

Show **all** of your work on this assignment and answer each question fully in the given context. Each individual part is worth 5 points and partial credit is awarded for close answers.

**If you cannot submit your homework in the class, you can drop it at my office door in 3220 Snedecore Hall by Thursday at 03:30 PM.**

Please staple your assignment!

1. [**Ch. 1.2 Exercise 1, pg. 13**] Describe a situation in your field where an observational study might be used to answer a question of real importance. Describe another situation where an experiment might be used.[5pts]

**Solution:** Answers might vary, but a simple answer could be as follows.

Observational study: You might be interested in assessing the job satisfaction of a large number of manufacturing workers; you could administer a survey to measure various dimensions of job satisfaction.

Experimental study: You might want to compare several different job routing schemes to see which one achieves the greatest throughput in a job shop.

2. [**Ch. 1.2 Exercise 2, pg. 13**] Describe two different contexts in your field where, respectively, qualitative and quantitative data might arise.[5pts]

**Solution:** There are different possible answers, but one of them is: Qualitative data: rating the quality of batches of ice cream as either poor, fair, good, or exceptional. Quantitative data: measuring the time (in hours) it takes for each of 1000 integrated circuit chips to fail in a high-stress environment.

3. [**Chapter 1, End of chapter exercise, Exercise 8, pg. 24**] Consider a situation like that of Example 1 in the class (involving the heat treating of gears). Suppose that the original gears can be purchased from a variety of vendors, they can be made out of a variety of materials, they can be heated according to a variety of regimens (involving different times and temperatures), they can be cooled in a number of different ways, and the furnace atmosphere can be adjusted to a variety of different conditions.

A number of features of the final gears are of interest, including their flatness, their concentricity, their hardness (both before and after heat treating), and their surface finish.

- (a) What kind of data arise if, for a single set of conditions, the Rockwell hardness of several gears is measured both before and after heat treating? (Use terminology of section 1.2. i.e. what kind of data that would be in terms of univariate/multivariate, quantitative or qualitative, if quantitative, whether they are discrete or continuous, ...)[5 pts]

**Solution:**Rockwell hardness: multivariate (bivariate), repeated measures (paired), quantitative data.

- (b) In the same context, suppose that engineering specifications on flatness require that measured flatness not exceed .40 mm. If flatness is measured for several gears and each gear is simply marked Acceptable or Not Acceptable, what kind of data are generated? (i.e. what kind of data that would be in terms of univariate/multivariate, quantitative or qualitative, if quantitative, whether they are discrete or continuous, ...)[5 pts]

**Solution:**Flatness: univariate, qualitative data.

- (c) Describe a three-factor full factorial study that might be carried out in this situation. Name the factors that will be used and describe the levels of each. Write out a list of all the different combinations of levels of the factors that will be studied. [10 pts]

**Solution:** There are many possibilities. Possible factors are Vendor, Material, Heating time, Heating Temperature, Cooling Method, and Furnace Atmosphere Condition. You could choose any number of levels for each factor. If you choose Vendor (1 VS. 2), Heating Time (short VS. Long), and Cooling Method (1 VS. 2), the factor-level combinations are given below:

Vendor	Heating Time	Cooling Method
1	short	1
2	short	1
1	long	1
2	long	1
1	short	2
2	short	2
1	long	2
2	long	2

4. [Ch. 2.3 Exercise 1, pg. 47] Consider the context of a study on making paper airplanes where two different Designs (say delta versus t wing), two different Papers (say construction versus typing) and two different Loading Conditions (with a paper clip versus without a paper clip) are of interest with regard to their impact on flight distance. Describe some variables that you would want to control in such a study. What are the response and experimental variables that would be appropriate in this context? Name a potential concomitant variable here. [5 pts]

**Solution:** Possible controlled variables are: operator, launch angle, launch force, paper clip size, paper manufacturer, plane constructor, distance measurer, and wind.

The response variable is flight distance and the experimental variables are Design, Paper Type and Loading Condition.

Concomitant variables might be wind speed, and direction (if these cannot be controlled), ambient temperature, humidity, and atmospheric pressure.

5. **Hockey game attendance.**

Caroline performs the following study to see if outside temperature has an effect on attendance at her college's hockey games. For each hockey game at her college, Caroline records the outside temperature and the attendance. Here are her results:

Day of Week	Temperature, deg. F	Attendance
Friday 12/14	35	840
Wednesday 12/19	20	560
Tuesday 1/ 8	-5	340
Friday 1/11	23	775
Wednesday 1/23	14	680
Saturday 2/ 2	30	950
Friday 2/ 8	28	950

- (a) Is this an experiment or observational study?[5 pts]

**Solution:**Observational study, the investigator (Caroline) has a passive role in the study. The temperature and the attendance are watched and data are recorded, but there is no intervention on the part of the person conducting the study

- (b) What type of variable is attendance?[5 pts]

**Solution:**Discrete quantitative (numerical)

Caroline analyzes her results and finds that outside temperature and attendance have a strong positive correlation (i.e., as one increases, the other also increases). She concludes that higher game day temperatures causes higher attendance at their college's hockey games.

- (c) Did she come to a proper conclusion for this study? Why or why not?[5 pts]

**Solution:**(Multiple answers are possible, if they are to the point, you get full credit for them)

In the first place it seems the answer is yes, but there are some hidden assumptions that might affect the study. Among many possible ones we can mention the following:

- The match day (weekend or weekdays)
- This game might not be much popular among the people in that city.
- The team might not have done well in that season.
- The match dates.
- The importance of the match.
- The opponent.

- (d) Look at the day of the week of the hockey games. What type of variable is this?[5 pts]

**Solution:**Qualitative (categorical)

- (e) Rewrite the data table, adding a new column "School Night" (using the values "no" if the game is on a Friday or Saturday, and "yes" if the game is on any other day). How does Attendance relate to School Night?[5 pts]

**Solution:**

Day of Week		Temperature, deg. F	Attendance	School Night
Friday	12/14	35	840	No
Wednesday	12/19	20	560	Yes
Tuesday	1/ 8	-5	340	Yes
Friday	1/11	23	775	No
Wednesday	1/23	14	680	Yes
Saturday	2/ 2	30	950	No
Friday	2/ 8	28	950	No

More people watch the game when the game is not on school nights.

### Washer stretching.

George works for a company that manufactures rubber washers. He randomly selects 1000 washers off the assembly line throughout two weeks for a study on the durability of these washers under stretching. To make sure that the washers are fit to be used in the real world, George must test the washers. Holding heat constant, George subjects each washer to one of various methods of

stretching. The washers are randomly assigned to be stretched under one of five different forces (low, medium-low, medium, medium-high, and high). After each test, George classifies a washer as either defective or non-defective.

1. Is this an experiment or observational study? [5 pts]

**Solution:**Experimental study

2. What type of variable is heat? [5 pts]

**Solution:**Quantitative (numerical)

3. What type of variable is the amount of stretching?[5 pts]

**Solution:**Qualitative (categorical)

4. What type of variable is response to the stretching method?[5 pts]

**Solution:**Qualitative (categorical)

5. The 1000 selected washers constitutes the sample. What is the population? [5 pts]

**Solution:**All rubber washers manufactured in the company

6. George analyzes the results and finds that the defect rate increases with the amount of stretching. Can George conclude that the amount of stretching causes a change in the defect rate of the washers? Why or why not?[5 pts]

**Solution:**Remember, though, that there always exists the chance that the sample was not properly representative of the population, and perhaps the 1000 washers he selected were some of the few washers in the population that showed no effect. But through proper experimental design, this chance is minimized and George can be highly confident in the results (this is again the matter of highly biased discussion in the class, but this study was different with the example of lightbulbs as the sampling was randomly over two weeks). More on confidence in Chapter 6.

Total: 90 pts