Science and Technology Class 01

Relevance of the topic and sources(1:07:00PM)

- **Prelims**
- You can expect 10-15 questions
- **Mains(Paper 3)**
- You can expect 3-4 questions
- **Sources**
- 9th and 10th NCERT
- The Hindu(Thursday and Sunday Science section, Explained pages, Editorials)
- Indian Express(Explained pages, Editorials)
- Classes will act as base material
- Complementary material- Monthly magazine
- **Class plan**
- Space technology
- Nuclear technology
- Nanotechnology
- ICT, Robotics
- Defence
- Intellectual Property Rights
- Contribution of Indians in Science and Technology
- Miscellaneous

Space Technology(1:18:00PM)

- Syllabus and PYQ discussion
- **Topics to be covered here:**
- Basics
- Orbits
- Satellites
- Launch vehicles
- Upcoming missions of ISRO
- Emerging issues
- **Basics**
- Copernicus said that Earth is revolving around Sun.
- Galileo used his telescope and confirmed the claims of Copernicus.
- Kepler gave his laws on planetary motion
- **Newton's laws of motions**
- In the **first law**, an object will not change its motion unless a force acts on it.
- In the **second law,** the force on an object is equal to its mass times its acceleration.
- In the **third law**, when two objects interact, they apply forces to each other of equal magnitude and opposite direction.
- **Vector and scalar**
- For certain quantities, magnitude and direction both are required. They are called **vectors.**
- Example: Displacement, Velocity, Acceleration, Force, Momentum.
- For certain quantities, only magnitude is required. They are called **scalars.**
- Example: Distance, Speed, Work, Energy, Mass
- **Circular motion**
- Magnitude is constant, however, the direction is changing at every instant. Therefore, the velocity is constantly changing.
- Force is required for such a motion.
- In the case of planets, the force is provided by the **gravitational force.**
- **The centripetal force** is always pointed toward the center of a circle and keeps an object moving in a circle.

Kepler's laws of Planetary motion(1:48:00PM)

- **First law**
- Explained with the help of a diagram.
- Every planet moves in an elliptical orbit around Sun with Sun being at one of the foci of the ellipse.

- **Second law**
- Explained with the help of a diagram.
- Planets sweep an equal area in equal time.
- This is a consequence of the **conservation of angular momentum.**
- **Third law**
- Explained with the help of a diagram
- The square of the time period of revolution is proportional to the cube of the semi-major axis of the ellipse.
- Doubt resolution

Orbits and their types around Earth(2:20:00PM)

- **Orbit**
- It is a curved path of a celestial object or an artificial satellite around another celestial object due to the force of gravity.
- Orbits around Earth are used by satellites for various purposes. They can be categorized based on many parameters:
- **Classification 1- Based on height**
- **a. Low Earth Orbit(LEO)- vary from 180-2000km**
- Benefit: Launching is easier, Better resolution- so good Earth observation
- Limitation- It can observe a portion only for a very short period of time
- **b. Medium Earth Orbit- from 2000 to 35785km**
- **c. Geosynchronous and High Earth orbits- >=35786km**
- Benefits: Good for communication, Can observe portions of Earth for a longer period of time
- Limitations: Resolution in case of Earth observation will be low, and launching is difficult
- **Karman line**- an imaginary line 100km above Earth's surface. Only a technical definition, no scientific basis.
- **Classification 2- Based on inclination**
- **a. Polar orbit(around 90degrees)**
- They are useful for Earth observation.
- They are especially beneficial because they provide global coverage with an excellent view of polar regions.
- Despite the fact that polar launches are more difficult(they do not get help from Earth's rotation), polar orbits are very useful for Earth's observation.
- **b. Equatorial orbit(around 0 degrees)**
- **c. Inclined orbits**
- **Classification 3- Based on the shape of the orbit**
- **a. Circular**
- Example: Geostationary orbit, some polar orbits
- **b. Elliptical**
- **Classification 4- Based on Earth's motion**
- **a. Rotation on axis**
- Example: Geosynchronous orbit
- **b. Revolution around Sun**
- Example: Sun-synchronous orbit

Geosynchronous orbit(3:21:00PM)

- In geosynchronous orbit, the satellite's orbital motion is in synchronisation with Earth's rotation on its axis. This means the satellite completes one orbit in **one sidereal day(23 hrs, 56 min 4 sec)** at an **altitude of 35786 km.**
- **Geostationary orbit** is a special case of geosynchronous where the **orbit lies in the equatorial plane.**
- In this orbit, the satellite seems to be fixed with respect to a point on Earth's equator.
- Geostationary is a **circular orbit.**
- These orbits are generally used for **communication satellites** and sometimes also for **Earth observation and navigational satellites.**
- **Geotransfer orbit**
- To attain geosynchronous and geostationary orbits, a spacecraft is first launched into a **highly elliptical orbit with an apogee in the range of 36000km.**
- Once it reaches to the apogee, it can be given a boost and injected into the desired orbit.
- The **temporary orbits** are called as **geotransfer orbits.**

Sun-synchronous orbit(3:40:00PM)

- In sun-synchronous orbits, **satellite's orientation is fixed relative to Sun throughout the year.**
- Whenever satellite observes a given ground location, the Sun is always in the same location in the sky.
- The satellite passes over a point of the planet surface at the **same local solar time.**
- This consistent lighting is a useful characteristic for satellites that image the Earth's surface. Scientists can **compare images** over several years without worrying about extreme changes in lighting and shadow.
- Sun-synchronous orbit height is about **600-800km** with an **inclination of 94 to 98 degrees.**
- It is also like a **polar orbit.**
- **How to achieve sun-synchronous orbit**
- Earth is not a perfect sphere.
- It has mass asymmetry that is, bulge on the equator and flatness on the poles
- Because of this mass asymmetry orbits of satellites around Earth itself changes. This is called **orbital precession.**
- This orbital precession is not desirable.
- In case of sun-synchronous orbit, we use this challenge as an opportunity.
- In this orbit, orbital precession cancels out daily change in the position of the Sun because of Earth's revolution around it.
- A 360deg precession is required in 365 days. Hence per day precession is approximately 1 deg.

Topics for next class: Sun-synchronous orbit continued and types of satellites
Science and Technology Class 02

A brief review of the last class and Doubt resolution
Types of satellites(1:15:00PM)

- 1. Communication satellites
- 2. Earth Observation satellites/ Remote sensing satellites
- 3. Navigational satellites and others.
- **1. Communication satellites**
- Communication satellites create a communication channel between a source transmitter and a receiver at different locations on Earth.
- These satellites relay and amplify a radio telecommunication signal via a transponder.
- They are generally placed in geosynchronous orbits.
- INSAT(Indian National Satellite) programme of ISRO is one of the largest communication programmes in the Asia-Pacific region.
- **Applications**
- a. Tele education- EDUSAT(Educational Satellite) programme of India
- b. Tele-medicine- Connecting remote rural colleges to speciality hospitals in cities via satellites.
- c. Radio, television
- **d. VSAT(Very Small Aperture Terminal)**
- These are Earth stations that receive and transmit data via satellites.
- Their antenna size is about 60 cm to 4 metres.
- e. Village resource centre- It is ISRO's programme using SATCOM to help some Panchayats in panchayat planning, vocational training, weather information, etc.
- f. COSPAS-SARSAT- It is an intergovernmental satellite-aided search and rescue programme. It can be used by aircraft, ships and also people.
- g. GAGAN

Earth Observation or remote sensing satellites(1:49:00PM)

- These satellites are designed for Earth observation from orbit.
- There are many sophisticated techniques such as spectroscopy, LIDAR(Light Detection and Ranging), Radar imaging, Synthetic Aperture Radar, Hyperspectral imaging.
- These techniques can be used to find the physical, chemical or even biological properties of a particular location on Earth.
- **Applications**
- Agriculture and soil monitoring
- Renewable energy capacity
- Environmental monitoring
- Geology and Geomorphology
- Groundwater resources

- Natural resource monitoring
- Ocean sciences
- Weather and climate
- Disaster management
- Governance
- EOS 01, Cartosat 3, etc are some of the recent remote sensing satellites.
- PYQ discussion

Data Relay Satellites(2:26:00PM)

- Explained through slides
- Earlier they were called **Indian Data Relay Satellite System(IDRSS)**, now they are known as **CMS 04**.
- **NISAR Mission**
- Explained through slides
- It is a collaboration between NASA and ISRO.
- NASA-ISRO Synthetic Aperture Radar
- **GISAT 1**
- Explained through slides

Navigational satellites(2:49:00PM)

- Navigational satellites allow small electronic receivers to provide their location(longitude, latitude and altitude to high precision).
- Example: GPS(USA), GLONASS(Russia), Galileo(European Union), BeiDou(China) , Quasizenith(Japan).
- **NAVIC**
- It is a regional navigational satellite system developed by ISRO.
- It consists of 7 IRNSS(Indian Regional Navigation Satellite System) satellites- 3 in Geostationary and 4 in Geosynchronous orbits.
- It will provide reliable locational services in India and the neighbourhood region, about 1500km beyond India's border.
- Like other navigational satellites, it will provide two types of services:
- **a. Standard Positioning Service** for civilian use
- **b. Restricted Service-** these are encrypted services provided only to authorised users such as military personnel, intelligence officials.
- **Difference between NAVIC and GPS**
-

NAVIC	GPS
Regional	Global
7 satellites	32 active satellites(may change)
Present in geosynchronous and geostationary orbits	Present in Medium Earth Orbit(around 20000km)
Low cost	High cost

- **Applications**
- Terrestrial, aerial and marine navigation
- Integration with mobile phones
- Vehicle tracking
- Disaster management
- Precise timing
- **GAGAN**
- Explained through slides
- Doubt resolution

Launch vehicles/Rockets(3:38:00PM)

- They are used to carry manned or unmanned missions to space.
- They have 4 major components: Fuel, Engine, Command Centre and Payload.
- **Rocket fuel**
- It is also called a propellant.
- It can be of 2 types-
- **a. Solid**
- They are cheaper, and simpler, however, once they start burning the resulting thrust can not be controlled.

- For example, HTPB(Hydroxy terminated polybutadiene)
- **b. Liquid**
- Dedicated infra is required for storage and transportation of liquid fuel which makes them more expensive.
- The flow of liquid fuel can be controlled and thus resulting thrust can be controlled.
- Examples:
- UDMH(Unsymmetric dimethyl hydrazine) + N2O4
- MMH(Monomethyl hydrazine) + MON(Mix of Nitrogen Oxides)
- Rockets often use a combination of solid and liquid fuel to get the best benefit of both.
- Doubt resolution

Topics for next class-Engines, Missions of ISRO
Science and Technology Class 03

Doubt resolution and a brief review of the last class
Engine(1:10:00PM)

- Engines can be divided into 2 categories:
- **a. Non-air breathing**
- Such engines carry both fuel and oxidizer.
- Examples: PSLV, GSLV
- **b. Air-breathing engine**
- Oxygen requirement is fulfilled from the atmosphere.
- Examples: Jet engine, Ramjet, and Scramjet engines.

Launch vehicles of ISRO(1:15:00PM)

- **Past**
- SLV(Satellite Launch Vehicle)
- ASLV(Augmented Satellite Launch Vehicle)
- **Present**
- PSLV(Polar Satellite Launch Vehicle)
- GSLV- Mark 2 (Geosynchronous Launch Vehicle)
- GSLV Mark 3(Geosynchronous Launch Vehicle)
- SSLV(Small satellite launch vehicle)
- **Future**
- RLV(Reusable Launch Vehicle)
- Scramjet

PSLV(Polar Satellite Launch Vehicle)

- It is one of the world's most reliable launch vehicles.
- It has 4 stages that alternate between solid and liquid fuels. (S-L-S-L)
- It is capable of placing multiple payloads into orbit.
- It is generally used for delivering Earth Observation satellites in Low-Earth Orbits.
- **Capacity:**
- LEO(1750kg) and GTO(1425kg)

GSLV(Geosynchronous Satellite Launch Vehicle)

- It was developed to launch communication satellites in geosynchronous transfer orbits.
- It comprises 3 stages- solid, liquid, and cryogenic.
- **Capacity:**
- GSLV Mk 2: LEO(5000kg) and GTO(2500kg)
- GSLV Mk 3: LEO(8000kg) and GTO(4000kg)
- **Cryogenic stage**
- A cryogenic rocket engine uses a cryogenic fuel or oxidizer or both at very low temperatures.
- At such low temperatures, hydrogen and oxygen exist in the liquid stage which is used as fuel and oxidizer.
- Technically, it is a very complex system because of associated thermal and structural problems.
- However, it is more efficient and provides more thrust compared to solid and traditional liquid stages.

SSLV(Small Satellite Launch Vehicle)

- It is a cost-effective launcher with a capacity of 500kg in LEO and 300kg in Polar Sun Synchronous orbit.
- It uses 3 solid stages and a velocity trimming module that uses liquid fuel.
- The production and launch of PSLV and SSLV are the responsibilities of NSIL(New Space India Limited)- the commercial wing of ISRO.
- Doubt resolution

ISRO in space sciences(1:53:00PM)

- **Past:**
- Chandrayaan 1
- Mars Orbiter Mission
- Astrosat
- Chandrayaan 2
- **Near future**
- Gaganyaan
- Aditya L1 mission
- Chandrayaan 3
- **Far future**
- Shukrayaan(Mission to Venus)
- MOM 2
- Xpo-sat
- Space station

Gaganyaan Mission

- ISRO is venturing into a manned space mission- a 3-member crew will spend about 6-7 days in Low Earth Orbit at about 400 km.
- GSLV Mk 3 will be used.
- **Challenges in the Gaganyaan mission**
- During the launch, itself huge amount of heat will be generated.
- All stages of GSLV must occur smoothly for a safe launch.
- Spending time in orbit in microgravity conditions, weightlessness, absence of breathable oxygen, no protection from cosmic radiation are some major challenges.
- Also, how the human body will behave in such extreme conditions is also a challenge.
- Atmospheric reentry which generates a lot of heat because of friction requires utmost precision. A small error can become disastrous.
- There is always a debate on the need for such costly missions vs spending on the social sector.
- India lacks training facilities for astronauts. ISRO is taking help from other space agencies such as Russia.
- **Benefits**
- It will be a stepping stone to having our own space station which has the potential for an enormous range of experiments.
- It will help in developing the basic understanding of the functioning of the human body which can have medical applications.
- ISRO or Indian companies can become one of the players in space tourism which is an emerging sector.
- Many of the present technologies were a result of space research such as telemedicine, laser surgery, and robotic surgery. methods in water purification and sewage recycling, methods to enhance the shelf life of perishable items, and thermal resistant materials among many others.
- It will enhance our national pride and inspire the younger generation to pursue science and technology in India.

Aditya L1 mission(2:53:00PM)

- Explained with the help of diagrams and video.
- It is India's first dedicated scientific mission to study the Sun in Halo orbit around Lagrangian point 1(L1).
- It will carry 7 payloads with the following objectives:
- **Objectives:**
- It will observe different layers of the Sun, that is photosphere, chromosphere, and Corona into multiple frequency bands.
- It will study the particle flux emanating from Sun and traveling through the solar system.
- It will calculate the intensity of the magnetic field of the particle flux coming from Corona.
- Corona is an aura of plasma that surrounds the Sun and other stars. It extends millions of km into space and is most easily seen during a total solar eclipse.
- **Halo orbit and Lagrangean points**
- Lagrangean points are 5 special points in space where a very smaller body gets the required centripetal force because of the gravitational effect of 2 larger bodies to complete its orbit.
- Even though it is a point in empty space, it can be orbited.
- **L1 point:**

- For the Earth-Sun system, the L1 point is between Sun and Earth approximately 1.5 million km away from Earth.
- It has the advantage of continuously viewing the Sun without any eclipse.
- It already has a very famous NASA observatory called SOHO(Solar and Heliospheric Observatory).
- **L2 point:**
- It is also 1.5 million km but in the opposite direction.
- It is ideal for astronomical observation because it can monitor the night sky without coming in the shadow of the earth and moon and at the same time can send data to Earth stations.
- L3 is not very useful as it always remains behind Sun.
- L4 and L5 are examples of stable equilibrium that is, objects at L4 and L5 will maintain their stable orbit without an external energy source.

Topics for next class- Some more space missions, Nuclear Technology
Science and Technology Class 04

A brief overview of the class and doubts. (1:04 PM)
Space Debris:

- Human beings have been launching space probes for more than 50 years
- Because of this lot of junk has accumulated in orbits
- Space debris is junk that is circling the earth
- They travel at very high speeds and even a relatively small piece can cause a lot of damage to satellites
- **The main source of space debris is as follows:**
- An explosion of satellite and rocket bodies
- Anti-satellite tests or demonstration
- Abandoned pieces of old satellites
- Upper stages of rockets
- **Kessler Syndrome:**
- It is a scenario in which the density of objects in low earth orbit is high enough that collisions between objects could cause a cascade where each collision generates space debris which further increases the livelihood of collision
- Space endeavours have become challenging, and expensive because of space debris
- The following steps can be taken:
- Tracking large pieces of debris - Project Netra of ISRO
- Code of conduct for space agencies to minimize debris; for example, Upper Stages should be separated at a lower altitude
- Similarly, there is a demand to ban Anti-Sattelite tests
- There is an international organisation called Inter-Agency Debris Co-ordination Committee to exchange information about Space Debris and to collaborate regarding their removal (ISRO is a member)
- Dedicated missions have been launched to remove debris from space. For example. remove debris project led by the University of Surrey

Nuclear Technology: (1:53 PM)

- It is the application of nuclear reactions
- This application includes energy production, agriculture, medicine, industry, and space among others
- **Nuclear Energy Production:**
- It mains occurs in two ways ie nuclear fission and fusion
- **Nuclear Fission:**
- In a Fission reaction, a heavy nucleus is bombarded with neutrons to make it unstable
- Fission involves the disintegration of this heavy nucleus into lighter nuclei
- In the process, a huge amount of energy is released
- The energy released can be calculated using Einstein's Mass-Energy Equivalence (E=mc2) ie mass of the product will be less than the reactant and the mass difference can be used to calculate the energy produced
- In a fission reaction, generally, excess neutrons are released
- These neutrons can carry forward the fission reaction, this reaction will grow exponentially and is called an uncontrolled nuclear fission chain reaction
- This is the mechanism of nuclear bombs which produces a huge amount of energy in a short span of time
- If the excess of neutrons is absorbed, this becomes a controlled chain reaction and energy output can be controlled

- This is the mechanism behind nuclear reactors

Nuclear Reactor: (3:01 PM)

- The goal of a nuclear reactor is to produce energy from nuclear fission in a controlled manner
- **It has 4 major components:**
- 1. Fissile Material: Those which can undergo fission easily; eg U-235, U-233
- 2. Moderator: It slows down the speed of neutrons; slow neutrons are better at causing fission eg water, heavy water
- 3. Coolant: Ensures stability of the core of the nuclear reactor and transports the heat away from the core. Generally, moderators and coolants are the same
- 4. Control Rods: It absorbs the excess of neutrons; made up of Boron, Cadmium, Graphite, etc
- **Types of Reactors**:
- Pressurized Heavy Water Reactor (Pressurized Water Reactor)
- Boiling Water Reactor
- Fast Breeder Reactor

Nuclear Fuel Cycle: (3:22 PM)

- It comprises: front-end and back-end steps
- The front end comprises of following:
- 1. Mining
- 2. Milling - Uranium ore is crushed and using physical and chemical methods. Natural uranium is recovered from uranium ore
- 3. Enrichment - Natural uranium comprises about 99.3% of Uranium-238 and only about 0.07% of U-235; U-238 is not a good fissile material. In the enrichment process using isotopic separation methods, the % of U-235 is increased up to 3-5%
- 4. Fabrication: Enriched uranium is made into spherical pellets. These spherical pellets are embedded into a metallic tube which is called a fuel rod. About 200 fuel rods are used in a fuel assembly and more than 150 assemblies are kept in the core of the reactor at once
- 5. Nuclear Fission at the reactor
- The back end comprises of following steps:
- 6. Interim Storage: Once fission is completed, the waste which is left is highly radioactive. This radioactive waste is kept in a pool of water for a few years so that water can absorb dangerous radiation
- 7. Spent Fuel Reprocessing: Fissile material for the next cycle is recovered from nuclear waste
- 8. Final Disposition: Nuclear waste is deposited in a permanent underground repository
- Few countries such as the US do not use spent fuel reprocessing. This is called the open nuclear fuel cycle
- India's nuclear programme is dependent upon spent fuel reprocessing. Such a cycle is a closed nuclear fuel cycle

Topics for the next class: Continuation of India's Nuclear Programme, etc

Science and Technology Class 05

***A Brief Overview of the Previous Class*:(01:07:00 PM)**

***India's Three-Staged Nuclear Program*:(01:09:00 PM)**

- The three-stage nuclear program was envisaged by Dr. Homi Jehangir Bhabha, who is considered the father of India's Nuclear program
- India has some Uranium and huge reserves of Thorium in the western ghats, especially in the Monazite sois of Kerala.
- Thorium is not a very good fissile material, the three-stage program was envisaged to insure that India can use its local resources as fissile material and use it for nuclear fission.
- *First Stage:*
- Pressurized heavy water reactors.
- Heavy water as moderator and Coolant
- Uranium 235 is the main fissile material in this stage while U-238 can absorb a neutron and convert itself into Plutonium-239.
- Natural Uranium(U-235 & U-238) it gives Plutonium -239 as byproduct.
- *Second Stage:*
- Fast breeder reactor(FBR).
- Here Plutonium-239 from the first Stage will be used as the main fissile material or fuel.
- Thorium 232 around the core of the reactor is also used which can capture a neutron and converts itself into U-233.
- It gives Uranium 233 as the product.

- Liquid Sodium is used as a coolant.
- Moderator is not used here because even though the fast neutrons are not very effective in causing fission they are very good at converting Thorium 232 to U-233.
- In fact the production of U-233 is faster than the fission of Plutonium 239 hence the name Fast Breeder.
- Both 1st and 2nd stages can operate for about 30 years each, and then with enough U-233, India can enter into 3rd Stage.
- *Third Stage:*
- A breeder reactor.
- U-233 obtained from the second stage is the main fissile material & Thorium 232 will simultaneously be converted into U- 233.
- With the amount of Thorium India has, this Stage can go on for 500 years.
- India still entering the 2nd stage.
- In fact the first fast breeder reactor in Kalpakkam Tamil Nadu is still not operational.

Challenges in 3rd Stage Program:(01:52:00)

- Because of low-grade Uranium, India's nuclear program got delayed as India is not a member of the Nuclear Supplier Group(NSG) and for many years could not import Uranium.
- Spent Fuel Reprocessing is easier said than done.
- There has always been a fear of nuclear waste management or reactor melt-down(ex, *Chernobyl disaster*, 1986).
- In 2008, a historic nuclear deal occurred between India and the USA, and it seemed like the nuclear energy program is going to take off.
- India got a waiver from the NSG and entered into bilateral agreements with many countries.
- However, after the Fukushima disaster of 2011 in Japan, where because of a Tsunami a nuclear reactor was destroyed.
- In India there have been powerful pressure groups against Nuclear energy production and with the Fukushima disaster opposition to nuclear energy intensified.
- In the last decade the cost of renewable energy especially solar energy has come down and nuclear energy remains expensive.
- Question1: With growing energy needs should India keep on expanding its nuclear energy program? Discuss the facts & fears associated with nuclear energy. (250 Words/15 Marks).
- Question 2: Discuss the growth and development of nuclear science and technology in India. What are the advantages of a fast breeder reactor? (15 Marks/150 Words)
- (Discussed the approaches to write the answers for the above-given questions)

Nuclear Fusion:(02:23:00 PM)

- It's the process where two or more than two lighter nuclei combine to form a heavy nucleus at a very high temperature, and in the process, a huge amount of energy is released.
- For example, It is responsible for energy production in stars.
- Even though fusion occurs among stars naturally we have not been able to produce fusion-based energy in a sustainable manner for civilian uses.
- It requires a very high temperature in the range of millions of degrees to overcome the electromagnetic repulsion between the nuclei.
- On Earth many devices are trying to make fusion possible.
- Even though nuclear fusion has been achieved, sustaining it and producing sufficient energy is not been achieved yet.

TOKAMAK:(02:56:00 PM)

- A lot of experiments are being conducted to attain nuclear fusion.
- Most of the reactions are trying to Deuterium and Tritium together.
- For example, the International Thermo-Experimental Reactor (ITER) TOKAMAK.
- India is a member of this experiment.
- Such experiments use the TOKAMAK device, which is designed to harness the energy of fusion.
- The device used magnetic fields to contain and control hot plasma, which enables the fusion between deuterium and tritium nuclei.
- The ITER Tokamak aims to produce 500 Mw of fusion-based power.
- Both Fission and fusion are sources of clean energy.
- However, fusion has more inherent benefits associated with it such as:
- a. Energy released is much greater.
- b. Deuterium is available in all forms of water and Tritium can easily be produced in labs.

- c. Fusion reactors do not produce long-lived radioactive waste.
- d. There is a limited risk of nuclear proliferation beacuse there are no enriched materials in a fusion reactor.
- e. It is difficult and maintains the precise conditions required for fusion, for example, a very high temperature and high magnetic field, thus if any disturbance occurs, the plasm colls within seconds and the reaction stops.
- Aditya Tokamak of India is being maintained by the Insitute of Plasma Research which is operated under the Department of Atomic Energy.
- India is also working on SST1(Steady State SUperconducting Tokamak, an upgradation over Aditya.

Radioactivity:(03:32:00 PM)

- There are certain nuclei that are not stable and to attain stability they emit some particles this phenomenon is called radioactivity.
- Such unstable nuclei try to achieve stability by emitting mainly three particles:
- Alpha Particle- It is a Helium nucleus.
- It will lead to a decrease of Atomic number by 2 and Atomic Mass by 4.
- Beta Particle: An emission of electron or Positron.
- Gamma Particle: It is a photon that has very high energy.
- Half-Life: It is the time taken for the radioactivity of a specified isotope to fall to half its original value.
- For example, Carbon-14 is unstable and has a half-life of around 5,730 years.
- Unstable nuclei can be produced artificially also in a device called Cyclotron.

Applications in Agriculture:(03:50:00 PM)

- *a. Plant Mutation Breeding:*
- Pant buddings and seeds can be exposed to Gamma radiations and some of those mutations can become desirable.
- For example, a plant variety with resistance to drought and salinity.

Topics for the next class: Continuation of applications, and then Nanotechnology.

Science and Technology Class 06

A Brief Overview of the Previous Class & Solved Queries (01:05:00 PM)

Application of Nuclear Technology (01:24:00 PM)

- ***1. In Agriculture:***
- *a. Fertilizer Efficiency:* A small amount of Nitrogen Isoptoe such as N15 can be used in Nitrogen-based fertilizer.
- And this labelling of fertilizers with a particular isotope provides means to ascertain how much has been taken up by the plants by measuring the Beta emission.
- This allows for better management of fertilizers.
- *b. Sterile Insect Techniques:* In this insects are exposed to small doses of gamma radiation which makes them sterile.
- These insects are released back and even though they are sexually competitive they can't reproduce.
- Thus used in pest management to control their population.
- *c. Food Irradiation:* It is the process of exposing foodstuff to radiations such as gamma, X-rays, or electron beams.
- Exposing perishable food items to high-energy radiation like gamma or X-rays kills microbial organisms that can cause food-borne diseases and increase shelf life.

Nuclear Technology in Medicine (01:42:00 PM)

- ***1. Cancer Treatment:***
- ***A. Radiation Therapy or External Beam Therapy***: For eliminating or controlling cancerous growth.
- It has a lot of side effects
- Cobalt 60 is used in radiation therapy to prevent cancer.
- ***B. Brachy Therapy:*** It is an advanced cancer treatment method wherein radioactive seeds are implanted near the tumour so that a high radiation dose occurs to the tumour while reducing radiation exposure in the surrounding healthy tissue.
- ***C. Proton Beam Therapy:*** Proton beam is used to treat cancer.
- It doesn't have many side effects.
- ***2. Diagnosis:***
- A small amount of radioactive material is injected into the bloodstream as a radiotracer.
- Radiotracers emit a small dose of Gamma rays.
- Interaction of Gamma rays with healthy and tumour cells can be recorded on a computer screen.

- It creates an image of the inside of the body which is not possible by any other method.
- ***3. Radiation sterilization of healthcare products:***
- the ability of gamma radiation to kill microorganisms is used in radiation sterilization of various products such as disposable syringes, cotton dressings and drugs, and related products.

Nuclear Technology In Space (02:05:00 PM)

- ***A. Radioisotope Thermoelectric Generator(RTG):***
- As solar energy can't be relied upon in a deep space mission.
- Plutonium 238 is used for deep-space experiments as a continuous source of thermal energy, which can be converted into electrical energy.
- The half-life of Plutonium 238 is 87.7 years.
- ***B. Nuclear Propulsion:***
- This is being explored by scientists for future interplanetary missions.
- ***Nuclear Technology In Defense:***
- **a. Nuclear Weapons:**
- Nuclear bombs by using uncontrolled Fission.
- **b. Nuclear-Powered Submarines:**
- Such submarines have a small nuclear reactor inside them they do not need to come on the surface of the water compared to diesel-powered submarines.
- For example, INS Arihant, the first Nuclear power submarine of India.
- INS Arighat, will be inducted next year.
- ***Nuclear Technology In Industries:***
- *A. For Material Analysis:*
- X Rays and Gamma Rays are used in industrial radiography to make images of the inside of solid products.
- Using radioactive tracers leakages in a pipe can be detected.
- *B. Water Desalination:*
- Nuclear energy is also being used for water desalination.
- *C. Carbon Dating:*
- It has many applications in Geology, Anthropology, and evolutionary biology among others.

Nano-Technology (02:51:00 PM)

- It is the science, technology, and engineering at the nanoscale(1nm to 100nm).
- Nanotechnology is the understanding and control of matter at the nanoscale.
- Matter exhibits unique/unusual chemical, physical and biological properties at the nanoscale very different from bulk materials.
- For example, Nono materials can have unique magnetic properties, they can be a better conductor of electricity, be more chemically reactive, or change colour as their size or structure is altered.
- If we can perform such manipulations at the nanoscale many different materials can be created with huge potential.
- For example, Gold at the nanoscale will have all different chemical and physical properties than that at the macro/bulk level.
- Also, the properties of nanomaterials are a function of size itself.
- For example nano gold at 100 nm will show different properties than nano gold at 20 nm.
- The properties may include magnetic properties, different conductivity, more chemically reactive, and better reflectors of light or colour.
- *The uniqueness of nanomaterials:*
- 1. At nanoscales, quantum effects dominate and rules the behaviour and properties of the particles.
- Properties of materials are size dependent in this size range, that is by changing the size the scientists can fine-tune material properties as desired.
- 2. At such a scale surface behaviour plays a very important role as nanomaterials have a very high surface area.
- A greater amount of material can come into contact with the surrounding material, thus affecting the reactivity.
- They help in creating better catalysts.
- 3. Most of the biology occurs at the nanoscale. For example, a strand of DNA molecules has a diameter of about 2 nm, similarly, Hemoglobin has a 5.5 nm diameter.
- Medical Scientists are exploring the possibility of using nanomaterials to devise nanomaterial or nano-medicine that are more precise and personalized medicines.
- 4. Nano-materials exhibit self-assembly:

- Self Assembly describes the process in which the group of components comes together to form an ordered structure driven by mutual interactions.

Nanomanufacturing (03:27:00 PM)

- There are two ways to manufacture nanomaterials:
- *A. Top-Down Approach:*
- It includes breaking down bulk materials into nano-sized particles by successive fragmentation and slicing.
- This requires a large number of materials and can lead to waste.
- *B. Bottom-Up Approach:*
- In this nanomaterials are built atom by atom, molecule by molecule.
- This is time-consuming and expensive but gives more control over the surface behaviour compared to the top-down approach.
- Nanomaterials can be of zero dimension, 1D nanomaterials (two dimensions are at the nano-scale), 2D Nano-materials (At atleast in one dimension it is on the nanoscale), or 3D Bulk nano-materials.
- Recently the government approved nano Ureas as fertilizer, which has been developed by IFFCO(Indian Farmers Fertilizers Cooperative Ltd) it has many benefits:
- One bag of Urea can be replaced with 450 millilitres of Non-urea, which can be absorbed by the stomata of plants, so it does not require to be used on the soil.
- This makes agriculture sustainable as soil productivity will not be affected much in the longer run.
- However, the experts have criticized this move on the following grounds:
- Any new fertilizer requires a trial for 3 years, for nano-urea this trial was only done for two years before approving it.
- It can not completely replace normal urea because Urea is generally used twice. First during the preparation of the field and second once the crop is grown a little bit. Nano Urea can only replace the second usage.

Generations of Nanotechnology (03:52:00 PM)

- Nanotechnology is predicted to have four distinct generations of advancements:
- *1. First-generation or Passive Nanomaterials:*
- These materials provide unique properties without altering the properties of the bulk materials. eg nano-coating.
- *2. Second-generation or Active Nanomaterials:*
- These nanomaterials are active in the sense that they can induce changes in their surroundings thus they have huge applications, for example, targeted drug delivery to destroy tumours.
- *3. Third generation or System of Nanosystem:*
- Here nanoparticles and nono material will work together to execute the task.
- Complex systems such as guided assembling, nanorobotics, etc
- *4. Fourth-generation or Molecular Nanosystem:*
- At this level, all the molecules that make up the nanomachine can be controlled and manipulated.
- This is the potential of nanomaterial yet to be realized where nanostructure can be used to control the growth of artificial organs.
- The 3rd & 4th generation nanotechnology is still in the exploratory stage.
- A lot of work is happening in the 1st & 2nd generations of nanotechnology.

Topics for the next class: Continuation of Nano-technology.

Science and Technology Class 07

A Brief Overview of the Previous Class & Resolved Querries:(01:10:00 PM)

Applications of Nanotechnology:(01:18:00 PM)

- ***A. In Daily Life:***
- *a. Fabrics:*
- Nanoscale materials addition can help fabrics in resisting wrinkling, staining, and even bacterial growth.
- Nanosensors can be used in clothes/smart fabrics they can help to measure the vitals of the body and help monitor health.
- These can be charged through solar energy or energy harvesting through the body's movements.
- *b. Glasses and Displays:*
- Nono scales films are used in eyeglasses, computers, camera displays, and others making the water and residue-repellent, anti-fog, self-cleaning and scratch resistant, etc.
- *c. Households:*
- Nanoengineered materials make superior household products like degreasers, detergents, stain removers, etc.

- *d. Cosmetics:*
- Nanoscale Titanium Dioxide and zinc oxide are used in sunscreen lotions to protect from sun rays.
- ***B. Medical & Healthcare Applications:***
- *a. Cancer Treatment:*
- Gold nanoparticles have been proven to be very effective in cancer treatments.
- *b. Targeted drug delivery:*
- Nanoparticles can help deliver medication directly to diseased cells and minimize the risk of damage to healthy tissues.
- *c. Disease Diagnosis:*
- Better imaging and tools enabled by nanotechnology.
- *d. Tissue Engineering:*
- Nanomaterial can be engineered to mimic human bones which can be very useful in tissue engineering.
- Some nanomaterials have regenerative medicinal properties which can be used in tissue engineering.
- *e. Vaccines:*
- Researchers are looking for nanotechnology to improve the efficiency and delivery mechanisms of vaccines.
- They can be used for gene editing or gene sequencing.
- *f. Killing Superbugs:*
- Quantum dots and other nanomaterials have been seen as effective in killing superbugs(bacteria that have developed antibiotic resistance).
- This can be key to ending/fighting antimicrobial resistance.
- ***C. Environmental Application:***
- Nanomembranes are more efficient than conventional filters for water filtration.
- Researchers are working on water-repellent nano-particles to get rid of oil spills in oceans.
- Industries are using nanoparticles for water treatment as well as to reduce air pollution.
- *Lighweigthing:* Nano additives are being used in automobiles, airplanes, and spacecraft that reduce their weight without compromising the material's properties.
- This leads to significant fuel savings and energy efficiency.
- Certain nanoparticles such as carbon nanotubes can make windmill bladed linger, stronger, and lighter.
- Carbon nanotubes can be used for storing hydrogen.
- ***D. In Electronics:***
- Transistors that enable all modern computing have gotten smaller and smaller through nanotechnology.
- Quantum dots-based displays produce ultra-high-definition displays with more vibrant colors than other display technologies.
- Flexible, bendable, and foldable displays, memory chips for smartphones, etc also use nanotechnology.

Carbon Nanotube & Quantum Dots:(01:54:00 PM)

- *(Explained with PPTs)*
- ***Carbon Nanotube:***
- These are cylindrical molecules consisting of single-layer carbon atoms of graphene in rolled-up sheets.
- They can be single-walled or multi-walled.
- They acquire properties of Graphene, however depending upon how they are folded or their size they can acquire unique properties.
- The hollow part of nanotubes can be used to fill with nanomaterials.
- ***Quantum Dots:***
- These are artificial semiconducting nanoparticles.
- Because of their unique optical properties, they have many applications in display technologies like (QLED), Solar panels, medical imaging, Quantum computing, and others.
- Quantum dots, can be fine-tuned to emit a particular frequency of light depending on their size.

Concerns with Nanotechnology:(02:24:00 PM)

- Some doctors worry that the nanoparticles can get into the body through the skin, lungs, digestive system, etc.
- They can produce toxic substances in the body because of high chemical reactivity.
- There is also a concern that nano-particles can cross the blood-brain barrier.
- They can affect a larger area because of their transboundary nature.
- The human body has developed a tolerance to the most naturally occurring elements and molecules that it has contact with, however, it has no natural immunity against synthetic nanomaterials.

Nanotechnology in India:**(02:31:00 PM)**

- The Ministry of Electronics and IT has a nanotechnology Initiative division with a focus on the application of nanotechnology in electronics.
- In the past, a National Mission on nanotechnology was led by the Dept of S&T which ended in 2020.
- India stands third in research papers publication after USA and China.
- But the quality of these standards is not up to the mark.
- Also, the Industry-Academia linkage is not adequate due to which they are not able to see the impacts of R&D on the ground.

Showed & Discussed MCQs:**(02:58:00 PM)**

Information & Communication Technology(ICT):**(03:11:00 PM)**

- *(Explained with PPTs)*
- *Electromagnetic Waves:*
- These are the oscillations of electric and magnetic fields perpendicular to each other and the wave propagates perpendicular to both electric and magnetic fields.
- Based on their frequency and amplitude electromagnetic waves can be divided into the following categories:
- In order to their decreasing frequency and energy and increasing wavelength:
- Gamma Rays
- X-rays,
- Ultraviolet light
- Visible light: (3800-7800 Angstroms)
- Infra Red
- Microwaves
- Radiowaves.
- The energy of the electromagnetic wave is proportional to the frequency.
- Energy per second is power.
- Intesity= Power/Area.
- Radiowaves have a frequency from 300kili Hertz to 300 Giga Hertz.
- Frequency: It is the number of oscillations per second(1/T).
- It has units: Per Second or Hertz.
- Time Period: Time required to complete one complete oscillation.
- Wavelength: It is the distance between two consecutive troughs or crests of the wave.
- Speed or velocity= Wavelength/Time period= Frequency*Wavelenght.

Topics for the next class: Continuation of Information & Communication Technology.

Science and Technology Class 08

A Brief Overview of the Previous Class:**(01:06:00 PM)**

Basic Terminologies Associated with ICT:**(01:08:00 PM)**

- *(Explained with PPTs and Charts)*
- ***1. Communication Systems(CS):***
- In a CS transmitter and receiver are located at different places.
- The CS can be wireless or wired.
- All CS also have imperfections because of this a receiver receives a corrupted version of the transmitted signal which is called *Noise*.
- ***2. Transducer:***
- It is a device that converts one form of energy into another.
- An electric transducer converts some physical variables such as pressure, displacement, and force, into electrical signals as outputs.
- ***3. Signal & its Types:***
- Signal: Information converted in electrical form and suitable for transmission is called a signal.
- A signal can be:
- ***a. Analogue:***
- These are the signals which are continuous variations of voltage or current.
- Such signals suffer from distortions in a communication medium.
- ***b. Digital:***
- These take discrete values of 0 and 1(Binary system) and any type of signal can be converted into a digital signal.

- (Note: there are many coding schemes used for digital communications. The most famous is American Standard Code for Information Interchange(ASCII))
- ***4. Attenuation:***
- The loss of strength of the signal as it propagates through a medium is called attenuation.
- Often amplification is necessary to compensate for such attenuation.
- ***5. Bandwidth:***
- It refers to the frequency range over which equipment operates or the portion of the spectrum occupied by the signal.
- The bandwidth of the signals depends upon their type such as text, voice, picture, etc.
- But it also depends upon the transmission medium.
- Coaxial cables provide less bandwidth than air. Optical fiber cables provide the highest bandwidth.
- Optical Fiber Cables:
- OFC operates on the principle of Total Internal Reflection (TIR).

Modulations:(02:10:00 PM)

- *(Explained with PPTs and Charts)*
- Waves themselves do not contain any information we need to encode the information.
- This method of encoding information from a message source using a carrier wave so that it is suitable for the transmission
- There are mainly two methods:
- ***1. Analog Modulation:***
- These are time-varying signals.
- There are three methods of analog modulation:
- *a. Amplitude Modulation(AM):*
- In AM the modulated signal and its amplitude continuously change according to the message signal.
- It is more prone to noise.
- AM radio has a larger range than FM radio.
- *b. Frequency Modulation:*
- Here the frequency of Modulated waves changes while the amplitude remains the same.
- It is less prone to noise but has a lesser range than AM.
- However, they use higher frequencies (88 to 112 MHz) hence signals can't travel very far.
- Using higher frequency, we can send more data with more speed but the wave is susceptible to scattering, and absorption.
- *c. Phase Modulation:*
- In phase modulation, the massive signal is encoded as variations in the phase of carrier waves.
- *Pulse modulation:* by simply switching on and off morse codes can be sent to thousands of kilometers
- ***2. Digital Modulation:***
- Digital modulation consists of discrete values.
- Analog signals suffer from many losses such as distortion, interference, and security breaches.
- To overcome these problems signals are digitized using different techniques
- Digital signals allow communication to be clearer and more accurate without losses.

5G Technology:(02:33:00 PM)

- *(Explained with PPTs and Charts)*
- For satellite telecommunication, a frequency range from 1 to 40 Giga Hertz has been allocated by International Telecommunication Union(ITU).
- This range of frequency is further divided into different bands.
- To prevent interference between different users the generation and transmission of radiowaves are strictly regulated by national laws and coordinated by an international body International Telecommunication Union(ITU).
- The 5G is the next generation of mobile technology that will provide higher speed, low latency, and more connection density and as a result, highly reliable communication is promised by this.
- As per the International Telecommunication Union(ITU), it will differ from 4G on the following parameters.
-

Technology	***4G***	***5G***
Maximum speed or peak data rate	1gbps	20gbps
Latency	20-30 ms	~1 ms

Connection density	100,000/sq km	1mn/sq km.
Available spectrum	3GHz	30GHz

Various 5G Technologies:(03:10:00 PM)

- *(Explained with PPTs and Charts)*
- 5G is not one technology but an amalgamation of many technologies and innovations such as:
- ***A. Millimeter waves (mm):***
- It is an electromagnetic wave with a frequency range of 30 to 300 GHz.
- The 5G spectrum has been divided mainly into three categories:
- 1. Low Bands: < 1 GHz. Used for 2g, 3g, 4g, and 5g.
- 2. Medium Bands:
- a. From 1 to 2.66 GHz. Used for 3g, 4g, and 5g.
- b. From 3.5 to 6 GHz. Used for 4g, and 5g.
- 3. High Bands: From 24 to 40 GHz. This is used for standalone 5G.
- ***B. Small Cell Stations:***
- They make use of low-power, short-range wireless transmission systems that cover small geographical areas.
- ***C. Massive Mimo:***
- MIMO- Multiple Input, Multiple Output.
- A wireless communication technique for sending and receiving multiple data signals simultaneously over the same radio channel.
- ***D. Beam Forming:***
- It focuses the wireless signal in the chosen direction towards a specific receiving device.
- This results in an improved signal, as well as less interference between the signals.

5G Network Slicing:(03:38:00 PM)

- *(Explained with PPTs and Charts)*
- Network slicing devices a single network connection into multiple distinct virtual connections that provide different amounts of resources to different types of traffic.
- The standards are deicide by the International Telecommunication Union(ITU) an agency of the UN and 3GPP(Third Generation Partnership Project)
- 3GPP unites 7 telecommunication standard developmental organizations of the world known as organizational partners.
- For example, the Telecommunication Standard Development Society of Inda(TSDSI) is a member, it is registered as a not-for-profit society under the Societies Registration Act 1860.

Challenges for 5G Adoption in India:(03:51:00 PM)

- *(Explained with PPTs and Charts)*
- In India, spectrum prices are one of the highest in the world
- Telecom companies are in huge debt.
- Optical fiber penetration is very low in India.
- We are dependent on imports for electronics and equipment.
- There is also a lack of uniform policy across states which has delayed the optical fiber cables and telecom towers.
- A perceived security threat from Huawei led to 5G which is a Chinese company. However, as of now, India has declined Huawei 5G trials.

Topics for the next Class: Continuation of ICT.

Science and Technology Class 09

Science and Technology Class 09 [13:09:00]
Q& A session and Brief overview of the class
5G Challenges

- A complete 5G supply chain has a high import dependency
- 5G raises cyber security concerns. It enhances the cyber vulnerability
- Few of the frequency bands may not be availed for 5G for example- The aviation industry has highlighted interference in 5G signal with the signal used for communication with Aeroplanes
- Mobile towers need to be connected with optical fiber cables. In India optical fiber penetration is low
- It may contribute to the existing digital divide in the country

- Interoperability issues- 5G network will not be accessible with older smartphones. 5G as a stand-alone system will not be dependent upon previous networks

Supercomputers and supercomputing [13:33:00]

- Supercomputers are the physical embodiment of high-performance computing allowing organizations to solve problems that would be impossible with regular computers
- Supercomputers work much more quickly by splitting problems into pieces and working on many pieces at once this is called parallel processing in contrast regular computers do one thing at a time in distinct series of operations which is called serial processing
- The capacity of supercomputers is measured in floating point operations per second (FLOPS)
- A typical supercomputer will be measured in petaflops (10^15)
- The capacity of ordinary computers is measured in million instructions per second (MIPS)

Applications of supercomputers [13:55:00]

- Weather prediction and climate modeling
- Computational biology- It is an interdisciplinary field that develops and applies computational methods to analyze biological data such as proteins samples, gene sequences, etc
- Big data analytics- It is the process of extracting useful information by analyzing different types of big data sets. It is used to discover hidden patterns for decision making
- Scientific research- A lot of research such as large hadron collider at CERN, Blackhole imaging by event horizon telescope among many other required supercomputers to make sense of data collected
- Optimization- It is the efficient utilization of a given situation, resources, or time for companies, the optimization problem is very important for cost-cutting
- Simulation- For disaster management simulation, atomic energy simulation, etc supercomputers can be useful

Supercomputing In India [14:16:00]

- The first supercomputer unveiled in India was Param 8000 in 1991
- 2 of the fastest supercomputers were Pratyush and Mihir used for weather prediction and climate modeling
- **National supercomputing mission, 2015**
- It aims to develop a supercomputing grid comprising more than 70 supercomputing facilities throughout the country
- It envisages empowering our academic, R& D institutions
- The supercomputers will be networked over a high-speed optical fiber cable part of the National knowledge network
- The mission also includes the development of professional human resources
- It is being implemented by the department of science and technology and the department of electronics and information technology through 2 organizations, C-DAC (Center for development and advanced computing) and IISc Bengaluru.
- The fastest supercomputer in India PARAM SIDDHI has been developed as part of this mission

Challenges

- Supercomputers consume huge amounts of power and also require dedicating cooling facilities hence they are not considered environmentally friendly.
- In India, there is import dependence to procure hardware components, lack of funding as well a lack of skilled workforce mainly due to brain drain

Quantum technologies [14:49:00]

- Quantum technologies are based on principles of Quantum Mechanics, a set of ideas that were developed in the early 20th century to explain how nature works at a very small scale
- There are mainly 4 major domains
- a) Quantum computing
- b) Quantum Simulation
- c) Quantum Communication
- d) Quantum Metrology
- Recently the government of India announced a national mission on Quantum technologies and applications with a Budget outlay of 8000 crore rupees to be implemented by the department of science and technology.

Quantum Computing [15:42:00]

- In a classical computer, information is stored using Binary units or Bits (0 or 1)
- A quantum computer takes advantage of Quantum mechanical properties to process information using Quantum Bits (Qubits)

- Qubits can be both 0 or 1 simultaneously with different probabilities this is called superposition
- Qubits can be correlated in a way that the state of one Qubit depends on the state of another this is called Quantum Entanglement
- Using these two principles, Qubits enable Quantum computers to solve difficult problems which are not solvable even by powerful supercomputers
- The computing power of a Quantum computer increases exponentially as Qubits are increased

Quantum Supremacy [15:53:00]

- It means that researchers have been able to use quantum computers to perform a single calculation faster than the most powerful supercomputer on the planet. It was established by google's quantum computer Sycamore

The Topic for the next class:- Quantum computing (continued).
Science and Technology Class 10

Challenges with Quantum Computers (01:12 PM)

- QC needs to be kept in an isolated condition at a very low temperature because qubits are highly sensitive to external interference.
- Any fluctuation such as pressure, and temperature can lead to a loss of quantum information.
- As the number of Qubits increases, their manipulation becomes more and more difficult.
- QC requires ecosystems of supporting software hardware algorithms.
- One of the challenges which will occur because of QC is that it has the potential to decrypt the world's encrypted data.
- The world has to prepare itself for the post-QC era.
- Even though it is in its nascent stages and in many areas such as quantum simulation, AI, cyber security, etc.
- In traditional cryptography, the security in the communication channel is usually based on the fact that usually, an eavesdropper can solve certain mathematical problems in the real-time frame, for example, finding the prime factor for a large number.
- This is called **public key distribution**.
- However quantum computers can solve this problem much faster and researchers are trying to find solutions to secure data and the solution is provided by Quantum mechanics itself.
- **For example**- **Quantum key distribution**
- In this method pair of entangled light particles, and photons are shared across a network if an eavesdropper, tries to read or copy photons in any way it will change the quantum state and the change will be deducted by the end coins.
- Both ISRO and DRDO have announced success in achieving quantum key distribution.

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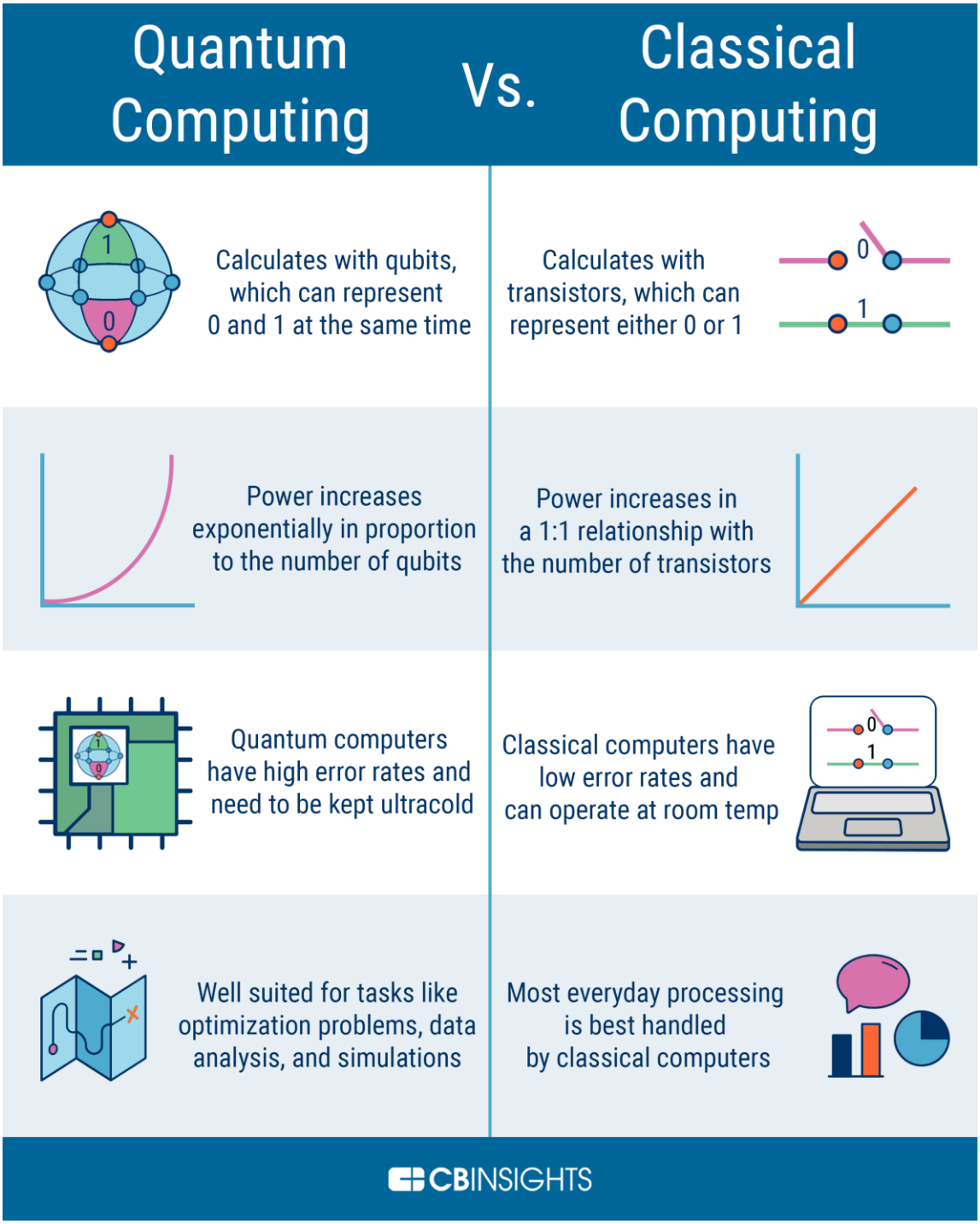
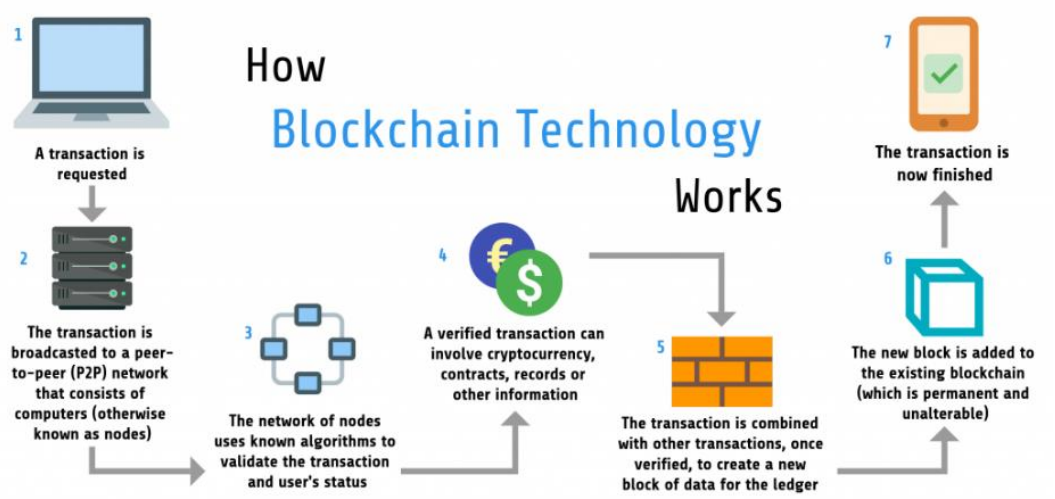


- **Quantum Metrology:**
- **Metrology** is the science of measurement and quantum sensors provide the most accurate measurements.
- **Quantum simulation-**
- To predict the behavior of nature at a very small scale such as atoms, molecules, and elementary particles, we require simulation techniques based on quantum mechanical ideas, for example- an important application of quantum computers will be Quantum simulation.
- This can be used to develop new types of materials.

Blockchain Technology (03:00 PM)

- Blockchains are open-distributed leisure that can chronologically record transactions between parties, it has the characteristics of decentralization, that is data is not stored at a central location but maintained across all devices that are a part of the blockchain.
- Blockchain technology was envisaged for cryptocurrencies even though cryptocurrencies are a debatable utility of blockchain in many areas, making it one of the key technologies

- Blockchains provide transparency, immutability, and no single point of failure, which enhances security because of which it can have applicability in banking and finance cyber security, non-fungible token, supply chain management, and smart contracts.
- **Challenges**-
- **i) Lack of scalability**
- The processing speed on the blockchain is very less compared to traditional transactional networks.
- **ii) Lack of interoperability-**
- Most of the blockchains present in the market work in silos in so many different approaches with blockchain space are in a state of confusion to adopt an approach.
- iii) Designing blockchain requires a skilled workforce
- iv) It is not environment friendly because of high power consumption



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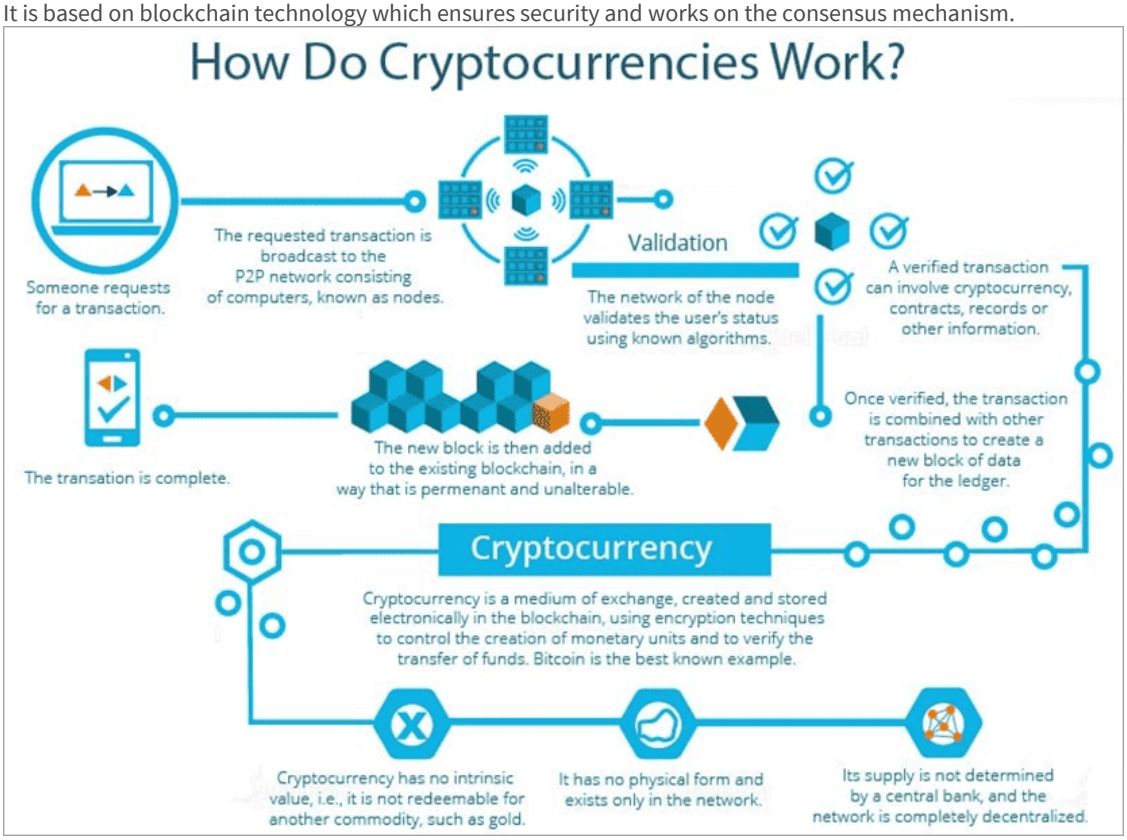
Cryptocurrency(03:21PM)

- It uses cryptography for security and anticounterfeiting purposes.
- It is not issued by any central authority, using blockchain technology.
- Transactions on blockchain will be examples of peer-to-peer transactions hence this transaction doesn't require validation from a third party.
- **Example**- Bitcoin
- **Benefits**-

- Counterfeiting is nearly impossible.
- There are not any transactional fees if the transaction is happening.
- Bitcoins provide anonymity and transparency.
- It provides an alternative to the banking system and fiat currencies.
- It is based on blockchain technology which ensures security and works on the consensus mechanism.



- Note: Refer to slides/ youtube video on Blockchain technology, link provided by sir.

Next Class: Blockchain Technology continues, the Dark web, etc.
Science and Technology Class 11

CHALLENGES AND ISSUES WITH CRYPTOCURRENCIES:

- Used in illegal activities, because cryptocurrencies provide anonymity and can be used for illegal activities such as smuggling of drugs, terror financing, child pornography, money laundering, etc.
- Cryptocurrencies have been very volatile, causing lots of instability in the market and economy.
- There is no investor protection scheme, for any dispute redressal.
- Cryptocurrency system is liable to malware attacks.
- They are not environmentally friendly because of high power consumption.
- Many experts do not consider cryptocurrencies as a viable economic system.

Proof of Work Versus Proof of Stake: (01:41 PM)

- Recently Ethereum switched to a proof of stake system, which is an alternative approach to designing a blockchain.
- It's different from the component of proof of work, which is used by Bitcoin and other cryptocurrencies.
- In the proof of stake system, the cryptocurrency owner validates block transactions, based on the number of stakes coins.
- While in proof of work minors are solving cryptographic problems, which leads to high power consumption.
- In proof of stake, the power consumption reduces by more than 99 %.

INTERNET-RELATED TOPICS: (01:56 PM)

Net Neutrality:

- It is a principle that internet service providers should treat all lawful data equally, i.e they cannot discriminate or charge differently by user, website, application, etc, and also practices like blocking, or granting preferential speeds to any content are prohibited.
- Net neutrality, is considered to be important for start-ups, freedom of speech and expression, and preventing monopolies of ISPs.

- Recently, this topic was in the news because some experts feel, that 5g network slicing violates net neutrality as it allocates different bandwidths for a different set of requirements.
- TRAI has a set of regulations, to protect net neutrality

Dark web: (02:13 PM)

- The content on the internet can be divided into:
- **Surface web:** it is the portion that is readily available to the general public and searchable with and searchable with standard web search engines.
- **Deep web:** it is part of the internet that can not be accessed by web search engines, and requires authentication, payment mechanism, or both to access, such as internet banking, email servers, and OTT.
- **Dark web:** is defined as a layer of information, that can only be accessed using special browsers, such as the TOR browser.
- The dark web provides complete anonymity, because of this it is a hub of many illegal activities.
- Security agencies, often find it difficult to establish guilts in courts because of technical challenges.
- Crypto based transaction on the dark web has become a favorite tool for dark net criminals.

Satellite-based internet: (02:46 PM)

- Recently star link program by SpaceX, made a record for launching 1000s of satellites, in Low Earth Orbit, to provide high-speed internet across the planet.
- Satellite-based internet, aims to provide global connectivity, without investment in fiber cables.
- This is especially significant for rural and remote areas, as a high seed, low latency internet will be accessible.
- These satellites are being launched into LEO.
- One Web is another program to provide satellite-based internet.
- However there are a few challenges such as the increased risk of collision in space, and obstruction to astronomical observation, which is done by radio-telescopes on the ground.

ARTIFICIAL INTELLIGENCE: (03: 10 PM)

- It is a branch of computer science concerned with making computers making computers mimic human-like intelligence.
- In contrast to normal hardware and software, AI enables a machine to perceive and respond to its changing environment.
- There are many branches of AI technology such as **Computer vision**.
- It is a field of AI that enables computers and systems to derive meaningful information from digital images, videos, and other visual inputs and take actions or make recommendations based on that information.
- **Audio processing** to extract meaningful information from ambient sounds and use them for decision-making.
- **Natural language processing** is concerned with giving computers the ability to understand in the same way human beings can.
- **Machine Learning** is an application of AI, that includes algorithms that learn from data and apply that learning to make informed decisions.
- Deep learning is a sub-field of machine learning, that creates artificial neural networks and can learn and make intelligent decisions on its own.
- It is designed to analyze data with a logical structure similar to how the human brain would draw conclusions.

The topic for the next class: the continuation of Artificial Intelligence.
Science and Technology Class 12

***A Brief Overview of the Previous Class:*(01:05:00 PM)**
***Challenges associated with Artificial Intelligence:*(01:10:00 PM)**

- *(Explain with charts and diagrams)*
- *Expert Systems:*
- An artificial Intelligence that is designed to solve complex problems and to provide the decision-making ability like a human expert.
- It performs this by extracting knowledge from its knowledge base using reasoning and inference according to queries.
- *1. Ethical Challenges:*
- a. Use deep fakes.
- b. AI can learn biasedness or it can be deliberately transferred by developers.
- c. Power without accountability. for example, Mass surveillance.
- *2. Super-intelligence:*

- A sufficiently intelligent AI can redesign itself or can create a better successor system leading to the intelligence explosion.
- It is crucial to ensure that this super-intelligence is good to humankind.
- *3. Legal Issues:*
- How will be treated? what laws and how they should be framed to regulate Ai are very complex and tricky.
- India has to ensure AI expertise, higher investments in the sector, and investment in cloud computing infrastructure, to ensure that India can compete with other counties in AI development.

Intellectual Property Rights(IPRs):(01:47:00 PM)

- *(Explain with charts and diagrams)*
- IPRs are the legal rights that are given to creators over the creation of their minds. Creators often get an exclusion right over the use of their creations for a certain period.
- It includes literary, artistic, and scientific works, trade-marks, designs, and scientific discoveries among others.
- It also ensures protection against unfair competition.

Types of IPR:(01:53:00 PM)

- *Patent:*
- It is granted for an invention that is a new product or process that meets the conditions of novelty, non-obviousness, and industrial use.
- Novelty means an inventive step that involves technical advancement compared to existing knowledge.
- Non-Obviousness means that the invention is not obvious to a person not skilled in the particular discipline.
- Industrial use means that the invention is capable of being made or used in industry.
- A patent provides a limited monopoly right granted by the state such that the inventor prohibits another person from manufacturing or selling the patented product without permission.
- It is granted for 20 years.
- In India it is governed by the Patent Act, of 1970.
- A major amendment happened in 2005, to make it TRIPS-compliant.
- *Things that can not be patented are:*
- Claims which are contrary to the established natural laws.
- Inventions contrary to public order, or morality, or which cause, serious prejudice, to human, animal, or plant life, for example, the gambling machine, biological warfare material, embryonic stem cells, etc.
- Discovery of living things or nonliving substances occurring in nature.
- Discovery of the scientific principle.
- A substance obtained by the mixture resulting only in an aggregation of properties.
- Method of agriculture or horticulture.
- Planta or animals in whole or in any part other than the micro-organisms.

Copyrights:(02:20:00 PM)

- It is the right given by the law to the creators of literary, dramatic, and artistic works and producers of films and sound recordings.
- This right allows its creator rights or reproduction, communication to the public, adaptation, and translation of the work.
- It is given for 60 years.
- For literary, dramatic, and artistic, works published during the lifetime of the artists 60 years is counted after the death of the artist.
- In India it is governed by the Copyright Act, of 1957.

Trademarks:(02:49:00 PM)

- Trademark is the mark capable of being represented graphically, distinguishing the goods and services of one undertaking from another.
- For example, a sign, word, letter, picture, or combination of colors, among others.
- In India, they are governed by the Trade Marks Act of 1999. They are given for 10 years and can be renewed very easily.
- *Industrial Design:*
- Design consists of shape, configuration, patterns, and composition of colors applied to any article in 2D or 3D by any industrial process so that the finished good has an aesthetic element associated with it.
- It is governed by the Designed Act, of 2000. Given for 10 years and can be renewed easily.

Geographical Indication(GI Tag):(02:57:00 PM)

- It is a sign used on agricultural, natural, or manufactured goods originating in a particular region of a country.
- It denotes its origin where a specific quality or reputation is attributed.
- It is governed by the Geographical Indication of Goods(Registration and Protection) Act 1999 or GI Act 1999.
- Given for 10 years and can be renewed easily.
- *Trade Secrets:*
- Some Inventions, data, and information, can provide an organization competitive advantage such information can be held confidential which is called Trade Secret.
- It can be an invention, idea, financial strategy, client database, survey methods, recipe, manufacturing process, etc.
- Since it does not require registration, theoretically, protection is for an unlimited period.
- Trade secrets can be preferred over patents in the following cases:
- a. When information is not patentable.
- b. Patent protection is only for 20 years, secrets can be kept beyond that period.
- c. When it is difficult to do reverse engineering.

Plant Variety Protection:(03:20:00 PM)

- It refers to the protection granted for new types of plant varieties.
- It aims to encourage research in agriculture.
- It is given to plant breeders, universities, agricultural institutes, and even farmers.
- For annual crop protection is for 15 years, for trees, it is 18 years.
- The act which protects it is The Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001.
- *Semiconductors & Integrated Layouts:*
- It means a layout of the transistors and other circuitry elements.
- It has been recognized as an IPR at the global level.
- In India it is governed by the Semiconductor Integrated circuits Layout- Design Act 2000.

International Organizations & Treaties for IPRs:(03:31:00 PM)

- *Trade-Related Aspects of Intellectual Property Rights(TRIPS):*
- It is an International agreement administered by the WTO, that sets down minimum standards for IP regulations for WTO member nations.
- In case of disputes, it can become an arbitrator, at the same time it provides a degree of flexibility to the developing countries to accommodate their intellectual property regime and developmental requirements.
- *The World Intellectual Property Organization(WIPO):*
- It is an agency of the UN created in 1967 to encourage intellectual activities and facilitate the transfer of technologies to developing countries.
- Berne Convention, 1886 under WIPO- It is to protect literary and artistic works.
- Paris Convention, 1883, for the protection of Industrial properties.
- Marrakesh Treaty-
- It creates an exception to Copyright Law wherein an organization that provides accessible format books to the visually impaired, does not require permission from the copyright holder.
- India was the first country to ratify this treaty.
- It was signed in 2013 and entered into force in 2016.
- Global Innovation Index:
- It is released by WIPO in collaboration with Cornell University and INSEAD.
- India's rank is 40th out of 132 countires.

IPR Issues between India and Developed Countries:(03:59:00 PM)

- Developed nations are huge critics of India's IPR regime.
- For example, India continues to be on the '*Priority Watch List*" on the annual '*Special 301 Report'* of the Office of the United States Trade Representative (USTR).

Topics for the next Class: Continuation of Issues related to IPR.

Science and Technology Class 13

A Brief Overview of the Previous Class:(01:16:00 PM)

Issues of Developed Countries with Indian IPR Regime:(01:20:00 PM)

- Copyright law in India does not promote the commercialization of content.
- Trademark violation is rampant.

- India does not have a dedicated Trade Secrets Law.
- India imposes high import duties on capital-intensive products such as solar panel equipment, medical equipment, capital goods, etc.
- IPR enforcement and adjudication are filed with bureaucratic red tape.
- India continues to apply restrictive patentability criteria, especially for pharma patents.
- Evergreening of Patents:
- It is a practice adopted by the companies to re-patent their products with minor modifications which can not be termed as a novelty.
- Section 3(d) of the Indian Patent Act, does not allow the evergreening of patents.
- for example, in 2013, the Novartis patent was canceled for the medicine Glivec which is used for Cancer treatment.
- Q: Critically evaluate Section 39(d) of the Indian patent Act, which does not allow the evergreening of patents. (10 Marks/150 words)

Compulsory Licensing(CL):(01:52:00 PM)

- It allows the government to allow the manufacturing of patented products without the permission of the patent holders in the larger public interest.
- It is a part of the TRIPs regime and Section 84 of the Indian Patent Act provides for CL.
- For example, in 2012, the government allowed an Indian company, Natco Pharma to manufacture the medicine Nexavar whose patent belonged to another company Bayer.
- *Patent waiver:*
- Because of the Covid-19 pandemic countries such as India and South Africa are demanding a patent waiver.
- A patent waiver allows any third party to develop and sell patented products without any fear of legal complications.
- It may also include technology transfer by the patent holders with a license agreement.
- *Patent Pool:*
- A patent pool is defined as the agreement between two or more parties for licensing their patents together with the purpose of sharing their intellectual property rights.
- It is usually made for complex technologies which necessitate complementary patents. For example, the Covid-19 pandemic.
- It can be a great idea to pool knowledge, capacity, resources, etc to develop new technologies.
- However there can be a downside it can foster monopoly, limited competition, and can promote cartel-like behavior.

Protection of Traditional Knowledge:(02:13:00 PM)

- Traditional knowledge signifies the sum total of practices adopted by indigenous people in a particular environment, climate, or culture, for diagnosing or treating diseases.
- India is bestowed with great biological diversity, and rich knowledge of traditional medicine such as Ayurveda, Siddha, the Sowa-Rigpa, etc.
- Other systems which are recognized are Yoga, Unani, homeopathy, and Naturopathy.
- Sometimes Multinational companies try to appropriate the traditional knowledge system of a particular region. Also, they use the biological resources of a region without giving credit to the local people who work for conservation. This is called Biopiracy.
- In the past, two very famous cases were where pharma companies were trying to claim novelty for the Indian system of medicine.
- In the USA a company wanted a patent for the wound-healing properties of turmeric, in Europe, a company claimed a patent for the anti-fungal properties of Neem.
- In both cases, India won the case but it took a lot of time and resources.

Traditional Knowledge Digital Library(TKDL):(02:52:00 PM)

- It is a pioneering initiative of the government of India where more than 0.4 Million medicinal formulations part of India's traditional Meicicnal system have been translated into 5 international languages(English, Spanish, German, French, and Japanese).
- Access to this library is given to international patent offices based on a non-disclosure agreement so that they can examine a patent and determine the novelty requirement.
- Many patents, at the global offices, have been rejected as these claims were part of India's traditional Knowledge.
- As of now, India has signed a TKDL access agreement with many countries such as the USA, Europe, Canada, Germany, Japan, the UK, and Australia, among others.
- India is a signatory of the Convention on Biological Diversity(CBD).

- As a signatory, the Biological Diversity Act, of 2002 has been passed.
- One of the objectives of this Act is the 'Equitable Sharing of Benefits' arising out of biological resources with local people.
- There is a three-tier mechanism to fulfill the objectives:
- National Biodiversity Authority,
- State Biodiversity Boards,
- Biodiversity Management Committee.
- Q: How is the government of India protecting the traditional knowledge of India? (15 Marks/250 Words)

Defense Technologies:(03:20:00 PM)

- Topics to be covered:
- Missiles.
- Ships & Submarines,
- Fighter Crafts.
- Recent development in warfare.
- *Issues in Indigenization of the Defense Sector:*
- Lack of adequate funding.
- Lack of adequate R&D.
- Dominated by the only public sector, no competition.
- Lack of adequate transparency.
- Lack of well-formed policy for indigenization.
- However, in recent times a lot of positive improvement has occurred. The government has allowed the private sector also.

Missiles:(03:30:00 PM)

- *(Explained with diagrams & charts)*
- The missile is a rocket system that can deliver an explosive warhead with great accuracy at high speed.
- There can be many types of Missiles based on different criteria:
- *1. Based on Trajectory:*
- *a. Ballistic Missile:*
- These missiles are guided for a brief duration in the starting phase of the trajectory and the rest of the path is like a free-falling projectile guided by the Earth's gravity.
- They can have a very large range and comparatively, consume lesser fuel.
- They are suitable for stationary targets.
- However, they can be intercepted easily by radar systems.
- Also, they are not useful for moving targets.
- For example, India's Agni and Prithvi Missiles.
- *b. Cruise Missile:*
- A guided missile remains in the atmosphere and flies the major portion with not a lot of variation in speed.
- They require continuous guidance, thus their path is not guided by gravity.
- They consume more fuel.
- Their range is also less compared to ballistic missiles.
- But they can be useful for even moving targets and it is more difficult to intercept them using radar systems.

Types of Missiles based on Launch platform & Target:(03:45:00 PM)

- *(Explained with diagrams & charts)*
- a. Surface to Surface: Prithvi.
- b. Surface to Air- Akash missile, Barak Missile.
- c. Air to Air- Astra Missile.
- d. Anti-Tank Missile- Nag Missile(used by Army), Helina(used by Air force)
- *Types of Missiles Based on Speed:*
- It is measured in the speed of sound which is measured in the Mach number(Speed of the object/Speed of Sound).
- Subsonic: Less than one Mach.
- Transonic: Around 1 Mach.
- Supersonic: From 1 Mach to 5 Mach.
- Hypersonic: More than 5 Mach.
- *Types of Missiles Based on Range:*

- It is mainly used for Ballistic missiles.
- Short Range: <1000 Km.
- Medium Range: 1000-3000 Km.
- Intermediate: 3000- 5000 Km.
- Long Range: More than 5000 Km.

Integrated Guided Missile Development Programme(IGMDP):(03:56:00 PM)

- *(Explained with PPTs.)*
- IGMDP was envisaged in 1982-83 by Dr. APJ Abdul Kalam to help India to achieve self-sufficiency in the field of Missile technology.
- It included the following projects:
- Prithvi, Aakash, Trishul, Nag, and Agni Missiles.

Topics for the next class: Continuation of defense technology.

Science and Technology Class 14

A brief overview of the previous class(1:26 pm)

Ballistic missile defense system(1:47 pm)

- *(Explained with diagrams & PPTs)*
- Ongoing Programme of DRDO, which aims to protect a region from any type of ballistic missile attack.
- It comprises the airborne warning control center, long-range tracking radar, and 2-tier missile defense system.
- First, we will try to intercept an incoming missile outside the atmosphere using PRITHVI air defense.
- If that does not become successful then an endo-atmospheric interception can occur using advanced air defense.
- Advance air defense will use AHWIN missiles.
- The S400 system which India is buying from Russia is one of the most advanced air systems in the world, which can intercept any type of aerial threat such as drone fighter jet missiles, and can neutralize many targets simultaneously.
- *(Illustrated image of the iron dome of Israel)*

Hypersonic missile(2:10 pm)

- *(Explained with diagrams & PPTs)*
- Subsonic(speed less than mach1)
- Transonic(speed=Mach1)
- Supersonic(speed greater than Mach1)
- Hypersonic cruise missiles can travel with a speed of more than Mach 5 within the atmosphere.
- There are significant challenges in attaining such high speeds
- a. The speed of the atmospheric drag.
- Atmospheric drag cause friction which generates heat and increases the temperature. Hypersonic systems should be able to stand at 1000 degree Celcius temperature.
- b. We require air-breathing engines such as ramjet and scramjet which have their challenges.
- Air-breathing engines can be of 3 types.
- Jet engine- It uses rotating parts to compress air so that combustion becomes possible.
- It can attain speed up to Mach 3
- Ramjet does not use rotating parts.
- The forward motion of the ramjet allows high combustion and compression.
- Ramjet does not start with 0 and works well between Mach 3 to 6.
- **Scramjet-** It is a further improvement of ramjet which allows a smooth flow of air throughout the system.
- It operates above Mach 6 and can attain higher hypersonic speed.
- US CHINA and RUSSIA have hypersonic missile capability.
- India recently successfully tested solid fuel ducted ramjet which was able to attain about Mach for a few seconds.
- *(Discussed previous years' prelims question).*

Ships and submarines (3:15 pm)

- *(Explained with diagrams & PPTs)*
- Submarines are water-submersible vehicles that can be propelled at very high speeds.
- It can be used for attacking enemy ships and submarines aircraft carrier protection intelligence gathering etc.
- They can be powered by diesel or nuclear power.

- Diesel-powered submarines are INS Sindhu Ghosh, INS Sindhu Vijay, and INS Sindhu Rashtra.
- Scorpene class- As part of the g2g agreement, 6 scorpene class submarines were developed in collaboration between India and France.
- This was developed under project 75 of the Indian navy.
- Six submarines are INS kalvari INS khanderi INS karanj INS vela INS vageer INS vagsheer,
- These submarines are fast attacking submarines with low acoustics and remain underwater for a longer duration.
- Nuclear power submarines powered by nuclear reactors under submarines,e.g INS Arighat (not commissioned yet)and INS Arihant.
- They are powered by a pressurized nuclear reactor.
- INS Arihant also carries a k4 missile which has a nuclear warhead.
- This gives it the nuclear triad capability to launch nuclear weapons from all three platforms' surface air and water.

Naval warships(3:38 pm)

- *(Explained with diagrams & PPTs)*
- (Note: Torpedoes are underwater missile that follows straight paths like cruise missiles. e.g Varunastra developed by DRDO.
- Mareech is an advanced torpedo system for torpedo detection and countermeasure.)
- Naval warships can be of four categories
- 1. Destroyers-These are often one of the largest ships equipped with missiles torpedoes radars and sonars.
- For example Ins Kolkata, INS Murmagoa, INS Vishakhapatnam.
- 2. Frigates- They are smaller but faster than destroyers.
- They are often used as maintaining supply line quick movements of troops; as escort vessels. For example INS Shivalik, INS Brahmaputra.
- 3. Corvettes-They is often the smallest warships in the naval fleet. They provide support to larger ships.
- They are used for coastal patrolling.
- Example INS Kamorta,INS Kavaratti.
- 4. Aircraft carrier-these are floating air bases in seas.
- They are often accompanied by destroyers frigates submarines etc. Example INS Vikramaditya,INS Vikrant.
- Despite the small airstrip aircraft can take off and land based on 2 separate mechanisms.
- 1. CATOBAR- Catapult Assisted Take-Off But Arrested Recovery- In CATOBAR a catapult mechanism under the deck provides kinetic energy to air crafts.
- This mechanism can be powered by a steam engine or electromagnetic lift. This is called The Electromagnetic Aircraft Launch System (EMALS)
- 2. The STOBAR- Frontal part of the deck is elevated to assist similar to the ski jump mechanism.
- Both INS Vikrant and INS Vikramaditya are examples of STOBAR.
- In arrested recovery, high-strength wires are placed on a deck. The aircraft has a tail hook that gets arrested in one of the wires and rapidly deaccelerates.

Stealth technology(4:06 pm)

- *(Explained with diagrams & PPTs)*
- It ensures making a plane invisible to the radar.
- It can occur in the following ways-
- a. The surface can be covered with materials that absorb radar signals.
- b. The shape of the surface can be changed in a way that radar signals are reflected from the radar equipment.
- c. Use of radio jammers- radio jammers can produce many radio waves which can work like noise for radar equipment.
- d. It can also intercept prevailing frequencies of radio waves and produce waves that lead to destructive interference.

Topics for the next class:- *Continuation of defense technology.*

Science and Technology Class 15

<u>A brief overview of previous class and queries- 1:08 PM</u>

Airforce- 1:21 PM

- **Aircraft-**
- From Russia- Combat aircraft- MIG21, Mig29, Sukhoi su30.
- From France- Mirage, Rafale.

- From UK- Jaguar- Sepecat.
- **Indian Aircraft- HAL- Tejas -** It is one of the highest and smaller multi-role supersonic fighter aircraft in its class. (Mach 2).
- It carries a range of weapons, Air to air, air to the surface with a payload capacity of 4000 KG.
- It has an air-to-air refueling capacity.
- **Airborne early warning and control system (AWACS)-** It is called a flying eye and is designed to detect air crafts, ships, missiles, and other incoming objects.
- The Indian air force has five airborne aircraft- 3 of Israel- **Falcon**, and 2 indigenous- **Netra.**
- **Directed energy weapons-** A weapon with highly focused energy without a solid projectile such as a laser beam, microwave, particle beam, sound beam, etc.
- Such weapons can destroy any incoming attack or can also be used to damage the electronic system on board.
- India is reported to have developed a system **called Kali** (kilo ampere linear injector) for targeting long-range missiles.

Contribution of Indians to Science and Technology- 1:58 PM

- **Dr. CV Raman-**
- He was a Nobel laureate and was awarded a Nobel prize for physics in 1930 for a discovery named after him i.e **Raman effect.**
- In the Raman effect, the light of some frequency when interacting with a molecule sample is scattered and the frequency of scattered light may increase or decrease.
- The Raman effect is the inelastic **scattering of photons** after interaction with a molecular sample.
- The use of the Raman effect in spectroscopy is called **Raman's spectroscopy** (it involves analyzing the pattern of light that a material emits, absorbs, transmits, or reflects).
- This depends upon the composition of the material, temperature, and also its motions.
- Raman's spectroscopy is the most preferred spectroscopic analysis tool across many industries such as Pharma, chemical, plastic, electronics, and even in the analysis of biological samples.
- **This is because of the following reasons:**
- It is not destructive in nature i.e sample can be analyzed many times without compromising on the integrity.
- It is easier and provides information quickly.
- It is sensitive to even small changes to material structure.
- It can be performed on almost all materials except pure metals.
- In Feb 2008 we commemorate the discovery of the Raman effect in 1928.

Dr. S. Chandrashekhar 2:56 PM

- He was an Indian-American astrophysicist who was awarded the noble prize in 1983 for theoretical studies regarding the structure and evolution of stars.
- He hypothesized that heavier stars compared to the sun will not end stable white dwarfs they will collapse further because of gravity leading to supernova explosions.
- Supernovas are considered one of the brightest regions in the universe, after that star can become a neutron star or even a black hole.
- The limit (known as the **Chandrashekhar limit- 1.4 times** the mass of the sun)was ignored by the scientific community because the logical conclusion was the existence of a black hole.
- This was considered a scientific impossibility, however with the help of Telescopes Chandrashekhar's ideas were confirmed and he was recognized by the **Nobel prize** committee.
- **Dr. JC Bose-** He was a polymath, physicist, botanist, and archaeologist.
- He pioneered the study of radio and microwave optics and was the first person to use **semiconductor junctions to detect radio signals**.
- He demonstrated wireless communication for the first time.
- He hypothesized that plants can feel pain and understand affection.
- He developed a device called a **crescograph** which can be used to measure plant response to various stimuli.
- He was the father of open technology as he made his inventions freely available for others to further develop.
- His reluctance for patenting his work is legendary.
- He also wrote science fiction stories in Bengali.
- **Dr. SN Bose-** He was a theoretical physicist known for his work on a class of particles that is named after him called **Bossons.**

- He figured out how an identical group of Bossons would behave using Quantum mechanics ideas.
- He sent his paper to Einstein who recognise the value of his calculation.
- Einstein generalizes the idea that other particles will also behave in a similar manner.
- These particles are called Bossons and the statistical law they follow is called **Bose-Einstein statistics.**
- Einstein also predicted that if we reduce the temperature to very close to absolute zero.
- All atoms will occupy the lowest energy state, at this state matter will exist in the 5th state known as **Bose-Einstein condensate (BEC).**
- BEC was known for two amazing low-temperature phenomena- **Superconductivity and Superfluidity.**

The topic for the next class- Robotics, Particle physics