

# ENGRD 2700: Basic Engineering Probability and Statistics

## Fall 2019

### Homework 1

Due Friday, September 13 by 11:59 pm. Submit to Gradescope by clicking the name of the assignment. See [https://people.orie.cornell.edu/yudong.chen/engrd2700\\_2019fa.html#homework](https://people.orie.cornell.edu/yudong.chen/engrd2700_2019fa.html#homework) for detailed submission instructions.

When completing this assignment (and all subsequent ones), keep in mind the following:

- You must complete the homework individually and independently.
- Provide evidence for each of your answers. If a calculation involves only very minor computation then explain the computation you performed and give the results. If a calculation involves more complicated steps on many many records then hand in the calculations and formulas for the first few records only.
- Write clearly and legibly. You are encouraged to *type* your work although you do not have to. We may deduct points if your answers are difficult to read or disorganized.
- For questions that you answer using R, attach any code that you write, along with the relevant plots. You may use other software, but the same condition applies.
- Submit your homework a single pdf file on Gradescope.

1. The file `Quartet.csv` contains four datasets of  $x$  and  $y$  values, side by side.
  - (a) Compute the sample mean, sample median, and sample standard deviation for each column of the dataset.
  - (b) Based solely upon the summary statistics you computed in part (a), how do the four datasets compare?
  - (c) Construct scatterplots for each of the four datasets. (Hint: In R, you can use the command `par(mfrow=c(2,2))` to combine multiple plots into a single 2-by-2 graph in R. If you do, this command should precede any code that you use to generate plots.)
  - (d) Based solely upon the plots you generated in part (c), how do the four datasets compare?
  - (e) What's the moral of the story? (That is, what does this example suggest about what should be done when analyzing data?)
2. Answer the questions below about the dataset `CountyData.csv` from the U.S. Census Bureau, performing any data analysis you deem appropriate. The dataset consists of 3143 observations on 53 variables, which are described in the file `CountyData.Info.pdf`.
  - (a) Provide a histogram of the per-county percentage of residents who speak a foreign language at home during 2006-2010.
  - (b) What was the median per-county amount of federal spending in 2009?
  - (c) Create a scatter plot of the percentage of residents below the poverty level ( $y$ -axis) versus the percentage of the population with a bachelors degree. Comment on what you see.
  - (d) What fraction of counties have a population whose percentage under the age of 18 is above 30%?
3. A subdivision of 24 houses has a mean price of \$500,000, a median of \$440,000, and a standard deviation of \$30,000. A new house is then built in the subdivision that has a price of \$700,000.
  - (a) What is the new mean house price?
  - (b) What is the new standard deviation?
  - (c) Does the median increase, decrease, or stay the same after the new house is built? Or can no conclusion be made? Explain.

4. Consider a data sample  $x_1, x_2, \dots, x_n$ . Let  $\bar{x}$  and  $s_x^2$  denote its sample mean and sample variance.

- (a) Suppose that you modify these data by adding a constant  $c$  to each observation in the sample, and then multiplying by another constant  $k$ , to obtain a modified sample  $y_1, \dots, y_n$ . (That is,  $y_i = (x_i + c) \times k$  for each  $i$ .)

What are  $\bar{y}$  and  $s_y^2$ , the sample mean and variance of the modified data? Justify your answer mathematically, using the definition of the sample mean and variance. (We saw a similar question in lecture; here you need to write down the proof yourself.)

- (b) Finally, suppose we built another modified data sample  $z_1, \dots, z_n$ , where

$$z_i = \frac{x_i - \bar{x}}{s_x},$$

where  $s_x$  is the sample standard deviation of the  $x$ -data. This procedure *standardizes* the original data. What are  $\bar{z}$  and  $s_z^2$ ? Justify your answer.