Question 1(a) [3 marks]

Define Cloud computing. Explain any two advantages of using cloud computing.

Answer:

Cloud Computing is the delivery of computing services over the internet including servers, storage, databases, and software.

Table: Cloud Computing Advantages

Advantage	Description
Cost-Effective	No upfront hardware costs, pay-as-you-use model
Scalability	Resources can be scaled up/down based on demand

Mnemonic: "Cloud Saves Cash" (Cost-effective, Scalable)

Question 1(b) [4 marks]

List the cloud service models. Justify: Infrastructure as a service model is the base of cloud computing structure.

Answer:

Table: Cloud Service Models

Model	Full Form	Description
IaaS	Infrastructure as a Service	Virtual machines, storage, networks
PaaS	Platform as a Service	Development platforms and tools
SaaS	Software as a Service	Ready-to-use applications

Justification: IaaS is the foundation because it provides basic computing infrastructure (servers, storage, networking) upon which PaaS and SaaS are built.

**Mnemonic:** "I Pay for Software" (IaaS, PaaS, SaaS)

Question 1(c) [7 marks]

Differentiate between edge and fog computing.

Answer:

Table: Edge vs Fog Computing

Aspect	Edge Computing	Fog Computing
Location	At device level (endpoints)	Between cloud and edge
Latency	Ultra-low (milliseconds)	Low (few seconds)
Processing	Limited local processing	Distributed processing
Storage	Minimal local storage	Moderate storage capacity
Use Cases	IoT sensors, autonomous vehicles	Smart cities, industrial IoT

Diagram:
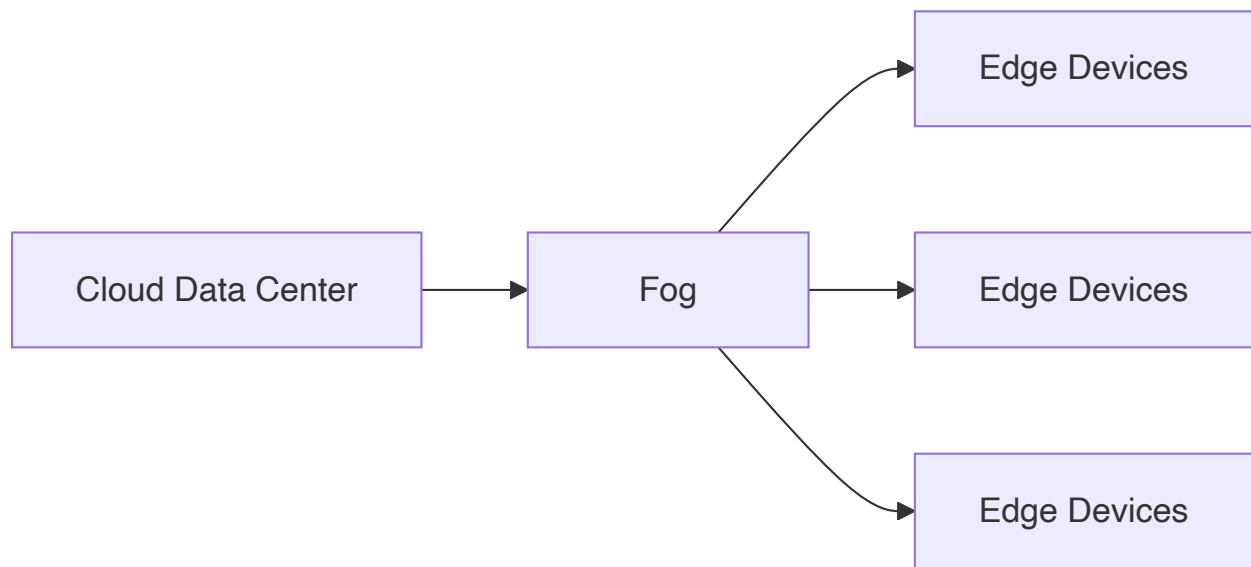
Mnemonic: "Edge is Extremely close, Fog is Further"

Question 1(c) OR [7 marks]

Explain distributed ledger technology used in cloud computing.

Answer:

Distributed Ledger Technology (DLT) is a decentralized database spread across multiple nodes in cloud computing.

Key Features:

- **Decentralization**: No single point of failure
- **Immutability**: Records cannot be altered once added
- **Transparency**: All participants can view transactions
- **Consensus**: Agreement required for new entries

Table: DLT Benefits in Cloud

Benefit	Description
Security	Enhanced data protection through cryptography
Trust	Eliminates need for intermediaries
Audit Trail	Complete transaction history

Mnemonic: "DLT Delivers Trusted Security"

Question 2(a) [3 marks]

List and explain the major components of virtualization environment.

Answer:

Table: Virtualization Components

Component	Description
Hypervisor	Software managing virtual machines
Virtual Machines	Isolated computing environments
Host OS	Operating system running hypervisor

Mnemonic: "Hypervisor Handles Virtual Machines"

Question 2(b) [4 marks]

Justify with example: Renting resources on cloud is more beneficial than actually buying them for small and midcap companies.

Answer:

Benefits of Cloud Renting:

- **Lower Initial Cost**: No upfront investment in hardware
- **Flexibility**: Scale resources based on demand
- **Maintenance-Free**: Provider handles updates and repairs

Example: A startup needs servers during peak season only. Buying costs ₹10 lakhs, while cloud renting costs ₹50,000 for 3 months usage.

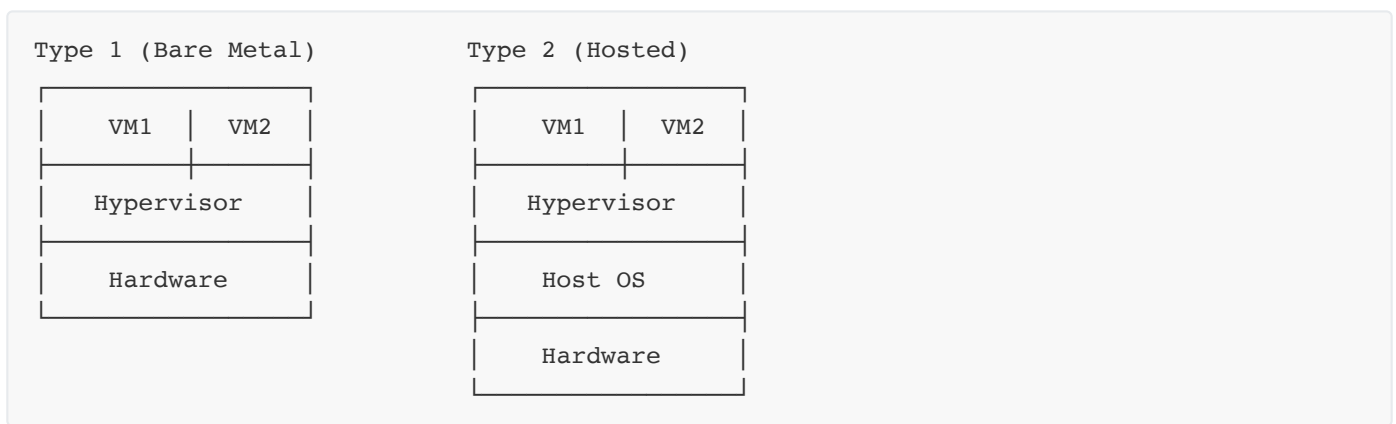**Mnemonic:** "Rent for Flexibility, Buy for Permanency"

Question 2(c) [7 marks]

Explain Hypervisor with its types.

Answer:

Hypervisor is software that creates and manages virtual machines by abstracting hardware resources.

Table: Hypervisor Types

Type	Name	Description	Examples
Type 1	Bare Metal	Runs directly on hardware	VMware ESXi, Hyper-V
Type 2	Hosted	Runs on host operating system	VirtualBox, VMware Workstation

Diagram:

```
Type 1 (Bare Metal)        Type 2 (Hosted)

 ┌─────────────────┐        ┌─────────────────┐
 │   VM1  │   VM2   │        │   VM1  │   VM2   │
 ├─────────────────┤        ├─────────────────┤
 │    Hypervisor   │        │    Hypervisor   │
 ├─────────────────┤        ├─────────────────┤
 │    Hardware     │        │    Host OS       │
 └─────────────────┘        ├─────────────────┤
                            │    Hardware     │
                            └─────────────────┘
```

Mnemonic: "Type 1 Touches Hardware, Type 2 Touches OS"

Question 2(a) OR [3 marks]

State the advantages of using virtualization. Explain any one.

Answer:

Virtualization Advantages:

- **Resource Optimization**: Better hardware utilization
- **Cost Reduction**: Fewer physical servers needed
- **Isolation**: Applications run independently

Resource Optimization: Multiple virtual machines can run on single physical server, utilizing 80-90% of hardware capacity instead of typical 15-20%.

Mnemonic: "Virtualization Optimizes Resources"

Question 2(b) OR [4 marks]

Explain Application-level virtualization.

Answer:

Application-level virtualization allows applications to run in isolated environments without installing them on the host OS.

Table: Application Virtualization Features

Feature	Description
Isolation	Apps don't interfere with each other
Portability	Apps run on different OS without modification
Security	Sandboxed execution environment

Example: Docker containers running applications with their dependencies packaged together.

Mnemonic: "Apps Are Isolated and Portable"

Question 2(c) OR [7 marks]

Explain hardware virtualization in cloud.

Answer:

Hardware virtualization creates virtual versions of physical hardware components in cloud environments.

Key Components:

- **CPU Virtualization**: Multiple VMs share physical processor
- **Memory Virtualization**: Virtual memory allocation to VMs
- **Storage Virtualization**: Abstract storage resources
- **Network Virtualization**: Virtual network interfaces

Table: Hardware Virtualization Benefits

Benefit	Description
Resource Sharing	Multiple VMs use same hardware
Isolation	VMs operate independently
Migration	VMs can move between hosts

Mnemonic: "Hardware Hosts Multiple Virtual Machines"

Question 3(a) [3 marks]

Define Data Center. List types of Data center.

Answer:

Data Center is a facility housing computing and networking equipment to store, process, and distribute data.

Table: Data Center Types

Type	Description
Enterprise	Private data centers for organizations
Colocation	Shared facilities for multiple clients
Cloud	Virtualized, scalable data centers

Mnemonic: "Enterprise, Colocation, Cloud Centers"

Question 3(b) [4 marks]

Why data centre automation is important?

Answer:

Data Center Automation Benefits:

- **Efficiency**: Reduces manual tasks and errors
- **Cost Savings**: Lower operational expenses
- **Scalability**: Quick resource provisioning
- **Reliability**: Consistent operations and monitoring

Table: Automation Areas

Area	Benefit
Provisioning	Faster server deployment
Monitoring	Real-time performance tracking
Maintenance	Automated updates and patches

Mnemonic: "Automation Enhances Efficiency"

Question 3(c) [7 marks]

Explain SDN (Software Defined Networking) architecture.

Answer:

SDN separates network control plane from data plane, enabling centralized network management.

SDN Architecture Layers:

Table: SDN Components

Component	Function
Controller	Centralized network control
Switches	Forward packets based on controller
Applications	Network services and policies

Benefits:

- **Centralized Control**: Single point of network management
- **Programmability**: Dynamic network configuration
- **Flexibility**: Easy policy implementation

Mnemonic: "SDN Separates Control from Data"

Question 3(a) OR [3 marks]

Define the following: (i) Cloud Elasticity (ii) Cloud Scalability

Answer:

Table: Cloud Elasticity vs Scalability

Term	Definition
Cloud Elasticity	Automatic resource adjustment based on demand
Cloud Scalability	Ability to handle increased workload by adding resources

Key Difference: Elasticity is automatic, scalability can be manual or automatic.

Mnemonic: "Elasticity is Automatic, Scalability is Adaptable"

Question 3(b) OR [4 marks]

Explain with reason: Vendor lock-in is a major problem in cloud computing services.

Answer:

Vendor Lock-in occurs when switching cloud providers becomes difficult due to dependency on specific services.

Problems:

- **High Migration Costs**: Data transfer and application modification expenses
- **Limited Flexibility**: Restricted choice of providers
- **Dependency**: Reliance on single vendor's technologies

Example: Using AWS-specific services makes migration to Google Cloud expensive and complex.

Mnemonic: "Lock-in Limits Liberty"

Question 3(c) OR [7 marks]

Explain Infrastructure as Code (IaC) with its different approaches.

Answer:

Infrastructure as Code (IaC) manages infrastructure through code rather than manual processes.

Table: IaC Approaches

Approach	Description	Tools
Declarative	Define desired end state	Terraform, ARM templates
Imperative	Define step-by-step instructions	Scripts, Ansible
Hybrid	Combination of both approaches	Pulumi

Benefits:

- **Consistency**: Repeatable infrastructure deployment
- **Version Control**: Track infrastructure changes
- **Automation**: Reduce manual configuration errors

Diagram:

```
Code  →  IaC Tool  →  Cloud Provider  →  Infrastructure
```

Mnemonic: "IaC Codes Infrastructure"

Question 4(a) [3 marks]

Define cloud storage. List the major cloud storage solutions.

Answer:

Cloud Storage is a service that stores data on remote servers accessible via internet.

Table: Major Cloud Storage Solutions

Provider	Service	Type
Amazon	S3	Object Storage
Google	Cloud Storage	Object Storage
Microsoft	Azure Blob	Object Storage

Mnemonic: "Amazon, Google, Microsoft Store Objects"

Question 4(b) [4 marks]

Justify with example: Data consistency is an essential feature of cloud storage

Answer:

Data Consistency ensures all copies of data across distributed systems show the same value.

Importance:

- **Reliability**: Users get correct data always
- **Integrity**: Prevents data corruption
- **Synchronization**: Multiple users see same information

Example: In banking system, account balance must be consistent across all ATMs and branches to prevent double spending.

**Mnemonic:** "Consistency Creates Confidence"

Question 4(c) [7 marks]

Explain types of cloud databases in detail.

Answer:

Table: Cloud Database Types

Type	Description	Examples	Use Cases
SQL Databases	Relational databases with ACID properties	Amazon RDS, Azure SQL	Transaction processing
NoSQL Databases	Non-relational, flexible schema	MongoDB Atlas, DynamoDB	Big data, real-time web apps
In-Memory	Data stored in RAM for speed	Redis, Memcached	Caching, real-time analytics
Graph Databases	Relationship-focused data storage	Neo4j, Amazon Neptune	Social networks, recommendations

SQL vs NoSQL Comparison:

```
Structured  →  SQL  →  ACID

Unstructured Data  →  NoSQL Database  →  High
```
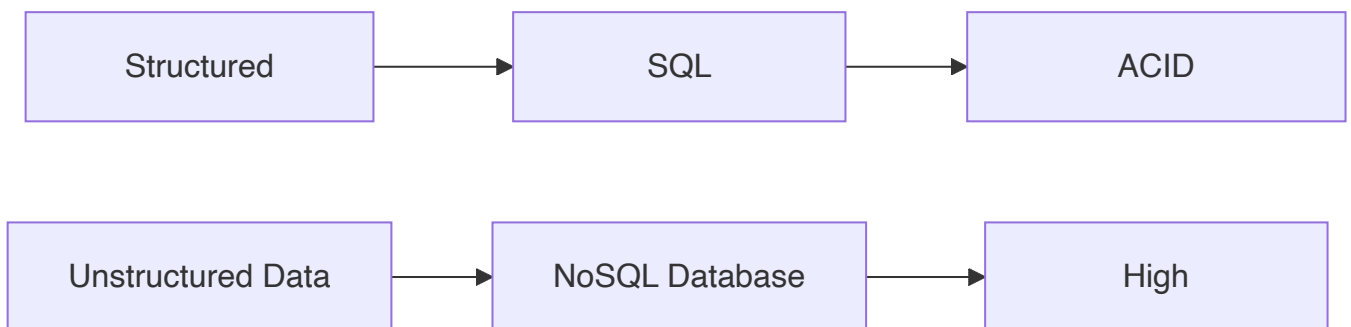
Mnemonic: "SQL for Structure, NoSQL for Scale"

Question 4(a) OR [3 marks]

Define database services in cloud. List the major features of database services

Answer:

Cloud Database Services are managed database solutions provided by cloud vendors.

Table: Major Features

Feature	Description
Auto-scaling	Automatic resource adjustment
Backup & Recovery	Automated data protection
High Availability	99.9% uptime guarantee

Mnemonic: "Databases Auto-scale, Backup, and stay Available"

Question 4(b) OR [4 marks]

Justify with example: Data durability is an essential feature of cloud storage.

Answer:

Data Durability ensures data persists over time without loss or corruption.

Importance:

- **Data Protection**: Prevents permanent data loss
- **Business Continuity**: Critical for operations
- **Compliance**: Required by regulations

Example: Amazon S3 provides 99.999999999% (11 9's) durability by storing data across multiple facilities and creating multiple copies.

Mnemonic: "Durability Delivers Data Protection"

Question 4(c) OR [7 marks]

Explain data scaling and replication in detail.

Answer:

Data Scaling is the ability to handle increased data load by adding resources.

Table: Scaling Types

Type	Description	Method
Vertical Scaling	Adding more power to existing machine	Increase CPU, RAM
Horizontal Scaling	Adding more machines	Add more servers

Data Replication creates copies of data across multiple locations.

Table: Replication Types

Type	Description	Use Case
Synchronous	Real-time data copying	Critical applications
Asynchronous	Delayed data copying	Backup systems

Diagram:
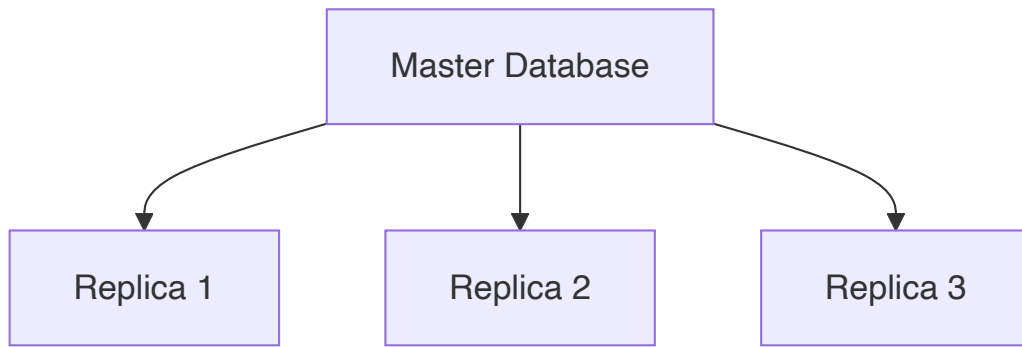
Mnemonic: "Scale Up or Scale Out, Replicate for Reliability"

Question 5(a) [3 marks]

Justify: Authentication and access control are two different aspects of security in cloud computing.

Answer:

Table: Authentication vs Access Control

Aspect	Authentication	Access Control
Purpose	Verify user identity	Determine permissions
Question	"Who are you?"	"What can you do?"
Methods	Passwords, biometrics	Roles, policies

Justification: Authentication verifies identity first, then access control determines what authenticated user can access.

Mnemonic: "Authenticate first, Authorize second"

Question 5(b) [4 marks]

State the role of machine learning in the cloud. Justify: Cloud computing aids in the task of machine learning.

Answer:

ML Role in Cloud:

- **Data Processing**: Handle large datasets efficiently
- **Model Training**: Scalable computing for complex algorithms
- **Deployment**: Easy model hosting and serving

Justification: Cloud provides necessary computational power, storage, and tools that make ML accessible without huge infrastructure investment.

Table: Cloud ML Benefits

Benefit	Description
Scalability	Handle massive datasets
Cost-Effective	Pay-per-use model
Accessibility	Pre-built ML services

**Mnemonic:** "Cloud Computes ML Models"

Question 5(c) [7 marks]

Explain cloud security challenges.

Answer:

Table: Major Cloud Security Challenges

Challenge	Description	Impact
Data Breaches	Unauthorized access to sensitive data	Financial loss, reputation damage
Identity Management	Managing user access and permissions	Security vulnerabilities
Compliance	Meeting regulatory requirements	Legal issues, penalties
Multi-tenancy	Shared resources among users	Data isolation concerns
Vendor Lock-in	Dependency on single provider	Limited security options

Security Layers:

```
Application Security → Data → Network Security → Infrastructure Security
```
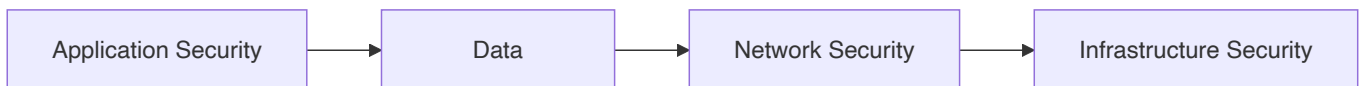
Mitigation Strategies:

- **Encryption**: Protect data in transit and at rest
- **Monitoring**: Continuous security assessment
- **Access Controls**: Role-based permissions

Mnemonic: "Data, Identity, Compliance Challenges"

Question 5(a) OR [3 marks]

State the role of identity access management.

Answer:

Identity Access Management (IAM) controls who can access what resources in cloud systems.

Table: IAM Functions

Function	Description
Authentication	Verify user identity
Authorization	Grant appropriate permissions
Audit	Track access activities

Mnemonic: "IAM Identifies, Authorizes, Audits"

Question 5(b) OR [4 marks]

Define Kubernetes. Explain with reason: Kubernetes is an essential component of cloud computing.

Answer:

Kubernetes is an open-source container orchestration platform that automates deployment, scaling, and management of applications.

Justification: Kubernetes is essential because it:

- **Automates Deployment**: Simplifies application management
- **Ensures Scalability**: Handles varying workloads automatically
- **Provides Reliability**: Self-healing capabilities

Table: Kubernetes Benefits

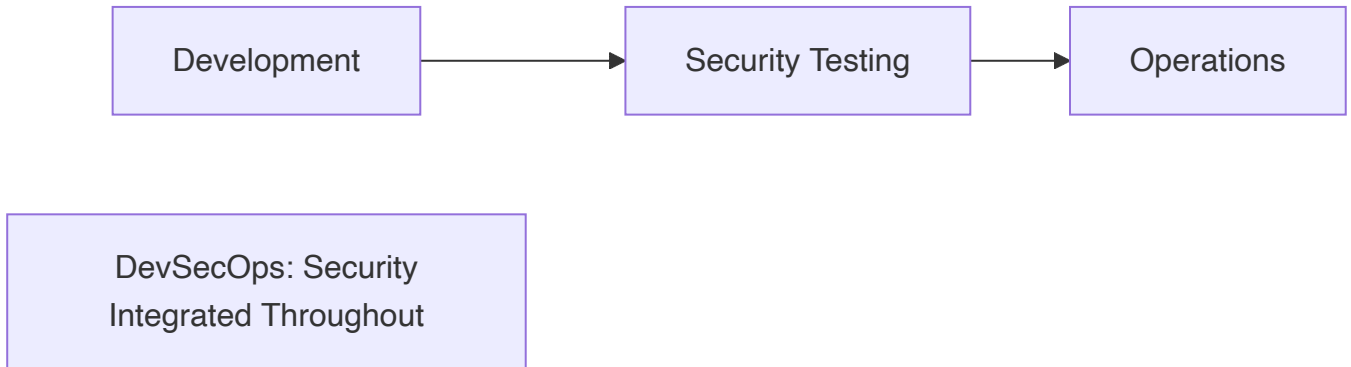| Benefit	Description
Portability	Run anywhere consistently
Efficiency	Optimal resource utilization
Automation	Reduces manual operations

Mnemonic: "Kubernetes Orchestrates Containers"

Question 5(c) OR [7 marks]

Explain DevSecOps (Development Security and Operations).

Answer:

DevSecOps integrates security practices into DevOps pipeline from development to deployment.

Traditional vs DevSecOps:

```
┌─────────────────┐     ┌─────────────────┐     ┌─────────────────┐
│  Development     │────▶│ Security Testing │────▶│   Operations    │
└─────────────────┘     └─────────────────┘     └─────────────────┘

┌─────────────────┐
│ DevSecOps: Security │
│ Integrated Throughout │
└─────────────────┘
```

Table: DevSecOps Principles

Principle	Description	Implementation
Shift Left	Early security testing	Security in code review
Automation	Automated security scans	CI/CD security tools
Collaboration	Security as shared responsibility	Cross-team security training
Continuous Monitoring	Ongoing security assessment	Real-time threat detection

Benefits:

- **Faster Delivery**: Security doesn't slow development
- **Reduced Risks**: Early vulnerability detection
- **Cost Savings**: Fix issues before production

Tools:

- **SAST**: Static Application Security Testing
- **DAST**: Dynamic Application Security Testing
- **Container Scanning**: Docker security tools

Mnemonic: "DevSecOps Develops Securely from Start"