

# MA139 Introduction to Statistical Reasoning Homework Booklet

Sterling Math Department

Welcome to the Homework Booklet for MA139, Introduction to Statistical Reasoning. In the pages that follow, you will be introduced to the two areas of homework you will have in this class - Problem sets and Seminar Sessions. Part I details the Problem set of 120 questions, while Part II details the Seminar Sessions. This endeavor aims to create a unique class experience, where your success in the class is dependent on your drive to think critically. The Problems supplement the PowerPoints, while the Seminars supplement the textbook. Together, the aim is to really delve deep and teach the ideas of statistics in a thoughtful and entertaining way.

## Dedicated to Sterling College

*We may throw the dice, but the Lord determines how they fall. - Proverbs 16:33*

*Again I saw that under the sun the race is not to the swift, nor the battle to the strong, nor bread to the wise, nor riches to the intelligent, nor favor to those with knowledge, but time and chance happen to them all. - Ecclesiastes 9:11*

## Course Outline

- Week 1: Syllabus, Chapters 1-2, Problems 1-20
- Week 2: Chapters 3-4, Seminar Session #1
- Week 3: Chapters 5-6, Problems 31-40
- Week 4: Chapters 7-9, Problems 41-59
- Week 5: Test 1, Mini Project #1, Seminar Session #2
- Week 6: Chapters 10-11, Seminar Session #3
- Week 7: Chapters 12-13, Problems 60-78
- Week 8: Chapters 14-15, Problems 79-94
- Week 9: Test 2, Mini Project #2, Seminar Session #4
- Week 10: Chapters 17-18, Chapter 20, Problems 95-105
- Week 11: Selected Topics from Chapters 21-24, Problems 106-120
- Week 12: Test 3, Mini Project #3, Seminar Session #5
- Week 13: Seminar Session #6, Work on Culminating Project
- Week 14: Work on Culminating Project
- Week 15: Culminating Project Presentations
- Finals Week: Finish Presentations

*\* Note this outline is subject to change, and you should pay attention to Canvas announcements for any changes to this. This is simply tentative, but we all know the best-laid plans of mice and men often go awry.*

## Grade Breakdown

Mini Project #1	25 points
Mini Project #2	25 points
Mini Project #3	25 points
Discussions	75 points
Test 1	100 points
Test 2	100 points
Test 3	100 points
Homework	150 points
Culminating Project	200 points
<b>Total:</b>	800 points

## Part I: The Problem Set

Assignments:

1. Week One: Problems 1-20
2. Week Three: Problems 21-40
3. Week Four: Problems 41-60
4. Week Seven: Problems 46-60
5. Week Nine: Problems 61-75
6. Week Eleven: Problems 76-90

7. Week Thirteen: Problems 91-105

8. Week Fifteen: Problems 106-120

Your answers to the given week's Problems are required to be posted on Canvas BEFORE class on Friday. This will be your Homework grade for the week. We will discuss the problems Friday in-class.

*The problems begin below. There are purposely no titles, chapters, or headlines given to clue you in on the topic. You are meant to use your critical thinking skills to answer each question. Best of luck!*

1. We all see and use statistics in our everyday lives, often without even thinking about it. But let's do just that- stop and think about it: What do you think statistics, as a subject, IS, and what statistics, as numbers, ARE?
2. An **individual** is an object described by a set of data, usually people, but can be animals or other things. A variable is any characteristic of an individual. Specifically, a **categorical variable** places individuals into one of several groups or categories. A **numerical variable** takes numeric values for which arithmetic operations make sense. Suppose a student is doing a survey of Sterling students. Can you name two categorical and two numerical variables that the survey might use? (Example: Gender may be asked in the survey - this is a categorical variable.)
3. Some argue that statistics are useless because they can say whatever someone wants them to say. What does this mean? Do you agree? Is there still a place for statistics? Defend your assertion.
4. A **response variable** is a variable that measures an outcome or result of a study. In a study deciding if smoking causes cancer, what would the response variable be? Why?
5. Who actually recycles? Researchers spent time weighing the stuff put into recycling bins in a California city. Do you think this variable, weight, tells us much about commitment to recycling? Why or why not? Defend your answer.

6. An **observational study** observes individuals and measures variables of interest but does not intervene to influence the responses. An important kind of observational study is the **sample survey**. The purpose of a sample survey is to select a **sample** of the **population** that can give information about the population as a whole. Who should be the population in a pre-election poll designed to survey who respondents are going to vote for President? All adults? citizens only? Registered voters? Democrats only? Explain and defend your answer.
  
7. The U.S. Census is tasked with counting the population and data about the population. One of these metrics is race. What races should be listed on the Census for people to choose from? What does this tell us about data and its relationship to society?
  
8. (Continuation) A **census** is a survey of the entire population. What valuable information does the census provide? Are there ways we might could live without it? Is a “census” even really a real census? (See if you can figure out what I mean.)
  
9. An **experiment** actively imposes a treatment to observe a response. It is important to understand the difference between an observational study and an experiment. Many people drink diet soda to control their weight; therefore, some researchers recruited 400 adults who identified themselves as diet soda drinkers. The drinkers recorded how many bottles or cans they drank for two years. Each participant was weighed at the beginning and end of this two-year period. The researchers found that the more diet soda one drank, the more likely one was to have gained weight during the two-year period. Is this an observational study or an experiment? Defend your assertion!
  
10. An experiment has a distinct advantage because it can show cause-and-effect, that one variable causes the other variable to change. An experiment has given evidence to support that children whose mothers are given welfare support tend to go on to have

higher-paying jobs. If Aiyla has a baby daughter and is on welfare, does that mean her daughter will go on to have a higher-paying job? Explain.

11. A town in Louisiana had been using one ambulance service for many years. A local paper decided to ask readers to call in to offer their opinion on if that should change. They got 3,763 calls, an unusually high number. However, upon further investigation, many of these calls of support came from the ambulance company office and employees. What does this say about the ease of sampling well versus sampling badly? Do you think the results of this poll were **biased** in favor of the company? Why?
  
12. Spotify once tried to revamp their shuffle feature to make it more random, and many people complained that the lists weren't good anymore. What does this say about randomness? The Spotify developer Mattias Ptter Johansson explained that "to humans, truly random does not feel random." What does he mean by this?
  
13. A **simple random sample** ensures that everyone in the population has equal chances of being selected. How might one go about conducting a simple random sample? Explain. Imagine this class is your population. How can we conduct an SRS within it?
  
14. A common type of survey is called a mall interview, where the survey taker asks people in a crowded place like a mall. This is an example of **convenience sampling**. What do you think this means? Are mall polls useful? What should be cause for concern?



15. A June 2018 Gallup Poll asked the question “On the whole, do you think immigration is a good thing or a bad thing for this country today?” The results are 75% of respondents think that immigration is a good thing for the United States. Can this be trusted? What more do we need to know?
  
16. During the 2018 NBA playoffs, the San Antonio Spurs were down 3 games to 1 against the Golden State Warriors. After game 4 of the series, KSAT in San Antonio ran a Twitter Poll asking followers “Do you think the Spurs will win game 5 and force the series back to San Antonio?” 57% of respondents said Yes. What can you say about this? Discuss.
  
17. The Denver Police Department wants to know if Hispanic residents of Denver believe that the police use racial profiling when making traffic stops. The DPD sends out a SRS of 200 letters to predominantly Hispanic neighborhoods and asks them what their views are. Does the fact that this was a SRS prevent bias? Is there any cause for concern? Explain.
  
18. In 2005, a San Francisco newspaper reported on a poll in New Zealand that found that New Zealanders opposed their nation’s new gay rights law passed 75% to 25%. This poll was a call-in poll that cost \$1 to participate in. A separate poll conducted by an independent organization found that 56% of New Zealanders favor the law. Explain to someone who knows nothing about statistics why the two polls can give such different results. Which poll is likely to be more reliable? Why?
  
19. (Continuation of #15) Gallup went on to report that the sample was taken by random digit dialing 30% landline phones and 70% cellular phones. Does this help or hurt your trust in the process? Explain. Defend your view.

20. A **parameter** is a number that describes the population. A **statistic** is a number that describes a sample. Which of these two do you think we usually don't know? Why? Can we estimate it somehow?
21. Another type of error, besides bias, we can have in samples is **variability**. This means if we have large variability, then repeated samples are unreliable, because they can vary widely from one sample to the next. Think about a bullseye and trying to hit the target (and ideally, the bullseye). See if you can explain bias and variability (both large and small amounts of each) using the bullseye target.
22. (Continuation from #20) In a study about if American adults feel that childhood vaccination is important, the population is 247 million American adults; we represent the percent or proportion of adults who feel it is important by  $p$  for "proportion". The statistic,  $\hat{p}$ , read "p-hat", is the proportion of the sample that feel it is important; let's say this statistic is 0.54. Is it a fact that 54% of the sample feel childhood vaccines are important? Is it a fact that 54% of the population of American adults feel childhood vaccines are important? What can we definitively say? What role does estimation play here?
23. How might we be able to reduce bias? What about variability? Can we totally eliminate either one? Explain.
24. A news poll says that 52% of Americans are unhappy with the direction of our country, with a margin of error of  $\pm 4\%$ . What do you think this means? Is this a clear majority? Why or why not?

25. (Continuation) A “quick and approximate” method for the margin of error when using the sample proportion  $\hat{p}$ , is  $\frac{1}{\sqrt{n}}$ . If the survey had 1,015 respondents, what margin of error would this method give us?
26. (Continuation) What if the survey had 10,015 respondents, what would the margin of error be? How do you think sample size affects the margin of error?
27. A **confidence interval** uses the margin of error and the sample statistic to estimate the population parameter. The general formula is:

$$\text{Sample statistic} \pm \text{Margin of Error}$$

The confidence interval also needs a confidence level, which says what percentage of samples taken will have confidence intervals that capture the true population parameter. In our study of statistics, we will just use a confidence level of 95%, which is standard among many practices. Do you think the confidence interval estimates the sample statistic or the population parameter? Do you think the conclusion is always certain? Why or why not? What do you think a confidence level of 90% or 99% changes about the confidence interval? Explain your reasoning.

28. Claim: *Taking a larger sample can never fix biased sampling methods.* Do you agree with this? Defend your assertion.
29. Consider pre-election polls that dominate the news leading up to a Presidential race. For example, in 2016, the polls incorrectly reported that Hillary Clinton would be the winner. The forecast doesn't always pan out. Can you think of some good arguments for having pre-election polls? Can you think of arguments against having them? Consider the country and how voter turnout could be influenced.

30. (Continuation) Consider exit polls. These occur after people vote, asking them as they leave who they voted for. These are usually very accurate, but again, in 2016, proved incorrect. Can you think of some good arguments for having exit polls? What about arguments against them? This is a very tricky issue with no clear answer, but statistics does not always help matters.
  
31. Consider this! Interviews conducted by phone miss the 2% of U.S. households without phones and also can't survey people without access to phones regularly like prison inmates or deployed members of the armed forces. Additionally, if a poll is only in English, other languages are left out. All of this are examples of undercoverage. Should laws be passed to get rid of undercoverage? After all, polls that affect people's lives should factor in everyone's voice, right? Discuss!
  
32. A survey done to poll the perceived effects of racial sensitivity training among law enforcement received 134 replies from the community out of 5500 homes it was sent out to - what can you say about this? Can you draw any conclusions based on any results this survey has?
  
33. Compare these two poll questions: "How would you rate the President's job so far, on a scale of 1 (low) to 5 (high)?" And "With 1 being "Not At All" to 5 being "Extremely Worried", how worried are you that the President's performance is destroying our country?" They are essentially aiming to ask the same thing, right? What's the difference?
  
34. **Nonresponse** is a big problem with many polls. A case study done by Pew Research estimated a 91% nonresponse rate. Can any real conclusions be drawn from such surveys? What are your thoughts? Can it be avoided or prevented?

35. In one survey, 77% of Americans strongly opposed the governments monitoring of U.S. citizens' phone records in order to make national security decisions. In a second survey, 68% of Americans strongly approved the use of government surveillance of suspected terrorists in order to save the country from an attack. The plot twist - this question is referencing the exact SAME NSA program. Discuss.
36. Can you think of any ways we might be able to live with nonsampling errors, such as nonresponse and undercoverage? Meaning we can't fully get rid of them, but can we limit their influence?
37. Do you feel the Internet is a net benefit or a net detractor for valid statistical results in surveys, studies, and experiments? Explain your answer.
38. Challenge yourself to see if you can list 5-10 questions you should ask yourself when looking at a survey, study, or experiment result to convince yourself that the results can be trusted and relied upon.
39. A **placebo** can still have a real effect, called the placebo effect. In such experiments that involve a placebo, many subjects report feeling better, even though they have received no real treatment of the **explanatory variable**. The placebo effect is well-documented and accepted as fact, though. Why do you think the placebo effect may be real? Or do you think it's fake? Why?

40. **Confounding variables** serve to muddy the water between our variables in an experiment. These are variables that hide in the background, influencing the results. Can you think of any way we might be able to mitigate the entanglement caused by the confounding variables?
41. Many doctors for many years believed that they could tell if a treatment works on a patient just by watching them over a period of time and seeing if they improve. What is wrong with this idea?
42. In a **double-blind experiment**, neither the subjects nor the people who work with them know which treatment each subject is receiving. What is the point of that?
43. On the popular show from the 2000s and 2010s, Mythbusters, the hosts investigated a common belief to determine if yawning was contagious. If they recruited 50 people by posting an ad, what type of sampling was used?
44. (Continuation) The hosts randomly assigned the individuals to one of the rooms: two with a pre-chosen yawner (unknown to the participants), and one without. Is this an observational study, an experiment, or neither? Why?
45. (Continuation) The hosts recorded whether each person yawned or did not yawn. Is this a categorical or quantitative variable?

46. (Continuation) If you were to design an experiment to test whether yawning was contagious, what, if any, changes would you make?
47. A college professor would like to investigate a new method for teaching statistics. He teaches two lecture sections. He will use the standard approach to teaching in one lecture section, and the new approach he will use in the other section. Should he seek institutional review board approval before proceeding? Explain your reasoning.
48. **Informed consent** is an extremely important concept, and both words are both important and controversial. What do you think it means, in your own words?
49. An elderly man with multiple sclerosis is hospitalized. His doctor feels he may need to be placed on a feeding tube. He asks the patient in the morning, and he agrees. However, in the evening (before the tube has been placed), he becomes disoriented and seems confused about his decision to have a feeding tube inserted. The doctor, seeing his life on the line, puts the feeding tube in. Did the doctor have informed consent? Explain your reasoning.
50. Who can give informed consent? Can small children? Intellectually disabled people? Medically compromised and unconscious people? Illiterate people? What limitations should be placed on informed consent? What is reasonable?
51. When should survey, study, and experiment results remain **confidential**? This is differ-

ent from anonymity - with anonymity, no one (not even the researchers) know who is in the study. What is an advantage and disadvantage of anonymity?

52. A cola chain conducted a survey and found that 44% loved their cola the most, 37% loved their competitor the most, and 19% didn't like either. They ran an advertising campaign stating "The most loved cola!" What can you say about this?
  
  
  
  
  
  
  
  
  
  
53. A researcher using 20 mice for experiments reported percentages of successes as 53%, 58%, 63%, and 44%. What is wrong with this data?
  
  
  
  
  
  
  
  
  
  
54. After Hurricane Katrina in 2005, one congressman wanted a relief bill to be sent to the 485,000 citizens of New Orleans, giving them \$250 billion to rebuild after the storm. What is wrong with this idea?
  
  
  
  
  
  
  
  
  
  
55. Suppose you are reviewing a colleague's papers, and in the first paper, you find a table with 50 subjects and all of their data for the study. In a second paper, you find a table with 45 of those same subjects with the exact same data. The first study is supposedly studying sleep patterns in adolescents. The second is supposedly studying retention of math lessons of high school seniors. It looks like just the labels on the data had been changed, but the raw data was the same between the two papers. What is your conclusion here? Explain.
  
  
  
  
  
  
  
  
  
  
56. In a Fox News show, one of the polls shown was asking if they believed global warming



to be man-made or not. 57% said yes, 39% said no, and 14% said they were unsure. What is your conclusion here? Explain.

57. You see a billboard on the road that says “Half of all heart disease victims are women.” What is your conclusion here? Explain.
58. Are men more promiscuous than women? One study finds that men had an average of 7 female sex partners, while women had an average of 4 male sex partners. Another study found even bigger results - that men had on average about 13 sex partners and women had on average about 6. Mathematically, what is wrong in both of these results? What could be plausible explanations?
59. If I did a study that found that 50% of obese people earn less than the national average income, would that support the idea that obesity leads to less money? Explain.
60. Consider the data set  $\{4, 6, 8, 10, 12, 12, 34\}$ . Can you think of a way to identify a single number that is most “typical” of this data set? There is more than one way to do this.
61. (Continuation) Does anything stand out about the numbers in the data set? Is anything unusual?

62. How would you create a “middle” for this set of numbers?  $\{2, 3, 4, 5, 6, 7\}$  How is this different from our previous attempt?
63. The **median** is the midpoint of a set of numbers, the number such that half of the numbers are smaller and the other half are larger. Can you figure out a way to find the median of the number sets in the previous questions, #60 and #62?
64. Suppose the Census Bureau says that the average American household earns \$51,356 annually. Is this a complete picture? Think about what else might be important about that set of data.
65. The **mean** is calculated by adding up the data points and dividing by the number of data points. It is the “average” we typically think of when discussing an average. Find the mean of the following data set  $\{70, 75, 75, 80, 80, 85, 85, 90, 95, 100\}$
66. The **first quartile**,  $Q_1$ , is the median of the lower half of the data. The **third quartile**,  $Q_3$ , is the median of the upper half of the data. Think about this - what might these two statistics tell us about the data?
67. Find the first quartile, median, and third quartile of the following data set:  $\{13, 17, 12, 19, 7, 15, 6, 3, 22, 27, 11, 17, 34, 15, 16\}$

68. (Continuation) The five-number summary adds to these the minimum (the lowest value) and the maximum (the highest value). Find the five-number summary of the data in the previous question.

69. Another measure of spread is the **standard deviation**. The steps to calculate it is as follows:

1. Find the distance of each observation from the mean, and square each of these distances.
2. Average the squared distances but divide by  $n - 1$  instead of by  $n$ .
3. Take the square root of the average found in the previous step.

Find the standard deviation of the data set  $\{0,5,10,15\}$ . What do you think this statistic tells us?

70. The mean and standard deviation, together, can describe a set of data, or you can use the median, and the five-number summary. Which one is best? In general, the mean and standard deviation are stronger statistics (for theoretical reasons) and should generally be used whenever possible. Consider the data set  $\{4, 5, 6, 7, 8, 9, 30\}$ . This is a set where the median and five-number summary would be better. Can you figure out why? Explain.

71. New York's mean income per person ranks sixth among the states, but its median house-

hold income is only 22nd. What's going on? Explain the discrepancy.

72. A **density curve of a distribution** is a continuous curve showing the values a data set can take on and how often. The area under the curve must be 1. The mean of the density curve is the balancing point of the distribution. Where do you think the median of the curve would lie? Would the mean and the median always coincide?

73. **Normal curves** are smooth, bell-shaped density curves that are identified by the mean and standard deviation of the underlying distribution. Why do you think they are called Normal curves?

74. The **Empirical Rule** says that 68% of observations fall within one standard deviation of the mean. 95% of observations fall within two standard deviations of the mean. And 99.7% of the observations fall within three standard deviations of the mean. Suppose the height of men is Normal at 67.8 inches with a standard deviation of 2.2 inches. What percent of guys would have a height over 5 feet 10 inches?

75. Suppose the real distribution of heights of men is approximately Normal with mean 69.2 inches and standard deviation 2.5 inches. What heights will encapsulate 95% of all men?

76. A standard score can be calculated as

$$\text{standard score} = \frac{\text{observed score} - \text{mean}}{\text{standard deviation}}$$

Let's say Elijah took the SAT and the ACT. On the SAT, he scored a 600 on the mathematics exam, which is Normal with a mean of 500 and standard deviation of 100. On the ACT math part, he scored a 21, which is Normal with a mean of 18 and standard deviation 6. Which test did he do better on?

77. (Continuation of #75) What is the standard score of a height of 72 inches (6 feet)?

78. For many centuries, people have made associations between brain size and intelligence. One of the best ways to plot associations between variables is with a **scatterplot**. A recent MRI study and IQ test found these results, shown below. Create a scatterplot of these data.

Brain Size:	100	90	95	92	88	106
IQ:	140	90	100	135	80	103

79. (Continuation) **Association** occurs when explanatory and response variables follow a distinct pattern. Positively associated means that above-average values of one tend to accompany above-average values of the other, and vice-versa. Two variables are negatively associated when above-average values of one tend to accompany below-average values of the other. In terms of a scatterplot, explain both of these cases.

80. During World War II, famous statistician Abraham Wald was once tasked with studying war planes that had returned from combat and asked where armor should be placed on the planes to make them safer. He compiled data on where bullet holes had pierced the

planes and found many in the cabin, wings, and tail of the plane, but very few on the engines. Where do you think Wald told them to put the armor on the planes? Why? (By the way, putting armor on “all of the plane” wasn’t an option because the extra weight lowered the fuel capacity of the planes and made them impractical to fly the distances needed.)

81. **Correlation** is a statistic that measures the straight-line relationship between two quantitative variables. Compare and contrast association with correlation.
  
82. Correlation ranges from -1 to 1, where -1 is a perfect negative linear relationship, and +1 is a perfect positive linear relationship. What do you think a correlation of zero means? What would you consider a weak correlation? Moderate correlation? Strong correlation? Explain.
  
83. (Continuation of #78) Estimate the correlation of the data in #78. Is it more or less than 0.5?
  
84. Should the median + five-number summary or the mean + standard deviation be used with correlation? Why?
  
85. Guess the correlation in each case: {A. This semester’s GPA and the previous semester’s GPA of an upper-class student, B. IQ and the scores on a test of reading ability of a seventh-grade student, C. The number of hours a student spends studying per week and

the average number of hours spent studying by his or her roommates, D. The cost of cable TV service and the number of channels provided by the service, E, The weight of a road-racing bicycle and the cost of the bicycle, F. The number of hours a student spends on social media and the student's GPA, G. The heights and salaries of faculty members at Sterling College}

86. The **regression line** is a straight line that describes how a response variable  $y$  changes as an explanatory variable  $x$  changes. On a scatterplot, a regression line is a “best fit” line through the data. What do you think this means?
87. The least-squares regression line equation is  $y = a + bx$ , where  $b$  is the slope of the line, and  $a$  is the intercept, the value of  $y$  when  $x=0$ . In terms of  $y$ , what do you think the slope tells us?
88. For young children, suppose a regression line for predicting height in inches given age in months is  $y = 20 + 0.3x$ . Predict the height of an 8-year old child.
89. (Continuation) Interpret the 0.3 and the 20 in the equation, in terms of  $y$ .
90. (Continuation) Predict the height of a 40-year old adult. What is the problem?

91. (Continuation) What is your advice on predicting long-term using a regression equation? Especially if it's data outside of the range of given data, what caution should we take?
92. The **square of the correlation** tells us what proportion of the variance in the response variable can be explained by the variance in the explanatory variable. Suppose we are modeling the effect of wind speed on turbine output, and find the square of the correlation to be 0.87. Interpret this, and what does this tell us?
93. Suppose a study was done to measure the amount of time outdoor swimming each summer with later-in-life incidence of skin cancer. There is a 0.82 correlation. Does this give us evidence to support that outdoor swimming causes skin cancer? Explain. Defend your assertion.
94. How do you suppose we can try and eliminate any confounding variable's effects when we are wanting to establish a cause-and-effect relationship?
95. Imagine the chances of winning the lottery are 1 in a million, literally. How rare would it be for someone, somewhere to win the lottery twice in their lifetime? Too rare to ever happen? Explain.
96. A fair coin has a 50/50 chance of landing on heads or on tails. What can you say about the next flip of the coin? What about the next 1,000 flips of the coin?



97. The **probability** of an event is between 0 and 1 (or between 0% and 100%) and describes the proportion of times the outcome would occur in a very long series of repetitions. Describe this in your own words.
98. Does God play dice? In other words, are randomness and random phenomenon unavoidable in the world around us?
99. A series of 1,000 coin flips has a run where 12 heads in a row occurred. Is this proof that the coin is unfair?
100. A common idea in sports is the idea of a “hot hand”...if a player normally has a 0.55 probability of making any given shot but has a string of 5 or 6 shots in a row, for instance, many spectators claim he is “hot” and that he’s on a roll. In such a situation, what would be the probability that the next shot is made - more, less, or exactly 0.55? How do you know? Explain.
101. C.S. Lewis once wrote the following: “If you tossed a coin a billion times, you could predict a nearly equal number of heads and tails.” Is this correct? If not, rewrite it to make it correct.
102. When flipping coins, with H being heads and T being tails, which result is more likely: HHHHHH or THTTHT? A similar question: When flipping 6 coins, what is more likely - 6 heads or 3 heads and 3 tails? Explain.

103. The **expected value** of a random phenomenon that has numerical outcome is found by multiplying each outcome by its probability and then adding all the products. Suppose you pay \$5 to play a dice game. If you roll a 1 or 2 or 3, you win nothing. However, if you roll a 4 or 5, you win your \$5 back. If you roll a 6, you win \$20. What is the expected value of this game? Is this game worth playing in the long-run?

104. The Census Bureau gives the following distribution for the number of a family household's related children under the age of 18 in American households in 2016:

Children:	0	1	2	3	4
Proportion:	0.58	0.18	0.16	0.06	0.02

Give the average number of children under 18 in a household.

105. How are casinos and lotteries able to remain profitable? Surely there's a chance that 10 people in a row win \$200 million dollars and bankrupt the lottery or casino. Is there anything to keep this from happening? How can they function as businesses with the uncertainty of randomness?

106. You hear a news report that says 20% of adolescents smoke. What does this mean? Is this shocking? What is important to know here? What if we define "smoker" as smoking half a pack on 2/3 of days in a month, only 4% of adolescents qualify. How does this change perception?

107. If we choose a simple random samples of size  $n$  from a large population that contains

an unknown proportion  $p$  of successes, we can find a sample proportion  $\hat{p}$  and calculate an approximate 95% confidence interval for the parameter  $p$  by:

$$\hat{p} \pm 2\sqrt{\frac{\hat{p}(1 - \hat{p})}{n}}$$

If we have a sample of 23,915 college seniors in Kansas and 5038 of them want to attend college or trade school, what would be an approximate 95% confidence interval for the true Kansas population of seniors who want to attend college or trade school?

108. A November 2018 Pew Research Center survey randomly sampled 4594 American adults why they watch YouTube. 51% said they wanted to learn how to do things they haven't done before. Find a 95% confidence interval for this. How would you interpret it?
109. A basketball player claims to make 80% of his free throws. You challenge him to prove it. He shoots 20 free throws and makes 8. Is this enough evidence for you to conclude he was wrong? How might you test this claim?
110. What does statistically significant mean? Does it mean "important"? Why do you feel that 0.05 level is chosen most often?
111. What are some questions you should ask yourself when you come across a confidence interval or test of significance? Does SRS matter? Do you think the results of inference would work for a stratified random sample? What about bias? Can the formulas save badly produced data? What about nonresponse, dropouts, nonadherers, etc? Do the formulas "know" about these non-random errors? Discuss.

112. Suppose your hypothesis is that “This coin is balanced.” Is any real coin ever exactly balanced? What is the point, then? Is there usefulness in any hypothesis we make that might not perfectly hold in the real world? If the coin has a 0.502 chance of a heads, can we say that’s balanced? Or not? Where does theoretical meet the practical here?
113. Claim: *A finding can be statistically significant without being practically important.* Agree or disagree? Discuss.
114. A statistical term called “power” refers to the ability to find a real effect if there is one. If a test finds no significance, can we say certainly that there is no effect? Does sample size matter? For example, if our sample size is 2, are we likely to catch a real effect? What about a sample size of 2 million? Does the absence of evidence give evidence of absence?
115. In January 2015, the editors of *Basic and Applied Social Psychology* (BASP) banned most forms of inferential statistics from their publications, including hypothesis testing and confidence intervals, p-values, test statistics, and all statements about statistical significance. BASP wants authors to use strong descriptive statistics and larger sample sizes that are more stable and have less sampling error. Do you think this practice is a good one? What are the advantages and disadvantages of such?
116. Suppose a study does not find statistically significant results. They do the study again and find a p-value less than 0.05. Success! They run to get it published, and they happily report their significant results. Comment on this. What is your view on this practice?

117. A **two-way table** can be used to express relationships among two categorical variables. Below is a two-way table showing people who applied for home mortgages in 2017 at a certain bank and if they are people of color or not. The result of the application is also shown. Do banks reject more people of color than white people for mortgages? Explain.

Mortgage	PoC	White
Approved	37	137
Decline	51	76

118. (Continuation) Shown below are two more two-way tables. This time, the data has been separated by Poor Credit Score (below 700 FICO score) and Good Credit Score (700 FICO score or above). Study these two tables carefully. Does it still show that the bank rejects the mortgage applications of people with color more? Does it seem to be because of their color?

**Below 700 FICO**

Mortgage	PoC	White
Approved	10	26
Decline	42	60

**700 or Above FICO**

Mortgage	PoC	White
Approved	27	111
Decline	9	16

119. (Continuation) **Simpson's Paradox** is a situation where an association that holds for multiple groups can disappear or even reverse direction when the data are combined to form a single group. This is often due to a confounding variable behind the scenes. In the above example, is it more likely that the bank is discriminating against applicants due to race, or is there another possible explanation? What confounding variable might be present?

120. We have reached the end of the course! This is a great time to stop and reflect. Give 3 ideas you have learned this semester, 3 ideas you want to learn more about, and 3 topics that you'd love to see covered more in the future in future versions of this class.

## Part II: Seminar Sessions

Let's lay out some of the ground rules for Seminar Sessions. These will be held on some certain days throughout the class, usually on Friday.

- It is imperative that the assigned reading is done BEFORE class.
- To prepare for the class, you have a submission to make on Canvas. The first task is to answer the Critical Thinking questions at the end of each chapter. As part of the submission, you will need to find THREE statistics to support your view on the topic. A late submission will NOT be accepted under any circumstances, since we have already discussed it in-class.
- The summary with statistics is to be posted on Canvas BEFORE class. This will be your Homework grade for that week.
- After briefly discussing the topic, the Seminar will begin. Four chairs will be placed in the front of the room, and two classmates agreeing with the question and two disagreeing with the question will begin the conversation.
- The Professor will serve as moderator and facilitator, but will intervene only as necessary to redirect and keep the flow going. The Professor may have a series of questions to ask to keep the conversation alive.
- Students will debate the topic, beginning a 2:00 timer. They are encouraged to use their summaries and statistics they have already prepared. If the conversation stagnates, the moderator will prod and introduce new ideas.
- At the end of the 2:00 timer, two members of the four will swap with two new classmates, and a new 2:00 discussion begins. This continues for 10-15 minutes until the conversation is exhausted.
- A debrief will then occur where the class as a whole, led by the Professor, discuss the topic and address any lingering concerns or points of interest.
- A second topic is then discussed, lasting an additional 15-20 minutes.
- To conclude the class, the last 15-30 minutes are spent with the class typing a discussion post on Canvas. This discussion post must summarize the talk and be a minimum of 100 words/12 sentences. This will count for a Discussion grade.

- The total time for a Seminar Session should be between 40-65 minutes (Closer to 40 for a 50-minute class, closer to 65 for a 75-minute class.)

### **Seminar Topics:**

1. Week 2: Chapter 1: Can an Overemphasis on Eating Healthy Become Unhealthy? / Chapter 10: Is there Support for Arming Teachers in Schools?
2. Week 5: Chapter 12: Is Criminal Behavior Determined Biologically? / Chapter 6: Does Immigration Benefit the Economy?
3. Week 6: Chapter 11: Is Minimum Wage Good for Business? / Chapter 3: Should There Be a Market in Human Organs?
4. Week 9: Chapter 2: Should Government Levy a “Fat Tax”? / Chapter 8: Is American Justice Too Severe?
5. Week 12: Chapter 13: Do “Three-Strikes” Sentencing Laws and Other “Get Tough” Approaches to Crime Really Work? / Chapter 9: Is the American Family in Trouble?
6. Week 13: Chapter 4: Should a Pregnant Women Be Punished for Exposing Her Fetus to Risk? / Chapter 7: Are Polls an Accurate Assessment of Public Opinion? / Chapter 5: Should Physicians Be Allowed to Assist in Patient Suicide?



## **Critical Thinking and Reflection: Chapter 1**

1. List the typical eating habits of a person who has orthorexia.
2. Outline the nutrition messages from USDA, professional health associations such as AMA and ADA, and registered dietitians related to healthy eating.
3. Compare characteristics of a person with orthorexia nervosa to one with anorexia nervosa.
4. Do you think the dietary messages and advice to “eat right” that many nutrition experts and government agencies encourage may cause orthorexia? Explain your answer.
5. Currently, the APA does not include orthorexia nervosa as a clinical mental disorder in their DSM-5. Why do you think it is not currently in their manual? Do you think it should be considered a mental health disorder? Explain your answer.

## **Critical Thinking and Reflection: Chapter 2**

1. List health problems associated with consumption of sugar-sweetened beverages (SSB).
2. Outline the various ways to calculate a tax on SSB as proposed by Brownell and colleagues.
3. Explain why some people think that SSB are addictive.
4. New York’s former Governor Paterson proposed a penny per ounce tax on SSB but it did not pass. There were several anti-tax groups that lobbied heavily against the tax proposal. What type of people do you think would be opposed to this form of “fat tax” and what arguments do you think they would have?
5. Many poor, slim people enjoy the taste, and actually benefit from the extra calories from SSB and high-fat snacks. What effect could taxation of sugary beverages have on poor, thin people? Design a strategy to ameliorate this problem.

### **Critical Thinking and Reflection: Chapter 3**

1. Is the idea of treating human organs or bodies as commodities morally troubling to you? Are there some things that simply should not be bought or sold? If so, how do organs compare to them?
2. Do you think that the opportunity to sell a loved one's organ would generate an incentive for you to offer it for transplantation?
3. The Institute of Medicine's committee argues that a market for organs would not function well. Explain and evaluate the committee's thinking.
4. Satel argues that a market for organs could be set up in such a way that organs would not go disproportionately to the rich: Are you persuaded that this would be possible? Do you agree that it would be a problem?

### **Critical Thinking and Reflection: Chapter 4**

1. The well-being of children is surely vitally important; how does the value attached to their well-being compare, as a matter of public policy, against the value of a woman's freedom and privacy?
2. Avoiding exposure to dangerous substances is about creating a good environment for the child; what is the responsibility of a person to make good decisions when environmental factors in their own life may not have helped them acquire good decision-making skills?
3. Does recognition that a child's well-being can be impaired by things that happen before the child is born lead one to conclude that a fetus is a person?
4. In your view, is protection of persons-to-be best achieved by criminalizing bad behavior or by fostering good behavior in mothers (and fathers)?

## **Critical Thinking and Reflection: Chapter 5**

1. In your view, does a person's autonomy ever encompass a right to end one's own life? If so, under what circumstances and with what safeguards?
2. What is the most compelling reason for permitting physician-assisted suicide - the curtailment of the patient's suffering or the completion of the patient's life plans?
3. If a patient who expresses a desire to die is diagnosed with depression, should the depression be treated before agreeing to help the patient die?
4. If physician-assisted death is permitted, would the physician's role as caregiver be undermined? Do you see physician-assisted death more as a case of commitment to patients or abandonment of patients? Why?

## **Critical Thinking and Reflection: Chapter 6**

1. The simple rule of morality is the greatest good for the greatest number (utilitarianism). Apply this rule to the issue of immigration. Do you accept the outcome or would you amend the rule?
2. Who benefits from heavy immigration and who benefits from very light immigration?
3. Why is America at an impasse on immigration legislation?
4. What are the various economic impacts of immigration and in sum does it help or harm the economy?
5. When did you or your ancestors come to America? Was that immigration good for America?
6. What should be done about "illegal" immigrants living in America? What should be done about children of illegal immigrants who were born here and are U.S. citizens?

## **Critical Thinking and Reflection: Chapter 7**

1. Think about how often you hear polls reported and consider the sponsor as well as the results.
2. Consider whether polls become the focus of news stories or are used to set our agenda (agenda setting theory) about what is important.
3. Reflect on the rigor of conducting a strong, statistically relevant poll.
4. Understand the difference between public opinion and public statements reflecting a topic.
5. Develop a more critical eye to understanding how public opinion influences public policy.

## **Critical Thinking and Reflection: Chapter 8**

1. Why are the authorities very likely to back up the police who seem to treat suspects too violently?
2. What should reformers like Holder do to correct the problems of police brutality and racism?
3. What are the consequences of the tough on crime policies?
4. How can the prison population be reduced without endangering the public?
5. Do you think American justice is too severe? Explain your answer.

## **Critical Thinking and Reflection: Chapter 9**

1. Which is more hurtful for children, having their parents divorcing or having their parents frequently fighting and angry at each other? How does your judgment change if spouse abuse is part of the picture? How does your judgment change if child abuse is part of the picture?
2. Do you favor or oppose laws that make divorce easier and why?
3. What factors contribute to the current relatively high divorce rates? How can these factors be changed to reduce divorce rates?
4. What are the impacts of divorces on society?
5. Do you think that marriage is in trouble? Explain your answer.
6. How are changing values and culture patterns affecting marriages?
7. How is the economy affecting marriages?

### **Critical Thinking and Reflection: Chapter 10**

1. What impact will having teachers and principals armed in schools have on what the real educational focus should be?
2. What are the liability concerns to consider in arming teachers and principals in school as opposed to trained school resource officers?
3. Will the dialogue continue to be discussed about arming school employees or will another disaster have to occur to keep it in the forefront of people's minds that are making the policy decisions?
4. What should teachers really be focused on each day in their classrooms: educational excellence or being armed for protection and safety of their students?
5. What type of firearm training should be a school system provide to the faculty and staff and who will cover the economic cost of training and providing guns and ammunition?

### **Critical Thinking and Reflection: Chapter 11**

1. Would increasing the minimum wage force business to lay off workers and result in higher unemployment or would it encourage economic growth and increased commerce?
2. Should the federal minimum wage be tied to inflation? Is there some other measure to which minimum wage could be linked?
3. What values guide your thinking about “good for business” and “good for people”? How does one affect the other?
4. Do you think that business has a responsibility to society in general or should business’ responsibility in the US focus on profit alone?

### **Critical Thinking and Reflection: Chapter 12**

1. What are the basic assumptions of the classical legal reform movement, including the principle of hedonism and the doctrine of utilitarianism?
2. Do “twin studies” provide evidence of a biological link to human behavior?
3. What factors seem to suggest a biological link to criminal behavior?
4. What are the social factors that appear to correlate with crime?
5. What types of social programs that appear to help to reduce crime rates?
6. How many cultural factors generate crime?
7. How many social learning contribute to crime?
8. How many social disorganization contribute to crime?

### **Critical Thinking and Reflection: Chapter 13**

1. Does increasing the severity of criminal sentences reduce crime in the United States?
2. What are the incapacitation, deterrence, retribution, and rehabilitation rationales for sentencing?
3. What are the financial costs of keeping persons incarcerated in state and federal prisons?
4. Have “three-strikes” sentencing laws been successful in the United States?
5. What is the “proportionality” principle as it relates to sentencing practices?
6. What do you think about the Supreme Court’s holding in *Johnson v. United States*?
7. Has the United States become a safer place because of stringent sentencing policies?

## 1 Appendix A: Glossary

- Biased: A flaw in a study that systematically favors certain outcomes.
- Categorical Variable: A variable that places individuals into groups or categories.
- Census: A survey of the entire population.
- Chi-square statistic: A statistic that measures how far the observed counts in a two-way table are from the expected counts.
- Confounding variable: A variable with an association with both the explanatory variable and the response variable in such a way that makes it impossible to discern any real effect on the response variable by the explanatory variable.
- Confidence interval: An interval using the sample statistic and the margin of error to produce a range that says how close the sample statistic lies to the population parameter  $C\%$  of the time, where  $C$  is the level of confidence.
- Confidential: The act of keeping private information secret.
- Convenience Sampling: Selection of whichever individuals are easiest to reach
- Correlation: A statistic that describes the direction and strength of the straight-line relationship between two quantitative variables.
- Density Curve of a Distribution: A continuous curve showing what values a data set can take and how often such that the area under the curve is 1.
- Double-Blind experiment: An experiment in which neither the subjects nor the people who work with them know which treatment each subject is receiving.
- Empirical Rule: In a Normal curve, 68% of observations fall within one standard deviation of the mean. 95% of observations fall within two standard deviations of the mean. And 99.7% of the observations fall within three standard deviations of the mean.
- Expected Value: A statistic that is found by multiplying each outcome by its probability and then adding all the products.
- Explanatory Variable: The variable that (we think) explains or causes a change in the response variable.
- Experiment: A study that deliberately imposes some treatment on individuals in order to observe their responses.
- First Quartile: The median of the lower half of the data.
- Individual: an object described by a set of data, usually people, but can be animals or other things.



- Informed Consent: The agreement of a willing participant to participate in a study, survey, or experiment; the participant is told in advance the nature of the study and any risk of harm it may bring, and consent must be given, usually in writing.
- Institutional Review Board (IRB): An independent board of a research institution whose job it is to allow research involving human beings, especially where safety or harm is a consideration.
- Mean: The arithmetic mean, the average of a set of numbers.
- Median: The middle of a set of data, the 50th percentile
- Normal curves: A symmetric, bell-shaped curve described by its mean and standard deviation.
- Numerical variable: A variable that takes on numeric values in which arithmetic operations make sense.
- Nonresponse: The refusal of a participant to respond or complete a survey, study, or experiment
- Observational study: A study that observes individuals and measures variables of interest but does not intervene to influence the responses.
- Parameter: A number that describes the population.
- Placebo: A dummy treatment with no real active treatment present.
- Population: The overall group the sample seeks to obtain information on.
- Probability: The likelihood of an event between 0 and 1 (or between 0% and 100%) and describes the proportion of times the outcome would occur in a very long series of repetitions
- Response variable: A variable that measures an outcome or result of a study.
- Regression Line: A straight line that describes how a response variable  $y$  changes as an explanatory variable  $x$  changes.
- Sample: A subset of the population selected for a survey, study, or experiment
- Sample survey: A survey in which some group of individuals are surveyed to represent the larger population.
- Scatterplot: A graph that shows the relationships between two quantitative variables measured on the same individuals; the values of the explanatory variable appear on the  $x$ -axis, and the values of the response variable appear on the  $y$ -axis; each individual of the data appears as a point.
- Simple random sample (SRS): A sample of size  $n$  that consists of  $n$  individuals from the population chosen in such a way that every set of  $n$  individuals has an equal chance to be the sample actually selected.

- Simpson's Paradox: a situation where an association holds for all of several groups but then disappears or reverses direction when the data are combined to form a single group.
- Square of the correlation: A statistic that explains what proportion of the variance of the response variable can be explained for by the variance in the explanatory variable.
- Standard deviation: The average distance of each data point from the mean.
- Statistic: A number that describes a sample.
- Third Quartile: The median of the upper half of the data.
- Two-way Table: A table that is used to describe the relationships between two categorical variables.
- Undercoverage: systematically denying a segment of the population the ability to be sampled.
- Variability: How the values of the sample statistic will vary when we take many samples; a measure of spread of the statistic.
- Variable: A characteristic of an individual.

## 2 Appendix B: Culminating Project

For your final in this class, you are going to be working solo, with 1 partner, or with 2 partners on creating a survey that you will then statistically analyze and report the results. If you do this with partners, you will share grades, so make sure to pick a partner that you trust to do his or her part.

### Steps:

1. Come up with a topic that you think will be interesting to do a survey about. It can literally be about anything.
2. Develop 5 questions for your survey. At least two of these must have quantitative data for answers, and at least one must have categorical data.
3. Administer your survey to AT LEAST 30 participants. Sterling's campus is probably your best bet to do this.
4. Prepare a report on your data, making sure to answer all of the questions below.

### Questions:

1. What does your survey seek to answer about the population? What is the population?

2. What parameters are used in the survey? What statistics are you gathering?
3. Identify potential sources of bias in your survey. What does this mean?
4. Identify potential sources of random error in your survey. What does this mean?
5. What is validity and what is reliability? Can you give supporting evidence that your survey has either or both of these? Explain.
6. What ethical issues should you be aware of while conducting your survey?
7. What type of sampling did you conduct for your survey? What are the strengths/weaknesses of this?
8. What nonresponse bias did you encounter in your survey? Do you see any potential remedies?
9. Did you encounter any undercoverage of key groups, such as women or minorities? Explain.
10. For one of your quantitative variables, give the mean and standard deviation. Explain what these mean.
11. For the same quantitative variable, give the 5-number summary and median. Explain what these mean.
12. Create a boxplot of that same quantitative variable, using the median and the 5-number summary.
13. Create a histogram of that same quantitative variable. Describe the shape, skew, and location of the distribution.
14. Based on the histogram, would the mean and standard deviation or the median and 5-number summary be a better measure of the data? Explain.
15. For two of your quantitative variables, create a scatterplot.
16. For the scatterplot in #15, use software to find the least-squares regression line.
17. Interpret the results of the scatterplot and regression line.
18. Create a minimum of THREE ADDITIONAL graphical displays of your survey's data, in addition to the ones already specified. Interpret each of these.
19. Discuss the strengths and weaknesses of your survey, and how it could be improved.