Technique Assignment 2: Probability
Cogs 109 Spring 2020
Due: Sunday April 26 11:59pm
100 points total

Submit your completed assignment on Gradescope as a pdf report. Additionally, include all Python code you generated either as part of a Jupyter notebook or as an appendix to your report. Include comments for clarity.

Section 1: Use Python and matplotlib to create and graph distributions

1. **(12)** Two six-sided dice are rolled and the two numbers showing are added to produce a sum between 2 and 12.
    a. Create a plot showing each event on the X axis and P(X), the probability of each event, on the Y axis. Include axis labels.
    b. Does this distribution look more like a normal distribution or a uniform distribution? Why?
    c. What is $P(X = 8 \text{ or } 9)$?

2. **(12)** For this problem, we will consider two normal (Gaussian) distributions: the first is characterized by $\mu=10$, $\sigma=3$. The second is characterized by $\mu=10$, $\sigma=1$. Hint: use the scipy.stats module and norm
    a. Plot both distributions in the same graph, including axis labels and a legend to distinguish the two distributions.
    b. Calculate $p(x>11)$ for each distribution.
    Hint: the integral of the pdf is called a cdf.
    c. Calculate $p(x>11)$ for each distribution using the array(s) you created in Python. It should be close to your answer in 2b, but may not match exactly.

3. **(12)** Suppose the local news tells you to expect a small earthquake tonight between midnight and 5am. You assume that the earthquake is equally likely to occur at any time during those five hours.
    a. Create a graph showing time on the X axis (x=0-5, minutes not necessary) and P(x) on the Y axis.
    b. What is E[X]?
    c. If you will be playing video games from midnight to 1:30am, what is the probability that the earthquake will happen during your gaming time?

Section 2: Probability. Note: **Do not** post homework hints on the Canvas discussion board or on Piazza for problems in this section (Q4-Q7). You may only define terms or clarify question wording.

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4. **(15)** Let's imagine flipping a penny 4 times.
    a. What is the probability of getting HHHH?
    b. What is the probability of getting HTHT?
    c. If event E is getting H on the first throw and event F is getting H on the second throw, what is $P(E \cap F)$?
    d. What is $P(E \cup F)$?
    e. What is the probability of getting at least one H?

Two events are **independent** if knowing something about one event does not change what you know about the other event (that is: $P(A \cap B) = P(A)P(B)$; $P(A|B) = P(A)$; $P(B|A) = P(B)$)

5. **(15)** Are the following pairs of events **dependent** or **independent**? A one-word answer is sufficient, but feel free to include an explanation if it helps you.
    a. Event P: Your car is parked in a UCSD parking garage
    Event S: Your car is parked on the street
    b. Event A: I randomly draw an unfair (weighted) coin from a set of fair and unfair coins
    Event B: I flip the coin I drew from the set of coins and produce HTHT
    c. Event A: The first time I flip a fair coin I get T
    Event B: The second time I flip the same coin I get H
    d. Event R: It is raining outside
    Event H: My hair gets wet when I walk outside
    e. Event D: It is **not** raining outside
    Event H: My hair gets wet when I walk outside

6. Contingency table **(12)** The contingency table shows how many students in each grade level of a high school are members of the school band or the school choir. Students **can** be in both. Please give the answer to each question as a decimal, percentage, or simplified fraction.

	Band	Choir	Neither	Total
Freshman	100	45	100	225
Sophomores	80	40	130	230
Juniors	50	50	160	250
Seniors	90	60	100	235
Total	320	195	490	940

   a. What is the probability that a randomly selected student will be a member of the band or the choir?
   b. What is the probability that a Freshman is in the band?
   c. If we know that a student is neither in band nor choir, what is the probability that that student is a Junior?
   d. What is P(inChoir | isSenior)?

7. Bayes' rule **(10)** There is a disease that affects 0.5% of a population. A test for the disease gives a positive result for 99% of people who have the disease. It also gives a positive result for 1% of people who do not have the disease (false positive). If a randomly selected person is tested and receives a positive result, what is the probability that they have the disease?

8. Conditional probability **(12)** You have two coins in your pocket. One is a regular coin and the other is a weighted coin that has a 75% chance of landing heads up. You can't tell the coins apart by inspecting them.

   You take a coin out of your pocket and toss it. It lands heads up.

   a. What is the probability that the coin is the fair coin?
   b. How many times would you decide to flip the coin before you are pretty sure it's the fair coin? Explain your answer.

9. **Extra credit** (Up to 10 points): Create a unique (your own) example question that uses Bayes' rule. You could use a contingency table, numerical probabilities, or a hypothetical scenario. Show how you solve the question.