

Final Examination (150 minutes)

No calculators allowed. Just set up your answers, for example, $P = 49/52$. If you want extra time, you can buy time at a price of 1 point a minute; for example, if your test is handed in 10 minutes after the scheduled finish time, 10 points will be subtracted from the test score.

1. The 5th-century BC Greek philosopher and atheist Diagoras of Melos was shown paintings of sailors in violent storms who prayed to the gods and returned home safely. He was told, "You can see from all these pictures how many people have escaped the fury of storms at sea by praying to the gods who have brought them safe to harbor." Which of the following is the statistical argument behind Diagoras' response: "Yes, indeed, but where are the pictures of all those who suffered shipwreck and perished in the waves?"
central limit theorem regression to the mean survivor bias fallacious law of averages

2. Identify the most appropriate null hypothesis and statistical test for each of these studies; for example,
 H_0 : the average difference is zero
 test: matched-pair t-test:
 - a. Data were collected on the market values of 25 South Napa homes 6 months before and after the 2014 South Napa earthquake to see what effect, if any, the quake had on home values.
 H_0 :
 test:

 - b. Daily stock returns in 2020 were collected for the S&P 500 index of stocks and for a portfolio of the 19 publicly traded stocks identified by Glassdoor on December 10, 2019, as among the 50 best companies to work for.
 H_0 :
 test:

 - c. It was estimated that 0.36 percent of the people living in Dublin have Brady as a last name and that 8 of the 999 people treated in Dublin hospitals for bradycardia (a slower than normal heart rate) have Brady as a last name.
 H_0 :
 test:

 - d. Thirty-six subjects read a paragraph about an elderly man named George. For 18 people, the paragraph described him as competent; for the other 18, he was described as incompetent. After reading the story, each subject indicated how warm and friendly George is on a scale from 1 (not at all) to 9 (very).
 H_0 :
 test:

 - e. After its development, the Pfizer mRNA vaccine was tested through a randomized controlled trial of 37,586 participants, with 18,801 people in the treatment group given the vaccine and 18,785 people in the control group given an injection of a saline placebo. There were 8 cases of COVID-19 in the treatment group, compared to 162 in the control group.
 H_0 :
 test:

3. A 2021 study compared the calories in 20 McDonald's menu items sold in the US and the United Kingdom:

	US	UK
Big Mac	550	508
Quarter Pounder w/ Cheese	520	518
Double Quarter Oounder w/ cheese	740	750
Hamburger	250	250
Cheeseburger	300	301
Double Cheeseburger	450	445
McChicken	400	388
Filet-o-Fish	380	329
Sausage & Egg McMuffin	480	430
6-piece chicken nuggets	255	259
French Fries (regular)	320	337
Pancakes	580	477
Apple Pie	240	250
McFlurry Oreo	340	258
Chocolate Milkshake	520	468
Vanilla Milkshake	510	469
Strawberry Milkshake	530	458
Cappuccino	120	128
Caramel Frappuccino	420	399
Hot Chocolate	370	231

- a. Carefully explain how you would determine if the observed differences are statistically persuasive. You do not need to do any calculations, but you should explain, step-by-step, the calculations you would make.
- b. Carefully explain how you would determine if the observed differences are substantial. Again, do not do any actual calculations.
4. Do you agree or disagree with the following statements:
- A difference-in-means test assumes equal sample sizes.
 - A difference-in-means test assumes equal standard deviations.
 - A normal distribution is better than a binomial distribution for a single-sample test of a probability.
 - A multiple regression model assumes that the explanatory variables are uncorrelated.
 - A multiple regression model assumes that the explanatory variables are normally distributed.

5. Epic claims that sepsis predictions made by its AI Epic Sepsis Model (ESM) are 76 percent to 83 percent accurate, but there were no credible independent tests until a medical team examined the hospital records of 38,455 patients at Michigan Medicine, of whom 2,552 (6.6 percent) experienced sepsis. ESM generated a (correct) sepsis alert for 843 of these 2,552 patients and (correctly) did not generate a sepsis alert for 29,775 of the 35,903 patients who did not have sepsis. What fraction of ESM's sepsis alerts were false positives?

6. In the game Roshambo (rock-scissors-paper), two players simultaneously show a fist (rock), two fingers (scissors), or an open hand (paper). Rock beats scissors, scissors beats paper, and paper beats rock. A researcher played this game against 120 people, recording the initial move of each opponent. Use these data to test the null hypothesis that rock, scissors, and paper are used equally often on the initial move: 27 rock, 54 scissors, and 39 paper.

7. Explain why you either agree or disagree with this procedure that was used when the coefficients of several of the 8 explanatory variables in a multiple regression equation had t -values below 2:
In fact, the issue at play was "multi co-linearity" wherein the variables were influencing one another. I found this out after consulting with an expert in the field, [name withheld], PhD Candidate at the University of Chicago Harris School of Public Policy. I verified the given advice by using a correlation matrix on STATA and discovering that six of my eight explanatory variables were correlated with each other. I consequently dropped five of these variables from my model.

8. One hundred people were asked to state their weights, after which they were weighed. Oddly enough, those who made the highest estimates weighed less, on average, than they estimated; yet those who weighed the most tended, on average, to underestimate their weight. How would you explain this seeming paradox?
9. On August 15, 2021, 5,634,634 of 6,937,546 Israelis were fully vaccinated for COVID-19, and 301 of the 515 Israelis hospitalized for COVID-19 were fully vaccinated. Do these data indicate that an Israeli is more or less likely to be hospitalized for COVID-19 if fully vaccinated? (Remember: You do not need to do any calculations; just show the calculations that need to be done.)
10. The card game *Blackjack* is played with a standard deck of 52 playing cards. A player is dealt 2 cards and has an immediate blackjack if one card is an ace and the other card is a king, queen, jack, or 10. (It doesn't matter if the ace is the first or second card dealt.) What is the probability of being dealt a blackjack hand?
11. A study of the use of the anti-parasitic medication Ivermectin for COVID-19 was reported to have involved 600 patients, among whom 410 ages were even numbers and 190 ages were odd numbers. If odd and even ages are equally likely, what is the probability of such a large disparity?
12. The following model of stock prices was estimated by ordinary least squares;
- $$P = 5447 - 95.6U - 204.2R$$
- where P is the S&P 500 index of stock prices, U is the national unemployment rate, and R is the interest rate on 10-year Treasury bonds. What is wrong with this interpretation of the results: "The interest rate coefficient is negative because the Fed increases interest rates when it wants to increase the unemployment rate in order to fight inflation."

13. Suppose that you run an experiment involving a treatment group and a control group with 20 subjects in each sample and a difference-in-means test gives a t -value of 2.7 and a 2-sided p -value of 0.01. Which of these statements are true and which are false?
- The probability that the null hypothesis is true is 0.01.
 - The probability that the treatment works is 0.99.
 - If you reject the null hypothesis, the probability that you made the wrong decision is 0.01.
 - If the study is done again, there is a 0.99 probability of obtaining the same results.
14. Identify 5 errors in these reported results from estimating a multiple regression model to predict home sales, using quarterly time-series data from 2001-2020:

Explanatory Variable	Coefficient	Standard Error	t-value	2-sided p-value
intercept	-1703.00	412.00	4.10	0.0001
GDP	32.33	6.20	5.21	-0.0271
Mortgage Rate	-2245.61	711.42	3.16	0.0023
Spring (1 if spring, 0 otherwise)	45.62	28.62	1.59	0.1161
Summer (1 if summer, 0 otherwise)	35.55	21.44	1.66	0.1012
Fall (1 if fall, 0 otherwise)	-12.11	4.63	2.62	0.9894
Winter (1 if winter, 0 otherwise)	-48.79	15.72	3.10	0.0027
$n = 20, R^2 = 1.69\%$				

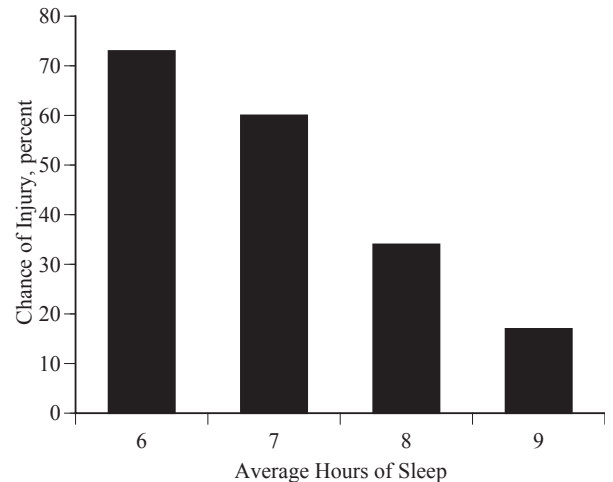
15. An experiment consists of a fair coin being flipped 10 times.
- What is the probability p that it will land heads every time?
 - If this experiment is repeated over and over, what is the expected wait w until an experiment occurs in which all 10 flips are heads?
 - If the experiment is repeated w times, what is the probability that in at least one of these experiments, all 10 flips will be heads?

16. Mahjong is played with four players using a set of 144 randomly shuffled face-down tiles, including 8 bonus tiles (4 flowers and 4 seasons) and 136 other tiles. In Taiwanese Mahjong, each of four players is dealt 16 tiles at the start of the game (which only they see) and then draw tiles one at a time from the remaining face-down tiles. The game ends if there are only 16 remaining face-down tiles and no one has won yet. What is the probability that the game will end with all 8 bonus tiles among the last 16 face down tiles?

17. A study found that the Mag-5 stocks (Facebook, Apple, Amazon, Microsoft, and Google) were the five biggest stocks in the S&P 500 index of 500 stock prices and that a portfolio of these five stocks had gone up 647.7% since 2009, compared to 393.8% for the S&P 500 as a whole. Give two reasons why these are not the correct data for comparing the performance of the 5 biggest stocks with other stocks.

18. Mathew Walker is a professor of neuroscience and psychology and founder of the Center for Human Sleep Science at the University of California, Berkeley. He has become famous for his books and a TED talk promoting the importance of sleep for health and performance. What is wrong with the figure he used to show adolescent athletes who sleep more are less likely to be injured?

Hours of Sleep	Chance of injury, %
5	60
6	74
7	60
8	34
9	16



19. In Walker’s TED talk, “Sleep is your superpower.” he made this argument:

I could tell you about sleep loss and your cardiovascular system, and that all it takes is one hour. Because there is a global experiment performed on 1.6 billion people across 70 countries twice a year, and it’s called daylight saving time. Now, in the spring, when we lose one hour of sleep, we see a subsequent 24-percent increase in heart attacks that following day. In the autumn, when we gain an hour of sleep, we see a 21-percent reduction in heart attacks. Isn’t that incredible? And you see exactly the same profile for car crashes, road traffic accidents, even suicide rates.

It turned out that this argument was based on Michigan heart attacks following four spring and three fall daylight savings time changes:

Relative Risk of Heart Attack During the Week After Daylight Saving Time Changes

	Spring Time Changes	Fall Time changes
Sunday	0.97	1.02
Monday	1.24	0.94
Tuesday	0.98	0.79
Wednesday	0.97	0.94
Thursday	0.97	1.10
Friday	0.97	0.91
Saturday	1.04	1.15

How, as a statistician, would you criticize the conclusion Walker drew from this study?

20. What is misleading about this figure that was used to show that real home prices are rising faster than real building costs?

