



# TARGET PRELIMS 2024

## BOOKLET-2; S&T-2

### SPACE AND ASTRONOMY-2

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## 1. INTERNATIONAL EFFORTS

### 1) SPACE GOVERNANCE: GLOBAL NORMS

- Current Space Regulations: Gaps and Loopholes
  - » United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) was established in 1958 with UN Office for outer space affairs as its secretariat. It oversees the implementation of five UN treaties related to outer space:
    - » Treaty on Principles Governing Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial bodies of 1967 (Outer Space Treaty)
      - It designates space as the “province of all mankind” and states that the exploration of the outer space would be for the benefit of all countries, irrespective of their degree of economic or scientific development. It also prohibits deployment of weapons of mass destruction in space, and establishment of military bases, installations, and fortifications.
      - Limitations: Doesn't clearly prohibit weapons other than weapon of mass destruction; Doesn't properly cover modern day technologies like lasers for communication.
      - Further, it doesn't provide a detailed mechanism to decide if activities are inconsistent with the treaty and it failed to address issues like growing weaponization of the space.
    - » Agreement on the Rescue of Astronauts, the Return of Astronauts and Return of Objects Launched into Outer Space of 1968 (Rescue Agreement)
    - » Convention on International Liability for Damage Caused by Space Objects of 1972 (Liability Convention)
      - Limitation: The **Liability Convention** and **OST** have the potential to impede the private sector investment as it makes state liable for all the damages thus compelling states to impose license and insurance on such entities.
    - » Convention on Registration of Objects Launched into outer space of 1976 (Registration Convention). It has helped in development of an international registration system. Full knowledge of the presence of objects in space is crucial for peaceful and safe use.
    - » The Agreement Governing the Activities of States on the Moon and other Celestial Bodies of 1979 (Moon Treaty).
    - » It also oversees **other related treaties** including Treaties Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and under Water (NTB) of 1963 and the **Brussels Convention Relating to the Distribution of Programme – Carrying Signals transmitted by Satellite (BRS) of 1979** among others.

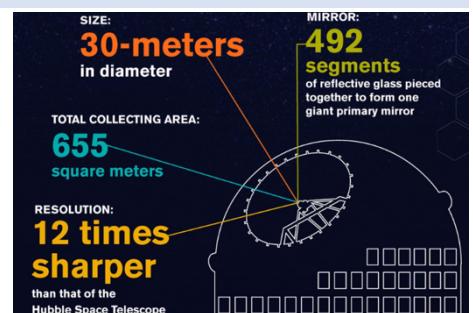
### 2) INTERNATIONAL SPACE STATION (ISS)

- The International Space Station (ISS) is a modular space station (habitable artificial satellite) in LEO.

- Its main construction was completed between 1988 and 2011, although the station continuously evolves to include new mission and experiments. It has been continuously occupied since Nov 2, 2000.
- It is a multinational collaboration with contribution from 15 nations.
  - A) NASA, ESA, ROSCOSMOS are the major partners of the space station and contribute most of the funding.
  - B) JAXA, and Canadian Space Agency are other partners.
  - C) Through a private company called Axiom Space, private astronauts are starting to work on the orbiting complex, from time to time.
  - D) The ownership and use of the space station is established by intergovernmental treaties and agreement.
- Details:
  - A) ISS is 109 meters from end to end with a weight of more than 4 lakh kg without visiting vehicles.
  - B) Orbits at an average height of 400 kms. It circles earth every 90 minutes at a speed of about 28,000 km/h.
- Space Vehicles to reach ISS:
  - A) Currently, astronauts travel to ISS via SpaceX's Crew Dragon capsule. Russian astronauts travel to the space station using Soyuz capsule.
  - B) Note: After retirement of NASA's Space Shuttle Program in 2011, Soyuz was the only spacecraft which could take humans to ISS. Later, in 2020, SpaceX's Crew Dragon also became available.
- Purpose:
  - A) It provides a platform for multi-gravity and space environment research laboratory.
- Future:
  - A) Current Plan calls for the space station to be operated through at least 2024 with the partners discussing a possible extension.
  - B) NASA has approved extension till 2030.
  - C) Russia has announced its withdrawal after 2024 to focus on building its own space station around 2028.
  - D) After 2030, plans for ISS are not clearly known. It could be deorbited or recycled for future commercial space stations in orbit.

## 1) THIRTY METER TELESCOPE (TMT)

- What is thirty-meter telescope?
  - Thirty-meter telescope is a new class of extremely large telescopes that will allow us to see deeper into space and observe cosmic objects with unprecedented sensitivity.
  - With its 30 m prime mirror diameter, TMT will be three times as wide, with nine times more area, than the largest



currently existing visible light telescope in the world. The images of TMT will be **12 times sharper than Hubble Space Telescope.**

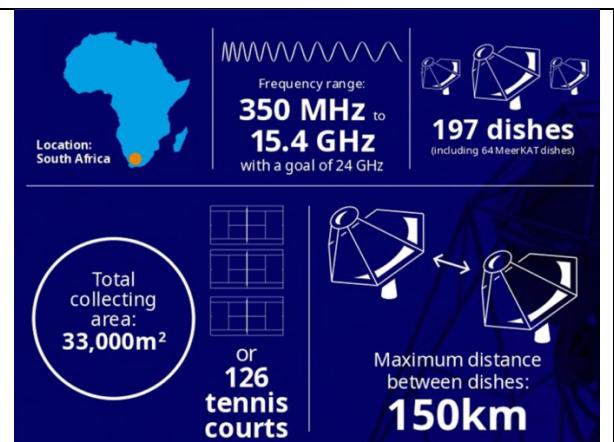
- The TMT will **observe wavelengths** ranging from the ultraviolet to the mid-infrared.
- **Who is building TMT?**
  - » It is being built by **TMT International Observatory LLC (TIO).**
- The TIO is a non-profit international partnership between the California Institute of Technology, the University of California, the National Institute of Natural Science of Japan, the National Astronomical Observatory of Chinese Academy of Sciences, the **DST India** and the National Research Council, Canada.

## 2) SKAO (SQUARE KILOMETER ARRAY OBSERVATORY)

- The Square Kilometer Array (SKA) is an inter-governmental radio telescope project under construction. Once completed it will be the world's largest and most powerful radio telescope.
- It will be built in two phases – with the core arrays located in:
  - **Australia:** Focusing on low frequency observation.
  - **South Africa:** Focusing on mid-frequency observation.
- **How will it function?**
  - The SKA will combine signals from thousands of smaller antennas spread across vast distances to function as a single giant telescope with exceptional sensitivity and angular resolution. This is achieved through a technique called aperture synthesis.
  - Some sub-arrays will also have very broad field view, allowing for surveying huge areas of the sky simultaneously.
- **The headquarters** and combining infrastructure, called the Square Kilometer Array Observatory (SKAO), are located at the Jodrell Bank Observatory in the UK.
- **The incredible sensitivity** of SKA will help understand the universe in a better way.
- **How will the SKA Observatory work?**

**The 197 dishes in South Africa** are collectively referred to as **SKA-Mid** and will observe at radiofrequencies between 350 MHz and 15.4 GHz. They have combined effective collecting area of 33,000 sq m.

SKA-Mid's resolution will be 4-times that of JVLA (the current best similar instrument in the world)



**In Australia**, the 131,072 low frequency antennas are known as **SKA-Low** and have combined collecting area of **419,000 sqm**.

Compared to LOFAR(Low Frequency Array) in the Netherlands, this will be 8x more sensitive.



- The collecting area is a crucial component that makes the SKAO so powerful. It makes the telescope detect even the fainter objects.

- **Progress:**

- The construction of the project began in 2018, with the first light (the start of the scientific observations) expected in 2027

#### A) INDIA MOVES TOWARDS BECOMING FULL MEMBER OF SKAO (JAN 2024)

- In Jan 2024, GOI has approved India's participation in SKA, with a financial sanction of Rs 1,250 crores. This is the first step towards ratification of SKAO Convention. Countries have to sign and ratify this convention to formally become members.
  - **India**, through the Pune-based National Centre for Radio Astrophysics (NCRA) and some other institutions, has been involved in the development of SKA since its inception in the 1990s. India contributed heavily to the design and development of the SKA telescope over time, particularly in software domain, having been involved in SKA project since its earliest days.
  - **Full membership** was long anticipated. The Indian government was a party to the negotiation of the SKAO Convention and participated in the preparatory activities that led to the creation of the observatory in early 2021.
- The approval covers the funding support for the construction phase of the international SKA Observatory (SKAO) spread over the next 7 years.
- The project will be jointly funded by DAE and DST, with DAE being the lead agency.
- This participation is nationwide including project led consortium of more than 20 academic and research institutes (with NCRA-TIFR as the nodal institute)

### 3) SPACE BASED INTERNET

- **Space X Plan**
  - **The Starlink Network** of SpaceX eventually plans to install 42,000 satellites to ensure non-stop internet services throughout the earth at a cost-effective rate. These satellites will be connected with their neighboring satellites using lasers.

- China's "Guowang" (GW) constellation has also been announced which is meant to meet satellite-based internet services.
  - It will also be a LEO based system with satellites operating at different heights (500-1145 km), inclinations (30-85 degrees) and frequency bands.
- **Other such projects:** Several other companies including Amazon, OneWeb and O3B have also planned large constellation of satellites in LEO and MEO – but these projects are very small compared to Starlink.
- **Comparing Geostationary vs LEO satellites** for providing internet services [Advantages of LEO – Low latency-> allows real time communication; Disadvantage -> need more satellites for coverage as they cover small part of earth]
- **Significance**
  - Prelable and uninterrupted internet services universally to everyone on earth.
  - Services during emergency: For e.g. During Russia Ukraine war in 2022, the Starlink played an important role in strengthening the Ukrainian military might after the European SATCOM system was cyber attacked.
  - IOT services
  - Better e-governance
- **Concerns:**
  - **Increased Space debris**
  - **Increased chances of collision of satellites**
  - **Difficulty in Space Observation -> Light Pollution**
  - **Increased crowding in LEO and signal interference** in space may emerge as another problem

## 2. NASA INITIATIVES

### 1) GREAT OBSERVATORY PROGRAM

- NASA's series of Great Observatories satellite are four large, powerful space-based telescopes. The four missions were designed to examine a specific region of the electromagnetic spectrum using very different technologies. The program was developed in 1994.
- **Great Observatories**

#### B) THE HUBBLE SPACE TELESCOPE (HST)

- The Hubble Space Telescope was deployed on April 25, 1990 from the space shuttle Discovery.
- It primarily observes visible light and near-ultraviolet. A servicing mission in 1999 added capability in near infrared range and one last mission in 2009 was to fix and extend the life of Hubble which resulted in some of the best results to date.

- Hubble is one of the largest and most versatile, and is well known as both vital research tool and a public relation boon for astronomy.

#### C) THE COMPTOM GAMMA RAY OBSERVATORY (CGRO) (NOT OPERATING CURRENTLY)

- Primarily observed gamma rays, though it extended into hard x rays as well. It was launched in 1991 aboard Atlantis and was deorbited in 2000 after failure of a gyroscope.

#### D) THE CHANDRA X-RAY OBSERVATORY (CXO)

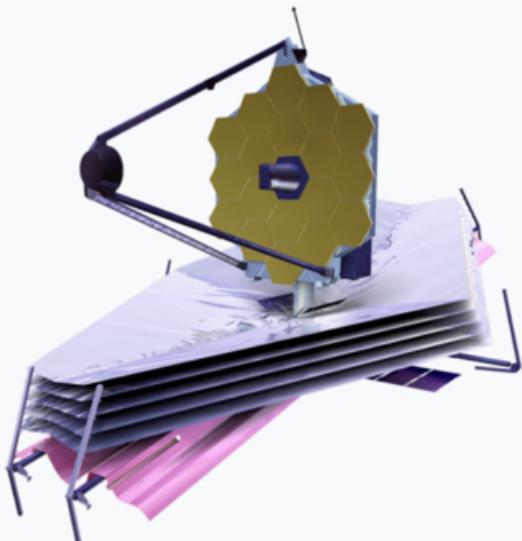
- It is primarily observing soft x-rays. It was launched in 1999 aboard Columbia and was initially named advanced X-ray Astronomical Facility (AXAF).
- Because X-Rays are absorbed by Earth's atmosphere, Chandra must orbit above it and therefore is a space-based telescope.

#### E) THE SPITZER SPACE TELESCOPE (SST)

It observes the infrared spectrum. It was launched in 2003 aboard a Delta II rocket and was called the Space Infrared Telescope Facility (SITF) before launch.

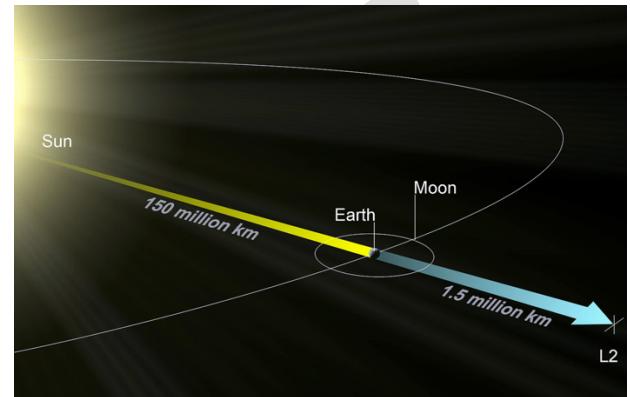
## 2) JAMES WEBB SPACE TELESCOPE

- It is the largest, most powerful, and complex space telescope ever built and launched into space. It is an infrared telescope with a 6.5-meter primary mirror.
- **International Collaboration:** JWST is an international collaboration between NASA, European Space Agency (ESA), and the Canadian Space Agency (CSA).
- **Some innovative technologies**
  - Primary Mirror made of 18 separate hexagonal segments that unfolded and adjusted to the shape after launch. The mirrors are made of ultra-lightweight beryllium and are gold coated. A single large mirror would have been too large for existing rockets to carry.
  - Biggest feature is a tennis court sized five-layer sunshield that attenuates heat from the Sun more than a million times. This sunshield is constructed from Kapton E, a commercially available polyimide film with membranes especially coated with aluminium on both sides and a layer of doped silicon on the sun facing die of the two hottest layers to reflect the sun's heat back into space.
- **Two basic reasons for it being more powerful than Hubble:**
  - It has the **biggest telescope mirror** to fly in space.



A rendering of the James Webb Space Telescope with its components fully deployed.

- 7 times light will be caught than collecting area of Hubble
- It is **designed to collect infrared light**, which **Hubble is not very sensitive to**.
  - **Why infrared observation?**
    - **High redshift (very old and distant)** objects have **their visible emissions shifted into the infrared**, and therefore their light can only be **observed today via infrared astronomy**.
    - **Colder objects** and planets **emit strongly in the infrared**.
    - Infrared rays can **better pierce cosmic dusts** and thus would be able to give **details about the earliest and furthest galaxies**. (Infrared wavelength can penetrate gas and dust)
  - **Why from L2 and what is the purpose of sunshield?**
    - **Earth's atmosphere glows in the infrared**, so measurement can't be made from the ground.
    - **Hubble emits its own heat**, which could obscure infrared readings.
    - JWST will **run close to absolute zero (around 50K or -232.2 degree C) in temperature** otherwise, infrared radiation from the telescope itself would overwhelm its instruments. For this, it would rest at a point in space called the **Lagrange Point 2**, which is **directly behind earth from the sun's perspective**. Further, the **five-layer sunshield** would attenuate heat from sun more than **a million times**.
- It was launched in 2021, and it reached **its final orbit at a distance of around 1.5 million km from the Earth in early 2022** and it took the engineers and scientists another six months to **ready the instruments before it could be used**.



### 3) NASA'S ARTEMIS ACCORD

- **Why in news?**
  - India signs US-led Artemis Accord. With this **India has become 27<sup>th</sup> signatory to the accord (June 2023)**
- **What is Artemis Accord?**
  - Artemis accord was **announced by NASA in Oct 2020** with an initial group of **eight signatories (USA, Canada, UK, Luxemburg, Italy, UAE, Japan, and Australia)**. Later, more countries joined the accord. **India became 27<sup>th</sup> country to sign the accord in June 2023**.
    - **Note:** China and Russia are not part of the accord.
  - It is a **set of 13 principles** which seek to promote **peaceful and cooperative exploration of space**. Signatory countries agree to abide by these principles which are **mostly a reiteration of established international law on space exploration** (for e.g. the OST of 1967).

- The parties who sign this would be able to participate in NASA's Artemis Program of crewed Lunar Exploration.
- The accord serves as preamble to bilateral, government-to-government agreements that participating nations will sign with the USA.
- **Key Provisions:**
  - **Peaceful purposes:** Conduct all space activities peacefully and in accordance with international law.
  - **Heritage Protection:** Help protect space heritage, such as Apollo landing sites.
  - **Transparency:** Publicly release scientific data in a timely manner
  - **Emergency Assistance:** Render aid to astronaut who need it.
  - **Interoperability:** Make their (signatory countries) hardware and other systems "interoperable" to maximize cooperative system.
  - **Registration of Space Objects:** The Artemis accord reinforces the critical nature of registration and urges any partner which isn't already a member of the Registration Convention to join ASAP.
  - **Space Resource:** Space resource extraction and utilization can and will be conducted under the auspices of the Outer Space Treaty, with specific emphasis on Article II, VI, and XI.
  - **Deconfliction of Activities:** NASA and partner nations will provide public information regarding the location and general nature of operations which will inform the scale and scope of 'Safety Zones'.
- **Analysis:**
  - **Why the project is collaborative?**
    - Huge costs involved in these projects -> so countries like USA are keen to take forward a collaborative agenda.
    - **Geopolitical dimension:** China and Russia are also planning a research station on Moon (surface or orbit), and they are also seeking partners.
  - **India's joining:**
    - India's joining of Artemis accord doesn't mean automatic participation in the Artemis program, but it does open up possibilities of much closer cooperation between the space agencies of the two countries. In fact, the text of the accord clearly mentions that its purpose is to establish a common vision and enhance the governance of civil exploration of outer space "with the intention of advancing the Artemis Program".

#### 4) NASA'S ARTEMIS LUNAR PROGRAM

- This is NASA's program for Crewed Lunar Exploration. Under this NASA aims to land two astronauts (including 1 women) near the Lunar south pole in 2024 and establish a sustainable human presence on and around the moon by the end of the decade.

- Perhaps the most ambitious of the Artemis mission's objectives involve using the moon as a **stepping stone for a mission to Mars**. Robots have done all the detective work on Mars so far, but NASA aims to send astronauts there by 2030s.
- NASA is collaborating with other countries and Private sector for this project.
- **Rockets and Spacecrafts:**
  - At the center of the Artemis Program are NASA's new megarocket, the **Space Launch Rocket (SLS)** and the **Orion Spacecraft**.
  - The **SLS** is a 322 foot tall (98 meters) rocket consisting of a core stage, upper stage, and twin five segment solid rocket boosters to launch payload into space. This rocket will launch the Orion Spacecraft to the moon.
  - **Orion** is a space capsule larger than the Apollo command modules that are designed to carry four astronauts on missions to the moon.

#### A) ARTEMIS-1 MISSION

- Artemis-1 is the first integrated test of NASA's deep space exploration systems: the Orion spacecraft, Space Launch System (SLS) rocket and the ground system at Kennedy Space Centre in Cape Canaveral, Florida. It was launched in Nov 2022 from NASA's Kennedy Space Centre in Florida.
- It tests the safety of the SLS rocket, and the Orion capsule's ability to reach moon, perform in lunar orbit and return to Earth for an ocean splashdown.
- It is an uncrewed flight test that will provide foundation for human deep space exploration and demonstrate NASA's commitment and capability to extend human existence to the Moon and beyond. It will pave the way for many moon missions including ones that will land the first woman and the first person of color on the Moon.

#### ORION SURPASSES APOLLO 13 RECORD DISTANCE FROM EARTH (NOV 2022)

- On day 11 of the Artemis 1 mission, Orion continued its journey beyond Moon after entering a distance retrograde orbit. Orion remained in this orbit for six days before exiting lunar orbit to put the spacecraft on a trajectory back to earth.
- **Orion surpassed** the distance record for a mission with a spacecraft designed to carry humans to deep space and back to Earth, on Nov 26, 2020.

#### B) ARTEMIS-2: 2024

- Carrying the first four Artemis astronauts, the Orion Capsule will take the crew farther from earth than humans have ever travelled before.
- Over the approximately 10-day mission, the crew will complete a lunar flyby and return to Earth, evaluating the spacecraft's systems while carrying humans.

### C) ARTEMIS-3: 2025

- It will see the **next man and first woman step onto the lunar surface**. Astronauts will land on the South pole of the moon using lunar lander. They will remain on the moon for around a week.

### D) NASA'S GATEWAY LUNAR ORBIT OUTPOST

#### - Details

- Gateway Lunar Orbit Outpost is basically a **spaceship that will orbit the Moon**. It will act as an airport, where spacecraft bound for lunar surface or surface of Mars can refuel or replace parts and resupply things like food, oxygen. It will also act as a temporary office and living quarters and lab for astronauts around 2,50,000 kms away from earth.

## 5) NASA'S MARS 2020 MISSION - PERSEVERANCE ROVER

#### - Details

- Perseverance (six-wheeled robot) is NASA's Martian rover. In Feb 2021, it touched down on the Martial soil when it successfully landed in Mar's Jezero Crater.
- Its design is similar to its predecessor rover- curiosity, from which it was moderately upgraded. It carries seven primary payload instruments, 19 cameras, and two microphones. It also carries a mini-helicopter Ingenuity, which in April 2021 made the **first ever powered flight on another planet**.
- The rover has **four science objectives** that support the **Mars Exploration Program's Science goals**:
  - » **Looking for habitability**
  - » **Astrobiology: Seeking biosignatures** – of possible past microbial life in those habitable environments, particularly in specific rock types known to preserve signs overtime.
  - » **Caching samples** – Collect core rocks and soil samples and store them on Martian surface which can be extracted by future programs.
  - » **Preparing for crewed missions** – Test oxygen production form the Martian atmosphere.
- The two microphones would listen to Martian sounds like the wind or the rover moving on the Martian soil.
- **Why Jajero Crater:**
  - » Jajero **crater preserves the evidence that it was once a lake** with an inflow channel and an outflow channel. There are good chances that if life existed on Mars in the past, the microorganisms could have lived here and preserved in the form of fossil here.
  - » **In Aug 2022**, NASA's perseverance found surprising volcanic rocks in Mars' Jezero Crater. The discovery was a complete surprise as the researchers initially expected to find sedimentary rocks formed by mud and detritus laid down by the ancient lake. These water altered rocks indicate the presence of water, which is an essential ingredient for a habitable environment.

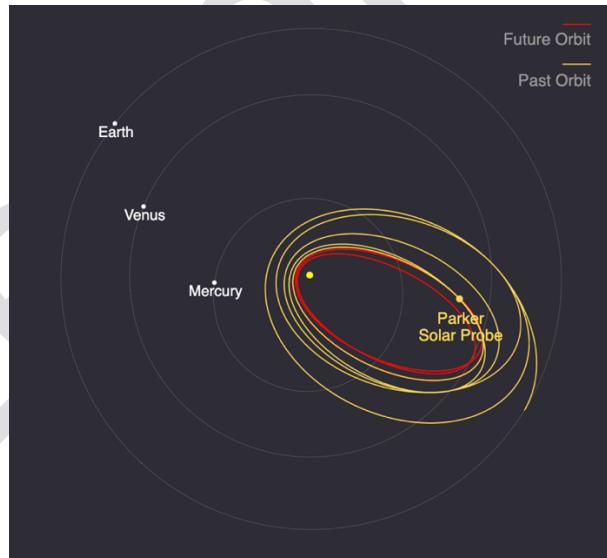
- In April 2021, NASA's Ingenuity Mars Helicopter became the first aircraft in history to make a powered, controlled flight on another planet.
  - » It is a **solar powered** helicopter.
  - » **Why flying on Mars is a challenge?**
    - Atmosphere density is only 1% of Earth's atmosphere.
    - To sustain flight, helicopter blades have to rotate at 2400 rpm (rotation per minute). For a helicopter to fly few meters from the ground on Mars, is equivalent for a helicopter to fly 2-3 times the height of Mt Everest.



## 6) PARKER SOLAR PROBE

### - Introduction

- The parker solar probe was launched in Aug 2018. It is designed to swoop through the sun's super-hot outer atmosphere and help scientists understand the way our star shapes the solar system.
  - **Using Venus' Gravity:** The parker probe has used Venus' gravity during seven flybys over nearly seven years to gradually bring its orbit closer to sun. It is done to slowdown the spacecraft to reduce gravitational pull of the Sun.
    - In June 2020, the probe reached as close as 832 kms above the planet's surface.
  - **Launch Site:** NASA's Kennedy Space Center, Florida
  - **Launch Vehicle:** Delta IV – Heavy with upper stage.



- It is designed to go closer to the sun (3.8 million miles from the solar surface), seven times closer than any other spacecraft before, facing brutal heat and radiation conditions – and ultimately provide humanity with the closest ever observation of the star. **In 2021 it has entered into the outermost part of sun's atmosphere**, known as the Corona. It is using in situ measurements and

imaging to revolutionize our understanding of the Corona. It is a monumental moment for solar science and a truly remarkable feat.

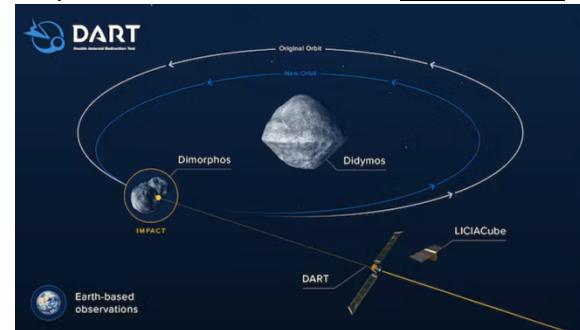
- The first passage through Corona – and the promise of more flybys to come – will continue to provide data on phenomena that are impossible to study from afar.

## 7) LUCY MISSION

- NASA has launched the LUCY spacecraft in Oct 2021, on a 12-year cruise to the Jupiter Trojan asteroids. It will fly by eight asteroids – 7 trojans and one main belt asteroid – over the next 12 years. It is NASA's first single aircraft mission which will explore so many asteroids at one go.
- LUCY will run on solar power out to 850 million kms away from sun. This makes it the farthest-flung solar powered spacecraft ever.
- **Significance:** It will look back into the origins and evolution of the solar system formed over 4 billion years ago through these celestial bodies.
- **Why named Lucy?**
  - Lucy is the name given to a hominin that lived 3.2 million years ago. She is known to be one of the most famous pre-human fossil in history.
  - Nearly, 40% of the fossilized skeleton of this hominin was discovered in 1974 by a team of Paleoanthropologists led by Donald Johanson. The name was inspired from the famous Beatles song "Lucy in the Sky with Diamonds", which Johanson's team listened to at camp the night of their discovery.

## 8) DART MISSION

- **Introduction**
  - DART is a planetary defense-driven test of technologies for preventing an impact of Earth by a hazardous asteroid.
  - Under this NASA launched a mission in Nov 2021, aboard Space X Falcon 9 rocket. It sent a space capsule of the size of a fridge towards an asteroid to shoot it off course. The target asteroids were 11 million kms away from Earth and DART mission reached here after 11 months of journey.
- **Target Asteroid:**
  - DART's test target was an asteroid (Dimorphos/Didymos B) that passed the earth in 2022 and will come back two years later.
  - Its primary body (Didymos A) is approx. 780 meters across, its secondary body (or “moonlet”) – Didymos B is about 160 meter in size, which is more typical of the size of asteroids that could pose the most likely significant threat to Earth.
  - NOTE: DART's target asteroid was **NOT** a threat to earth, and it is only a test mission.



- In Sep 2022, this space capsule was crashed into **Dimorphous/Didymos-B**.
- It used **autonomous targeting**, using images of the asteroids it acquires as it approaches. DART needed to recognize the asteroid itself, automatically lock onto Dimorphous, and adjust its trajectory to hit it. This is while it was moving at a speed of 24,000 km per hour.
  
- **Technology: Kinetic Impact Technique:**
  
- **Why Didymos system was chosen:** Easy to measure impact (binary pair); No risk to humans.
- **How observations were made:**
  - Measurements from telescopes on Earth.
  - **LICIACube:** It is an Italian Space Agency CubeSat (a small type of satellite) that was deployed from a spring-loaded box aboard the craft on 11<sup>th</sup> Sep. LICIACube followed along and photographed the collision and its aftermath.
  
- **Outcome:**
  - **For the first time**, human has changed the orbit of a planetary body. The impact shortened Dimorphos' orbit time by 32 minutes.
  - **Proof:** The test was a proof of concept for many technologies, that NASA has invested over the last few years.
  - **DART** has also given some fascinating data about both asteroid properties and the effectiveness of a kinetic impactor as a planetary defence technology.

## 9) VOYAGER-2

- **Why in news?**
  - NASA's Voyager 2 spacecraft, which is now travelling in interstellar space, has gotten a new lease of life after mission engineers developed a new plan to keep its instruments running for longer (April 2023)
- **About Voyager 2**
  - Voyager 2 is a **space probe launched by NASA in 1977 to study the outer planets**.
  - Its primary mission ended with the exploration of the Neptunian system in 1989. It had visited Jupiter, Saturn and Uranus earlier.
  - It is second spacecraft to enter interstellar space. On 10<sup>th</sup> Dec 2018, the spacecraft joined its twin – Voyager 1 – as the only human-made objects to enter the space between the stars.
- **Power:** The spacecraft is equipped with **3 Multi-hundred-Watt radioisotope thermoelectric generators (MHW RTG)**.
- **April 2023 Updates:**
  - The ageing voyager 2 spacecraft has begun using a small reservoir of backup power to keep its instruments working despite a reduced power supply. This backup power was set aside as part of an onboard safety mechanism. The spacecraft was scheduled to shut down its science instruments in 2023, but with this move, it can continue operating them until 2026.
  
- **Achievements**
  - It is the **only spacecraft to study all four of the solar system's giant planets** at close range.

- The craft is now travelling more than 11.6 billion miles from earth. It is **beyond heliopause**, or boundary region, where the sun's influence ends and the **interstellar medium begins**.
- Note:** Although both the Voyager probes – Voyager-1, launched on Sep 5, 1977, and Voyager 2, launched 16 days before its twin – have left the heliosphere, neither spacecraft has yet left the solar system, and won't be leaving anytime soon. The boundary of the solar system is considered to be beyond the outer edge of the Oort Cloud, a collection of small objects that are still under the influence of sun's gravity.

The width of the Oort Cloud is not known precisely, but it is estimated to begin at about 1,000 astronomical units from the sun and to extend to about 100,000 AU (1 AU is the distance from the sun to Earth). It will take about 300 years for Voyager 2 to reach the inner edge of the Oort Cloud and possibly 30,000 years to fly beyond it.

### 3. PEREGRINE MISSION-1: FIRST US SPACECRAFT DUE TO LAND ON MOON SINCE THE APOLLO MISSIONS IN THE 1970S LIFTS OFF

#### Why in news?

Peregrine Mission-1 is the first US attempt to land on Moon in more than half a century (since Apollo 17 in 1972). It lifted off in space as planned (Jan 2024)

#### Soft Landing on Moon So Far:

As of Jan 2024, **Soft landing on moon** has been achieved by **only four national space agencies**:

**Soviet Union** was first in 1966.

It was followed by USA's NASA which still remains the only space agency to put humans on Moon.

In the last decade, China soft landed on moon thrice in its Chang'e-3, Chang'e-4, and Chang'e-5 missions.

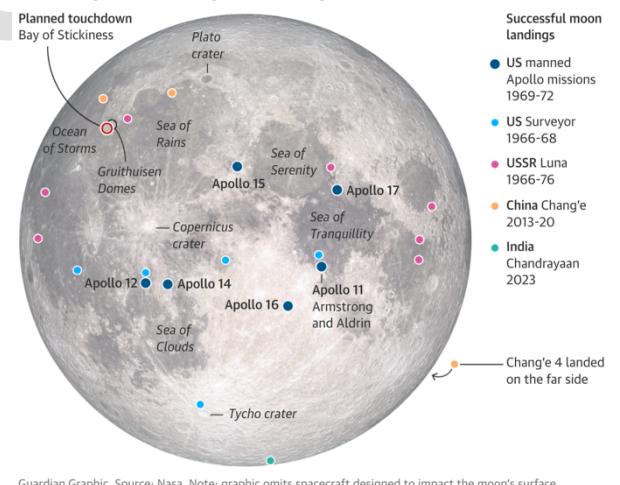
**India** achieved soft landing in 2023 in its Chandrayaan-3 mission.

#### Failures:

Private Missions by Israel and Japan, as well as an attempt by the Russian Space Agency – have all ended in failures.

**Why limited successes?** Controlled touchdown on moon is a challenging task due to absence of atmosphere and treacherous terrain.

The Peregrine lunar lander is expected to touch down on **23 February** in the newly named Bay of Stickiness



Guardian Graphic. Source: Nasa. Note: graphic omits spacecraft designed to impact the moon's surface

#### Details Of Peregrine Mission-1

**Rocket Used: Vulcan Centaur:** It's a brand-new rocket of United Launch Alliance. Peregrine Mission-1 is its maiden launch.

- » The rocket has reusable first stage booster engines which is expected to reduce cost of launches.
- » **Note:** ULA is a joint venture between Lockheed Martin and Boeing.

**Peregrine Lander:** It has been developed by a US company Astrobotic, which has been selected for NASA's Commercial Lunar Payload Services (CLPS) programme.

**Launch site:** Cape Canaveral Space Force Station, Florida.

**Touchdown:** Peregrine is schedule to touch on a mid-latitude region of the Moon called Sinus Viscositas.

NASA has contracted private players under Commercial Lunar Payload Services (CLPS) programme.

**Payload Carried:**

A suite of scientific instruments by NASA to probe radiation and surface composition – helping to pave the way for return of the astronauts.

**Some Unique Cargos:** A shoebox-sized rover built by Carnegie Mellon University (CMU), a physical bitcoin, and cremated remains and DNA including those of Star Trek creator Gene Roddenberry, legendary sci-fi author, scientist Arthur C. Clarke, and a dog.

**Note:** The Navajo Nation, the USA's largest indigenous tribe, had opposed it as sending these to the moon desecrates a body they consider sacred to their culture.

**Significance:**

- » **Stimulate Broader Lunar Economy:** USA has turned to commercial sector to stimulate broader lunar economy.
- » **Cost Reduction:** NASA has paid the startup just \$180 million for five scientific instruments to be carried to the moon – a fraction of cost of launching its own mission.

#### Future Commercial Launches:

Another US company, which NASA has contracted, Houston-based Intuitive Machines, is looking to launch in Feb 2024 and land near the south pole.

## 4. CHINA

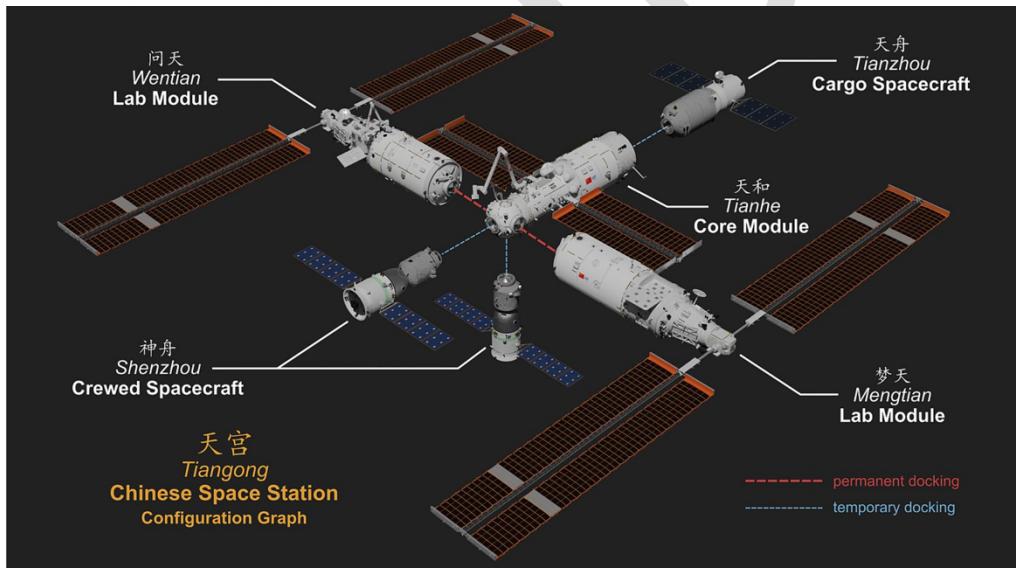
### 1) CHINA'S SPACE STATION: TIANGONG

- **Details**

- **Background:**

- China's crewed space program is officially three decades old. It truly got underway, when in 2003, China became only third country in the world, after USA and Russia, to put a human into space using its own resources.

- Work on the space station programme began a decade ago with the launch of a **space lab Tiangong-1** in 2011, and later, **Tiangong-2** in 2016.
- **Details of the Space Station - Tiangong:** It is a **T-Shaped space station** which will be able to accommodate 25 lab cabinets, each a micro lab that can be used to conduct experiments. The space station will weigh 66 tonnes – a fraction of ISS which weighs 465 tonnes.
  - It will have **three modules**
    - **Tianhe Module** (launched in April 2021) on Long March-5B.
    - **Wentian Module** (launched in July 2022) will be equipped to support life science research. It will also have airlock cabins for extravehicular trips, as well as short-term living quarters for astronauts during crew rotation.
    - **Mengtian Module** (launched in Oct 2022) will focus on microgravity experiment. It is the third and final module which docked with the station in Nov 2022.
  - The space station is designed for a lifespan of at least a decade.
  - It has facilities for long term accommodation of just three astronauts (compared to 7 of ISS). Still China has invited foreign astronauts in an effort to internationalize the space station.
  - **Scope of expansion in future:** The Three module T Shaped station could be expanded into a four-module cross shaped configuration in future.



## 2) CHANG'E-5

- **Details**
  - The Chang'e-5 probe, comprising an orbiter, a lander, an ascender, and a returner was launched on Nov 24, 2020, and its lander-ascender combination touched down on the north of the Mons Rumker in Oceanus Procellarum, also known as the ocean of Storms, on the near side of the Moon on 1<sup>st</sup> Dec 2020.
  - It was the third Chinese mission to land on the moon.

- The Chang'e-5 probe returned to earth in Dec 2020 and it brought along with it about 1,731 grams of samples. Scientists will carry out the storage, analysis, and research of the country's first samples collected from the extra-terrestrial object.

The Chang'e-5 mission marks a successful conclusion of China's current three-step lunar exploration programme of orbiting and landing and bringing back samples which began in 2004.

## 5. SPACE TOURISM

- **Why in news?**
  - » ISRO is planning space tourism by 2030
- **What is suborbital Flight?**
  - » Suborbital flights don't have enough speed to escape into orbit. Any orbit without enough energy to reach orbit will instead follow a parabolic trajectory, looping up and then back down again. This will be a suborbital space mission or suborbital flight.
  - » Such flights are short, but passengers can experience mind-blowing view of Earth and will also experience several minutes of weightlessness. This thus can attract space tourists.
  - » **Why weightlessness?**
    - During downward path, a section of the flight is a free fall.
  - » **Other Significances:**
    - Microgravity experiments can also be carried out on these flights. This would be much cheaper than doing these experiments in International Space Stations.
    - It could also be a cheaper way of testing space flight technologies or experiments before they are sent on more expensive orbital or deep space missions.
- **Space Tourism**
  - » Space Tourism is the segment of space travel which provides non-astronauts the ability to go to space for recreational, leisure or business purposes. The idea is to make space more accessible for anyone who can afford it.
  - » In the past, NASA and Russian Space Agency used to take tourists for space travel. For e.g. Dennis Tito was the first commercial spaceflight passenger before which only astronauts used to go to space. He went to space on Russian Soyuz TMA Launch Vehicle in April 2001. After him, between 2001-2009, few other space tourists went to space, aboard a Russian Soyuz space to ISS, brokered by Space Adventures (an American Space Tourist company) in conjunction with Roscosmos.
- **Recent tourism space flights:**
  - » Virgin Galactic is a company which was established by British Entrepreneur Richard Branson in 2004.
    - In July 2021, Richard Branson and five others undertook a brief trip to the edge of the space, taking off on a VSS unity spaceship.



- » Blue Origin was established by Jeff Bezos in 2000. It's reusable rocket New Shepherd successfully completed first human flight to space recently (**20<sup>th</sup> July 2021**) with **four private citizens onboard**. The flight went about **107 km** high.
- SpaceX's Inspiration4 – debut of SpaceX's tourism business (Sep 2021)
  - » Falcon 9 rocket took a crew Dragon spacecraft with 4 civilians (first all civilian space flight) into space. They travelled to an altitude of 575 km, even higher than HST and ISS.
  - » Isaacman, the founder and CEO of Shift4 payments, is largely responsible for the mission's planning from birth to launch.
- Other than these three, companies such as Virgin Atlantic, XCOR Aerospace, Armadillo Aerospace are working on providing space tourism services to people.
- **Concerns**
  - » Climate change may be aggravated by Space Tourism.
  - » Available only for highly rich people

## 6. RUSSIA:

### 1) LUNA-25

- **Why in news?**
  - Russia's LUNA-25 failed to land on Moon and crashed onto Moon's surface (Aug 2023)
- **Details**
  - **Why the failure?**  
An anomalous engine burn-> Instead of a planned propulsive nudge of 84 seconds, the engine operated for 127 seconds, more than the "required value" in readying the probe for its descent burn. This added impulse caused Luna-25 to smash into the moon.
  - **More about Luna-25:**

- i. It was modern Russia's first Moon mission. It was heralded as the first domestically produced moon probe in Modern Russia history. Luna-25's flight was important in both political and scientific terms. The implication of its failure is likely to be considerable.
- ii. The final soviet moon mission, Luna-24, successfully hauled home to Earth about 170 grams of lunar samples in 1976.

## 7. GENERAL SPACE ISSUES

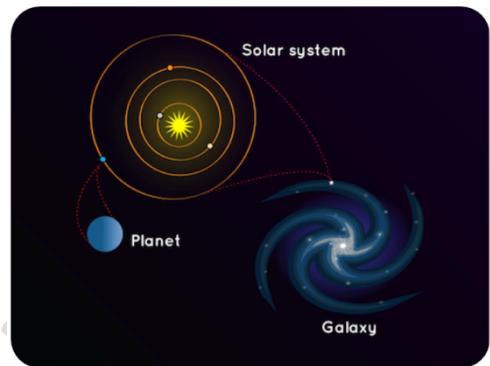
### 1) SPACE DEBRIS

- **Introduction**
  - The term “space debris” refers to **defunct human made objects which are moving in orbit around earth**. It includes big and small things like discarded boosters, retired satellites, leftover bits and pieces from spacecrafts, screwdrivers, tools, nuts, bolts, lost gloves, flecks of paints etc.
  - There are more than 20,000 pieces of debris that are larger than 5-10 cms and can be tracked and catalogued. There are hundreds of millions that we cannot because of their small size. They are all dangerous as they are moving at very high speeds.
- **How are Space Debris created?**
  - **Breakup of older spacecrafts:** For e.g., breakup of US' spacecraft called USA 109 in 2015, created 100 debris pieces and 50,000 shards larger than 1 mm.
  - **Accidently left-over objects**
  - **Testing of Space Weapons**
    - For e.g., China's testing of A-SAT missile in 2007 created more than 34,000 debris.
  - **Further breakup of space debris:** More debris increase the chance of collision – a cascade effect known as the **Kessler Syndrome**. The fear is that the space could eventually become inoperable.
  - **Mega constellations** (e.g., Starlink satellite internet constellation) would launch thousands of satellites in coming years and would make space more vulnerable to collision and debris creation.
- **Key Concerns Raised by Space Debris**
  - **Endanger the prospects for Space Missions** (Civilian, Commercial or military)
  - **Sometimes crash land on earth** harming life and livelihood of people
    - Recently parts of Zenit rocket debris are reported to have ended up crash-landing in Peru.

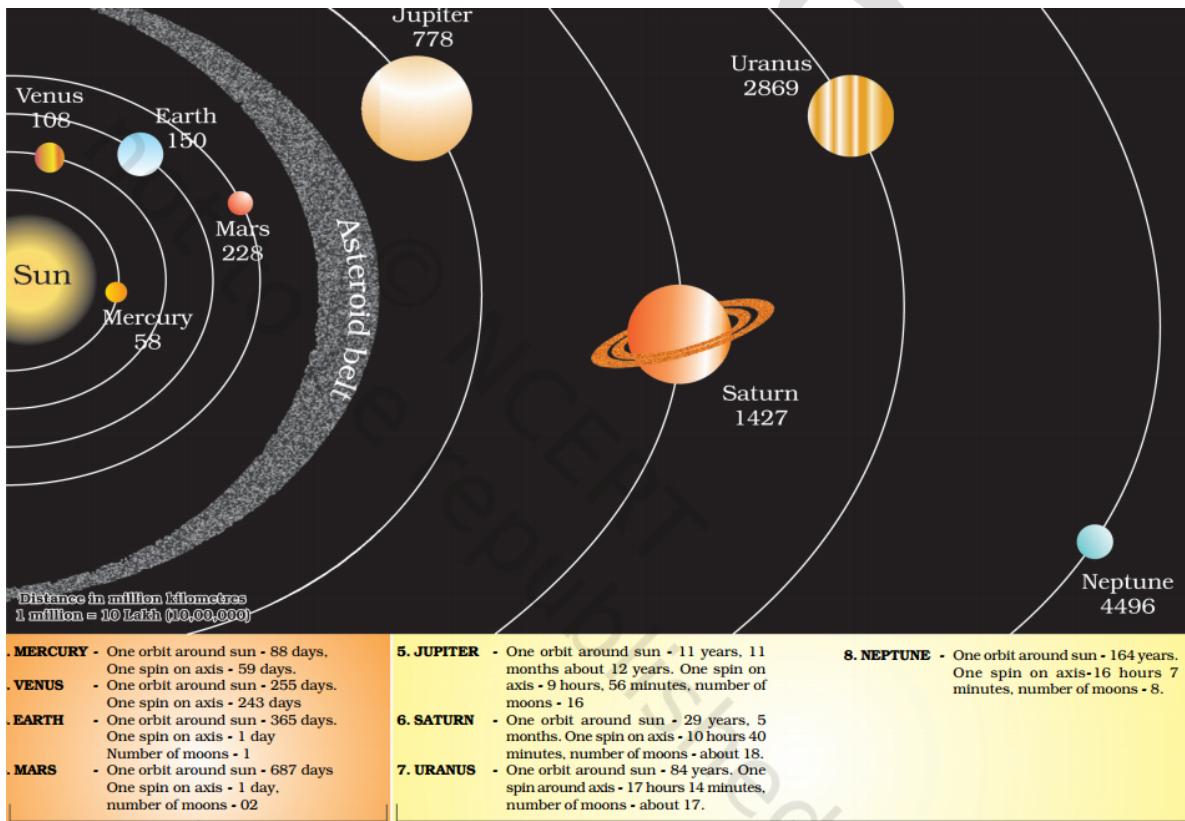
## 8. BASICS OF ASTRONOMY

### 1) GALAXY

- » Galaxies are like building blocks of Universe.
- » A galaxy is huge collection of gas, dust, and billions of stars and their solar systems. A galaxy is held together by their gravity. Our galaxy, the Milky Way, also has a supermassive black hole in the middle.
- » When we look up at the stars in the night sky, we see other stars in the Milky Way.
- » There are many galaxies besides ours. Some scientists estimate the total number of galaxies to be as much as one hundred billion.



### 2) OUR SOLAR SYSTEM



#### - Planets

- » **8 (My Very efficient mother just served us nuts)**
- » Venus is considered as 'Earth's twin' because its size and shape are very much similar to that of earth

- » **Pluto:** Till recently (August 2006) was called a planet. However, in a meeting of **International Astronomical Union**, a decision was taken that Pluto like other celestial objects (Ceres, 2003 UB<sub>313</sub>) discovered in recent past may be called a dwarf planet<sup>1</sup>.

**Inner Planet :** Mercury, Venus, Earth, Mars (*very close to sun, made of rocks*). They are called *inner planets* as they lie between the sun and the belt of asteroids. They are also called **terrestrial planets**, meaning earth like as they are made up of rock and metals, and have relatively high densities.

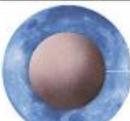
**Outer Planet:** Jupiter, Saturn, Uranus, Neptune. They are called outer planets. They are also known as **Jovian or Gas** planets. Jovian means Jupiter like. Most of them are much larger than the terrestrial planet and have a thick atmosphere, mostly of helium and hydrogen.

- **The difference between terrestrial and Jovian planets can be attributed to the following conditions**
  - i. The terrestrial planets were formed in the close vicinity of the parent star where it was too warm for gases to condense to solid particles. Jovian planets were formed at quite a distant location. ()
  - ii. The solar wind was most intense nearer the sun; so, it blew off lots of gas and dust from the terrestrial planets. The solar winds are not all that intense to cause similar removal of gases from the Jovian planets.

The terrestrial planets are smaller and their lower gravity could not hold the escaping gas.

### 3) PLANETS, DWARF PLANTS AND OTHER CELESTIAL BODIES

#### DWARFS, THEIR DIAMETERS

	<b>CERES</b>	<b>950 km</b>
Between Mars and Jupiter		
	<b>PLUTO</b>	<b>2,400 km</b>
Beyond Neptune, once seen as planet		
	<b>ERIS</b>	<b>2,300 km</b>
Beyond Neptune, close to Pluto in size		
	<b>MAKEMAKE</b>	<b>1,400 km</b>
Beyond Neptune, discovered in 2005		
	<b>HAUMEA</b>	<b>1,400 km</b>
Beyond Neptune; measurements vary		

## 4) MOON

- » It is Earth's only natural satellite
- » **Size:** 1737.1 km (Radius)
- » **Distance:** 3,84,400 km away from earth
- » **Only one side visible**
  - The moon moves around the earth in about **27 days**. It takes exactly the same time to complete one spin. As a result, only one side of the moon is visible to us on earth.

## 5) PLANETS WITH HIGHEST NUMBER OF MOON

- SATURN

## 6) ASTEROIDS

- Apart from the stars, planets and satellite, there are numerous tiny bodies which also move around sun. These bodies are called asteroids. They are found between **orbits of Mars and Jupiter**. Scientists are of the view that asteroids are parts of a planet which exploded many years back.

### A) NEAR EARTH ASTEROID:

- **About Near Earth Objects**
  - NEOs are comets and asteroids nudged by the gravitational attraction of nearby planets into orbits which allows them to enter the Earth's neighborhood. They occasionally approach close to the Earth as they orbit the sun.
  - NASA's Center for Near-Earth Object Study (CNEOS) determines the times and distances of these objects as and when their approach to the Earth is close.
- **Significance of Near-Earth Objects:**
  - Scientific interest in comets and asteroids is largely due to their status as relatively unchanged remnant debris from the solar system formation process over 4.6 billion years ago. Therefore, they can give clue regarding original conditions which led to formation of planets.
  - Further, **an asteroid** is considered as one of the existential dangers for life on earth. Therefore, it's important to study these near-earth objects and prepare to ward off any future hit.
- **When is an Asteroid considered PHA (Potentially hazardous asteroid)?**
  - Asteroids with a minimum orbit intersection distance (MOID) of about 0.05 AU (i.e. roughly 7,480,000 km or less and a diameter more than 150 meters) is considered PHAs.
  - **Note:** It is not necessary that asteroids classified as PHAs will necessarily impact the earth. It only means that there is a possibility of such threat.

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## B) PSYCHE

- **Example Questions:**
  - Launched on 13<sup>th</sup> October 2023, Psyche Mission has been much in news since then. What are the key goals of the mission? What potential benefit does it hold for human race? [10 marks, 150 words]
- **About Psyche Asteroid:**
  - Psyche is one of the asteroids in the asteroid belt. What makes the asteroid unique is that it appears to be the exposed nickel-iron core of an early planet, one of the building blocks of our solar system.
- **About Psyche Mission:**
  - The Psyche Mission is a NASA space mission launched on 13<sup>th</sup> Oct 2023 to explore origin of planetary cores by orbiting and studying the metallic asteroid Psyche in 2029. The mission consists of Psyche Aircraft.
- **Significance:**
  - **Understanding the Core of a Planet:** Deep within rocky terrestrial planets – including Earth – scientists infer the presence of metallic cores. But these remain unreachably far below the planets' rocky mantles and crusts. Psyche offers a unique window into the violent history of collisions and acceleration that created terrestrial planets.
  - **Science Goals include:**
    - **Understand a previously unexplored building block of planet formation:** Iron cores.
    - **Look inside terrestrial planets, including Earth,** by directly examining the interior of a different body, which otherwise couldn't be seen.
    - **Explore a new type of world** made of metal (and not of rock and ice)
  - **Science Objectives:**
    - Understanding Psyche – Whether it is a core, or if it is an unmelted material, relative ages of psyche's surface etc.
  - **Deep Space Optical Communication (DSOC):** The Psyche mission is also testing a sophisticated new laser communication technology that encodes data in photons at near-infrared wavelength (rather than radio waves) to communicate between a probe in deep space and Earth.

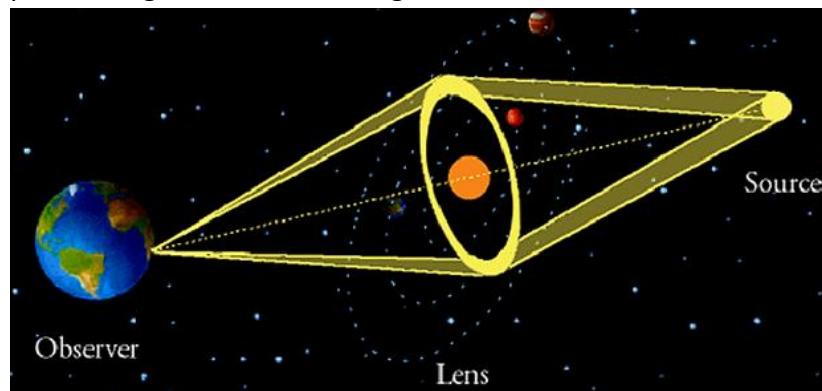
## 7) JUPITER TROJANS (CLASS DISCUSSION)

## 8) EXOPLANETS (CLASS DISCUSSION)

## 9) GRAVITATIONAL LENSING

### » Basics

- Gravity bends the time-space around us. And since light travels through space, it also bends while passing through this bent time space.
- This bending of light creates the same effect as the bending of light through a glass lens and the phenomenon is called gravitational lensing (i.e. lensing effect created by gravity). **Einstein** first predicted gravitational lensing in 1912 and is an effect of his theory of general relativity.



- It is clearly observable when gravitational force is high (i.e. bending of space-time is high) such as in case of large galaxies or cluster of galaxies. Thus, large galaxies can behave like large natural telescopes.

### » Applications

- Scientists use this phenomenon to **study distant stars/galaxies** in Universe which would otherwise have been difficult to see even by the most powerful space telescopes. The image of the distant object would be magnified if there is a gravitational source (like a large galaxy) in the path.
- The phenomenon also helps us in **understanding the origin of a galaxy/star** as we can observe light from distant stars when there were still getting formed.
  - For e.g. NASA under its **TEMPLATES** initiative is using gravitational lensing to study how galaxies are forming stars and how the star formation is distributed across galaxies.

» It also helps us in studying of super massive blackholes at cosmological distance.

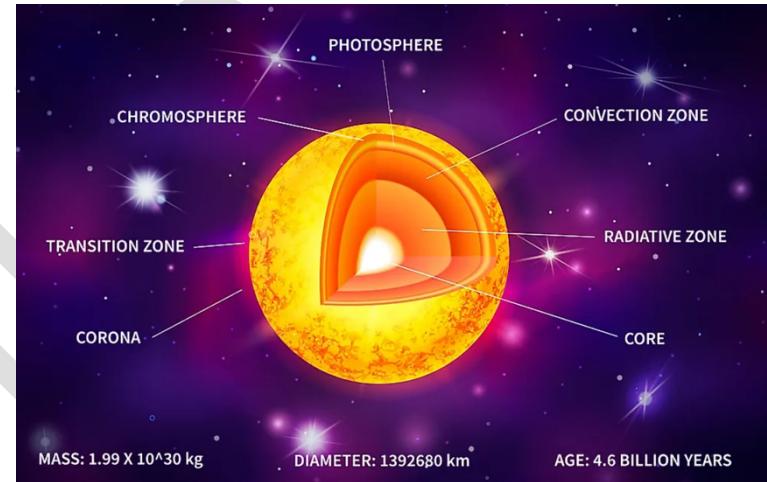
## 9. SUN

### A) BASICS ABOUT SUN

- Distance: 150 million km away from earth
- Radius: 696,000 km

## B) SUN'S STRUCTURE – 3 ATMOSPHERIC LAYERS

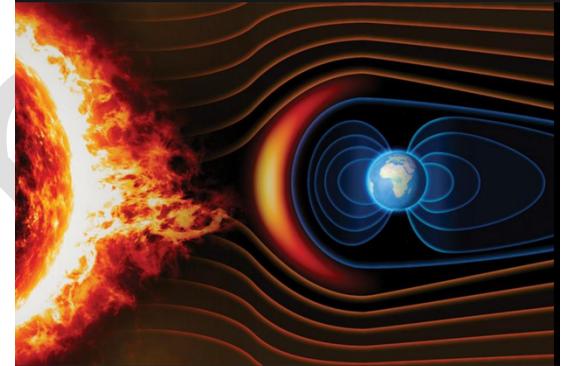
- Sun has **six layers**. The **core, radiative zone and convection zone** consist of the inner layers or the parts of the sun which is not visible. **Photosphere, Chromosphere and Corona** comprise of the sun's atmosphere or outer layer.
- **Inner Layer**
  - Core:** It is the innermost layer of sun. The Core is Plasma, but its movement is extremely similar to gas. The temperature in Sun's core is nearly 15-million-degree Celsius.
  - Radiative Zone:** It is the second layer of sun and sits outside the core. This zone has temperature of millions degree Celsius. The layer serves as a passage for all the energy that is released by the core.
  - Convection Zone:** It is the outermost layer and completely surrounds Radiative zone. In this layer, all the hot material found near the center of the Sun rises cools down and drops back into the radiative zone to get more heat. This is the movement that creates sunspot and Solar flares.
- **Outer Layers:**
  - Photosphere** is the deepest layer of the sun that we can observe directly. It reaches from the surface to about 250 miles above that. Temperature varies from about 6700-degree Celsius to 3,700-degree celsius. Most of the photosphere is covered by granulations (caused by convection current) of the plasma within the Sun's convective zones.
  - Chromosphere:** The chromosphere is a layer in the Sun between about 250 miles and 1300 miles above the solar surface (the photosphere). The temperature in the chromosphere varies between (3700 (**lowest temperature**) at the bottom to 7700-degree C at the top), so in this layer (and higher layers) it actually gets hotter if you go further away from the sun, unlike in the lower layers, where it gets hotter if you go closer to the centre of the sun.
  - Transition Zone:** The transition region is very narrow (60 miles / 100 km) layer between the chromosphere and the corona where the **temperature rises abruptly** from about 7700-degree celsius to 5,00,000-degree C
  - Corona:** It is the outermost layer of the Sun, starting at about 13,00 miles above the solar surface (the photosphere). The temperature in the Corona is 5,00,000-degree celsius or



more upto a few million-degree celsius. It can't be seen with naked eyes except during a total solar eclipse or with use of a coronagraph. It doesn't have any upper limit.

### C) UNDERSTANDING SOLAR WINDS

- The solar wind is a **stream of charged particles released from the upper atmosphere of the sun, the Corona**. The solar wind streams plasma (a mix of positively and negatively charged particles) and particles from the sun out into space.
- **Cause**
  - The temperature of Corona reaches upto 1.1-million-degree celsius (2-million-degree Fahrenheit).
  - As rising heat and pressure push that material away from the Sun, it reaches a point where gravity and magnetic field are too weak to contain it. That point, known as the **Alfven Critical Surface**, marks the end of Solar Atmosphere and beginning of Solar Wind.
- **Why does the property of solar winds change with time?**
  - The sun's activity shifts over the course of its 11 year cycle, with sun spot numbers, radiation levels, and ejected material changing over time.
  - The wind also differs based on where on the sun it comes from and how quickly that portion is rotating.
  - As the plasma material leaves the sun, carried by solar wind, it becomes more gas-like.
- **How does it affect the earth?**
  - As the wind travels off the sun, it carries charged particles and magnetic clouds. This is constantly hitting our planet with interesting effects.
  - If the solar wind reached the earth's surface, its radiation would do severe damage to any life that might exist. They can affect Earth's satellite and the Global Positioning Systems (GPS).
  - But earth's magnetic field acts as shield, redirecting the material around the planet so that it streams beyond it.
  - The force of the wind stretches out the magnetic field so that it is smooshed inward on the sun-side and stretched out on the night side.
  - **Solar Storms (Coronal Mass Ejections - CMEs)**
    - » Sometimes, especially during the active period of the cycle - known as the solar maximum, the sun spits out large burst of plasma known as Coronal mass ejections (CMEs). These have stronger effect than the standard solar wind.



- » When the solar wind carries CMEs and other powerful bursts of radiation into a planet's magnetic field, it can cause the **magnetic field on the back side to press together**, a process known as **Magnetic Reconnection**.
- » Charged particles in case of magnetic reconnection stream back towards the **planet's magnetic poles**, causing beautiful displays known as the **aurora borealis** in the upper atmosphere.

▫ **About Auroras**

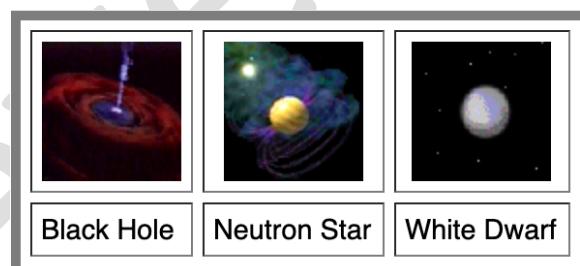
- » In the north the phenomenon is called the **aurora borealis** or the **northern light**. In the southern hemisphere, it's the **aurora australis**, or southern lights.
- » Even though the **earth's magnetic field stretches symmetrically from the north to the south**, recent satellite images of the entire planet showed **mismatched auroras happening at the same time in the two hemispheres**.
- » **Why?** Our **magnetic field is squeezed asymmetrically by solar winds approaching from an angle**, twisting and displacing the northern and southern lights in different forms and locations.

▫ **Useful video to understand Auroras:** <https://youtu.be/PgIKsuZ3RZU>

## 1) LIFE CYCLE OF STARS: STARS – DWARF STARS – NEUTRON STARS – BLACK HOLES

### A) LIFE CYCLE OF A STAR

- Where a star ends up at the end of its life depends on the mass it was born with.
  - **Stars with lots of mass** may end their lives as **black holes or neutron stars**.
  - **A low or medium mass star** (with mass less than 8 times the mass of sun) will become a **white dwarf**.



### B) MEDIUM STARS - > RED GIANT -> WHITE DWARF -> BLACK DWARF

- Class Discussion

#### CHANDRASHEKHAR LIMIT

- The Chandrasekhar Limit, named after the Indian astrophysicist Subrahmanyan Chandrasekhar, is the **maximum mass that a stable white dwarf star can have**. It is an **important concept in astrophysics**, particularly in the study of stellar evolution. Chandrasekhar discovered that if a white dwarf's mass exceeds approximately **1.4 times**

the mass of Sun (Known as Chandrasekhar mass), the pressure generated by the electrons is no longer sufficient to counteract gravity. As a result white dwarf becomes unstable and collapse under its own weight.

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### c) NEUTRON STAR

- **Neutron Star:** It is formed by catastrophic collapse of the core of a massive star. While a white dwarf is supported by electron degeneracy pressure, neutron stars are supported by neutron degeneracy pressure.
- **How is Neutron Star formed:** In its dying phase, when a star with a core containing mainly iron exhausts all its fuel, it collapses under gravity and explodes as supernova. The extreme high pressure causes protons and electrons to combine together to form neutron (thus forming a neutron star). They energy released during the process blows away the outer layer of the star.
- **Would a neutron star further collapse into blackhole?** -> It would depend on the mass of the neutron star's core. If the mass is less than three solar masses it remains as a neutron star, but if the star's mass more than about 3 solar masses, then it collapses further to form a black hole.
- **The highest possible mass** of a neutron star is not very well known, but it can't be theoretically more than 3 solar masses (beyond which, it should be a black hole). The **maximum mass** for a neutron star, which has been precisely measured so far, is around 2.1 solar mass.
- The neutron stars are among the densest objects in the universe. They have a radius of 10-20 km but carry a weight of upto 2.5 times the mass of Sun.
- A **big difference between Neutron star and Black Hole** is that neutron star has a hard surface unlike that of a black hole.

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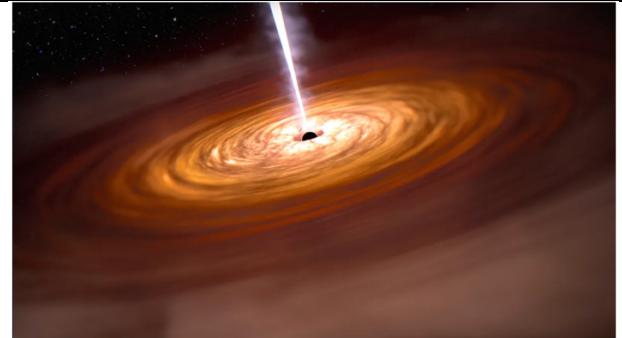
### D) BLACK HOLE

- **Why in news?**
  - » Ferocious black holes reveal 'time dilation' in early universe (July 2023: Source: The Hindu)
  - » Spotting black holes (Sep 2023: Source – The Hindu)
- **What is a Black Hole?**
  - » A Black hole is a place in space where gravity pulls so much that even light can't get out. This strong gravity is because matter has been squeezed into a tiny space. This can happen when a star is dying.
  - » Since, no light is emitted from them, they are invisible.
  - » They are generally **detected** by telescopes by analyzing the behavior of stars that are very close to this black hole.
  - » **How large is a black hole?**
    - A black hole can be as small as an atom (but having the mass of a mountain) and they can be very large as well.

- **Stellar** is a kind of blackhole whose mass is around 20 times the mass of sun. There are many many stellar blackholes in our Milky Way Galaxy.
- “**Supermassive**” are the largest black holes. These black holes have masses that are more than 1 million suns together. Every large galaxy contains a supermassive blackhole at its center. The Supermassive blackhole at the center of the **Milky Way galaxy** is called **Sagittarius**. It has a mass of 4 million suns and would fit inside a very large ball that could hold a few million earths.

**Quasars:** Quasars are a subclass of active galactic nuclei (AGNs), extremely luminous galactic cores where gas and dust falling into a supermassive black hole emit electromagnetic radiation across the entire electromagnetic spectrum. They are among the brightest objects in the Universe.

**Note:** All Quasars are AGN, but not all AGN are Quasar



- » The boundary of black hole is called **event horizon** which acts as one way towards the black hole and allows nothing to get out of it.
- **Singularities and Blackhole**
  - » In 1915 Karl Schwarzschild noticed that Einstein's then new-general theory of relativity predicted the existence of strange objects known as “**singularities**”. They were places where his new equation describing gravity seemed to go haywire. Inside them there was a bizarre place where time stopped, and space became infinite. Over the years evidence have piled up explaining that singularities do exist in our universe as **black holes**.
- **Spotting black holes: How do we identify blackholes?**
  - » A blackhole is identified by the **gravitational force** it exerts on nearby stars.

Astronomers have found systems in which a visible star orbits around an unseen companion. One cannot conclude that the companion is blackhole always; it might merely be a star that is too faint.

- If the unseen companion happens to be a black hole, then because of its high gravity it will start pulling matter off the surface of the visible star. This matter start falling towards the blackhole in a characteristic spiral path. In the process it also emits X-Rays which can be detected from earth.
- From the observed orbit of visible star one can determine the lowest possible mass of the black hole.

- Recent Updates about Blackholes
  - a. Scientists have discovered oldest black hole yet (Nov 2023)
    - A study published in Nov 2023 have confirmed that supermassive blackholes existed at the dawn of the universe. NASA's JWST and Chandra X-Ray Observatory have teamed up to confirm this observation.
    - Given the age of the Universe is 13.7 billion years old, the age of this black hole is 13.2 billion years. Further, this blackhole is whopper – 10 times bigger than the black hole in our milky way galaxy. It is believed to weigh from 10% to 100% the mass of all the stars in its galaxy.
    - How was it formed?
      - a. The researchers believed that the black hole was formed from colossal clouds of gas that collapsed in a galaxy next door to one with stars. The two galaxies merged, and the black hole was formed.
    - Role of Chandra X-Ray Observatory: The fact that Chandra X-Ray detected it confirms without doubt that it is a black hole. With X-rays you discover the gas that is being gravitationally pulled into the black hole, sped up and it starts glowing int the X-Ray.
    - This one is considered quasar since it is actively growing, and the gas is blindingly bright.

b. Ferocious Blackholes reveal time dilation in Early Universe (July 2023)

- Scientists have used observation of a ferocious class of black holes called quasars to demonstrate “time dilation” in the early Universe, showing how time then passed only about a fifth as quickly as it does today. The observation stretches back to about 12.3 billion years ago, when the universe was roughly 1/10<sup>th</sup> of its present age.

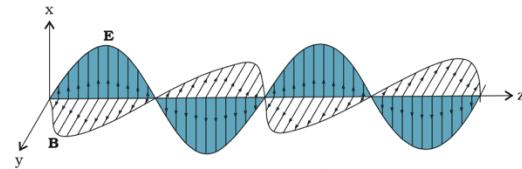
**Quasars were used as a “clock”** in the study to measure time in the deep past. The researchers used observations involving the brightness of 190 quasars across the universe dating to about 1.5 billion years after the Big Bang even that gave rise to the Cosmos. **They compared the brightness of these quasars at various wavelengths to that of quasars existing today**, finding that certain fluctuations that occur in a particular amount of time today did five times more slowly in the most ancient quasars.

## 10. ELECTROMAGNETIC WAVES AND WIRELESS COMMUNICATION

- As per Maxwell's theory accelerated charges radiate electromagnetic waves.
- Key contribution of various scientists:
  - **Hertz:** He experimentally demonstrated that accelerated charged particles emitted electromagnetic waves. [Hertz Experiment 1887] (He did it for low frequency – Radio waves)
  - **JC Bose** working at Kolkata succeeded in producing and observing electromagnetic waves of much shorter wavelength (25 mm to 5mm). His experiment like that of Hertz was confined to the laboratory.

- **Guglielmo Marconi** followed Hertz work and succeeded in transmitting electromagnetic waves over distances of many kilometers. Marconi's experiment marked the beginning of the field of communication using electromagnetic waves.

#### - Key Features of Electromagnetic Waves:

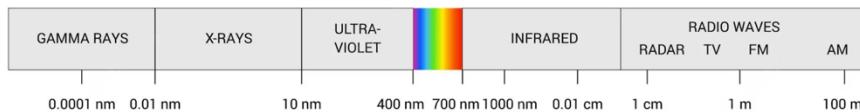
- Electric and Magnetic field are perpendicular to each other, and to the direction of propagation.
- The adjacent figure shows a linearly polarized electromagnetic wave propagating in the z-direction with the oscillating electric field **E** along the x direction and the oscillating magnetic field **B** along the y-direction.
- 
- They are self-sustaining oscillations of electric and magnetic fields in free space or vacuum.
  - It can travel in vacuum and no material medium is involved in the vibrations of the electric and magnetic fields.
  - In vacuum (free space), electromagnetic wave travels with a speed of light  $2.99792458 \times 10^8$  m/s (or roughly  $3 \times 10^8$  m/s).
    - » The constancy of the velocity is EM waves in vacuum is so strongly supported by experiments and the actual value is so well known now that this is used to define a standard of length.
  - Hertz has also established wave nature of the radiation. He demonstrated that the waves, which had wavelength ten million times that of the light waves, could be diffracted, refracted, and polarized.

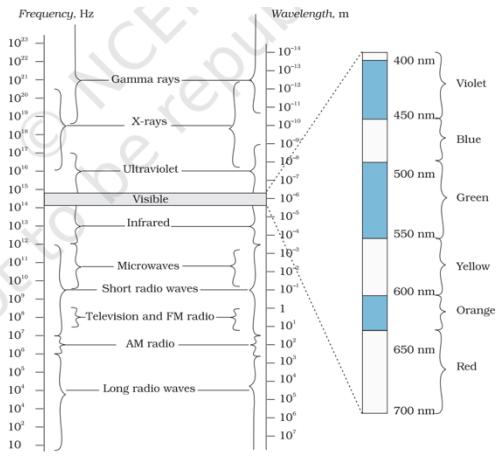
## 1) ELECTROMAGNETIC SPECTRUM

At the time Maxwell predicted the existence of electromagnetic waves, the only familiar electromagnetic waves were the visible light waves. The existence of ultraviolet and infrared waves was barely established. By the end of the nineteenth century, X-rays and gamma rays had also been discovered

- Electromagnetic Waves include radio waves, microwaves, infrared, visible light, ultraviolet, x rays and gamma rays. The classification of EM waves according to frequency is the **electromagnetic spectrum**. Note, that there is no sharp division between one kind of wave and the next. The classification is based on roughly on how the waves are produced and/or detected.

SPECTRUM





**Different Types of Electromagnetic waves, in order of increasing frequency/decreasing wavelength:**

#### A) RADIO WAVES:

- B) They are produced by accelerated motion of charges in the conducting wires.
- C) **Uses:** They are used in Radio and Television communication.
- D) **Wavelength:** They range from around a foot long to several kms.
- E) **Frequency ~: 500 KHz to 1000 MHz**
  - The AM (Amplitude Modulated) band is from 530 KHz to 1710 KHz.
  - The FM (Frequency Modulated) band is from 88 MHz to 108 MHz.
  - The TV waves range from 54 MHz to 89 MHz.
  - Cellular phones use radio waves to transmit voice communication in the Ultra High Frequency (UHF) band.
    - For e.g., in 2014, the DoT auctioned 2G telecom spectrum in the frequency range of 900 MHz and 1800 MHz.
    - For e.g., In 2022 auction, Jio bought frequencies in 700 MHz as well as in 1800 MHz band.
    - In 2022, 700 MHz was sold for the first time. Jio bought the spectrum,

#### B) MICROWAVES

- F) **Microwaves** (short wavelength radio waves) are produced by special vacuum tubes (called klystrons, magnetrons, and Gunn Diodes).
- G) **Frequency: GHz range**
- H) **Applications:**
  - **Radar:** Their short wavelength makes them suitable for Radar system in aeroplanes. Due to their short wavelength, they are suitable for Radar systems used in aircraft navigation. Radar also provides the basis for the speed guns used to time fast balls, tennis serves, and automobiles.
  - **Microwave Ovens** are an interesting application of these waves. In such ovens, the frequency of microwaves is selected to match the resonant frequency of water molecules

so that energy from the waves is transferred efficiently to kinetic energy of the molecules.  
This raises the temperature of any food containing water.

**Details of how microwave work:**

**When the temperature of a body rises, the energy of the random motion of atoms and molecules increases and the molecules travel or vibrate or rotate with higher energies.**

The frequency of rotation of water molecules is about 300 crore hertz, which is 3 gigahertz (GHz). If water receives microwaves of this frequency, its molecules absorb this radiation, which is equivalent to heating up water. These molecules share this energy with neighbouring food molecules, heating up the food.

One should use porcelain vessels and not metal containers in a microwave oven because of the danger of getting a shock from accumulated electric charges. Metals may also melt from heating. The porcelain container remains unaffected and cool, because its large molecules vibrate and rotate with much smaller frequencies, and thus cannot absorb microwaves. Hence, they do not get heated up. Thus, the basic principle of a microwave oven is to generate microwave radiation of appropriate frequency in the working space of the oven where we keep food. This way energy is not wasted in heating up the vessel. In the conventional heating method, the vessel on the burner gets heated first, and then the food inside gets heated because of transfer of energy from the vessel. In the microwave oven, on the other hand, energy is directly delivered to water molecules which is shared by the entire food.

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**c) INFRARED WAVES**

- I) Produced by hot bodies and molecules. They are sometimes also referred as heat waves. This is because, water molecules produced in most materials readily absorb infrared waves (many other molecules, for example, CO<sub>2</sub>, NH<sub>3</sub>, also absorb infrared waves). After absorption, their thermal motion increase i.e. they heat up and heat up their surroundings.
- J) **Infrared lamps** are used in physical therapy.
- K) Infrared waves also play a crucial role in maintaining the earth's warmth or the average temperature through Greenhouse Effect.
- L) Infrared Emitting Devices (IrEDs) are used in remotes of TV, AC etc.

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**D) VISIBLE RAYS**

- M) Part of the spectrum detected by Human eyes.
- N) **Frequency range:**  $4 \times 10^{14}$  Hz to about  $7 \times 10^{14}$  Hz.
- O) **Wavelength:** 700 nm to 400 nm (note: Speed of light = frequency \* Wavelength)
- P) **Note:** Different animals are sensitive to different electromagnetic spectrum. For e.g. snakes can detect infrared waves, and the 'visible' range of many insects extends well into ultraviolet.

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**E) ULTRAVIOLET RAYS**

- Q) **Wavelength:** 400 nm to 0.6 nm
- R) UV radiations are produced by special lamps or very hot objects. For e.g. Sun is an important source of ultraviolet rays, but fortunately, most of the radiation is absorbed in the ozone layer. This is because UV radiation in large quantities will be harmful for human health and other forms of biodiversity.
- S) **Applications:**
- Due to very short wavelengths, UV radiation can be focused on very narrow beams for high precision application such as LASIK (Laser assisted in situ keratomileusis) eye surgery.
  - **UV lamps** are used to kill germs in water purifiers.

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#### F) X-RAYS

- T) **Wavelength:**  $10 \text{ nm}$  to  $10^{-4} \text{ nm}$  ( $10^{-13} \text{ m}$ )
- U) One common way of generating X-Rays is to bombard a metal target by high energy electrons.
- V) **Applications:**
- They are used in diagnostic tools in medicine and as a treatment for various kinds of cancer.

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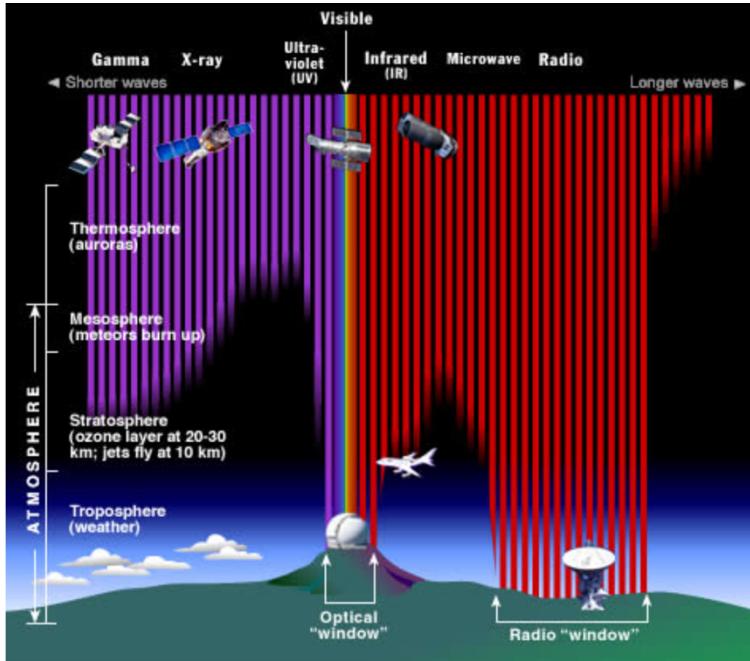
#### G) GAMMA RAYS

- W) **Wavelength:**  $10^{-10} \text{ m}$  to  $10^{-14} \text{ m}$
- X) Produced in nuclear reactions and also emitted by radioactive nuclei. They are used in radiative cancer therapies.

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### C) 2) PENETRATION OF VARIOUS EM WAVES IN EARTH'S ATMOSPHERE

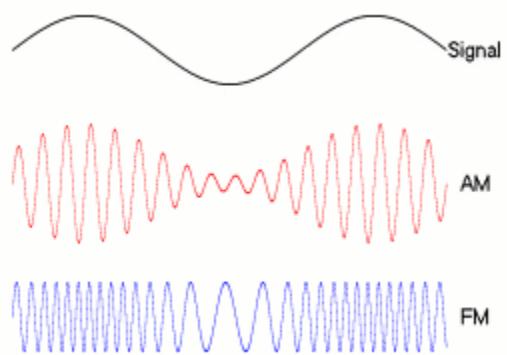
- Y) The Earth's atmosphere stops most type of EM radiation from reaching earth's surface. This illustration shows how far into the atmosphere different parts of EM spectrum can go before being absorbed. Only portions of radio and visible light reach the surface.
- Z) Radio frequencies, visible light and some part of ultraviolet lights makes it to sea level. These wavelength ranges are called atmospheric window. Ground based astronomical observation employs optical and radio telescopes that take advantage of atmospheric windows.
- AA) Astronomers can observe some infrared wavelengths by putting telescopes on mountain tops.
- BB) But, earth's atmosphere absorbs the majority of ultraviolet, X-Rays, and gamma rays. So they can only be absorbed using balloons and astronomical satellites outside the earth's atmosphere.
- CC) **Note:** Long wavelength radio waves and infrared rays also don't reach the surface.
- DD) **Note:**



## 2) WIRELESS COMMUNICATION – DIFFERENT FREQUENCY BANDS AND THEIR APPLICATIONS

### A) RADIO WAVES (500 KHZ – 1 G HZ)

- The AM (Amplitude Modulated) band is from 530 KHz to 1710 KHz.
- The FM (Frequency Modulated) band is from 88 MHz to 108 MHz.
- The TV waves range from 54 MHz to 89 MHz
- Used for broadcasting radio and TV Programmes. Anyone with receiver can tune it to the radio frequency to pick the signal. When radio stations use similar transmission frequencies the waves sometimes interfere with each other.
- Medium wavelength radio waves are reflected from the ionosphere so they can be used for long distance communication, but not for communicating with satellite above the ionosphere. Thus, they can only be used for low earth orbit satellite communication.
- **AM vs FM**



	<b>AM</b>	<b>FM</b>
<b>Full form</b>	AM stands for Amplitude modulation	Frequency modulation
<b>First used</b>	AM method of audio transmission first carried out in the mid-1870s	FM radio was developed in the US states in the 1930s, mainly by Edwin Armstrong

<b>Modulating difference</b>	In AM, a radio wave known as the "carrier" or "carrier wave" is <u>modulated in amplitude by the signal that is to be transmitted</u> . The frequency and the phase remain same	In FM, <u>a radio wave known as carrier wave is modulated in frequency by the signal that is to be transmitted</u> . The <u>amplitude and phase remains the same</u> .
<b>Pros and Cons</b>	AM has <u>poorer sound quality</u> compared with FM but is <u>cheaper and can be transmitted over long distances</u> . It has <u>lower bandwidth</u> so it can have <u>more stations available in any frequency range</u> .	FM is <u>less prone to interference than AM</u> . However, <u>FM signals are impacted by physical barriers</u> . FM has <u>better sound quality due to higher bandwidth</u> .
<b>Frequency Range</b>	AM radio ranges from <u>535 to 1705 KHz (OR) Up to 1200 bits per second</u> .	FM radio ranges in a <u>higher spectrum</u> from <u>88 to 108 MHz</u> . (OR) <u>1200 to 2400 bits per second</u>
<b>Bandwidth requirement</b>	Twice the <u>highest modulating signal</u> . In AM radio broadcasting, the modulating signal has bandwidth of 15 KHz, and hence the bandwidth of an amplitude-modulated signal is 30 KHz	Twice the <u>sum of the modulating signal frequency and the frequency deviation</u> . If the frequency deviation is 75 KHz and the modulating signal frequency is 15 KHz, the bandwidth required is 180 KHz.
<b>Zero crossing in modulated signal</b>	Equidistant	Not Equidistant
<b>Complexity</b>	Transmitter and receiver are simple but synchronization is needed in case of SSBSC AM carrier.	Transmitter and receiver are more complex as variation of modulating signal has to be converted and detected from corresponding variation in frequencies (i.e. voltage to frequency and frequency to voltage conversion has to be done)
<b>NOISE</b>	AM is more <u>susceptible to noise</u> because <u>noise effects amplitude</u> , which is where information is stored in AM.	FM is <u>less susceptible to noise</u> because <u>information in an FM signal is transmitted through varying of frequency</u> , and not amplitude.

## A) MICROWAVES

- Microwaves have shorter wavelength and thus can **pass through ionosphere**. They can thus be used for **long distance satellite communications**.
  - **Line of sight -> Prerequisite:**
  - Signals are sent to and from satellites, which relay signals around the Earth. This may be for TV programmes, telephone conversations or monitoring the earth, for example weather forecasting.
  - **Types**
- 

### L BAND: 1-2 GHZ

- Low bandwidth -> not suitable for streaming applications like video, voice, and broadband connectivity.
  - Radars, GPS signals
  - **Other advantages** -> least expensive and easiest to implement.
- 

### S BAND:

- It is a part of microwave band of the electromagnetic spectrum. It is defined by IEEE standard of radio waves with frequencies that range from **2 to 4 GHz**, crossing the conventional boundary between UHF (Ultra High Frequency) and SHF (Super High frequency) at 3.0 GHz.
  - **Used by**
    - » Weather radar
    - » Surface ship radar
    - » Some Communication Satellites
- 

### C BAND

- The C Band is the name given to certain portions of the electromagnetic spectrum, including wavelength of microwaves that are used for long-distance radio-telecommunication.
  - The IEEE C Band (**4 - 8 GHz**) and its slight variations contain frequency ranges that are used for many satellite communication transmission, some Wi-Fi devices, some cordless telephones, and some weather radar system.
- 

### Ku BAND

- Name given to **12-18 GHz** portion of electromagnetic spectrum in the microwave range of frequencies.
  - Uses
    - » Primarily used for satellite communication, most notably for fixed and broadcast services
- 

### K BAND (18-27 GHZ)

### KA BAND (27 – 40 GHZ)

### V BAND (40 – 75 GHZ)

### W BAND (75-110 GHZ)

### MILLIMETER BAND (110-300 GHZ)

## D) DEEP SPACE OPTICAL COMMUNICATION

1. Why in news?
  - a. NASA's Deep Space Optical Communication Demo sends, receives first data (Nov 2023)
2. Need of Deep Space Optical Communication:
  - a. **Low bandwidth of radio frequency communications:** Future space missions are going to require higher bandwidth of communication as they will need to transmit higher volumes of science data, images, videos etc.
  - b. **Higher frequencies (shorter wavelengths)** which can carry more data suffer from the problems of getting blocked by atmosphere, and higher scattering when it is contacted with any interference.
3. NASA's Psyche Spacecraft is on its way to Psyche asteroid and will reach there by 2029. But in between it is involved in experiments related to Deep Space Optical Communication (DSOC).
4. Primary Objective of DSOC is to give tools and technology to future NASA initiatives to communicate at much higher bandwidth.
5. Demo:
  - a. DSOC has achieved 'first light' sending data via laser to and from far beyond the Moon for the first time.
  - b. NASA's DSOC experiment has beamed a near-infrared laser encoded with test data from nearly 16 million kms away – about 40 times further than the Moon is from Earth – to the Hale Telescope at Caltech's Palomar Observatory in San Diego County, California. This is the farthest ever demonstration of optical communication.
6. Key features:
  - a. It is pioneering the use of near-infrared laser signal for communication with spacecraft.
  - b. Its bandwidth is more than 10 times higher than the state of art radio-telecommunication system of comparable size and power. This enables higher resolution images, larger volumes of science data, and streaming of videos.
7. Advantages: Higher Bandwidth, faster data transmission, improved image resolution, reduced power consumption, potential for streaming video and real-time communication
8. How were the limitations of high frequency communication overcome?
  - a. Extremely precise pointing: To achieve this, the transceiver aboard the spacecraft needs to be isolated from the craft's vibration.
  - b. Compensating for movements of spacecraft and Earth: The targeting has to adjust for this continuous movement.

- c. **Extracting information from weak signal:** Since the signal will travel several million kms, the received signal will be very weak. New Signal processing tools have to be utilized to extract precise information from the communication.
9. Psyche spacecraft is the first to carry a DSOC transceiver and will be testing high bandwidth optical communications to Earth during the first two years of the spacecraft's journey to the main asteroid belt.
- a. Achieving the first light is one of many critical DSOC milestones in the coming months, paving the way toward higher-data-rate communication.
10. Has Space based optical communication happened in past?
- a. In 2013, NASA's Lunar Laser Communications Demonstration tested record breaking uplink and downlink rates between Earth and the Moon using similar technology.
  - b. But DSOC is taking optical communication to Deep Space, paving the way for high-bandwidth communication far beyond the Moon and over 1,000 times further than any optical communication test to date.
11. **Significance:**
- a. The DSOC holds the key for future space missions. As humans travel deep into space, they would want fast way of sending and receiving large amount of data from earth.
  - b. It would pave the way for high data rate communications capable of sending scientific information, high-definition imagery, and streaming video in support of humanity's next giant leap: Sending humans to Mars.

## PYQS

1	Cryogenic Engines find applications in: [Prelims 1995] <ul style="list-style-type: none"> <li>A. Sub-marine propulsion</li> <li>B. Frost-free refrigerator</li> <li>C. Rocket technology</li> <li>D. Research and Superconductivity</li> </ul>
2	Consider the following statements: [Prelims 1996] <p>A person in a spaceship located halfway between the earth and the sun will notice that the:</p> <ol style="list-style-type: none"> <li>1. Sky is jet black</li> <li>2. Stars don't twinkle</li> <li>3. Temperature outside the spaceship is much higher than that on the surface of earth</li> </ol> <p>Which of the above statements is/are correct?</p> <ul style="list-style-type: none"> <li>A. 3 only</li> <li>B. 1 and 2 only</li> <li>C. 1 and 3 only</li> <li>D. 1, 2 and 3 only</li> </ul>

3	<p>The tail of a comet is directed away from the sun because: [Prelims 1997]</p> <ul style="list-style-type: none"> <li>(a) As the comet rotates around the sun, the lighter mass of the comet is pushed away due to the centrifugal force alone.</li> <li>(b) As the comet rotates, the lighter mass of the comet is attracted by some stars situated in the direction of its tail</li> <li>(c) The radiation emitted by the sun exerts a radial pressure on the comet throwing its tail away from sun</li> <li>(d) The tail of the comet always exists in the same orientation</li> </ul>
4	<p>A 'black hole' is a body in space which doesn't allow any radiation to come out. This property is due to its: [Prelims 2000]</p> <ul style="list-style-type: none"> <li>(a) very small size</li> <li>(b) very large size</li> <li>(c) very high density</li> <li>(d) very low size</li> </ul>
5	<p>Assertion (A): Artificial Satellites are always launched from the earth in the eastward direction. [2002]  Reason (R): The earth rotates from west to east and so the satellite retains the escape velocity.</p> <ul style="list-style-type: none"> <li>(a) Both A and R are true and R is the correct explanation of A</li> <li>(b) Both A and R are true but R is not a correct explanation of A</li> <li>(c) A is true but R is false</li> <li>(d) A is false but R is true</li> </ul>
6	<p>Consider the following statements: [Prelims 2005]</p> <ol style="list-style-type: none"> <li>1. A Geostationary satellite is at an approximate height of 10000 km</li> <li>2. FM transmission of music is of very good quality because the atmospheric or manmade noises can do little harm.</li> </ol> <ul style="list-style-type: none"> <li>a. 1 only</li> <li>b. 2 only</li> <li>c. Both 1 and 2</li> <li>d. Neither 1 nor 2</li> </ul>
7	<p>Consider the following statements in respect of a jet engine and a rocket: [Prelims 2008]</p> <ol style="list-style-type: none"> <li>1. A jet engine uses the surrounding air for its oxygen supply and so is unsuitable for motion in space</li> <li>2. A rocket carries its own supply of oxygen in the gas form, and fuel</li> </ol> <p>Which of the statements given above is/are correct?</p> <ul style="list-style-type: none"> <li>A. 1 only</li> <li>B. 2 only</li> </ul>

	<p>C. Both 1 and 2 D. Neither 1 nor 2</p>
8	<p>Satellites used for telecommunication relay are kept in a geostationary orbit. A satellite is said to be in such an orbit when: [Prelims 2011]</p> <ol style="list-style-type: none"> <li>1. The orbit is geosynchronous.</li> <li>2. The orbit is circular</li> <li>3. The orbit lies above the earth's equator</li> <li>4. The orbit is an altitude of 22,236 km</li> </ol> <p>Choose the correct answer using the code given below:</p> <ol style="list-style-type: none"> <li>a. 1, 2 and 3 only</li> <li>b. 1,3 and 4 only</li> <li>c. 2 and 4 only</li> <li>d. 1,2,3 and 4</li> </ol>
9	<p>Cape Canaveral, the site from which space shuttles are launched is located on the coast of: [Prelims 2011]</p> <ol style="list-style-type: none"> <li>1. Florida</li> <li>2. Virginia</li> <li>3. North Carolina</li> <li>4. South Carolina</li> </ol>
10	<p>An artificial satellite orbiting around the earth does not fall down. This is so because the attraction of earth: [Prelims 2011]</p> <ol style="list-style-type: none"> <li>a. Doesn't exist at such distance</li> <li>b. Is neutralized by the attraction of the moon</li> <li>c. Provides the necessary speed for its steady motion</li> <li>d. Provides the necessary acceleration for its motion</li> </ol>
12	<p>In which of the following activities are Indian Remote Sensing (IRS) satellite used? [Prelims 2015]</p>

1. Assessment of crop productivity
2. Locating groundwater resources
3. Mineral Exploration
4. Telecommunication
5. Traffic studies

Select the correct answer using the code given below:

- a. 1, 2 and 3 only
- b. 4 and 5 only
- c. 1 and 2 only
- d. 1,2, 3, 4 and 5

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**Consider the following statements: [2016]**

The Mangalyaan launched by ISRO

1. Is also called the Mars Orbiter Mission
2. Made India the second country to have a spacecraft orbit the Mars after the USA
3. Made India the only country to be successful in making its spacecraft orbit the Mars in its very first attempt

Which of the statements given above is/are correct?

- a) 1 only
- b) 2 and 3 only
- c) 1 and 3 only
- d) 1,2 and 3 only

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The terms 'Event Horizon', 'Singularity', 'String Theory' and Standard Model are sometimes seen in the news in the context of [Prelims 2017]

- (a) Observation and Understanding of the Universe
- (b) Study of the Solar and Lunar Eclipse
- (c) Placing Satellite in the orbit of the earth
- (d) Origin and Evolution of Living Organisms on Earth

15

With reference to India's satellite launch vehicles, consider the following statements: (Pre 2018)

- PSLVs launch the satellites useful for Earth resources monitoring whereas GSLVs are designed mainly to launch communication satellites.
- Satellites launched by PSLV appear to remain permanently fixed in the same position in the sky, as viewed from a particular location on Earth.
- GSLV Mk III is a four-staged launch I vehicle with the first and third stages using solid rocket motors; and the second and fourth stages using liquid rocket engines.

Which of the statements given above is/are correct?

- A. 1 only
- B. 2 and 3
- C. 1 and 2
- D. 3 only

16 In which of the following areas can GPS technology be used? (Pre 2018)

- Mobile phone operations
- Banking operations
- Controlling the power grids

Select the correct answer using the code given below:

- a. 1 only
- b. 2 and 3 only
- c. 1 and 3 only
- d. 1, 2 and 3

17 With reference to the Indian Regional Navigation Satellite System (IRNSS), consider the following statements: (PRE 2018)

- IRNSS has three satellites in geostationary and four satellites in geosynchronous orbits.
- IRNSS covers entire India and about 5500 sq. km beyond its borders.
- India will have its own satellite navigation system with full global coverage by the middle of 2020.

Which of the statements given above is/are correct?

- a. 1 only
- b. 1 and 2 only
- c. 2 and 3 only
- d. None

18 For the measurement/estimation of which of the following are satellite images/remote sensing data used?

- Chlorophyll content in the vegetation of a specific location
- Greenhouse gas emissions from rice paddies of a specific location
- Land Surface temperature of a specific location

Select the correct answer using the codes given below:

- (a) 1 only

	(b) 2 and 3 only (c) 3 only (d) 1, 2 and 3
19	Which one of the following countries has its own Satellite Navigation System? [Prelims 2023] (a) Australia (b) Canada (c) Australia (d) Japan