

# MIDTERM EXAM

## CEE 260/MIE 273: Probability & Statistics in Civil Engineering

October 14, 2025

TIME LIMIT: TWO HOURS

### Instructions

This exam contains **10 pages** (including the front and back pages) and **9 problems, 64 points**. You have **2 hours** to complete it. Either print out the PDF and complete by hand and upload, or complete it digitally and upload as a PDF on Canvas. This is an **open resource examination**. You are expected to complete the exam individually. Asking anyone (colleague, friend, tutor, etc) questions about the exam is **not allowed**. If any questions arise during the exam, direct them to me (via email).

The following rules apply:

- **Organize your work**, in a reasonably neat and coherent way.
- **Show ALL your work where appropriate**. The work you show will be evaluated as well as your final answer. Thus, provide ample justification for each step you take. Indicate when you have used Python to obtain a result and show the function or statement you used to arrive at your result. In the long response questions, simply putting down an answer without showing your steps will not merit full credit. **EXCEPTION:** For short response or “True/False” questions, *no explanations are required*. However, the more work you show, the greater your chance of receiving partial credit.
- As much as possible, put your answers in the allotted space in order to facilitate grading.
- Questions are roughly in order of the lectures, so later questions may not necessarily be harder. If you are stuck on a problem, it may be better to skip it and get to it later.
- Manage your time wisely.

**Problem 1**     *True/False questions (10 points)*

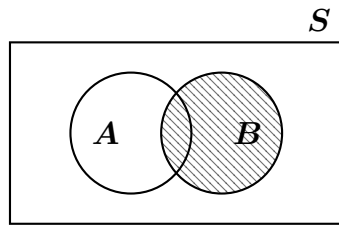
Respond “T” (*True*) or “F” (*False*) to the following statements. Use the boxes provided. Each response is worth 1 point. Note that a statement can only be regarded as true in this framework if it always holds in all circumstances. If a statement does not hold under a given condition not already explicitly excluded, then it should be regarded as false.

- (i) ☐ For a given online account, your password must have 10 alphanumeric characters (no caps). Assuming you are the first user to create an account, the number of possibilities for your password is  $26^{10}$ .
- (ii) ☐ The area under the curve of a PDF is given by the integral of the PDF.
- (iii) ☐ In a right-skewed distribution, the mean is less than the median.
- (iv) ☐  $P(A \cup B) = P(A) - P(B)$  for two events  $A$  and  $B$  that are mutually exclusive.
- (v) ☐ If  $A$  and  $B$  are statistically independent events, then  $P(A|B) = P(A)$ .
- (vi) ☐ The minimum value of any cumulative distribution function is 0.
- (vii) ☐ Under certain conditions, a binomial distribution with parameters  $(n, p)$  can be approximated by a normal distribution with  $\sigma = \sqrt{n(1-p)p}$ .
- (viii) ☐ Given a normal distribution with parameters  $\mu$  and  $\sigma$ , the variance of the distribution is  $\mu^2$ .
- (ix) ☐ The standard normal variate  $Z$  has a standard deviation of 1.
- (x) ☐ If a variable  $X$  is lognormally distributed with parameters  $\mu$  and  $\sigma$ , then the median of  $X$  is given by  $\exp(\mu)$ .

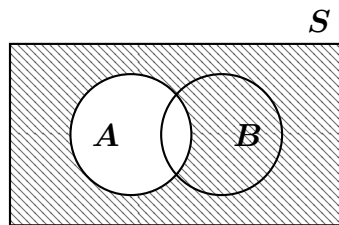
## Problem 2 Venn diagrams (6 points)

Write the combination of events (using set notation) depicted in each of the figures below.

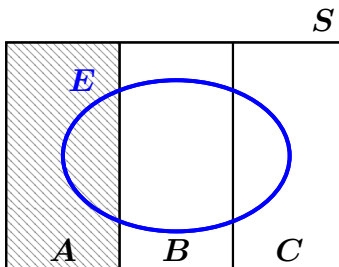
(a) (d)

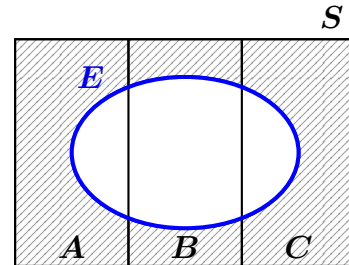



(b)

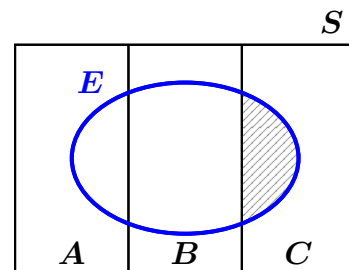



(c)

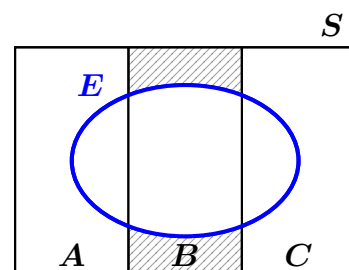





(e)

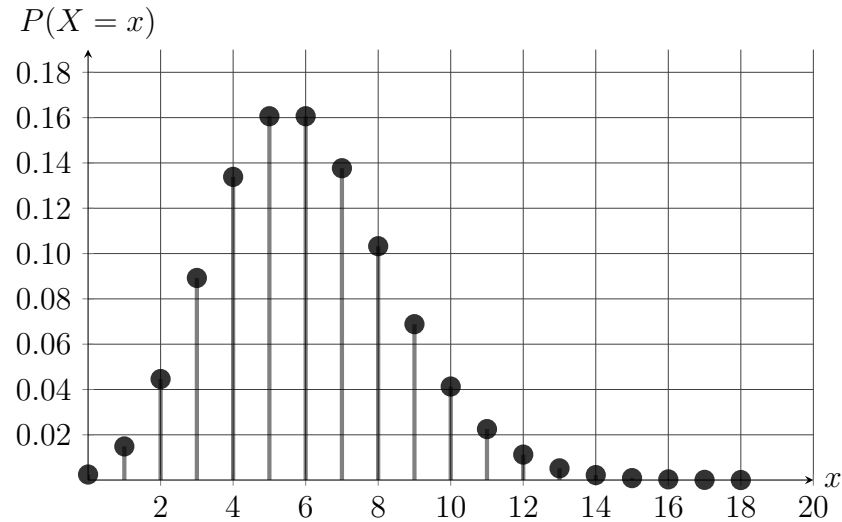



(f)



### Problem 3 *Discrete distribution (4 points)*

The PMF of a random variable  $X$  is given in the figure below. Use the figure to answer the following questions.



- [1] (a) Estimate the probability  $P(X = 6)$ .

- [2] (b) Estimate the probability  $P(4 < X \leq 7)$ .

- [1] (c) If the distribution shown has a single parameter  $\lambda$ , what distribution is it?

- [1] (d) Which of the following would be your best guess for  $\lambda$ ? (Circle or underline the correct answer.)

i. 4

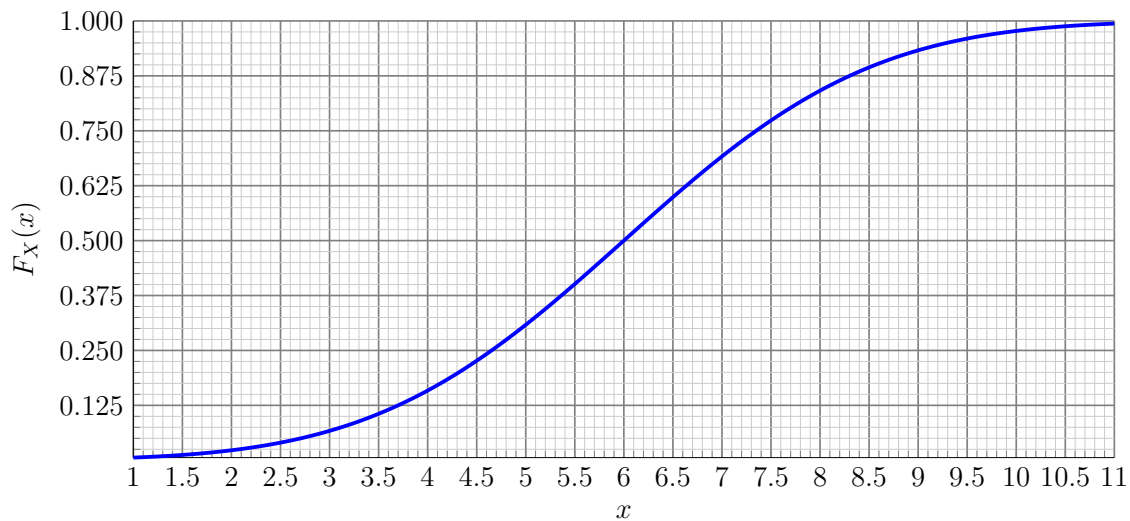
ii. 6

iii. 8

iv. 10

**Problem 4**     *CDF (5 points)*

Below is the CDF of a given distribution. Use the graph to answer the following.



- (a) Estimate the first quartile (to 1 decimal place).

[1]

**Answer:**

- (b) What is the second quartile?

[1]

**Answer:**

- (c) Estimate the third quartile (to 1 decimal place).

[1]

**Answer:**

- (d) Compute the interquartile range (IQR).

[1]

**Answer:**

- (e) If you are told that the above CDF is that of a normal distribution, what is its mean?

[1]

**Answer:**

**Problem 5**     *Probabilities I (6 points)*

The table below summarizes the results of a survey we did in class. Use it to answer the following questions.

|                               |           | Do you drink coffee? |    | Grand Total |
|-------------------------------|-----------|----------------------|----|-------------|
|                               |           | Yes                  | No |             |
| Where do you typically study? | Library   | 14                   | 22 | 36          |
|                               | Elsewhere | 52                   | 67 | 119         |
| Grand Total                   |           | 66                   | 89 | 155         |

[2]     (a) What is the probability that a randomly selected student studies in the library?

[2]     (b) What is the probability that a randomly selected student does not drink coffee?

[2]     (c) What is the probability that a randomly selected student studies in the library and does not drink coffee?

**Problem 6**     *Probabilities II (8 points)*

The table below summarizes the results of a survey we did in class. Answer the following questions (drawing on results from the previous problem).

|                               |           | Do you drink coffee? |    | Grand Total |
|-------------------------------|-----------|----------------------|----|-------------|
|                               |           | Yes                  | No |             |
| Where do you typically study? | Library   | 14                   | 22 | 36          |
|                               | Elsewhere | 52                   | 67 | 119         |
| Grand Total                   |           | 66                   | 89 | 155         |

- (a) What is the probability that a randomly selected student studies in the library, given that they do not drink coffee? [2]
- (b) Are the events that a student studies in the library and does not drink coffee independent? Justify your answer. [3]
- (c) What is the probability that a randomly selected student either studies in the library or does not drink coffee? [3]

**Problem 7**     *Normal distribution (9 points)*

The drainage from a community during a storm is a normal random variable estimated to have a mean of 1.2 million gallons per day (mgd) and an SD of 0.4 mgd. If the storm drain system is designed with a maximum drainage capacity of 1.5 mgd, answer the following questions (and show the code you use where appropriate).

- [3]     (a) Sketch the normal distribution, showing both the mean and the maximum drainage capacity.
- [2]     (b) What is the underlying probability of flooding during a storm that is assumed in the design of the drainage system? (Note: flooding occurs when the maximum drainage capacity is exceeded.)
- [2]     (c) What is the probability that the drainage is less than 1 mgd?
- [2]     (d) Find the 95th-percentile drainage load from the community during a storm.



**Problem 8**     *Logormal distribution (8 points)*

The distribution of the number of words (sentence length) from random sentences collected in class fitted a lognormal distribution with parameters  $\mu = 2.59, \sigma = 0.65$ . Now, use this distribution to answer the following questions.

- (a) What is the median sentence length? [2]
- (b) What is the probability that the sentence length is at least 10 words? [3]
- (c) Sketch the distribution, indicating the median and shading the portion of the PDF corresponding to the probability in part (b). [3]

**Problem 9**     *Short answer (8 points)*

In each case, show your work/code.

- [3]     (a) A random variable  $X$  is binomially distributed with  $n = 50$  and  $p = 0.3$ . Find the probability that  $X < 10$ .
- [2]     (b) A random variable  $T$  is exponentially distributed with a rate parameter of  $\lambda = 20$  occurrences/minute. What is the mean of  $T$ ?
- [3]     (c) In how many ways can you have 3 successes out of 10 trials in which the outcome of each trial is either success or failure?



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