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Physics 9

Comprehensive Notes with Short Questions, Long Questions, MCQs, and Problems

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Important Definitions

Unit 1 Physical Quantities and Measurements

1. **Physical Quantities**: Physical quantities are quantities that can be measured directly or indirectly using tools and instruments, such as the length of an object using a ruler, the time duration of an event using a clock.

2. **Non-physical Quantities**: Quantities that cannot be measured using tools and instruments.

   For examples include love, affection, fear, wisdom, and beauty, which often pertain to the perception or interpretation of the observer.

3. **Base Quantities**: Quantities selected arbitrarily by scientists to play a key role in describing physical phenomena.

   Base quantities are length, mass, time, temperature, electric current, etc.

4. **Derived Physical Quantities**: Quantities that can be described in terms of one or more base quantities.

   For example, speed, area, volume, etc.

5. **Measurement**: Measurement is a process of comparison of an unknown quantity with a widely accepted standard quantity.

6. **Unit**: The standard amount of a physical quantity, which is used to compare larger or smaller amounts, is called the unit.

7. **The International System of Units (SI)**: The International System of Units (SI) is a system of measurement consisting of seven base units, recommended by the international committee on weights and measures in 1961.

8. **Base Units**: Base units cannot be derived from one another and cannot be resolved into anything more basic.

9. **Derived Units**: Derived units are the units of quantities that can be expressed in terms of base units.

10. **Prefixes**: Prefixes are words or symbols added before SI units to express quantities as multiples or sub-multiples of base units using powers of 10.

11. **Scientific notation**: Scientific notation is a method of representing very large or very small numbers in a compact form. It expresses numbers as a product of a number between 1 and 10, multiplied by a power of 10.

12. **Metre rule:** A metre rule is commonly used in laboratories to measure length. The smallest division on a metre rule is 1 mm, which is known as the least count of the metre rule.

13. **Parallax error:** Parallax error occurs due to the incorrect position of the eye when taking measurements. This results in inaccurate readings.

14. **Measuring tape:** A measuring tape is used to measure lengths ranging from $1\ mm$ to several metres. Its least count is $1\ mm$.

15. **Vernier Calliper:** The Vernier Calliper is an instrument used to measure small lengths with high precision, down to $\frac{1}{10}th$ of a millimetre.

16. **Least count of a Vernier Calliper:** The least count of a Vernier Calliper is the difference between one main scale division $(1\ mm)$ and one Vernier scale division $(0.9\ mm)$. Hence,

$$\begin{aligned} least\ count &= 1\ M.S\ div\ -\ 1V.S\ div \\ &= 1\ mm\ -\ 0.9\ mm \\ &= 0.1\ mm \end{aligned}$$

17. **Zero error of Vernier Callipers:** Zero error occurs if, on joining the jaws of Vernier Callipers, the zeros of the main scale and Vernier scale do not exactly coincide with each other. This error in the instrument is called zero error.

18. **Positive Zero Error:** The zero of the Vernier scale is on the right side of the main scale zero.

19. **Negative Zero Error:** The zero of the Vernier scale is on the left side of the main scale zero.

20. **Screw gauge:** A screw gauge is an instrument used to measure very small lengths, such as the diameter of a wire or the thickness of a metal sheet.

21. **Pitch of the screw gauge:** The pitch of the screw gauge is the distance the spindle moves along the main scale when the thimble completes one full rotation.

22. **Least count of a screw gauge**: The least count of a screw gauge is calculated using the formula:

$$Least\ Count = \frac{Pitch\ of\ the\ Screw\ Gauge}{Number\ of\ Divisions\ on\ the\ Circular\ Scale}$$

$$Least\ Count = \frac{0.5mm}{50}$$

$$Least\ Count = 0.01\ mm\ \ or\ 0.001\ cm$$

23. **Stopwatch:** The duration of an event is measured by a stopwatch, which contains two needles: one for seconds and one for minutes.

    The dial is divided into 30 big divisions, each further divided into 10 small divisions. Each small division

represents one-tenth $\left(\frac{1}{10}\right)$ of a **second**, making $\frac{1}{10}$ of a second the least count of the **stopwatch**.

24. **Measuring cylinder:** A measuring cylinder is a cylinder made of glass or transparent plastic, with a scale marked in cubic centimeters (cm^3 or cc) or milliliters (mL).

25. **Meniscus:** The meniscus is the curved surface of the liquid.

26. **Significant figures (or digits)**: Significant figures (or digits) are the digits of a measurement that are reliably known.

    They include all the accurately known digits and the first doubtful digit, which is determined by estimation and has a probability of error.

27. **Precision of a measurement**: Precision of a measurement refers to how close together a group of measurements are to each other.

28. **Accuracy of a measurement**: Accuracy of a measurement refers to how close the measured value is to some accepted or true value.

Unit 2 Kinematics

1. **Mechanics:** Mechanics is the branch of physics that deals with the motion of objects and the forces that change it.

2. **Kinematics:** The study of motion without referring to forces.

3. **Dynamics:** The study of forces and their effect on motion.

4. **Scalar Quantity:** A scalar is that physical quantity which can be described completely by its magnitude only.

5. **Vector Quantity:** A vector is that physical quantity which needs magnitude as well as direction to describe it completely.

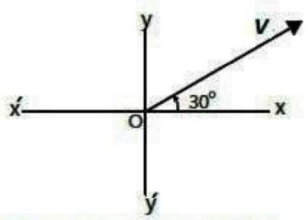
6. **Vector Representation (Symbolic):** In the textbook, a vector is represented by a boldface letter such as **A**, **v**, **F** etc. Since boldface cannot be written on paper, a vector is written with a small arrow over it, i.e., $\vec{A}$, $\vec{v}$, $\vec{F}$, $\vec{d}$. The magnitude of a vector is represented by an italic letter without an arrowhead.

7. **Vector Representation (Graphical):** A vector is graphically represented by drawing a straight line with an arrowhead at one end. The length of the line represents the magnitude of the vector according to a suitable scale, while the arrowhead indicates the direction of the vector.

8. **Reference Axes & Origin:** The horizontal line (XX') is called the $x\text{-}axis$, and the vertical line (YY') is called the $y\text{-}axis$.

    The point where these axes meet is known as the **origin**, usually denoted by $\boldsymbol{O}$. These axes are called **reference axes**.

9. **Direction of a Vector:** A vector is drawn from the origin of the reference axes towards the given direction. The direction is usually given by an angle $\boldsymbol{\theta}$ (theta) with the $x\text{-}axis$. This angle is always measured from the right side of the $x\text{-}axis$ in the anti-clockwise direction.



A Vector V making angle 30° with x-axis

10. **Resultant Vector:** A resultant vector is a single vector obtained by adding two or more vectors. It has the same effect as the combined effect of all the vectors being added.

11. **Head-to-Tail Rule:** To add a number of vectors, redraw their representative lines such that the head of one line coincides with the tail of the other. The resultant vector is given by a single vector which is directed from the tail of the first vector to the head of the last vector.

12. **Rest:** If a body does not change its position with respect to its surroundings, it is said to be at rest.

    For example, objects like buildings, trees, and electric poles are in a state of rest as they do not change their position.

13. **Motion:** If a body continuously changes its position with respect to its surroundings, it is said to be in motion.

    A moving car, running water, or a flying bird are examples of motion.

14. **Translatory Motion:** If the motion of a body is such that every particle of the body moves uniformly in the same direction, it is called translatory motion.

    For example, the motion of a train or a car.

15. **Rotatory Motion:** If each point of a body moves around a fixed point (axis), the motion of this body is called rotatory motion.

    For example, the motion of an electric fan or a spinning top.

16. **Vibratory Motion:** When a body repeats its to and fro motion about a fixed position, the motion is called vibratory motion.

For example, a swing in a children's park.

17. **Linear Motion:** If the body moves along a straight line, it is called linear motion.

    For example, a freely falling body.

18. **Random Motion:** If the body moves along an irregular path, the motion is called random motion.

    For example, the motion of a bee.

19. **Circular Motion:** The motion of a body along a circle is called circular motion.

    For example, a Ferris wheel or a ball tied to a string and whirled in a circle.

20. **Distance:** The distance is the length of the actual path of the motion.

21. **Displacement:** The displacement of an object is a vector quantity whose magnitude is the shortest distance between the initial and final positions of the motion. Its direction is from the initial position to the final position. We can also call this the change in position.
    OR
    The shortest distance between the initial and final positions of a body is called its displacement.

22. **Position:** Position of any object is its distance and direction from a fixed point.

23. **Speed:** Speed is the distance covered in unit time. It tells us how fast a body is moving.

$$Speed = \frac{Distance}{Time}$$

$$v = \frac{S}{t}$$

    Speed is a **scalar quantity** and its **SI unit** is $\boldsymbol{ms^{-1}}$ or $\boldsymbol{kmh^{-1}}$.

24. **Instantaneous Speed:** The speed of a vehicle at any given instant is called instantaneous speed. It is the reading shown on a speedometer at that moment.

25. **Average Speed:** Since speed is not constant during a journey, we often use average speed, which is defined as:

$$Average\ speed = \frac{Total\ distance\ covered}{Total\ time\ taken}$$

$$v_{av} = \frac{S}{t}$$

26. **Velocity:** Velocity is the net displacement of a body in unit time.

$$Average\ velocity = \frac{Displacement}{Time}$$

$$\boldsymbol{v_{av} = \frac{d}{t}}$$

    The **SI unit** of velocity is $\boldsymbol{ms^{-1}}$ or $\boldsymbol{kmh^{-1}}$.

27. **Uniform Velocity:** The velocity is said to be uniform if the speed and direction of a moving body do not change.

28. **Non-uniform Velocity:** If the speed or direction or both of them change, it is known as variable velocity or non-uniform velocity.

29. **Acceleration:** Acceleration is defined as the time rate of change of velocity.

    The $average\ acceleration$ is given by:

$$Average\ acceleration = \frac{Change\ in\ velocity}{Time\ taken}$$

$$\boldsymbol{a_{av} = \frac{v_f - v_i}{t} \ldots (i)}$$

$$\boldsymbol{a_{av} = \frac{\Delta v}{t}}$$

    The **SI unit of acceleration** is meter per second square (ms^{-2}).

    If acceleration a is constant, then Eq (i) can be written as $v_f = v_i + at$

30. **Positive Acceleration:** If the velocity is increasing, the acceleration is positive.

31. **Negative Acceleration (Retardation):** If the velocity is decreasing, the acceleration is negative.

32. **Uniform Acceleration:** If the time rate of change of velocity is constant, the acceleration is said to be uniform acceleration.

33. **Non-Uniform Acceleration:** If anyone of the magnitude or direction or both changes, the acceleration is called variable or non-uniform acceleration.

34. **Graph:** A graph is a pictorial diagram in the form of a straight line or a curve that shows the relationship between two physical quantities.

35. **Gradient of a Distance-Time Graph:** The gradient is the measure of the slope of a line. In a distance-time graph, the gradient is equal to the average speed of the body.

36. **Gradient of a Speed-Time Graph:** The gradient (slope) of a speed-time graph is equal to the average acceleration of the body.

37. **Area Under Speed-Time Graph:** The area under speed-time graph is equal to the distance covered by an object.

38. **Gravitational Acceleration (g):** When a body falls freely under the action of Earth's gravity, the

acceleration acting on it is called gravitational acceleration and is denoted by g.

39. **Universal Speed Limit:** The speed of light is a universal constant with a value of approximately $3 \times 10^8\ ms^{-1}$. No object with mass can achieve speeds equal to or greater than that of light.

Unit 3 Dynamics

1. **Dynamics:** Dynamics deals with the forces that produce changes in the motion of bodies.
2. **Force:** A force is a push or pull that can start, stop, or change the magnitude and direction of a body's velocity.
3. **Contact Forces:** A contact force is a force that is exerted by one object on the other at the point of contact.

   Examples: Friction, drag, thrust, normal force, air resistance, tension force, elastic force.
4. **Friction:** It is the force that resists motion when the surface of one object comes in contact with the surface of another.
5. **Drag:** The drag force is the resistant force caused by the motion of a body through a fluid. It acts opposite to the relative motion of any object moving with respect to surrounding fluid.
6. **Thrust:** It is an upward force exerted by a liquid on an object immersed in it. For example, when we try to immerse an object in water, we feel an upward force exerted on the object.
7. **Normal Force:** It is the force of reaction exerted by the surface on an object lying on it. This force acts outward and perpendicular to the surface.
8. **Air Resistance:** It is the resistance (opposition) offered by air when an object falls through it.
9. **Tension Force:** It is the force experienced by a rope when a person or load pulls it.
10. **Elastic Force:** It is a force that brings certain materials back to their original shape after being deformed. Examples include rubber bands, springs, and trampolines.
11. **Non-contact Forces:** A non-contact force is defined as the force between two objects which are not in physical contact.

    Examples: Gravitational force, electrostatic force, magnetic force, strong and weak nuclear forces.
12. **Four Fundamental Forces:**
    (i) **Gravitational Force:** An attractive force between masses.
    (ii) **Electromagnetic Force:** Interaction between charged particles.
    (iii) **Strong Nuclear Force:** Binds protons and neutrons in a nucleus.
    (iv) **Weak Nuclear Force:** Responsible for beta decay.
13. **Free-Body Diagram:** A diagram showing all external forces acting on an object, represented by arrows indicating magnitude and direction.
14. **Newton's First Law of Motion:** A body continues its state of rest or of uniform motion in a straight line unless acted upon by some external force.
15. **Inertia:** The property of a body to maintain its state of rest or of uniform motion in a straight line.

    For example, when a **tablecloth** is pulled abruptly from under dishes, the objects remain in their original positions due to **inertia**.
16. **Newton's Second Law of Motion:** If a net external force acts upon a body, it accelerates the body in the direction of force. Mathematically: $F = ma$.
17. **Newton's Third Law of Motion:** For every action, there is always an equal and opposite reaction.
18. **Action and Reaction:** When two bodies interact, if body A exerts a force on body B (**action**), then body B exerts an equal and opposite force on body A (**reaction**).
19. **limitations of Newton's Laws:** Newton's laws of motion have limitations in certain conditions:
    High Velocities: When dealing with objects moving at speeds close to the speed of light, Newton's laws fail to provide accurate results. In such cases, relativistic mechanics developed by Albert Einstein is used.
    Elementary Particles: Newton's laws are not suitable for describing the motion of elementary particles at atomic or subatomic scales.
20. **Unit of Force ($Newton$):** One newton is the force which produces an acceleration of $1\ ms^{-2}$ in a body of mass $1\ kg$. From equation $F = ma$
    $$1N = 1\ kg \times 1\ ms^{-2}$$
21. **Mass:** Mass of a body is the quantity of matter in it. It determines the magnitude of acceleration produced when a force acts on it. Mass of a body does not vary. It is a scalar quantity and its unit is kilogram (kg).
22. **Weight:** The weight of an object is equal to the force with which the Earth attracts the body towards its centre. (SI unit: N).
23. **Gravitational Field:** The gravitational field is the space around a mass where another mass experiences a force due to gravitational attraction.

24. **Gravitational Field Strength:** The gravitational field strength is defined as the gravitational force acting on a unit mass.

    For a mass m on the surface of the Earth, the force it experiences (its weight) is given by:

    $$w = mg$$

    where g is the gravitational field strength, with a standard value of $10\ N\ kg^{-1}$.

25. **Mechanical Balance:** A device with a rigid beam and pans to compare masses using standard weights.

26. **Electronic Balance:** A precise instrument displaying mass digitally without standard weights.

27. **Force Meter (Newton Meter):** A force meter is a scientific instrument used to measure force. It is also called a $newton\ meter$ or a $spring\ balance$.

    A digital force meter measures the weight of an object directly in newtons.

28. **Friction:** Friction is a dissipative force that opposes motion, causing energy to be wasted as work is done against it. The lost energy appears in the form of heat.

29. **Static Friction:** Resists motion before sliding begins.

30. **Kinetic Friction:** Opposes motion after sliding starts.

31. **Terminal Velocity:** The constant velocity attained when air resistance balances gravity.

32. **Rolling Friction:** Friction when an object rolls over a surface (lesser than sliding friction).

33. **Methods to Reduce Friction:** The following methods are used to reduce friction:
    - **(i)** The parts which slide against each other are highly polished.
    - **(ii)** Since the friction of liquids is less than that of solid surfaces, oil or grease is applied between the moving parts of the machinery.
    - **(iii)** As rolling friction is much less than the sliding friction, sliding friction is converted into rolling friction by the use of ball bearings in the machines and wheels under heavy objects.
    - **(iv)** High-speed vehicles, airplanes, and ships face friction from air or water. Their bodies are made streamlined (pointed front) to allow smooth airflow and reduce resistance.

34. **Momentum:** The momentum of a moving body is the product of its mass and velocity. Mathematically $p = mv$ $(SI\ unit\ \boldsymbol{kgms^{-1} = Ns})$.

35. **Impulse:** When a large force F acts on an object for a short time $\triangle t$, the product $F \times \triangle t$ is called **Impulse**, which is equal to the total change in momentum of the object. Mathematically, $Impulse = F \times \triangle t$

36. **Principle of Conservation of Momentum:** If no external force acts on an isolated system, the final total momentum of the system is equal to the initial total momentum of the system.

Unir 4 Turning Effects of Force

1. **Like and unlike parallel forces**: If the parallel forces are acting in the same direction, then they are called like parallel forces, and if their directions are opposite to one another, they are called unlike parallel forces.

2. **Rigid body**: If the distance between two points of the body remains the same under the action of a force, it is called a rigid body.

3. **Axis of rotation**: During rotation, all the particles of the rigid body rotate along fixed circles. The straight line joining the centres of these circles is called the axis of rotation.

4. **Line of action of a force**: The line along which the force acts is called the line of action of the force.

5. **Moment arm**: The perpendicular distance of the line of action of a force from the axis of rotation is known as moment arm of the force, or simply moment arm.

6. **Turning effect of a force**: The turning effect of a force is the force that causes a rigid body to rotate about an axis.

7. **Moment of a force or torque**: Moment of a force or torque is defined as the product of the force and the moment arm. The magnitude of torque is given by:

    $$\tau = F \times l$$

    Where τ (tau) is the torque, F is the applied force, and l is the moment arm.
    The **SI unit** of torque is newton metre (Nm).

8. **Couple**: When two equal and opposite parallel forces act at two different points of the same body, they form a couple. A couple is a special type of torque.

9. **Resolution of a force**: The process of dividing a force into its components is known as the resolution of a force.

10. **Perpendicular component:** Typically, a force is resolved into two components that are perpendicular to each other. These components are called the perpendicular or rectangular components of the force.

11. **Trigonometry**: Trigonometry is a branch of mathematics that deals with the properties of a right-angled triangle.

12. **Principle of moments**: The principle of moments is defined as: When a body is in balanced position, the sum of clockwise moments about any point equals the sum of anticlockwise moments about that point.

13. **Centre of gravity**: Centre of gravity is that point where total weight of the body appears to be acting.

14. **Centre of mass**: The centre of mass of a body is that point where the whole mass of the body is assumed to be concentrated.

15. **Equilibrium**: A body is said to be in equilibrium if it has no acceleration.

16. **Static equilibrium**: A body at rest is said to be in static equilibrium.

17. **Dynamic equilibrium**: A body moving with uniform velocity is said to be in dynamic equilibrium.

18. **First Condition of Equilibrium**: A body is said to be in translational equilibrium only if the vector sum of all the external forces acting on it is equal to zero. Mathematically, $\sum F = 0$

19. **Second Condition of Equilibrium**: The vector sum of all the torques acting on a body about any point must be zero. Mathematically, $\sum \tau = 0$

20. **Stable equilibrium**: A body is said to be in a state of stable equilibrium, if after a slight tilt, it comes back to its original position.

21. **Unstable equilibrium**: A body is said to be in a state of unstable equilibrium if, after a slight tilt, it tends to move further away from its original position.

22. **Neutral equilibrium**: A body is in neutral equilibrium if it comes to rest in its new position after disturbance without any change in its centre of mass.

23. **Centripetal force**: The force that causes an object to move in a circle at constant speed is called the centripetal force. Mathematically, $F_c = \frac{mv^2}{r}$

Unit 5 Work, Energy And Power

1. **Work**: Work is said to be done when a force acts on an object and moves it through some distance. Mathematically,

$$Work = Magnitude\ of\ force \times Distance$$
$$W = F \times S$$

2. **SI Unit of work:** One joule work is done when a force of one newton acting on a body moves it through a distance of one metre in its own direction.

From equation $W = FS$:

$$1J = 1\ N \times 1\ m$$
$$1\text{J} = 1\text{N m}$$

Bigger units of work are also used like $1\ kJ = 10^3\ J$ and $1\ MJ = 10^6\ J$.

3. **Work done at an angle θ**: When a force acts at an angle θ with the direction of motion: $W = FS\cos\theta$

4. **Energy**: Energy is the ability of a body to do work. $SI\ unit\ joule\ (J)$.

5. **SI unit of energy:** When one joule of work is done on a body, the amount of energy spent is one joule.

6. **Mechanical Energy**: The combination of kinetic energy and potential energy is called mechanical energy. Forms: kinetic energy and potential energy.

7. **Kinetic Energy**: Kinetic energy of a body is the energy that a body possesses by virtue of its motion.

$$E_k = \frac{1}{2}mv^2$$

8. **Potential Energy**: Potential energy is defined as the energy that a body possesses by virtue of its position or deformation. $E_p = mgh$

9. **Gravitational Potential Energy:** The energy possessed by an object due to its position relative to the Earth. For example, water stored at a height in a dam.

10. **Elastic Potential Energy:** The energy stored in a compressed or stretched spring or elastic material. This energy is due to the deformation of the object.

11. **Chemical Potential Energy:** The energy stored in chemicals, such as in batteries or fuels. It is released during chemical reactions and may be converted into electrical or thermal energy.

12. **Thermal (Internal) Energy:** This is the energy released by burning fossil fuels like coal, oil, or gas through chemical reactions.

13. **Nuclear Energy:** The energy stored in the nucleus of an atom. When the nucleus splits (nuclear fission), a large amount of energy is released in the form of heat and radiation.

14. **Conservation of Energy**: Energy cannot be created or destroyed. It may be transformed from one form to another, but the total amount of energy never changes. Example: A falling body converts potential energy $(E_p = mgh)$ to kinetic energy $\left(E_k = \frac{1}{2}mv^2\right)$, but total energy remains mgh.

15. **Renewable Energy Sources**: The resources of energy which are replaced by new ones after their use are called renewable energy sources.

16. **Non-renewable Energy Sources**: Non-renewable sources are those, which are depleted with the continuous use.

17. **Fossil Fuel Energy**: Fossil fuel energy is the energy that is released by burning of oil, coal and natural gas.

18. **Hydroelectric energy:** Hydroelectric generation is the electricity generated from the power of falling water.

19. **Solar Energy**: Sun is the biggest source of energy. The energy obtained from sunlight is referred to as solar energy.

20. **Solar cell:** Solar cells are also known as photo voltaic cells. The voltage produced by a single voltaic cell is very low.

21. **Solar panel:** In order to get sufficient high voltage for practical use, a large number of such cells are connected in series to form a solar cell panel.

22. **Nuclear Energy**: The energy released by breaking the nucleus of an atom is known as nuclear energy.

23. **Geothermal Energy**: Geothermal energy is the heat energy of the hot rocks present deep under the surface of the Earth.

24. **Wind Energy**: Wind energy is the electrical energy produced by using the kinetic energy of the fast-blowing wind.

25. **Tidal Energy**: Tidal energy is a renewable energy source that uses the movement of ocean tides (caused by the moon's gravity) to generate electricity.

26. **Wave Energy**: Wave energy uses ocean waves (made by wind and tides) to make electricity.

27. **Biomass Energy**: It is that energy which is obtained from the biomass.

28. **Power**: Power is defined as the time rate of doing work.

$$Power = \frac{Work}{Time}$$

$$P = \frac{W}{t}$$

It tells us how fast or slow work is done.

Power of any $agency$ can also be $defined\ as$ energy transferred per unit time.

29. **SI unit of power:** SI unit of power is watt (W). One watt is the work done at the rate of one joule per second.

$$1\,W = \frac{1\,J}{1\,s} \qquad or \qquad 1\,Js^{-1}$$

30. **Bigger Units of Power:** Bigger units of power are kilowatt (kW), megawatt (MW) etc.

$$\mathbf{1\ mega\ watt\ (MW) = 10^6 W = 1000\,000\ W}$$

In British engineering system, the unit of power used is **horse-power (hp)**. The horse power is defined as

$$1\ horse\ power\ (1hp) = 746\ W$$

31. **Efficiency**: The ratio of useful output energy and the total input energy is called the efficiency of a working system. Thus

$$Efficiency = \frac{Useful\ output\ energy}{Total\ input\ energy}$$

Efficiency is often multiplied by 100 to give percentage efficiency. Thus,

$$Percentage\ Efficiency = \frac{Useful\ output\ energy}{Total\ input\ energy} \times 100$$

32. **Perpetual Machine**: A perpetual machine cannot work because some energy is always lost as heat due to friction and air resistance.

Unit 6 Mechanical Properties of Matter

1. **Deforming Force:** An external force applied on an object can change its size or shape. Such a force is known as a deforming force.

2. **Elasticity:** Elasticity is the property of solids by which they come back to their original shape when deforming force ceases to act.

3. **Elastic Limit:** Most of the materials are elastic up to a certain limit known as elastic limit. Beyond the elastic limit, the change becomes permanent, and the object does not regain its original shape or size even after the removal of the deforming force.

4. **Inelastic Materials:** Some materials such as clay dough or plasticine do not return to their original shape after the removal of the deforming force. They are known as inelastic materials.

5. **Hooke's Law:** Within the elastic limit of a helical spring, the extension or compression in it is directly proportional to the applied force. This is known as Hooke's law.

If force F is applied on a spring to stretch or compress it, the extension or compression x has been found directly proportional to the applied force within the **elastic limit**. Thus,

$$F \propto x$$

$$F = kx$$

$$k = \frac{F}{x}$$

Here, k is the constant of proportionality and is known as the **spring constant**.

6. **Spring Constant:** Spring constant is defined as the ratio of applied force to the change in length of spring. Spring constant written as $k = \frac{F}{x}$

7. **Density:** Density of a substance is defined as its mass per unit volume.

$$Density = \frac{mass\ of\ sustance}{volume\ of\ that\ substantce}$$

$$\rho = \frac{m}{v}$$

SI unit of density is kilogram per cubic meter (kgm^{-3}). Othe unit also in use is gcm^{-3}.

8. **Pressure:** Pressure is defined as the force exerted normally on unit area of an object.

$$Pressure = \frac{Force}{Area}$$

$$P = \frac{F}{A}$$

Pressure is a scalar quantity. In **SI units**, the unit of pressure is Nm^{-2} also called pascal (Pa).

$$Nm^{-2} = 1\ Pa$$

9. **Atmospheric Pressure:** The atmosphere exerts pressure on the surface of the Earth and on everything on the Earth. This pressure is called atmospheric pressure. Standard value at sea level: $1.013 \times 10^5\ Pa$.

10. **Liquid Pressure at Depth:** The pressure at depth h in a liquid is: $P = \rho gh$ where ρ is liquid density and g is gravitational acceleration.

11. **Pascal's Law:** When pressure is applied at one point in an enclosed fluid, it is transmitted equally to all parts of the fluid without loss.

12. **Barometer:** Atmospheric pressure is usually measured by the height of mercury column which it can support. Instruments which measure the atmospheric pressure are called barometers.

13. **Barometer Principle:** Atmospheric pressure is measured by the height of a mercury column it supports.

$$P = \rho gh$$

At sea level: $760\ mm\ Hg\ = 1.013 \times 10^5\ Pa$

14. **Manometer:** A **simple manometer** consists of a U-shaped glass tube containing mercury. Initially, the atmospheric pressure at both open ends is the same, so the mercury level in both arms remains equal.

15. **Hydraulic Press (Force Multiplier):** A system where a small force F_1 on a small piston (area A_1) creates a larger force F_2 on a larger piston (area A_2):

$$F_2 = F_1 \times \left(\frac{A_2}{A_1}\right)$$

16. **Hydraulic Brakes:** Hydraulic Brakes work on Pascal's law. Pressure from brake pedal is transmitted equally to all wheels, creating friction to slow the vehicle.

Unit 7 Thermal Properties of Matter

1. **Kinetic Molecular Theory of Matter:** Matter is composed of very small particles called **molecules**, which are always in motion. Their motion may be **vibrational**, **rotational**, or **linear**. A mutual force of attraction called **intermolecular force** exists between the molecules. This force depends on the **distance between molecules** and **decreases** as the distance increases.

2. **Solids:** In solids, the intermolecular forces are **very strong**, so molecules are held at fixed positions, showing only vibrational motion. That is why solids have a definite shape and volume.

3. **Liquids:** In liquids, the intermolecular forces are **weaker**, allowing molecules to slide over each other in random directions. Therefore, liquids have a definite volume but no definite shape, and take the shape of the container.

4. **Gases:** In gases, the molecules are **far apart** and the intermolecular forces are very weak. Gas molecules move freely in all directions, so a gas has no definite shape or volume.

5. **Plasma (Fourth State of Matter): Plasma** is a gas in which most of the atoms are **ionized**, containing **positive ions** and **electrons**. These particles move freely within the volume of the gas. Because of the presence of these charged particles, plasma is a **conducting state of matter**, allowing **electric current** to pass through it.

6. **Temperature:** Temperature of a body is defined as the degree of its hotness or coldness. **(Alternate definition in terms of thermal energy):** Temperature can be defined as a physical quantity which determines the direction of flow of thermal energy.

7. **Heat:** Heat is the energy which is transferred from one object to another due to the difference of temperature between the two bodies.

8. **Internal Energy:** The sum of kinetic and potential energies of the molecules of an object is called its internal energy.

9. **Thermometer:** A **thermometer** is an instrument used for the exact measurement of the hotness or temperature of a substance.

10. **Liquid-in-Glass Thermometer:** Liquids expand on heating. So, expansion in the volume of a liquid can be used for the measurement of temperature. This is known as a liquid-in-glass thermometer.

11. **Fixed point:** For the measurement of temperature, two reference temperatures called **fixed points** are required.

12. **Upper fixed point:** This is the steam point, slightly above the boiling point of water at standard atmospheric pressure.

13. **Lower fixed point:** This is the melting point of pure ice, also known as the ice point.

14. **Celsius (Centigrade) scale:** Lower fixed point: 0℃; Upper fixed point: 100℃.

15. **Fahrenheit scale:** Lower fixed point: 32℉; Upper fixed point: 212°F.

16. **Kelvin scale (Absolute temperature scale):** Lower fixed point: 273 K; Upper fixed point: 373 K.

17. **Absolute Zero:** Absolute zero is the temperature at which molecular motion ceases, and the average kinetic energy of particles becomes zero. On the Kelvin scale, it is defined as $0\ K$, which is equivalent to $-273.15°C$ (rounded to -273℃ for calculations). It is the lowest possible temperature in the universe.

18. **Thermocouple Thermometer:** Thermocouple thermometer is based on the flow of electric current between two junctions of two wires of different materials due to difference of temperatures at the junctions.

19. **Sensitivity of a Thermometer:** Sensitivity of a thermometer refers to its ability to detect small changes in the temperature of an object.

20. **Range of a Thermometer:** This refers to the **span of temperature**, from low to high, over which the thermometer can measure accurately.

21. **Linearity of a Thermometer:** This refers to a direct proportional relationship between the temperature and scale reading across the entire range of measurement.

22. **Direction of Heat Flow:** Temperature difference determines the direction of heat flow. Heat always flows from a body at higher temperature to one at lower temperature.

23. **Mercury as a Thermometric Liquid:** Mercury is preferred because it has a uniform expansion, is opaque and shiny (making it easy to read), does not stick to glass, and remains in liquid state over a wide temperature range.

Unit 8 Magnetism

1. **Magnetism:** Magnetism is a force that acts at a distance upon magnetic materials. These materials are attracted to magnets and are called **magnetic materials**.

2. **Magnetic Materials:** Materials such as iron, nickel, and cobalt are **magnetic materials** because they are attracted to magnets.

3. **Non-Magnetic Materials:** Non-magnetic materials include brass, copper, wood, glass, and plastic as they are not attracted to magnets.

4. **Magnet:** A magnet is an object that produces a magnetic field, which exerts a force on magnetic materials. A key property of a magnet is that it has north and south poles.

5. **Magnetic Material:** Magnetic materials, such as iron, nickel, and cobalt, are attracted by magnets. These materials do not generate a magnetic field of their own but are drawn to the magnetic force when a magnet is nearby.

6. **Properties of Magnets:** The magnets exhibit the following properties:
   a) Magnetic Poles
   b) Attraction and Repulsion of Magnetic Poles
   c) Identification of a Magnet
   d) Is Isolated Magnetic Pole Possible?

7. **Magnetic Poles:** If a bar magnet is suspended horizontally through a string and allowed to come to rest, it will point in north-south direction. The end of the magnet that points north is called the north magnetic pole (N), and the end that points south is the south magnetic pole (S).

8. **Attraction and Repulsion of Magnetic Poles:** Like poles repel and unlike poles attract.

9. **Temporary Magnets:** Temporary magnets are the magnets that work only in the presence of a magnetic field of permanent magnets. Once the magnetic field vanishes, they lose their magnetic properties.

10. **Permanent Magnets:** Permanent magnets are those which retain their magnetic properties forever.

11. **Magnetization:** Magnetic material such as iron or steel can be made a magnet. This is known as magnetization.

12. **Magnetic Field:** A magnetic field is the region around a magnet where another magnetic object experiences a force on it.

13. **Magnetic Lines of Force:** The pattern of a magnetic field around a bar magnet can be seen very easily by a simple experiment. If iron filings are sprinkled on a thin glass plate placed over a bar magnet, the filings become tiny magnets through magnetic induction. Now if the glass surface is gently tapped, the filings form a pattern. This pattern is known as the magnetic field pattern. This pattern can be better shown by lines that correspond to the path of the filings. These lines are called magnetic lines of force.

14. **Strength of the magnetic field:** The strength of the magnetic field is proportional to the number of magnetic lines of force passing through unit area placed perpendicular to the lines.

15. **Electromagnet:** Electromagnets are a kind of temporary magnets. An iron nail or rod becomes a magnet when an electric current passes through a coil of wire wound around it. This setup is called an electromagnet.

16. **Magnetic Relay:** A magnetic relay is a type of switch that operates using an electromagnet. It is used as an input circuit that works with a low current for safety purposes.

17. **Circuit Breaker:** A circuit breaker is a safety device designed to allow only a certain maximum current to pass through it. If the current becomes excessive, it automatically switches OFF the circuit, thereby protecting electric appliances from damage or burning.

18. **Domain Theory of Magnetism:** It is observed that the magnetic field of a bar magnet is similar to that of a solenoid carrying current. This suggests that magnetism is caused by moving charges. In a solenoid, charges move through the wire, while in a bar magnet, magnetism is due to spinning and revolving electrons within atoms.

19. **Paramagnetic Materials:** If the orbital and spin axes of the electrons in an atom are so oriented that their fields support one another and the atom behaves like a tiny magnet, the materials with such atoms are called paramagnetic materials, such as aluminium and lithium.

20. **Diamagnetic Materials:** Magnetic fields produced by both orbital and spin motions of the electrons in an atom may add up to zero. In this case, the atom has no resultant field. The materials with such atoms are called diamagnetic materials. Some of their examples are copper, bismuth, water, etc.

21. **Ferromagnetic Materials:** There are some solid substances such as *iron*, *steel*, *nickel*, *cobalt*, etc. in which **cancellation** of any type does not occur for large groups of neighbouring atoms of the order of 10^{16} because they have **electron spins** that are naturally aligned **parallel** to each other. These are known as **ferromagnetic materials**.

22. **Magnetic Domains:** The group of atoms in this type of material form a region of about 0.1 mm size that is highly magnetized. This region is called a magnetic domain. Each domain behaves as a small magnet with its own north and south poles.

23. **Right Hand Grip Rule:** Grip the solenoid with the right hand such that the fingers are curled along the direction of current (from the positive to the negative terminal of the battery) in the solenoid, then the thumb points to the **N-pole** of the bar end. **OR** Grip the solenoid with the right hand so fingers curl in the direction of current, and the thumb points to the N-pole.

24. **Permeability:** Soft iron has high magnetic permeability. Permeability is the ability of a material to allow magnetic flux or lines of force to pass through it when placed inside a magnetic field.

25. **Magnetic Field:** A **magnetic field** is the region around a magnet where another magnetic object experiences a force on it.

26. **Fringe Field:** A fringe field is the curved part of the magnetic field that comes out from the gap between the poles of a magnet. It helps to magnetize the tape by entering the magnetic coating during recording.

Unit 9 Nature of Science

1. **Science:** Science is a collective knowledge about the natural phenomena, processes, and events occurring around us.

2. **Branches of Science: Biological Science:** The biological sciences which deals the living things. **Physical Science:** The physical science which is about the study of non-living things.

3. **Natural Philosophy:** Natural Philosophy is the *study of nature* that gave birth to a single discipline, now known as science.

4. **Physics:** *Physics is the fundamental science that deals with the constituents of the universe—matter, energy, space, time, and their mutual relationships and interactions.*

5. **Space (Physics):** Space is the three-dimensional extent in which all objects and events occur. It provides the framework to define positions and motions of various objects under some force.

6. **Time (Physics):** Time measures the *sequence and duration* of events. It is considered the fourth dimension.

7. **Theory of relativity:** Theory of relativity explains that space and time are not absolute, but are related to each other and are influenced by gravity and speed.

8. **Quantum mechanics:** Quantum mechanics explains the behavior of particles at the atomic and subatomic levels.

9. **Mechanics:** It is a study of motion and the physical effects which influence motion. It is based on Newton's laws of motion and gravitation and is often called classical mechanics.

10. **Heat and Thermodynamics:** It deal with the thermal energy possessed by the materials and it is used when it flows from one body to another.

11. **Acoustics:** It deals with the nature and physical aspects of audible sound energy.

12. **Optics:** It deal with the physical aspects of visible light.

13. **Electromagnetism:** It is the study of electromagnetic phenomenon and mutual relationship between electric current and magnetic field.

14. **Quantum Mechanics:** It explains the behavior of particles at the atomic and subatomic level.

15. **Relativistic Mechanics:** It explains how space and time are not absolute quantities but related to observer. It describes the relationship between them and how they are influenced by gravity and speed.

16. **Nuclear Physics:** It is the study of the properties of nuclei of the atoms.

17. **Particle Physics:** It is the study of subatomic particles and elementary particles which are basic building blocks of matter.

18. **Astronomy:** It is study of distribution of celestial bodies like planets, stars and galaxies.

19. **Cosmology:** It explores the large structure and evolution of the universe.

20. **Solid State Physics:** It is the study of some specific properties of matter in solid form.

21. **Interdisciplinary Nature of Physics:** Interdisciplinary nature of Physics refers to integration and interaction of Physics with various other fields of study.

22. **Biophysics:** Some biological systems and processes are described using the principles and technique of physics under this field of Study.

23. **Medical Physics:** It applies physical principles to develop techniques and technologies for health diagnosis and treatment.

24. **Astrophysics:** It deals with the physical properties and processes of celestial bodies and phenomena.

25. **Geophysics:** It applies physical principle to the study of internal structure of the Earth, its magnetic and gravitational fields, seismic activity, volcanoes, etc.

26. **Climate Physics:** It includes the study of physical processes in the environment, including atmospheric dynamics, climate change and weather conditions.

27. **Computational Physics:** It is about the use of computational techniques and methods to solve complex physical problems.

28. **Interdisciplinary Research:** Interdisciplinary research involves collaboration between different scientific disciplines to address complex issues and challenges.

29. **Scientific Method:** Scientific method is a systematic approach used to search for truth of an issue and problem solving regarding natural and physical world.

30. **Steps of Scientific Method:**
    - **(i) Observation:** The first step in scientific method is to make observations of natural processes and to collect the data about them.
    - **(ii) Hypothesis:** On the basis of the data collected through observations or experimentation, we can develop a hypothesis.
    - **(iii) Experiment:** Experiment is an organized repeatable process which is used to test the truth of a hypothesis.
    - **(iv) Theory:** After the successful verification of an assumption and with the help of careful experimentation, it becomes a theory.
    - **(v) Prediction:** After the careful analysis of a theory we can make predictions about certain unknown aspects of nature.
    - **(vi) Falsifiability:** It is a concept introduced that suggests a theory to be considered scientific if it also makes predictions that can be tested and potentially proven false.
    - **(vii) Law:** When a theory has been tested many times and generally accepted as true, it is called a law.

31. **Mass-Energy Equivalence (Einstein):** In the 20th century, Albert Einstein declared that mass and energy, the two concerns of Physics, are forms of each other.

32. **Science vs. Technology vs. Engineering: Science:** Physics plays a vital role being the core of each invention based on physical laws and principles.

Technology: Technology refers to the methods and techniques developed by using **scientific knowledge**.
Engineering: Engineering is the process of applying various technologies and scientific principles to design various instruments, tools and build things that help to meet specific needs in every walk of life.

33. **Falsifiability:** Falsifiability means that a scientific idea or theory can be tested to show whether it is right or wrong.

34. **Laser Technology:** Laser technology is based on principle of atomic physics.