Electromagnetic Radiations / waves

EMR/Fiber Optics

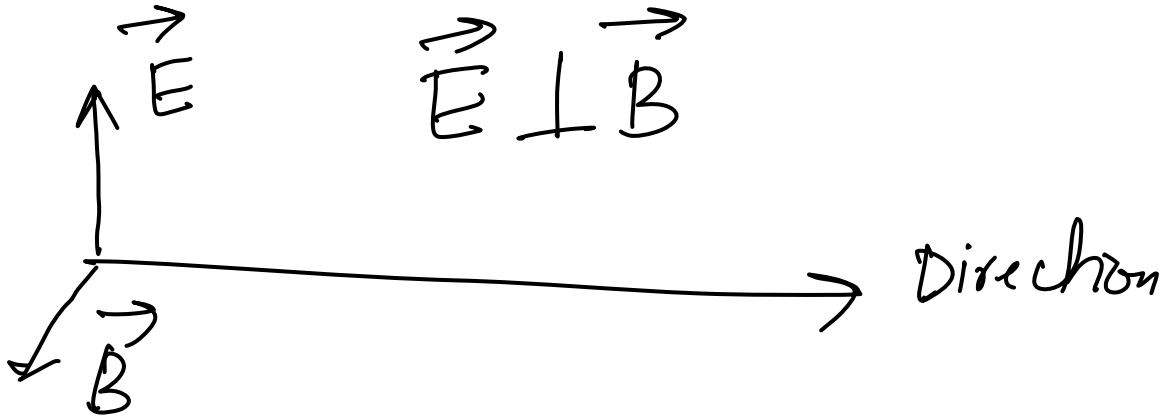
Mobile Communication
Satellite (GPS, NAVSTAR: The Navigation Satellite Timing and Ranging GPS)
Basics of Computer

EMR → The energy emitted and propagated through space in the form of electro-magnetic waves is called EMR.

→ Speed = Travels at the speed of light $c = 3 \times 10^8 m/s$

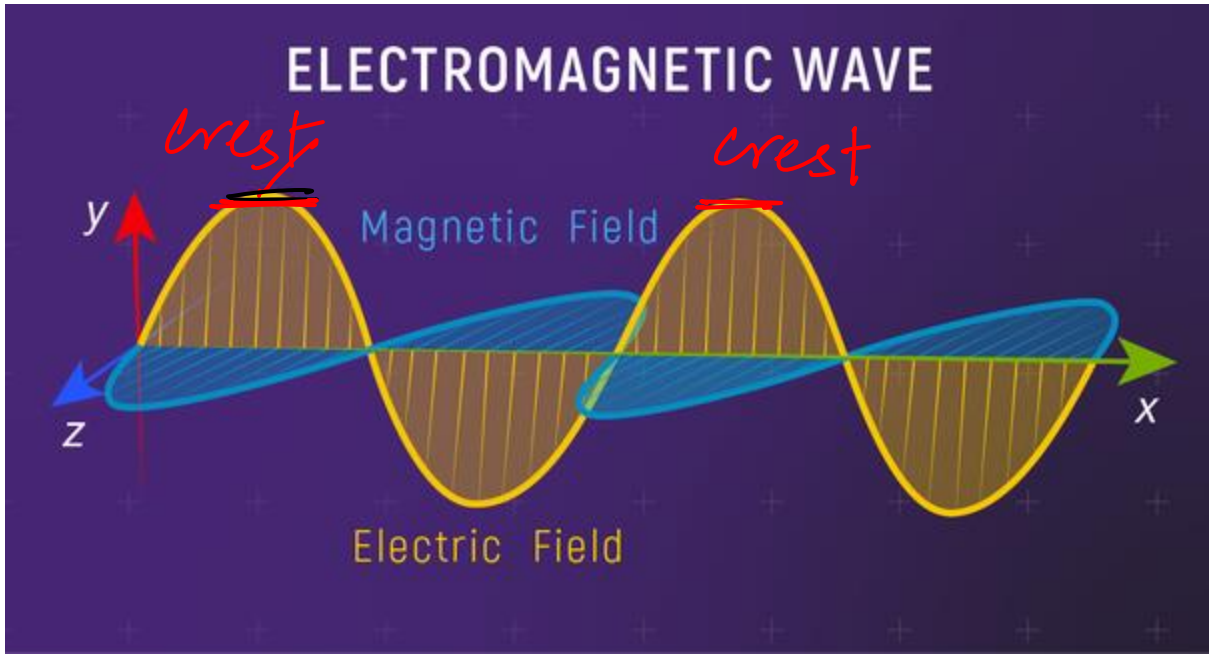
Nature:-

Wave form:-



Linda = λ

Distance (unit)



Wave Spectrum:

RMI-VU-XG

	Name	Wave length (λ) m	Freq (Hz) f
1	Radio-waves	10^{3}	10^{4}
2	Micro-waves	10^{-2}	10^{8}
3	Infrared	10^{-5}	10^{12}
4	Visible	$\frac{10^{-6}}{2} = 0.5 \times 10^{-6}$	10^{15}
5	Ultraviolet	10^{-8}	10^{16}
6	X-rays	10^{-10}	10^{18}
7	Gamma rays	10^{-12}	10^{20}

(↑) (↑)

(4) $E(\uparrow) \propto f(\uparrow)$

(↑) $E(\downarrow) \propto \frac{1}{\lambda(\uparrow)}$ (↓)

Note: Higher frequency and shorter wave length means higher energy.

(5) Interaction with Matter: EMR can interact with matter in various ways..

(1) Reflection ✓ (2) Refraction

(3) Absorption (4) Transmission:

→ These interaction are the basis of many natural & Scientific phenomena.

→ Sky → Blue., Blackhole, GHE

→

→

⑥ Applications:

① Telecommunication (Radio, wifi, Infrared) ✓

② X-rays Imaging (Medical), MRI

③ Brodcasting (TV, satellite)

④ Industrial uses → NDT (Non-Destructive Testing)

⑤ Aviation, sat

⑥ Radar → military & security

⑦ Sterilization

⑧ Heating purposes.

9. Weather forecasting.
10. Tanning bed → Internal Healing
11. PET → positron Emission Tomography.
12. P Sources →
13. Cancer Treatment, Gamma Knife
14. Forensic
15. Camera, film

⑦ Ionization :-

↳ X-rays & Gamma ray ✓

→ freq (↑), ionization

→ freq (↓), E(↓), Non-ionization

⑧ Health Concern :- Different types of EMR have different effect on human health.

→ X-rays & Gamma → Harmful

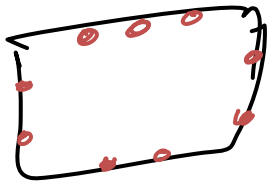
→ Radio/micro/visible → less harmful

→ Limited / controlled exposure is safe but unlimited / uncontrolled exposure is harmful.

Radioactivity: The emmission of radioactive radiation from certain elements.

Discovery: (i) 1896, Henri Bacqual, photographic plate

→ Uranium salt → paper →



(iii) **Madam Curie & Pierre:**

Elements → Radium (Ra), Plonium

Radioactive element:

Atomic No > 82 (unstable element)

→ 82 — 92 (Transuranic element

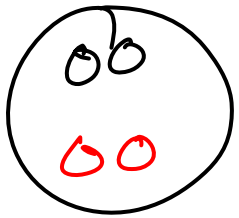
92 → above

(1) Alpha Radiation (α)

↳ Not an electromagnetic radiation but charged radiation.

eg Helium

α → Heaviest



2 proton

2 neutron

+2

Charge = +2

Mass No = 4

(2) Beta (β) Radiation: EMR(X)

↳ Charged radiation.

Emission → electron or positron

$^{0}_{-1}\beta$, $^{0}_{1}\beta$

→ Lighter than α-particle

P → mass = 1.67×10^{-27} kg ✓

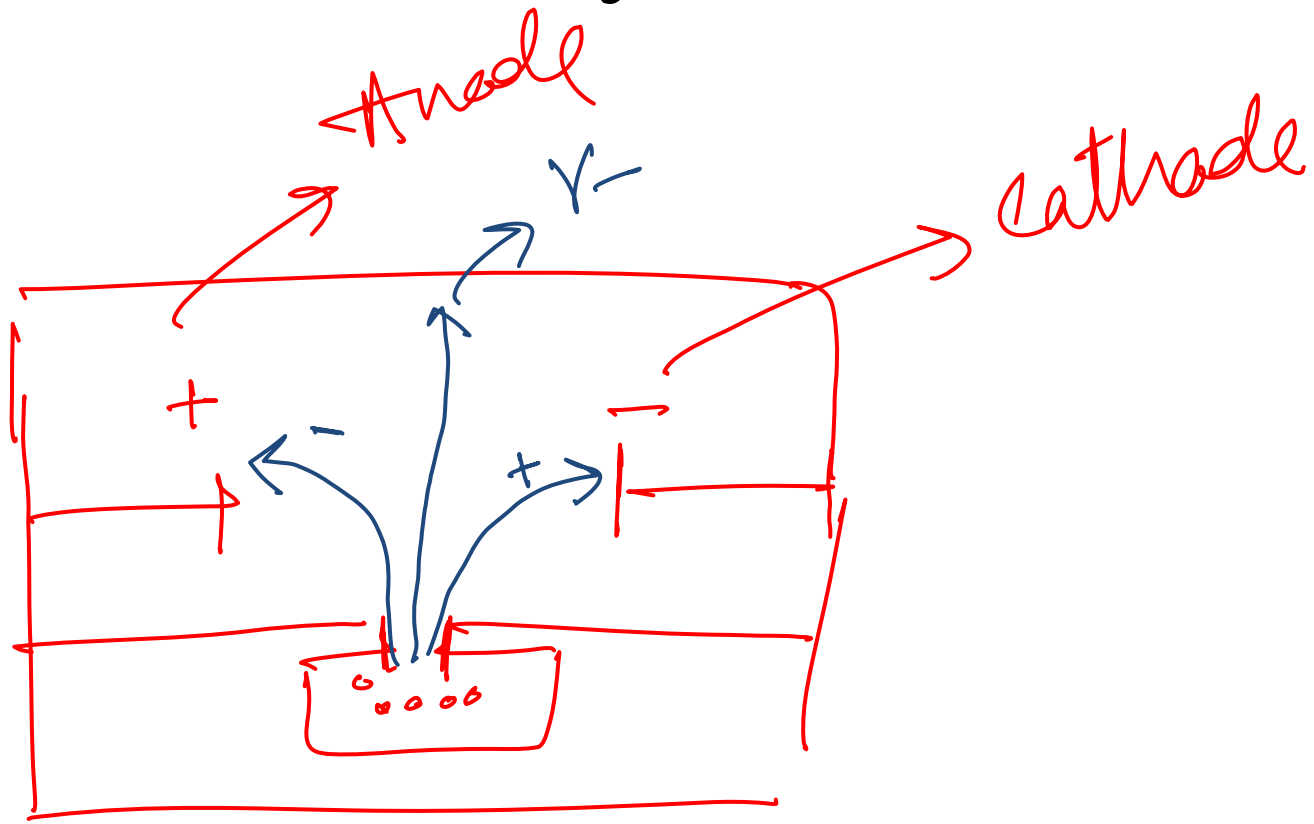
e → mass = 9.11×10^{-31} kg ,

n-mass = 1.76×10^{-27} kg

③ Gamma radiation (γ):

EMR, emission of photon

Experiment:-



Nuclear Decay:-

$$X \xrightarrow{\text{Decay}} Y$$

Parent Nucleus — Daughter nucleus

(1) Alpha - Decay:-

$$A-4+4 = A, \quad Z-2+2$$

$${}^{A}_{Z}X \xrightarrow{\text{Decay}} {}^{A-4}_{Z-2}Y + {}^{4}_{2}\alpha$$

$${}^{226}_{88}Ra \xrightarrow{\text{Decay}} {}^{222}_{86}Rn + {}^{4}_{2}\alpha$$

Radium — Radon

(2) $^{234}_{92}U \longrightarrow {}^{230}_{90}Th + {}^{4}_{2}\alpha + Mev$

Thorium

(3) $^{230}_{90}Th \longrightarrow {}^{226}_{88}Ra + {}^{4}_{2}\alpha + Mev$

$\downarrow$

Radon (Rn)

② Beta Decay:

β^-_{-1}, β^+_{1}

(1) $n^1_0 \longrightarrow p^1_{+1} + \beta^0_{-1}$

(2) $p^1_{+1} \longrightarrow n^1_0 + \beta^0_{1}$

$$^{234}_{90}Th \longrightarrow {}^{234}_{91}Pa + \beta^0_{-1}$$

Protactinium

③ Gamma - radiation:

Produced by the decay of atomic nuclei, nuclear reactions and certain sub-atomic processes.

→ Cobalt - 60 →

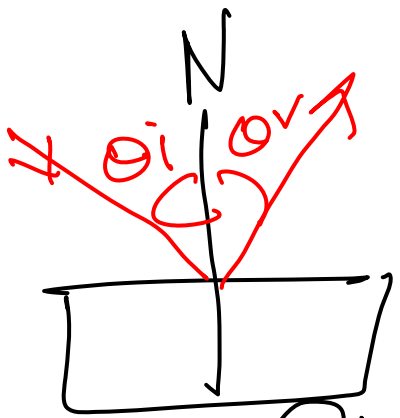
→ Super nova →

optical fiber:- It is a digital form of energy transfer in the form light from one point to another through the core/plastic/Glass.

Speed = 3×10^8 m/s

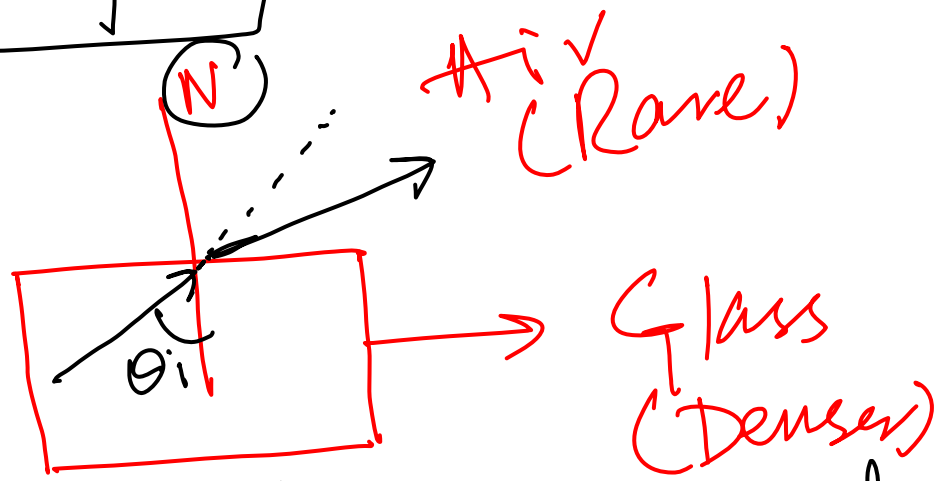
Working principle :-

→ Total internal Refleection:



① Reflection :-

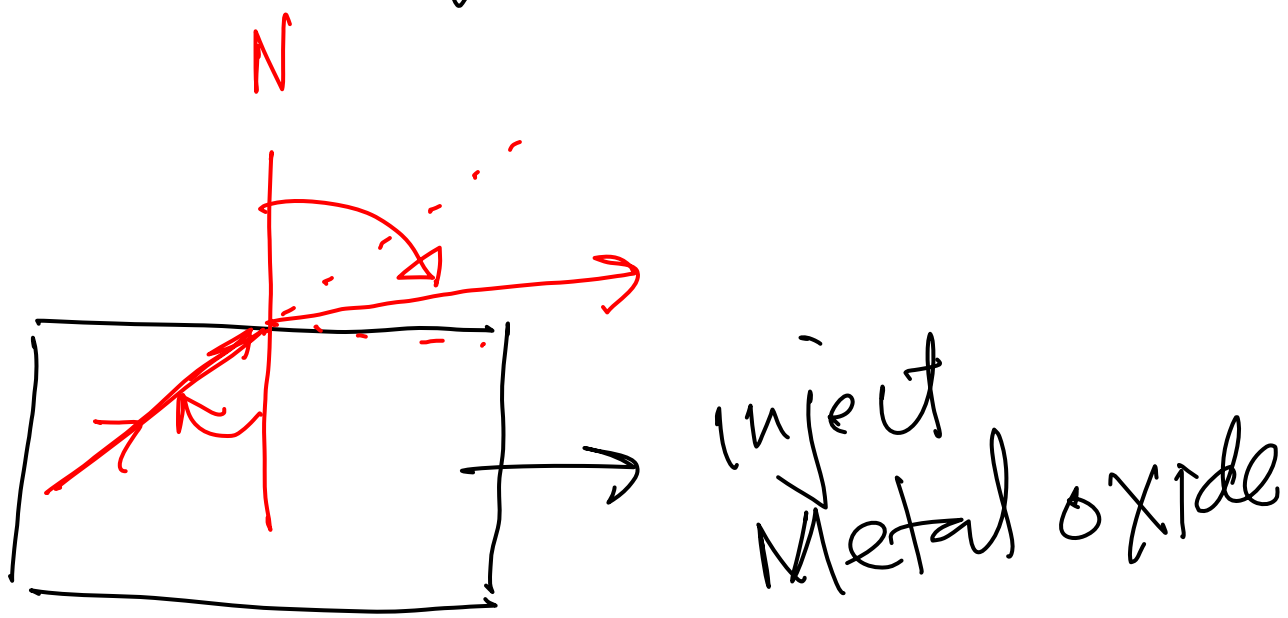
② Refreehon :-



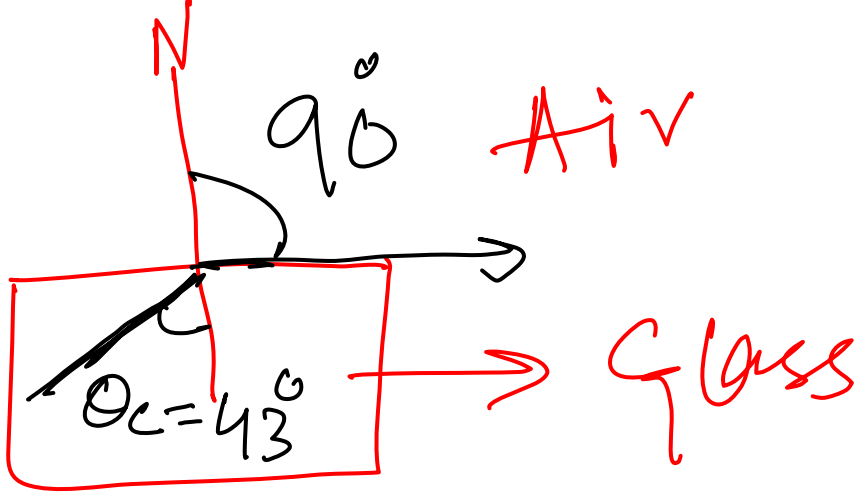
Denser → Rare
it will bent away from Normal

Refractive index = $n = \frac{\text{speed of light in vacuum}}{\text{speed of light in a medium}}$

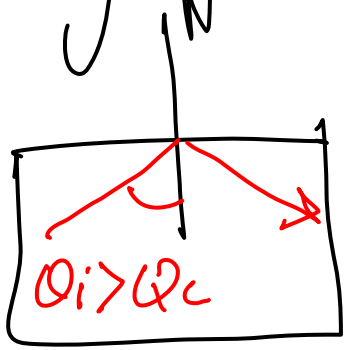
$$n = \frac{c}{v}$$

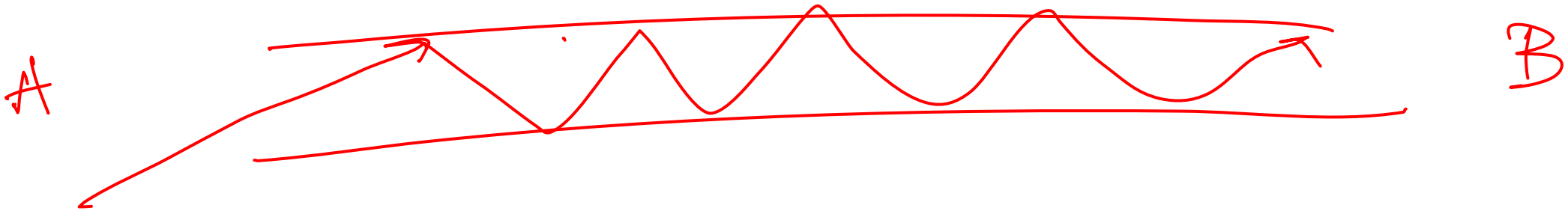


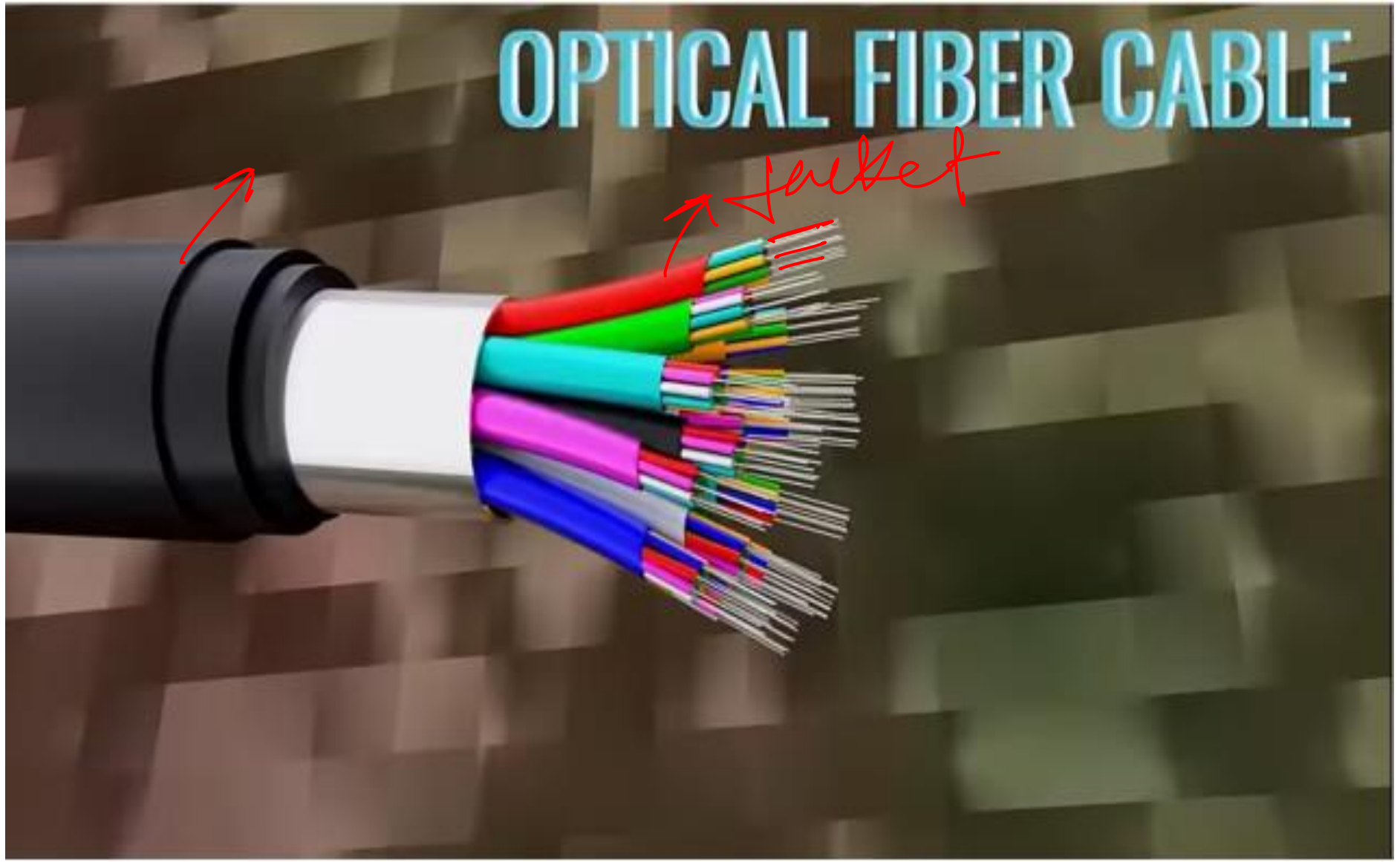
Critical Angle:-

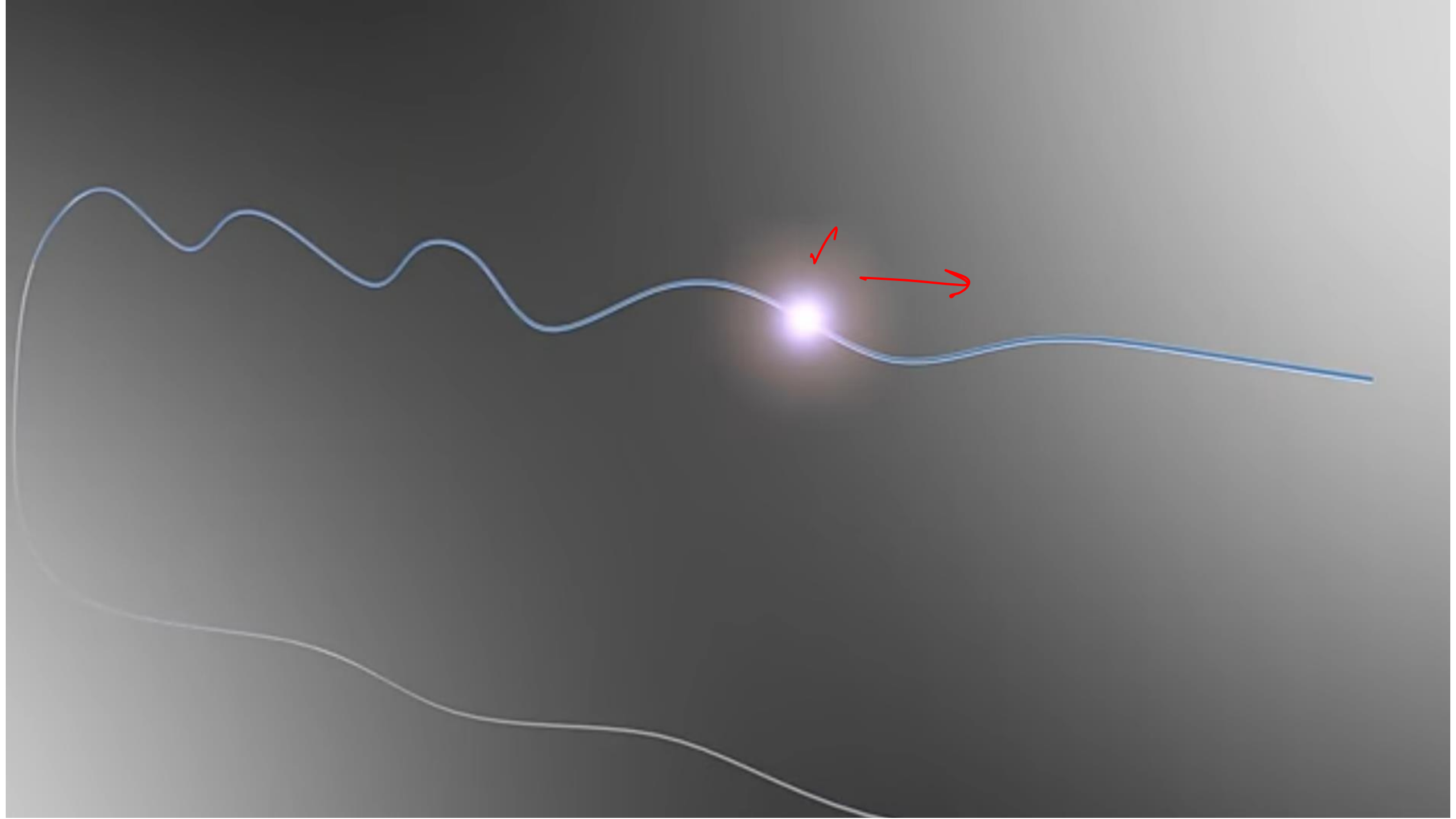


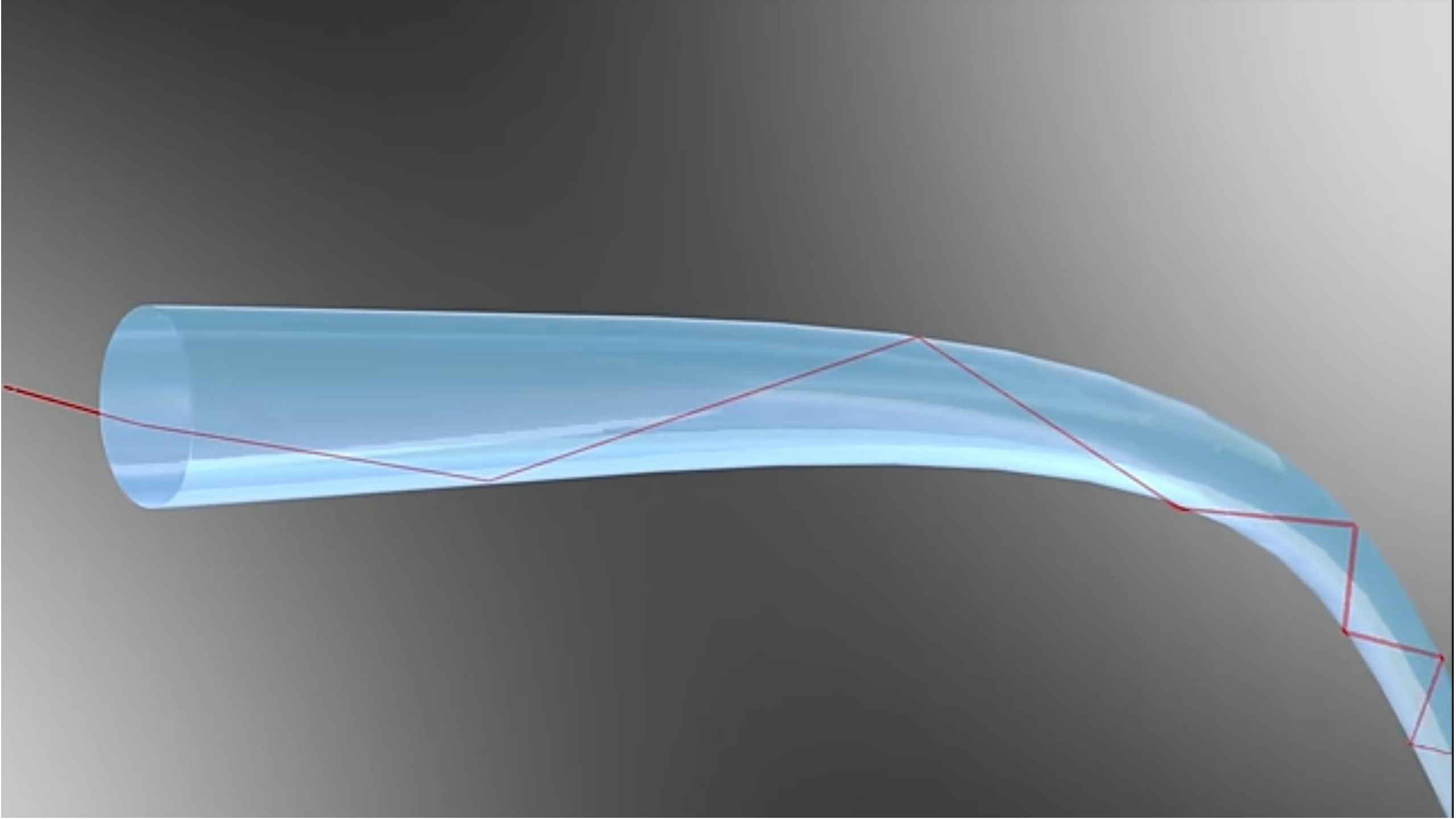
Total internal Reflection occurs when the incident angle is greater than critical angle:

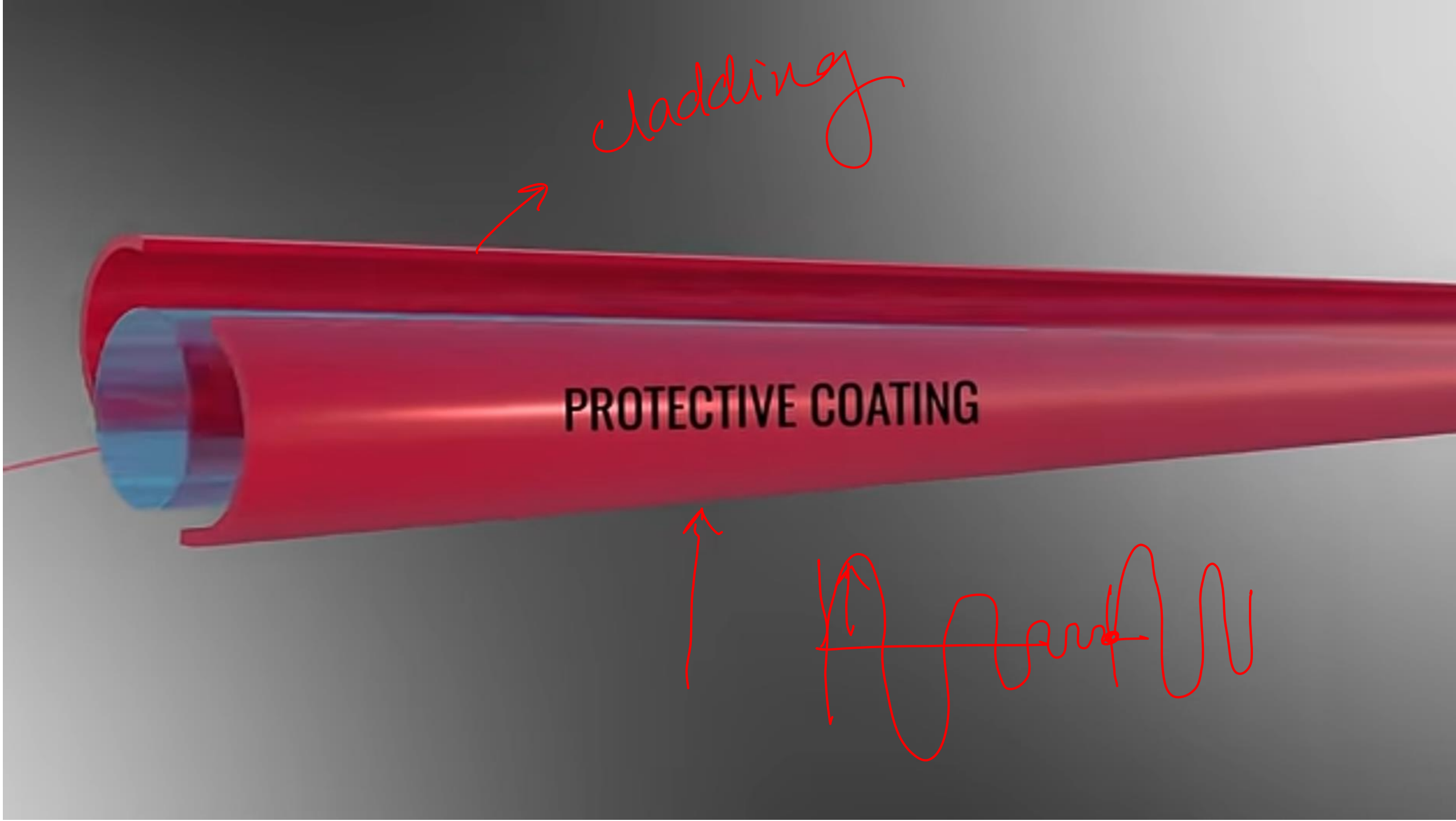


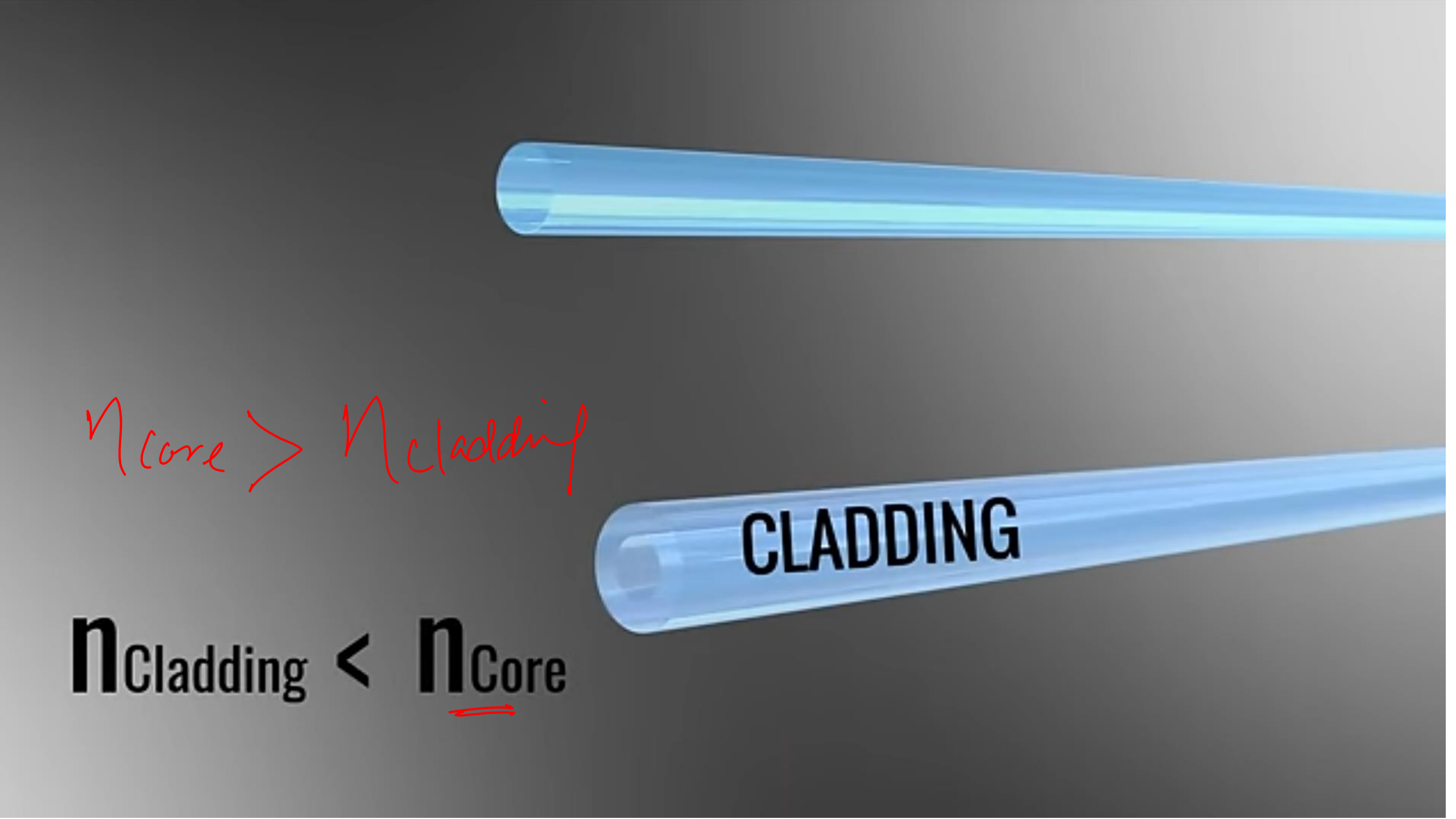

A
B

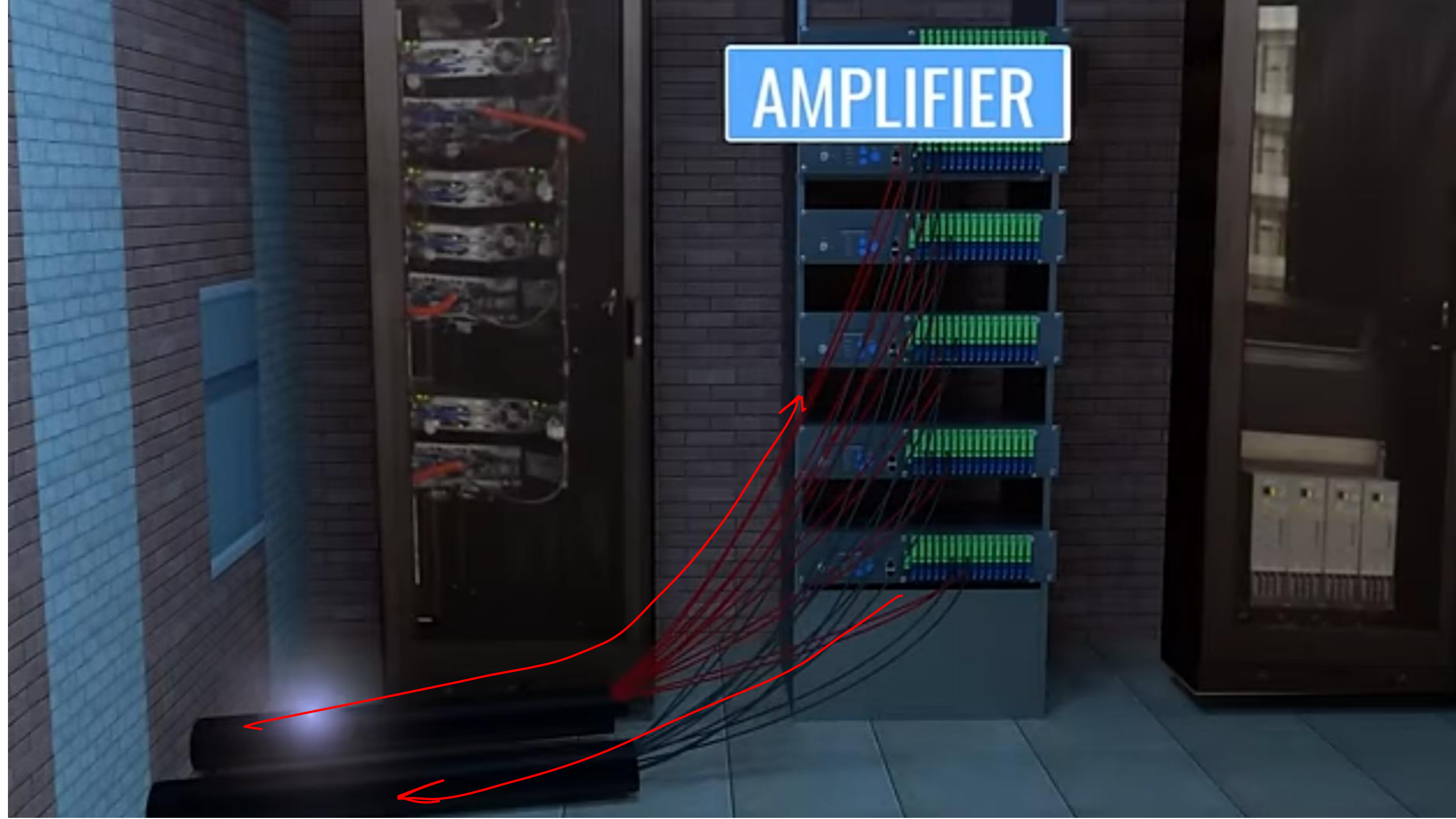

OPTICAL FIBER CABLE
Jacket

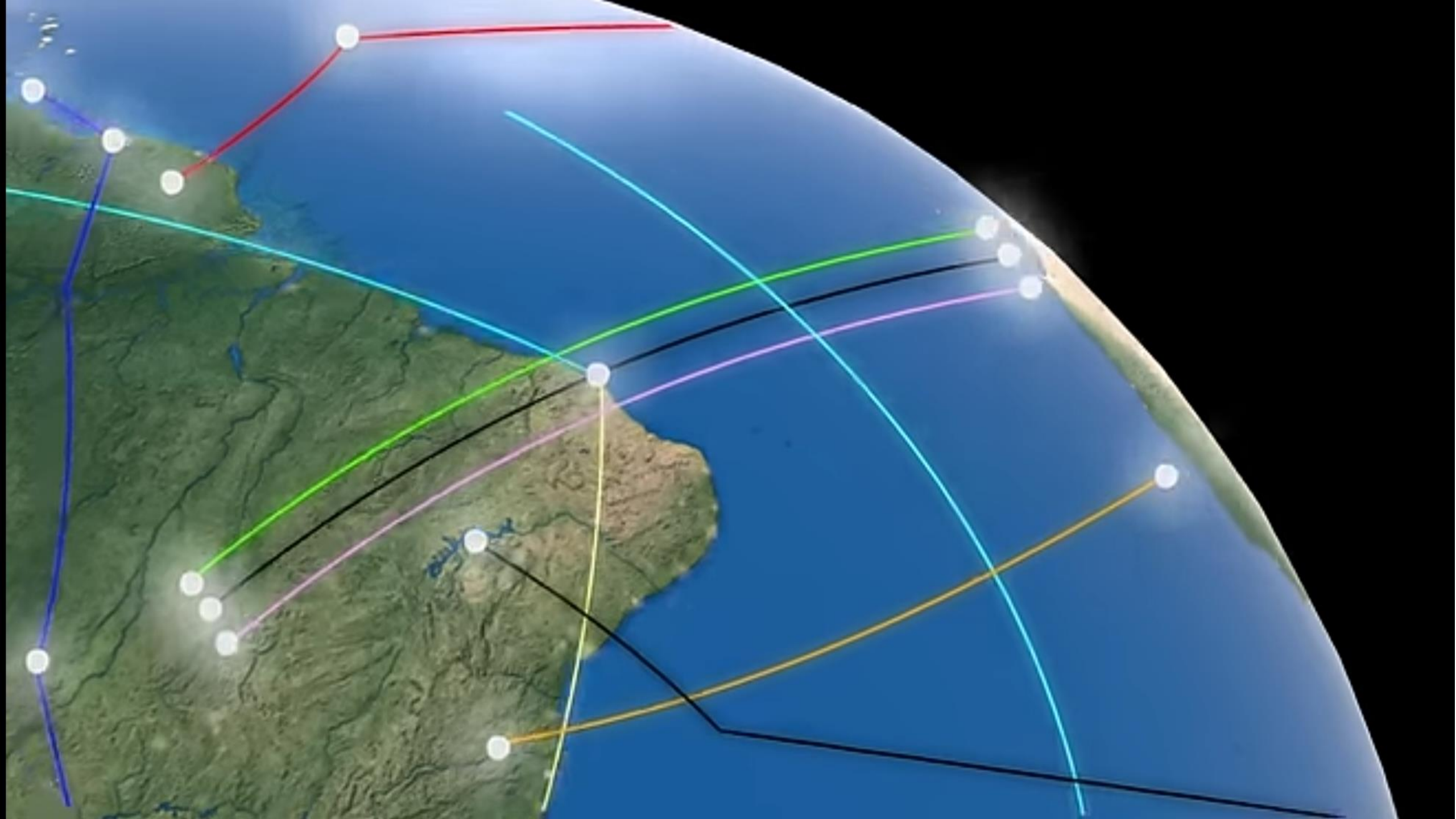


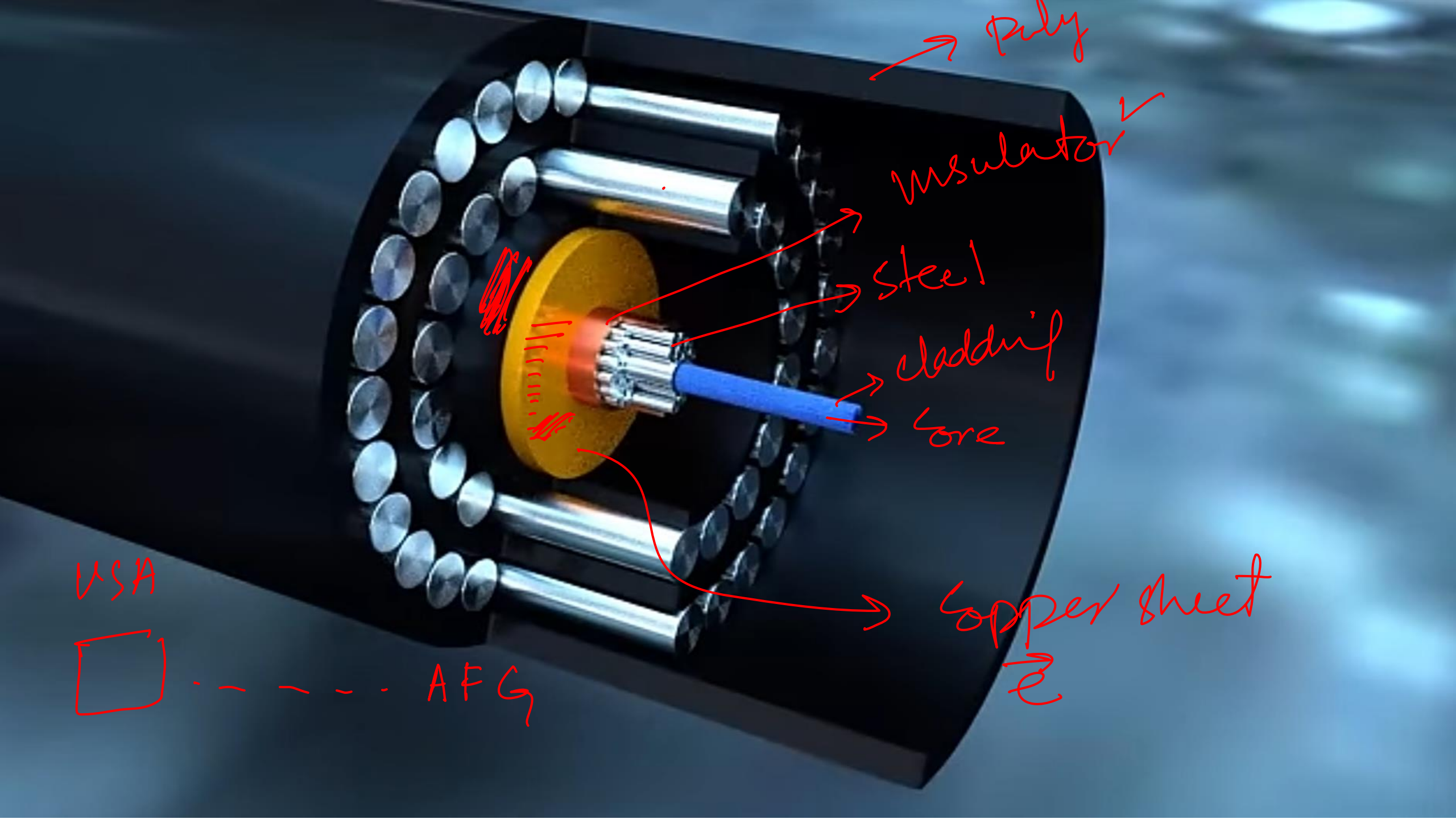


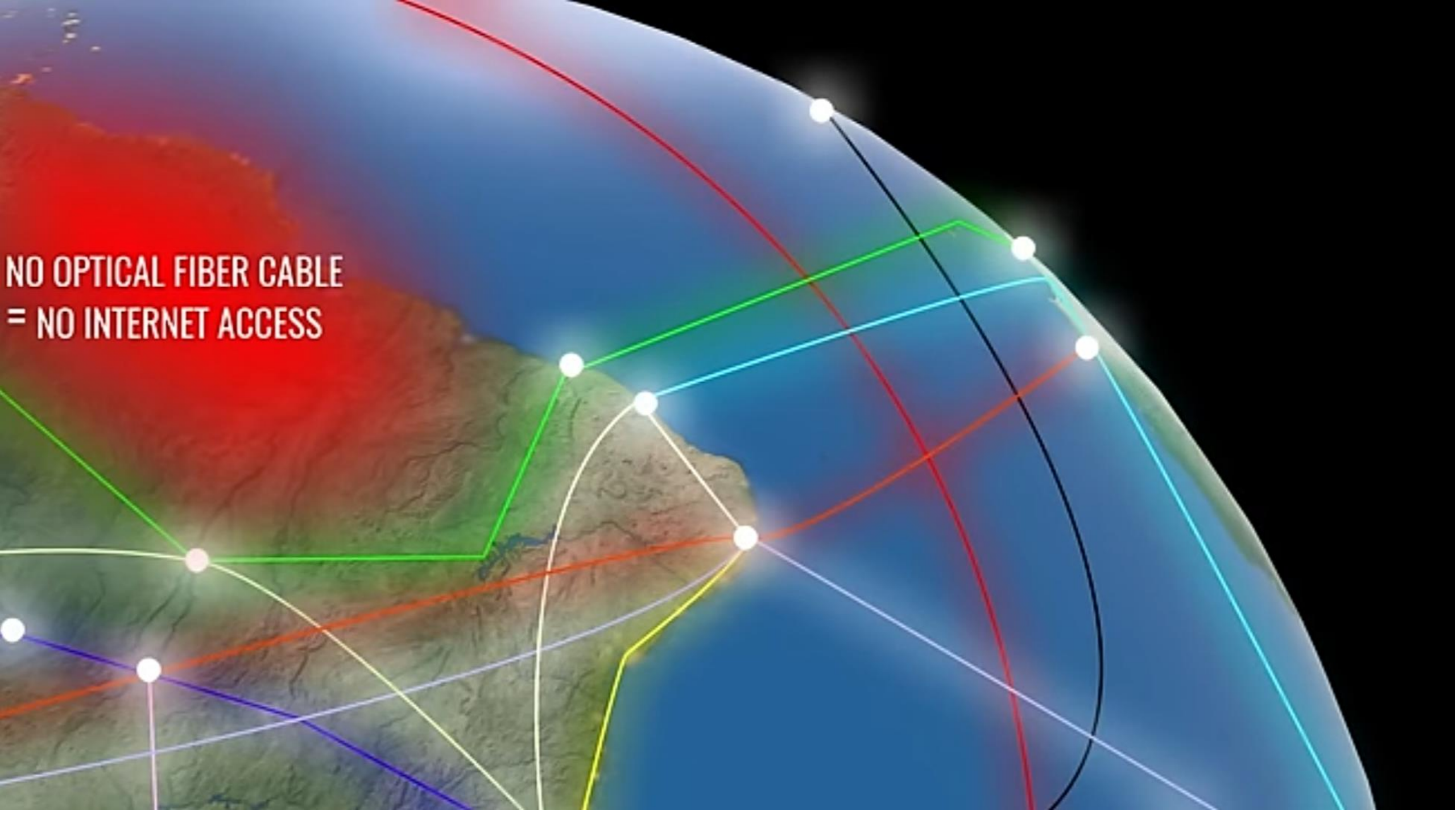

cladding
PROTECTIVE COATING

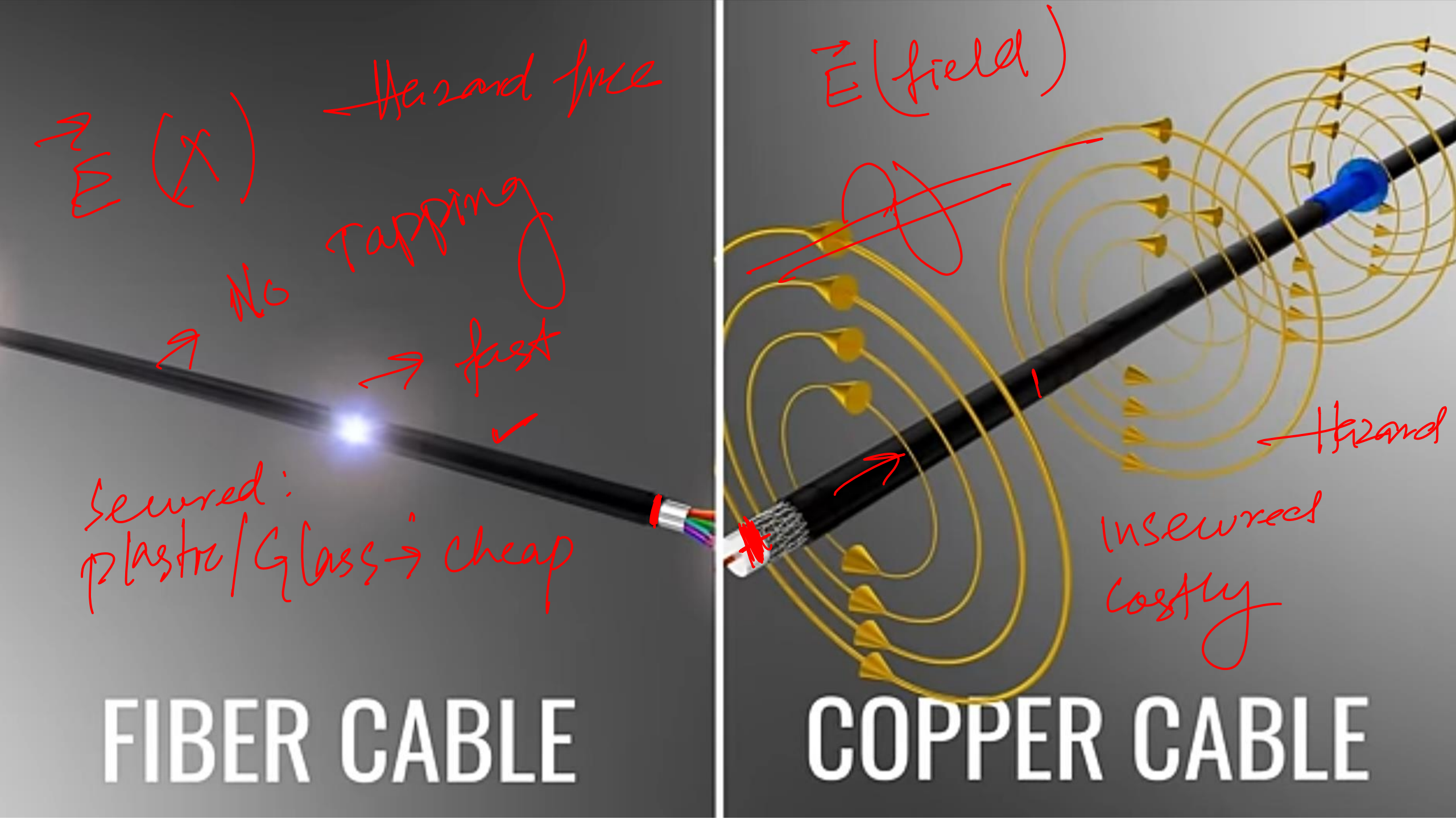

CLADDING
$n_{Cladding} < n_{Core}$


AMPLIFIER




poly
insulator
steel
cladding
core
copper sheet
USA
AFG


NO OPTICAL FIBER CABLE
= NO INTERNET ACCESS

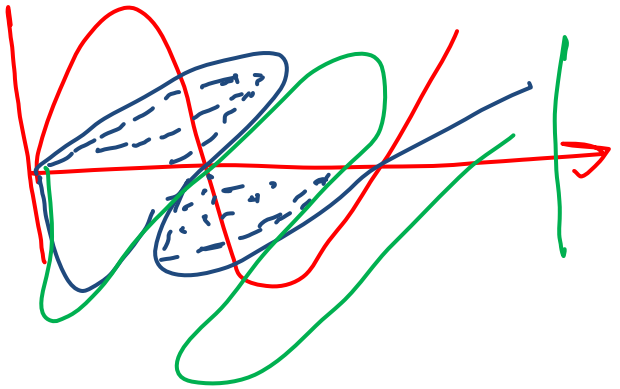

$\vec{E}(x)$
Hazard free
No tapping
fast
Secured: plastic/Glass → cheap
$\vec{E}$ (field)
Hazard
Insecured costly
FIBER CABLE
COPPER CABLE

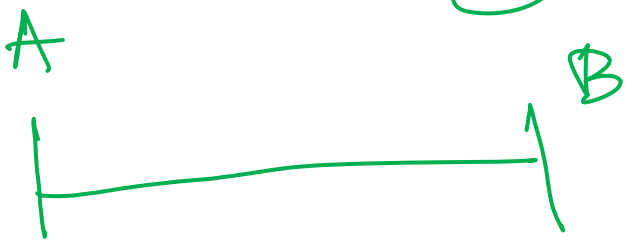
Basic of Fiber

- Core: Light mainly propagates along the core, glass/plastic
- Cladding: Glass/Plastic
  Reduces loss of light from the core into the surrounding
  Reduces scattering loss at the surface of the core
  Protects the fiber from absorbing surface containments
  Add mechanical strength
- Coating: Used to protect the fiber from physical damage
  Elastic in nature
- Jackets: Used to bundle all fiber in one cable

Types of Fiber

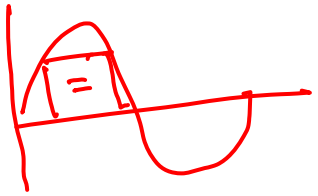
- Multimode: (Orange)
  Designed to carry more than one signal at a time
  Each with a slightly different reflection angle
  Used for short distance (*less* than 500m)
- Single-mode: (Yellow)
  One signal at a time
  Narrow core
  For long distances (more than 500m)



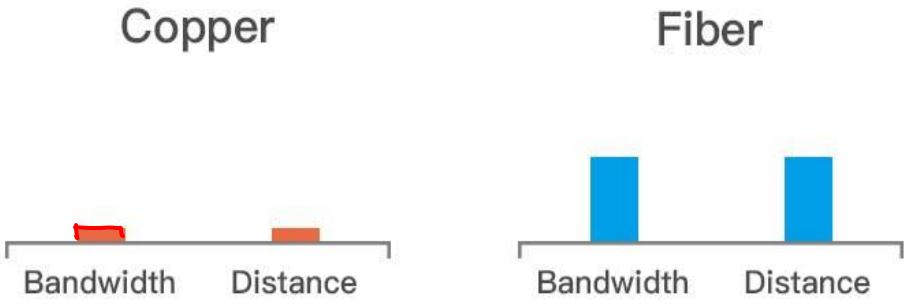


Advantages and Disadvantages

- Bandwidth, greater than metal cables
- Low power loss
- Interference free
- Size (cross sectional area less than copper)
- Weight
- Safe (dielectric, doesn't present a spark hazard)
- Secure (difficult to tap)
- Flexible
- Cost efficient



- Cost: Expensive to install
- Transmission: require repeating at distance
- Fragile
- Protection: Require more protection

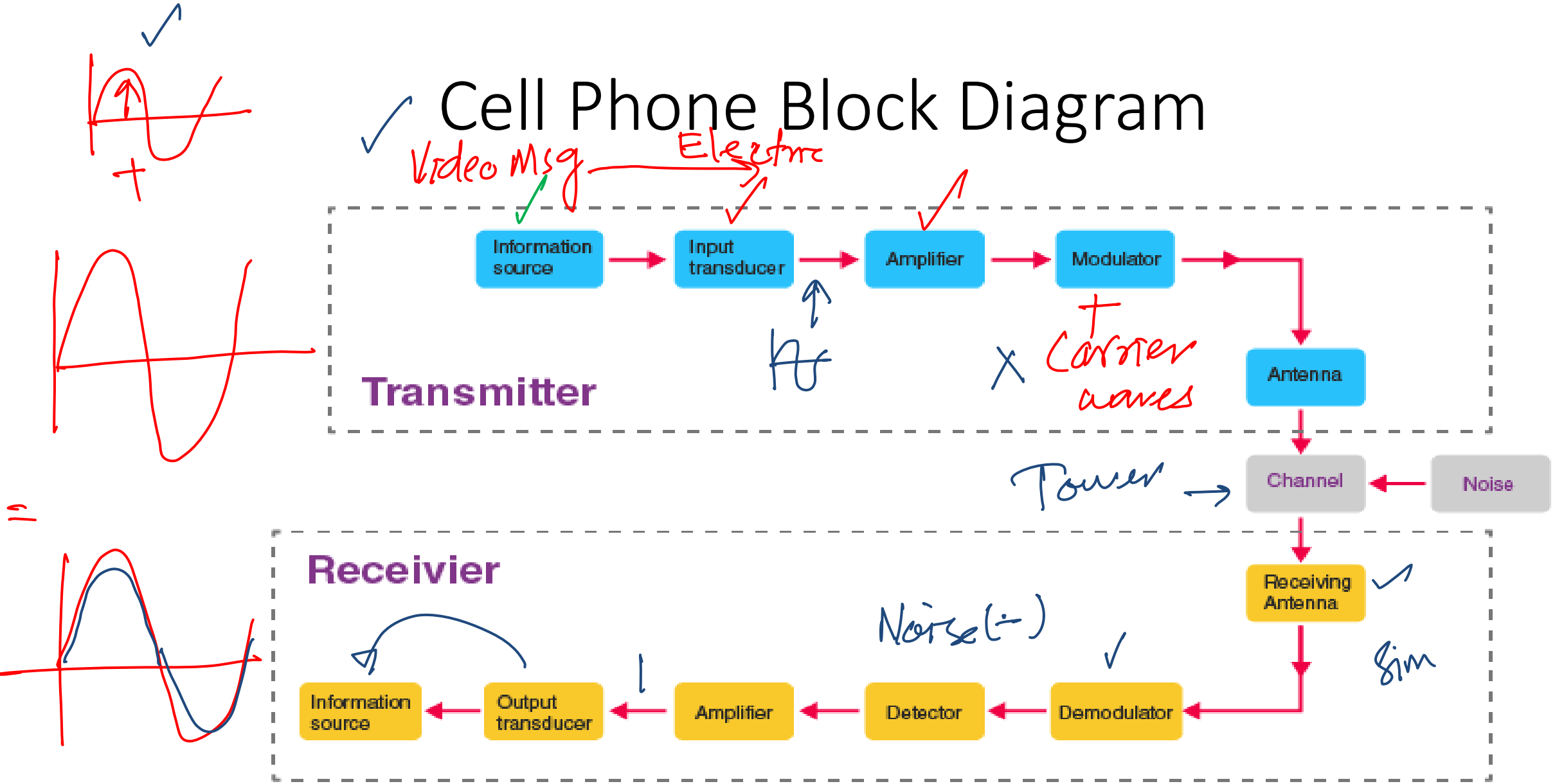


USES

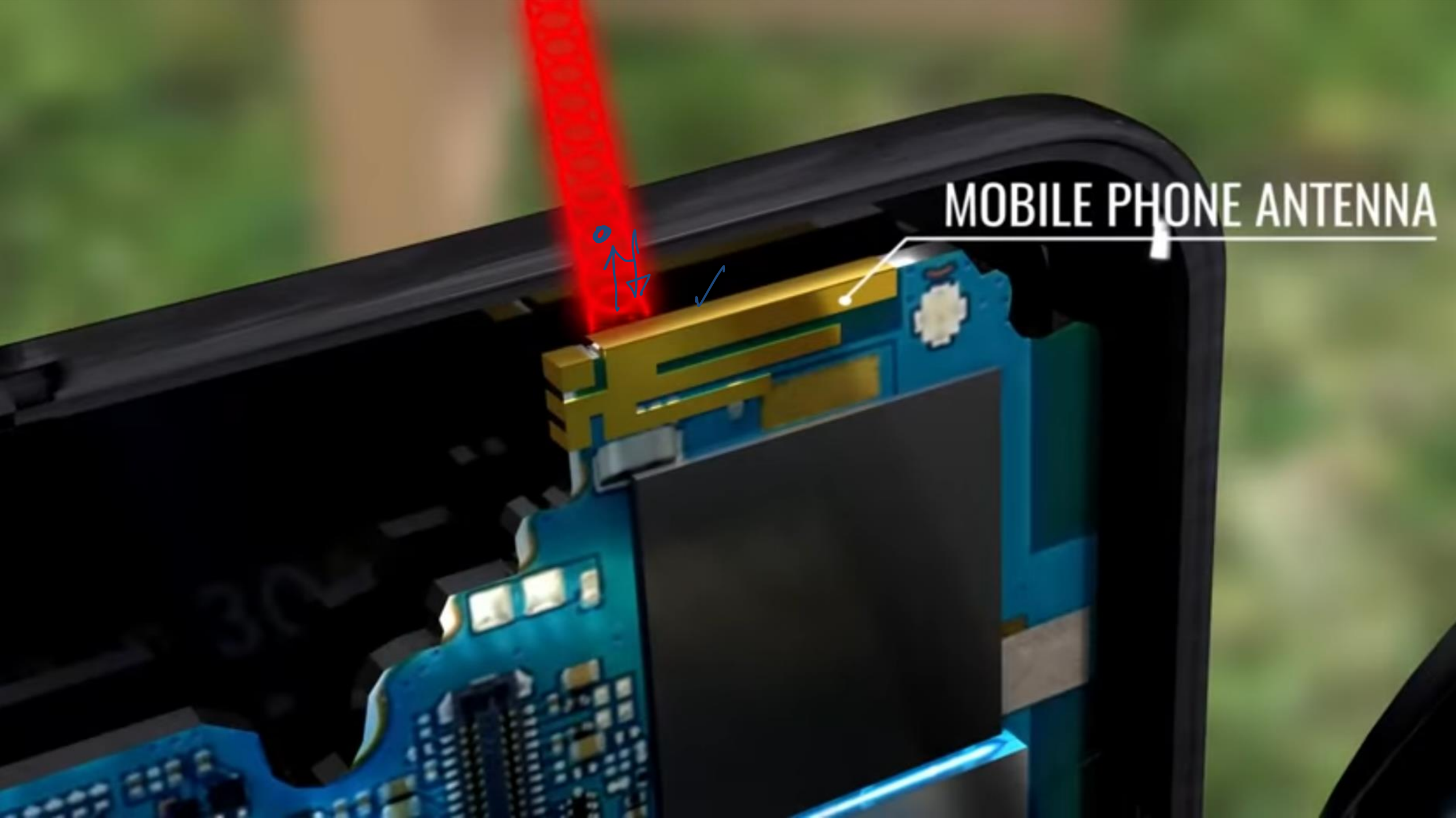
- Telecommunication
- Broadcasting and Streaming
- Automotive and aerospace
- Banking and Financial transaction
- Underwater and submarine communication
- Retail and E-commerce
- Medical Imaging and surgery
- Defense and Military Communication
- Industrial automation
- Power and Energy sector
- Security system
- Remote sensing and environmental monitoring
- Robotic Industry

Mobile Communication

Cell Phone Block Diagram



- Signal: The signal-valued function of time carries the information.
  Converted into electrical form.
- Transducer: Converts one form of energy to another.
  The Photo detector: Light signal into electrical signal
- Amplifier: Increases the amplitude or strength of transmitted signals.
  B/w transmitter and receiver.
  DC power source will be provided.
- Modulator: An original message (Signal) cannot be transmitted over a large distance because of their low frequency and amplitude, they are superimposed with high frequency and amplitude waves called carrier waves.
  Amplitude Modulation
  Frequency Modulation
  Phase Modulation
- Transmitter: It is the arrangement that process the message signal into a suitable form for transmission
- Receiver: An arrangement that extracts the message or information from the transmitted signal at the output end
- Antenna: A structure or devices tat will radiate and receive electromagnetic waves.
  Basically a metallic object, often a collection of wires
- Demodulator: Opposite of modulation, separation of message signal from carrier waves
- Repeater (Tower): Repeaters are placed at different locations b/w the transmitter and receivers.
  A repeater receives the transmitted signals, amplifies it and sends it to the next repeater without distorting the original signal

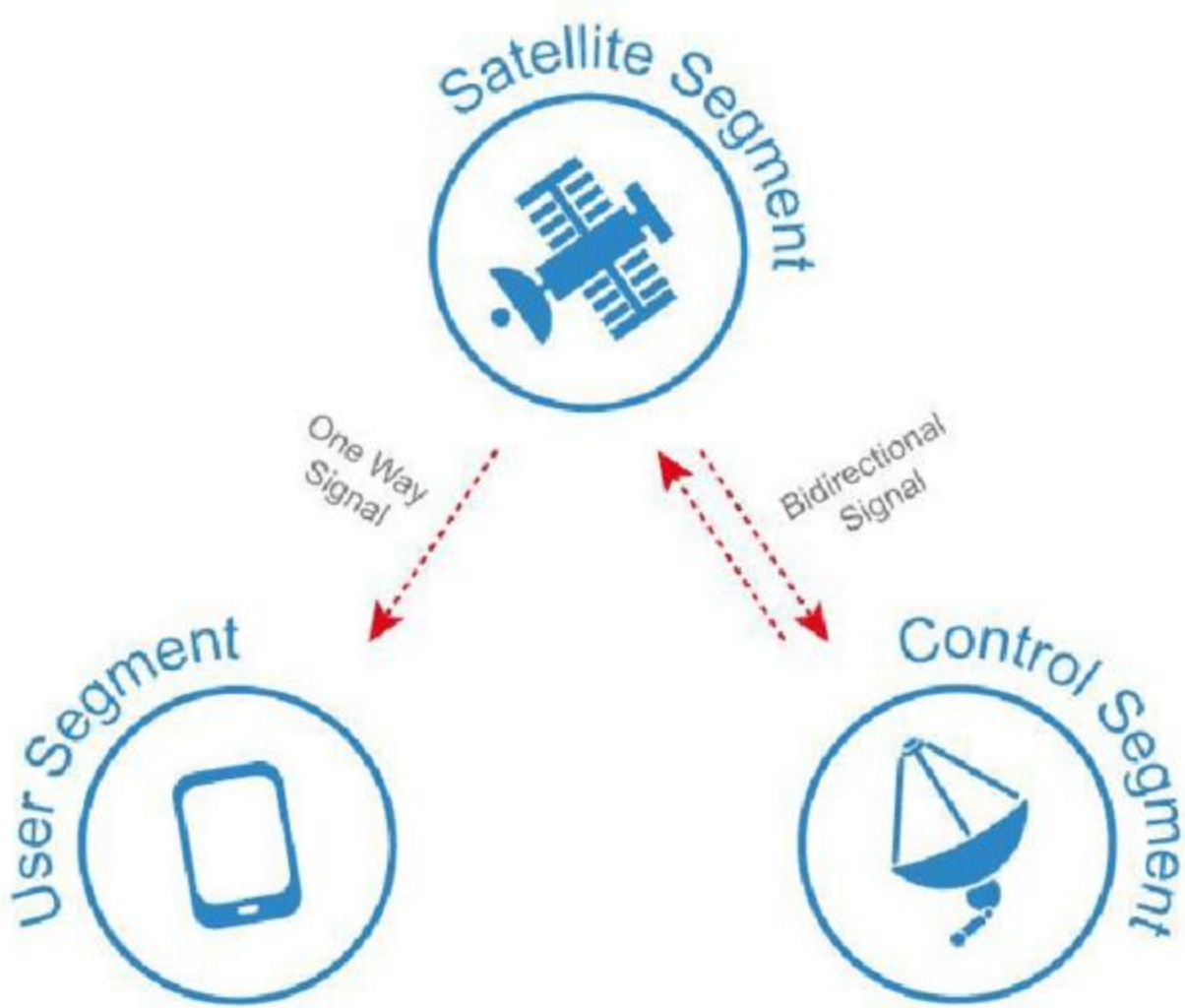

MOBILE PHONE ANTENNA

Satellite

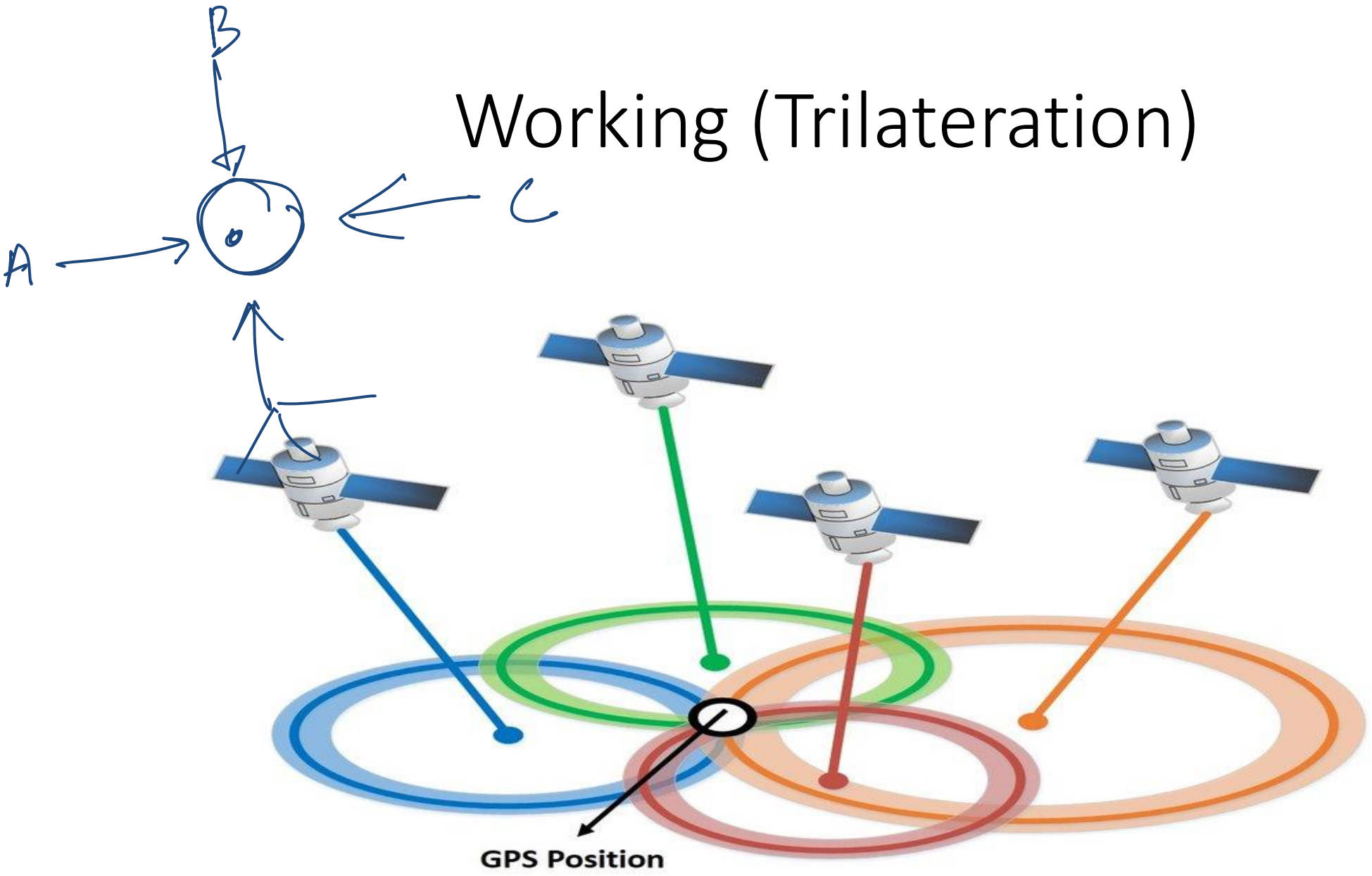
- A satellite is an object that orbits a larger object in space:
- **Natural satellites**: Celestial bodies that orbit a larger body, such as the Earth and Moon
- **Man-made satellites**: Machines launched into space to orbit a body, such as the Hubble Space Telescope and the International Space Station

GPS

- A satellite based navigation system that allows users to determine their precise location, speed and time anywhere on Earth
- Uses radio waves to navigate or share information
- Segments:
  1. Space Segment
  2. GPS Control Segment
  a. Master Control Stations (Ground Segment, send data to satellite)
  b. Grand Antennas and Monitoring Stations (Receiver, data from satellite)
  3. User Segment


Satellite Segment
One Way Signal
Bidirectional Signal
User Segment
Control Segment

Working (Trilateration)



USES

- Navigation for Transportation
- Aviation navigation
- Military and defense
- Weather prediction
- Wildlife conservation
- Agriculture
- Mining and geology
- Maritime Application
- Space exploration and satellite tracking
- Emergency services
- Surveying and Mapping
- Telecommunication and Network synchronization
- Disaster Response and Management

Types

GEO

- Above equator
- Communication (TV)
- Weather forecasting
- Take one day to complete the orbit
- 36000km from surface
- 42200km from center
- Synchronized with Earth’s rotation
- Above earth

Polar

- Above north and south pole
- Earth observation
- Two orbit in one day
- Detailed information of whole earth
- 200km to 1000km
- High resolution
- Sun-synchronization
- Spy, Scientific research
- Above pole

Artificial Intelligence (AI)

- With circuits and codes, it learns to think, mimicking minds in each data link, a future forged in algorithmic ink
- The science and engineering of making intelligent machines
- AI as systems capable of exhibiting behavior that would be considered intelligent if performed by humans

Importance

- Health care diagnostic
- Enhanced security
- Agriculture innovation
- Improved transportation
- Efficient data management
- Personalized education
- Predictive maintenance
- Financial forecasting
- Nature disaster prediction
- Environmental monitoring
- Supply chain optimization

Impacts

- Job displacement
- Death of creativity
- Cyber security threats
- Labor market transformation
- Health care disparities
- Ethical dilemma
- Economic inequality
- Social manipulation
- Dependence of technology
- Mental health issues
- Enhanced surveillance states
- Cultural homogenization
- Erosion of traditional jobs
- Impact on International Relations

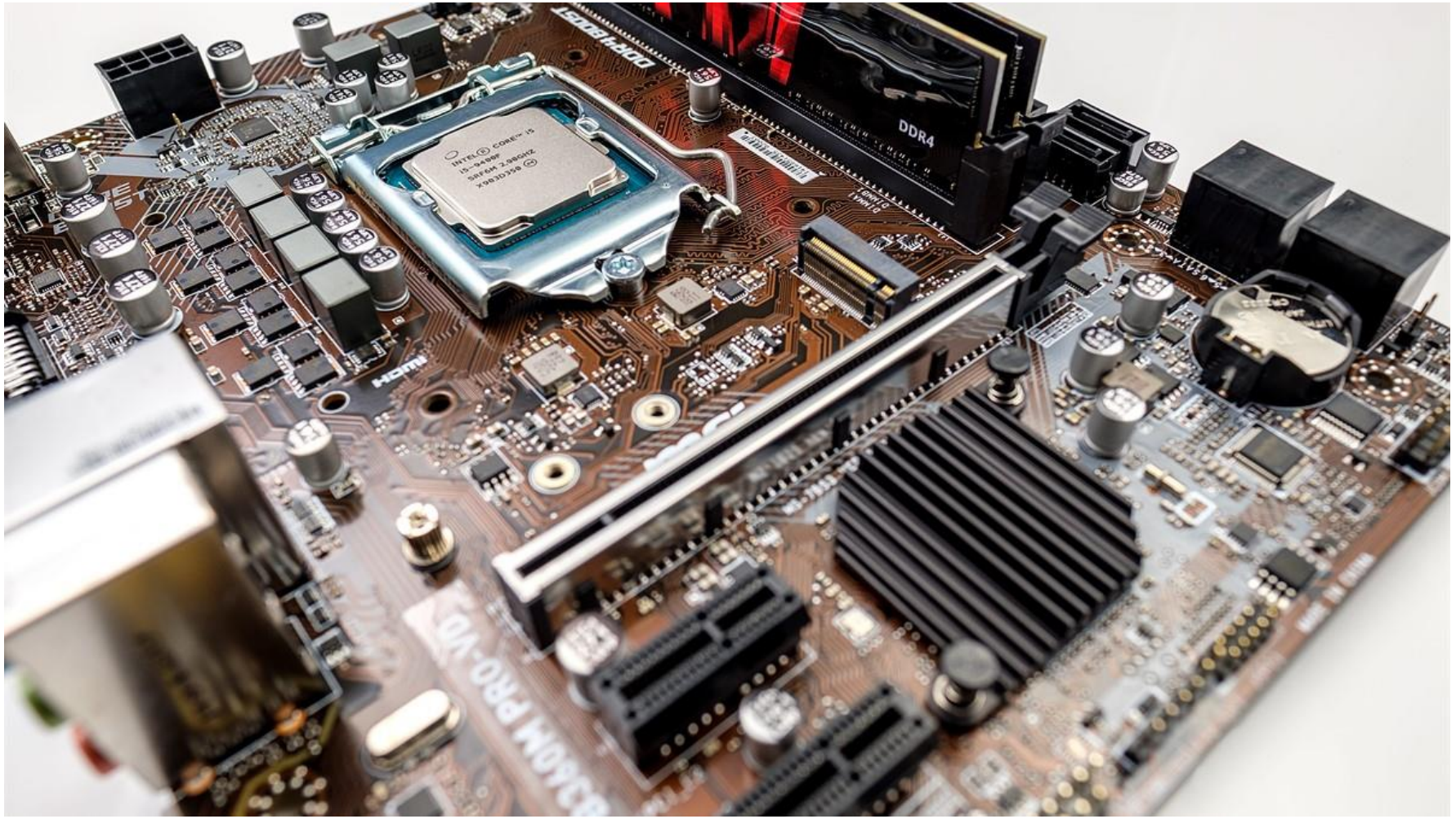
Hardware

- The physical part of a computer that can be touched and manipulated
- An umbrella term of physical components
- Required to function a component in sequential order
- E.g. Input devices, output devices, motherboard, CPU, heat sink, VR, transistors, dielectric etc

Basic Of Computer

1. Input Devices: Mouse, Keyboard, Camera, microphone, joystick, scanner, light pen, etc.
2. Output Devices: Monitor, Printer, Projector, speaker, headphones, etc.

Motherboard



Motherboard

- Main circuit
- Connects all the internal components (Memory, graphics cards, processor and other hardware)
- Provides power to each component and allows them to communicate (through slots and ports) with each others

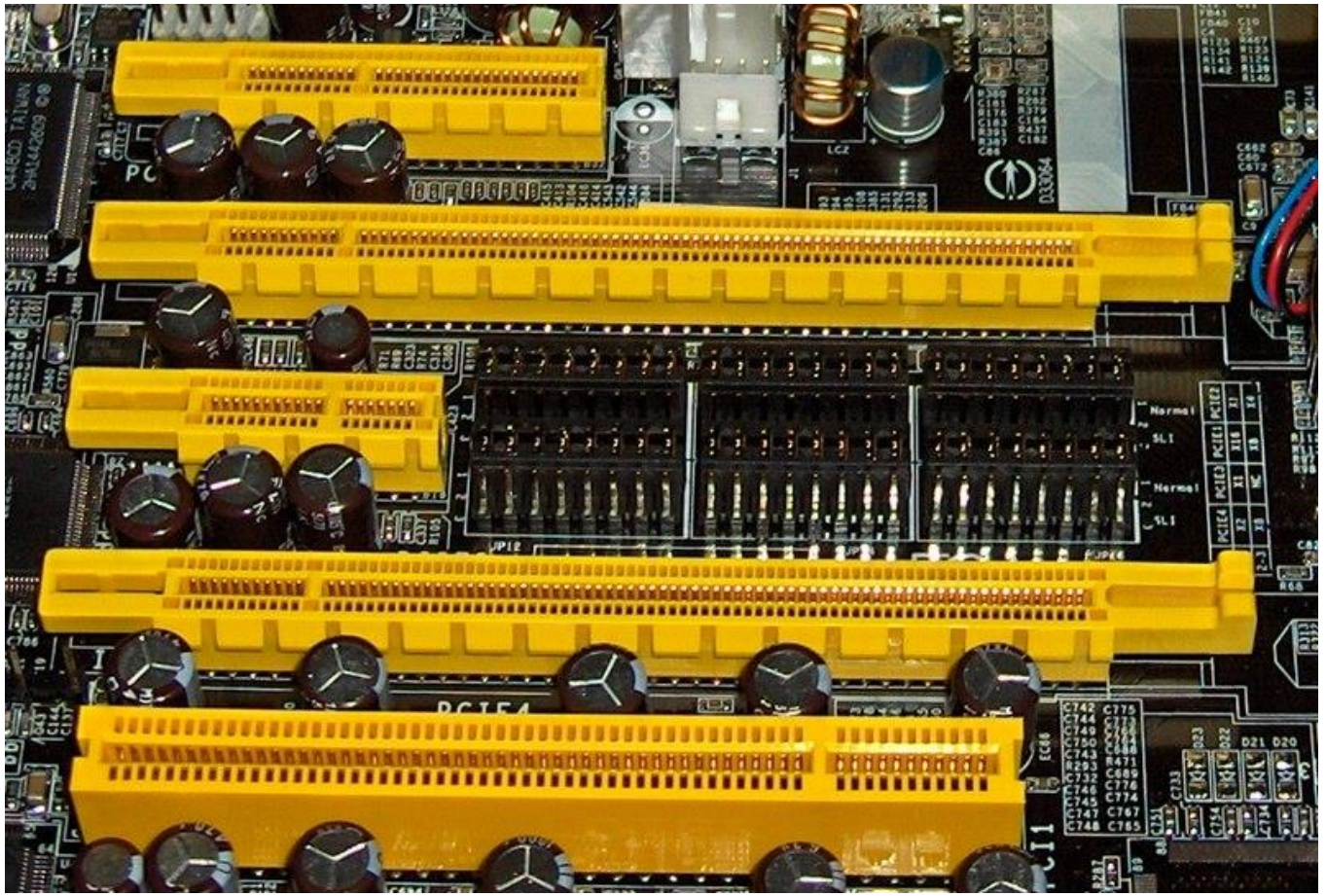
CPU

- Block Diagram
- Electric Circuitry (Transistors)
- Carries out the instruction of a computer
- Connects with DRAM
- Performs the basic arithmetic logics and control the input operation
- Processors: Multi, dual and Quad-Core processors
- ALU: Perform basic arithmetic and comparison using binary number (0,1).
- CU: Manager of all operations, handles all processor control signals, direct all the input and output flow, it issues order and ensure execution correctly. Brain of Processor.

GPU

- Graphic processing unit
- Chip based devices used for graphical quality

Computer Buses



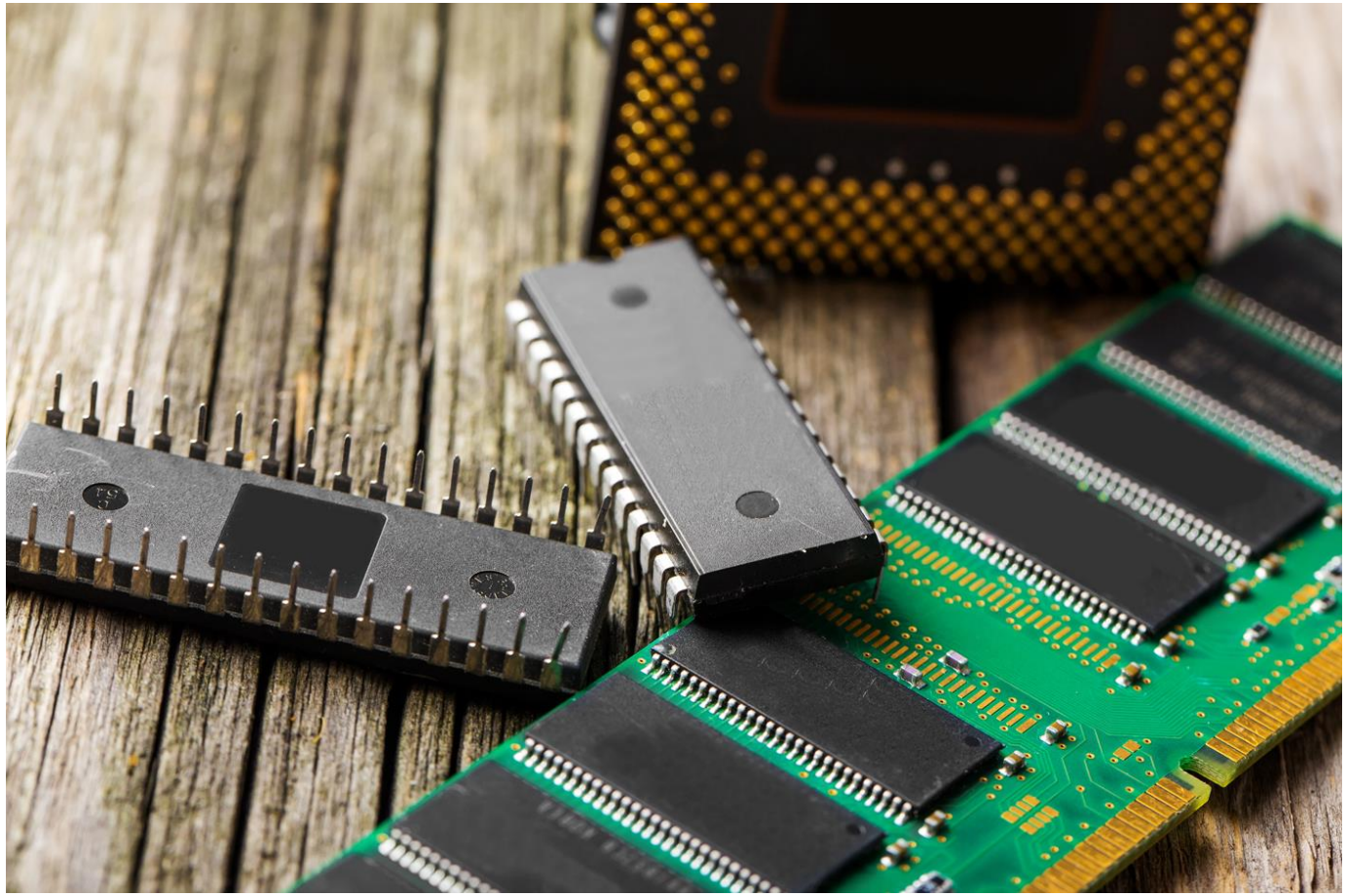
Computer Buses

- Consists of a parallel lines
- Used to transfer data between different component of the computer
- One-line buses can transfer one bit at a time
- The capacity of a computer bus depends on the number of lines on it
- A bus is a communication system that transfer data b/w component inside a computer
- System Buses: (part of motherboard)
- Internal Buses: (connect internal components of a computer)
- External Buses: (connect the different external devices, such as printer etc.)

Types of Buses

- Data Buses:
  Transfer data to and from the memory of a computer
  It acts like an engine
- Address Buses:
  Provide address to data access
  The address is stored in the form of a binary numbers to enable the data bus the access memory storage
- Control Buses:
  Manage communication b/w CPU and Other components
  Coordinate and regulate the hardware actions
  Ensuring that operations are carried out in correct sequence

Memory (RAM&ROM)



RAM
(Random Access Memory)

- Volatile memory: Temporary storage on motherboard in modules called DIMMS (dual line memory modules), 168, 184, 240, 288 pins
- Installed in the memory slots
- Stores data and machine code currently being used
- Allows to read or write in the same amount of time irrespective of their physical location
- Increasing the numbers of RAMs will make computer faster
- Requires constant electric supply to store data
- RAM contains multiplexer and demultiplexer
- Non-Volatile RAMs have developed (e.g. NOR-Flash)

Types

- DRAM: Dynamic RAM (contains capacitors)
- SDRAM: Synchronous-DRAM
- RIMM: Rambus inline memory modules (184pins)
- DDR: Double data rate
- DDR2&DDR3 (240pins)
- DDR4: (288pins)
- ECC: Error correction code

ROM
(Read Only Memory)

- ROM is a memory containing hard-wired instructions that the computer uses when it boots up
- Non-Volatile: Permanent Memory
- Memory is maintained even after the power is shut off.
- The data stored cannot be changed
- Data stored from the factory
- Can be overwrite through a special process
- When the power is supplied to the system, by turning on, it knows what to do
- BIOS: Instructor (Memory that is hard-wired, such as diode)

Types

- MROM: Masked Read Only Memory
- PROM: Programmable read only memory
- EPROM: Erasable-PROM
- EEPROM: Electrically-EPROM

Software

- A set of instructions that tell a computer, what to do, how to do and when to do
- A collection of programs, procedures and routines that run a computer system

Types

- System Software:
  Controls the computer internal functions, including the operating system, monitor, printer and storage devices
  a. System management program
  Operating System
  Device Drivers
  System Utilities
  b. Developing Software
  Language and Translator
- Application Software:
  Directs the computer to perform tasks based on user commands
  a. For General Purpose (Word processor, image editor, paint etc)
  b. Specific Purpose (Reservation system, NOA LMS, Attendance system, Billing System, Report card etc)

Importance of software

- Accessibility. This is the degree to which a diverse group of people, including individuals who require adaptive technologies such as voice recognition and screen magnifiers, can comfortably use the software.
- Compatibility. This is the suitability of the software for use in a variety of environments. Software compatibility is important for different devices and browsers.
- Efficiency. This is the ability of the software to perform well without wasting energy, resources, effort, time or money.
- Functionality. This is software's ability to carry out its specified functions.
- Installation. This is the ability of the software to be installed in a specified environment.
- Localization. For software to function correctly, it needs localization, which entails the various languages, time zones and other features a software program can works in.

- Maintainability. This is how easily the software can be modified to add and improve features and fix bugs.
- Performance. This is how fast the software performs under a specific load.
- Portability. This is the ease with which the software can be transferred from one location to another.
- Reliability. This is the software's ability to perform a required function under specific conditions and for a defined period without any errors.
- Scalability. A software's ability to increase or decrease performance in response to changes in its processing demands is its scalability.
- Security. This is the software's ability to protect against unauthorized access, invasion of privacy, theft, data loss and malicious software.
- Testability. This is how easy it is to test the software.
- Usability. This is how easy it is to use the software.

Information System

- An information system (IS) is a collection of hardware, software, data, people, and processes that work together to collect, store, process, and transmit data and digital information.
  Operational IS (TPS)
  Business IS (MIS, ESS)
  Specialized IS (GIS, KMS)

- Transaction Processing System:
  TPS meet the data collection, storage, processing and outputting functionalities for the core operations of a business. E.g. Payroll system, fund management, budgeting system, sales management system etc.
- Business Information System (BIS):
  Identify, extract and analyze data for various operational needs, particularly for decision-making purposes
  BIS may provide analysis that predicts future sales patterns, summarize current costs and forecast sales revenues.
- Management Information System (MIS):
  Provide lower and middle management with printed or electronic reports with inquiry capabilities, so that they can control, organize and plan more effectively and efficiently.
  Extract the summarized data from TPS

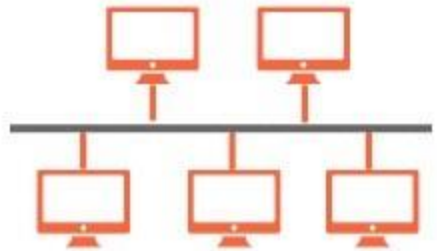
- Executive Supports System (ESS):
  Used by senior managers to make decisions
  ESS serves the strategic level of the organization
  Address the non routine decisions requiring judgment, evaluation and insight
- Geographical Information System (GIS):
  Capability of assembling, storing, manipulating and displaying geographically referenced information that is identified according to its location
- Knowledgeable Management System (KMS):
  An IT system that includes content, search, guidance, and insight.

Networking and Internet

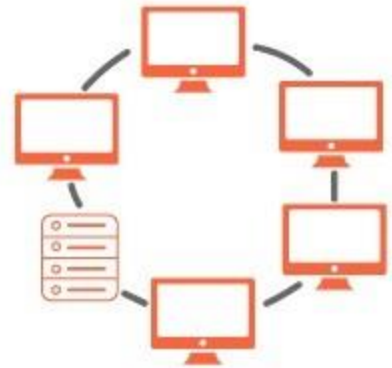
- Networking: The process of building relationships and making connections
- The internet is defined as a global network of linked computers, servers, phones, and smart appliances that communicate with each other using the transmission control protocol (TCP) standard to enable the fast exchange of information and files, along with other types of services.

Network Topology Types

Point to Point

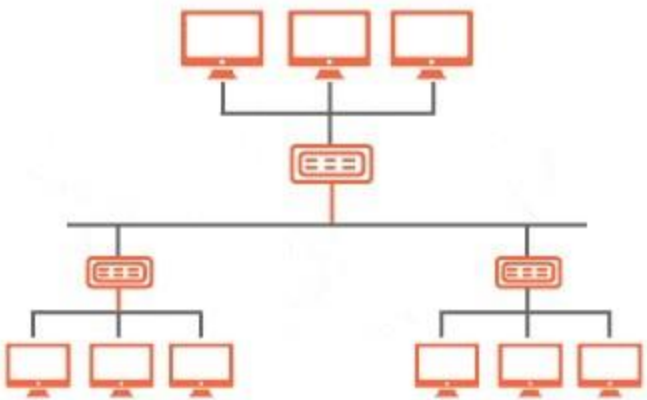


Bus

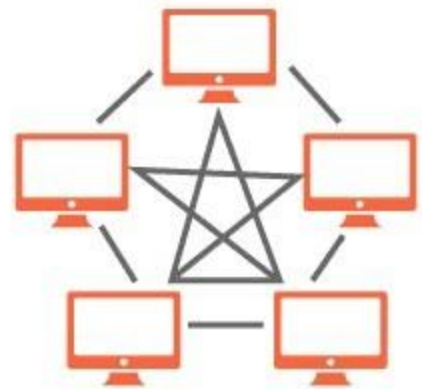


Ring

Star



Tree



Mesh

Line

Semiconductors

- A solid material that can conduct electricity under certain conditions
- P-type Semiconductors
- N-type Semiconductors

Ceramics

- An organic non-metallic solid made up of clay that have been shaped and then hardened by heating to high temperature, like tiles, bricks, plates, glass and toilets
- Ceramic can be found in: Watches, Automobiles

General Properties

- Hard, extremely strong, showing considerable stiffness under compression and bending
- Corrosion resistant and durable
- High melting point
- Do not react with most liquids, gases, alkalis and acids
- Thermal and electrical insulators but some conduct electricity (Chromium dioxide)
- Non-magnetic but some containing Iron oxide
- Oxidation resistant
- Brittle, having little elasticity