**Answers**

**Q1. What is Bayes' theorem?**

Bayes' theorem is a fundamental concept in probability theory and statistics that describes the relationship between conditional probabilities. It allows the updating of probabilities for a hypothesis as new evidence is introduced.

**Q2. What is the formula for Bayes' theorem?**

The formula for Bayes' theorem is:

P(H∣E)=P(E∣H)⋅P(H)P(E)P(H|E) = \frac{P(E|H) \cdot P(H)}{P(E)}

Where:

* P(H∣E)P(H|E): Posterior probability of hypothesis HH given evidence EE.
* P(E∣H)P(E|H): Likelihood of evidence EE given hypothesis HH.
* P(H)P(H): Prior probability of hypothesis HH.
* P(E)P(E): Marginal probability of evidence EE.

**Q3. How is Bayes' theorem used in practice?**

Bayes' theorem is widely used in various fields such as:

* **Spam Filtering**: Determining whether an email is spam based on its content.
* **Medical Diagnosis**: Calculating the likelihood of a disease given symptoms.
* **Machine Learning**: Foundation for algorithms like Naive Bayes classifiers.
* **Risk Assessment**: Updating risk estimates with new data.
* **Natural Language Processing**: Applications in sentiment analysis and text classification.

**Q4. What is the relationship between Bayes' theorem and conditional probability?**

Bayes' theorem is derived from the definition of conditional probability. It mathematically expresses how to reverse the conditioning, allowing us to find P(H∣E)P(H|E) using P(E∣H)P(E|H). In essence, it connects the probability of HH given EE to the probability of EE given HH.

**Q5. How do you choose which type of Naive Bayes classifier to use for any given problem?**

The choice of Naive Bayes classifier depends on the type of data:

* **Gaussian Naive Bayes**: Use for continuous data assuming it follows a Gaussian (normal) distribution.
* **Multinomial Naive Bayes**: Suitable for discrete data, especially for text classification problems with term frequencies.
* **Bernoulli Naive Bayes**: Best for binary data, such as presence/absence of words in text data.

**Q6. Assignment**

We need to classify the instance with X1=3X1 = 3 and X2=4X2 = 4 using Naive Bayes.

**Step 1: Calculate the likelihoods for each class.**

For class AA:

P(X1=3∣A)=Frequency of X1=3 in class ATotal frequency of X1 in class A=410P(X1 = 3 | A) = \frac{\text{Frequency of } X1 = 3 \text{ in class } A}{\text{Total frequency of } X1 \text{ in class } A} = \frac{4}{10} P(X2=4∣A)=Frequency of X2=4 in class ATotal frequency of X2 in class A=313P(X2 = 4 | A) = \frac{\text{Frequency of } X2 = 4 \text{ in class } A}{\text{Total frequency of } X2 \text{ in class } A} = \frac{3}{13}

For class BB:

P(X1=3∣B)=Frequency of X1=3 in class BTotal frequency of X1 in class B=P(X1 = 3 | B) = \frac{\text{Frequency of } X1 = 3 \text{ in class } B}{\text{Total frequency of } X1 \text{ in class } B} =

Continuing with the calculation for class BB:

P(X1=3∣B)=Frequency of X1=3 in class BTotal frequency of X1 in class B=15P(X1 = 3 | B) = \frac{\text{Frequency of } X1 = 3 \text{ in class } B}{\text{Total frequency of } X1 \text{ in class } B} = \frac{1}{5} P(X2=4∣B)=Frequency of X2=4 in class BTotal frequency of X2 in class B=39P(X2 = 4 | B) = \frac{\text{Frequency of } X2 = 4 \text{ in class } B}{\text{Total frequency of } X2 \text{ in class } B} = \frac{3}{9}

**Step 2: Compute the joint probabilities for each class.**

Assuming equal prior probabilities (P(A)=P(B)=0.5P(A) = P(B) = 0.5) and independence of X1X1 and X2X2:

For AA:

P(A∣X1=3,X2=4)∝P(X1=3∣A)⋅P(X2=4∣A)⋅P(A)P(A | X1 = 3, X2 = 4) \propto P(X1 = 3 | A) \cdot P(X2 = 4 | A) \cdot P(A) P(A∣X1=3,X2=4)∝410⋅313⋅0.5=12260=0.0462P(A | X1 = 3, X2 = 4) \propto \frac{4}{10} \cdot \frac{3}{13} \cdot 0.5 = \frac{12}{260} = 0.0462

For BB:

P(B∣X1=3,X2=4)∝P(X1=3∣B)⋅P(X2=4∣B)⋅P(B)P(B | X1 = 3, X2 = 4) \propto P(X1 = 3 | B) \cdot P(X2 = 4 | B) \cdot P(B) P(B∣X1=3,X2=4)∝15⋅39⋅0.5=390=0.0333P(B | X1 = 3, X2 = 4) \propto \frac{1}{5} \cdot \frac{3}{9} \cdot 0.5 = \frac{3}{90} = 0.0333

**Step 3: Compare the probabilities.**

Since P(A∣X1=3,X2=4)>P(B∣X1=3,X2=4)P(A | X1 = 3, X2 = 4) > P(B | X1 = 3, X2 = 4), the Naive Bayes classifier predicts that the instance belongs to **class AA**.