Science and Technology Class 01

3rd July, 2023 at 9:00 AM

Overall introduction to Science and Technology (9:08 AM)

Prelims :

- For prelims, science and technology could be vague and difficult as the syllabus is not well defined.
- In recent years, most questions have been from technology than basic sciences.
- We can expect around 10-13 questions in the prelims.
- Current affairs & newspapers remain important for science and technology.

Mains:

- They will be simpler as the syllabus for General Studies 3 is much more well-defined.
- The questions most probably come on expected lines.
- we expect around 3-4 questions in the mains.
- Just like prelims, current affairs remain very important for mains too.

Sources:

- 9^{th}, 10^{th} Ncert(Mandatory for non-science background students).
- The Hindu, especially its Thursday and Sunday coverage.
- Even coverage of the Indian Express has improved in this regard.
- Their **Explained** pages, and editorials with respect to Science and Technology.
- Monthly Magazines are good but they must be complementary sources and not the main source.
- There is no substitute for newspapers.
- There is no need for any other source as such.
- Students must go through previous years' papers to understand that only basics are required both for prelims and mains.
- It would be very helpful if students can know how and where to use the data and facts that they read.
- Students can refer to the weekly video coverages of **www.indiascience.in**
- It is an educational site maintained by the **Department of Science and Technology and Prasar Bharti.**
- Students can also use **ChatGPT** for science & technology and overall preparation as well.

Important topics to be covered:

- Important developments in the field of Science & Technology & their applications.
- Contribution of Indians in Science & Technology.
- Space Technology.
- Nanotechnology.
- Information and Communication Technology.
- Robotics.
- Intellectual Property Rights.
- Nuclear Technology.
- Defense Technology.
- Miscellaneous topics from Current Affairs.
- Previous Year Questions both Prelims and Mains must be gone through to get an idea about the demand of the exam.

Progression of the class:

- Space technology- around 4 classes.
- Nuclear technology- around 1.5 classes.
- Nanotechnology- around 1 class.
- Information & Communication technologies and robotics- around 5 classes.
- Defence- around 1.5 classes.
- Intellectual Property Rights- around 1.5 classes.
- Contribution of Indians to Science and Technology- around 2 classes.

The demand of the examination:

- Questions will be conceptual and application based.
- Most questions are doable, even for non-science backgrounds students.
- We are not supposed to get into too much technical and analytical depth of all topics.
- Only brief ideas about definitions, uses, challenges, and recent steps regarding any science & technology topic in the news would be enough.

Science & Technology:

- Science refers to the systematic and rigorous study to attain knowledge of how things work around us at both macro and micro levels.
- This knowledge is attained through experiments, facts & data.
- Technology is the application of the knowledge hence attained to make our lives easier.
- The journey of science has interfered with the long-held beliefs of people.
- Many scientists like Bruno and Copernicus had to face the consequences of saying things that were later found to be true.

SPACE TECHNOLOGY (9:30 AM):

The sub-topics to be covered:

- Types of orbits.
- Types of Satellites and their Applications.
- Launch Vehicles of ISRO.
- Upcoming and previous missions of ISRO.
- Issues like space debris, weaponization of space, etc.

Explanation of some basic concepts:
Kepler's laws of planetary motion:

- **First Law-**Every planet moves in an elliptical orbit around the sun with the sun being at one of the foci of the ellipse.
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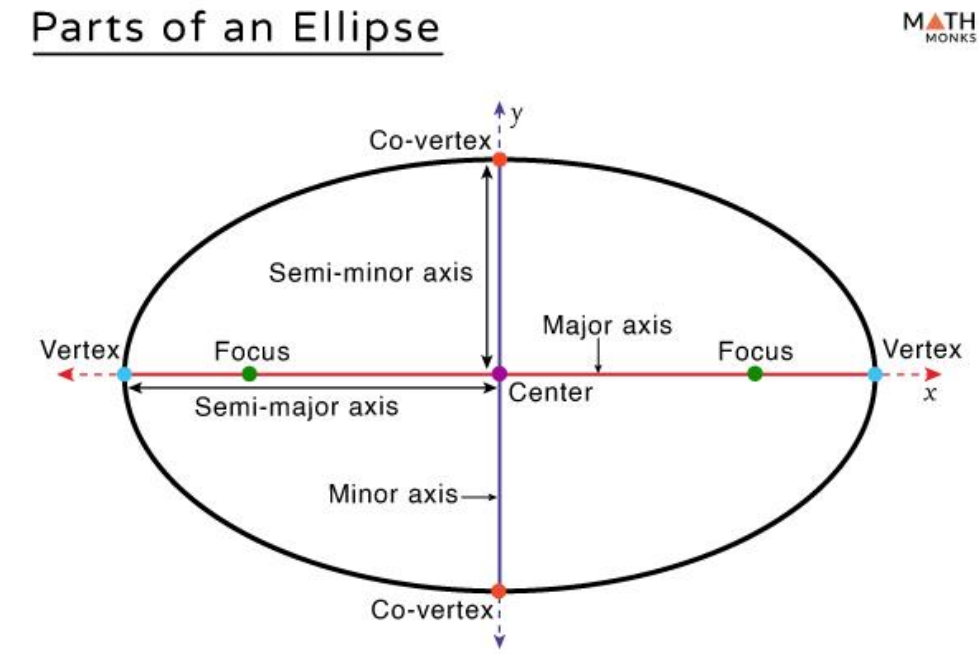
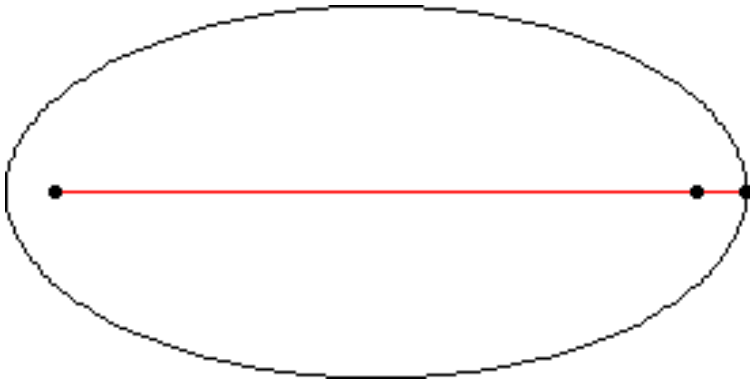
Ellipse:

It is a closed plane curve generated by a point moving in such a way that the sum of its distances from two fixed points is constant.





The circle is a special case of an ellipse.

Satellites in circular orbit have a constant Speed, but a changing velocity because the direction keeps changing continuously.

Newton’s law of motions:

First Law of Motion:

- Objects have a natural tendency to either remain at rest or keep moving in a straight line motion unless there is an external force.
- We get the concept of Inertia.
- If the **net force** on an object remains zero then the object will remain unaccelerated.
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- Acceleration means a change in velocity per unit time.
- Velocity is displacement per unit of time.
- Velocity can be changed in three ways:
- I. Change in Magnitude.
- II. Change in Direction.
- III. Change in both Magnitude and Direction.
- **Friction** is the opposing force that resists the relative motion of two bodies in contact with each other.
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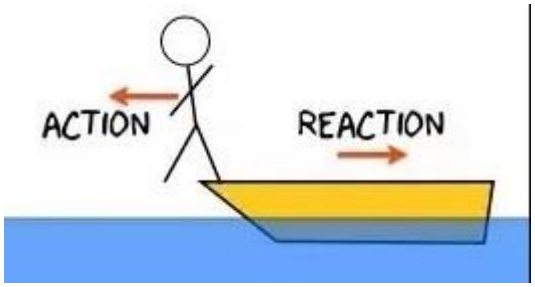
VECTOR AND SCALAR QUANTITIES (10:00 AM):

- **Vector** quantities are the quantities that have both directions as well as magnitude.
- **For example-**Displacement, velocity, acceleration, force, momentum, etc.
- Mass is a scalar quantity and is a measure of Inertia, while Weight is a vector quantity and is a measure of Force.
- **For example-** If someone's mass is 80 kg, his/her weight under normal circumstances will be 80 (9.8m/s^2) = 784 Newtons.
- **Scalar** quantities are quantities that are described only by magnitude.
- They do not have a direction of action.
- For example-Temperature, mass, electric charge, speed, etc.

The second law of Motion:

- The rate of change of momentum is proportional to the force applied.
- **Momentum (p)= Mass(m) * Velocity(v).**
- If the momentum changes from p1 to p2 in a time t, the force must be proportional to (p2-p1)t.
- F (mass* acceleration) gets proportional to (mv1-mv2)/t.
- The application of the law can be seen when a fielder swings his hands backwards after taking a catch.
- He is trying to protect his hands from the momentum by increasing the reaction time.

- **Third law of Motion:**
- Every action has an equal and opposite reaction.
- 

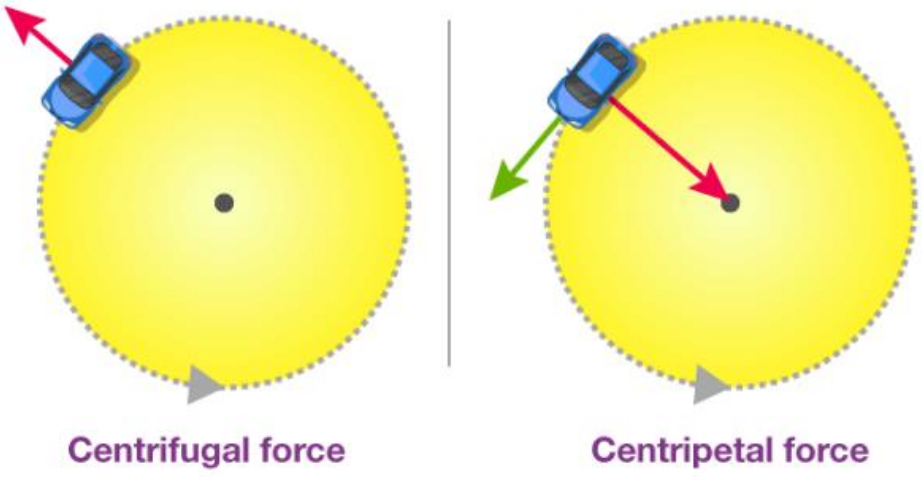
Newton’s law of gravitation:

- Any particle of matter in the universe attracts any other with a force varying directly as the product of the masses and inversely as the square of the distance between them.
- The idea of this planetary attraction was also given by many ancient thinkers like **Brahmagupta,** but Newton was the first to give the specific mathematical expression.

Escape velocity:

- Escape velocity is defined to be the minimum velocity an object must have in order to escape the gravitational field of the earth.
- If an object has enough kinetic energy to overcome the gravitational potential.
- For the Earth, it is 11.2 kilometres per second.
- Objects orbit each other because of gravity
- When an object gets into the orbit of any planet, it will continue to orbit the planet till it is acted upon by an external force.

- **Centrifugal force:**
- It is the apparent force/Pseudo force that is felt by an object moving in a curved path that acts outwardly away from the centre of rotation.
- **Centripetal force:**
- It is the pseudo force that acts on an object in order to direct it toward a center of curvature.



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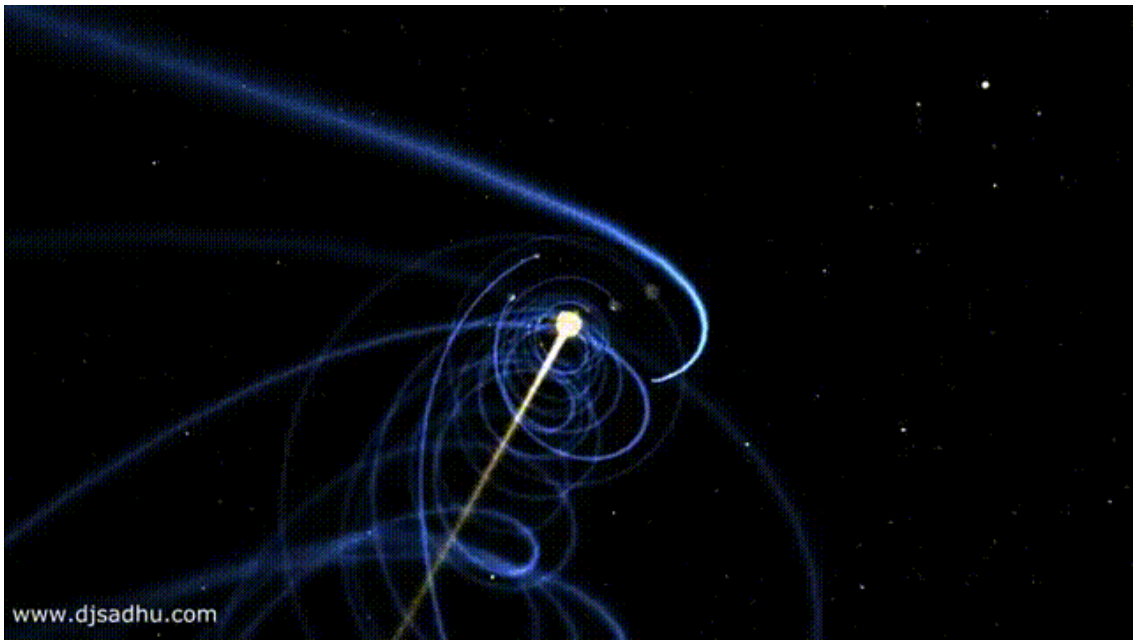
The frame of reference:

It is a coordinate system used to specify the relationship between a moving observer and the phenomenon under observation.

Revolution by the Sun:

- The sun orbits around the center of the Milky Way galaxy.
- This will be noticeable only if seen from outside of the milky way galaxy.
- 

ORBITS AND THEIR TYPES (10:30 AM):

- An orbit is a curved path of one celestial object around another celestial object/artificial object because of gravitational attraction.
- Satellites are launched into different types of orbits around the Earth.
- These orbits can be categorized based on different criteria:

Criteria 1: Based on the Shape:

- **Circular orbit:**
- Earth will be at the centre.
- The orbiting satellite will be situated at the same distance at all times.
- The speed will remain the same, but the velocity will keep on changing.
- This is because the direction of motion will keep on changing continuously to keep the path circular.

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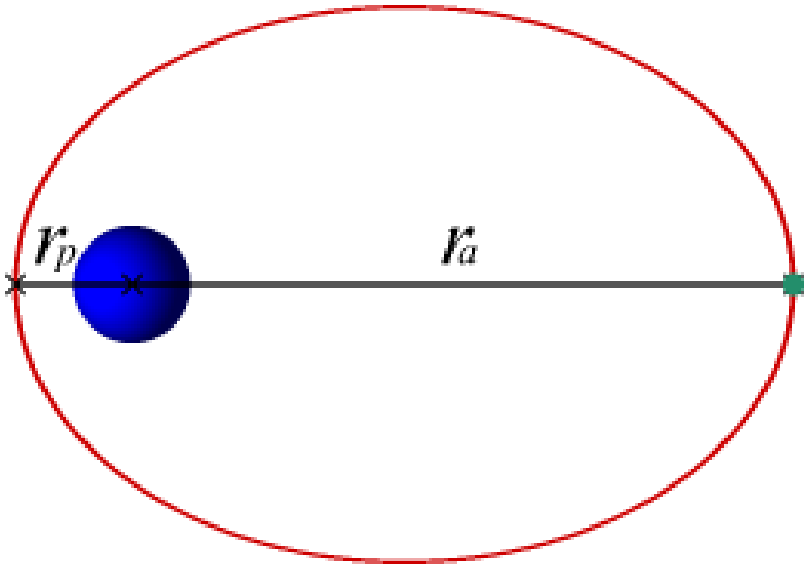
- Geostationary and some Polar satellites use this.

Elliptical orbit:

- Earth will be at one of the focal points of the ellipse.
- The distance between the orbiting body and the earth will keep on changing- **Apogee**- farthest, **Perigee**- closest.
- Both the speed and velocity of the orbiting body will keep changing.
- Most of the satellites are placed here.



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Criteria 2: Based on the height

- **Low-Earth orbit (LEO):**
- They are at a height of 200-2000 Km from the mean sea level.
- They are less costly to achieve as compared to higher orbits.
- They are suitable for earth observation, however, they can only collect data from a point for a brief period of duration.
- Higher orbits are more suitable to establish a communication channel.

Medium-Earth orbit(MEO):

- This is at the height of 2000-35786 km from the mean sea level.

Geosynchronous Orbit (GEO) and High Earth Orbit:

- They lie at a height of more than 35,786 Km from the mean sea level

CRITERIA 2: BASED ON INCLINATION: (11:05 AM):

- **Equatorial orbit** with an inclination of about zero degrees.
- A **Polar Orbit** is inclined at about 90 degrees.
- **Inclined orbit** includes any other orbit from 0-180 degrees.
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- The orbit's center and the center of the earth must coincide.
- In a satellite is placed with some other center of orbit, we cannot use the earth's gravitational force.
- This is as per the concept of the **Center of Mass.**
- For such a satellite, we must need fuel continuously to keep them in orbit.

Satellite-launch:

- It is easier to launch a satellite from an equatorial orbit.
- This is because such satellites it can take optimum advantage of the Earth's substantial rotational speed.
- Sitting on the launch pad near the equator, it is already moving at a speed of over 1650 km per hour
- On the surface of the earth, each static point/object is moving eastward at around a speed of 800 miles per hour.

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- Therefore most of the satellites are launched from the east coast to utilize this angular momentum from the earth's rotation as an extra propelling force.
- In India, this also means that the parts of the launch vehicle will fall in the Bay of Bengal.
- Polar orbits are more difficult than equatorial launches because rockets do not get assistance from the earth's rotation in case of polar launches.
- Despite that, polar orbits are very useful because as the earth rotates below the satellite, it can observe the entire earth by being in the polar orbit.

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- This is not possible in an equatorial orbit.
- Polar satellites provide an excellent view of the poles which is not possible from low-inclined orbits.
- Observing the poles would be very difficult for equatorial orbit satellites.
- Also, polar orbits provide an excellent view of polar regions which is very important for climatic studies.

CRITERIA 4:BASED ON EARTH'S MOTION (11:40 AM):

- **Rotation on its axis**- Geosynchronous orbit
- **Revolution around the sun**- Sun- Synchronous orbit
- In terms of telecommunication, geostationary, and geosynchronous orbits are much more efficient.
- In terms of earth observation, the lower earth orbit is much more efficient.

Geosynchronous orbit:

- If the satellite's rotation is synchronized with the earth's rotation on its axis, i.e. the satellite completes one revolution in one sidereal day(23 hours,56 minutes 4 seconds).
- Such orbits are called geosynchronous orbits.
- **Geostationary orbit** is a special case of geosynchronous orbit.
- It is an equatorial circular orbit and satellites in this orbit seem to be fixed with respect to a point on the equator.
- This satellite will seemed to be fixed with respect to a point on the equator.
- Both the geostationary and geosynchronous orbits are placed at an altitude of 35786 km from the Earth.
- Both the geostationary and geosynchronous orbits are very useful for communication satellites as they can maintain a line of communication with a ground station on Earth.
- This orbit is a very crowded orbit.
- Permission is needed from **International Telecommunication Union,** a UN body for launching satellites in the geostationary orbit.
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The topics for the next class are Sun-synchronous orbit, types of satellites, etc.