

Q1.

- (a) Define sample space and event. Give an example.
- (b) Write the formula for joint probability of two events A and B, when they are (i) mutually exclusive, (ii) independent.

Q2.

- (a) State Bayes' theorem.
- (b) Explain each term of above theorem with an example.

Q3.

- (a) What is a Bernoulli random variable?
- (b) Why is a Bernoulli distribution considered a special case of the Binomial distribution?

Q4.

- (a) Explain the difference between discrete and continuous random variables.
- (b) Explain the role of covariance in measuring relationships between variables.

Q5.

- (a) Define MAP (Maximum a Posteriori) hypothesis.
- (b) Explain why Bayesian methods are important in machine learning.

Q6.

- (a) What is a Naïve Bayes classifier?
- (b) How does a Naïve Bayes classifier perform classification? Explain why Naïve Bayes works well even with limited training data.

Q7.

- (a) What is a Bayesian Belief Network?
- (b) Analyze the advantage of Bayesian Belief Networks over Naïve Bayes classifier.

Q8.

- (a) Define classification in supervised learning.
- (b) Explain the steps involved in classification learning.

Q9.

- (a) Define k-Nearest Neighbours (kNN) algorithm. Explain why the choice of k is important in kNN.
- (b) Why kNN is called a lazy learner? Explain the strength and weakness of kNN algorithm.

Q10.

- (a) What is a decision tree?
- (b) Discuss the strength and weakness of decision trees.

Q11.

Q12.

Q13.

- (a) What is a Random Forest?
- (b) Compare decision trees and Random Forests approaches.
- (a) Define Support Vector Machine (SVM) concept.
- (b) Analyze how SVM handles non-linearly separable data.
- (a) Define regression in supervised learning.
- (b) What are the key assumptions of linear regression?

Q14. Explain why multicollinearity is a problem in regression. What are the remedies to overcome multicollinearity.

Q15. Explain why multiple linear regression is useful in real-world problems.

GIVE ME QUESTION WITH ANSWERS IN DETAIL AND A SHORT ANSWER TO THE POINT

Below is a **clean exam-ready solution set**.

For **each question**, you get:

- **Detailed Answer** (for full marks 🍷)
- **Short Answer** (to-the-point, for quick revision ⚡)

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**Q1**

**(a) Sample Space and Event**

**Detailed Answer:**

A **sample space (S)** is the set of all possible outcomes of a random experiment.

An **event (E)** is any subset of the sample space.

**Example:**

If a die is rolled:

Sample space:

$$S = \{1, 2, 3, 4, 5, 6\}$$

Event "getting an even number":

$$E = \{2, 4, 6\}$$

**Short Answer:**

Sample space = all possible outcomes; Event = subset of sample space.

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## (b) Joint Probability of Events A and B

(i) Mutually Exclusive:

$$P(A \cap B) = 0$$

(ii) Independent:

$$P(A \cap B) = P(A) \cdot P(B)$$

**Short Answer:**

Mutually exclusive  $\Rightarrow$  no overlap; Independent  $\Rightarrow$  product of probabilities.

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## Q2

### (a) Bayes' Theorem

**Detailed Answer:**

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

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### (b) Explanation of Each Term

**Example:** Disease testing

- $P(A)$ : Prior probability of disease
- $P(B|A)$ : Probability test is positive given disease
- $P(B)$ : Total probability of positive test
- $P(A|B)$ : Probability of disease after test result

**Short Answer:**

Bayes' theorem updates prior belief using new evidence.

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### Q3

#### (a) Bernoulli Random Variable

**Detailed Answer:**

A **Bernoulli random variable** takes only two values:

- 1 (success) with probability  $p$
- 0 (failure) with probability  $1 - p$

**Example:** Tossing a coin (Head = 1, Tail = 0)

**Short Answer:**

A random variable with only two outcomes.

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#### (b) Bernoulli as Special Case of Binomial

**Detailed Answer:**

Binomial distribution counts successes in  $n$  trials.

For  $n = 1$ , it becomes Bernoulli distribution.

**Short Answer:**

Bernoulli = Binomial with one trial.

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### Q4

#### (a) Discrete vs Continuous Random Variables

**Detailed Answer:**

Discrete	Continuous
Countable values	Infinite values
PMF	PDF
Example: dice	Example: height

**Short Answer:**

Discrete = countable, Continuous = measurable.

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**(b) Role of Covariance****Detailed Answer:**

Covariance measures how two variables vary together.

- Positive → move in same direction
- Negative → move in opposite directions
- Zero → no linear relationship

**Short Answer:**

Covariance shows direction of relationship between variables.

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**Q5****(a) MAP Hypothesis****Detailed Answer:**

MAP selects the hypothesis with **maximum posterior probability**:

$$h_{MAP} = \arg \max_h P(h|D)$$

**Short Answer:**

MAP chooses the most probable hypothesis after seeing data.

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**(b) Importance of Bayesian Methods****Detailed Answer:**

- Handle uncertainty
- Work with small data
- Incorporate prior knowledge
- Probabilistic interpretation

**Short Answer:**

Bayesian methods combine prior knowledge with data.

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## Q6

### (a) Naïve Bayes Classifier

#### Detailed Answer:

A probabilistic classifier based on Bayes' theorem assuming **feature independence**.

#### Short Answer:

A simple Bayesian classifier with independence assumption.

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### (b) Working of Naïve Bayes

#### Detailed Answer:

1. Compute prior probabilities
2. Compute likelihoods
3. Apply Bayes' theorem
4. Choose class with highest probability

Works well with small data because it estimates fewer parameters.

#### Short Answer:

Calculates class probabilities and picks the highest one.

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## Q7

### (a) Bayesian Belief Network

#### Detailed Answer:

A **directed acyclic graph (DAG)** representing probabilistic dependencies among variables.

#### Short Answer:

Graphical model showing conditional dependencies.

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### (b) Advantage over Naïve Bayes

#### Detailed Answer:

- Models dependencies
- More realistic
- Handles missing data

**Short Answer:**

BBN captures feature relationships; Naïve Bayes does not.

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**Q8****(a) Classification****Detailed Answer:**

Classification assigns input data to predefined class labels.

**Short Answer:**

Predicting class labels from data.

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**(b) Steps in Classification Learning****Detailed Answer:**

1. Data collection
2. Feature extraction
3. Model training
4. Model testing
5. Prediction

**Short Answer:**

Train model → test → predict.

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**Q9****(a) k-Nearest Neighbours (kNN)****Detailed Answer:**

kNN classifies a point based on majority class of its **k nearest neighbors**.

Choice of k:

- Small k → noisy
- Large k → smooth but biased

**Short Answer:**

kNN uses nearby points to classify new data.

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## **(b) Lazy Learner, Strength & Weakness**

### **Detailed Answer:**

kNN stores data and computes at prediction time → **lazy learner**.

### **Strengths:**

- Simple
- No training phase

### **Weaknesses:**

- Slow prediction
- Sensitive to noise

### **Short Answer:**

Lazy because no training; slow but simple.

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## **Q10**

### **(a) Decision Tree**

#### **Detailed Answer:**

A tree-structured model that splits data using decision rules.

#### **Short Answer:**

Tree-based model for decision making.

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### **(b) Strength & Weakness**

#### **Detailed Answer:**

#### **Strengths:**

- Easy to interpret
- Handles non-linear data

#### **Weaknesses:**

- Overfitting
- Unstable

#### **Short Answer:**

Interpretable but prone to overfitting.



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## Q11–Q13

### Random Forest

**(a) Definition:**

An ensemble of decision trees using bagging and feature randomness.

**(b) Comparison:**

Decision Tree	Random Forest
Single tree	Multiple trees
Overfits	Reduces overfitting
Fast	More accurate

**Short Answer:**

Random Forest improves decision trees using ensembles.

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### Support Vector Machine (SVM)

**(a) Definition:**

SVM finds the optimal hyperplane that maximizes margin.

**(b) Non-linear Data:**

Uses **kernel trick** to map data to higher dimensions.

**Short Answer:**

SVM separates data using maximum margin and kernels.

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### Regression

**(a) Definition:**

Predicts continuous output values.

**(b) Assumptions:**

- Linearity
- Independence

- Homoscedasticity
- Normal errors

**Short Answer:**

Regression predicts continuous values.

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## Q14 Multicollinearity

**Detailed Answer:**

Occurs when independent variables are highly correlated.

Problems:

- Unstable coefficients
- Reduced interpretability

**Remedies:**

- Remove variables
- PCA
- Ridge regression

**Short Answer:**

High correlation among predictors harms regression.

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## Q15 Multiple Linear Regression

**Detailed Answer:**

Used when output depends on multiple factors.

Examples:

- House price prediction
- Sales forecasting
- Medical diagnosis

**Short Answer:**

Models real-world problems with many influencing variables.

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If you want, I can also:

- Convert this into **exam-ready PDF**
- Create **2-mark / 5-mark versions**
- Add **numerical examples**

Just say the word 🚀

