial experiment in blocks and estimate the variance component for blocks. Does it appear that blocking was useful in this experiment?

5.38. Reconsider the three-factor factorial experiment in Problem 5.19. Suppose that this experiment had been

conducted in three blocks, with each replicate a block. Assume that the observations in the data table are given in order, that is, the first observation in each cell comes from the first replicate, and so on. Reanalyze the data as a factorial experiment in blocks and estimate the variance component for blocks. Does it appear that blocking was useful in this experiment?

5.39. Reconsider the bone anchor experiment in Problem 5.29. Suppose that this experiment had been conducted in two blocks, with each replicate a block. Assume that the observations in the data table are given in order, that is, the first observation in each cell comes from the first replicate, and so on. Reanalyze the data as a factorial experiment in blocks and estimate the variance component for blocks. Does it appear that blocking was useful in this experiment?

5.40. Reconsider the keyboard experiment in Problem 5.30. Suppose that this experiment had been conducted in three blocks, with each replicate a block. Assume that the observations in the data table are given in order, that is, the first observation in each cell comes from the first replicate, and so on. Reanalyze the data as a factorial experiment in blocks and estimate the variance component for blocks. Does it appear that blocking was useful in this experiment?

5.41. The C. F. Eye Care company manufactures lenses for transplantation into the eye following cataract surgery. An engineering group has conducted an experiment involving two factors to determine their effect on the lens polishing process. The results of this experiment are summarized in the following ANOVA display:

Source	DF	SS	MS	F	P-value
Factor A	—	—	0.0833	0.05	0.952
Factor B	—	96.333	96.3333	57.80	<0.001
Interaction	2	12.167	6.0833	3.65	—
Error	6	10.000	—	—	—
Total	11	118.667	—	—	—

Answer the following questions about this experiment.

- The sum of squares for factor A is _____.
- The number of degrees of freedom for factor A in the experiment is _____.
- The number of degrees of freedom for factor B is _____.
- The mean square for error is _____.
- An upper bound for the P-value for the interaction test statistic is _____.
- The engineers used _____ levels of the factor A in this experiment.
- The engineers used _____ levels of the factor B in this experiment.
- There are _____ replicates of this experiment.

- Would you conclude that the effect of factor B depends on the level of factor A (Yes or No)?
- An estimate of the standard deviation of the response variable is _____.

5.42. Reconsider the lens polishing experiment in Problem 5.41. Suppose that this experiment had been conducted as a randomized complete block design. The sum of squares for blocks is 4.00. Reconstruct the ANOVA given this new information. What impact does the blocking have on the conclusions from the original experiment?

5.43. In Problem 4.53 you met physics PhD student Laura Van Ertia who had conducted a single-factor experiment in her pursuit of the unified theory. She is at it again, and this time she has moved on to a two-factor factorial conducted as a completely randomized design. From her experiment, Laura has constructed the following incomplete ANOVA display:

Source	SS	DF	MS	F
A	350.00	2		
B	300.00		150	
AB	200.00		50	
Error	150.00	18		
Total	1000.00			

- How many levels of factor B did she use in the experiment? _____
- How many degrees of freedom are associated with interaction? _____
- The error mean square is _____.
- The mean square for factor A is _____.
- How many replicates of the experiment were conducted? _____
- What are your conclusions about interaction and the two main effects?
- An estimate of the standard deviation of the response variable is _____.
- If this experiment had been run in blocks there would have been _____ degrees of freedom for blocks.

5.44. Continuation of Problem 5.43. Suppose that Laura did actually conduct the experiment in Problem 5.43 as a randomized complete block design. Assume that the block sum of squares is 60.00. Reconstruct the ANOVA display under this new set of assumptions.

5.45. Consider the following ANOVA for a two-factor factorial experiment:

Source	DF	SS	MS	F	P
A	2	8.0000	4.0000	2.00	0.216
B	1	8.3333	8.3333	4.17	0.087
Interaction	2	10.6667	5.3333	2.67	0.148
Error	6	12.0000	2.0000		
Total	11	39.0000			

In addition to the ANOVA, you are given the following data totals. Row totals (factor A) = 18, 10, 14; column totals (factor B) = 16, 26; cell totals = 10, 8, 2, 8, 4, 10; and replicate totals = 19, 23. The grand total is 42. The original experiment was a completely randomized design. Now suppose that the experiment had been run in two complete blocks. Answer the following questions about the ANOVA for the blocked experiment.

- The block sum of squares is _____.
- There are _____ degrees of freedom for blocks.
- The error sum of squares is now _____.
- The interaction effect is now significant at 1 percent (Yes or No).

5.46. Consider the following incomplete ANOVA table:

Source	SS	DF	MS	F
A	50.00	1	50.00	
B	80.00	2	40.00	
AB	30.00	2	15.00	
Error		12		
Total	172.00	17		

In addition to the ANOVA table, you know that the experiment has been replicated three times and that the totals of the three replicates are 10, 12, and 14, respectively. The original experiment was run as a completely randomized design. Answer the following questions:

- The pure error estimate of the standard deviation of the sample observations is 1 (Yes or No).
- Suppose that the experiment had been run in blocks, so that it is a randomized complete block design. The number of degrees of freedom for blocks would be _____.
- The block sum of squares is _____.
- The error sum of squares in the randomized complete block design is now _____.
- For the randomized complete block design, what is the estimate of the standard deviation of the sample observations?