AE Additional Exercises

1. An experimenter often uses a randomized block design to reduce variation by comparing the treatments in homogeneous groups of experimental units called blocks. In many cases, differences in treatments are more likely to be detected with such a design than if the blocking factor were ignored. In each of the following situations, give an example of how one would run a randomized block design to make the comparison in each case. Be aware that there may be more than one correct answer in each example.

a. Three different methods of teaching science are to be analyzed by comparing final exam scores from classes taught by the different methods. Assume that the same final exam is given to each class.

b. Five hypertensive treatments are to be compared based on their ability to reduce systolic blood pressure. It is felt that the performance of the drugs is affected by the weight of the participant in the study.

c. It is desired to compare three different ethnic groups on their knowledge of American history. Each person in the study will be given a 50-question multiple choice test to determine their overall knowledge of the subject.

2. A pharmacist is interested in studying the rate at which three different sinus headache drugs are absorbed into the bloodstream. She randomly selects 12 people, and then randomly assigns four people to try each drug. She administers the drug to each participant and measures the time it takes for the drug to be absorbed into the patient's bloodstream (in minutes). The results of the study are as follows.

Drug Absorption Time (Minutes)		
Drug 1	Drug 2	Drug 3
5	10	6
4	11	7
6	9	5
3	8	5

a. Can the pharmacist conclude at $\alpha = 0.01$ that there is a significant difference among the average times required for absorption into the bloodstream for the three drugs?

b. What assumptions did the pharmacist make in performing the test procedure in part **a.**? Do the data appear to satisfy these assumptions? Explain.

c. Describe an alternate design that the pharmacist could have used for the above analysis. What are the advantages and disadvantages of this design?

3. An FDA representative is interested in knowing if there is a difference in the average fat contents of three different brands of margarine. The representative randomly selects six samples of each of the brands of margarine and measures the average fat contents per serving. The results of the study are displayed in the following table.

Fat Content per Serving (Grams)		
Margarine #1	Margarine #2	Margarine #3
6	5	9
7	6	8
6	5	7
8	4	8
6	6	9
8	5	7

a. Do the data indicate a difference among average fat contents per serving for the three brands of margarine at $\alpha = 0.01$?

b. What assumptions were made for the test in part **a.**? Do the data appear to satisfy these assumptions? Explain.

c. Why wouldn't a randomized block design be appropriate for this experiment?

4. Psychological reactance may be viewed as the motivational state resulting when someone's freedom is threatened or eliminated. A study relating psychological reactance to one's age was reported in "Psychological Reactance: Effects of Age and Gender" in the *Journal of Social Psychology*. In order to determine the degree of psychological reactance, participants were asked to fill out a questionnaire which was then scored. The higher the score, the more acute the degree of psychological reactance. The means, standard deviations, and group sizes (for different age groups) are given in the following table.

Psychological Reactance			
Age Group	**Mean**	**Standard Deviation**	**Group Size**
18–24	3.36	0.60	1011
24–29	3.28	0.65	321
30–40	3.16	0.64	385

Although the summary statistics were given in the article, the actual data values upon which the statistics were based were not listed. This is standard procedure in many scientific journals.

a. Compute the sums of squares and their degrees of freedom for treatments and error based upon the statistics given in the table.

b. Compute MST and MSE.

c. With $\alpha = 0.01$, can we conclude that there is a significant difference among the degrees of psychological reactance for the different age groups?

d. What assumptions are necessary for performing the test in part **c.**? Can they be checked in this instance?

5. Interviews of fans following an Australian Football League game were summarized in the article "On Being a Sore Loser: How Fans React to Their Team's Failure" in the *Australian Journal of Psychology*. The study divided the fans interviewed into losers (those who supported the losing team), winners (those who supported the winning team), and non-partisans (those who were indifferent to the outcome of the game). Each fan was asked several questions, all dealing with the fan's perceptions of the game. The purpose of the study was to see if the groups differed on their responses to any of the questions. One question asked the fans to rate the umpire's performance on a five-point scale from *very bad* (1) to *very good* (5). The mean responses and group sizes associated with this question are given in the following table.

Umpire Performance		
Group	**Mean**	**Group Size**
Losers	2.8	49
Winners	3.7	35
Non-Partisans	3.5	57

a. Compute the grand mean and the sum of squares for treatments (SST).

b. Compute the *F*-statistic for testing for equality of the group means. The sum of squares for error (SSE) was given in the article as 39.3.

c. With $\alpha = 0.01$, can we conclude that there is a significant difference among the groups in the perception of the umpire?

d. What assumptions are necessary for performing the test in part **c.**? Can they be checked in this instance?

6. Consider the following data regarding median starting and mid-career salaries for graduates from schools in different regions of the United States.

Starting and Mid-Career (Salaries by Region)		
School	**Starting Median Salary ($)**	**Mid-Career Median Salary ($)**
Midwest		
Notre Dame	52,900	107,000
Carleton College	42,800	98,300
Illinois Institute of Technology	52,000	96,000
Denison University	40,600	94,000
University of Chicago	46,900	92,700
Northwestern University	49,900	88,300
Washington University in St. Louis	51,200	87,700
Northeast		
Princeton	56,900	130,000
Harvard	54,100	116,000
Massachusetts Institute of Technology	69,700	115,000
Dartmouth	51,600	114,000
Bucknell University	52,600	108,000
Manhattan College	53,900	107,000
Williams College	51,800	105,000
South		
Duke University	54,400	113,000
Vanderbilt University	51,300	100,000
Washington and Lee University	48,600	99,800
Wake Forest University	46,000	98,800
Rice University	51,100	97,400
Georgetown University	50,300	96,900
College of William and Mary	45,000	96,500
West		
University of Colorado – Boulder	45,900	90,400
University of Washington	46,700	88,400
Gonzaga University	44,200	87,700
Brigham Young University	47,400	86,800
University of Arizona	45,400	81,600
University of Oregon	39,700	79,200
Santa Clara University	52,900	105,000

Source: Payscale.com

a. Using $\alpha = 0.05$, is there a significant difference among average starting salaries for the four different regions?

b. What is the value of F for this test?

c. Using $\alpha = 0.05$, is there a significant difference among average mid-career salaries for the four different regions?

d. State the assumptions made for the two hypothesis tests in parts **a.** and **c.**

e. Do you have any concerns about these data? Explain.

7. Consider the following data regarding the median starting and mid-career salaries by type of major.

Starting and Mid-Career Salaries by Major

Major	Starting Median Pay ($)	Mid-Career Median Pay ($)	Major	Starting Median Pay ($)	Mid-Career Median Pay ($)
Engineering			**Math and Science**		
Petroleum Engineering	97,900	155,000	Applied Mathematics	52,600	98,600
Chemical Engineering	64,500	109,000	Computer Science	56,600	97,900
Electrical Engineering	61,300	103,000	Statistics	49,000	93,800
Aerospace Engineering	60,700	102,000	Mathematics	47,000	89,900
Computer Engineering	61,800	101,000	Physics	49,800	101,000
Nuclear Engineering	65,100	97,800	Biochemistry	41,700	84,700
Biomedical Engineering	53,800	97,800	Food Science	43,300	83,700
Mechanical Engineering	58,400	94,500	Geology	45,300	83,300
Industrial Engineering	57,400	93,100	Molecular Biology	40,500	81,200
Civil Engineering	53,100	90,200	Chemistry	42,000	80,900
Environmental Engineering	51,700	88,600	**Other**		
Business			Economics	47,300	94,700
Finance	46,500	87,300	Film Production	41,600	80,700
Supply Chain Management	50,200	84,700	Political Science	39,900	80,100
International Business	41,600	83,700	International Relations	40,500	79,400
Accounting	44,700	75,700	Philosophy	39,800	75,600
Advertising	37,700	74,700	History	37,800	69,000
Marketing	38,200	73,500	Communications	38,000	66,900
Business	41,000	70,500	Journalism	36,100	66,400
Public Relations	35,500	65,700	Spanish	36,400	58,400

Source: Payscale.com

a. State the null and alternative hypotheses to test if there is a significant difference in starting salary among the four types of majors.

b. Use $\alpha = 0.01$ to test for a significant difference among average starting salaries for the different types of majors.

c. State the null and alternative hypotheses to test if there is a significant difference among average mid-career salaries for the four types of majors.

d. Use $\alpha = 0.01$ to test for a significant difference among average mid-career salaries for the different types of majors.

8. Consider the following partially completed ANOVA table for a 3×4 factorial experiment with two replications.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*
Factor A	0.800	2		
Factor B	5.300	3		
Interaction	9.600			
Within				
Total	17.000	26		

a. Complete the ANOVA table.

b. At the 0.05 level, is there evidence of significant interaction between A and B? Justify your answer.

c. At the 0.05 level, is there evidence of a significant Factor A effect? Justify your answer.

d. At the 0.05 level, is there evidence of a significant Factor B effect? Justify your answer.

e. Does the result of the test for interaction suggest further investigation? Justify your answer.

9. In an experiment to determine the best method by which to assess college students, a group of students were exposed to one of three types of tests. The three methods were: all multiple choice questions, all free-response questions, and mixed questions (a mixture of multiple choice and free-response questions). The scores were recorded for each test taken. Fifteen students were used in the study and were grouped by class level (freshman, sophomore, junior, senior, and graduate). The following table contains the results of the experiment.

	Testing Methods		
Class Level	**Multiple Choice**	**Free-Response**	**Mixed**
Freshman	78	84	90
Sophomore	82	90	95
Junior	90	94	98
Senior	88	96	100
Graduate	95	98	99

a. Graphically plot the test scores by class level and testing method. Discuss the graph.

b. Perform an analysis of the data using the class-level blocks. Are blocking effects significant at the 0.05 level of significance? Explain.

c. Is the experiment useful having been analyzed as a completely randomized block design? Explain.

10. A randomized block design yielded the following ANOVA table.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*
Treatment	500.000	5	100	7.502
Block	230.000	3	76.67	5.752
Error	120.000	9	13.33	
Total	850.000	17		

a. How many blocks are used in the experiment?

b. How many treatments are used in the experiment?

c. How many observations are used in the experiment?

d. What are the null and alternative hypotheses to test if there is a difference among the treatment means?

e. What test statistic should be used to conduct the test in part **d.**?

f. What is the rejection region for the test in parts **d.** and **e.**?

g. Carry out the test and state your conclusion based on a significance level of 0.05.

11. JAS & Associates, a commercial developer, usually gets three cost estimates for many of the jobs for their building projects. Even though one contractor normally works on each potential job, it is in the best interest of the company to get additional estimates and compare them for consistency, no matter who gets the job. To check the consistency of the estimates, several projects are selected and three contractors are asked to submit estimates. The estimates (in thousands of dollars) for the 10 jobs are given in the following table.

Contractor Cost Estimates (Thousands of Dollars)

Job	Contractor A	Contractor B	Contractor C
1	27	26	28
2	20	18	22
3	14	13	17
4	18	21	20
5	23	20	22
6	19	17	19
7	12	14	15
8	10	12	13
9	16	20	19
10	40	42	47

a. Perform the appropriate analysis on the data given and generate the ANOVA table for the analysis.

b. Do the data provide sufficient evidence to conclude that there is a difference among the cost estimates supplied by the contractors? Use a significance level of 0.05 to make your decision.

c. What is the *P*-value for the test performed in part **a.**? Interpret this value.

12. The following table is a 3 × 3 factorial design with three observations for each factor level.

Factorial Design Data

Factor A	Factor B		
	1	2	3
1	30	47	36
	30	42	37
	30	42	38
2	12	27	35
	14	24	31
	15	22	33
3	10	34	24
	13	31	20
	12	31	22

a. Plot the treatment means using Factor A as the *x*-axis and Factor B as plotting symbols. Do the means appear to be different? Does interaction between factors A and B appear to be present? Justify your answers.

b. Perform the analysis using a software package, generating the ANOVA table.

c. Test for significant interaction using a 0.05 level of significance. Discuss your findings.

d. Test for A and B effects using a 0.05 level of significance. Discuss your findings.

13. Tech SportsPlex (TSP) is conducting a study to determine the effectiveness of three types of marketing/advertising methods: e-coupons, newspaper ads, and price discounts. Three counties (believed to be of equal size and close driving distance to TSP) were selected for the marketing campaign. Each strategy was used for a three-month period. It is known that the sales would be seasonal (i.e. TSP's management expects less activity during the summer months). The revenue data (in thousands of dollars) from the study are given in the following table.

TSP Revenues by Marketing Strategy (Thousands of Dollars)

Quarter	e-Coupons	Newspaper Ads	Price Discounts
1	48	42	37
2	25	18	21
3	20	15	18
4	40	30	24

a. Specify the null and alternative hypotheses to determine if there is a significant difference among average revenues for the three advertising strategies.

b. Generate the ANOVA table to test the hypotheses in **a.**

c. Conduct the test in **a.** using a significance level of 0.05.

d. Was the variation among the observed revenues significantly reduced by blocking? Explain using $\alpha = 0.05$.