

# *Science and Technology*

# Syllabus

- Science and Technology- developments and their applications and effects in everyday life
- Achievements of Indians in science & technology
- Indigenization of technology and developing new technology
- Awareness in the fields of
  - IT
  - Space
  - Computers
  - Robotics
  - Nano-technology
  - Bio-technology
  - Issues relating to intellectual property rights.

# 2022 Questions

1. Launched on 25th December, 2021, James Webb Space Telescope has been much in the news since then. What are its unique features which make it superior to its predecessor Space Telescopes ? What are the key goals of this mission ? What potential benefits does it hold for the human race? (Answer in 250 words) 15
2. What is the basic principle behind vaccine development? How do vaccines work? What approaches were adopted by the Indian vaccine manufacturers to produce COVID-19 vaccines ? (Answer in 250 words) 15

# Past Year Questions - Mains

- **Space technology**

- What is India's plan to have its own space station and how will it benefit our space programme? 2019
- India has achieved remarkable successes in unmanned space missions including the Chandrayaan and Mars Orbiter Mission, but has not ventured into manned space mission, both in terms of technology and logistics? Explain critically. 2017
- Discuss India's achievements in the field of Space Science and Technology. How the application of this technology has helped India in its socio-economic development? 2016
- What do you understand by 'Standard Positioning Systems' and 'Protection Positioning Systems' in the GPS era? Discuss the advantages India perceives from its ambitious IRNSS programme employing just seven satellites. 2015

- **Biotechnology**

- What are the research and developmental achievements in applied biotechnology/? How will these achievements help to uplift the poorer sections of the society? (Answer in 250 words) 2022
- How can biotechnology improve the living standards of farmers? 2019
- Why is there so much activity in the field of biotechnology in our country? How has this activity benefitted the field of biopharmacy? 2018
- Stem cell therapy is gaining popularity in India to treat a wide variety of medical conditions including Leukaemia, Thalassemia, damaged cornea and several burns. Describe briefly what stem cell therapy is and what advantages it has over other treatments. 2017

# Past Year Questions - Mains

- **Nanotechnology**

- What do you understand by nanotechnology and how is it helping in health sector? 2020
- Why is nanotechnology one of the key technologies of the 21st century? Describe the salient features of Indian Government's Mission on Nanoscience and Technology and the scope of its application in the development process of the country. 2016

- **IPR Related Issues**

- How is the government of India protecting traditional knowledge of medicine from patenting by pharmaceutical companies? 2019
- India's Traditional Knowledge Digital Library (TKDL) which has a database containing formatted information on more than 2 million medicinal formulations is proving a powerful weapon in the country's fight against erroneous patents. Discuss the pros and cons making this database publicly available under open-source licensing. 2015
- In a globalised world, intellectual property rights assume significance and are a source of litigation. Broadly distinguish between the terms – copyrights, patents and trade secrets. 2014

# Past Year Questions - Mains

- **Nuclear Technology**

- With growing energy needs should India keep on expanding its nuclear energy programme? Discuss the facts and fears associated with nuclear energy. 2018
- Give an account of the growth and development of nuclear science and technology in India. What is the advantage of fast breeder reactor programme in India? 2017

- **Contributions of India in Science and Technology**

- How was India benefited from the contributions of Sir M. Visvesvaraya and Dr. M. S. Swaminathan in the fields of water engineering and agricultural science respectively? 2019
- Discuss the work of 'Bose-Einstein Statistics' done by Prof. Satyendra Nath Bose and show how it revolutionized the field of Physics. 2018

- **Robotics**

- What are the areas of prohibitive labour that can be sustainably managed by robots? Discuss the initiatives that can propel research in premier research institutes for substantive and gainful innovation. 2015

# Past Year Questions - Mains

- **Science and Technology – Developments and Applications**
  - The Nobel Prize in Physics of 2014 was jointly awarded to Akasaki, Amano and Nakamura for the invention of Blue LEDs in 1990s. How has this invention impacted the everyday life of human beings ? (Answer in 250 words) 2022
  - **COVID-19 pandemic has caused unprecedented devastation worldwide. However, technological advancements are being availed readily to win over the crisis. Give an account of how technology was sought to aid management of the pandemic. 2020**
  - **How is science interwoven deeply with our lives? What are the striking changes in agriculture triggered off by the science-based technologies? 2020**
  - **Scientific research in Indian universities is declining, because a career in science is not as attractive as our business operations, engineering or administration, and the universities are becoming consumer oriented. Critically comment. 2014**
  - Can overuse and the availability of antibiotics without doctor's prescription, the contributors to the emergence of drug-resistant diseases in India? What are the available mechanisms for monitoring and control? Critically discuss the various issues involved. 2014
- **Defence**
  - How is S-400 air defence system technically superior to any other system presently available in the world? (Answer in 150 words) 2022



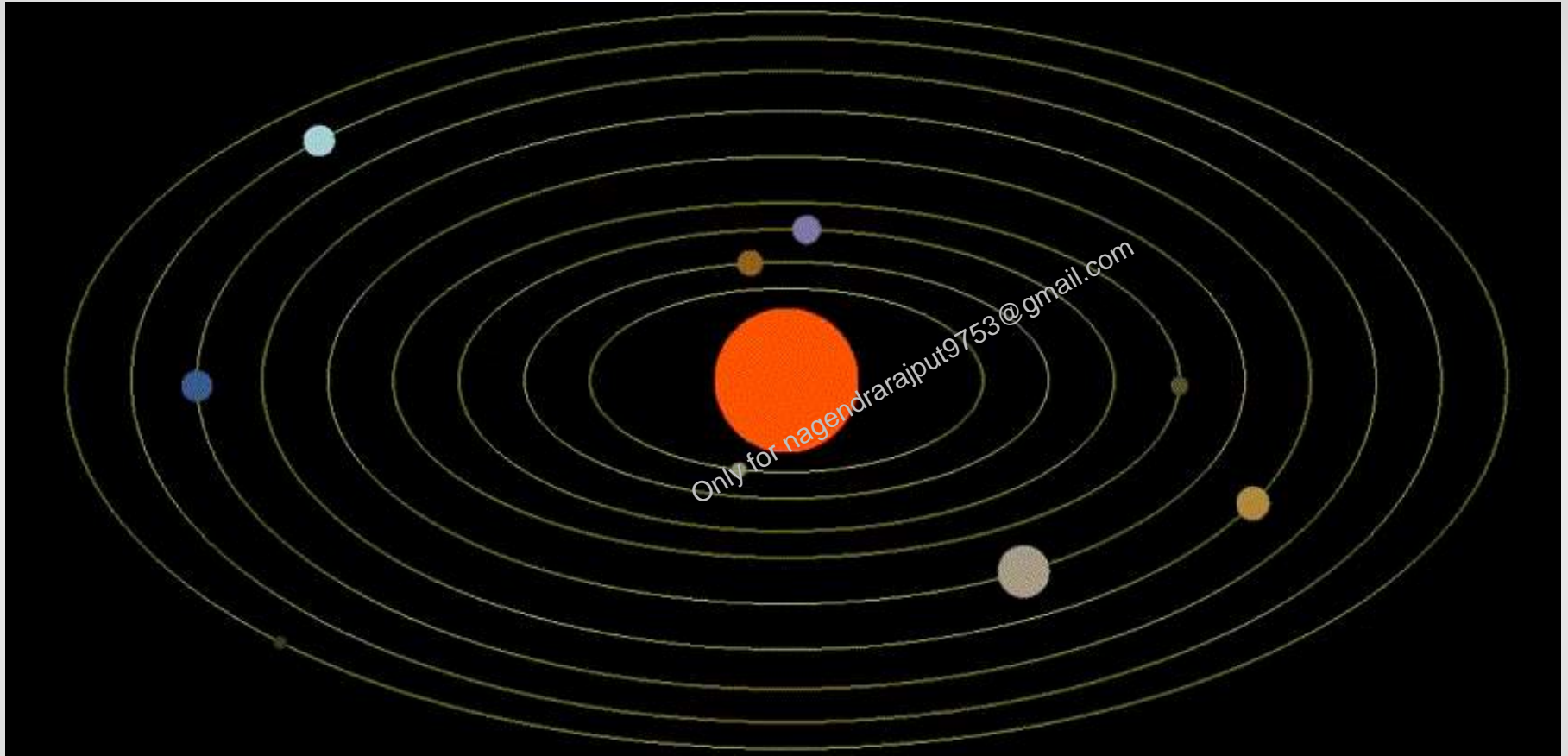
# Space Technology

only for ragendra.raiput9753@gmail.com



# Topics to Be covered

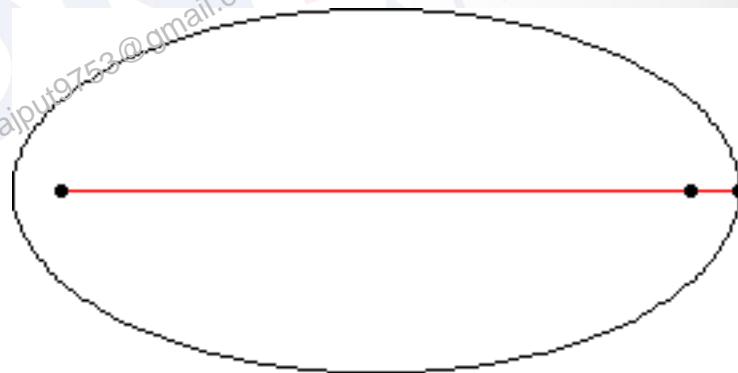
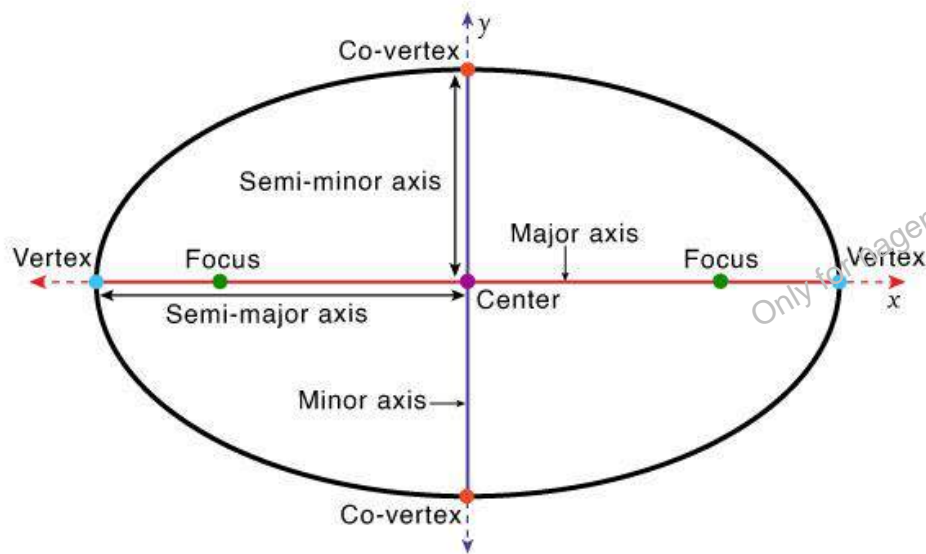
- Scope of Space Technology
- Why Satellites revolve and why Rockets go upwards? – Newton's laws of motion
- Orbit of Planets around sun – Kepler's laws
- Types of orbits around Earth
- Types of Satellites and their applications
- Launch Vehicles of ISRO
- Upcoming missions of ISRO
- Emerging issues in Space Technology





## Parts of an Ellipse

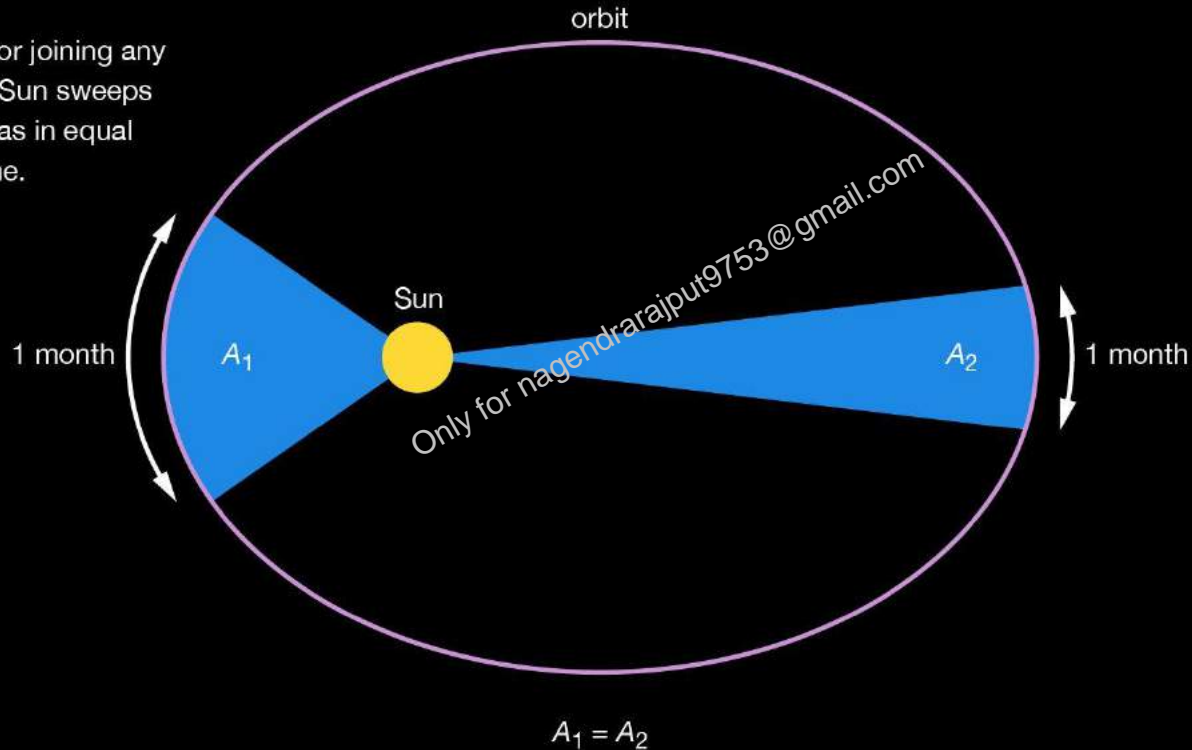
MATH  
MONKS



## Kepler's laws of planetary motion

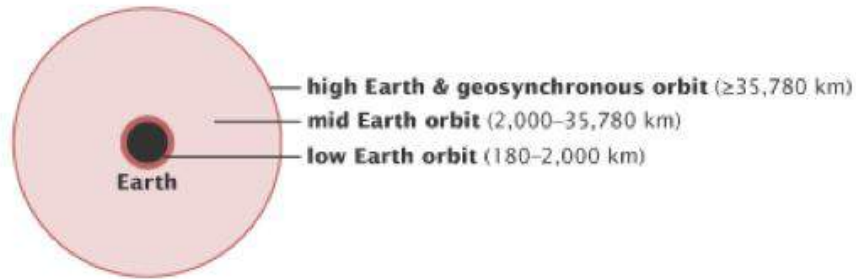
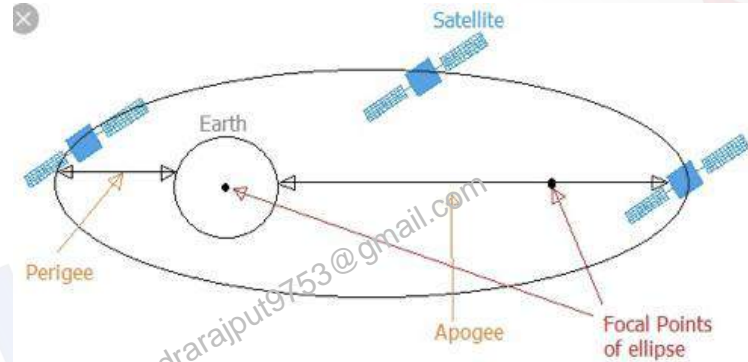
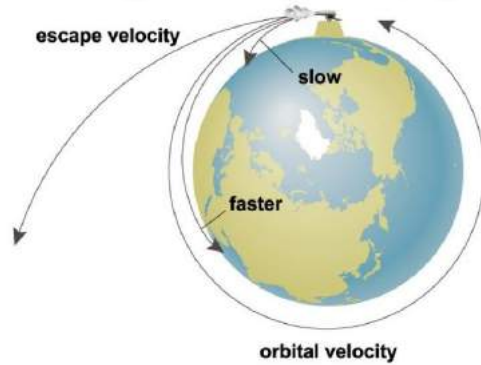
### Second law

A radius vector joining any planet to the Sun sweeps out equal areas in equal lengths of time.



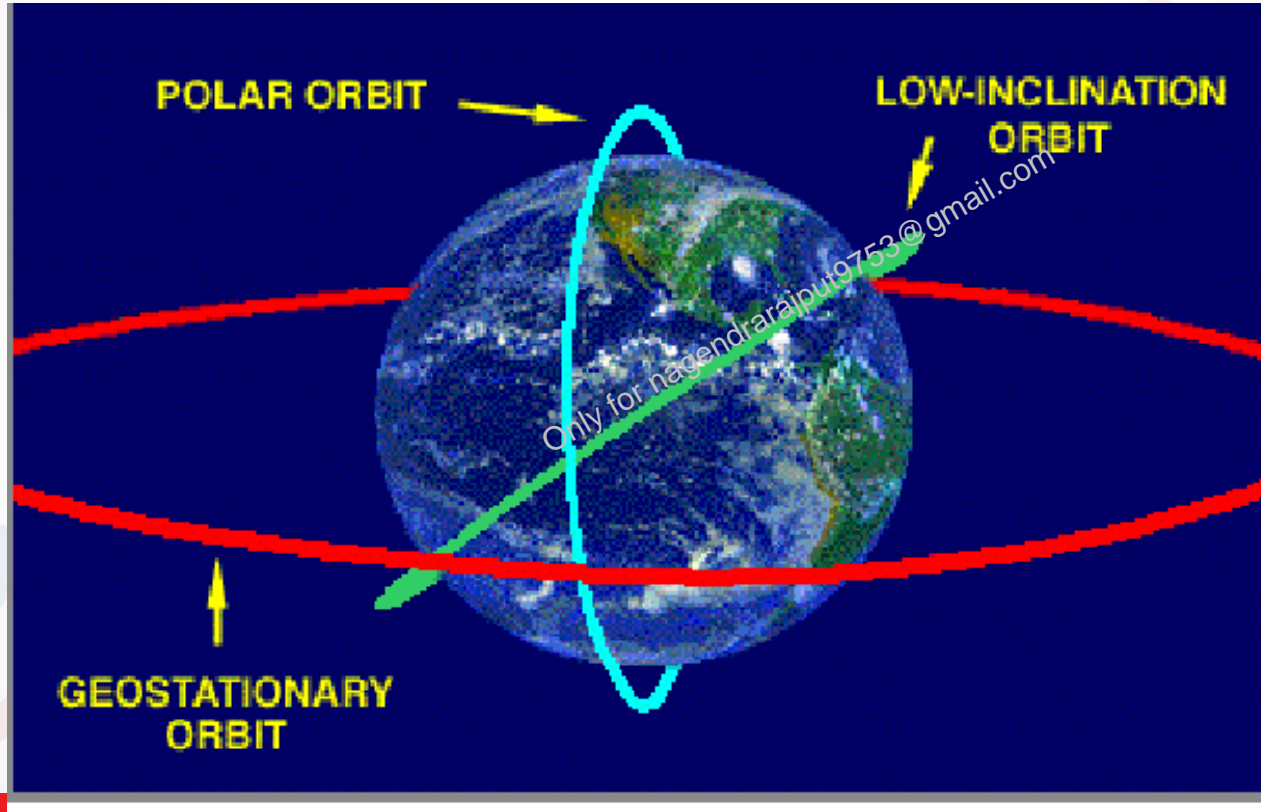
© Encyclopædia Britannica, Inc.

# Orbits around Earth

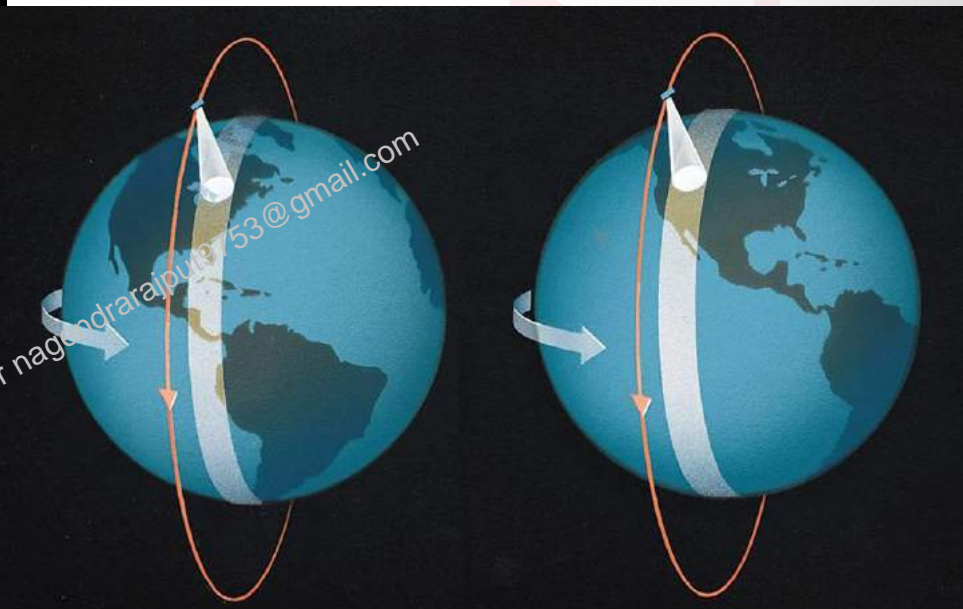
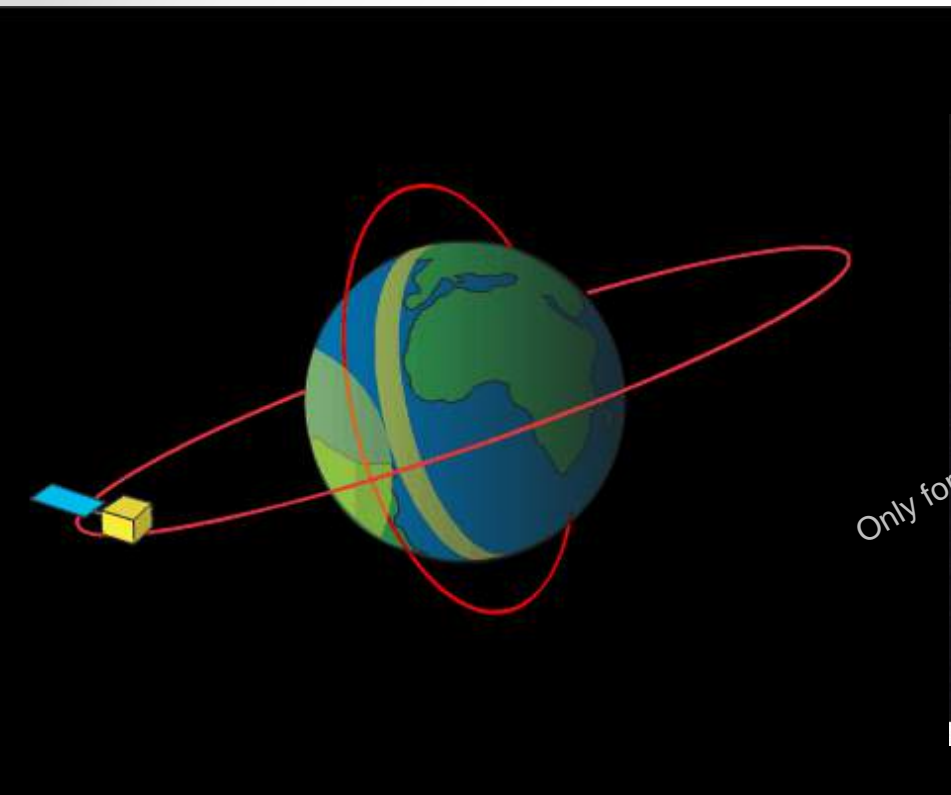


lunar orbit (384,000 km)

# Inclination of Orbits



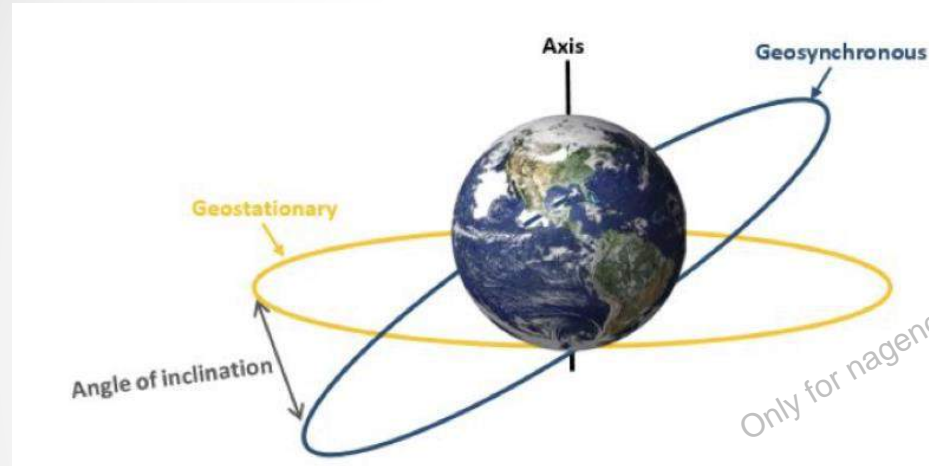




© 2007 Thomson Higher Education



# Geosynchronous, Geostationary and Geo Transfer orbit



## Geosynchronous orbit

- satellite completes one orbit around the earth in one sidereal day (23 hours 59 minutes, 4.091 seconds)
- an altitude of about 35,786 km
- Communications and surveillance satellites

<https://www.youtube.com/watch?v=6dISKhVdX7g&list=PLbwlDcoXvJYf0iV288yJTVIwpGEydfqFr&index=12&t=1s>

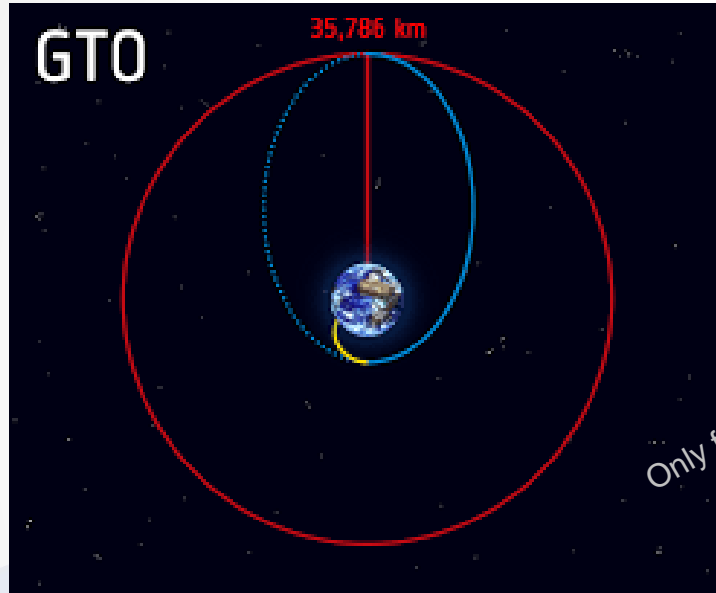
# Geosynchronous, Geostationary and Geo Transfer orbit



## Geostationary orbit

- Circular Orbit
- a special case of a geosynchronous orbit
- stay over the same point of the earth's equator
- Orbit lies in Equatorial plane

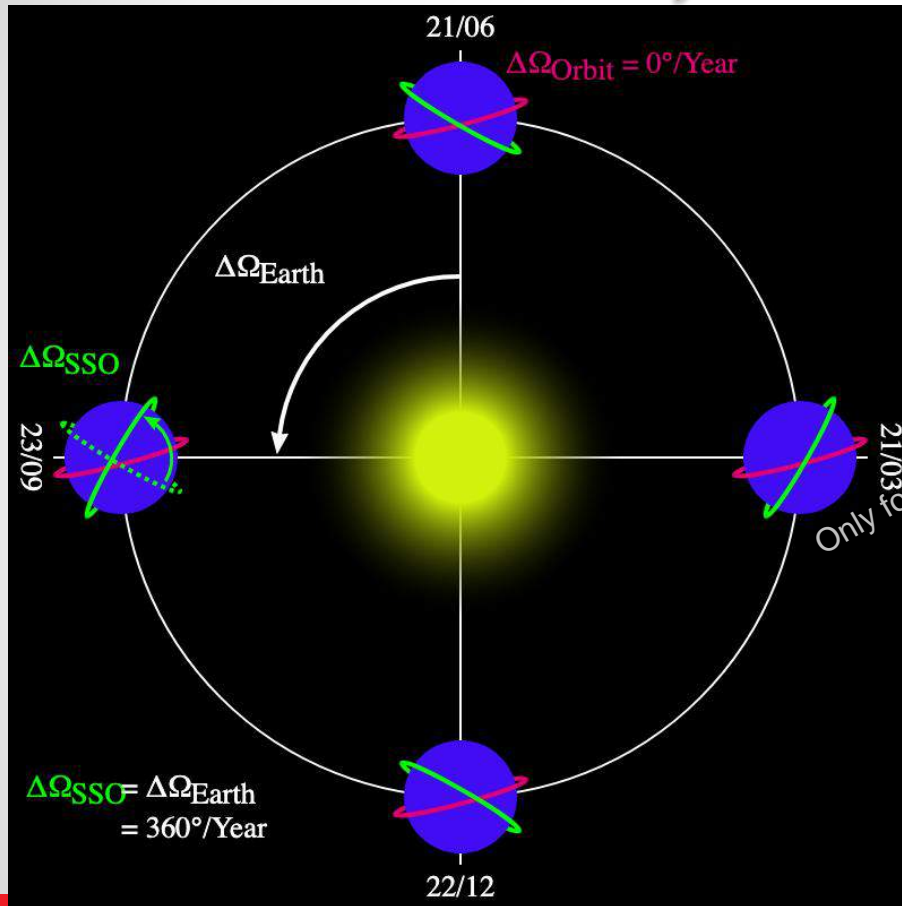
# Geosynchronous, Geostationary and Geo Transfer orbit



## Geo Transfer orbit

- an elliptical orbit used to transfer a spacecraft from a low altitude orbit or flight trajectory to geostationary/geosynchronous orbit.
- Apogee – 35,786 km

# Polar Sun synchronous orbit (PSSO)

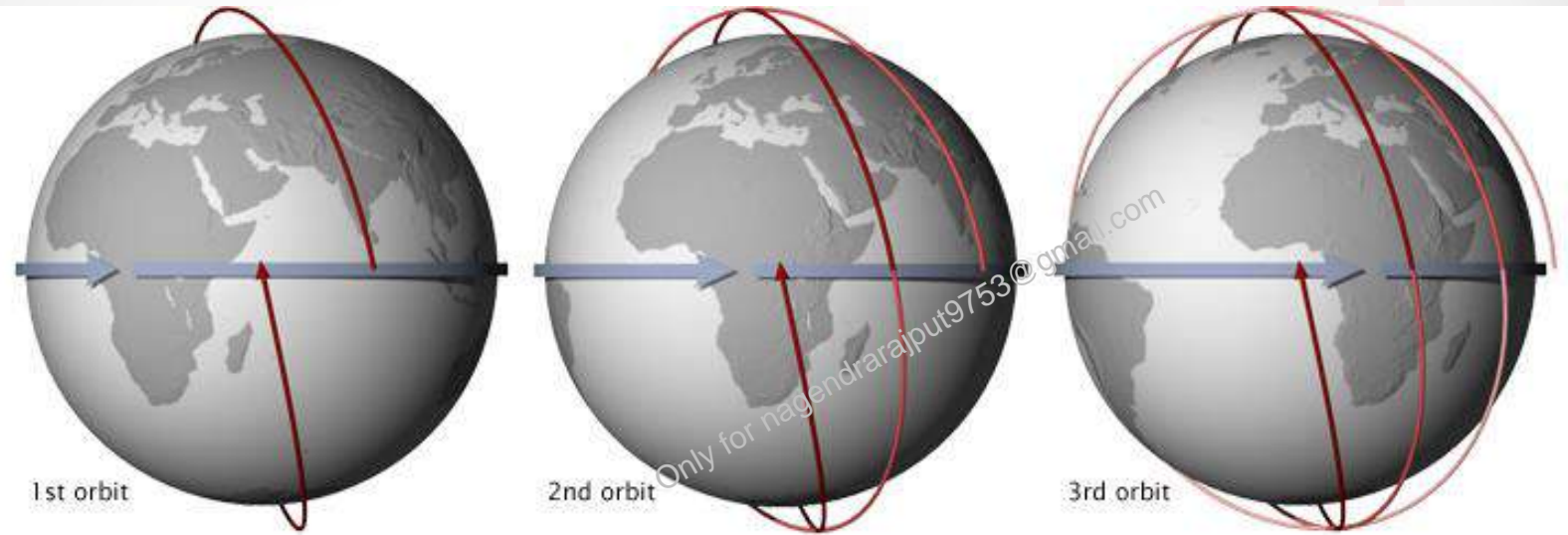


## Polar Sun synchronous orbit

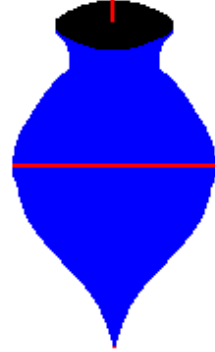
- satellite's orientation is fixed relative to the Sun throughout the year
- whenever the satellite observes a given ground location, the Sun is always in the same location in the sky.
- satellite passes over any given point of the planet's surface at the same local solar time.

<https://www.youtube.com/watch?v=tOp1UYbmp0Y>

# Polar Sun synchronous orbit (PSSO)

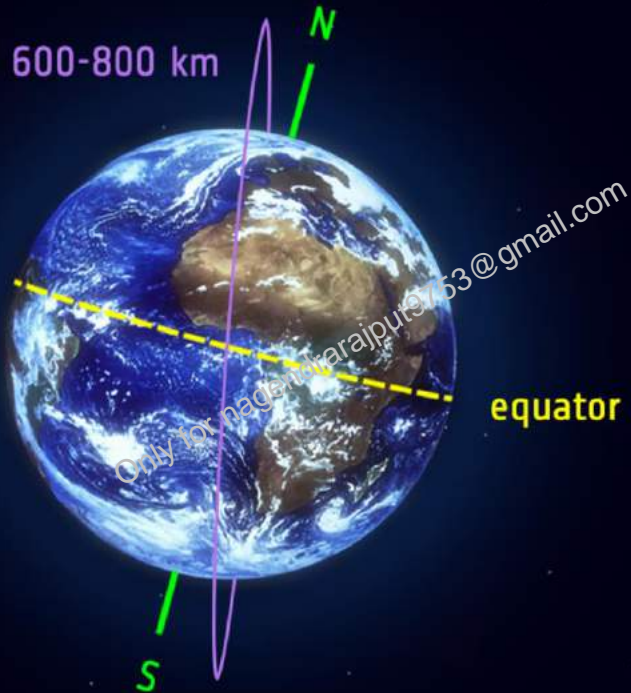


- This consistent lighting is a useful characteristic for satellites that image the Earth's surface
- can compare images from the same season over several years
- very useful thing for a weather or Earth Observation/Remote Sensing satellite
- precession of the orbital plane around the Earth due to gravitational irregularities keeps the plane at a constant angle with respect to a line between the Earth and Sun throughout the year.
- 96–98°, LEO



Only for nagendraput9753@gmail.com

# SSO



# UPSC Prelims Questions

An artificial satellite orbiting around the Earth does not fall down. This is so because the attraction of Earth.

- (a) Does not exist at such distance
- (b) Is neutralized by the attraction of the moon
- (c) Provides the necessary speed for its steady motion
- (d) Provides the necessary acceleration for its motion

Satellites used for telecommunication relay are kept in a geostationary orbit. A satellite is said to be in such an orbit when

- 1. The orbit is geosynchronous.
- 2. The orbit is circular.
- 3. The orbit lies in the plane of the Earth's equator.
- 4. The orbit is at an altitude of 22,236 km.

Select the correct answer using the codes given below:

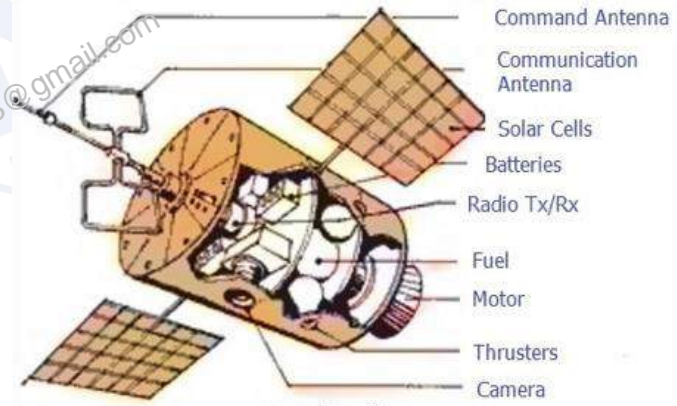
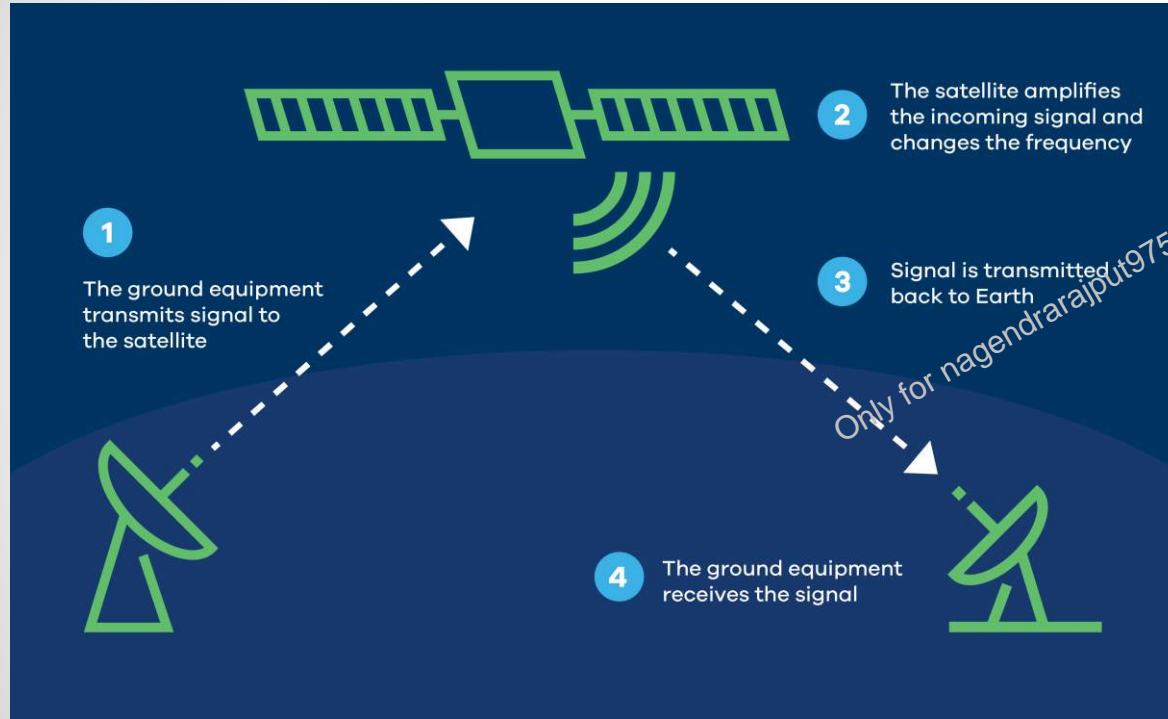
- (a) 1,2 and 3 only
- (b) 1, 3 and 4 only
- (c) 2 and 4 only
- (d) 1, 2, 3 and 4



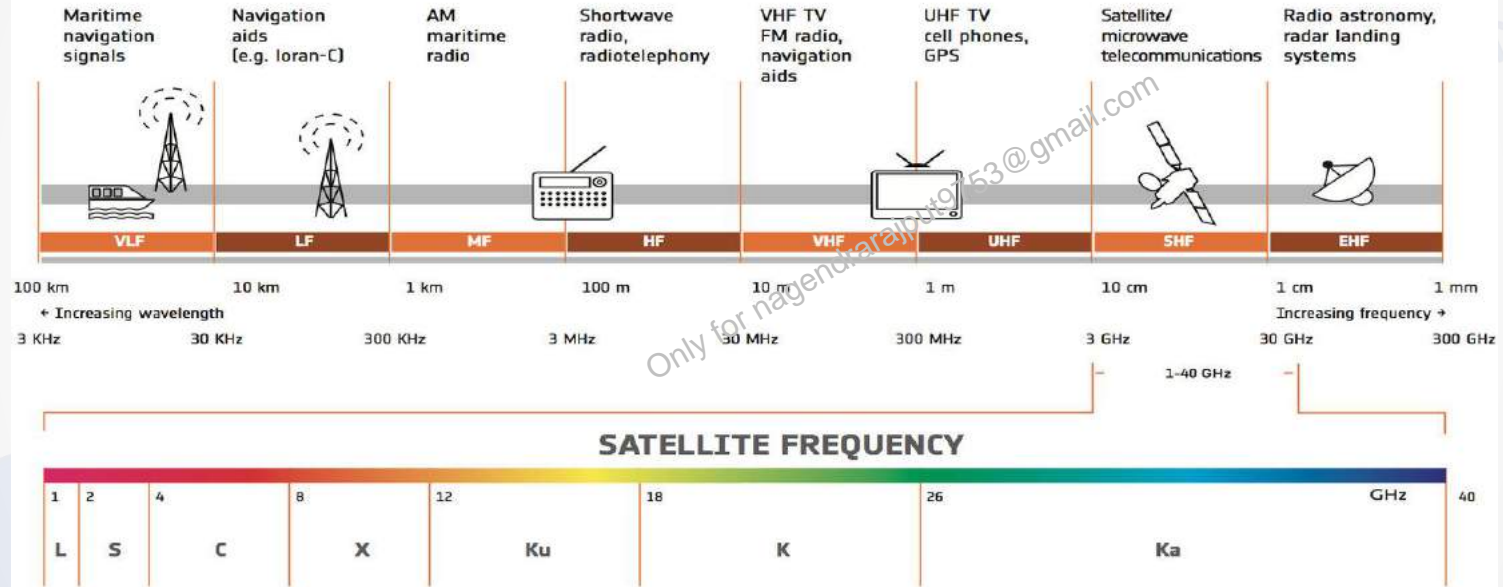
# ISRO Classification of Satellites

- Communication
- Earth Observations
- Navigation
- Space Science
- Experimental
- Small Satellite
- University / Academic Institute Satellites

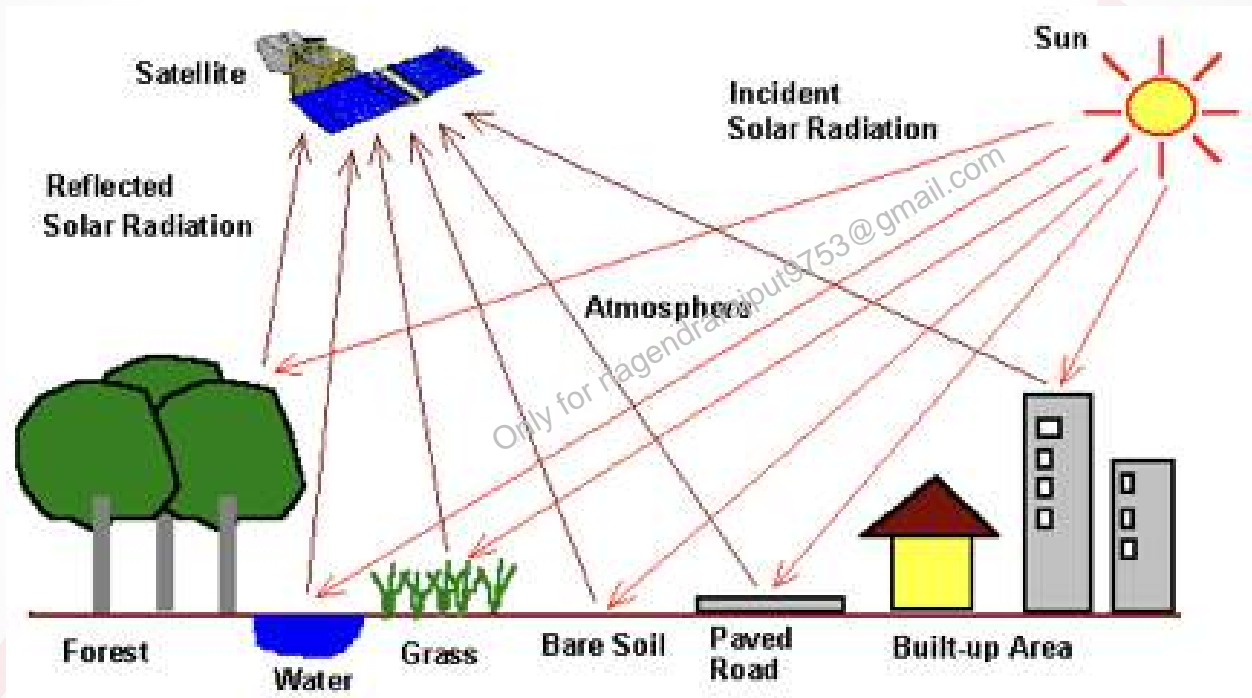
# Communication Satellites

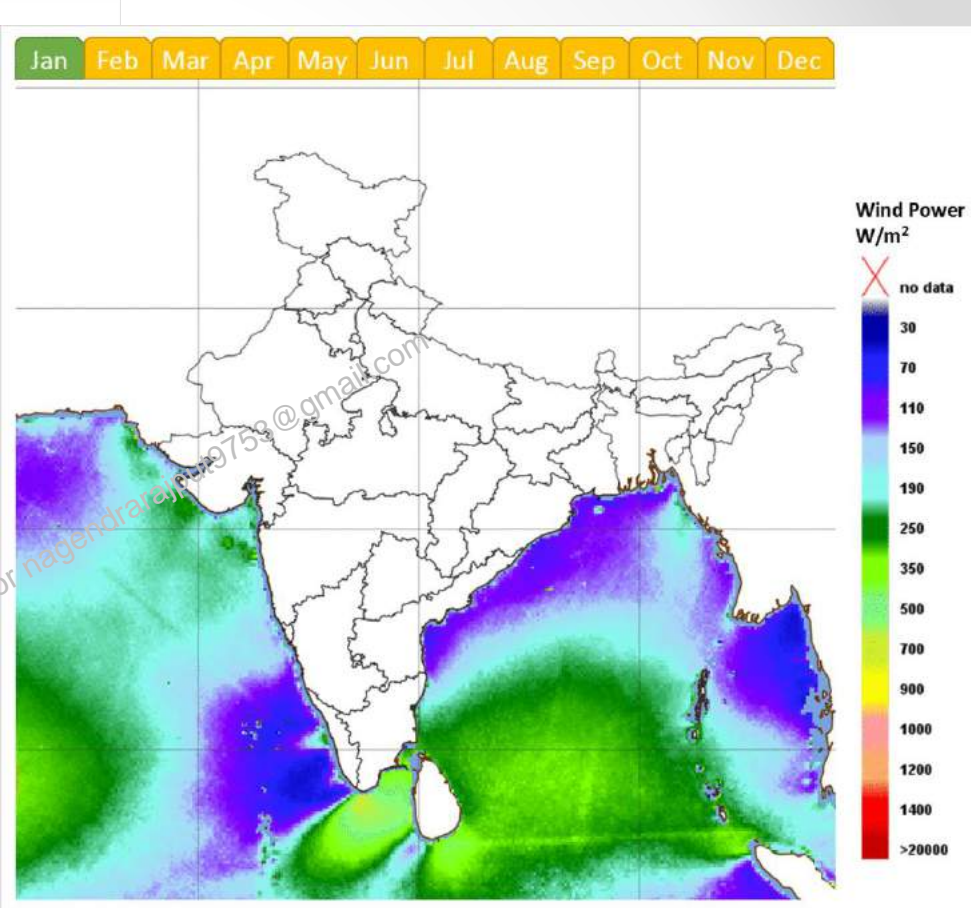
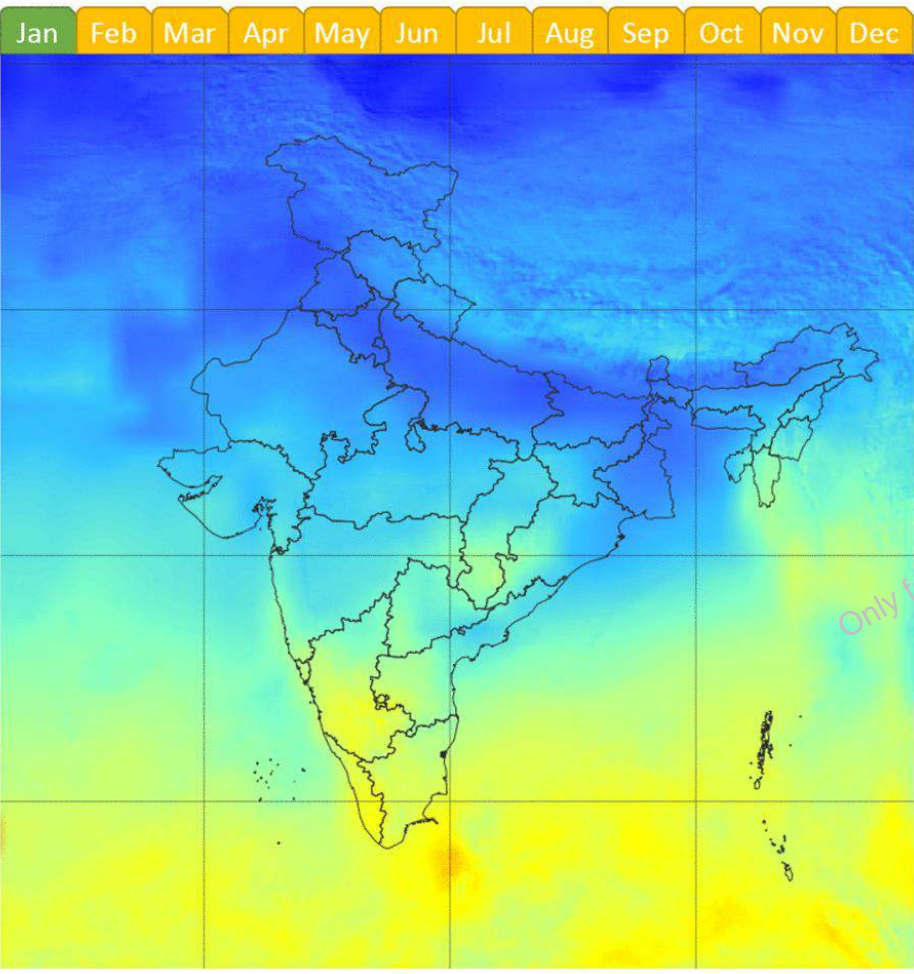


# Satellite frequency



# Remote sensing satellite



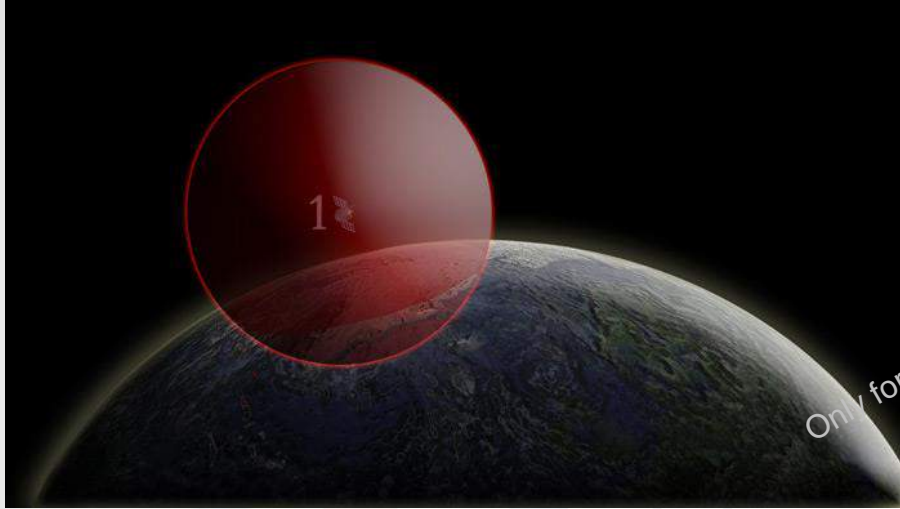


# NISAR Mission

- NASA-ISRO Synthetic Aperture Radar
  - a technique for producing fine-resolution images
  - It requires that the radar be moving either on an airplane or orbiting in space.
- **dual frequency L-band and S- band radar mission,**
- map Earth every 12 days from two directions.
- **studying hazards and global environmental change**
  - ecosystem disturbances, ice-sheet collapse, and natural hazards such as earthquakes, tsunamis, volcanoes and landslides



# Satellite Navigation



- It takes four GPS satellites to calculate a precise location
- three to determine a position on the Earth, and one to adjust for the error in the receiver's clock



- With one satellite you could be anywhere on an imaginary red sphere.
- Add a second satellite (green sphere), you can only be where these two imaginary spheres intersect

# Satellite Navigation



- Add a third satellite (blue sphere) and In this situation, there are only two points (the two white points) where you could possibly be



- To correct for the GPS receiver's clock error and find your precise position, a fourth satellite (yellow sphere) must be used.



**IRNSS**

## Indian Regional Navigation Satellite System

IRNSS (NavIC) is designed to provide accurate real-time positioning and timing services to users in India as well as region extending up to 1,500 km from its boundary

### NAVIGATION CONSTELLATION CONSISTS OF SEVEN SATELLITES

**3** in geostationary  
earth orbit  
(GEO) and  
**4** in geosynchro-  
nous orbit (GSO)  
inclined at 29  
degrees to equator

Each sat has  
three rubidium  
atomic clocks,  
which provide  
accurate  
locational data

### IT WILL PROVIDE TWO TYPES OF SERVICES

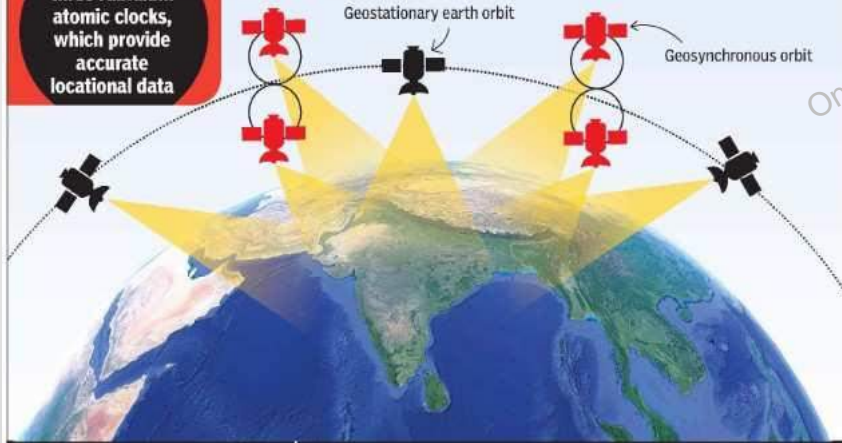
**1 Standard positioning  
service** | Meant  
for all users

**2 Restricted service** | Encrypted service  
provided only to authorised users  
(military and security agencies)

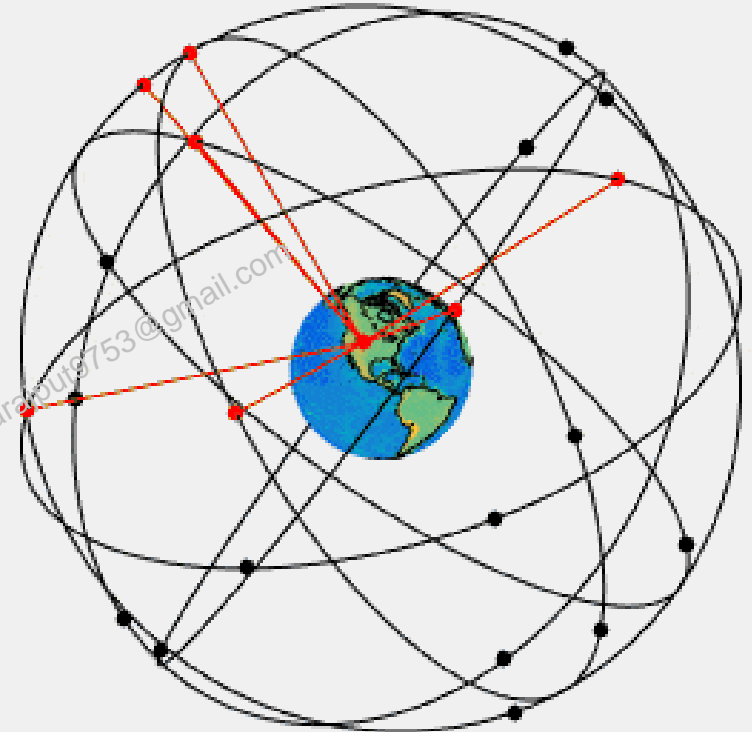
### Applications of IRNSS are:

Terrestrial, aerial and marine  
navigation; disaster management;  
vehicle tracking and fleet  
management; precise timing  
mapping and geodetic data capture;  
terrestrial navigation aid for hikers  
and travellers; visual and  
voice navigation for drivers

While American GPS has  
**24 satellites** in orbit, the  
number of sats visible to  
ground receiver is limited.  
In **IRNSS, four satellites** are  
always in geosynchronous  
orbits, hence always visible  
to a receiver in a region  
**1,500 km** around India



## GPS



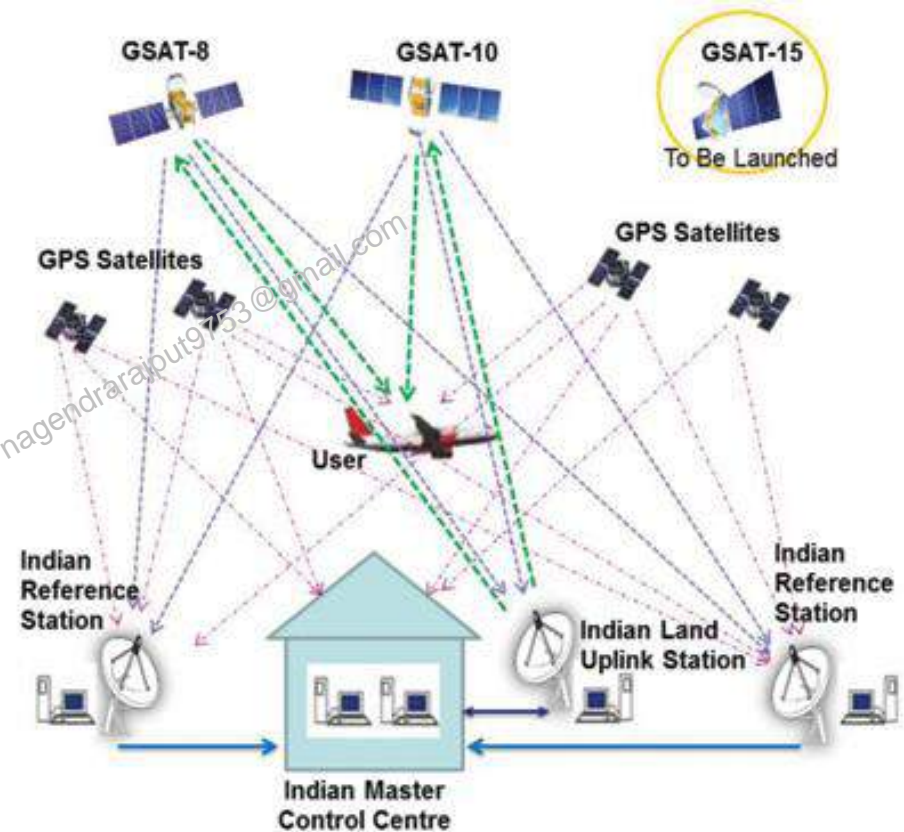
7 visible satellites

# NAVIC

- an independent regional navigation satellite system being developed by India
- to provide Reliable **Position, Navigation and Timing** services over India and its neighbourhood
- **1500 km beyond border**
- consists of the IRNSS constellation of seven satellites
- 3 satellites in the geostationary orbit and the remaining 4 in geosynchronous orbits
- **Standard Positioning and Restricted Services**

# GAGAN

- Airports Authority of India (AAI) and ISRO
- to provide Satellite-based Navigation services for civil aviation applications
- to provide better Air Traffic Management over Indian Airspace



# EVOLUTION OF THE INDIAN LAUNCH VEHICLE

## Satellite Launch Vehicle (SLV-3):

**Height:** 22m

**Fuel:** Four solid stages

**Weight:** 17 tonnes

**Capability:** Placing 40kg class payloads in low earth orbit



## Augmented Satellite Launch Vehicle

**Height:** 23.8m

**Weight:** 40 tonnes, 23.8 m tall

**Fuel:** Five stage, all-solid propellant

**Capability:** Orbiting 150kg class satellites into 400km circular orbits



## Polar Satellite Launch Vehicle

**Height:** 44.4m

**Weight:** 295 tonnes

**Capability:** 1600kg satellites in 620km sun-synchronous polar orbit and 1,050kg satellite in geo-synchronous transfer orbit (GTO)

**Fuel:** Four stages using solid and liquid propulsion systems alternately



## GSLV Mark I and II

**Height:** 49 m

**Weight:** 414 tonne

**Capability:** Placing INSAT-II class of satellites (2000 - 2,500kg) into GTO

**Fuel:** Three stages, S125 solid booster with four liquid (L40) strap-ons, GS2 liquid engine and GS3 cryogenic stage



## GSLV Mark III

**Height:** 42.4m

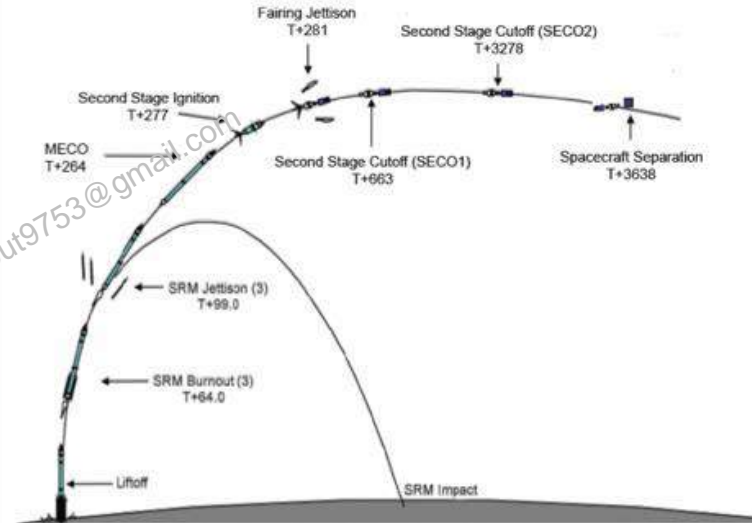
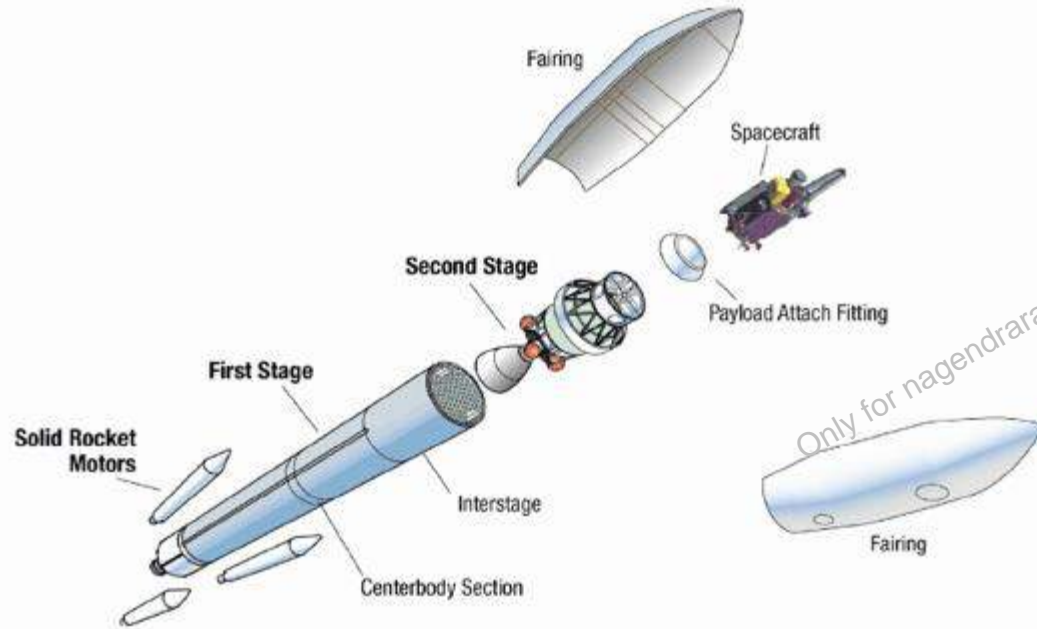
**Weight:** 630 tonnes

**Fuel:** Three stage; two identical S200 Large Solid Booster (LSB) with 200 tonne solid propellant, the L110 re-startable liquid stage, the cryogenic stage

**Capability:** Placing communication satellites of INSAT-4 class, weighing 4,500-5,000kg in GTO, LEO, polar and intermediate circular orbits



# Stages of a Launch vehicle







<https://www.youtube.com/watch?v=n0HnrG6xafU&t=3525s>

33:47 T-10  
33:57 LIFTOFF  
35:50 STAGE 2 SEPERATION  
36:55 FAIRING SEPERATION  
38:17 STAGE 3 SEPERATION  
40:27 ENGINE CUTOFF  
43:44 STAGE 4 SEPERATION  
48:48 STAGE IGNITION  
50:59 ENGINE CUTOFF  
51:57 SATTELITE SEPERATION 1  
53:16 SATTELITE SEPERATION 2

### PSLV

- 1750 kg payload to 600 km
- 1425 kg to GTO
- 4 stage: S-L-S-L
- For LEO



### **GSLV MK II**

- 6000 kg payload to LEO
- 2,250 kg to GTO
- S-L-C



### **LVM 3 (GSLV MK III)**

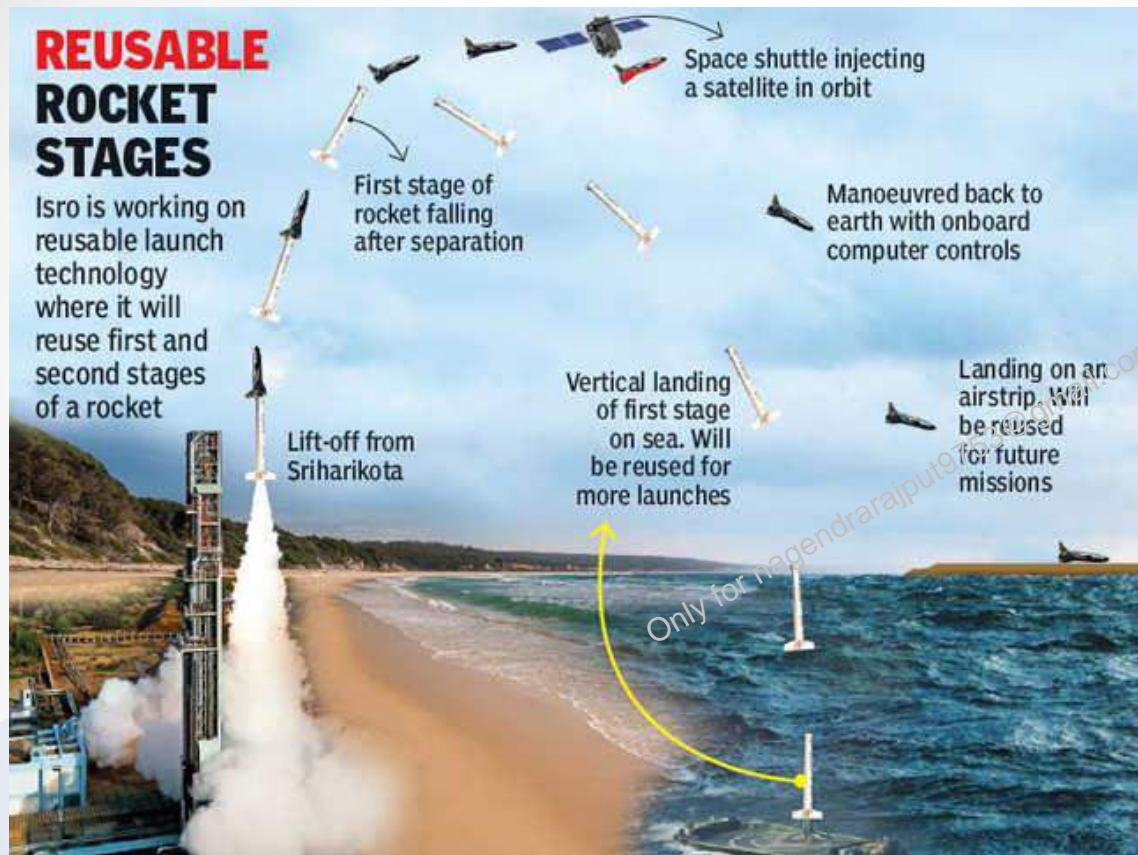
- 8000 kg payload to 600 km
- 4000 kg to GTO
- 3 stage: S-L-C





### **Small Satellite Launch Vehicle (SSLV)**

- Cost effective launcher, launch on demand
- 500kg in 500km orbit
- 3 solid propulsion stages and Liquid Velocity Trimming module as terminal stage



<https://www.youtube.com/watch?v=Tk338VXcb24&t=98s> – Falcon 9 Animation

# UPSC Prelims Questions

In which of the following activities are Indian Remote Sensing Satellites used?

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

Select the correct answers 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

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

1. Chlorophyll content in the vegetation of a specific location
2. Greenhouse gas emissions from rice paddies of a specific location
3. Land surface temperatures of a specific location

Select the correct answer using the code given below.

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

# UPSC Prelims Questions

In which of the following areas can GPS technology be used?

1. Mobile phone operations
2. Banking operations
3. 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

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

1. IRNSS has three satellites in geostationary and four satellites in geosynchronous orbits.
2. IRNSS covers entire India and about 5500 sq. km beyond its borders.
3. India will have its own satellite navigation system with full global coverage by the middle of 2019.

Which of the statements given above is/are correct?

- |                  |                  |
|------------------|------------------|
| (a) 1 only       | (b) 1 and 2 only |
| (c) 2 and 3 only | (d) None         |

# UPSC Prelims Questions

With reference to India's satellite launch vehicles, consider the following statements:

1. PSLVs launch the satellite useful for Earth resources monitoring whereas GSLVs are designed mainly to launch communication satellites.

2. Satellites launched by PSLV appear to remain permanently fixed in the same position in the sky, as viewed from a particular location in Earth.

3. GSLV Mk III is a fourstaged launch 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



# GAGANYAAN

- Precursor missions to Gaganyaan
  - **Space Capsule Recovery Experiment (SRE-2007)**
  - **Crew module Atmospheric Reentry Experiment (CARE-2014)**
  - **GSLV Mk-III (2014)**
  - **Crew Escape System and Pad Abort Test**
- Help from France and Russia
- 3 people (or maybe only 1) for 7 days, LEO (300-400 km), collaboration with IAF
- If successful – India will be 4<sup>th</sup> country after USSR, USA and China



Vyom Mitra: half humanoid, AI based robotic system for Unmanned mission before Gaganyaan, developed by ISRO and IISc

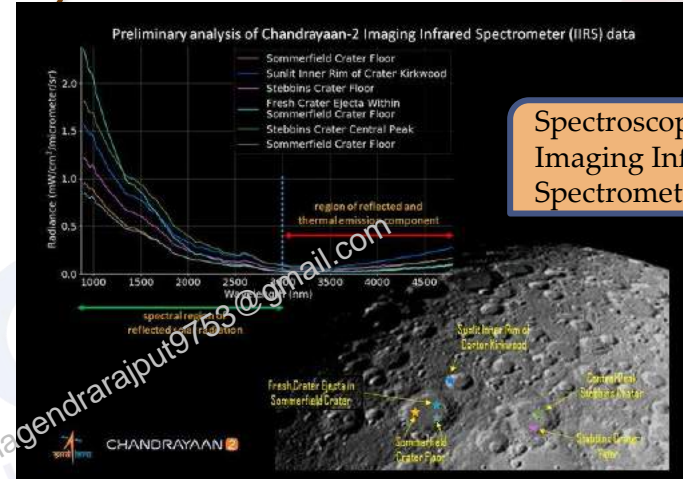
# GAGANYAAN



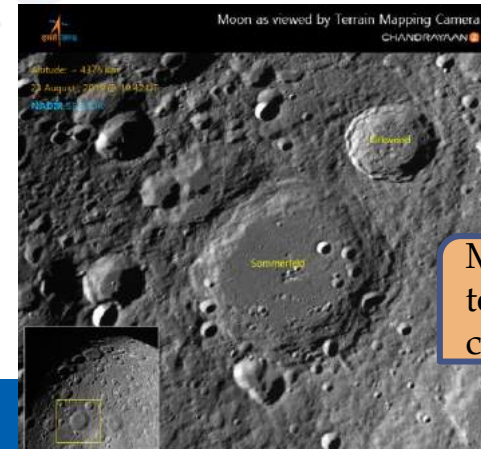


# Chandrayaan 2

- Orbiter, Lander (Vikram) and Rover (Pragyan), GSLV MK III
- 14 payloads (8+4+2)
- Chandrayaan 1: Detection of water, Magma ocean hypothesis, Spinel rich rock, X-Ray signals
- South Pole Region:
  - remains in shadow
  - much larger than that at the North Pole.
  - possibility of the presence of water in
  - fossil record of the early Solar System.
  - untapped source of essential resources.



Spectroscopical analysis by Imaging Infrared Spectrometer (IIRS).



Moon as viewed by terrain mapping camera.

# Chandrayaan 3



# Inflatable Aerodynamic Deflator

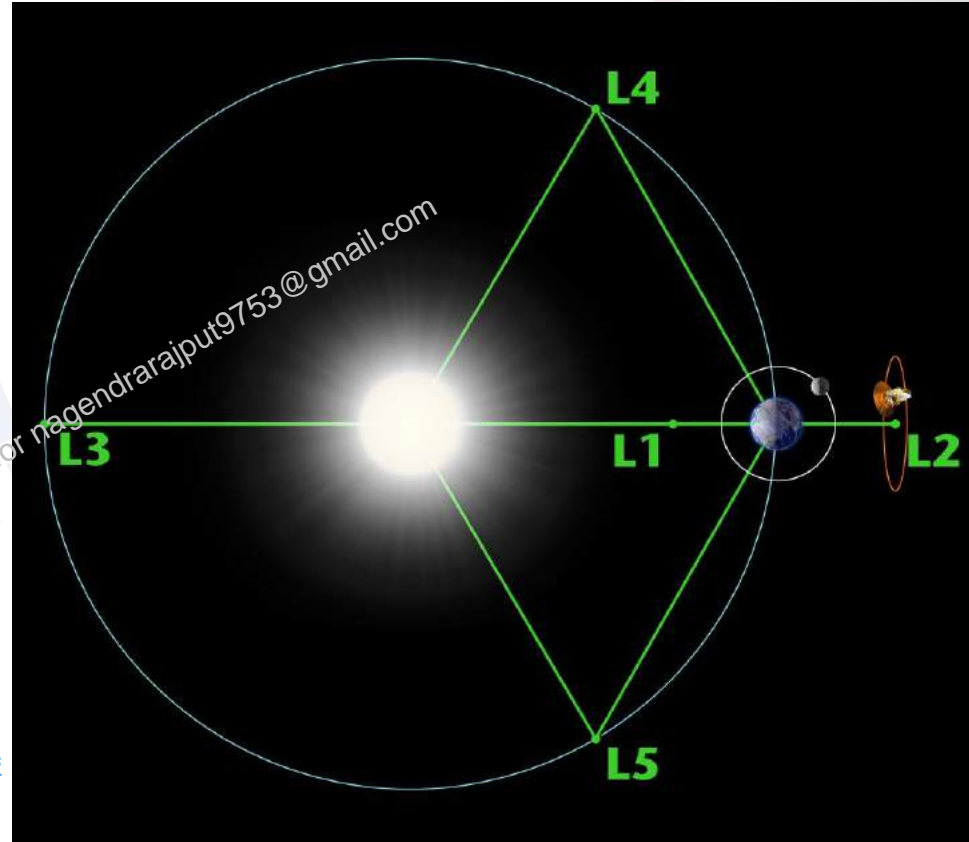


- to increase drag upon entering the atmosphere of any planetary body, like Earth, Mars, or even Moon.
- Its shape is maintained by a closed, gas-pressured body

# Aditya L1 mission

- halo orbit around the **Sun-Earth Lagrangian point (L1)**,
- about 1.5 million km from the Earth.
- ISRO's first scientific expedition to study Sun
- 400 kg-class satellite
- **7 payloads on board** to study Sun's corona, solar emissions, solar winds and flares, and Coronal Mass Ejections, and will carry out round-the-clock imaging of Sun.

<https://www.youtube.com/watch?v=6cUe4oMk69E&list=TLGG8tIphgpDAHkyNzAxMjAyMg&t=1s>

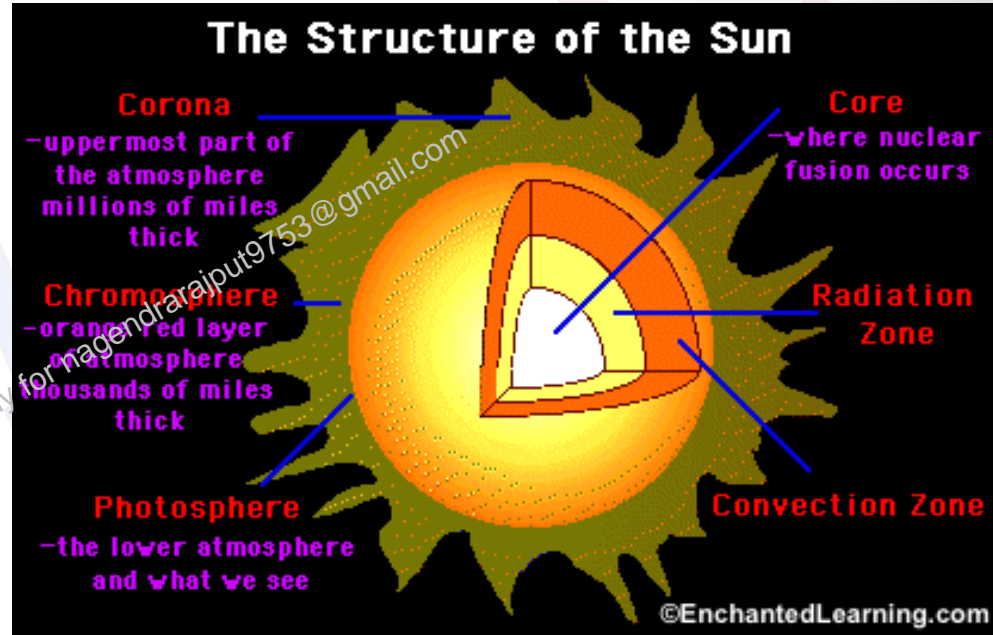
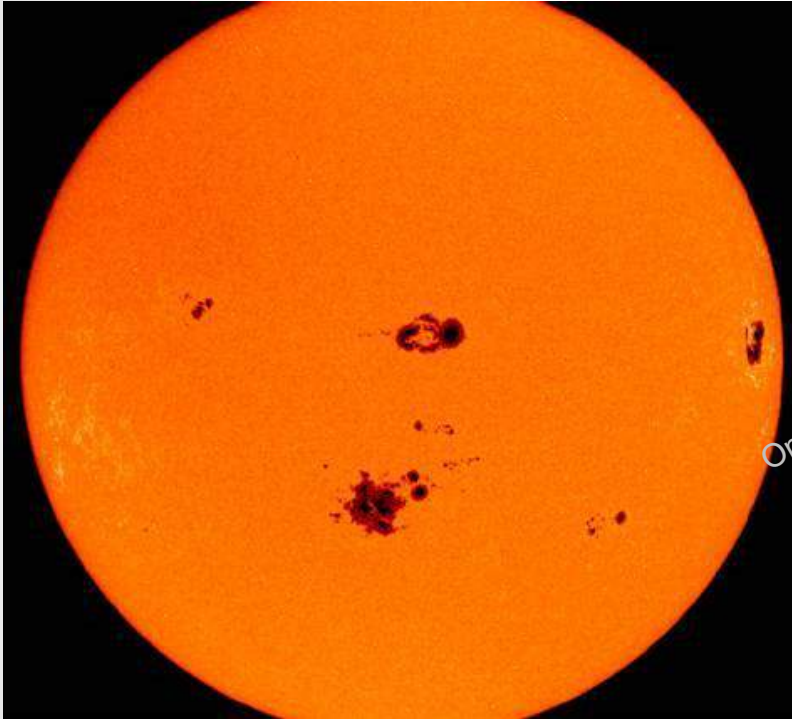


# Lagrange Points and Halo Orbit

- 5 special points where a small mass can orbit in a constant pattern with two larger masses.
- gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them.
- **The orbits around the Lagrangian point is called Halo Orbit.**
- **The L1 point** of the Earth-Sun system affords an uninterrupted view of the sun and is currently home to the **Solar and Heliospheric Observatory Satellite SOHO.**
- **L2 is ideal for astronomy** because a spacecraft is close enough to readily communicate with Earth, can keep Sun, Earth and Moon behind the spacecraft for solar power and provides a clear view of deep space for our telescopes.



# Sun Spot Cycle

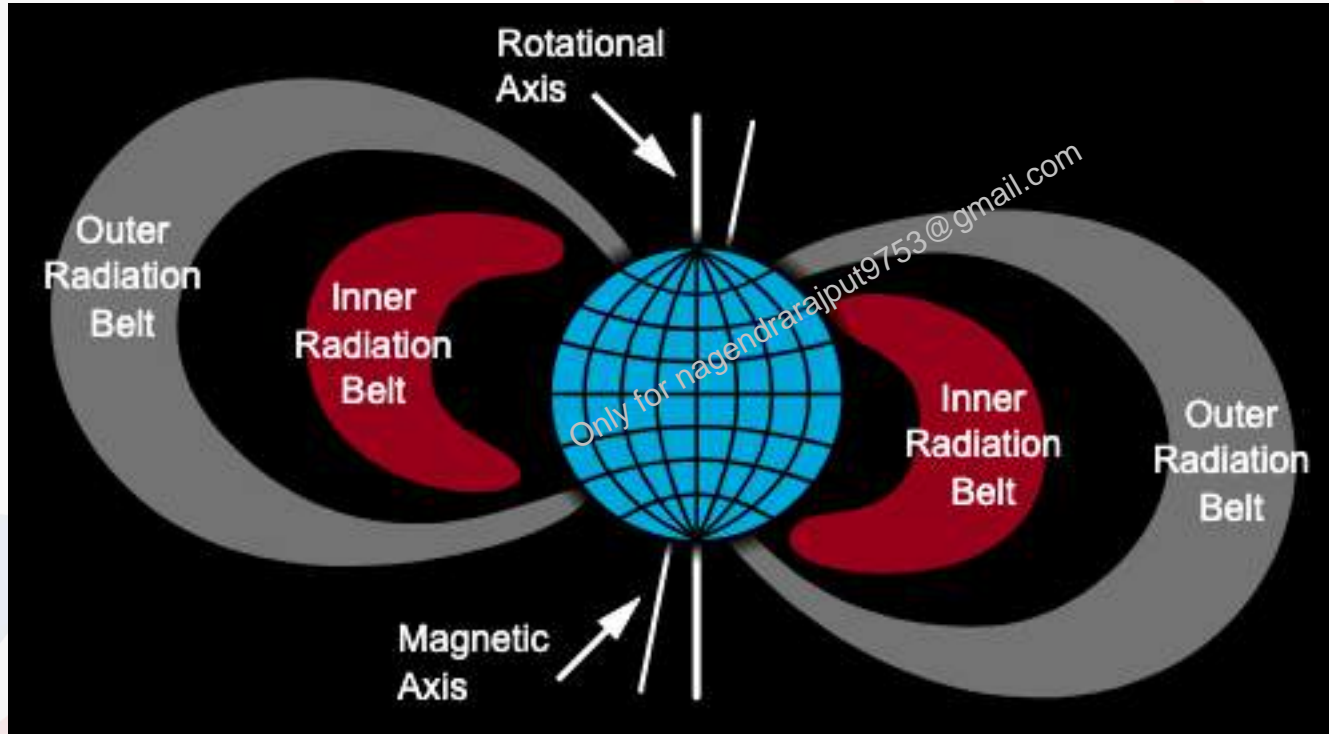


# Sun Spot Cycle

- Sunspots are areas that appear dark on the surface of the Sun
- cooler than other parts of the Sun's surface.
- **Strong magnetic fields:** they some of the heat within the Sun from reaching the surfa
- **Sun Spot Cycle:** the recurring increase and decrease in the number of sunspots over a period averaging about eleven years.
- Solar Maximum and Solar Minimum
- <https://www.youtube.com/watch?v=1DXHE4kt3Fw>
- Solar Wind, Solar Flare and Coronal Mass Ejection



# Van Allen Radiation Belt



If a major solar storm (solar-flare) reaches the Earth, which of the following are the possible effects on the Earth ?

1. GPS and navigation systems could fail.
2. Tsunamis could occur at equatorial regions.
3. Power grids could be damaged.
4. Intense auroras could occur over much of the Earth.
5. Forest fires could take place over much of the planet.
6. Orbits of the satellites could be disturbed.
7. Shortwave radio communication of the aircraft flying over polar regions could be interrupted.

Select the correct answer using the code given below :

- (a) 1, 2, 4 and 5 only
- (b) 2, 3, 5, 6 and 7 only
- (c) 1, 3, 4, 6 and 7 only
- (d) 1, 2, 3, 4, 5, 6 and 7

# Other proposed missions

- XPOSAT
  - X-ray Polarimeter Satellite, is a planned dedicated mission **to study polarisation.**
  - degree and angle of polarisation of bright X-ray sources
  - 5 years, 500-700km orbit
  - study neutron stars, supenova remnants, pulsars and regions around black holes.
- Shukrayaan
- Mangalyaan 2

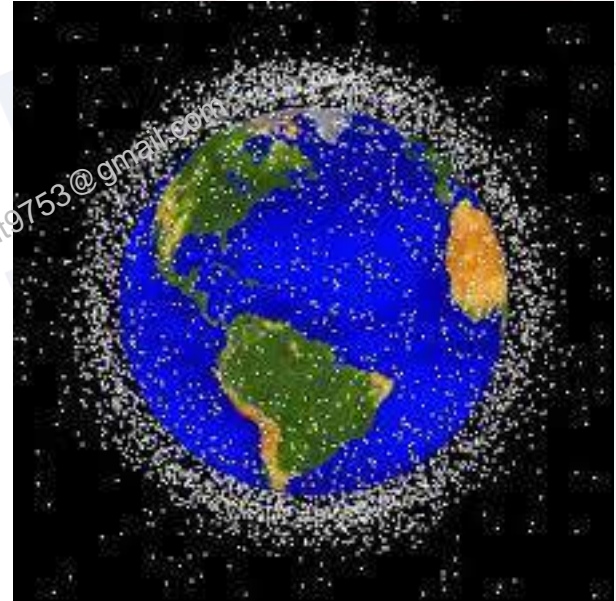
# Space Debris

- Sources:

- Fragmentation of spacecraft and rocket bodies
- Discarded rocket stages:
- Defunct or outdated satellites
- Human-made objects: Other human-made objects, such as tools, cameras
- Natural sources: Even natural events, such as micrometeoroid impacts

- Way Forward:

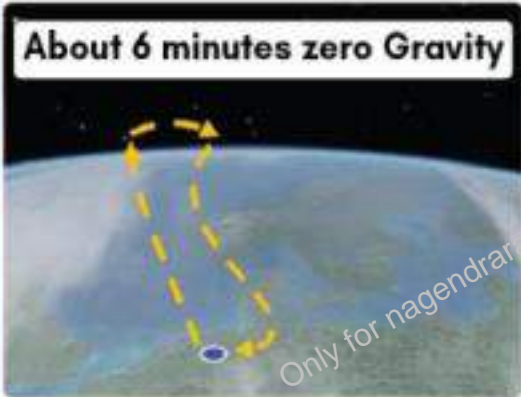



- Space situational awareness
- Minimizing creation of debris
- Active removal of debris



# Weaponization of Space



# Space Tourism

	Suborbital tourism	Orbital tourism
	<p>About 6 minutes zero Gravity</p> 	<p>Day, Weeks in Orbit</p> 
 <b>Altitude</b>	About 100 km	Over 400 km
 <b>Feature</b>	Experiencing <b>a few minutes in a low gravity environment</b> , see the earth from space and the curvature of the earth.	Spacecraft is placed on a trajectory where it could remain in space for <b>at least one orbit</b> .



# Newspace India LTD.

- Commercial arm of ISRO **NewSpace India Limited (NSIL), Bengaluru.**
- Manufacturing and production **Satellite Launch Vehicle (SSLV)** and **Polar Satellite Launch Vehicle (PSLV)**
- **Budget 2019**
- **Antrix:** commercial arm of ISRO, Mini Ratna