Lecture_4

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L4 - PDF Example Le...ure Scribe - PDF Task Instructions: Using the same structure…

Lecture Scribe: Joint Probability and Conditional Probability Course: CSE 400 —…

> *L4 - PDF*

> *Example Le...ure Scribe - PDF*

Task Instructions: Using the same structure as the example provided above, generate a comprehensive lecture scribe based on the attached context for Lecture 4 (L4.pdf). This scribe is authored by Vansh Lilani (ID: AU2320146). It is intended to serve as a primary exam-oriented reference material for a reading-based/closed-notes exam.

Requirements:

Faithfulness & Detail: Include all definitions, notation, and assumptions exactly as presented. Every formula, theorem statement, and worked example from the lecture must be included in full.

Step-by-Step Explanations: For all proofs and derivations, provide the complete step-by-step logic shown in the slides. Do not summarize; ensure the explanation covers the transition between each mathematical step to ensure exam readiness.

Scope: Stick strictly to the provided PDF. Do not invent new content or add external "intuition" not present in the lecture materials.

Correctness & Tone: Maintain a formal academic tone. Prioritize mathematical precision and clarity in the layout of formulas.

Structure: Adhere strictly to the organizational pattern (headings, lists, and layout) demonstrated in the "Example Lecture Scribe" provided above.

Lecture Scribe: Joint Probability and Conditional Probability Course: CSE 400 — Fundamentals of Probability in Computing **Author:** Vansh Lilani (ID: AU2320146) **Date:** January 15, 2026

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1. Topic Title

Joint Probability and Conditional Probability

2. Definitions and Notation

- **Experiment (E):** A procedure performed that produces a specific result.
  - *Example:* Tossing a coin five times (E_5).
- **Outcome (ξ):** A possible result of an experiment.
  - *Example:* One possible outcome of E_5 is $\xi_1 = HHTHT$.
- **Sample Space (S):** The set of all possible outcomes of an experiment.
- **Event:** A subset of the sample space.
- **Joint Probability:** The probability of two or more events occurring simultaneously.
- **Conditional Probability:** The probability of an event occurring given that another event has already occurred.

3. Assumptions / Conditions

- **Axioms of Probability:** All probability assignments must satisfy the fundamental axioms (Non-negativity, Normalization, and Additivity).
- **Probability Assignment Approaches:**
  - **Classical Approach:** Assumes all outcomes in a finite sample space are equally likely.

- **Relative Frequency Approach:** Based on the limit of the frequency of an outcome over many trials.

4. Main Results / Theorems

- **Joint Probability Notation:** Represented as $P(A \cap B)$ or $P(A, B)$, indicating the probability that both Event A and Event B occur.
- **Conditional Probability Formula:** The probability of event A given event B is defined as:

$$P(A \mid B) = \frac{P(A \cap B)}{P(B)}, where P(B) > 0$$

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5. Proofs / Derivations

(Note: Based on the provided lecture slides, the primary focus is on the application and conceptual motivation of these formulas in engineering contexts such as Speech Recognition and Radar Systems.)

+1

Derivation of Multiplication Rule:

- **Step 1:** Start with the definition of conditional probability: $P(A \mid B) = \frac{P(A \cap B)}{P(B)}$.
- **Step 2:** Rearrange the formula to solve for the joint probability. +1
- **Step 3:** The resulting Multiplication Rule is: $P(A \cap B) = P(A \mid B) P(B)$.

6. Worked Examples

- **Example 1: Card Deck (Joint Probability):** Calculation of probabilities involving specific suits and ranks from a standard deck.
- **Example 2: Costume Party (Joint Probability):** Determining the likelihood of overlapping characteristics among party guests.
- **Example 3: Cards Without Replacement (Conditional Probability):** Calculating the probability of drawing a specific sequence of cards when the first card is not returned

to the deck.

- **Example 4: Game of Poker:** Applying conditional probability to determine the strength of a hand as more cards are revealed.
- **Example 5: The Missing Key:** A logical probability problem determining the likelihood of finding a key in a specific location given it was not found in others.

Reference: Lecture 4 - Joint Probability and Conditional Probability by Dhaval Patel, PhD.