Do not open the packet until the exam begins. When it begins, please rip this page off your exam.

Instructions

- You have twenty minutes to complete this exam.
- You are permitted one piece of 8.5x11 inch paper with handwritten notes (notes are allowed on both sides of the paper). You should also get a provided formula sheet.
- You may not use a calculator or any other electronic devices during the exam.
- We will be scanning your exams before grading them. Please write legibly, and avoid writing up to the edge of the paper.
- Since you don't have a calculator, you are generally free to **not** simplify expressions (though you may if you think it will be helpful).
- In general, you should show us the work you used to get to an answer, and explanations will help us reward partial credit, but we do **not** expect explanations at the level we usually require on homeworks.

Simplification Expectations

- Since you don't have a calculator for this exam, you do not have to do simplifications that could be done easily with a scientific calculator. For example, the expression below is simplified enough to be a final answer.

$$\frac{\binom{5}{3} \cdot 17^2}{1-p} + 5^3$$

- However, answers which are much more complicated than the expected answer may receive deductions. For example:
  - $\sum_{i=0}^{n} \binom{n}{i}$ or $\binom{n}{0} + \binom{n}{1} + \binom{n}{2} + \cdots + \binom{n}{n}$ are **not** simplified sufficiently
  - $\int_1^3 x^3 dx$ or $\left(2t^3\right)\Big|_0^x$ are **not** simplified sufficiently

  Generally derivatives, integrals, summations, or "..." are not sufficiently simple, unless otherwise indicated.

Advice

- Writing a few words about where an expression came from is often very helpful for awarding partial credit.
- Remember to take deep breaths.

Question	Max points
CLT	10
Tail Bounds	12
Multiple choice	3
Total	**25**

There are no problems on this page, go to the next one.

CSE 312 : Autumn 2025 Quiz 4 Retake Form 1

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1. Central Limit Theorem [10 points]

Suppose you have a fair, 5-sided die, with sides numbered 1 through 5. Let X be the sum of 40 independent rolls of the die.

(a) Calculate the expected value of X. [2 points]

(b) Calculate the variance of X. [2 points]

(c) Using the Central Limit Theorem, estimate the probability that the sum of our dice rolls is between 80 and 150 inclusive. Write your answer in terms of $\Phi(\cdot)$, the CDF of a $\mathcal{N}(0, 1)$ random variable.
In applying the CLT, **apply a continuity correction** if and only if it is usually appropriate for approximating a variable like X.
You may also write your answer in terms of a and b, your answers from parts (a) and (b) respectively. [6 points]

2. Heads or Tails? [12 points]

Suppose you flip a biased coin 200 times (independent of each other), where each flip comes up tails with probability 0.6. Let Y be the total number of tails.
Note that $\mathbb{E}[Y] = 120$.

(a) Calculate the variance of Y. [2 points]

(b) Using Markov's inequality, give a bound on the probability that we see at least 170 tails. [5 points]

$$\mathbb{P}\left(Y \geq 170\right) \underset{\text{inequality}}{\square} \underset{\text{bound}}{\square}$$

(c) Using Chebyshev's inequality, give a bound on the probability that we see between 106 and 134 tails. You may write your answer in terms of a, your answer from part (a). [5 points]

$$\mathbb{P}\left(106 \leq Y \leq 134\right) \underset{\text{inequality}}{\square} \underset{\text{bound}}{\square}$$

3. Multiple Choice [3 points]

(a) Let random variables X, Y be as defined in problems 1 and 2 respectively; recall that X is the sum of 40 independent rolls of a fair 5-sided die, and Y is the number of tails in 200 independent flips of a biased coin that comes up tails with probability 0.6.

Suppose we want to bound $\mathbb{P}(X \geq 180)$ and $\mathbb{P}(Y \geq 180)$. Can we (directly) apply the Chernoff bound? [3 points]

- ◯ Yes, for $\mathbb{P}(X \geq 180)$ only
- ◯ Yes, for $\mathbb{P}(Y \geq 180)$ only
- ◯ Yes, for <u>both</u> $\mathbb{P}(X \geq 180)$ and $\mathbb{P}(Y \geq 180)$
- ◯ No, we cannot use Chernoff to bound either expression