QUESTION ONE – COMPULSORY [30 Marks]

a) i) Name and explain any two topologies used in network design (8 marks)

1. **Bus Topology**
    a. All devices are connected to a single central cable called the bus.
    b. Data sent by one node is available to all others; only the intended recipient accepts it.
    c. **Advantages**: Cost-effective, easy to install.
    d. **Disadvantages**: Difficult to troubleshoot, entire network fails if the main cable breaks, limited cable length and number of nodes.
2. **Star Topology**
    a. Each device connects to a central hub or switch using individual cables.
    b. Data from a node goes to the hub, which routes it to the destination.
    c. **Advantages**: Easy to install, configure, and troubleshoot. One cable failure doesn't affect the rest of the network.
    d. **Disadvantages**: If the central hub fails, the whole network goes down. Requires more cabling.

a) ii) Differentiate between IEEE 802.3, IEEE 802.5, and IEEE 802.11 standards (9 marks)

Feature	IEEE 802.3 (Ethernet)	IEEE 802.5 (Token Ring)	IEEE 802.11 (Wi-Fi)
Medium	Wired (UTP/Fiber)	Wired (Shielded Twisted Pair)	Wireless (radio waves)
Access Method	CSMA/CD	Token Passing	CSMA/CA
Topology	Bus or Star	Logical Ring	Star (with Access Point)
Speed	10 Mbps to 100 Gbps	4/16 Mbps	1 Mbps to several Gbps
Usage	LANs, backbone	Legacy LANs	WLANs, mobile devices

b) i) Subnetting with example (8 marks)

Subnetting divides a large network into smaller, more efficient sub-networks called subnets.

Example:

- Original Network: 192.168.1.0/24 (Subnet mask 255.255.255.0)
- Goal: Create 4 subnets.

To achieve 4 subnets:

- Borrow 2 bits from host portion → Subnet mask becomes /26 = 255.255.255.192
- Each subnet will have $26=64^6 = 64$26=64 addresses → 62 usable hosts.

Subnets:

1. 192.168.1.0 – 192.168.1.63
2. 192.168.1.64 – 192.168.1.127
3. 192.168.1.128 – 192.168.1.191
4. 192.168.1.192 – 192.168.1.255

Benefits:

- Reduces network traffic
- Enhances security and management
- Efficient IP address allocation

b) ii) Time Division Multiple Access (TDMA) in multiplexers (5 marks)

TDMA is a **channel access method** used in shared medium networks. It divides time into time slots and assigns each slot to a user or device.

- Each device transmits only in its designated time slot.
- Prevents collisions and ensures fair bandwidth distribution.
- Used in digital cellular networks and satellite communications.

Example: In GSM mobile networks, multiple users share the same frequency but transmit in alternating time slots.

QUESTION TWO [20 Marks]

a) Describe how the following media function (6 marks)

1. **Infrared**:
    a. Uses light in the infrared spectrum (below visible light) for short-range, line-of-sight communication.
    b. Used in remote controls and wireless peripherals.
2. **Microwave**:
    a. High-frequency radio waves used for long-distance point-to-point communication.
    b. Used in cellular towers and satellite systems.
    c. Requires line-of-sight; affected by weather.
3. **Unshielded Twisted Pair (UTP)**:
    a. Consists of pairs of copper wires twisted together to reduce interference.
    b. Common in Ethernet LANs (Cat5e, Cat6 cables).
    c. Cost-effective, flexible, and easy to install.

b) Illustrate the OSI Model and explain any three layers (14 marks)

OSI Model (7 layers):

1. **Application** – Interface for end-user processes (e.g., HTTP, FTP).
2. **Presentation** – Translates, encrypts, compresses data (e.g., JPEG, ASCII).
3. **Session** – Manages sessions between applications.
4. **Transport** – Ensures end-to-end delivery (TCP/UDP).
5. **Network** – Routing and addressing (IP).
6. **Data Link** – MAC addressing and error detection.
7. **Physical** – Transmission of raw bits over media.

Three Layers Explained:

1. **Transport Layer**:

    a. Ensures reliable delivery using TCP (connection-oriented) or UDP (connectionless).
    b. Manages flow control, error control, segmentation.
2. **Network Layer**:
    a. Determines the best path for data.
    b. Adds source and destination IP addresses.
    c. Protocols: IP, ICMP, ARP.
3. **Data Link Layer**:
    a. Breaks data into frames; adds MAC addresses.
    b. Handles error detection via CRC.
    c. Protocols: Ethernet, PPP.

QUESTION THREE [20 Marks]

a) i) Metrics used by routers (6 marks)

1. **Hop Count**:
    a. Number of intermediate devices (routers) a packet passes through.
    b. Shorter paths are preferred.
2. **Bandwidth**:
    a. Data capacity of a path.
    b. Higher bandwidth paths are favored.
3. **Delay**:
    a. Time it takes for a packet to travel from source to destination.
    b. Includes transmission, propagation, queuing, and processing delays.

a) ii) Differences in routing algorithms (6 marks)

- **Single-path vs Multipath**:
    - Single-path: Only one best route used.
    - Multipath: Multiple routes used for load balancing and fault tolerance.
- **Flat vs Hierarchical**:
    - Flat: All routers are equal (e.g., RIP).
    - Hierarchical: Routers grouped into layers (e.g., OSPF areas, core networks).

- **Intra-domain vs Inter-domain**:
    - Intra-domain: Routing within an autonomous system (e.g., OSPF, EIGRP).
    - Inter-domain: Routing between different autonomous systems (e.g., BGP).

b) i) Fault management in FDDI (4 marks)

- FDDI uses **dual rings** (primary and secondary).
- If the primary ring fails, the system uses the secondary ring to maintain connectivity.
- This self-healing mechanism ensures **network redundancy** and high availability.
- Monitors ring integrity using beaconing and token management.

b) ii) CSMA/CD in Ethernet (4 marks)

- **Carrier Sense**: Device checks if the medium is idle before transmitting.
- **Multiple Access**: Multiple devices can access the medium.
- **Collision Detection**: If two devices transmit simultaneously, a collision occurs.
- Devices detect the collision, stop transmission, and wait for a random time before retrying.

Used in **IEEE 802.3 (Ethernet)**; now largely replaced by full-duplex switches.

QUESTION FOUR [20 Marks]

a) Prove Class B first octet range (8 marks)

- Class B IP addresses start with binary 10xxxxxx.
- Range:
    - Lowest: 10000000 = 128
    - Highest: 10111111 = 191
- Thus, first octet of Class B ranges from **128 to 191**.

Class B characteristics:

- Default subnet mask: 255.255.0.0
- Supports up to 65,534 hosts per network
- Used in medium to large-sized networks

b) Function of bridges and repeaters (6 + 6 = 12 marks)

1. **Bridges**:
    a. Operate at Data Link Layer (Layer 2).
    b. Filter traffic using MAC addresses.
    c. Segment large networks into smaller, manageable parts.
    d. Improve performance by reducing collisions.
2. **Repeaters**:
    a. Operate at Physical Layer (Layer 1).
    b. Regenerate and amplify signals to overcome distance limitations.
    c. Useful in extending the range of LANs.
    d. No filtering or routing – simply forwards data.

QUESTION FIVE [20 Marks]

Cycle Time in Ring Topology — Derivation (ICS 2306)

I· Definition

In a ring topology, the **cycle time** (tc) is the time taken for a frame (e.g., token or data packet) to make a complete round trip around the ring.

I· Notations

Let:

- L = Total ring propagation/transmission time (seconds)
- λ = Average packet arrival rate (packets/second)
- T = Average service time per packet (seconds/packet)
- $\rho = \lambda T$ = Network utilization

I· Derivation

To model total delay under increasing load, we use the formula:

$$t_c = \frac{L}{1 - \lambda T}$$

Where:

- t_c is the **cycle time**
- $1 - \lambda T$ represents the unused network capacity

Explanation

- As the network traffic increases ($\lambda T \to 1$), the denominator approaches 0, and t_t becomes **very large**.
- When $\lambda T = 1$, the network is **fully utilized → infinite delay**.
- When $\lambda T \approx 0$, the delay is minimal, and $t_o \approx L$.

Summary Table

Load Condition	Behavior
$\lambda T \approx 0$	Low traffic → $t_o \approx L$
$\lambda T \to 1$	High traffic → $t_o \to \infty$ (congested)

Applications

- Used in **Token Ring** and **FDDI** (Fiber Distributed Data Interface) networks.
- Helps estimate:
  - Network **latency**
  - **Token rotation delay**
  - System **throughput limits**

Optional ASCII Illustration

To visualize:

```
css                                                    Copy    Edit

[Station A] -- [Station B] -- [Station C] -- [Station D] -- (back to A)
        ↺ (Frame circulates the ring with total latency L)
```

b) Three WAN Technologies (8 marks)

1. **Frame Relay**:
   a. Packet-switched WAN protocol.
   b. Uses virtual circuits.
   c. Efficient for intermittent traffic between LANs.
2. **MPLS (Multiprotocol Label Switching)**:
   a. Directs data using short path labels rather than long network addresses.
   b. Supports VPNs, QoS, and traffic engineering.
   c. Fast and scalable.

3. **Leased Line**:
    a. Dedicated point-to-point connection.
    b. Fixed bandwidth; low latency.
    c. Ideal for critical business communications.