TARGET PRELIMS 2024
BOOKLET-6; S&T-6
COMPUTER & IT - 3

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2. CRYPTOGRAPHY

- **Introduction**
  - » Encryption is conversion of electronic data into another form, called cipher text, which cannot be easily understood by anyone except authorized parties.
  - » **Key purpose:** Confidentiality, Authentication, Integrity and Non-Repudiation

- **Historical development**
  - » Spartans using stick of fixed diameter.
  - » **Symmetric Algorithms** (Same key for encryption and decryption)
    - Ceaser Shift cipher.
    - Polyalphabetic substitution -> which uses multiple substitute alphabets to limit the use of frequency analysis to crack a cipher.
      - Most famous example: Enigma electro-mechanic rotor cipher machine used by Germans during WW-2.
    - » All the above methods used the same key for encryption and decryption.
    - » **Limitations**: Requires secure channel for key transfer

  - » **Asymmetric Cryptography or Public Key Cryptography**
    - » It uses pairs of keys.
      - Public key that may be disseminated widely.
      - Private key which is known only to the owner.

    - » Public key algorithms, unlike symmetric key algorithms, do not require a secure channel for initial exchange of one (or more) secret keys between the parties.
    - » Famous examples: Digital Signature algorithm, RSA algorithm (based on the problem of factoring the product of two large prime numbers - the factoring problem), AES etc.

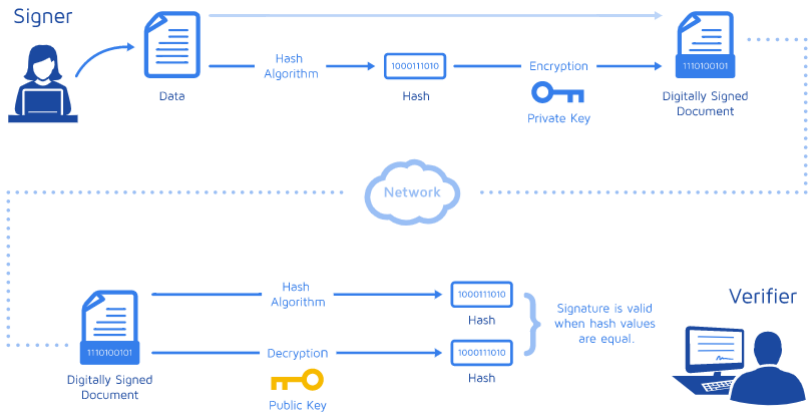
  - » **Where is Encryption used today?**
    - » Before coming of the Diffie-Hellman key exchange (public key algorithm) and RSA algorithm, governments and their armies were the only real users of encryption.
    - » Now, the broad use of encryption in **the commercial and consumer realms** to protect data both while it is being sent across a network (data in transit) and stored, such as on hard drive, smartphone, or flash drive.
    - » Other uses included uses in Modems, Set Top Boxes, Smart Cards, SIM Cards etc.

1) DIGITAL SIGNATURE

- Digital signature is a mathematical technique (cryptography mechanism) that is used to validate the **authenticity and integrity** of a message, software, and digital document.
- It offers security features like evidence of origin, identity, and Status of an electronic document, transaction or message and can thus acknowledge informed consent by a signer (i.e. nonrepudiation).
- **How Digital Signature Works?**
  - » It uses public key cryptography such as RSA. The individual who is generating the digital signature uses their own private key to encrypt signature-related data.

» The only way to decrypt this data is with signer's public key. This is how signer's signatures are authenticated.

- **How to create digital signature?**
  - » To create a digital signature, signing software – such as an email program – creates a one-way hash of the electronic data to be signed. The private key is then used to encrypt the hash. The encrypted hash – along with other information, such as hashing algorithm is the digital signature.
  - »



  - » **Note:** Digital signature technology requires all the parties to trust that the **individual creating the signature has been able to keep their own private keys secret**.
- **Uses of Digital Signature**
  - » **Government** publishes electronic versions of various **documents** such as budget, laws, bill etc. with digital signatures.
  - » **Various legal works** like processing tax returns, filing applications, verifying business to government transactions etc. use digital signature.
  - » Industries use the digital signature to **speed up the process**, including product design, quality assurance, manufacturing enhancements etc.

2) END TO END ENCRYPTION

- **Why in news?**
  - » The recent leaking of WhatsApp chats of several Bollywood celebrities has brought back questions around WhatsApp's privacy and security

- **Introduction**
  - » End to End Encryption (E2EE) is a **method of secure communication that prevents third parties from accessing data while it's transferred** from one end system or device to another.
  - » In E2EE, the data is **encrypted on the senders' system** or device and **only recipient is able to decrypt it**. Nobody in between, be they an Internet Service Provider, Application Service Provider, or hacker, can read or tamper with it.
  - » The cryptographic keys used to encrypt and decrypt the message are stored exclusively on the endpoints; a trick made possible through the use of public key encryption.

- **Whatsapp Encryption** (started from April 2016)
  - » **Step-1: Key Generation**: When you install Whatsapp, the app generates a pair of cryptographic key – a public key and private key.

» **Step-2**: **Key Exchange**: When you communicate with someone, your device and recipient's device exchange each other's public key. The exchange happens automatically in the background using a secure **Signal Protocol**.

» **Step-3**: **Message Encryption**: While sending a message, your device uses recipient's public key to encrypt so that only recipient will be able to decrypt. The encryption and decryption process happen locally on the devices involved meaning that Whatsapp servers don't have plaintext of your message. Therefore, even if Whatsapp servers are compromised, your messages are secure.

» **Feature of Perfect Forward Secrecy**: It ensures that even if some malicious actor gets access to your private key, they would be able to decrypt messages sent after the compromise, **past messages are secure**.

- This is done with the help of ephemeral (temporary) session keys.

» **Feature of verification of identity through security codes**: Whatsapp allows users to verify the identity of their contacts by comparing security codes. These codes are unique to each conversation and help ensure that the keys used for encryption are not tampered with.

3) QUANTUM CRYPTOGRAPHY/ QUANTUM KEY DISTRIBUTION

- **About Quantum Cryptography:** It is a protocol to distribute secret keys using the principles of quantum mechanics. It is a new technique that ensures the confidentiality of information transmitted between two parties, by exploiting counter intuitive behavior of elementary particles called as **photons**.

» **How Quantum Mechanics is used – Heisenberg's Uncertainty Principle**

» The security of the quantum key distribution is guaranteed by the laws of quantum physics.

- Following uncertainty principle, an eavesdropper cannot know everything about a photon that carries a bit and will destroy a part of the information. Hence eavesdropping causes errors in transmission line, which can be detected by Alice (sender) and Bob (Receiver).
- If an eavesdropper, tries to determine the key, she will be detected. The legitimate parties will then discard the key, while no confidential information has been transmitted yet. If, on the other hand, no tapping is detected, the secrecy of the distributed key is guaranteed.

» Other advantage of Quantum Cryptography/Quantum Key Distribution?

- It can distribute long key as often as possible between Sender and Receiver

» Long term secrecy of confidential data transmission

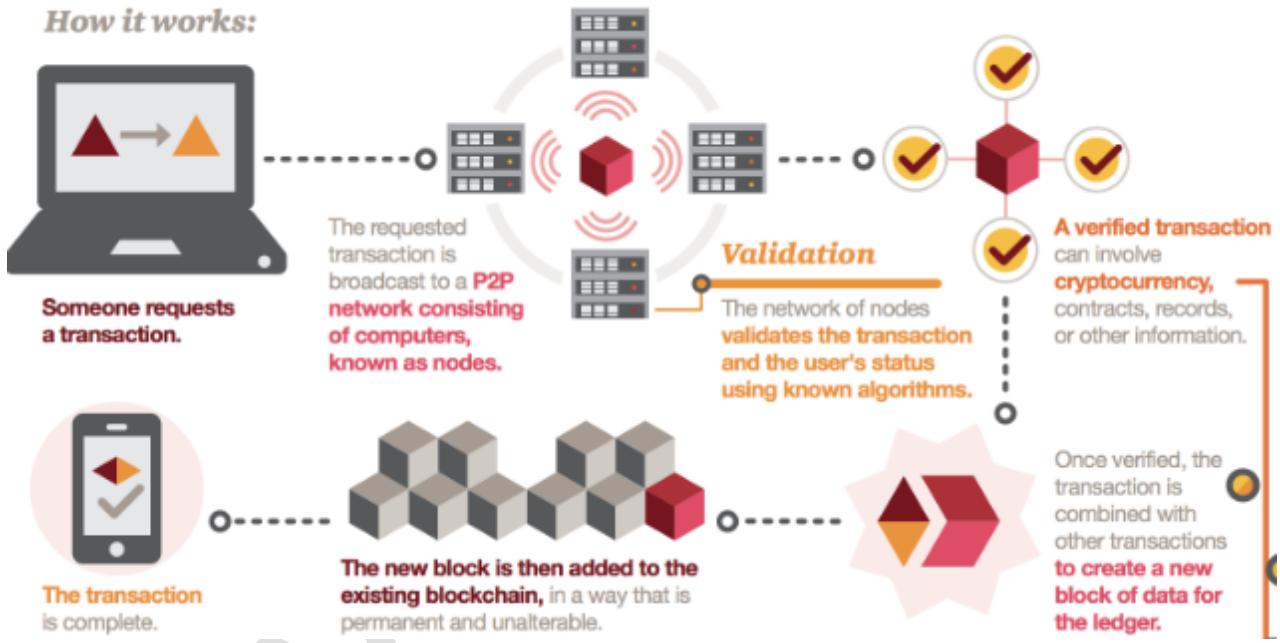
3. BLOCKCHAIN TECHNOLOGY

- **Introduction**
  - Blockchain is an **incorruptible, decentralized, digital ledger** of transactions that can be programmed to record not just financial transactions but virtually anything of value. Using this technology, participants can **confirm transactions without the need of central certifying authority**. In other words, blockchain is a distributed database that is used to maintain a continuously growing list of records/transaction, called blocks.
  - It was first used in the design and development of Bitcoin – Cryptocurrency in 2009 by **Satoshi Nakamoto**.

- It offers all parties involved in a business network a secured and synchronized record of transactions. It records every sequence of transaction from beginning to end, whether it is 100s of transaction in supply chain or a single online payment.
- **Block:** As each transaction occurs it is put into a block.
- **Chain:** Each block is connected to one before and after. Groups of transactions are blocked together, and a fingerprint of each block is added to the next thus creating an irreversible chain.

- **Data/Transactions** stored in the blocks are **secured against tempering using cryptographic hash algorithm** and are validated and verified through consensus **(consensus protocol)** across nodes of blockchain network.

- **How blockchain transaction functions**



- **Positives/Advantages**
  - **Security -> Built in robustness ->** no single point of failure i.e. no centralized points of vulnerability that hackers can exploit.
  - **Trust -> Increased Transparency and incorruptibility**
    - Data is embedded within network as a whole, by definition it is public.
    - Altering any unit of information on the blockchain would mean using a huge amount of computing power to override the entire network.
      - In theory, this would be possible. In practice, it's unlikely to happen.
  - **Permanent Ledger**
  - **Reduces the role of intermediary.**
  - **Speeds up the process.**
  - **Lowers transaction cost**
  - **Applications in various sectors**

- **Applications (Current and Future Potential)**

- **Economy and Finance** offers the strongest use cases for the technology.
  - **Financial transactions** are typically granted by third party and block chain could be used to automate the process, reducing overall costs, by cutting out the middleman with autonomous smart contract acting as trusted intermediaries between parties on the network.
  - **Faster, Cheaper settlements could** save billions of dollars from transaction costs while improving transparency.
  - **Stocks, mutual funds, bonds, and pensions** may one day be stored on blockchains as many financial organizations explore the technology.
- **Automotive:** Consumers could use the blockchain application to manage the fractional ownership in autonomous cars.
- **Public Ledger Information:** Many governments are looking to adopt this technology to store information about the citizens and census. A decentralized platform to safely store data regarding, birth, death crime etc. can contribute to effectively curbing fraudulent activities. Even our judiciary can benefit by using this platform to store court judgments, making our legal system more transparent and accessible to litigants.
- **Voting:** Using a blockchain code, constituents could cast votes via smartphone, tablet etc. resulting in **immediately verifiable results**. Voting by blockchain can eliminate election frauds by making each vote stored as a block on the block chain, rendering it impossible to tamper with.
- **Healthcare:** Patients encrypted information could be shared with multiple providers without the risk of privacy breaches.
- **Smart Contracts:** Every agreement, every process, every task, and every payment would have **a digital record and signature** that could be identified, validated, stored, and shared. Intermediaries like lawyers, brokers, bankers might not be necessary.
- **Secure File storage**
  - Distributing data throughout the network protects files from getting hacked or lost.
- **Identity Management:** Decentralized, used controlled digital identity holds the potential to unblock economic opportunity for refugees and others who are disadvantaged, while concurrently improving the lives of those simply trying to navigate cyberspace securely and privately.
  - There is definite need for better identity management on the web.
- **Supply chain auditing**
- **Protection of intellectual property**
  - Smart contracts can protect copyright and automate the sale of creative works online, eliminating the risk of file copying and redistribution.
  - Further, a blockchain storage can provide a consolidated platform where trademark and copyright filings can **be stored**. With entries that can't be tampered with and accurate time stamps, the number of disputes concerning IP may well decrease.
- **Anti-Money laundering and Know Your Customer (KYC)**
- AML and KYC practices have a strong potential for being adapted to blockchain

4. CRYPTO CURRENCY

- Cryptocurrency is a form of **digital cash** which uses **encryption technology** to make it secure. Since, this is a completely digital system, it **doesn't exist in physical form**.
- **Records of cryptocurrency transactions** have to be stored in a secure database. **Blockchain** serves the role of an incorruptible ledger for most of the cryptocurrencies.
- People can store their cryptocurrency in virtual wallets that resemble online bank accounts.

A) CRYPTO MINING

- Crypto mining refers to the process by which new units of cryptocurrency are created **by solving complex mathematical problem**.
- The miner who mines the cryptocurrency gets to add a new block of verified transactions to the blockchain.
- **Remember some key aspects:**
  - » **Resource intensive:** Solving mathematical problems consume a lot of processing power leading to environmental concerns.
  - » **Increasing Competition**: As coins keep getting mined, future coin becomes more difficult to mine.
  - » **Not all cryptocurrencies** may use mining.

BHUTAN TO EMERGE AS CARBON NEUTRAL HUB FOR CRYPTO MINING

- **In May 2023,** Singapore based mining company, Bitdeer (BTDR) announced a partnership with Bhutan to build a $500 million closed end fund which will be used **to build mining facilities powered entirely by carbon-free hydropower**.
- The first phase of the project – **Gedu data centre**, with a total aggregate electrical capacity of 100 MW, has been operational since Aug 2023.

1) BITCOINS

- **Bitcoin** is the first cryptocurrency created and held electronically. It is a decentralized system (No one controls it). Bitcoins aren't printed, like Rupees or dollars - they are produced by people, and increasingly businesses, running computers all around the world, using software that solve mathematical problems.
- **Who created bitcoins -> Satoshi Nakamoto?**
- **Limited number bitcoins**
  - » The bitcoin protocol - the rules that make bitcoin work - say that only 21 million bitcoins can ever be created by miners. However, these coins can be divided into smaller parts (the smallest divisible amount is one hundred millionth of a bitcoin and is called a 'Satoshi', after the founder of bitcoin.

▫ **What is bitcoin based on?**

- Bitcoin is based on **mathematics.** Around the world, people are using software programs that follow a mathematical formula to produce bitcoins. The mathematical formula is freely available, so that anyone can check it.

▫ **Advantages/Positive Characteristics of Crypto Currencies**

- **Decentralized**: No central control and hence flexibility to use.
- **Easy, Fast Set up:**
  - » Conventional banks -> complicated process to open bank account, merchant account for payment more complicated
  - » Bitcoin address can be set up in seconds, no questions asked, and with no fees payable.
- **Protects Privacy/Anonymous**
  - » Users can hold multiple bitcoin addresses, and they are not linked to names, addresses, or other personally identifying information.

- **Completely Transparent**
  - » Bitcoin stores details of every single transaction that ever happened in the network in a huge version of a general ledger, called the **blockchain**. The blockchain tells all.
  - » If you have a publicly used bitcoin address, anyone can tell how many bitcoins are stored at that address. They just don't know that it's yours.
- **Transaction fee is miniscule and transaction is fast** (almost real time, even cross border)
- **It's non-repudiable.**
  - » When your bitcoins are sent, there's no getting them back, unless the recipient returns them to you. They're gone forever.

▫ **Limitations/Disadvantages of Cryptocurrencies**

- **Acceptance is limited** -> banned in countries like China and India
- **Loss of wallet -> no recovery option**
  - » If hard drive crashes, or wallet corrupts data. This can bankrupt a wealthy Bitcoin investor within seconds with no form of recovery
- **Volatile** -> no valuation guarantee
- **No grievance redressal/** No Buyer protection in case of online purchase
  - » If seller doesn't send the bought goods, nothing can be done -> there is no provision of refund/reverse transaction
- Risk of **unknown technical flaws**
- **Built in deflation (in bitcoin)**
- **No physical form** -> Cannot be used in physical stores
- **Extremely high processing power/energy requirement** -> Environmentally unsustainable. According to a study by University of Cambridge, Bitcoin currently uses more energy than Argentina every year.
- Can be used for **criminal activities**
  - » Lack of centralized control allows its use for criminal activities such as by ransomware attackers.
- This may also be used by money launderers to launder black money**.**

2) LIBRA (DIEM) (PROJECT ABANDONED IN JAN 2022)

3) MOST FAMOUS CRYPTOCURRENCIES

- Bitcoin (BTC)
- Ethereum (ETH)
- Tether USDt (USDT)
- BNB (BNB)
- Solana (SOL)

4) CRYPTOCURRENCY AND INDIA

- In **April 2018,** RBI prohibited banks from providing services to firms and individuals who deal in bitcoin and other such virtual currencies. But, in **March 2020**, the **Supreme Court had set aside the RBI Ban on cryptocurrency transactions** by setting aside the April 2018 circular of the RBI prohibiting banks and entities regulated by it from providing services in relation to virtual currencies (VCs). The Court found the RBI circular "disproportionate" with an otherwise consistent stand taken by the Central Bank that VCs are not prohibited in the country. Further, the court held that the RBI didn't consider the availability of alternatives before issuing a circular.

- In 2019 **Inter-Ministerial Committee** (IMC) chaired by **Subhash Chandra Garg** that was setup to assess the viability of virtual currencies in India had also recommended that India should **ban private crypto currencies such as Bitcoin**. Through a **draft bill** they recommend a maximum of 10-year punishment for those who mine, trade, buy or sell cryptocurrencies.
  - » What is **IMC's view on Distributed Ledger Technologies** (DLT) and Cryptocurrencies?
    i. IMC recognizes the potential of DLT and Blockchain.
    ii. Therefore, it **recommends the Department of Economic Affairs** to take necessary measures to facilitate the use of **DLT** in the entire financial fields after identifying its uses.
    iii. The IMC also **recommends that regulators** – RBI, SEBI, IRDA, PFRDA, and IBBI – **explore evolving appropriate regulations** for development of DLT in their respective areas.

  - » However, IMC has recommended a **ban on "private" cryptocurrencies**. It recommended the **introduction of a single cryptocurrency** for the whole country that is backed by Reserve Bank of India.

  - » **Why?**
    i. Non-official virtual currencies can be **used to defraud consumers**, particularly unsophisticated consumers or investors.
    ii. Further such currencies often experience **tremendous volatility** in their values.
    iii. The scaling up of private blockchain based currencies require **crippling level of energy resources**. According to a report by Bank of International Settlement, Bitcoin processing already consumes as much energy as is used by Switzerland; it called this an environmental disaster.
    iv. If the private cryptocurrencies are allowed to continue, **RBI would lose control over the monetary policy and financial stability**, as it would not be able to keep a tab on the money supply in economy.
    v. Further, the anonymity of private digital currencies makes them **vulnerable to money laundering** and **use in terror financing activities** while making law enforcement difficult.
    vi. Finally, there is **no grievance redressal mechanism** in such system, as all transactions are irreversible.

A) THE CRYPTOCURRENCY AND REGULATION OF OFFICIAL DIGITAL CURRENCY BILL, 2021

- **Yet to be officially approved by the Union Cabinet**
- It seeks to create a facilitative framework for creation of the official digital currency (to be issued by RBI)
- **Note:** RBI is looking at launching a pilot project for an official digital currency soon.
- It also seeks to prohibit all private cryptocurrencies in India. However, it allows for certain exceptions to promote the underlying technology of cryptocurrencies and its uses.

B) BUDGET 2022-23

- Virtual Digital Assets (VDAs) will be taxed at 30% (on the gain on the sale of such assets). Benefits of basic exemption limit is also not applicable. No deduction in respect of any expenditure other than cost of acquisition shall be allowed. Also, TDS of 1% shall be deducted on the transaction value from 1st July Subject to certain conditions.
- They mainly include Crypto currencies, NFTs etc. Prima facie, this excludes digital gold, central bank digital currency, or other traditional digital assets and hence aimed at specifically taxing cryptocurrencies.

5. NFT

6. WEB 3.0

- **Background: Understanding Web 1.0 and Web 2.0**
  - Web 1.0 is the world wide web or the internet that was invented in 1989. It became popular in 1993. The internet in the Web 1.0 was mostly static web pages. Here most of the users visited websites and **read and interacted with the static material availab**le there. It was a **closed environment** and users themselves couldn't create post content and reviews.

  - **Web 2.0** started in some form by late 1990s. By 2004, most of the features of web 2.0 was available for implementation. Here websites were more dynamic where users could create content, post comment, write reviews etc. They could also upload photos and videos. Primarily, a social media kind of interaction is the differentiating trait of Web 2.0.

- **Concerns of Web 2.0:**
  - Most of the data on internet is owned and controlled by a few **behemoth companies**. It has created issues related to data privacy, data security and abuse of such data. It has kind of disappointed experts that the original purpose of internet has been distorted.

- Web3 or Web 3.0 is a term used to describe the **next phase of the internet.**
  - It runs on the decentralized technology of blockchain and would be different from web 1.0 and web 2.0. Here, users have ownership stakes in platforms (unlike now where tech behemoths control everything). Here users will control their own data.
  - Thus, the need of intermediaries (like Amazon, Facebook, etc.) is removed. This will end data monopoly.
  - The **key concepts in Web3** seen so far are peer to peer transactions and block chain.

- The spirit of Web3 is **Decentralized Autonomous Organization (DAO)** which is that all business rules and governing rules in any transaction are transparently available for anyone to see and the software will be written conforming to these rules.
  - **Crypto-Currency and Blockchain** follow the DAO principle. With DAO, there is no need for a central authority to authenticate or validate.

- **Summarizing significance of web3.0:**
  - Prevents monopoly over data.
  - Promotes data privacy.

- Increase competition in fields like search engine businesses as control over content now restricted to just a few companies would end.
- New technology will give India an opportunity to innovate and develop.

- **Future of Web 3.0: Will it take off?**
  - **Tech honchos** like Elon Musk and Jack Dorsey don't see a future for Web3.
  - There are **technological changes required**: For e.g., it will require deviation from the current architecture where there is a front-end, middle layer and back-end. Web3's architecture will need backend solutions for handling block chain, persisting and indexing data in block chain, peer to peer communications and so forth. Similarly, middle layer would also need to change to handle block-chain based backend.

7. AUGMENTED REALITY/ VIRTUAL REALITY

A) AUGMENTED REALITY

- AR is the integration of digital information with the user's environment in real time. AR is a technology that layers computer generated enhancements atop an existing reality to make it more meaningful through the ability to interact with it.
  - AR is developed into apps and used on mobile devices to blend digital component in real world in such a way that they enhance each other but can also be told apart easily.
- **Boeing researcher Thomas Caudell coined the term in 1990.**
- **Current application of Augmented reality**
  - Google glass, heads-up displays in car windshields are perhaps the most-well known consumer AR products.
  - It is used in many industries including health care, public safety, gas and oil, tourism and marketing.

VIRTUAL REALITY

- VR is an artificial, computer-generated simulation or recreation of a real-life environment or situation.
  - It immerses the user by making them feel like they are experiencing the simulated reality firsthand, primarily by simulating their vision and hearing.
- VR is typically achieved by wearing a headset like the Facebook's **Oculus** equipped with the technology and is used prominently in two different ways.
  - To create and enhance an imaginary reality for gaming, entertainment, and play.
  - To enhance training for real life environments by creating a simulation of reality where people can practice beforehand (such as flight simulators for pilots)

8. METAVERSE

- **Definition:**
  - » Metaverse is a digital place inhabited by the digital representations of people (Avatars) and things. It is a new vision of internet.
    - https://youtu.be/Qw6UCwCt4bE
  - » Metaverse is a network of 3D virtual worlds focused on social connections.
  - » It is often described as iteration of internet as a single, universal virtual world that is facilitated by the use of **virtual and augmented reality**.

» Metaverse has its origin in the 1992 science fiction novel "Snow Crash" as a combination for "meta" and "Universe". In this he envisioned lifelike avatars who met in realistic 3D buildings and other virtual reality environments.
» Some of the platforms already developed can be considered metaverse (e.g., **"second life")**.

- **E.g., applications of Metaverse:**
  » Meta envisions a virtual world where digital avatars connect through work, travel or entertainment using VR headsets. For e.g., it may include fake houses where you can invite all your friends to hang out in.
    - https://youtu.be/Uvufun6xer8?t=237
  » Microsoft envisages that it could **involve virtual meeting rooms** to train new hires or chat with your remote coworkers.
  » **Entertainment:** Attend a Concert virtually
    - https://www.youtube.com/watch?v=Uvufun6xer8&t=775s

  - **Key Challenges:**
    » **VR headsets** are still very clunky, and most people experience motion sickness or physical pain if it is worn for too long.
    » **Many Technological challenges** – For e.g., if the person would be wearing headsets, how the facial expressions would be scanned and made available in real time.
    » **Lack of Common Standards:** Various big tech players are building their own versions of an extended virtual reality.
    » **Cyber Security:** For e.g., by not limiting the number of avatars, Metaverse would allow users to create **online representations of others without their consent or verification**. While celebrities may be protected by various impersonation mechanisms. Common people would be more vulnerable.
    - Users are going to require regulatory support which integrates governments, industries, and other users.

  - **What is being done and what is the way ahead?**
    » Mark Zuckerberg, the CEO of the newly named Meta (formerly Facebook), estimates it could take 5 to 10 years before key features of the metaverse become mainstream. But various components of metaverse already exist – Ultrafast broadband speed, virtual reality headsets and persistent always-on online worlds are already up and running.
    » Open-Source Platforms like Web3D Consortium, World Wide Web Consortium, XR Association, and several other industry players have come together as the Metaverse Standards forum to build interoperability into the metaverse.
    » It is important that the work on regulating metaverse starts parallelly. Here civil society, tech companies and government will need to work together to evolve appropriate rules and cybersecurity framework.

9. ELECTRONICS – BASICS

1) Semiconductors: These are materials which have a conductivity between conductors (generally metals) and nonconductors or insulators (such as most ceramics).

- They can be pure elements like silicon or germanium, or compounds such as gallium arsenide or cadmium selenide.
- In a process called **doping** small number of impurities are added to pure semiconductors causing large changes in the conductivity of the materials.
- They are crucial in the development of electronic devices and there would be no radio, TV, Computers etc. without semiconductors.
- An important property of semiconductors is that it has very high resistivity at 0K and its resistivity falls as the temperature goes up unlike metals which have high conductivity at 0K and whose resistivity increase as the temperature increase.
- Semiconductor devices also display other **useful properties** such as passing current more easily in one direction than the other, showing variable resistance and sensitivity to **light or heat**.
- Because **electrical properties** of a semiconductor can be modified by doping, or by the application of electric fields or light, devices made by semiconductors can be used for amplification, switching, and energy conversion.

2) **Diode:** It is defined as a **two-terminal electronic component** that only **conducts current in one direction**. An ideal diode will have **zero resistance (**negligible**)** in one direction, and **infinite resistance** (very large) in the reverse direction. It is effective like a valve for electric current.
   - A **PN junction** is he simplest form of a semiconductor diode. In ideal conditions, this PN junction behaves like a **short circuit** when it is forward biased (current flowing in forward direction), and as an **open circuit** when it is in the reverse biased (current flowing in reverse direction).

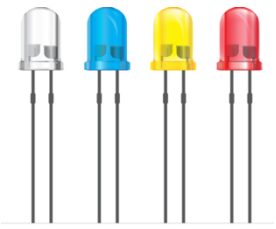
3) **Transistor:** It is a semiconductor device used to **amplify or switch electronic signals and electric powers**. It is one of the basic building blocks of modern electronics. It is composed of semiconductor material usually with at least three terminals of connection to an external circuit.

4) **Amplifier:** It is an electronic device that can **increase the power of a signal** (a time varying voltage of current). It is a **two-part electronic circuit** that uses electric power from a power supply to increase the amplitude of a signal applied to its input terminals, producing a **producing a proportionately greater amplitude signal at its output**.

10. OPTOELECTRONICS

- Optoelectronics is a special discipline of electronics that focuses on light emitting or light detecting electronic devices.

- Light emitting devices **use voltage and current to produce electromagnetic radiation (i.e. light)**. These are commonly used for illumination or indication purposes.
  - E.g. LEDs



- **Light Detecting Devices**, such as photo transistors, **convert received electromagnetic energy into electric current or voltage**. (e.g. photo resistors, solar cells etc.)

- **Light Bulbs** such **as incandescent lights**, are devices that convert electric current into visible lights. **Tungsten wire** has high resistivity and it converts light into heat which results into visible light (photons) to be emitted.

- **Halogen lamps** use a filament that resides inside a gas-pressurized bulb. The pressurized gas consists of an inert gas and a small amount of halogen element such as bromine or iodine. The **combination of** a halogen gas (small amount of iodine or bromine in inert gas) and tungsten filament produces a **halogen cycle** chemical reaction which **redeposits evaporated tungsten to the filament**, increasing its life and maintaining clarity of the envelope. This allows filament to **operate at a higher temperature** than a standard incandescent lamp of similar power and operative life;

- **Fluorescent bulbs** are very different. They consist of **mercury vapor filled glass tube** whose inner wall is coated with a material that fluoresces. When electrons which are emitted from the fluorescent bulb's inner cathode electrode, collide with the mercury atoms, UV radiation is emitted. This **UV radiation is absorbed by the lamp's fluorescent coating, which in turn releases a visible light**.

- **LEDs:** Discussed in detail below.

- **Laser diode** is a semiconductor laser device that is very similar in both form and operation, to a light emitting diode (LED). The laser diode is electrically equivalent to a **PIN diode**. A Pin diode is a diode with a wide undoped intrinsic semiconductor region sandwiched between a p-type semiconductor and an n-type semiconductor.

- **Photo Resistors** are light controlled variable resistors, also known as light dependent resistors (LDRs). Generally, when a photo-resistor is placed in dark, it has high resistance and when it is illuminated the resistance drops dramatically. They are used in light sensitive switching devices.

- **Photo diodes** are semiconductor devices that convert light energy (i.e. photons) directly into electric current.
- **Solar Cells** are photodiodes with exceptionally large surface areas.

11.LIGHT EMITTING DIODES

- **Introduction**
  - » A light emitting **diode** is a semiconductor devise that emits visible light when an electric current passes through it.
  - » The light is **not particularly bright** but, in most LEDs, **it is monochromatic, occurring at a single wavelength**.
  - » The output from an LED can range from **red** (at a wavelength of approximately 700 nanometers) to a blue violet (about 400 nanometers).
  - » Some LEDs emit infrared (IR) energy (830 nanometers or longer); such devices are known as an infrared-emitting diodes **(IRED).**

- **Technical Details**
  - » An LED or IRED consists of two elements of processed material called the P-type semiconductors and N-type semiconductors. These two elements are placed in direct contact, forming a region called **P-N junction**. In this respect, the LED and IRED resemble most other diode types but there are important

differences. The LED and IRED had transparent package, allowing visible or IR energy to pass through. Also, the LED and IRED has a large PN-junction area whose shape is tailored to the application.
  - » **Electrons in the semiconductor** recombine with electron holes, releasing energy in the form of photons.

- **Benefits of LED and IRED,** compared to incandescent and fluorescent illuminating devices, include:
  - » **Low Power Requirement:** Most can be operated with battery power supplies.
  - » **High Efficiency:** Most of the power supplied to an LED or IRED is converted into radiation in the desired form, with minimal heat production.
  - » **Long life:** when properly installed, an LED or IRED can function for decades

- **Other associated benefits**
  - » Climate change
  - » Power deficiency help
  - » Mercury pollution protection (CFLs)

- **Typical Applications include**
  - » **Indicator lights**: These can be two-state (i.e., on/off), bar graph, or alphabetical-numeric readouts.
  - » **LCD panel backlighting**: Specialized white LEDs are used in flat panel computer display
  - » **Fiber Optic Data Transmission**: Ease of modulation allows wide communications bandwidth with minimal noise, resulting in high speed and accuracy
  - » **Remote Control**: Most home entertainment "remotes" use **IREDs** to transmit data to the transmitter.
  - » **Optoisolater**: It is a semiconductor device that uses a **short optical transmission** path **to transfer an electrical signal between circuits or elements of a circuit**, while keeping them electrically isolated from each other.
  - » **Lighting**: LED bulbs
    - **Unnat Jyoti for Affordable LED (UJALA Scheme)**

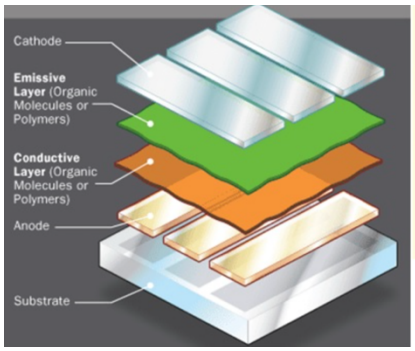
12.ORGANIC LEDS

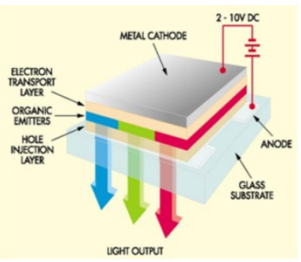
- **OLEDs** are solid-state semiconductor devices composed of thin films of organic molecules that create light with the application of electricity. They are 100 to 500 nm thick or about 200 times smaller than human hair.
- **Advantages**: OLEDs can provide **brighter, crisper displays on electronic devices** and use **less power than conventional LEDs and LCDs (liquid Crystal displays)**.

- **How OLEDs work?**

  OLEDs have two layers or three layers of organic material. It consists of **following parts**:
  - **Substrate** (clear plastic, glass, foil): The substrate supports the OLED.
  - **Anode** (Positive Terminal) (transparent) – the anode removes electrons (adds electrons “holes”) when a current flows through the device.
  - **Organic Layers:** These layers are made of organic molecules or polymers:

a) **Conducting Layers**: This layer is made up of organic plastic molecules that transport "holes" from the anode. One conducting polymer used in OLEDs is **Polyaniline**.



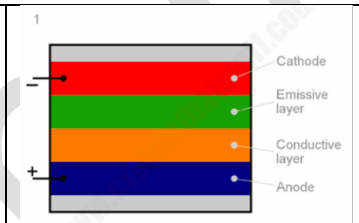
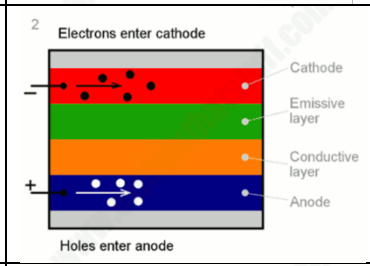
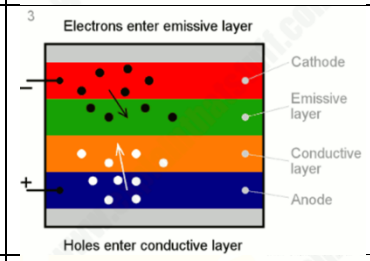
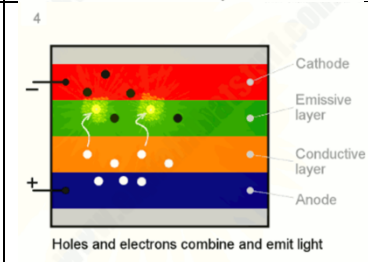


OLED Structure

b) **Emissive Layers**: The layer is made up of organic plastic molecules (different ones from the conducting layer) that **transport electrons from the cathode**; this is where light is made. One polymer using in the emissive layer is **Polyfluorene**.

c) **Cathode (**negative terminal**):** (may or may not be transparent depending upon the type of OLED) – The cathode injects the electron when a current flows through the device.

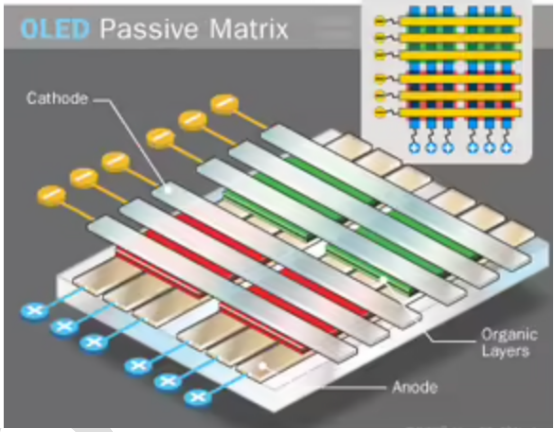
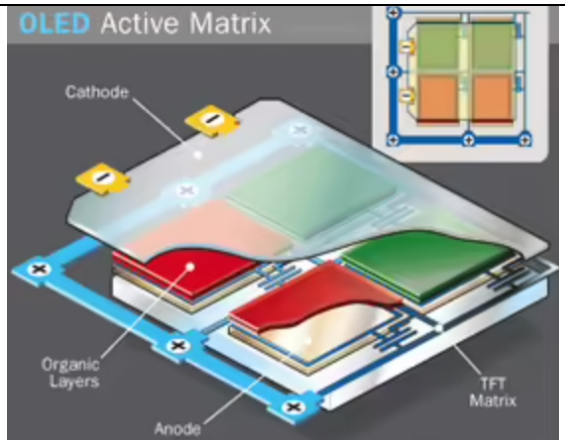
How OLEDS emit light?

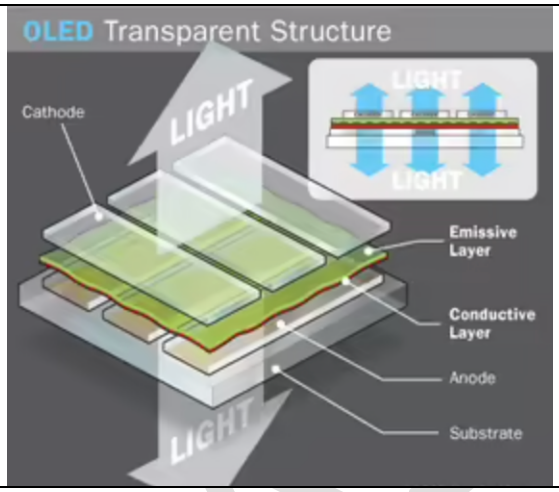
Attach a voltage across cathode and anode.	
As the electricity starts to flow, the cathode receives electrons from the power source and the anode loses them (or it receives holes)	
Added electron is making the emissive layer negatively charged (similar to n-type layer in a junction diode), while the conductive layer is becoming positively charged (similar to p-type material)	
Positive holes are much more mobile than negative electrons, so they jump across the boundary from the conductive layer to emissive layer. When a hole (lack of electron) meets an electron, the two things cancel out and releases a brief burst of energy in the form of a particle of light – a photon.	

- The color of light depends on the type of organic molecule in the emissive layer. Manufacturers place several types of organic films on the same OLED to make colored display.

- **The intensity or brightness** of the light depends on the amount of electrical current applied: the more current, the brighter the light.
- Unlike LEDs, which are small-point light source, **OLEDs are made in sheets that are diffuse-area**. OLED technology is developing rapidly and there are handful of products offering with efficacy, lifetime, or color quality specs that are comparable to LEDs.

Types of OLEDs: They are several types of OLEDs:

Passive-Matrix OLEDs (PMOLED): It consist of strips of cathode, organic layers, and strips of anodes. The anode strips are arranged perpendicular to the cathode strips. The **intersection** of the cathode and anode make up the **pixels** where light is emitted. External circuit applies current to selected strips of anode and cathode, determining which pixels get turned on and which pixels remain off. Brightness of each pixel is proportional to the amount of applied current. **Advantages:** Easy to make **Limitations**: Consumes more powers than other types of OLED, mainly due to power needed for external circuit. **Application**: Suitable for text and icons and thus are best suited for screens (2 to 3 inch) such as those used in cell phones, PDAs, and MP3 players. **Note:** Even with external circuitry, passive matrix OLEDs consume less battery power than the LCDs that currently power these devices.	
AMOLED (Active-matrix OLED): They have full layers of cathode, organic molecules and anode, but the anode layers overlay **a thin film transistor (TFT) array** that forms a matrix. The TFT array itself is a circuitry that determines which pixels get turned on to form an image. **Advantages**: - Consumes less power than PMOLEDs because TFT array requires less power than external circuitry, so they are efficient for large displays. - They also have faster refresh rates suitable for videos. **Applications**: Computer Monitor, large-screen TVs and electronic signs or billboards.	

Transparent OLEDs: They have only transparent components (substrate, cathode, anode) and, when turned off, are upto 85% as transparent as their substrate. When a transparent OLED display is turned on, it allows light to pass in both directions. It can be PMOLED or AMOLED. This technology may be used for **heads-up displays**.	
Top Emitting OLEDS: They have substrate that is either opaque or reflective. They are best suited to active-matrix design. Manufacturers may use top-emitting OLED displays in smart cards.	
Foldable OLEDs: They have substrate made of very flexible metallic foils or plastics. They are lightweight and durable. Their use in devices such as cell phone and PDAs can reduce breakage, a major cause of phone repairs. They can also be used for making smart clothing.	
White OLEDs: they emit light that is brighter, more uniform and more energy efficient than that emitted by fluorescent lights. They also have the true color quality of incandescent lighting. Because OLEDs can be made in large sheets, they can replace fluorescent lights that are currently used in homes and buildings. Their use can reduce the energy cost of lighting.	

Advantages of OLEDs:

- **OLEDs** can be **configured as large-area, more diffuse light sources** whose soft light can be viewed directly. This eliminates the need of shades, diffusers, lenses, or parabolic shells.
  - This diffused light allows them to be used very close to the task surface without creating glare for the user.
- **OLEDs** can be made very thin, increasing their eye appeal and allowing for easy attachment to the surface of walls and ceilings.
- The Plastic, organic layers of an OLED are **thinner, lighter, and more flexible** than the crystalline layers in LED or LCD.
- OLEDS are brighter than LEDs.
- Because the organic layers of an OLED are much thinner than the corresponding inorganic crystal layer of an LED, the conductive and emissive layer of an OLED can by multilayered. Further, it doesn't require glass for support (which is needed by LED)

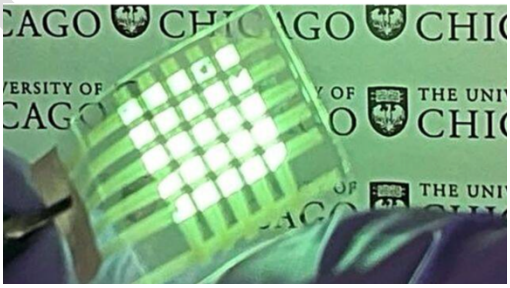
» **OLEDs** are much more energy efficient.
» OLEDs don't require backlighting like LCDs. LCDs work selectively blocking areas of backlighting to make the images that you see, while OLEDs generate light themselves. Because OLEDs don't require backlighting, they consume much less power than LCDs (most of the LCD power goes to the backlighting). This is specially important for battery-operated devices such as cell phones.
» **OLEDs** are easier to produce and can be larger in size. Because OLEDs are essentially plastic, they can be made into large, thin sheets.
» OLEDs have **larger field view,** about 170 degrees. Because LCDs work by blocking light, they have an inherent viewing obstacle from certain angles.
» **OLEDs** can be made up of almost any shape and can be deposited on flexible substrates.

Limitations of OLEDS:
» **Lifetime**: Blue organics currently have much shorter lifetime.
» **Expensive manufacturing**
» **Water** can easily damage OLEDS.

13.FLEXIBLE OLEDS

- **Why in news?**
  - Researchers have developed a stretchable OLED display technology that could power wearable electronics and other flexible form factors devices in future (April 2023)

- **Details**
  - Researchers at the University of Chicago have developed an OLED material that is **so flexible** that it can be bent in half or stretched to more than twice its original length while still emitting light.



  - It represents a new technology that could possibly be used to develop stretchable fabric-like displays in the future. It could be used in flexible displays for a variety of applications, including wearable electronics, health sensors, and even foldable devices, according to the University of Chicago.
- **Need**: The material that are currently used in OLED displays are very brittle and are not very stretchable. With this in mind, the researchers set out to create a material than mantained the light-emitting properties of OLED but was also stretchable.
- **Design Strategy**: Design strategy of inserting flexible, linear units into polymer backbones can greatly increase stretchability without affecting light-emitting performance.

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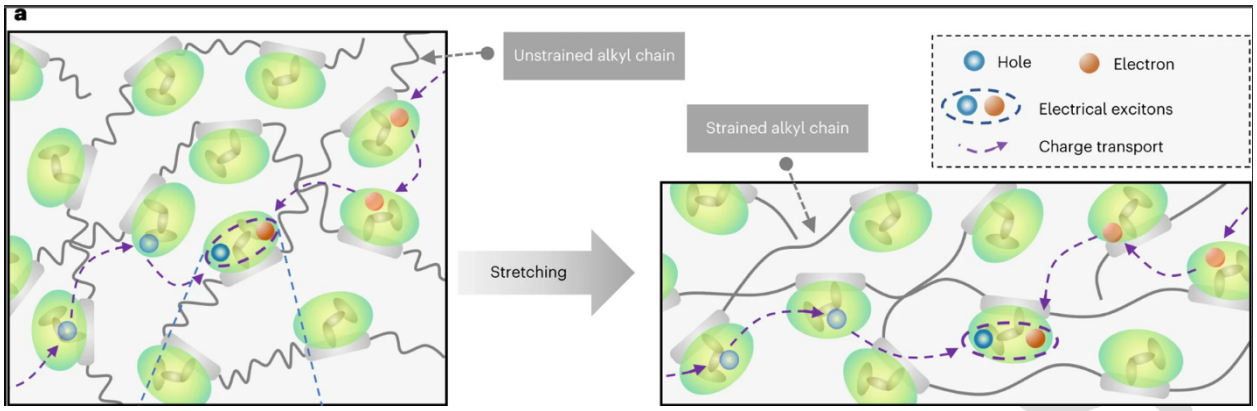


14.LASER (LIGHT AMPLIFICATION BY SIMULATED EMISSION OF RADIATION)

- **Introduction**
  - A laser is a device that generates an intense beam of **coherent monochromatic light** (or other electromagnetic radiation) by stimulating of photons from excited atoms or molecules.
  - **How does laser differ from normal light?**
    - **Monochromatic: Same Wavelength/frequency** (whereas normal light contains multiple wavelength)
      - This wavelength is determined by the amount of energy released when the excited electrons drop to a lower orbit.
    - **Coherent** (ordinary light is not coherent): It means that all light waves are in phase with one another.
    - **Very narrow, highly directional and doesn't diverge**:
    - The laser beam is **extremely intense**.
- **Uses**: Lasers are used in
  - Precision tools to cut through diamonds or thick metal.
  - Laser surgery
  - Skin treatment
  - Optical disk drive
  - Laser printers
  - Barcode scanners
  - Fiber optics
  - Free space optical communication
  - Drilling, cutting and welding materials
  - Military and law enforcement devices
  - Laser light display in entertainment
  - Remote sensing

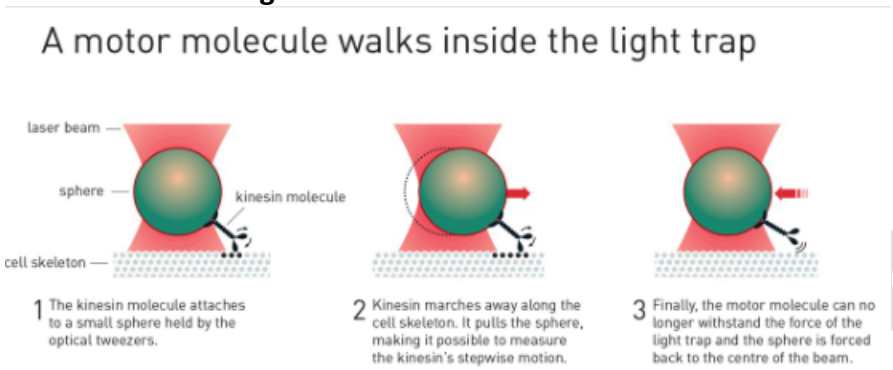
Lasers in India

India currently has two lasers that produce 100 Terawatt (10 to the power 12) beams.

The Raja Ramanna Centre for Advanced Technology in Indore is in the process of installing two petawatt systems, while another is likely to be installed in Hyderabad.

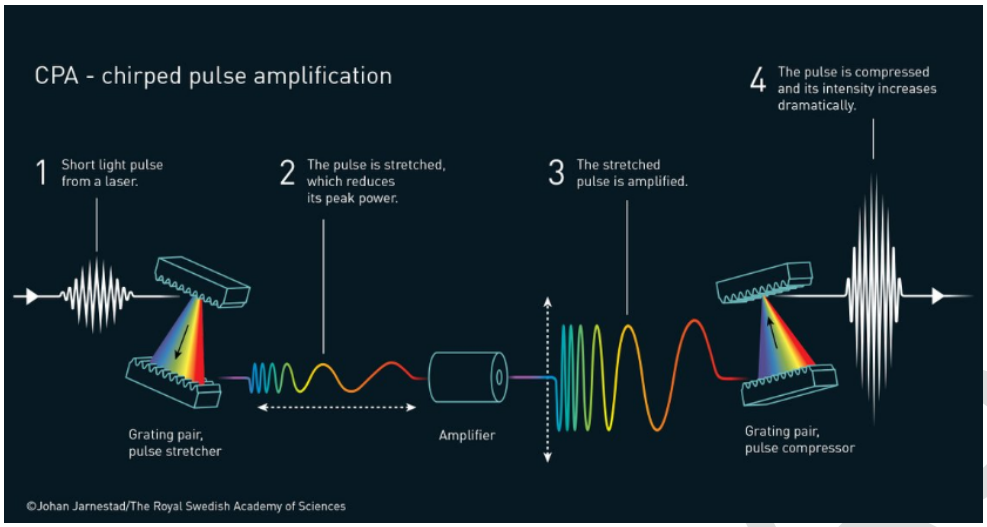
- **Nobel Prize in Physics, 2018 for LASER Physics Work**
  - **Arthur Ashkin** received the prize for the **optical tweezers** and their applications to biological system

- These optical tweezers are able to grab particles, atoms, viruses, and other livings cells with **laser beam fingers**.

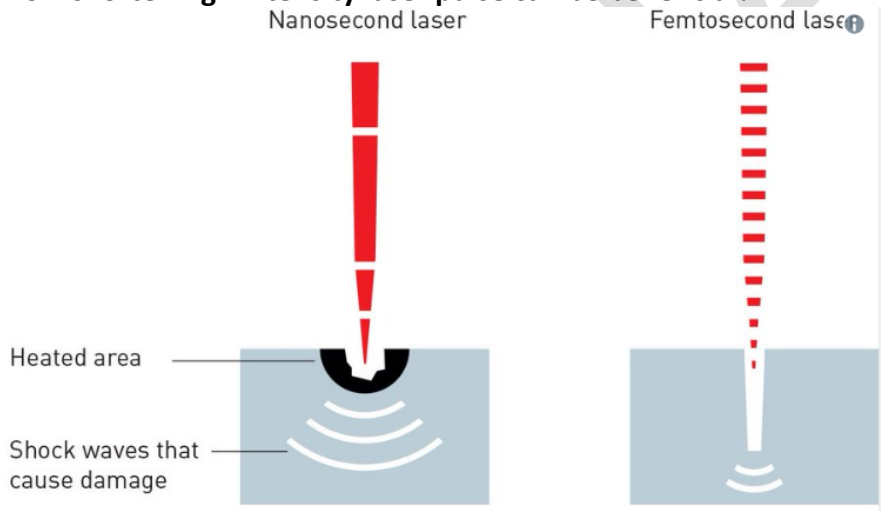


- These optical tweezers are widely used for isolating and examining very small particles, such as individual atoms, DNA strands, or biological cells.
- This helped scientists understand the behavior of single atom or cells, instead of studying the average behavior of an aggregation of such particles.
- The tweezers can capture living bacteria without harming them, a breakthrough he achieved back in 1987.
- **Note:** Arthur Ashkin, at the age of 96, has become the oldest scientist ever to be awarded a Noble Prize.

- **Gerard Mourou and Donna Strickland** were jointly awarded for their method of **generating high-intensity, ultra-short optical pulses**.
  - They created ultrashort high-intensity laser pulses without destroying the amplifying material, thus paving the way towards the shortest and most intense laser pulses ever created by mankind.
    - **Note: Donna Strickland** is only the third women to receive nobel prize in physics. Before her, **Marie Curie** had won it in 1903 and **Maria Goeppert-Mayer** in 1963.
  - **What was the problem earlier**?
    - Within a few years of the invention of laser, laboratory tabletop lasers had started achieving very high power of about a gigawatt. But after this state of peak power was reached, more intense pulses of power could not be produced without **damaging the amplifying material**.
  - **How the problem was solved?**
    - The two scientists increased the duration of the pulses before the light was amplified so that the intensity comes down.
    - The light could then be amplified normally.
    - This amplified pulse could then be compressed back to its original time duration, and thus increasing its intensity by several order of magnitude.
  - Their innovative technique, known as '**chirped pulse amplification**' (CPA), has now become standard for high intensity lasers, including the ultra-sharp beam used in corrective eye surgeries. It allows to cut and drill very precisely in various matter.



- **How shorter high intensity laser pulse can be beneficial?**



- With ultrashort and intense laser pulses, we can see events that previously seemed instantaneous. Laser pulses shorter than 100 attoseconds reveal dramatic world of electrons.
- It has also made it possible to cut and drill holes in material and living matter incredibly precisely.
- This has allowed corrective eye operations for millions of users.

A) LIDAR

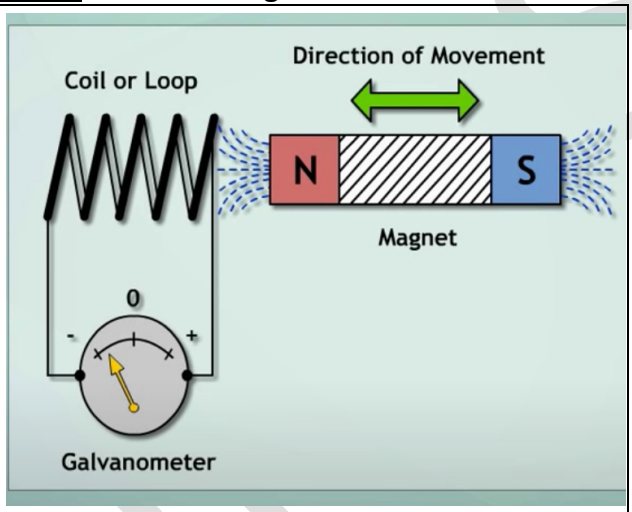
- It stands for Light Detection and Ranging. It is a **remote sensing method** that uses light in the form of a pulsed laser to measure ranges (variable distance) to the Earth.
- These light pulses - combined with other data recorded by the airborne system - generate precise, three-dimensional information about the shape of the earth and its surface characteristics.
- LiDAR instrument principally consists of a laser, a scanner, and a specialized GPS receiver.
- **Two types of LIDAR** are **topographic** and **bathymetric**.
  Topographic LIDAR typically uses a **near-infrared laser** to map the land, while
  Bathymetric Lidar uses water-penetrating green light to also measure seafloor and riverbed elevations.
- **Applications**
  - Used in projects related to roads, canals, surface transport, city planning, landslides, irrigation etc.

- The system can be brought to use for engineering designs, conservative planning, floodplain mapping, surface feature extraction (trees, shrubs, roads and building) and vegetation mapping (height and density).

15. WIRELESS CHARGING

- Inductive charging (also known as wireless charging) uses an electromagnetic field to transfer energy between two objects through electromagnetic induction.
- The **induction of an electromotive force (voltage)** by the motion of a conductor across a magnetic field or by a change in magnetic flux in a magnetic field is called **'Electromagnetic Induction'**.

- **Understanding Law of Induction in 1830**:



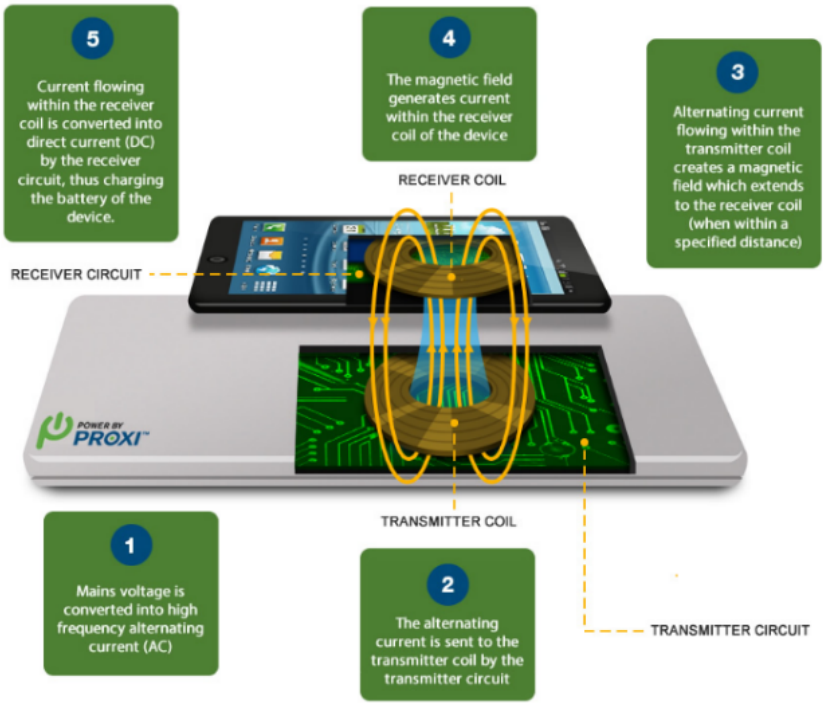
- **Michael Faraday** discovered **Law of Induction** in 1830.
  - **First Law:** Whenever a conductor is placed in a varying magnetic field, EMF induces and this emf is called an induced emf and if the conductor is closed circuit than the induced current flows through it.
  - **Second Law:** The **magnitude of EMF** id equal to the rate of change of flux linkages.
- The machines like generators, transformers, motors etc. work on the principle of electromagnetic induction.
- Similarly, while magnets can create magnetic fields, **electric fields can also create magnetic fields**.
- In fact, every time you change a magnetic field, you create an electric field. This is called Faraday's Law of Induction.
- Similarly, every time you change an electric field, you create a magnetic field. This is called the **Maxwell-Ampere Law**

- **This is what happens in wireless charging.** Energy is sent through inductive coupling to an electrical device, which can then use the energy to charge batteries or run the device.
-

- **Advantages of inductive charging/wireless charging?**
  - **Protected Connection** -> No Corrosion, less risk of electric faults, short circuits etc.
  - **Low infection risk**
  - **Durability**

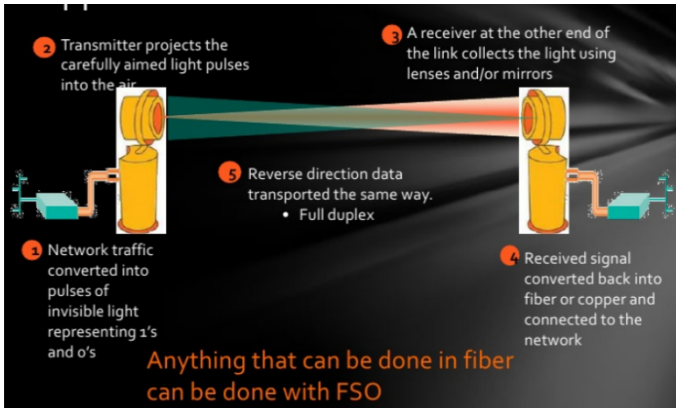
- **Increased convenience and aesthetic quality**

- **Limitations**
  - **Less efficient**
  - **Slower Charging**
  - **More Expensive**
  - **Inconvenient**
  - **Multiple Standards**
    - Magne Charge, Qi etc are multiple standards being used in the market. This confuses the user and same charger cannot be used for all the devices.



16. FREE SPACE OPTICAL COMMUNICATION

- **Introduction**
  - It is a communication technology which uses light propagating in free space to wirelessly transmit data for telecommunications or computer networking.
  - Most of the time laser beams are used, although non-lasing sources such as Light emitting diodes (LED) or IR-emitting diodes (IREDs) will serve the purpose too.
  - "Free space" could mean air, outer space, vacuum etc.



- **How does FSO work?**
  - The basic principle is similar to fiber optics transmission other than the fact that here the energy beam is collimated and sent through clear air or space, rather than guided through optical fiber.
  - At the source, the visible or IR energy is modulated with the data to be transmitted. At the destination, the beam is intercepted by a photodetector, and data is extracted from the visible or IR beam (demodulated).
  - Optical transceiver on both ends ensure bidirectional (duplex) capabilities.
- **Line of Sight Requirements**

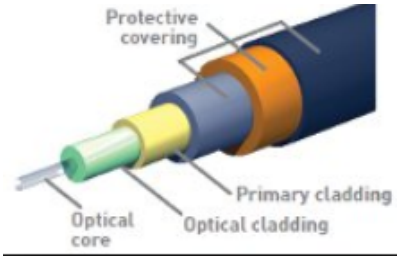
- Theoretically, FSO technologies can work over distance of several kms, as long as the source and the destination are in line of sight.

- **Uses**
  - The technology is very useful where physical connections are impractical due to high cost or other considerations.
  - It can be used for communication between spacecrafts. The first gigabit laser-based communication was achieved by the European Space Agency and called European Data Relay System (EDRS) in 2014. The system is still in operation.
  - LAN-to-LAN connections in campuses for very high-speed Ethernet access
  - To cross a public space (like road) which user doesn't own.
  - For temporary network installations, this is a better option as minimum infra set up is needed.
  - In disaster situation, it can re-establish data connections quickly
  - For high speed inter and intra chip communication.
- **Advantages**
  - Ease of deployment (very less infrastructure investment)
  - Can be used to power devices
  - License free long-range operations (as opposed to spectrum allocation licenses for microwave/radio wave communications)
  - Very high data bandwidth (very high speed of data communication)
  - Immunity from electromagnetic interference
  - Full duplex operation
  - Increased security when working with narrow beams (line of sight operation ensures security)
- **Limitations**
  - Stability and quality of the link is highly dependent on atmospheric factors such as rain, fog, dust and heat.
  - Doesn't work for non-line of sight senders and receivers

17.FIBER OPTICS COMMUNICATION

- **Introduction**
  - FOC is the method of transmitting information from one place to another by sending pulses of light through an optical fiber. Light basically forms the electromagnetic carrier wave that is modulated to carry information.

- **Key components**
  - **Transmitter** (light source) generates a light stream modulated to enable it to carry the data. Conventionally a pulse of light indicates "1" and absence of light indicates '0".



- **Fibre Optic cable** is the very thin fibre of glass or other suitable material through which the modulated light stream travels to reach the destination. An optical fibre cable consists of a **core**, **cladding**, and **a buffer** (a protective outer coating). Cladding guides the light along the core by using the method of total internal reflection. The core and the cladding (which is of lower-refractive index) are usually made of high quality silica glass or plastic.

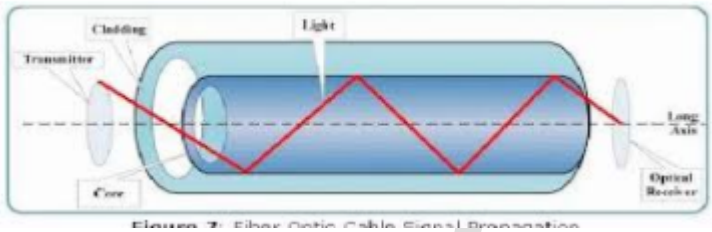


Figure 7: Fiber Optic Cable Signal Propagation

- **Optical repeater and amplifier:** In order to overcome the effects of attenuation of the cable, distortion of the light signal along the cable and to ensure that signal gets transmitted over long distances, repeaters and amplifiers are used.
- **Receiver** (Detector) converts the pulses of light into equivalent electrical pulses.

- **Advantages of fiber optics over electrical cabling**
  - Lower Signal Attenuation
  - Higher Bandwidth
  - Can travel longer distances
  - Fiber optics cables are much lighter than the coaxial cable (that might otherwise be used). This is very crucial in cases like that of aircraft
  - No sparks – important for flammable and explosive gas environment
  - Fiber optics do not suffer from stray interference pick up that occurs with coaxial cables.
  - Further fiber optics transmission also doesn't suffer from cross talks in contrast to some type of electrical transmission signal.
  - Resistant to corrosion due to non-metallic transmission medium.

- **Limitations of fiber optics over electrical cable**
  - Fiber optical system are more expensive to install
    - The cost of cable, the transmitter and receiver is higher in case of fiber optics
  - Electrical cable has the capability of carrying electrical currents as well as signals (in properly designated cables), whereas optical fibers can only be carrying signals.

- **Applications**
  - Telecommunication (telephone signals, internet communication and cable tv)
  - Due to lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance, high demand applications and high-resolution content.

- **India and Fiber Optic Communication**
  - The **National Optical Fiber Network** (NFON) is a project initiated in 2011 to provide broadband connectivity to 2.5 lakh **gram panchayats** of India (min bandwidth of 100 Mbps) at an initial cost of 20,000 crore rupees.
    - The project intended to enable government of India to provide e-services and e-applications nationally.

- **BharatNet (**rechristening of NOFN) is a project of national importance to establish, by 2017, a highly scalable network infrastructure accessible on a non-discriminatory basis, to provide **on demand**, affordable broadband connectivity of 2 Mbps to 20 Mbps for **all households** and on demand capacity to **all institutions**, to realize the **vision of digital India**, in partnership with states and private sector.
  - The entire service is being funded by Universal Service Obligation Fund (USOF), which was set for improving telecom services in rural and remote areas of the country.
  - The **objective** is to facilitate the delivery of e-governance, e-health, e-education, e-banking, Internet and other services to rural India.
  - **Implementation:** the project is a centre-state collaboration, with the states contributing free Rights of Way for establishing the Optical Fiber Network.

18.3D PRINTING

- **Intro**
  - 3D Printing (also known as additive manufacturing) is a process where an object is created by adding material layer by layer from a computer blueprint/design. It allows designers to create complex parts for machines, airplanes and cars at a fraction of cost and time of standard means like forging, molding and sculpting.
  - Now, smaller consumer friendly 3D printers are bringing additive manufacturing to homes and businesses.

- **Key steps involved in 3D printing**
  - **Create a blueprint** of the object that requires to be printed. **Modelling software like blenders, CADs** etc. can be used to create the design to be printed.
  - **Printing** works on the layering principle where layers of material is added till the final object is created. Most common material used in 3D printing is plastic, but other material can also be used.

- **Three key advantages of 3D printing** are **shorter lead time**, **design freedom**, and **lower costs**.
- **Main uses:** It's hard to find a sector where 3D printing hasn't had an impact.
  - **Manufacturing and other industrial sector** can now use 3D printing to develop prototype models and test new components.
  - It is also playing a significant role on **fashion industry** with fashion designers experimenting with 3D-printed clothes shoes etc.
  - **Medical Sector** has been one of the biggest beneficiaries of the technology
    - Doctors have been testing biomaterials for regenerative medicines. Some surgeons have even tested 3D printed organs for transplant.
  - **Cultural Heritage preservation, restoration, and dissemination**
    - Many museums in advanced countries have started using the 3D printing technology for actively creating missing pieces of relics.
  - **Homes and other buildings:** Recently a giant 3D printer in China **printed 10 houses** in just one day and at a cost of less than $5,000 per house. It proved how cost and time efficient 3D printing can be.
  - **Food Industry:** 3D printing is being used for designing cakes on demand and other food items.
  - **Defence Sector**:
    - For e.g., the corps of Engineers used 3D printing to construct 22,000 temperatures controlled, relocatable, habitat in the high-altitude areas of LAC.

- In addition to 3D printing habitat, the Army's Corps of Engineers in consultation with IIT Gandhinagar, came up with **3D printed permanent defenses** for forward areas. Trials have shown that these **3D printed defences** can take direct hit from T-90 tank from 100 meters away and can be constructed in a much shorter time frame compared to regular defensive bunkers.

- **Key Concerns**
  - **Intellectual Property Rights**: Once 3D printing becomes very popular, it would be difficult to prevent the IPR violation by individuals at their homes and privately.
  - **Health Issues:** Experts have raised concerns about potential health implications of the technology due to exposure to gases and other materials including nanomaterial. Particle emissions from a fused filament generally peaks during printing and may include a large number of ultrafine particles and volatile organic compounds.
  - **Public Safety** may become an issue with 3-D printing advanced guns being available with anti-social elements, including terrorists.

19.BARCODE AND QR CODES

A) QR CODE (QUICK RESPONSE CODE) – A TYPE OF 2D BAR CODE

- **What is QR Code and how does it work?**
- Developed in 1994 by a Japanese Cooperation Denso Wave – a subsidiary of Toyota motors.

- QR Code, in full Quick Response Code, **is a type of bar code that consists of printed square pattern of small black and white squares that encode data which can be scanned into a computer system**.
- The black and white square can represent numbers from 0-9, letters A-Z, or characters in non-Latin scripts such as Japanese Kanji.
- The three corners of the QR code contain the finder pattern, a nested series of black and white squares that, when detected by an optical scanner and interpreted by software, allows the scanning device to determine the **orientation of the QR code**.
- **Advantages over barcode**
  - Store hundred times more information
  - Can be scanned from any direction for 360 degrees. This makes it easier for devices to read and lessens the possibility of background interference. Further, it doesn't need a special laser emitting device to read, camera of a smart phone or tablet computer is good enough for scanning the information.
  - Fewer errors – since QR codes have more storage, it can store same information multiple times to reduce the impact of physical damage of the code.
  - More Secure – as it is possible to encode the information in bar codes.
  - In **marketing**, the code's appearance is unique and interesting, increasing the likelihood of engaging the customers.
- **Uses:**
  - Used in advertising, to encode URL of a website that contain a coupon or information about a product.
  - Used in books to help students easily access the webpage.

B) BAR CODE

- Bar code is an optical, machine readable form of data. It is a printed series of parallel bars or lines of varying width that is used for entering data into a computer system. This data usually defines something about the product which carries the barcode.
- Barcodes represent data by varying the widths and spacing of parallel lines.
- **Uses:**
  - **Automation of supermarket checkout** is the most common place where we see bar code scanner. In fact, this use of barcode has almost become universal.
  - **Supply chain management**
    - **Advantages**
  - Speed of processing
  - Better tracking **(**in case of supply chain management)
  - Low cost and very accurate (compared to key entry)
    - **How does a bar code scanner work**?
  - Laser/LED is reflected back better from the white spaces (and not from the black bar).
  - This reflection is converted into on-off pulse in the binary digit by an electronic circuit attached to the scanner.

20.TOPICS TO BE COVERED IN FUTURE BOOKLETS

- Wireless Communication (5G/6G), Bluetooth, WiFi, NFC, RFID etc.
- VOLTE/ VoIP/ VoWiFI