Unit 1

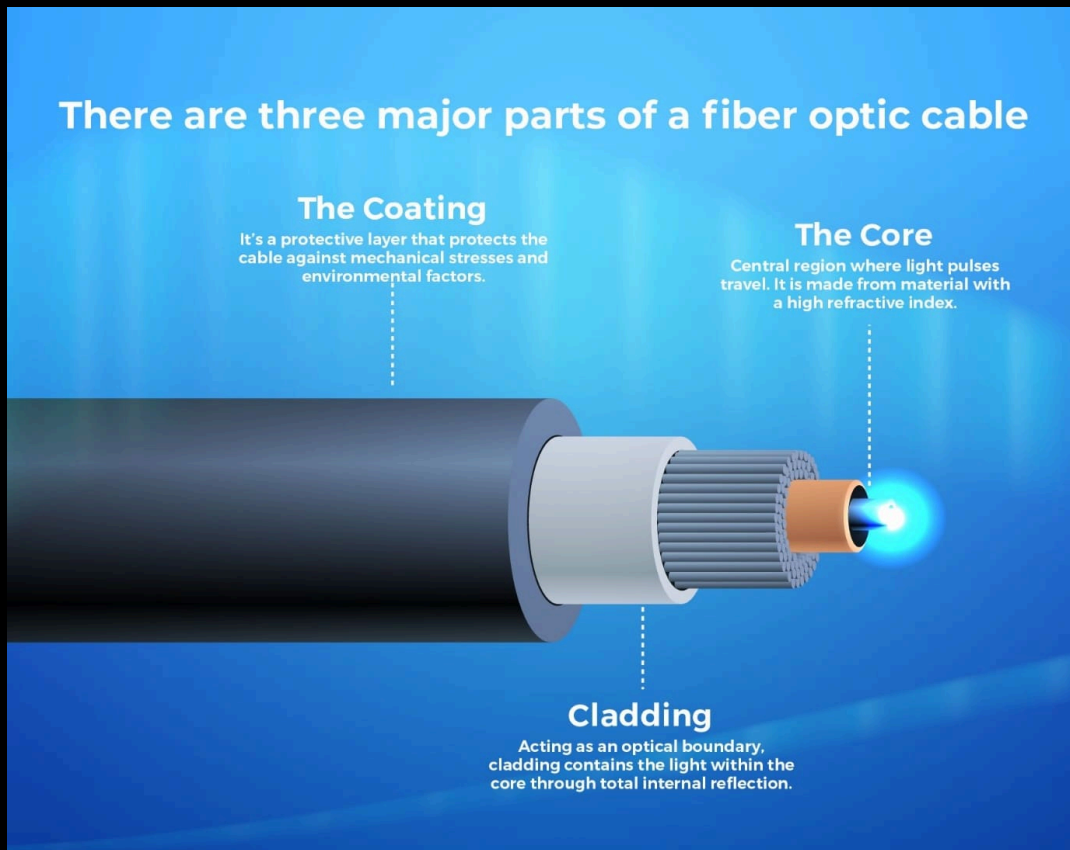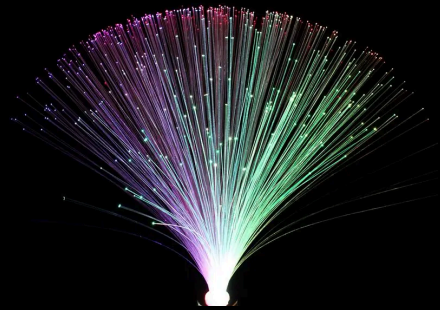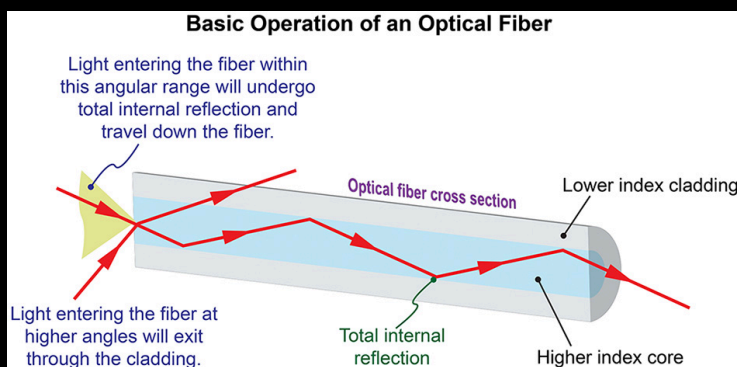## Optical Networking

Introduction to Optical Networking

Optical networking refers to the use of light to transmit data within a communication network. It utilizes optical fibers and light signals to achieve high-speed, reliable, and long-distance data transmission.

Basic Operation of an Optical Fiber

There are three major parts of a fiber optic cable

The Coating — It's a protective layer that protects the cable against mechanical stresses and environmental factors.

The Core — Central region where light pulses travel. It is made from material with a high refractive index.

Cladding — Acting as an optical boundary, cladding contains the light within the core through total internal reflection.

SONET / SDH Standard

These are standardized protocols for synchronous data transmission over optical fiber.

1. SONET (Synchronous Optical Network)

    It is primarily used in North America.

    It uses Optical Carrier (OC) levels.

    It has 27 bytes of transport overheads.

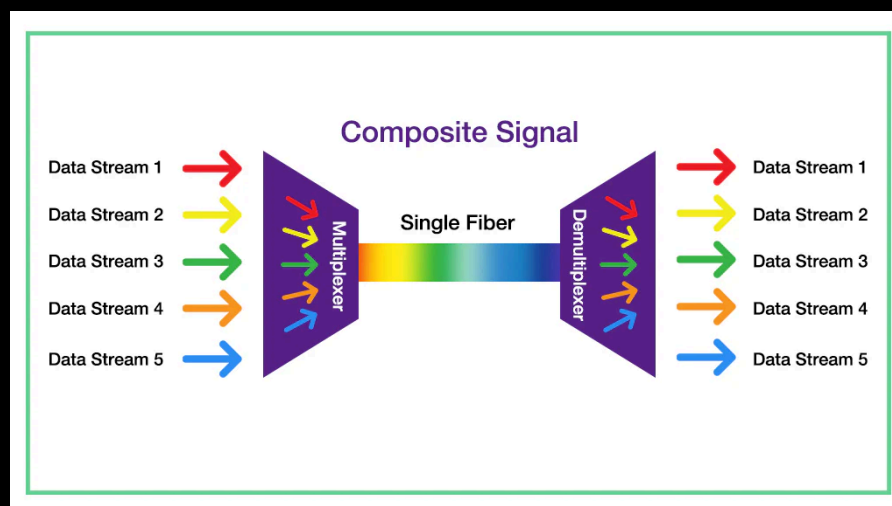2. SDH (Synchronous Digital Hierarchy)

    It is the global standard.

    It uses Synchronous Transport Module (STM) levels.

    It has 81 bytes.

DWDM

Dense Wavelength Division Multiplexing (DWDM) is a technology used in optical fiber networks to increase bandwidth and capacity by transmitting multiple signals at different wavelengths over the same fiber.

Unit 2

ATM The WAN Protocol

Introduction ATM Technology

- ATM (Asynchronous Transfer Mode) is a high-speed networking technology designed to integrate voice, video, and data into a single communication system.
- Works mainly at the Data Link Layer (Layer 2) of the OSI model.
- Uses fixed-size cells (53 bytes) for fast and efficient switching.

ATM Cell Structure (53 bytes)

Header (5 bytes)	Payload (48 bytes)
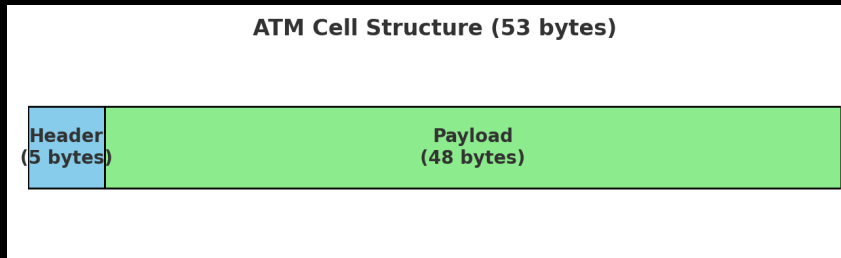
- payload(**actual data being carried** inside a packet).
- ATM = Fixed 53-byte cells + High speed + Multimedia support.

Introducing Faces of ATM

- As a Switching technology — Fast cell switching.
- As a Multiplexing technology — Supports multiple services (voice, video, data).
- As a Transfer mode — Defines how data is transferred in fixed 53-byte cells.

Exploring the B-ISDN reference model

OSI Layer	B-ISDN Reference Model
Application, Presentation, Session	User Plane (Applications)
Transport, Network, Data Link	ATM Adaptation Layer + ATM Layer
Physical	Physical Layer

Explaining the Physical Layer

- Responsible for transmission of bits over the medium (fiber optics mainly).

Explaining the ATM Layer

- It is the core layer of B-ISDN which handles cell switching and multiplexing.

Explaining the ATM Adaptation Layer

- Adapts higher-layer services (like voice, video, IP packets) into 48-byte payloads for ATM cells.
- Types of AAL:
  - **AAL1:** Constant bit rate (voice, video).
  - **AAL2:** Variable bit rate, real-time.
  - **AAL3/4:** Data & signaling.
  - **AAL5:** Common for IP/data transfer.

Exploring ATM physical interface

- Functions of ATM Physical Layer
  - Transmission of bits → Converts ATM cells into bit streams.
  - Line Coding → Ensures synchronization and error detection.
  - Framing → Defines how ATM cells are placed on a physical medium.
  - Clock Synchronization → Sender and receiver stay in sync.
  - Error Detection → Detects transmission errors at the physical level.

Choosing an appropriate ATM public service

- ATM Public Services allow users to access ATM backbone networks.
- Common options:
  - PNNI Private Network-Network Interface (for large enterprises).
  - **Broadband ISDN** service (for multimedia).
  - Frame Relay/Leased Line interworking (for legacy integration).
- Choice depends on application type, bandwidth, cost, and compatibility.

Unit 3

Packet Switching Protocols

Introduction to Packet Switching
- Packet Switching is a method of transmitting data by breaking it into small packets.
- Each packet has a header (control info) + payload (actual data).
- Packets may take different routes and are reassembled at the destination.
- Used in most modern networks (including the Internet).
- Types of Packet Switching
    - Datagram Packet Switching
    - Virtual Circuit Packet Switching

Introduction to Virtual Circuit Packet Switching
- A logical path (circuit) is established before transmission.
- All packets follow the same path.
- Example: X.25, Frame Relay, ATM.

Introduction to X.25
- X.25 is one of the earliest packet-switched network protocols.
- Developed in the 1970s by ITU-T (International Telecommunication Union).
- It provides reliable, connection-oriented communication over wide area networks (WANs).
- Used mainly in banking and early data networks.

Introducing switched multimegabit data service
- A high-speed, connectionless, packet-switched service.
- Provides data transfer rates from 1.5 Mbps up to 45 Mbps.
- High Bandwidth → Supports multimedia and large data transfers.
- Cell/Packet-Based like ATM fixed-size 53-byte cells internally.
- Addressing → Uses E.164 addresses (same as ISDN telephone numbering).
- Scalable → Designed to interconnect LANs across cities (MAN → WAN).

Unit 4

Protocols and Interfaces in Upper Layers of TCP/IP

Introducing TCP/P suite
- TCP/IP = Transmission Control Protocol / Internet Protocol.
- It is a set of communication protocols that define how data is transmitted across the Internet.
- TCP/IP suite = set of protocols enabling Internet communication.
- Reference Model = 4 layers (Application, Transport, Internet, Network Access).
- Core protocols = TCP, UDP, IP, ICMP, ARP, DNS, HTTP, FTP, SMTP.
- Applications = Web, Email, Streaming, File Transfer.

Explaining Network Layer Protocols
- IP (Internet Protocol) two versions:
  - IPv4 (32-bit addresses, ~4.3 billion).
  - IPv6 (128-bit addresses, huge address space).
- Functions of Network Layer Protocols.
  - Logical addressing (IP, IPv6).
  - Routing.
    - **RIP** (Routing Information Protocol) – distance-vector.
    - **OSPF** (Open Shortest Path First) – link-state.
    - **BGP** (Border Gateway Protocol) – used on the Internet between ISPs.
  - Error handling –)ICMP (Internet Control Message Protocol).
  - Address resolution (ARP/NDP)
    - To Maps **IP addresses** → **MAC addresses** (so packets can be delivered on the local network).
    - Works in IPv4 networks.
    - IPv6 replaces ARP (Address Resolution Protocol) with **NDP** (Neighbor Discovery Protocol).

  - Segmentation & reassembly of packets.

Explaining Transport Layer Protocol
- Main transport layer protocols
  - TCP (Transmission Control Protocol)
    - Ensures **reliable delivery**: retransmits lost packets, correct order, error checking.
    - Used for: **Web (HTTP/HTTPS), Email (SMTP, IMAP), File transfer (FTP), Remote login (SSH).**
  - UDP (User Datagram Protocol)
    - **Faster but unreliable**: no error recovery, no guarantee of order.
    - Used for: **Streaming (YouTube, Netflix), Gaming, VoIP, DNS lookups.**

Feature	TCP	UDP
Connection type	Connection-oriented	Connectionless
Reliability	Reliable	Unreliable
Error recovery	Yes (ACKs, retransmission)	No
Ordering	Yes (sequencing)	No
Speed	Slower	Faster
Overhead	Higher	Lower
Typical uses	Web, Email, FTP, SSH	Streaming, Gaming, DNS, VoIP

Explaining Application Layer Protocol.
- It is the top layer of the OSI model (Layer 7) and the closest to users.
- Provides network services directly to applications like browsers, email clients, chat apps, etc.
- Handles:
  - User interfaces for network communication
  - Resource sharing
  - File, email, web access
  - Name resolution

Protocol	Purpose	Example Use
HTTP/HTTPS	Web communication	Browsing websites
SMTP	Send emails	Gmail sending mail
POP3/IMAP	Retrieve emails	Outlook, Thunderbird
FTP	File transfer	Upload/download files
DNS	Name resolution	google.com → IP
Telnet/SSH	Remote login	Server access
SNMP	Device management	Router monitoring