Bayes' Theorem, Venn Diagrams, Mutually Exclusive Events & Laplace Smoothing in Naive Bayes

1. Bayes' Theorem using Venn Diagram

- Sample space contains two events A and B
- Overlap = $A \cap B$

$P(A|B) = P(A \cap B) / P(B)$

$P(B|A) = P(A \cap B) / P(A)$

Bayes' Theorem:

$P(A|B) = [P(B|A) * P(A)] / P(B)$

2. Mutually Exclusive Events

- A and B never overlap
- $A \cap B = \emptyset$
- $P(A \cap B) = 0$
- $P(A|B) = 0$
- $P(B|A) = 0$

Mutually Exclusive ≠ Independent

3. Zero Frequency Problem in Naive Bayes

If count(x, y) = 0

Then $P(x|y) = 0$

Entire posterior becomes zero

4. Why Laplace Smoothing is Used

To avoid treating unseen events as impossible

Laplace Smoothing Formula:

$P(x = v \mid y) = (\text{count}(x=v, y) + 1) / (\text{count}(y) + K)$

K = number of possible feature values

5. Intuition

Laplace smoothing adds a small overlap instead of zero probability.

Prevents false mutual exclusivity in Naive Bayes.

6. Interview One-liner:

Laplace smoothing prevents zero probabilities in Naive Bayes caused by unseen feature-class combinations.