17th TEST

Marks : 300
Time : 3 Hrs

TARGETING

TNPSC

GROUP-II 2023

QUESTION WITH SIMPLIFIED ANSWER

MAINS WRITTEN EXAM

SCIENCE & TECH

PHYSICS - I

- Nature of universe
- General scientific laws
- Scientific instruments
- Inventions and discoveries
- Science glossary - Physical quantities, standards and units
- Mechanics and properties of matter

English Medium

SURESH' IAS ACADEMY

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TEST 17 வெற்றி ஒன்றே இலக்கு

Answer Key - English

Unit - 1

1) Define the escape speed and orbital speed?

Escape Speed 3

- The escape speed, the minimum speed required by an object to escape Earth's gravitational field, hence replace v with v_ie

.i.e, $E_i = \frac{1}{2}Mv_i^2 - \frac{GMM_E}{R_E}$

- where, M_E is the mass of the Earth and R_E the radius of the Earth. The term $-\frac{GMM_E}{R_E}$ is the potential energy of the mass M.

Using $g = \frac{GM_E}{R_E^2}$,

$v_e^2 = 2gR_E$

$v_e = \sqrt{2gR_E}$

- The escape speed depends on two factors: acceleration due to gravity and radius of the Earth. It is completely independent of the mass of the object. By substituting the values of g (9.8 m s^{-2}) and R_e = 6400 m, the escape speed of the Earth is v_e = 11.2kms^{-1}
- The escape speed is independent of the direction in which the object is thrown. Irrespective of whether the object is thrown vertically up, radially outwards or tangentially it requires the same initial speed to escape Earth's gravity.

Orbital Speed 3

- The orbital speed of the object is the speed at which it orbits around the bary center of a system which is usually around a massive body around the sun orbital speed of the earth is 108,000 km / h.

$V_{orbit} = \sqrt{\frac{G_M}{R}}$

2) Describe about the acceleration due to the gravity of earth?

Acceleration Due to Gravity of the Earth 6

- When objects fall on the Earth, the acceleration of the object is towards the Earth.
- From Newton's second law, an object is accelerated only under the action of a force.
- The gravitational force exerted by Earth on the mass m near the surface of the Earth is given by $\vec{F} = -\frac{GmM_e}{R_e^2}\hat{r}$
- Now equating Gravitational force to Newton's second law, $m\vec{a} = \frac{GmM_e}{R_e^2}\hat{r}$
- Hence, acceleration is, $\vec{a} = \frac{GM_e}{R_e^2}\hat{r}$
- The acceleration experienced by the object near the surface of the Earth due to its gravity is called acceleration due to gravity. It is denoted by the symbol g.
- The magnitude of acceleration due to gravity is $|g| = g = \frac{GM_e}{R_e^2}$
- It is to be noted that the acceleration experienced by any object is independent of its mass.
- Infact, Galileo arrived at the same conclusion 400 years ago that all objects fall towards the Earth with the same acceleration through various quantitative experiments.

3) Write about the International space station and its benefits?

International Space Station 3

- ISS is a large spacecraft which can house astronauts. It goes around in low Earth orbit at approximately 400 km distance.

- It is also a science laboratory.Its very first part was placed in orbit in 1998 and its core construction was completed by 2011.
- It is the largest man-made object in space which can also be seen from the Earth through the naked eye.
- The first human crew went to the ISS in 2000. Ever since that, it has never been unoccupied by humans.
- At any given instant, at least six humans will be present in the ISS. According to the current plan, ISS will be operated until 2024, with a possible extension until 2028.

Benefits of ISS 1

- According to NASA, the following are some of the ways in which the ISS is already benefitting us or will benefit us in the future.

Supporting water-purification efforts

- Using the technology developed for the ISS, areas having water scarcity can gain access to advanced water filtration and purification systems.
- The water recovery system (WRS) and the oxygen generation system (OGS) developed for the ISS have already saved a village in Iraq from being deserted due to lack of clean water.

Eye tracking technology 1

- The Eye Tracking Device, built for a microgravity experiment, has proved ideal to be used in many laser surgeries.
- Also, eye tracking technology is helping disabled people with limited movement and speech.
- For example, a kid who has severe disability in body movements can use his eye-movements alone and do routine tasks and lead an independent life.

Robotic arms and surgeries Robotic arms

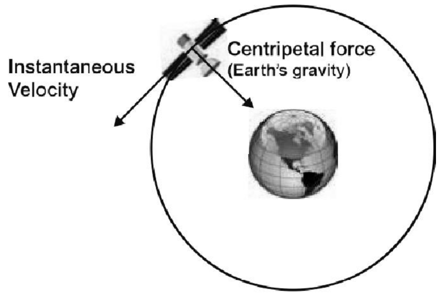
- It is developed for research in the ISS are providing significant help to the surgeons in removing inoperable tumours (e.g., brain tumours) and taking biopsies with great accuracies.
- Its inventors say that the robot could take biopsies with remarkable precision and consistency.

ISS and International Cooperation 1

- As great as the ISS' scientific achievements are, no less in a complishment is the international co-operation which resulted in the construction of the ISS.
- An international collaboration of five different space agencies of 16 countries provides, maintains and operates the ISS.
- They are: NASA (USA), Roskosmos (Ru sia), ESA (Europe), JAXA (Japan) and CSA (Cananda).
- Belgium, Brazil, Denmark, France, Germany, Italy, Holland, Norway, Spain, Sweden, Switzerland and the UK are also part of the consortium.

4) Write a short note on Orbital velocity?

Orbital Velocity 3



Orbital velocity

- We saw that there are natural satellites moving around the planets. There will be gravitational force between the planet and satellites.
- Nowadays many artificial satellites are launched into the Earth's orbit. The first artificial satellite Sputnik was launched in 1956.
- India launched its first satellite Aryabhatta on April 19, 1975. Artificial satellites are made to revolve in an orbit at a height of few hundred kilometres.
- At this altitude, the friction due to air is negligible. The satellite is carried by a rocket to the desired height and released horizontally with a high velocity, so that it remains moving in a nearly circular orbit.

Figure-Orbital velocity 3

- The orbital velocity of the satellite depends on its altitude above Earth. Nearer the object to the Earth, the faster is the required orbital velocity.
- At an altitude of 200 kilometres, the required orbital velocity is little more than 27,400 kph. That orbital speed and distance permit the satellite to make one revolution in 24 hours.

- Since Earth also rotates once in 24 hours, a satellite stays in a fixed position relative to a point on Earth's surface.
- Because the satellite stays over the same spot all the time, this kind of orbit is called 'geostationary'.
- Orbital velocity can be calculated using the following formula. where, $v = \sqrt{\frac{GM}{(R+h)}}$

  G = Gravitational constant (6.673×10^{-11} Nm^2 kg^{-2})

  M = Mass of the Earth (5.972×10^{24} kg)

  R = Radius of the Earth (6371 km)

  h = Height of the satellite from the surface of the Earth.

5) Write a short notes on 'Stars'? 2

- Stars are the fundamental building blocks of galaxies.
- Stars were formed when the galaxies were formed during the Big Bang.
- Stars produce heat, light, ultraviolet rays, x-rays, and other forms of radiation.
- They are largely composed of gas and plasma (a superheated state of matter). Stars are built by hydrogen gases.

<u>Formation of the stars</u> 1

- Hydrogen atoms fuse together to form helium atoms and in the process they produce large amount of heat.
- In a dark night we can see nearly 3,000 stars with the naked eye.
- We don't know how many stars exist.
- Our universe contains more than 100 billion galaxies, and each of those galaxies may have more than 100 billion stars.

<u>Types of Stars</u> 1.5

- Though the stars appear to be alone, most of the stars exist as pairs.
- The brightness of a star depends on their intensity and the distance from the Earth.
- Stars also appear to be in different colours depending on their temperature.
- Hot stars are white or blue, whereas cooler stars are orange or red in colour.
- They also occur in many sizes

<u>Constellation</u> 1.5

- A group of stars forms an imaginary outline or meaningful pattern on the space.
- They represent an animal, mythological person or creature, a god, or an object.
- This group of stars is called constellations.
- There are 88 formally accepted constellations.
- Aries, Gemini, Leo, Orion, Scorpius and Cassiopeia are some of the constellations.
- All stars appear to us as moving from east to west, where as there is one star which appears to us stationary in its position.
- It has been named as Pole star.
- The pole star appears to us as fixed in space at the same place in the sky in the north direction because it lies on the axis of rotation of the Earth which itself is fixed and does not change its position in space.

6) What is Kepler 452B? 6

- Kepler 452 B is the first near - Earth size world to be found in the habitable zone of star that is similar to our sun.
- Until its discovery in 2015, the Kepler telescope had only detected 12 Earth - size planets (smaller than twice the size of Earth) in the habitable zone of their smaller and cooler stars.
- Kepler 452 B is the first planet orbiting a star about the same size and temperature as the sun.
- When looking too planets that might support life, scientists start with the habitable zone.- The habitable zone is a region around a star where temperatures are right for water an essential ingredient for life as we know it to pool on the surface.
- Scientists don't know if Kepler - 452B can support life.
- What is known about the planet is that it is about 60% larger than Earth, placing it in a class of planets dubbed 'Super - Earth' with an orbit of 385 days.
- Scientists believe that Kepler - 452B is about 6 billion years old, much older than Earth.

7) Write a short note on Ohm's law?

<u>Ohm's Law</u> 6

- A German physicist, Georg Simon Ohm established the relation between the potential difference and current, which is known as Ohm's Law.
- This relationship can be understood from the following activity.-According to Ohm's law, at a constant temperature, the steady current 'I' flowing through a conductor is directly

proportional to the potential difference 'V' between the two ends of the conductor. I $\propto$ V. Hence, $=\frac{I}{V}$ constant.-The value of this proportionality constant is found to be

- Therefore, $I = \frac{1}{R}V$

  V = I R
- Here, R is a constant for a given material (say Nichrome) at a given temperature and is known as the resistance of the material.
- Since, the potential difference V is proportional to the current I, the graph between V and I is a straight line for a conductor.

8) Write a short note on Malu's law?

Malus' law 4

- When a plane polarised light is seen through an analyser, the intensity of transmitted light varies as the analyser is rotated through an angle perpendicular to the incident direction.
- In 1809, French Physicist E.N Malus discovered that when a beam of plane polarised light of intensity I_0 is incident on an analyser, the light transmitted of intensity
- I from the analyser varies directly as the square of the cosine of the angle θ between the transmission axis of polariser and analyser as shown in Figure
- This is known as Malus' law.

  $I = I_0 \cos2\ \theta$
- The amplitude a of the incident light has two rectangular components, $a\cos\theta$ èand $a\sin\theta$ which are the parallel and perpendicular components to the axis of transmission of the analyser.
- Only the component $a\cos\theta$ will be transmitted by the analyser. The intensity of light transmitted from the analyser is proportional to the square of the component of the amplitude transmitted by the analyser.

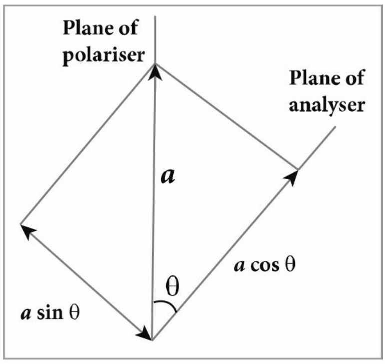
  $I \propto (a \cos\theta)^2$

  $I = k\,(a \cos\theta)^2$
- Where k is constant of proportionality.

  $I = ka^2 \cos^2\theta$

  $I = I_0 \cos^2\theta$
- Where, $I_0 = ka^2$ is the maximum intensity of light transmitted from the analyser.

- The following are few special cases. 2



Malus' law

- Case (i) When $\theta = 0^o$, $\cos 0^o = 1$, $I = I_0$
- When the transmission axis of polariser is along that of the analyser, the intensity of light transmitted from the analyser is equal to the incident light that falls on it from the polariser.
- Case (ii) When $\theta = 90^o$, $\cos 90^o = 0$, $I = 0$

9) Write a short note on Brewster's law?

Brewster's Law 4

- In 1808, Malus discovered that when ordinary light is incident on the surface of a transparent medium, the reflected light is partially plane polarised.
- The extent of polarisation depends on the angle of incidence. For a particular angle of incidence, the reflected light is found to be plane polarised.
- The angle of incidence at which a beam of unpolarised light falling on a transparent surface is reflected as a beam of plane polarised light is called polarising angle or Brewster's angle. It is denoted by i_p.
- Further, the British Physicist, Sir. David Brewster found that at the incidence of polarising angle, the reflected and transmitted rays are perpendicular to each other. Suppose, i_p is the polarising angle and r_p is the corresponding angle of refraction.

  $i_p + 90^o + r_p = 180^o$

  $r_p = 90^o - i_p$
- From Snell's law, the refractive index of the transparent medium is, $\frac{\sin i_p}{\sin r_p} = n$
- where n is the refractive index of the medium with respect to air.

- Substituting the value of r_p from Equation we get, **2**
- $$\frac{\sin i_p}{\sin(90^o - i_p)} = \frac{\sin i_p}{\cos i_p} = n$$

  $\tan i_p = n$
- This relation is known as Brewster's law. The law states that the tangent of the polarising angle for a transparent medium is equal to its refractive index.
- The value of Brewster's angle depends on the nature of the transparent refracting medium and the wavelength of light used.

10) Write about photo electric cells and its applications?

Photo electric cells and their applications

Photo cell **2**

- Photo electric cell or photo cell is a device which converts light energy into electrical energy. It works on the principle of photo electric effect. When light is incident on the photosensitive materials, their electric properties will get affected, based on which photo cells are classified into three types. They are

i) Photo emissive cell:
- Its working depends on the electron emission from a metal cathode due to irradiation of light or other radiations.

ii) Photo voltaic cell:
- Here sensitive element made of semiconductor is used which generates voltage proportional to the intensity of light or other radiations.

iii) Photo conductive cell:
- In this, the resistance of the semiconductor changes in accordance with the radiant energy incident on it.

Photo emissive cell **2**

Construction:
- It consists of an evacuated glass or quartz bulb in which two metallic electrodes – that is, a cathode and an anode.
- The cathode C is semi-cylindrical in shape and is coated with a photo sensitive material.
- The anode A is a thin rod or wire kept along the axis of the semi-cylindrical cathode.
- A potential difference is applied between the anode and the cathode through a galvanometer G.

Working:
- When cathode is illuminated, electrons are emitted from it.
- These electrons are attracted by anode and hence a current is produced which is measured by the galvanometer.
- For a given cathode, the magnitude of the current depends on

i) the intensity to incident radiation and ii) the potential difference between anode and cathode.

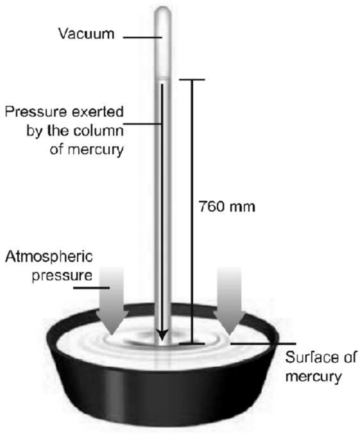
Applications of photo cells: **2**
- Photo cells have many applications, especially as switches and sensors.
- Automatic lights that turn on when it gets dark use photocells, as well as street lights that switch on and off according to whether it is night or day.
- Photo cells are used for reproduction of sound in motion pictures and are used as timers to measure the speeds of athletes during a race.
- Photo cells of exposure meters in photography are used to measure the intensity of the given light and to calculate the exact time of exposure.

11) Explain Atmospheric pressure and its measurements?

Atmospheric pressure **3**
- Earth is surrounded by a layer of air up to certain height (nearly 300 km) and this layer of air around the earth is called atmosphere of the earth. Since air occupies space and has weight, it also exerts pressure.
- This pressure is called atmospheric pressure. The atmospheric pressure we normally refer is the air pressure at sea level.
- The air gets 'thinner' with increasing altitude. Hence, the atmospheric pressure decreases as we go up in mountains. On the other hand air gets heavier as we go down below sea level like mines.

Measurement of atmospheric pressure **3**
- The instrument used to measure atmospheric pressure is called barometer. A mercury barometer, first designed by an Italian Physicist Torricelli, consists of a long glass tube (closed at one end, open at the other) filled with mercury and turned upside down into a container of mercury.
- This is done by closing the open end of the mercury filled tube with the thumb and then

opening it after immersing it in to a trough of mercury (Fig.).



Mercury barometer

- The barometer works by balancing the mercury in the glass tube against the outside air pressure. If the air pressure increases, it pushes more of the mercury up into the tub and if the air pressure decreases, more of the mercury drains from the tube. As there is no air trapped in the space between mercury and the closed end, there is vacuum in that space.
- Vacuum cannot exert any pressure. So the level of mercury in the tube provides a precise measure of air pressure which is called atmospheric pressure.
- This type of instrument can be used in a lab or weather station.
- On a typical day at sea level, the height of the mercury column is 760 mm. Let us calculate the pressure due to the mercury column of 760 mm which is equal to the atmospheric pressure.
- The density of mercury is 13600 kg m^{-3}.
- Pressure, P = $h\rho g$
  = (760 x 10^{-3}m) x (13600 kgm^{-3}) x (9.8 ms^{-2})
  = 1.013 x 10^5 Pa.
- This pressure is called one atmospheric pressure (atm). There is also another unit called (bar) that is also used to express such high values of pressure.
  1 atm = 1.013 × 10^5 Pa.
  1 bar = 1 × 10^5 Pa.
  Hence, 1 atm = 1.013 bar.
- Expressing the value in kilopascal gives 101.3 k Pa. This means that, on each
  1 m^2 of surface, the force acting is 1.013 k N.

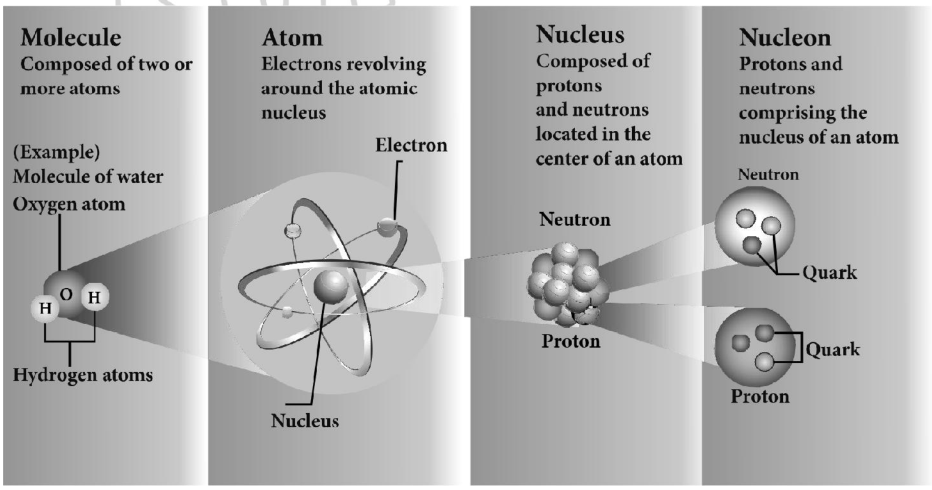
12) Write a short note on:

a) Particle physics

b) Cosmology

a) Particle physics **3**

- Particle physics deals with the theory of fundamental particles of nature and it is one of the active research areas in physics.
- Initially it was thought that atom is the fundamental entity of matter. In 1930s, it was established that atoms are made up of electrons, protons and neutrons.



- In the 1960s, quarks were discovered and it was understood that proton and neutron are made up of quarks.
- It is the field which received more number of noble prizes.
- Recently in the year 2013, famous 'Higgs particles' also known as "God" particles were discovered and for this, Peter Higgs and Englert received noble prize in Physics. It is the 'Higgs particle' which gives mass to many particles like protons, neutrons etc.

b) Cosmology 3

- Cosmology is the branch that involves the origin and evloution of the universe. It deals with formation of starts, galaxy etc.
- In the year 2015, the existence of "gravitational waves" was discovered and noble prize was awarded for this discovery in the year 2017.
- Gravitational waves are the disturbances in the curvature of space-time and it travels with speed of light. Any accelerated charge emits electromagnetic wave.
- Similarly any accelerated mass emits gravitational waves but these waves are very weak even for masses like earth. The strongest source of gravitational waves are black holes.
- In fact, Albert Einstein theoretically proposed the existence of 'gravitational waves' in the year 1915. After 100 years, it is experimentally proved that his predictions are correct.
- Black holes are end stage of stars which are highly dense massive object. Its mass ranges from 20 times mass of the sun to 1 million times mass of the sun.
- It has very strong gravitational force such that no particle or even light can escape from it.
- The existence of black holes is studied when the stars orbiting the black hole behave differently from the other stars. Every galaxy has black hole at its center.
- Sagittarius A* is the black hole at the center of the Milky Way galaxy.
- The famous physicist Stephen Hawking worked in the field of black holes.

13) Write a short notes on Quantum information theory.

Quantum information theory. 6

- It is another fast developing research area which deals with improving the information storage using quantum computers.
- The present computers store information in the form of 'bits' but quantum computers store information in the form of 'qubits'.
- 'qubit' refers to quantum bit and it is the basic unit of quantum information. Classical bit implies either 0 or 1.
- But cubit not only includes 0 or 1 and also linear superposition of 0 and 1.
- This technology reduces the calculating time exponentially. This research field has very promising application in future.

14) Name the laureates and explain their achievements, who got Noble prize for physics in 2022? 6

- The Nobel prize for physics in 2022 has given to Aline aspect , john clauser, Anton zeilinger.
- It was announced by Royal Swedish academy of science.
- They have awarded for quantum information theory of science.
- They make continuous research on entangled quantum state. They infer that two particles acts under the same unit.
- Quantum entanglement is a bizarre, counter initiative phenomenon that explains how two subatomic particles can be intimately linked to each other even if separated by billions of light-years of space.
- Despite their vast separation, a change induced in one will affect the other.
- Their invention will bring adverse change in quantum computer and quantum networks.
- The computer follows the quantum motion, when it undertakes complex functions.
- There is now a large field of research that includes quantum computers, Quantum networks and secure quantum encrypted communication.

15) Difference between mass and weight?

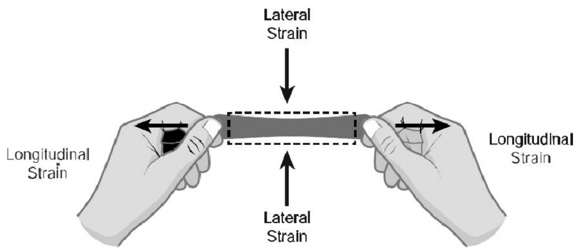
Difference between mass and weight 2

- Mass (m) is the quantity of matter contained in a body. Weight (w) is the normal force (N) exerted by the surface on the body to balance against gravitational pull on the object.
- In the case of spring scale, the tension in the spring balances the gravitational pull on the object.
- When a man is standing on the surface of the earth or floor, the surface exerts a normal force on the body which is equivalent to gravitational force.
- The gravitational force acting on the object is given by 'mg'.
- Here, m is mass of the object and 'g' is acceleration due to gravity.
- The pull of gravity on the Moon is 1/6 times weaker than that on the Earth.
- This causes the weight of the object on the Moon to be less than that on the Earth by six times.
- Acceleration due to gravity on the Moon = 1.63 ms^{-2}
- If the mass of a man is 70 kg then his weight on the Earth is 686 N and on the Moon is 114 N.
- But his mass is still 70 kg on the Moon.

Mass	Weight 4
It is a fundamental quantity.	It is a derived quantity.
It has magnitude alone – scalar quantity.	It has magnitude and direction – vector quantity.
It is the amount of matter contained in a body.	It is the normal force exerted by the surface on the object against gravitational pull.
Remains the same everywhere.	Varies from place to place.
It is measured using physical balance.	It is measured using spring balance.
Its unit is kilogram.	Its unit is newton.
Mass = Volume $\times$ density	Weight = Mass $\times$ Acceleration due to gravity

16) Write a short note on Poisson's ratio?

Poisson's ratio 4



- Suppose we stretch a wire, its length increases (elongation) but its diameter decreases (contraction).
- Similarly, when we stretch a rubber band (elongation), it becomes noticeably thinner (contraction).
- That is, deformation of the material in one direction produces deformation in another direction.
- To quantify this, French Physicist S.D. Poisson proposed a ratio, known as Poisson's ratio.
- It is defined as the ratio of relative contraction (lateral strain) to relative expansion (longitudinal strain).
- It is denoted by the symbol μ. Poisson's ratio, μ = $\mu = \frac{\text{lateral strain}}{\text{longitudinal strain}}$
- Consider a wire of length L with diameter D. Due to applied force, wire stretches and let the increase in length be l and decrease in diameter be d. Then $\mu = \frac{\frac{d}{D}}{\frac{l}{L}} = -\frac{L}{l} \times \frac{d}{D}$
- Negative sign indicates the elongation is along longitudinal and the contraction along lateral dimension.
- Further, notice that it is the ratio between quantities of the same dimension.
- So, Poisson's ratio has no unit and no dimension (dimensionless number).
- The Poisson's ratio values of some of the materials are listed

Poisson's ratio of some of the materials 2

Material	Poisson's ratio
Rubber	0.4999
Gold	0.42 -0.44
Copper	0.33
Stainless steel	0.30-0.31
Steel	0.27-0.30
Cast iron	0.21-0.26
Concrete	0.1-0.2
Glass	0.18-0.3
Foam	0.10-0.50
Cork	0.0

17) Write a short note on Reynold's number?

Reynold's number 3

- We have learnt that the flow of a fluid becomes steady or laminar when the velocity of flow is less than the critical velocity v_c otherwise, the flow becomes turbulent.
- Osborne Reynolds (1842-1912) formulated an equation to find out the nature of the flow of fluid, whether it is streamlined or turbulent.

$$R_c = \frac{\rho v D}{\eta}$$

- It is a dimensionless number called 'Reynold's number'.
- It is denoted by the symbol R_c or K.
- In the equation, ρ denotes the density of the fluid, v the velocity of the flowing fluid, D is

the diameter of the pipe in which the fluid flow, and η s the coefficient of viscosity of the fluid.

- The value of R_c remains the same in any system of units.

To understand the flow of liquid, Reynold has estimated the value of Rc as follows 1

S. No	Reynold's number	Flow
1	$Rc < 1000$	Streamline
2	$1000 < Rc < 2000$	Unsteady
3	$Rc > 2000$	Turbulent

- Hence, Reynold's number Rc is a critical variable which decides whether the flow of a fluid through a cylindrical pipe is streamlined or turbulent. 2
- In fact, the critical value of Rc at which the turbulence sets is found to be the same for geometrically similar flows.
- For example, when two liquids (say oil and water) of different densities and viscosities flow in pipes of same shapes and sizes, the turbulence sets in at almost the same value of Rc.
- The above fact leads to the Law of similarity which states that when there are two geometrically similar flows, both are essentially equal to each other, as long as they embrace the same Reynold's number.
- The Law of similarity plays a very important role in technological applications.
- The shape of ships, submarines, racing cars, and airplanes are designed in such a way that their speed can be maximized.

18) Write a short note on

a) Streamlined flow

b) Turbulent flow.

a) Streamlined flow 3

- The flow of fluids occurs in different ways.
- It can be a steady or streamlined flow, unsteady or turbulent flow, compressible or incompressible flow or even viscous or non-viscous flow.
- For example, consider a calm flow of water through a river.
- Careful observation reveals that the velocity of water at different locations of the river is quite different.
- It is almost faster at the center and slowest near the banks.
- However, the velocity of the particle at any point is constant.
- For better understanding, assume that the velocity of the particle is about 4 meter per second at the center of the river.
- Hence it will be of the same value for all other particles crossing through this point.
- In a similar way, if the velocity of the particle flowing near the bank of the river is 0.5 meter per second, then the succeeding particles flowing through it will have the same value.
- When a liquid flows such that each particle of the liquid passing through a point moves along the same path with the same velocity as its predecessor then the flow of liquid is said to be a streamlined flow.
- It is also referred to as steady or laminar flow.
- The actual path taken by the particle of the moving fluid is called a streamline, which is a curve, the tangent to which at any point gives the direction of the flow of the fluid at that point as shown
- It is named so because the flow looks like the flow of a stream or river under ideal conditions.
- If we assume a bundle of streamlines having the same velocity over any cross section perpendicular to the direction of flow then such bundle is called a 'tube of flow'.
- Thus, it is important to note that any particle in a tube of flow always remains in the tube throughout its motion and cannot mix with liquid in another tube.
- Always the axis of the tube of flow gives the streamline.
- The streamlines always represent the trajectories of the fluid particles.
- The flow of fluid is streamlined up to a certain velocity called critical velocity.
- This means a steady flow can be achieved at low flow speeds below the critical speed.

b) Turbulent flow 3

- When the speed of the moving fluid exceeds the critical speed vc, the motion becomes turbulent.
- In this case, the velocity changes both in magnitude and direction from particle to particle and hence the individual particles do not move in a streamlined path.
- Hence, the path taken by the particles in turbulent flow becomes erratic and whirlpool-like circles called eddy current or eddies

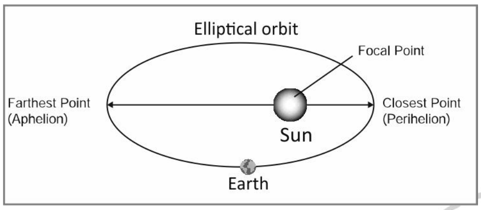
- The flow of water just behind a boat or a ship and the air flow behind a moving bus are a few examples of turbulent flow
- The distinction between the two types of motion can be easily demonstrated by injecting a jet of ink axially in a wide tube through which water flows.
- When the velocity of the fluid is small, the ink will move in a straight line path.
- Conversely, when the velocity is increased beyond a certain value, the ink will spread out showing the disorderliness and hence the motion becomes turbulent.
- The zig-zag motion results in the formation of eddy currents and as a consequence, much energy is dissipated.

Unit - 2

1) Explain the Kepler's laws of Motion?

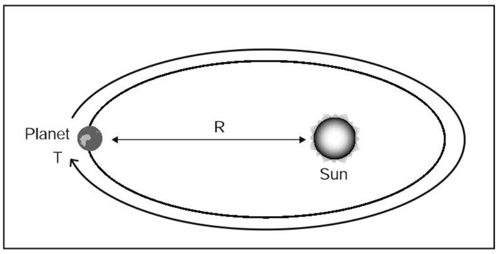
- Kepler's Laws of Planetary Motion Kepler's laws are stated as follows:

Law of orbits: 4



- Each planet moves around the Sun in an elliptical orbit with the Sun at one of the foci.
- The closest point of approach of the planet to the Sun 'P' is called perihelion and the farthest point 'A' is called aphelion.
- The semi-major axis is 'a' and semi-minor axis is 'b'. In fact, both Copernicus and Ptolemy considered planetary orbits to be circular, but Kepler discovered that the actual orbits of the planets are elliptical.

Law of area 4

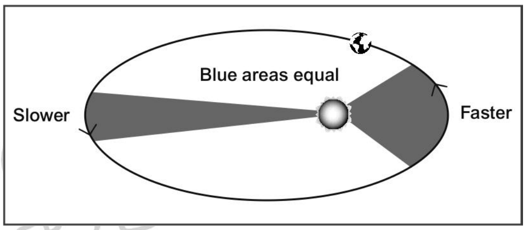


- The radial vector (line joining the Sun to a planet) sweeps equal areas in equal intervals of time.
- The white shaded portion is the area swept in a small interval of time , by a planet around the Sun.
- Since the Sun is not at the center of the ellipse, the planets travel faster when they are nearer to the Sun and slower when they are farther from it, to cover equal area in equal intervals of time.
- Kepler discovered the law of area by carefully noting the variation in the speed of planets.

Law of period: 4

- The square of the time period of revolution of a planet around the Sun in its elliptical orbit is directly proportional to the cube of the semi-major axis of the ellipse. It can be written as: $T^2 \propto a^3$

$\frac{T^2}{a^3}$ = constant



- where, T is the time period of revolution for a planet and a is the semi-major axis.
- Physically this law implies that as the distance of the planet from the Sun increases, the time period also increases but not at the same rate.
- The time period of revolution of planets around the Sun along with their semi-major axes are given. We can realize that $\frac{T^2}{a^3}$ is nearly a constant endorsing Kepler's third law.

2) Write about the Universal Law of Gravitation and important features of gravitational force?

Universal Law of Gravitation 6

- Even though Kepler's laws were above to explain the planetary motion, they failed to explain the forces responsible for it.
- It was Isaac Newton who analyzed Kepler's laws, Galileo's observations and deduced the law of gravitation.
- Newton's law of gravitation states that a particle of mass M_1 attracts any other particle

of mass M_2 in the universe with an attractive force.

- The strength of this force of attraction was found to be directly proportional to the product of their masses and is inversely proportional to the square of the distance between them. In mathematical form, it can be written as:

$$\vec{F} = -\frac{Gm_1m_2}{r_2}\hat{r}$$

- Where r is the unit vector from M_1 towards M_2 and G is the Gravitational constant that has the value of 6.67 x $10^{-11}Nm^2kg^{-2}$, and r is the distance between the two masses M_1 and M_2.
- The vector denotes the gravitational force experienced by M_2 due to M_1.
- Here the negative sign indicates that the gravitational force is always attractive in nature and the direction of the force is along the ling joining the two masses.

Importance features of gravitational force 6

- The gravitational forces between two particles always constitute and action reaction pair. It implies that the gravitational force exerted by the Sun on the Earth is always towards the Sun.
- The reaction - force is exerted by the Earth on the Sun. The direction of this reaction force is towards Earth.
- The torque experienced by the Earth due to the gravitational force of the Sun if given by

$$\vec{\tau} = \vec{r} \times \vec{F} = \vec{r} \times \left(-\frac{GM_sM_E}{r^2}\hat{r} \right) = 0$$

Because, $\vec{r} = r\hat{r}, \left(\hat{r} \times \hat{r} \right) = 0$

So, $\vec{\tau} = \frac{d\vec{L}}{dt} = 0$

- So It implies that angular momentum L is a constant vector. The angular momentum of the Earth about the Sun is constant throughout the motion. It is true for all the planets. In fact, this constancy of angular momentum leads to the Kepler's second law.
- The expression has one inherent assumption that both M_1 and M_2 are treated as point masses. When it is said that Earth orbits around the Sun due to Sun's gravitational force, we assumed Earth and Sun to be point masses.
- This assumption is a good approximation because the distance between the two bodies is very much larger than their diameters.
- However, this assumption about point masses holds even for small distance for one special case.
- To calculate force of attraction between a hollow sphere of mass M with uniform density and point mass m kept outside the hollow sphere, we can replace the hollow sphere of mass M as equivalent to a point mass M located at the center of the hollow sphere.
- The force of attraction between the hollow sphere of mass M and point mass m can be calculated by treating the hollow sphere also as another point mass.
- Essentially the entire mass of the hollow sphere appears to be concentrated at the center of the hollow sphere.
- There is also another interesting result. Consider a hollow sphere of mass M. If we place another object of mass 'm' inside this hollow sphere. The force experienced by this mass 'm' will be zero.

3) Explain the various motions of earth and its causes?

Motions of the earth 3

- The earth has two basic movements:

i) Rotation

ii) Revolution.

Galactic movement:

- This is the movement of the earth with the sun and the rest of the solar system in an orbit around the centre of the MilkyWay Galaxy.
- This, however, has little effect upon the changing environment of the earth.

Rotation:

- The spinning of the earth around its axis is called the rotation of the earth. The axis is the imaginary line passing through the centre of the earth.
- The earth completes one rotation in 23 hours, 56 minutes and 4.09 seconds. It rotates in an eastward direction opposite to the apparent movement of the sun.

- The earth's axis is inclined at an angle of 66½° to the orbital plane as it moves around the sun.
- We can say, the earth's axis is tilted at an angle of 23½° (Figure) from a perpendicular to the elliptic plane. The velocity of earth's rotation varies d pending on the distance of a given place from the equator.
- The rotational velocity at the poles is nearly zero. The greatest velocity of the rotation is found at the equator.
- The velocity of rotation at the equator is 1,670 km per hour and in the poles it is about zero.

Effects of earth's rotation: 3

- The rotation of the earth causes the following effects:
- The apparent rising and setting of the sun is actually caused by the earth's rotation which results in the alternate occurrence of day and night everywhere on the earth's surface.
- Rotation of the earth is also responsible for the difference in time between different places on the earth.
- A 24 hour period divided by 360 degrees gives a difference of 4 minutes for every degree of longitude that passes the sun. The hour (60 minutes) is thus 1/24 of a day.
- When you observe through a moving train, trees, houses and fields on the other side of the track appear to move in the direction opposite to that of the speeding train.
- The apparent movement of the sun and the other heavenly bodies in relation to the rotating earth is similar.
- As the earth rotates from west to east, the sun, moon, planets and stars appear to rise in the east and set in the west.
- Rotation causes the working of the Coriolis force which results in the deflection of the winds and the ocean currents from their normal path.
- Tide is caused by the rotation of the earth apart from the gravitational pull of the sun and the moon.
- Rotation causes a flattening of Earth at the two poles and bulging at the Equator.
- Hence, there is a difference in diameter at the poles and equator.

Circle of Illumination: 1

- The line around the earth separating the light and dark is known as the circle of illumination.
- It passes through the poles and allows the entire earth to have an equal amount of time during the daylight and night time hours.
- This line can be seen from space, and the exact location of the line is dependent on the various seasons.

Revolution of the Earth 3

- The movement of the earth in its orbit around the sun in an anti-clockwise direction, that is, from west to east is called revolution of the earth.
- The earth revolves in an orbit at an average distance of 150 million km. The distance of the earth from sun varies time to time due to the elliptical shape of the orbit.
- About January 3rd the earth is closest to the sun and it is said to be at Perihelion ('peri' means close to and Helios means sun).
- At Perihelion, the distance is 147 million km. Around July 4th the earth is farthest from the sun and it is said to be at Aphelion (Ap means away and Helios means sun).
- At Aphelion the distance of the earth is 152 million km away from the sun.
- The period taken by the earth to complete one revolution around the sun is 365 days and 6 hours (5 hours, 48 minutes and 45 seconds) or 365¼ days.
- The speed N of the revolution is 1,07,000 km per hour. The speed is 30 km per second. The bullet from a gun travels with a speed of 9 km per second.

Difference between Rotation and Revolution 2

Rotation	Revolution
Spinning of the earth from west to east on its axis.	Movement of the earth around the sun in its elliptical orbit.
It takes 24 hours to complete a rotation (or a day)	It takes 365¼ days to complete one revolution (or a year)
It is known as the daily or diurnal movement.	It is known as the annual movement of the earth.
Rotation causes days and nights to alternate, tides, deflection of winds and ocean currents and also gives the earth its shape.	Revolution results in the varying lengths of day and night, changes in the altitude of the midday sun and change of seasons.

4) Explain about Doppler effect and its applications.

Doppler effect 3

- The whistle of a fast moving train appears to increase in pitch as it approaches a stationary listener and it appears to decrease as the train moves away from the listener.
- This apparent change in frequency was first observed and explained by Christian Doppler (1803-1853), an Austrian Mathematician and Physicist.
- He observed that the frequency of the sound as received by a listener is different from the original frequency produced by the source whenever there is a relative motion between the source and the listener.
- This is known as Doppler effect This relative motion could be due to various possibilities as follows:
- The listener moves towards or away from a stationary source
- The source moves towards or away from a stationary listener
- Both source and listener move towards or away from one other
- The medium moves when both source and listener are at rest

Definition 4

- Whenever there is a relative motion between a source and a listener, the frequency of the sound heard by the listener is different from the original frequency of sound emitted by the source.
- This is known as "Doppler effect".
- For simplicity of calculation, it is assumed that the medium is at rest.
- That is the velocity of the medium is zero.
- Let S and L be the source and the listener moving with velocities vS and vL respectively.
- Consider the case of source and listener moving towards each other.
- As the distance between them decreases, the apparent frequency will be more than the actual source frequency.
- Let n and n' be the frequency of the sound produced by the source and the sound observed by the listener respectively.
- Then, the expression for the apparent frequency n' is $n' = \left(\frac{v + v_L}{v - v_s}\right) n$
- Here, v is the velocity of sound waves in the given medium.
- Let us consider different possibilities of motions of the source and the listener.

Conditions for no Doppler effect 2

- Under the following circumstances, there will be no Doppler effect and the apparent frequency as heard by the listener will be the same as the source frequency.
- When source (S) and listener (L) both are at rest.
- When S and L move in such a way that distance between them remains constant.
- When source S and L are moving in mutually perpendicular directions.
- If the source is situated at the center of the circle along which the listener is moving.

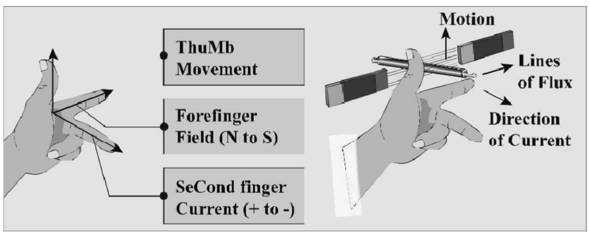
Applications of Doppler effect 3

- To measure the speed of an automobile
- Tracking a satellite
- RADAR (RAdio Detection And Ranging)
- SONAR

5) Explain about Fleming's left hand and right hand rule?

Fleming's left hand rule 6

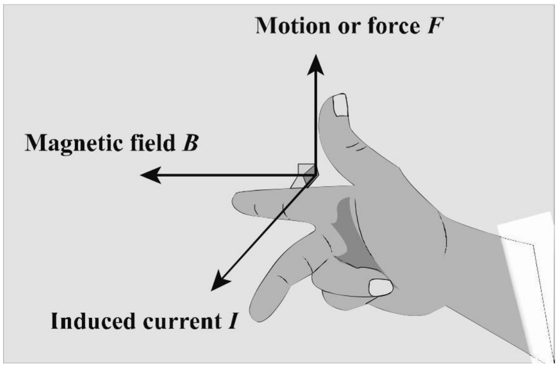
- The force is always a vector quantity. A vector quantity has both magnitude and direction. It means we should know the direction in which the force would act.
- The direction is often found using what is known as Fleming's Left hand Rule (formulated by the scientist John Ambrose Fleming).



- The law states that while stretching the three fingers of left hand in perpendicular manner with each other, if the direction of the current is denoted by the middle finger of the left hand and the second finger is for direction of the magnetic field, then the thumb of the left hand denotes the direction of the force or movement of the conductor (Fig.).

Fleming's Right Hand Rule 6

- Stretch the thumb, fore finger and middle finger of your right hand mutually perpendicular to each other.
- If the fore finger indicates the direction of magnetic field and the thumb indicates the direction of motion of the conductor, then the middle finger will indicate the direction of induced current.



- Fleming's Right hand rule is also called 'generator rule'.

6) Describe about the Vernier caliper and its method of measuring?

Description of Vernier caliper 3

- The Vernier caliper consists of a thin long steel scale graduated in cm and mm called main scale.
- To the left end of the main scale an upper and a lower jaw are fixed perpendicular to the bar. These are named as fixed jaws.
- To the right of the fixed jaws, a slider with an upper and a lower moveable jaw is fixed. The slider can be moved or fixed to any position using a screw.
- The Vernier scale is marked on the slider and it moves along with the movable jaws and the slider.
- The lower jaws are used to measure the external dimensions and the upper jaws are used to measure the internal dimensions of the objects.
- The thin bar attached to the right side of the Vernier scale is used to measure the depth of hollow objects.

Usage of Vernier caliper 2

- The first step in using the Vernier caliper is to find out its least count, range and zero error

Least count

- Least count of the instrument (L.C)

$$= \frac{\text{value of one main scale division}}{\text{Total number of vernier scale division}}$$

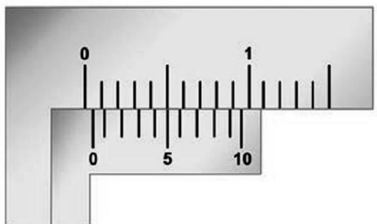
- The main scale division will be in centimeter, further divided into millimetre.
- The value of the smallest main scale division is 1 mm. In the Vernier scale there will be 10 divisions.

$$\text{L.C.} = \frac{1\text{mm}}{10} = 0.1\text{mm} = 0.01\text{cm}$$

Zero error 2

- Unscrew the slider and move it to the left, such that both the jaws touch each other.
- Check whether the zero marking of the main scale coincides with that of the zero of the vernier scale.
- If they coincide then there is no zero error. If they do not coincide with each other, the instrument is said to possess zero error. Zero error may be positive or negative.
- If the zero of a vernier is shifted to the right of main scale, it is called positive error.
- On the other hand, if the zero of the vernier is shifted to the left of the zero of main scale, then the error is negative.

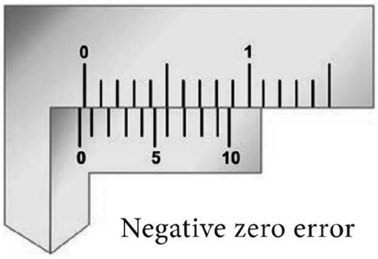
Positive zero error 1.5



Positive zero error

- It shows the positive zero error. From the figure you can see that zero of the vernier scale is shifted to the right of the zero of the main scale.
- In this case the reading will be more than the actual reading. Hence, this error should be corrected.
- In order to correct this error, find out which vernier division is coinciding with any of the main scale divisions.
- Here, fifth vernier division is coinciding with a main scale division.
- So, positive zero error = +5 × LC = +5 × 0.01 = 0.05 cm and the zero correction is negative.
- Hence, zero correction is –0.05 cm. (figure)

Negative zero error 1.5



- The zero of the vernier scale is shifted to the left of the zero of the main scale.
- So, the obtained reading will be less than the actual reading. To correct this error we should first find which vernier division is coinciding with any of the main scale divisions, as we found in the previous case.
- In this case, you can see that sixth line is coinciding. To find the negative error, we can count backward (from 10).
- Here, the fourth line is coinciding. Therefore, negative zero error = $-4 \times LC = -4 \times 0.01 = -0.04$ cm.
- Then zero correction is positive. Hence, zero correction is +0.04 cm. (figure)

Digital Vernier caliper 2

- We are living in a digital world and the digital version of the vernier callipers are available nowadays.
- Digital Vernier caliper has a digital display on the slider, which calculates and displays the measured value.
- The user need not manually calculate the least count, zero error etc.

7) **Describe briefly about the Nano science and Nano technology?**

Nanoscience 2

- Nanoscience is the study of structures and materials on the scale of nanometers. Nano means one - billionth of a meter that is 10^{-9} m.
- If mater is divided into such small objects the mechanical, electrical, optical, magnetic and other properties change.

Nanotechnology 2

- Nanotechnology is a technology involving the design, production, characterization, and applications of nano structured materials.

Nanoparticles 2

- The solids are made up of particles. Each of the particle has a definite number of size less than 100nm, it is said to be a; 'nano solid'. When the particle size exceeds 100nm, it is a 'bulk solid'. It is to be noted that nano and bulk solids may be of the same chemical composition.
- For example, ZnO can be both in bulk and nano form. Though chemical composition is the same, nano form of the material shows strikingly different properties when compared to its bulk counterpart.
- In the nano scale dimensions (reduced dimensions), two important phenomena govern nano properties.
- They are quantum confinement effects and surface effects. Students can explore these effects in higher education and the explanation is avoided at school level.

Interdisciplinary nature of nanotechnology 1

- Nanoscience and technology is the interdisciplinary area covering its application in various fields.

1. Molecular Biology
2. Applied Mathematics & computer science
3. Physics
4. Chemistry
5. Electrical & Mechanical Engineering
6. Materials science

Nano in Nature

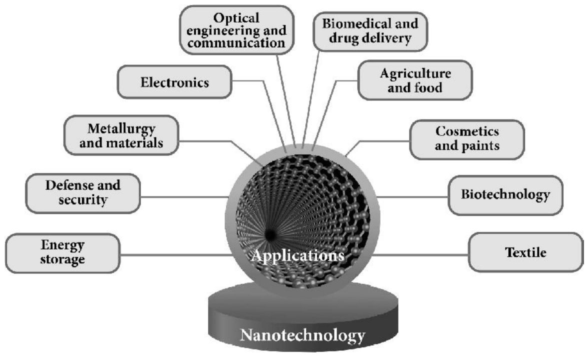
- Nanoscale structures existed in nature long before scientists began studying them in laboratories.

A few examples 1

- **Object:** A single strand of DNA, the building block of all living things, is about three nanometers wide.
- single strand DNA
- double strand DNA
- **Peacock feathers:** Peacock feathers get their iridescent coloration from light interacting with 2 dimensional photonic crystal structures just tens of nanometers thick.
- Similar nano structures are made in labe to glow in different colors.
- **Morpho butterfly:** The scales on the wings of a morpho butterfly contain nanostructures that change the way light waves interact with each other, giving the wings brilliant metallic blue and green hues.

- Manipulation of colours by adjusting the size of nano particles with which the materials are made.
- Parrot fish crunches up coral all day. The source of the parrot fish's powerful bite is the interwoven fibre nanostructure.
- Crystals of a mineral called fluorapatite are woven together in a chain mail-like arrangement.
- This structure gives parrotfish teech incredible durability.
- The natural structure provides a blueprint for creating ultra-durable synthetic materials that could be useful for mechanical components in electronics, and in other devices that undergo repetitive movement, abrasion, and contact stress.
- **Object :**Lotus leaf surface Scanning electron micrograph (SEM) showing the nano structures on the surface of a leaf from a lotus plant. This is the reason for self cleaning process in lotus leaf.
- Water repellant Nano paints are made. Coating with such nano paints give durability, protection against stains and dirt also enhances fuel efficiency when coated on ships.

Applications of Nano technology 1.5



Applications of nano material based products in different areas 1.5

Automotive Industry	Chemical industry	Engineering
Lightweight construction Painting (fillers, base coat, clear coat) Catalysts Tires (fillers) Sensors Coatings for wind-screen and car bodies	Fillers for paint systems Coating systems based on nanocomposites Impregnation of papers Switchable adhesives magnetic fluids	Wear protection for tools and machines (anti blocking coatings, scratch resistant coatings on plastic parts, etc).
Electronic industry	**Construction**	**Medicine**
Data memory] Displays Laser diodes Glass fibres Optical switches Filters (IR - blocking) Conductive, antistatic coatings	Construction materials Thermal insulation Flame retardants Surface - functionalised building materials for wood, floors, stone, facades, tiles, roof tiles, etc. Facade coatings	Drug delivery systems Active agents Contrast medium Medical rapid tests Prostheses and implants Antimicrobial agents and coatings Agents in cancer therapy
Textile / fabrics / non - wovens	**Energy**	**Cosmetics**
Surface - processed textiles Smart clothes	Fuel cells Solar cells Batteries Capacitors	Sun protection Lipsticks Skin creams Tooth paste
Food and drinks	**Household**	**Sports / outdoor**
Package materials Storage life sensors Additives Clarification of fruit juices	Ceramic coatings for irons Odours catalyst Cleaner for glass, ceramic, floor, windows	Ski wax Antifogging of glasses / goggles Antifouling coatings for ships/ boats Reinforced tennis rackets and balls

Possible harmful effects of nanoparticles 1

- The research on the harmful impact of application of nanotechnology is also equally important and fast developing.
- The major concern here is that the nanoparicles have the dimensions same as that of the biological molecules such as proteins.
- They may easily get absorbed onto the surface of living organisms and they might enter the tissues and fluids of the body.
- The adsorbing nature depends on the surface of the nanoparticle. Indeed, it is possible to deliver a drug directly to a specific cell in the body by designing the surface of a nanoparticle so that it absorbs specifically onto the surface of the target cell.
- The interaction with living systems is also affected by the dimensions of the nanoparticles of a few nanometers size may reach well inside biomolcules, which is not possible for larger nanoparticles. Nanoparticles can also cross cell membranes.
- It is also possible for the inhaled nanoparticles to reach the blood, to reach other sites such as the liver, heart or blood cells.
- Researchers are trying to understand the response of living organisms to the presence of nanoparticles of varying size, shape, chemical composition and surface characteristics.

8) Explain about the various innovations used in medical diagnosis?

The recent advancement in medical technology includes 4

1. Virtual reality
2. Precision Medicine
3. Health Wearables
4. Artificial organs
5. 3D printing
6. Wireless brain sensors
7. Robotic surgery
8. Smart inhalers

- The innovation in medical diagnosis has taken leaps and bounds due to the integration of technology and basic physics. A few of such advancements are discussed.

1. Virtual reality 1

- Medical virtual reality is effectively used to stop the brain from processing pain and cure soreness in the hospitalized patients.
- Virtual reality has enhanced surgeries by the use of 3D models by surgeons to plan operations. It helps in the treatment of Autism, Memory loss, and Mental illness.

2. Precision medicine 1

- Precision medicine is an emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person.
- In this medical model it is possible to customise healthcare, with medical decisions, treatments, practices, or products which are tailored to the individual patient.

3. Health Wearables 1

- A health wearable is a devise used for tacking a wearer's vital signs or health and fitness related data, location, etc. medical wearables with artifical intelligence and big data provide an added value to healthcare with a focus on diagnosis, treatment, patient monitoring and prevention.

Note

- Big Data: Extremely large data sets that may be analysed computationally to reveal patterns, trends, and associations, especially relating to human behaviour and interactions.

4. Artificial organs 1

- An artificial organ is an engineered device or tissue that is implanted or integrated into a human. It is possible to interface it with living tissue or to replace a natural organ.
- It duplicates or augments a specific functions or functions of human organs so that the patient may return to a normal life as soon as possible.

5. 3D printing 1

- Advanced 3D printer systems and materials assist physicians in a range of operations in the medical field from audiology, dentistry, orthopedics and other applications.

6. Wireless brain sensors 1

- Wireless brain sensors monitor intracranial pressure and temperature and then are absorbed by the body. Hence there is no need for surgery to remove these devices.

7. Robotic surgery 1

- Robotc surgery is a type of surgical procedure that is done using robotic systems. Robotically - assisted surgery helps to overcome the limitations of pre-existing minimally -

invasive surgical procedures and to enhance the capabilities of sugeons performing open surgery.

8. Smart inhalers 1

- Inhalers are the main treatment option for asthma. Smart inhalers are designed with health sustems and patients in mind so that they can offer maximum benefit.
- Smart inhalers use bluetooth technology to detect inhaler use, remind patients when to take their medication and gather data to help guide care.

9) Describe the various errors in measurements?

Errors in Measurement

- The uncertainity in a measurement is called an error.
- Random error, systematic error and gross error are the three possible errors.

(i) Systematic errors 4

- Systematic errors are reproducible inaccuracies that are consistently in the same direction.
- These occur often due to a problem that persists throughout the experiment.
- Systematic errors can be classified as follows

Instrumental errors

- When an instrument is not calibrated properly at the time of manufacture, instrumental errors may arise.
- If a measurement is made with a meter scale whose end is worn out, the result obtained will have errors.
- These errors can be corrected by choosing the instrument carefully.

Imperfections in experimental technique or procedure

- These errors arise due to the limitations in the experimental arrangement.
- As an example, while performing experiments with a calorimeter, if there is no proper insulation, there will be radiation losses.
- This results in errors and to overcome these, necessary correction has to be applied.

Personal errors

- These errors are due to individuals performing the experiment, may be due to incorrect initial setting up of the experiment or carelessness of the individual making the observation due to improper precautions.

Errors due to external causes

- The change in the external conditions during an experiment can cause error in measurement.
- For example, changes in temperature, humidity, or pressure during measurements may affect the result of the measurement.

Least count error

- Least count is the smallest value that can be measured by the measuring instrument, and the error due to this measurement is least count error.
- The instrument's resolution hence is the cause of this error. Least count error can be reduced by using a high precision instrument for the measurement.

(ii) Random errors 4

- Random errors may arise due to random and unpredictable variations in experimental conditions like pressure, temperature, voltage supply etc.
- Errors may also be due to personal errors by the observer who performs the experiment.
- Random errors are sometimes called "chance error". When different readings are obtained by a person every time he repeats the experiment, personal error occurs.
- For example, consider the case of the thickness of a wire measured using a screw gauge.
- The readings taken may be different for different trials.
- In this case, a large number of measurements are made and then the arithmetic mean is taken.
- If n number of trial readings are taken in an experiment, and the readings are a_1, a_2, a_3,…………………. a_n.
- The arithmetic mean is

$$a_m = \frac{a_1 + a_2 + a_3 + ...a_n}{n} \text{ or } a_m = \frac{1}{n}\sum_{i=1}^{n} a_i$$

- Usually this arithmetic mean is taken as the best possible true value of the quantity
- Certain procedures to be followed to minimize experimental errors, along with examples are shown.

(iii) Gross Error 4

- The error caused due to the shear carelessness of an observer is called gross error.

For example

- Reading an instrument without setting it properly.
- Taking observations in a wrong manner without bothering about the sources of errors and the precautions.
- Recording wrong observations.
- Using wrong values of the observations in calculations.
- These errors can be minimized only when an observer is careful and mentally alert.

10) Explain about capillarity and its practical applications?

Capillarity 4

- The word 'capilla' means hair in Latin.
- If the tubes were hair thin, then the rise would be very large.
- It means that the tube having a very small diameter is called a 'capillary tube'.
- When a glass capillary tube open at both ends is dipped vertically in water, the water in the tube will rise above the level of water in the vessel.
- In case of mercury, the liquid is depressed in the tube below the level of mercury in the vessel.
- In a liquid whose angle of contact with solid is less than 90°, suffers capillary rise.
- On the other hand, in a liquid whose angle of contact is greater than 90°, suffers capillary fall.
- The rise or fall of a liquid in a narrow tube is called capillarity or capillary action.
- Depending on the diameter of the capillary tube, liquid rises or falls to different heights.

Capillary rise and fall 4

Contact angle	Strength of Cohesive force	Strength of Adhesive force	Degree of wetting	Meniscus	Rise or fall of liquid in the capillary tube
θ=0 (A)	Weak	Strong	Perfect Wetting	Plane	Neither rises nor is depressed
θ<90 (B)	Weak	Strong	High	Concave	Rise of liquid
θ>90 (C)	Strong	Weak	Low	Convex	Fall of liquid

Practical applications of capillarity 4

- Due to capillary action, oil rises in the cotton within an earthen lamp.
- Likewise, sap rises from the roots of a plant to its leaves and branches.
- Absorption of ink by a blotting paper
- Capillary action is also essential for the tear fluid from the eye to drain constantly.
- Cotton dresses are preferred in summer because cotton dresses have fine pores which act as capillaries for sweat

11) Write about viscosity? Explain the causes and co-efficient of viscosity? 4

- A fluid in motion is a complex phenomenon as it possesses potential, kinetic, and gravitational energy besides causing friction viscous forces to come into play.
- Therefore, it is necessary to consider the case of an ideal liquid to simplify the task.
- An ideal liquid is incompressible (i.e., bulk modulus is infinity) and in which no shearing forces can be maintained (i.e., the coefficient of viscosity is zero).
- Most of the fluids offer resistance towards motion.
- A frictional force acts at the contact surface when a fluid moves relative to a solid or when two fluids move relative to each other. -This resistance to fluid motion is similar to the friction produced when a solid moves on a surface.
- The internal friction existing between the layers of a moving fluid is viscosity.
- So, viscosity is defined as the property of a fluid to oppose the relative motion between its layers.

Cause of viscosity 4

- Consider a liquid flowing over a horizontal surface with two neighbouring layers.
- The upper layer tends to accelerate the lower layer and in turn, the lower layer tends to retard the upper layer.
- As a result, a backward tangential force is set-up.
- This tends to destroy the relative motion.

- This accounts for the viscous behaviour of fluids.

Coeûcient of viscosity 4

- Consider a liquid flowing steadily over a horizontal fixed layer
- The velocities of the layers increase uniformly as we move away from the fixed layer.
- Consider any two parallel layers A and B.
- Let v and v + dv be the velocities of the neighbouring layers at distances x and x + dx respectively from the fixed layer.
- The force of viscosity F acting tangentially between two layers is given by Newton's First law.
- This force is proportional to (i) area A of the liquid and (ii) the velocity gradient , $\frac{dv}{dx}$, $F \propto A$ and $F \propto \frac{dv}{dx}$

$$\Rightarrow F = -\eta A \frac{dv}{dx}$$

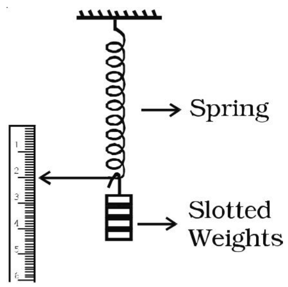
- Where the constant of proportionality ç is called the coefficient of viscosity of the liquid and the negative sign implies that the force is frictional and it opposes the relative motion.
- The dimensional formula for coefficient of viscosity is $[ML^{-1}T^{-1}]$

12) Explain about Hooke's law and give its experimental verification?

Hooke's law 6

- English Physicist Robert Hooke (1635 - 1703) in the year 1676put forward the relation between the extension produced in a wire and the restoring force developed in it.
- The law formulated on the basis of this study is known as Hooke's law.
- According to Hooke's law, within the elastic limit, strain produced in a body is directly proportional to the stress that produces it. (i.e) stress α strain
- $\frac{\text{Stress}}{\text{Strain}}$ = a constant, known as modulus of elasticity.-Its unit is N m^{-2} and its dimensional formula is $ML^{-1}T^{-2}$.

Experimental verification of Hooke's law 6



Experimental setup to verify Hooke's law

- A spring is suspended from a rigid support as shown in the Fig. A weight hanger and alight pointer is attached at its lower end such that the pointer can side over a scale graduated in millimeters.
- The initial reading on the scale is noted. A slotted weight of m kg is added to the weight hanger and the pointer position is noted.
- The same procedure is repeated with every additional m kg weight. It will be observed that the extension of the spring is proportional to the weight. This verifies Hooke's law.

Unit - 3

1) **Explain**

a) **Lunar eclipse and measurement of shadows of earth?**

b) **Why there are no lunar eclipse and solar eclipse every month?**

c) **Why do we have seasons on earth?**

a) **Lunar eclipse and measurement of shadows of earth?** 5

Lunar eclipse

- **Definition**: when the Earth comes between the Sun and the Moon, the Moon is completely or partially covered. As a result of which the condition of partial or total lunar eclipse occurs.
- On January 31, 2018 there was a total lunar eclipse which was observed from various places including Tamil Nadu.
- The last lunar eclipse of the year 2022 is going to happen on 8 November 2022.
- It is possible to measure the radius of shadow of the Earth at the point where the Moon crosses.
- When the Moon is inside the umbra shadow, it appears red in color. As soon as the Moon

exits from the umbra shadow, it appears in crescent shape.

Measurement of shadow of Earth

- By finding the apparent radii of the Earth's umbra shadow and the Moon, the ratio of the these radii can be calculated.
- The apparent radius of Earth's umbra shadow = R_s = 13.2 cm
- The apparent radius of the Moon = R_m = 5.15 cm
- The ratio $\frac{R_s}{R_m} \approx 2.56$
- The radius of the Earth's umbra shadow is R_s = 256 x R_m
- The radius of Moon R_m = 1737 km.
- The radius of the Earth's umbra shadow is Rs = 2.56 x 1737km $\cong$ 4.446 km
- The correct radius is 4610 km.
- The percentage of error in the calculation

$$\frac{4610-4446}{4610} \times 100 = 3.5\%$$

- Early astronomers proved that Earth is spherical in shape by looking at the shape of the shadow cast by Earth on the Moon during lunar eclipse.

b) Why there are no lunar eclipse and solar eclipse every month? 5

- If the orbits of the Moon and Earth lie on the same plane, during full Moon of every month, we can observe lunar eclipse. If this is so during new Moon we can observe solar eclipse.
- But Moon's orbit is tilted 5° with respect to Earth's orbit. Due to this 5° tilt, only during certain periods of the year, the Sun, Earth and Moon align in straight line leading to either lunar eclipse or solar eclipse depending on the alignment.

c) Why do we have seasons on Earth? 5

- The common misconception is that 'Earth revolves around the Sun, so when the Earth is very far away, it is winter and when the Earth is nearer, it is summer'.
- Actually, the seasons in the Earth arise due to the rotation of Earth around the Sun with 23.5° tilt.
- Due to this 23.5° tilt, when the northern part of Earth is farther to the Sun, the southern part is nearer to the Sun. So when it is summer in the northern hemisphere, the southern hemisphere experience winter

2) Briefly describe about the solar system and its nature?

The Solar System 1

- Sun and the celestial bodies which revolve around it form the solar system.
- It consists of large number of bodies such as planets, comets, asteroids and meteors.
- The gravitational force of attraction between the Sun and these objects keep them revolving around it.

The Sun

- The Sun is a medium sized star, a very fiery spinning ball of hot gases. Three quarters of the Sun has hydrogen gas and one quarter has helium gas.

Nuclear Fusion 1

- It is over a million times as big as the Earth. Hydrogen atoms combine or fuse together to form helium under enormous pressure.
- This process, called nuclear fusion releases enormous amount of energy as light and heat.
- It is this energy which makes Sun shine and provide heat. Sun is situated at the centre of the solar system.
- The strong gravitational fields cause other solar matter, mainly planets, asteroids, comets, meteoroids and other debris, to orbit around it. Sun is believed to be more than 4.6 billion years old.

Planets 1

- A planet revolves around the Sun along a definite curved path which is called an orbit. It is elliptical.
- The time taken by a planet to complete one revolution is called its period of revolution.
- Besides revolving around the Sun, a planet also rotates on its own axis like a top. The time taken by a planet to complete one rotation is called its period of rotation.
- The period of rotation of the Earth is 23 hours and 56 minutes and so the length of a day on Earth is taken as 24 hours.
- Table tells about the length of a day on each planet.

Length of a day on each planet 1

Planets	Length of a day
Mercury	58.65 days
Venus	243 days
Earth	23.93 hours
Mars	24.62 hours
Jupiter	9.92 hours
Saturn	10.23 hours
Uranus	17 hours
Neptune	18 hours

Spatial Distribution of Planets

- The planets are spaced unevenly.

Inner solar system: 1

- The first four planets are relatively close together and close to the Sun.
- They form the inner solar system. Farther from the Sun is the outer solar system, where the planets are much more spread out.
- Thus the distance between Saturn and Uranus is much greater (about 20 times) than the distance between the Earth and the Mars.
- The four planets grouped together in the inner solar system are Mercury, Venus, Earth and Mars.
- They are called inner planets. They have a surface of solid rock crust and so are called terrestrial or rocky planets.
- Their insides, surfaces and atmospheres are formed in a similar way and form similar pattern. Our planet, Earth can be taken as a model of the other three planets.

Outer Solar system: 1

- The four large planets Jupiter, Saturn, Uranus and Neptune spread out in the outer solar system and slowly orbit the Sun are called outer planets.
- They are made of hydrogen, helium and other gases in huge amounts and have very dense atmosphere.
- They are known as gas giants and are called gaseous planets.
- The four outer planets Jupiter, Saturn, Uranus and Neptune have rings whereas the four inner planets do not have any rings.
- The rings are actually tiny pieces of rock covered with ice.

Mercury: 1

- Mercury is a rocky planet nearest to the Sun. It is very hot during day but very cold at night.
- Mercury can be easily observed through telescope than naked eye since it is very faint and small. It always appears in the eastern horizon or western horizon of the sky.

Venus: 1

- Venus is a special planet from the Sun, almost the same size as the Earth. It is the hottest planet in our solar system. After our moon, it is the brightest heavenly body in our night sky.
- This planet spins in the opposite direction to all other planets. So, unlike Earth, the Sun rises in the west and sets in the east here. Venus can be seen clearly through naked eye. It always appears in the horizon of eastern or western sky.

The Earth: 1

- The Earth where we live is the only planet in the solar system which supports life.
- Due to its right distance from the Sun it has the right temperature, the presence of water and suitable atmosphere and a blanket of ozone.
- All these have made continuation of life possible on the Earth. From space, the Earth appears bluish green due to the reflection of light from water and land mass on its surface.

Mars: 1

- The first planet outside the orbit of the Earth is Mars. It appears slightly reddish and therefore it is also called the red planet. It has two small natural satellites (Deimos and Phobos).

Jupiter: 1

- Jupiter is called as Giant planet. It is the largest of all planets (about 11 times larger and 318 times heavier than Earth). It has 3 rings and 65 moons.
- Its moon Ganymede is the largest moon of our solar system.

Saturn: 1

- Known for its bright shiny rings, Saturn appears yellowish in colour.
- It is the second biggest and a giant gas planet in the outer solar system. At least 60 moons are present - the largest being Titan.
- Titan is the only moon in the solar system with clouds. Having least density of all (30 times less than Earth), this planet is solight.

Uranus: 1

- Uranus is a cold gas giant and it can be seen only with the help of large telescope.
- It has a greatly tilted axis of rotation. As a result, in its orbital motion it appears to roll on its side.
- Due to its peculiar tilt, it has the longest summers and winters each lasting 42 years.

Neptune: 1

- It appears as Greenish star. It is the eighth planet from the Sun and is the windiest planet.
- Every 248 years, Pluto crosses its orbit. This situation continues for 20 years. It has 13 moons – Triton being the largest.
- Triton is the only moon in the solar system that moves in the opposite direction to the direction in which its planet spins.

Conclusion 1

- There are also a number of artificial satellites orbiting the Earth which are created by humans. They are launched from the Earth's surface. They orbit the Earth much closer than the moon, the Earth's natural satellite.
- Several artificial satellites have been built and launched by India. The first Indian satellite was Aryabhata. Other Indian satellites include INSAT, IRS, Kalpana-1, EDU SAT, and others.
- Artificial satellites have a wide range of applications. They are used for weather forecasting as well as transmitting television and radio signals. They are also used in communications and remote sensing.

3) Explain about Couloumb's law and Important aspects of Couloumb's law?

Couloumb's law 4

- In the year 1786, Coulomb deduced the expression for the force between two stationary point charges in vacuum or free space.
- Coulomb's law states that the electrostatic force is directly proportional to the product of the magnitude of the two point charges and is inversely proportional to the square of the distance between the two point charges.
- Consider two point charges q_1 and q_2 at rest in vacuum, and separated by a distance of r
- According to Coulomb, the force on the point charge q_2 exerted by another point charge q_1 is

$$\overline{F_{21}} = k\frac{q^1 q^2}{r^2}\hat{r}_{12}$$

where $\hat{r}_{12}$ is the unit vector directed from charge q_1 to charge q_2 and k is the proportionality constant

where $\hat{r}_{12}$ is the unit vector directed from charge q_1 to charge q_2 and k is the proportionality constant.

Important aspects of Coulomb's law 2

- The force on the charge q_2 exerted by the charge q_1 always lies along the line joining the two charges.
- $\hat{r}_{12}$ is the unit vector pointing from charge q_1 to q_2.
- Likewise, the force on the charge q_1 exerted by q_2 is along $-\hat{r}_{12}$ (i.e., in the direction opposite to $\hat{r}_{12}$).
- In SI units, $k = \frac{1}{4\pi k}$ and its value is 9×10^9 Nm^2C^{-2}.

Permittivity of free space 1

- Here is the permittivity of free space or vacuum and its value is
- $\varepsilon_o = k = \frac{1}{4\pi k} = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$.

Magnitude of the electrostatic force 1

- The magnitude of the electrostatic force between two charges each of one coulomb and separated by a distance of 1 m is calculated as follows:

$$|F| = \frac{9\times10^9\times1\times1}{12} = 9\times10^9 N$$

- This is a huge quantity, almost equivalent to the weight of one million ton.
- We never come across 1 coulomb of charge in practice.
- Most of the electrical phenomena in day-to-day life involve electrical charges of the order of µC (micro coulomb) or nC (nano coulomb).

Coulomb's law in vacuum 1

- In SI units, Coulomb's law in vacuum takes the form $\bar{F}_{21} = \frac{1}{4\pi\epsilon o}\frac{q_1 q_2}{r_2}\hat{r}_{12}$

- In a medium of permittivity, the force between two point charges is given by

$$\bar{F}_{21} = \frac{1}{4\pi \epsilon o} \frac{q_1 q_2}{r_2} \hat{r}_{12}$$

- Since $\epsilon > \epsilon_o$, the force between two point charges in a medium other than vacuum is always less than that in vacuum.
- We define the relative permittivity for a given medium as $\epsilon_r = \frac{\epsilon}{\epsilon_o}$
- For vacuum or air, ϵ_r = 1 and for all other media > 1.

Relation between Coulomb's law and Newton's law of gravitation 2

- Coulomb's law has same structure as Newton's law of gravitation.
- Both are inversely proportional to the square of the distance between the particles.
- The electrostatic force is directly proportional to the product of the magnitude of two point charges and gravitational force is directly proportional to the product of two masses.

Difference between Coulomb's law and Newton's law of gravitation 3

- But there are some important differences between these two laws.
- The force on a charge q_1 exerted by a point charge q_2 is given by

$$\overline{F_{12}} = \frac{1}{4\pi \epsilon_o} \frac{q_1 q_2}{r_2} \hat{r}_{21}$$

- Here $\hat{r}_{21}$ is the unit vector from charge q_2 to q_1.

But = $\hat{r}_{21} = -\hat{r}_{12}$,

$$\overline{F_{12}} = \frac{1}{4\pi \epsilon_o} \frac{q_1 q_2}{r_2}\left(-\hat{r}_{12}\right) = -\frac{1}{4\pi \epsilon_o} \frac{q_1 q_2}{r_2}\left(\hat{r}_{12}\right)$$

- Therefore, the electrostatic force obeys Newton's third law.
- The expression for Coulomb force is true only for point charges. But the point charge is an ideal concept.

Conclusion 1

- However we can apply Coulomb's law for two charged objects whose sizes are very much smaller than the distance between them.
- In fact, Coulomb discovered his law by considering the charged spheres in the torsion balance as point charges.
- The distance between the two charged spheres is much greater than the radii of the spheres.

4) Explain about spectrometer and its parts? Write about the adjustment to be made in spectrometer?

Spectrometer 3

- The spectrometer is an optical instrument used to study the spectra of different sources of light and to measure the refractive indices of materials.
- It consists of basically three parts. They are (i) collimator (ii) prism table and (iii) Telescope.

Parts of Spectrometer 6

i) Collimator

- The collimator is an arrangement to produce a parallel beam of light.
- It consists of a long cylindrical tube with a convex lens at the inner end and a vertical slit at the outer end of the tube.
- The distance between the slit and the lens can be adjusted such that the slit is at the focus of the lens.
- The slit is kept facing the source of light. The width of the slit can be adjusted.
- The collimator is rigidly fixed to the base of the instrument.

ii) Prism table

- The prism table is used for mounting the prism, grating etc. It consists of two circular metal discs provided with three levelling screws.
- It can be rotated about a vertical axis passing through its centre and its position can be read with verniers V_1 and V_2 .
- The prism table can be raised or lowered and can be fixed at any desired height.

iii) Telescope

- The telescope is an astronomical type. It consists of an eyepiece provided with cross wires at one end and an objective lens at its other end.
- The distance between the objective lens and the eyepiece can be adjusted so that the telescope forms a clear image at the cross wires, when a parallel beam from the collimator is incident on it.
- The telescope is attached to an arm which is capable of rotation about the same vertical axis as the prism table.
- A circular scale graduated in half degree is attached to it.
- Both the telescope and prism table are provided with radial screws for fixing them in a desired position and tangential screws for fine adjustments.

Adjustments of the spectrometer 6

- The following adjustments must be made before doing the experiment using spectrometer.

a) Adjustment of the eyepiece

- The telescope is turned towards an illuminated surface and the eyepiece is moved to and fro until the cross wires are clearly seen.

b) Adjustment of the telescope

- The telescope is adjusted to receive parallel rays by turning it towards a distant object and adjusting the distance between the objective lens and the eyepiece to get a clear image on the cross wire.

c) Adjustment of the collimator

- The telescope is brought along the axial line with the collimator.
- The slit of the collimator is illuminated by a source of light.
- The distance between the slit and the lens of the collimator is adjusted until a clear image of the slit is seen at the cross wire of the telescope.
- Since the telescope is already adjusted for parallel rays, a well defined image of the slit can be formed, only when the light rays emerging from the collimator are parallel.

d) Levelling the prism table

- The prism table is adjusted or leveled to be in horizontal position by means of leveling screws and a spirit level.

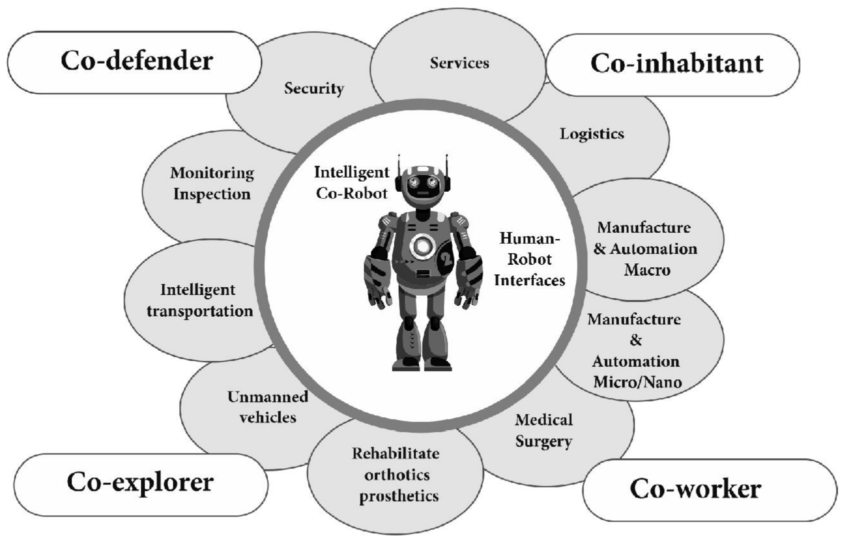
5) Discuss briefly about Robotics? Explain the features, types and applications of robotics?

Robotics

What is robotics? 2

- Robotics is an integrated study of mechanical engineering, electronic engineering, computer engineering, and science.
- Robot is a mechanical device designed with electronic circuitry and programmed to perform a specific task.
- These automated machines are highly significant in this robotic era.
- They can take up the role of humans in certain dangerous environments that are hazardous to people like defusing bombs, finding survivors in unstable ruins, and exploring mines and shipwrecks.

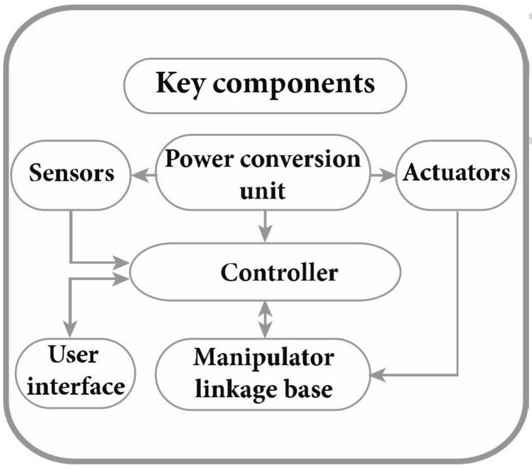
Evolution of Robotics 2



- In 1954, George Devol invented the first digitally operated programmable robot called Unimate.
- George Devol and Josepg Engelberger, the father of the modern robotics industry formed the world's first robot company in 1956.
- In 1961, Unimate, was operated in a General Motors automobile factory for moving car parts around in New Jersey.

Components of Robotics 2

- The robotic system mainly consists of sensors, power supplies, control systems, manipulators and necessary software.
- Most robots are composed of 3 main parts:
- **The Controller -** also known as the "brain" which is run by a computer program. It gives commands for the moving parts to perform the job.
- **Mechanical parts -** motors, pistons, grippers, wheels, and gears that make the robot move, grab, turn, and lift.
- **Sensors -** to tel the robot about its surroundings. It helps to determine the sizes and shapes of the objects around, distance between the objects, and directions as well.



Types of Robots 2

- **Human Robot -** Certain robots are made to resemble humans in appearance and replicate the human activities like walking, lifting, and sensing etc.

1. **Power conversion unit:** Robots are powered by batteries, solar power, and hydraulics.
2. **Actuators:** Converts energy into movement. The majority of the actuators produce rotational or linear motion.
3. **Electric motors:** They are used to actuate the parts of the robots like wheels, arms, fingers, legs, sensors, camera, weapon systems etc. Different types of electric motors are used.
4. **AC Muscles:** The most often Used ones are AC Muscles are devices that can contract and expand when air is pumped inside. It can replicate the function of a human muscle. They contract almost 40% when the air is sucked inside them.
5. **Muscle wires:** They are thin strands of wire made of shape memory alloys. They can contract by 5% when electric current is passed through them.
6. **Piezo Motors and Ultrasonic Motors:** Basically, we use it for industrial robots.
7. **Sensors:** Generally used in task environments as it provides information of real-time knowldge.
8. **Robot locomotion:** Provides the types of movements to a robot. The different types are

a) Legged
b) Wheeled
c) Combination of Legged and Wheeled Locomotion
d) Tracked slip/skid

Industrial Robots

- Six main types of industrial robots

1. Cartesian
2. SCARA
3. Cylindrical
4. Delta
5. Polar
6. Vertically articulated

Artificial Intelligence 1

- The aim of artificial intelligence is to bring in human like behaviour in robots.

Applications of AI

1. Face recognition
2. Providing response to player's actions in computer games
3. Taking decisions based on previous actions
4. To regulate the traffic by analyzing the density of traffic on roads.
5. Translate words from one language to another

Space Exploration 1

- **Outer space:** Exploring stars, planets etc., investigation of the mineralogy of the rocks and soils on Mars, analysis of elements found in rocks and soils.

- Mats Rovers of NASA
- Twin Mars Rovers
- Mars Pathfinder Mission

Use 1

1. Litter robot	- Welding
2. Cutting	- Assembling
3. Vacuum Cleaners	- Packing
4. Transport	- Surgery
5. Weaponry	- Lawn mowing
6. Laboratory	- Underwater
7. Hospitals	- Agriculture
8. Swimming Pool	- Cleaning

Nanorobots in medical field 1

- The size of the nano robots is reduced to microscopic level to perform a task in very small spaces. However, it is only in the developmental stage.
- The future prospects of it are much expected in the medical field: nano - robots in blood stream to perform small surgical procedures, to fight against bacteria, repairing individual cell in the body.
- It can travel into the body and once after the job is performed it can find its way out. Chinese scientists have created the world's first autonomous DNA robots to combat cancer tumours.

Materials used to make robots 1

- For robots, aluminum and steel are the most common metals. Aluminum is a softer metal and is therefore easier to work with, but steel is several times stronger. In any case, because of the inherent strength of metal, robot bodies are made using sheet, bar, rod, channel, and other shapes.

Advantages of Robotics 1

1. The robots are much cheaper than humans.
2. Robots never get tired like humans. It can work for 24 x 7. Hence absenteeism in work place can be reduced.
3. Robots are more precise and error free in performing the task.
4. Stronger and faster than humans.
5. Robots can work in extreme environmental conditions: extreme hot or cold, space or underwater. In dangerous situations like bomb detection and bomb deactivation.
6. In warfare, robots can save human lives.
7. Robots are significantly used in handling materials in chemical industries especially in nuclear plants which can lead to health hazards in humans.

Disadvantages of Robotics 1

1. Robots have no sense of emotions or conscience.
2. They lack empathy and hence create an emotionless workplace.
3. If ultimately robots would do all the work, and the humans will just sit and monitor them, health hazards will increase rapidly.
4. Unemployment problem will increase.
5. Robots can perform defined tasks and cannot handle unexpected situations
6. The robots are well programmed to do a job and if a small thing goes wrong it ends up in a big loss to the company.
7. If a robot malfunctions, it takes time to identify the problem, rectify it, and even reprogram if necessary. This process requires significant time.
8. Humans cannot be replaced by robots in decision making.

- Till the robot reaches the level of human intelligence, the humans in work place will exit.

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6) Explain

a) Physical quantities and its types?

b) Unit and its types?

c) Different types of Measurement system?

a) Physical quantities and its types 5

Definition of Physical Quantity

- Quantities that can be measured, and in terms of which, laws of physics are described are called physical quantities.
- Examples are length, mass, time, force, energy, etc.

Types of Physical Quantities

- Physical quantities are classified into two types.

1. Fundamental quantities and
2. Derived quantities.

Fundamental Quantities

- Fundamental or base quantities are quantities which cannot be expressed in terms of any other physical quantities.
- These are length, mass, time, electric current, temperature, luminous intensity and amount of substance.

Derived quantities

- Quantities that can be expressed in terms of fundamental quantities are called derived quantities.
- For example, area, volume, velocity, acceleration, force, etc.

b) Unit and its types 5

- The process of measurement is basically a process of comparison.
- To measure a quantity, we always compare it with some reference standard.
- For example, when we state that a rope is 10 meter long, it is to say that it is 10 times as long as an object whose length is defined as 1 metre.
- Such a standard is known as the unit of the quantity.
- Here 1 metre is the unit of the quantity 'length'.
- An arbitrarily chosen standard of measurement of a quantity, which is accepted internationally is called unit of the quantity.
- The units in which the fundamental quantities are measured are called fundamental or base units and the units of measurement of all other physical quantities, which can be obtained by a suitable multiplication or division of powers of fundamental units, are called derived units.

c) Different types of measurement system 5

- A complete set of units which is used to measure all kinds of fundamental and derived quantities is called a system of units.
- Here are the common system of units used in mechanics:

a) **the f.p.s. system** is the British Engineering system of units, which uses foot, pound and second as the three basic units for measuring length, mass and time respectively.

b) **The c.g.s system** is the Gaussian system, which uses centimeter, gram and second as the three basic units for measuring length, mass and time respectively.

c) **The m.k.s system** is based on metre, kilogram and second as the three basic units for measuring length, mass and time respectively.

- The cgs, mks and SI are metric or decimal system of units.
- The fps system is not a metric system.

7) Explain about stress and strain and its various types?

Stress 2

- When a force is applied, the size or shape or both may change due to the change in relative positions of atoms or molecules.
- This deformation may not be noticeable to our naked eyes but it exists in the material itself.
- **Restoring force:** When a body is subjected to such a deforming force, internal force is developed in it, called as restoring force.
- The force per unit area is called as stress.

Stress, $\sigma = \frac{\text{Force}}{\text{Area}} = \frac{F}{A}$

- The SI unit of stress is Nm^{-2} or pascal (Pa) and its dimension is $[ML^{-1}T^{-2}]$.
- Stress is a tensor.

Types of stress 2

Longitudinal stress and shearing stress

- When many forces act on the system (body), the center of mass (defined in unit 5) remains at rest.
- However, the body gets deformed due to these forces and so the internal forces appear.
- Let ΔA be the cross sectional area of the body.
- The parts of the body on two sides of ΔA exert internal forces $\vec{F}$ and - $\vec{F}$ on each other which is due to deformation.
- The force can be resolved in two components; F_n normal to the surface ΔA (perpendicular to the surface) and F_t tangential to the surface ΔA (tangent to the surface).
- The normal stress or longitudinal stress (σ_n) over the area is defined as $\sigma_n = \frac{F_n}{\Delta A}$
- Similarly, the tangential stress or shearing stress σt over the area is defined as $\sigma_t = \frac{F_t}{\Delta A}$
- Longitudinal stress can be classified into two types, tensile stress and compressive stress.

Tensile stress 1

- Internal forces on the two sides of ΔA may pull each other, i.e., it is stretched by equal and opposite forces.

- Then, the longitudinal stress is called tensile stress.

Compressive stress 1

- When forces acting on the two sides of Δ A push each other, Δ A is pushed by equal and opposite forces at the two ends.
- In this case, Δ A is said to be under compression.
- Then, the longitudinal stress is called compressive stress.

Volume stress 1.5

- This happens when a body is acted by forces everywhere on the surface such that the force at any point is normal to the surface and the magnitude of the force on a small surface area is proportional to the area.
- For instance, when a solid is immersed in a fluid, the pressure at the location of the solid is P, the force on any area Δ A is
  F = P Δ A Where, F is perpendicular to the area.
- Thus, force per unit area is called volume stress. $\sigma_v = \frac{F}{A}$ which is the same as the pressure.

Strain 2

- Strain measures how much an object is stretched or deformed when a force is applied.
- Strain deals with the fractional change in the size of the object, in other words, strain measures the degree of deformation.
- As an example, in one dimension, consider a rod of length L when it stretches to a new length Δ L then

$$\text{Strain, } \varepsilon = \frac{\text{change in size}}{\text{original size}} = \frac{l}{l}$$

- ε is a dimensionless quantity and has no unit. Strain is classified into three types.

Types of Strain

Longitudinal strain 1.5

- When a rod of length L is pulled by equal and opposite forces, the longitudinal strain is defined as

$$\varepsilon l = \frac{\text{increase in length of the rod}}{\text{original or natural length of the rod}} = \frac{\Delta l}{l}$$

- Longitudinal strain can be classified into two types

(i) Tensile strain: If the length is increased from its natural length then it is known as tensile strain.

(ii) Compressive strain: If the length is decreased from its natural length then it is known as compressive strain.

Shearing strain 1.5

- Let us assume that the body remains in translational and rotational equilibrium.
- Let us apply the tangential force F along AD such that the cuboid deforms.
- Hence, shearing strain or shear is (ε_s)

$$\varepsilon_s = \frac{AA'}{BA} = \frac{x}{h} = \tan\theta$$

- For small angle, $\tan\theta \simeq \theta$
- Therefore, shearing strain or shear,

$$\varepsilon_s = \frac{x}{h} = \theta = \text{Angle of shear}$$

Volume strain 1.5

- If the body is subjected to a volume stress, the volume will change.
- Let V be the original volume of the body before stress and V + Δ V be the change in volume due to stress.
- The volume strain which measures the fractional change in volume is

$$\text{Volume strain, } \varepsilon_v = \frac{\Delta V}{V}$$

Elastic Limit 1

- The maximum stress within which the body regains its original size and shape after the removal of deforming force is called the elastic limit.
- If the deforming force exceeds the elastic limit, the body acquires a permanent deformation.
- For example, rubber band loses its elasticity if pulled apart too much. It changes its size and becomes misfit to be used again.

8) Discuss about surface tension and factors affecting the surface tension of a liquid?

Surface Tension 2

- it may be defined as the tensile force acting on the surface of a liquid in contact with a gas or on the surface between two immiscible liquids such that the contact surface behaves like a membrane under tension.
- Surface tension is caused by the effects of intermolecular forces at the interface. Surface tension depends on the nature of the liquid, the surrounding environment and temperature.

Intermolecular forces 1

- Some liquids do not mix together due to their physical properties such as density, surface tension force, etc.
- For example, water and kerosene do not mix together. Mercury does not wet the glass but water sticks to it.

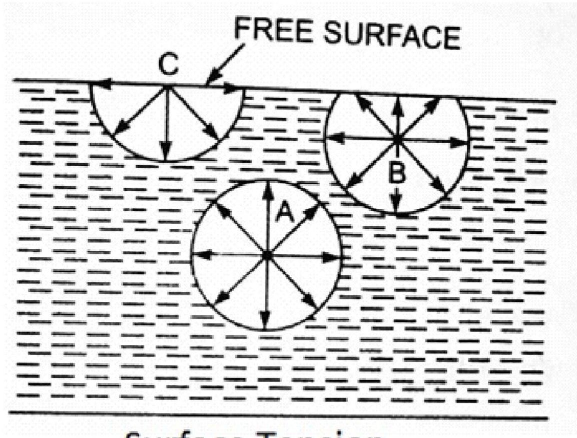
Surface Energy 1

- Water rises up to the leaves through the stem.
- They are mostly related to the free surfaces of liquids.
- Liquids have no definite shape but have a definite volume.
- Hence they acquire a free surface when poured into a container.
- Therefore, the surfaces have some additional energy, called as surface energy.
- The phenomenon behind the above fact is called surface tension.

Laplace and Gauss theory 1

- Laplace and Gauss developed the theory of surface and motion of a liquid under various situations.
- The molecules of a liquid are not rigidly fixed like in a solid.
- They are free to move.
- **Cohesive force:** The force between the like molecules which holds the liquid together is called 'cohesive force'.
- **Adhesive force:** When the liquid is in contact with a solid, the molecules of these solid and liquid will experience an attractive force which is called 'adhesive force'.
- These molecular forces are effective only when the distance between the molecules is very small about 10^{-9} m (i.e., 10 Å).
- **Sphere of influence:** The distance through which the influence of these molecular forces can be felt in all directions constitute a range and is called sphere of influence.
- The forces outside this range are rather negligible.

Experiment 2



Surface Tension

- Consider three different molecules A, B, and C in a given liquid as shown.
- Let a molecule 'A' be considered well inside the liquid within the sphere of influence.
- Since this molecule interacts with all other molecules in all directions, the net force experienced by A is zero.
- Now consider a molecule 'B' in which three-fourth lies below the liquid surface and one–fourth on the air.
- Since B has more molecules towards its lower side than the upper side, it experiences a net force in the downward direction.
- In a similar way, if another molecule 'C' is chosen on the liquid surface (i.e, upper half in air and lower half in liquid), it experiences a maximum downward force due to the availability of more number of liquid molecules on the lower part.

Observation 2

- Hence it is obvious that all molecules of the liquid that falls within the molecular range inside the liquid interact with the molecule and hence experience a downward force.

- When any molecule is brought towards the surface from the interior of the liquid, work is done against the cohesive force among the molecules of the surface.
- This work is stored as potential energy in molecules.
- So the molecules on the surface will have greater potential energy than that of molecules in the interior of the liquid.
- But for a system to be under stable equilibrium, its potential energy (or surface energy) must be a minimum.
- Therefore, in order to maintain stable equilibrium, a liquid always tends to have a minimum number of molecules.
- In other words, the liquid tends to occupy a minimum surface area.
- This behaviour of the liquid gives rise to surface tension.

<u>Factors affecting the surface tension of a liquid</u> **3**

- Surface tension for a given liquid varies in following situations
- **The presence of any contamination or impurities** considerably affects the force of surface tension depending upon the degree of contamination.
- **The presence of dissolved substances** can also affect the value of surface tension. For example, a highly soluble substance like sodium chloride (NaCl) when dissolved in water (H_20) increases the surface tension of water.
- But the sparingly soluble substance like phenol or soap solution when mixed in water decreases the surface tension of water.
- **Electrification** affects the surface tension. When a liquid is electrified, surface tension decreases.
- Since external force acts on the liquid surface due to electrification, area of the liquid surface increases which acts against the contraction phenomenon of the surface tension. Hence, it decreases.
- **Temperature** plays a very crucial role in altering the surface tension of a liquid.
- Obviously, the surface tension decreases linearly with the rise of temperature.

<u>Examples:</u>

1. Hot soup tastes better than the cold soup.
2. Machinery parts get jammed in winter.

<u>Relation between surface tension and temperature</u> **3**

- For a small range of temperature, the surface tension at T_t at t°C is
- Where, T_0 is the surface tension at temperature 0°C and α is the temperature coefficient of surface tension.
- It is to be noted that at the critical temperature, the surface tension is zero as the interface between liquid and vapour disappear.
- For example, the critical temperature of water is 374°C.
- Therefore, the surface tension of water is zero at that temperature.
- Vander Wall suggested the important relation between the surface tension and the critical temperature as $T_t = T_0\left(1-\frac{t}{t_c}\right)^{\frac{3}{2}}$
- Generalizing the above relation, we get

$$T_t = T_0\left(1-\frac{t}{t_c}\right)^{n}$$

- which gives more accurate value. Here, n varies for different liquids and t and t_c denote the temperature and critical temperature in absolute scale (Kelvin scale) respectively.