

CLASS IX

PHYSICS

COMPLETE BOOK NOTES

9th PHYSICS

THE KNOWLEDGE HUB

CH #1: PHYSICAL QUANTITIES AND MEASUREMENTS

1. What are physical and non-physical quantities?

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.

Non-physical Quantities: Quantities that cannot be measured using tools and instruments. **Examples** include love, affection, fear, wisdom, and beauty etc.

2. What is difference between base quantities derived physical quantities?

Base Quantities: Scientists have selected arbitrarily some quantities to play a key role. Base quantities are length, mass, time, temperature, electric current, etc.

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

Example: speed is a derived quantity depending on distance and time.

3. Is a non-physical quantity has dimensions?

No, non-physical quantities do not have dimensions because they cannot be measured.

4. What is measurement? Name its two parts.

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

Its two parts are: A number (magnitude). & a unit (standard of measurement).

5. What is a Unit?

The standard of measurement is called the unit.

6. What is 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.

7. What is the advantage of SI Units?

The SI system is used all over the world, enabling scientists to share and compare their observations and results easily.

8. What is difference between Base Units and Derived Units?

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

No.	Physical quantity	Unit	Symbol	No.	Physical quantity	Unit	Symbol
1	Length	Metre	<i>m</i>	5	Electric current	Ampere	<i>A</i>
2	Mass	Kilogram	<i>kg</i>	6	Intensity of light	Candela	<i>cd</i>
3	Time	Second	<i>s</i>	7	Amount of substance	Mole	<i>mol</i>
4	Temperature	Kelvin	<i>K</i>				

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

No.	Physical quantity	Unit	Symbol	No.	Physical quantity	Unit	Symbol
1	Area	square metre	<i>m</i> ²	5	Pressure	Pascal	<i>Pa</i>
2	Volume	cubic metre	<i>m</i> ³	6	Electric charge	coulomb	<i>C</i>
3	Speed	metre per second	<i>ms</i> ⁻¹	7	Plane angle	radian	<i>rad</i>
4	Force	newton	<i>N</i>				

9. What is prefix?

Prefixes are words or symbols added before SI units to express quantities as multiples or sub-multiples of base units using powers of 10. Prefixes helps simplify large or small quantities for convenience.

Example: 50000000 m can be written as 5×10^7 m, and 0.00004 m can be written as 4×10^{-5} m.

Type	Prefix	Symbol	Powers of Ten	Type	Prefix	Symbol	Powers of Ten
Sub-multiples	Atto	a	10^{-18}	Multiples	kilo	k	10^3
	Femto	f	10^{-15}		mega	M	10^6
	Pico	p	10^{-12}		giga	G	10^9
	Nano	n	10^{-9}		tera	T	10^{12}

Micro	μ	10^{-6}	peta	P	10^{15}
Milli	m	10^{-3}	exa	E	10^{18}
Centi	c	10^{-2}			
Deci	d	10^{-1}			

10. What is scientific notation?

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

11. What is a metre rule? Also define least count.

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.

Least count: The least count is the smallest measurement that can be accurately taken with an instrument.

12. What is parallax error?

Parallax error occurs due to the incorrect position of the eye when taking measurements. It can be avoided by keeping eye perpendicular to the scale reading.

13. What is a measuring tape?

A measuring tape is used to measure lengths ranging from 1 mm to several metres. Its least count is 1 mm.

14. What is the purpose of Vernier Callipers?

The Vernier Calliper is an instrument used to measure small lengths with high precision, down to 1/10th of a millimeter. It can measure the thickness, diameter, width, or depth of an object.

15. Write about the scales of Vernier Callipers.

Main Scale: A main scale which has marking of 1mm each.

Vernier Scale: A Vernier Scale of length 9mm and it is divided into 10 equal parts.

16. Write about the jaws of Vernier Calliper.

Outside Jaw: Jaws are used to measure the external dimensions of an object.

Inside Jaws: Jaws are used to measure the internal dimensions of an object.

Additionally, a narrow strip called the tail or depth gauge is used to measure the depth of a hollow object.

17. How is the least count of a Vernier Calliper determined?

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, $\text{least count} = 1 \text{ M.S div} - 1 \text{ V.S div} = 1 \text{ mm} - 0.9 \text{ mm} = 0.1 \text{ mm}$

18. How is the length of an object measured using Vernier Callipers?

Suppose an object is placed between the two jaws, the position of the Vernier scale on the main scale is observed.

- Read the main scale marking just in front of zero of the Vernier scale.
- Find the Vernier scale marking or division which is in line with any of the main scale markings.
- The formula to calculate the length of an object is: $\text{Length of object} = \text{M.S reading} + (\text{L.C} \times \text{V.S reading})$

19. What is zero error in Vernier Callipers?

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.

20. Difference Between Positive and Negative Zero Errors in Vernier Callipers.

Positive Zero Error: The zero of the Vernier scale is on the right side of the main scale zero. The zero error is subtracted from the observed measurement.

Negative Zero Error: The zero of the Vernier scale is on the left side of the main scale zero. The zero error is added to the observed measurement.

21. What is a Micrometer 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.

22. Write about the scales of screw gauge.

Main Scale: Located on the sleeve, it has markings of 0.5 mm each.

Circular Scale: Located on the thimble, it has 50 divisions. Some instruments may have main scale markings of 1 mm and 100 divisions on the thimble.

23. What is the pitch of a 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.

24. Define least count of screw gauge.

The least count of a screw gauge is calculated using the formula

$$\text{Least Count} = \frac{\text{Pitch of the Screw Gauge}}{\text{Number of Divisions on the Circular Scale}}$$
$$\text{Least Count} = \frac{0.5\text{mm}}{50} \quad \text{Least Count} = 0.01 \text{ mm or } 0.001 \text{ cm}$$

25. What is zero error in a screw gauge?

Zero error in a screw gauge occurs when the zero of the circular scale does not coincide with the horizontal line of the main scale when the anvil and spindle are fully closed.

26. How can zero error in a screw gauge be identified and corrected?

- If the zero of the circular scale coincides with the horizontal line, there is no zero error.
- If the zero of the circular scale is below the horizontal line, the screw gauge will measure slightly more than the actual thickness. In this case, the zero error is subtracted from the observed measurement.
- If the zero of the circular scale is above the horizontal line, the screw gauge will measure slightly less than the actual thickness. In this case, the zero error is added to the observed measurement.

27. How can the thickness of a steel sheet be measured using a screw gauge?

Suppose a steel sheet is placed between the anvil and spindle, and the position of the circular scale.

- Read the marking on the sleeve just before the thimble.
- Read the circular scale marking that aligns with the main scale.
- The thickness of the steel sheet is calculated as:

$$\text{Thickness} = \text{M.S.R} + (\text{C.S.R} \times \text{Least Count})$$

28. Differentiate between mass and weight.

Mass: Mass is the measure of the quantity of matter in a body. Measured in kilograms (*kg*) or grams (*g*).

Weight: Weight is the force by which a body is attracted toward the Earth. Measured in Newton (*N*).

29. How is mass measured using a physical balance?

The mass of an object is determined by comparing it with known standard masses, a process called weighing. In laboratories, a physical balance is used, which works on the principle of levers.

30. What is a stopwatch?

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

31. What is a measuring cylinder and what is it used for?

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).

32. Explain the human errors, random errors and systematic errors in experiments.

Human Errors: These occur due to personal performance. It caused by limitation of human perception. Its correct measurement needs to line up the eye right in front of the level.

Systematic Errors: Refer to effects that influence all measurements equally, causing a consistent difference in readings. It occur due to a definite rule, such as: Zero error and incorrect marking and it can be reduced by Comparing with a more accurate instrument

Random Errors: It Occur when repeated measurements give different values under the same conditions. It caused by unknown or unpredictable factors such as Temperature, Pressure etc. and it can be reduced by taking several readings and finding the average (mean) value.

33. What is uncertainty in measurement?

Uncertainty is the range of possible error in a measurement, showing how much the measured value may differ from the true value due to limitations of instruments or methods.

34. What are significant figures?

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.

35. What are the rules for determining the number of significant figures in a measurement?

- All digits from 1 to 9 are significant. Example: 345 m has 3 significant figures.
- **Zeros may or may not be significant:**
 - (i) Zero between digits is significant.
 - (ii) Zeros on the left side of a measured value are not significant.
 - (iii) Zeros to the right of a decimal are significant.
- In scientific notation, all digits before the exponent are significant.

Example: In $3.50 \times 10^4 \text{ m}$, all digits (3, 5 and 0) are significant, so the number has 3 significant figures.

36. What is the difference between precision and accuracy in physical measurements?

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

Accuracy of a measurement refers to how close the measured value is to some true value.

37. How do you round off numbers to a specific number of significant figures?

When rounding numbers to a certain number of significant figures, round to the nearest value. If the last digit is more than 5, increase the retained digit by one. If the last digit is less than 5, retain it as it is.

38. What is the rule when rounding numbers that end in 5?

- If the number before the 5 is odd, add 1 to the last digit.
- If the number before the 5 is even, retain the last digit.

EXERCISE

Multiple Choice Questions:

1	The instrument that is most suitable for measuring the thickness of a few sheets of cardboard is:	metre rule	measuring tape	Vernier Callipers	micrometer screw gauge✓
2	One Femtometre is equal to:	10^{-9} m	$10^{-15} \text{ m}✓$	10^9 m	10^{15} m
3	A light year is a unit of:	Light	time	distance✓	speed
4	Which one is a non-physical quantity?	Distance	density	color✓	temperature
5	When using a measuring cylinder, one precaution to take is to:	check for the zero error	look at the meniscus from below the level of the water surface	take several readings by looking from more than one direction	position the eye in line with the bottom of the meniscus✓
6	Volume of water consumed by you per day is estimated in:	Milliliter	litre✓	kilogram	cubic metre
7	A displacement can be used to measure:	mass of a liquid	mass of a solid	volume of a liquid	volume of a solid✓
8	Two rods with lengths 12.321 cm and 10.3 cm are placed side by side, the difference in their lengths is:	2.02 cm	2.0 cm	2 cm	2.021 cm✓
9	Four students measure the diameter of a cylinder with Vernier Callipers. Which of the following readings is correct?	3.4 cm	3.475 cm	3.47 cm ✓	3.5 cm

10	Which of the following measures are likely to represent the thickness of a sheet of this book?	$6 \times 10^{-25} \text{ m}$	$1 \times 10^{-4} \text{ m} \checkmark$	$1.2 \times 10^{-15} \text{ m}$	$4 \times 10^{-2} \text{ m}$
11	In a Vernier Callipers ten smallest divisions of the Vernier scale are equal to nine smallest divisions of the main scale. If the smallest division of the main scale is half millimeter, the Vernier constant is equal to:	0.5 mm	0.1 mm	0.05 mm $\checkmark$	0.001 mm

Exercise Short Questions:

1.1. Can a non-physical quantity can be measured? If yes, then how?

No, Because Non-physical are those quantities that cannot be measured using any tool or instrument. For example Love, Fear etc. cannot be measured using any tool.

1.2. What is measurement? Name its two parts.

See Q# 4.

1.3. Why do we need a standard unit for measurements?

These units helps to measure things correctly and equally.

1.4. Write the name of three base quantities and 3 derived quantities.

Base Quantities: length, mass, time Derived quantities: force, area, volume

1.5. Which SI unit will you use to express height of your desk?

Metre (m) or its sub-multiples e.g., centimeters, cm use to express the height of desk.

1.6. Write the name and symbols of all SI base units.

See Q# 8.

1.7. Why prefixes is used? Name 3 multiples and 3 submultiples prefixes with their symbols.

See Q# 9.

1.8. What is meant by: (a) 5 pm (b) 15 ns (c) 6 μm (d) 5 fs

5 picometres = $5 \times 10^{-12} \text{ m}$

15 nanoseconds = $15 \times 10^{-9} \text{ s}$

6 micrometres = $6 \times 10^{-6} \text{ m}$

5 femtoseconds = $5 \times 10^{-15} \text{ s}$

1.9. (a) for what purpose, a Vernier Callipers is used? (b) Name its two main parts. (c) How is least count found?

(d) What is meant by zero error?

(a) See Q# 14.

(b) Main scale and Vernier Scale

(c) See Q# 17.

(d) See Q# 19.

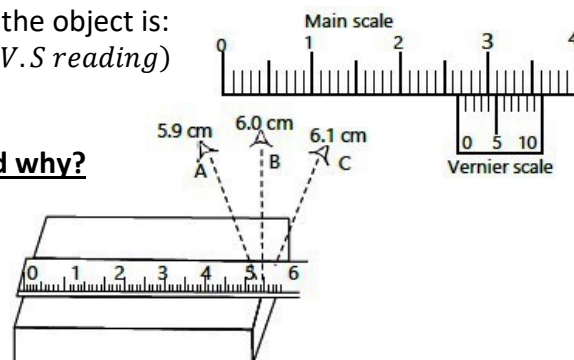
1.10. State least count and Vernier scale reading as shown in the figure and hence, find the length.

The least count of Vernier Callipers is 0.01 cm. The main scale reading before the zero of the Vernier scale is 2.6 cm and the Vernier scale reading is 4 as shown in figure, then length of the object is:

$$\begin{aligned} \text{Length} &= \text{M.S reading} + (\text{L.C} \times \text{V.S reading}) \\ &= 2.6 + (0.01 \times 4) \\ &= 2.64 \text{ cm} \end{aligned}$$

1.11. Which reading out of A, B and C shows the correct length and why?

B is the correct reading because it minimizes parallax error and aligns accurately with the scale.



Constructed Response Questions:

1.1 In what unit will you express each of the following?

- (a)** Thickness of a five rupee coin: (millimeter)
- (b)** Length of a block: (centimeter)
- (c)** Length of football field: (meter)
- (d)** The distance between two cities: (Kilometer)
- (e)** Mass of five rupee coin: (gram)
- (f)** Mass of your school bag: (Kilogram)
- (g)** Duration of your class period: (minutes)
- (h)** Volume of petrol filled in the tank of a car: (litre)
- (i)** Time to boil one litre milk: (minutes)

1.2 Why might a standard system of measurement be helpful to a tailor?

A standard system of measurement is helpful to a tailor so they can communicate easily and ensure accuracy in measurement.

1.3 The minimum main scale reading of a micrometer screw gauge is 1 mm and there are 100 divisions on the circular scale. When thimble is rotated once, 1 mm is its measurement on the main scale. What is the least count of the instrument? The reading for thickness of a steel rod as show in the figure. What is the thickness of the rod?

Least count of screw gauge = 0.01mm

Thickness of steel rod = Main Scale reading + Circular scale reading $\times$ 0.01mm

1.4 You provide a meter scale and a bundle of pencils; how can the diameter of a pencil be measured using the meter scale with the same precision as that of Vernier Callipers? Describe briefly.

Place 10 or 20 pencils side by side tightly. Measure the total width with the meter scale, then divided by the number of pencils to get the diameter of one. This minimize the zero error and least count limitations, just like Vernier Callipers use multiple divisions for precision.

1.5 The end of a meter scale is worn out. Where will you place a pencil to find the length?

Start measuring from a point where the scale is still clear. It will give accurate measurement.

1.6 Why is it better to place the object close to the meter scale?

It helps us to see the measurement more clearly and it is easy to read.

1.7 Why a standard unit is needed to measure a quantity correctly?

Because it ensures consistency, accuracy and clear communication.

1.8 Suggest some natural phenomena that could serve as a reasonably accurate time standard.

Earth rotation, Earth revolution around the Sun, Lunar phase.

1.9 It is difficult to locate the meniscus in a wider vessel. Why?

Because it makes curve harder to see clearly and accurately.

1.10 Which instrument can be used to measure: (a) Internal diameter of a test tube (b) depth of a beaker?

- (a) Vernier Calliper using its inner jaws
- (b) Depth gauge or the depth rod of Vernier Callipers

CH #2: KINEMATICS

1. What is Mechanics?

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

2. What are the branches of Mechanics?

Kinematics: The study of motion without referring to forces.

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

3. Define scalar and vector quantities.

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

Scalars can be added like numbers. **Examples:** distance, length, time, speed, energy, temperature.

Vector Quantity: A vector is that physical quantity which needs magnitude as well as direction to describe it completely. Vectors cannot be added like scalars; their directions must be considered. **Examples:** displacement, velocity, acceleration, weight, force.

4. How is a vector represented symbolically?

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.

5. How can a vector be represented graphically?

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.

6. What is a 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.

7. State head-to-tail rule for addition of vectors.

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.

8. What is difference between rest and motion?

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

Example: A motorcyclist standing on the road.

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

Example: A moving motorcyclist.

9. What are the different types of motion?

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. **Example:** the motion of a train or a car.

Rotatory Motion: If each point of a body moves around a fixed point (axis), the motion of this body is called rotatory motion. **Example:** the motion of an electric fan or a spinning top.

Vibratory Motion: When a body repeats its to and fro motion about a fixed position, the motion is called vibratory motion. **Example:** a swing in a children's park.

10. What are the types of translatory motion?

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

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

Example: the motion of a bee.

Circular Motion: The motion of a body along a circle is called circular motion. **Example:** a Ferris wheel or a ball tied to a string and whirled in a circle.

11. What is the difference between distance and displacement?

Distance: The distance is the length of the actual path of the motion. Distance is a scalar quantity.

Displacement: The shortest distance between the initial and final positions of a body is called its displacement. Displacement is a vector quantity.

12. What is speed? Write its formula and SI unit.

Speed is the distance covered in unit time. It tells us how fast a body is moving. Speed is a scalar quantity

Formula: Speed = Distance/time or $V = S/t$, **Unit:** ms^{-1} or kmh^{-1} .

13. Differentiate between instantaneous speed and average speed.

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.

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

Average Speed = Total Distance Covered / Total time taken or $V_{av} = S/t$

14. What is velocity? Write its formula and SI unit.

Velocity is the net displacement of a body in unit time. It is a vector quantity, meaning it has both magnitude and direction. **Formula:** Average Velocity= Displacement/ time or $V_{av}=d/t$ **Unit:** ms^{-1} or kmh^{-1} .

15. What is uniform and non-uniform velocity?

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

Example: the downward motion of a paratrooper is uniform velocity.

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

16. What is acceleration?

Acceleration is defined as the time rate of change of velocity. It is a vector quantity, meaning its direction is the same as that of the change in velocity.

17. What is average acceleration?

If a body is moving with an initial velocity V_i and after some time t , its velocity changes to V_f , then the change in velocity is $\Delta v = v_f - v_i$

Average acceleration= Change in Velocity/Time Taken or $\alpha_{av}=V_f - V_i / t$ or $\alpha_{av}=\Delta v/t$ **Unit:** ms^{-2}

18. What are the types of acceleration?

Positive Acceleration: If the velocity is increasing, the acceleration is positive. **Example:** when a car overtakes another vehicle, it accelerates to a greater velocity.

Negative Acceleration (Deceleration or Retardation): If the velocity is decreasing, the acceleration is negative.

Example: when brakes are applied to slow down a bicycle or a car, the velocity decreases.

19. What is uniform and non-uniform acceleration?

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

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

20. What is a 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.

21. How variables are assigned to the axes?

Normally, the independent quantity is taken along the *x-axis*, and the dependent variable quantity along the *y-axis*.

22. What is a distance-time graph?

A distance-time graph shows the relation between distance (S) and time (t) taken by a moving body.

23. What does a straight-line distance-time graph indicate?

A straight-line distance-time graph indicates that the body is moving with uniform speed, covering equal distances in equal time intervals.

24. What is meant by the 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.

25. What is a speed-time graph?

A speed-time graph shows the relationship between speed (v) and time (t) taken by a moving body.

26. What is meant by the gradient of a speed-time graph?

In a speed-time graph, the gradient is equal to the average acceleration of the body.

27. What is Area under speed-time graph?

The area under the speed –time graph up to the time axis is numerically equal to the distance covered by the objects.

28. Write the three equations of motion.

$$v_f = v_i + at$$

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$$S = v_i t + \frac{1}{2} a t^2$$

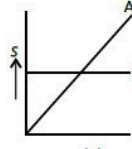
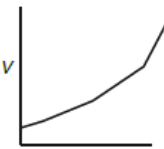
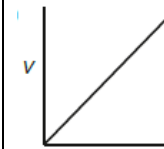
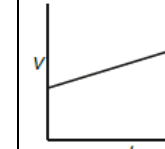
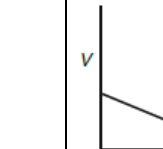
$$2aS = v_f^2 - v_i^2$$

29. What is gravitational acceleration?

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 . The direction of gravitational acceleration is downwards. Its value is 9.8 ms^{-2} .

EXERCISE

Multiple Choice Questions:

1	The numerical ratio of displacement to distance is:	always less than one	always equal to one	always greater than one	equal to or less than one✓
2	If a body does not change its position with respect to some fixed point, then it will be in a state of:	rest✓	motion	uniform motion	variable motion
3	A ball is dropped from the top of a tower, the distance covered by it in the first second is:	5 m ✓	10 m	50 m	100 m
4	A body accelerates from rest to a velocity of 144 kmh^{-1} in 20 seconds. The distance covered by it is:	100 m	400 m ✓	1400 m	1440 m
5	A body is moving with constant acceleration starting from rest. It covers a distance S in 4 seconds. How much time does it take to cover one-fourth of this distance?	1 s	2 s ✓	4 s	16 s
6	The displacement time graphs of two objects A and B are shown in the figure. Point out the true statement from the following: 	The velocity of A is greater than B✓	The velocity of A is less than B	The velocity of A is equal to that of B	The graph gives no information in this regard
7	The area under the speed-time graph is numerically equal to:	Velocity	uniform velocity	acceleration	distance covered✓
8	Gradient of the speed-time graph is equal to:	Speed	velocity	acceleration✓	distance covered
9	Gradient of the distance-time graph is equal to the:	speed✓	velocity	distance covered	acceleration
10	A car accelerates uniformly from 80.5 Kmh^{-1} at $t = 0$ to 113 Kmh^{-1} at $t=9\text{s}$. Which graph best describes the motion of the car?			 ✓	

Exercise Short Questions:

2.1. Define scalar & vectors quantities.

See Q# 3.

2.2. Give 5 examples of scalar and vector quantities.

Scalar: Mass, length, time, speed, volume, energy. **Vector:** Velocity, displacement, force, momentum, torque.

2.3. Define Head to tail rule of vector addition.

See Q# 7.

2.4. What are distance-time graph and speed-time graph?

See Q# 22 and 25.

2.5. Falling object near the earth have the same constant acceleration. Does this imply that a heavier object will fall faster than a lighter object?

No, heavier object does not fall faster than a lighter object.

Reason: Near earth's surface all objects feels the same gravitational acceleration (i.e. 9.8 ms^{-2}).

2.6. The vector quantities are sometimes written in scalar notation (not bold face). How is the direction indicated?

The direction of these vectors is shown by a small arrow above them i.e. $\vec{A}$, $\vec{v}$

2.7. A body is moving with uniform speed. Will its velocity be uniform? Give reason.

No, because speed is a scalar quantity that has only magnitude. While velocity is a vector quantity that has both magnitude and direction.

2.8. Is it possible for a body to have acceleration? When moving with: (i) constant velocity (ii) constant speed

(i) No, the body will not have acceleration, because the rate of change of velocity is called acceleration.

(ii) Yes, the body can have acceleration if it moves on a circular track.

Constructed Response Questions:

2.1. Distance and displacement may or may not be equal in magnitude. Explain this statement.

They are equal only when motion is in a straight line without changing direction.

They are not equal when the path is curved, zigzag or involves turning back.

2.2. When a bullet is fired, its velocity with which it leaves the barrel is called the muzzle velocity of the gun.

The muzzle velocity of one gun with a longer barrel is lesser than that of another gun with a shorter barrel. In which gun is the acceleration of the bullet larger? Explain your answer.

The gun with shorter barrel has a larger acceleration of the bullet.

Reason: This is because the bullet in the shorter barrel achieves a higher muzzle velocity within that shorter distance, implying a greater rate of change of velocity (acceleration).

2.3. For a complete trip, average velocity was calculated. Its value came out to be positive. Is it possible that its instantaneous velocity at any time during the trip had the negative value? Give justification of your answer.

Yes, at any instant, instantaneous velocity can be negative when the body temporarily reverse its direction.

2.6. Is it possible that the velocity of an object is zero at an instant of time, but its acceleration is not zero? If yes, give an example of such a case.

Yes it is possible. For example, when an object is thrown vertically upwards, its velocity becomes zero momentarily at the highest point, but the acceleration due to gravity is still acting on it.

CH #3: DYNAMICS

1. Define dynamics?

Dynamics deals with the forces that produce changes in the motion of bodies.

2. Define force?

A force is a push or pull that can start, stop, or change the magnitude and direction of a body's velocity.

Example: opening a door (pushing or pulling), lifting and moving a wheelbarrow.

3. What are contact and non-contact forces?

Contact Forces: A contact force is a force that is exerted by one object on the other at the point of contact.

Applied forces (push, pull, and twist) are contact forces.

Non-contact Forces: The force between two objects which are not in physical contact. The non-contact forces can work from a distance, and there is always a field linked with a non-contact force. Due to this property, non-contact forces are also called field forces.

4. Define some Contact Forces?

Friction: It is the force that resists motion when the surface of one object comes in contact with the surface of another.

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.

Thrust: It is an upward force exerted by a liquid on an object immersed in it.

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.

Air Resistance: It is the resistance (opposition) offered by air when an object falls through it.

Tension Force: It is the force experienced by a rope when a person or load pulls it.

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.

5. Define some Non-Contact Forces?

Gravitational Force: It is an attractive force that exists among all bodies which have mass. **Example:** when an apple falls from a tree, it is the gravitational force of the Earth that pulls it downward. The gravitational force is given by Newton's Law of Gravitation:

$$F = G \frac{m_1 m_2}{r^2} \quad \text{Where } G = 6.673 \times 10^{-11} \text{ Nm}^2\text{Kg}^{-2} \text{ is the gravitational constant.}$$

Electrostatic Force: An electrostatic force acts between two charged objects. Opposite charges attract each other and similar charges repel each other.

Magnetic Force: It is a force which a magnet exerts on other magnets and magnetic materials like iron, nickel, and cobalt. Magnetic force between the poles of two magnets can be either attractive or repulsive.

Strong and Weak Nuclear Forces: These are non-contact forces acting between the subatomic particles inside the nucleus of an atom.

6. What are the four fundamental forces in nature?

Gravitational Force: The gravitational force is an attractive force that exists between all objects with mass.

Although it is the weakest among the four fundamental forces. **Example:** it is the force that pulls an apple to the ground and keeps planets in orbit around the Sun.

Electromagnetic Force: The electromagnetic force causes the interaction between electrically charged particles. It is a long-range force and is much stronger than gravitational and weak nuclear forces. **Example:** A moving magnet produces an electric current.

Strong Nuclear Force: The strong nuclear force is the strongest of the four forces but acts only over a very short range (10^{-14} meters). It holds the atomic nucleus together by binding protons and neutrons.

Weak Nuclear Force: The weak nuclear force is responsible for certain types of nuclear reactions. The weak nuclear force has a short range (10^{-17} meters). It is stronger than gravitational force but weaker than the electromagnetic force.

7. What is Unification of Weak Nuclear and Electromagnetic Forces?

In 1979, Dr. Abdus Salam (a Pakistani scientist), along with Sheldon Glashow and Steven Weinberg, received the Nobel Prize in Physics for their work on the unification of the weak nuclear force and the electromagnetic force into a single framework called the electroweak force.

8. What are free body diagrams?

Free-body diagrams are used to show the relative magnitudes and directions of all the forces acting on an object in a given situation. In other words, a free-body diagram is a special example of the vector diagrams.

9. State 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."

Example: A book placed on a table remains there unless a force is applied to move it. A ball rolling on the floor should continue to move with the same velocity in the absence of an applied force.

10. Define Force according to First Law of Motion.

Force is an agency which changes or tends to change the state of rest or of uniform motion of a body.

11. Define inertia.

The property of a body to maintain its state of rest or of uniform motion in a straight line is called inertia.

12. Why Newton's First Law of Motion is sometimes called the Law of Inertia?

Because it describes how objects resist changes in their state of motion unless acted upon by an external force.

13. State Newton's Second Law of Motion.

"If a net external force acts upon a body, it accelerates the body in the direction of force. The magnitude of acceleration is directly proportional to the magnitude of force and is inversely proportional to the mass of the body." **Mathematically:** $a = (\text{constant}) \frac{F}{m}$

14. Define Newton.

One newton is the force which produces an acceleration of 1 ms^{-2} in a body of mass 1 Kg.

From equation $F = ma$ $1\text{N} = 1 \text{ kg} \times 1 \text{ ms}^{-2}$

15. What is the effect of force on velocity according to Newton's second law?

According to Newton's second law, a force can change the velocity of a body by producing acceleration or deceleration.

16. State Newton's Third Law of Motion.

Newton's Third Law of Motion: For every action, there is always an equal and opposite reaction.

Example: when we press a spring, the force applied by our hand on the spring is the action. The spring pushes back on our hand with an equal and opposite force, which is the reaction.

17. What are the limitations of Newton's Laws of Motion?

Newton's laws of motion are not exact for all types of motion but offer a good approximation for most practical situations, except when an object is very small or moving near the speed of light.

18. What is difference between mass and weight?

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. It is a scalar quantity. Mass remains constant everywhere. The SI unit of mass is kilogram (kg).

Weight: The weight of an object is equal to the force with which the Earth attracts the body towards its center. It is a vector quantity. Weight varies with the gravitational field. The SI unit of weight is newton (N).

19. What is a gravitational field?

The gravitational field is the space around a mass where another mass experiences a force due to gravitational attraction.

20. What is gravitational field strength?

The gravitational field strength is defined as the gravitational force acting on a unit mass.

21. What is a mechanical balance?

A mechanical balance consists of a rigid horizontal beam that oscillates on a central knife edge acting as a fulcrum. It has two end knife edges equidistant from the center. Two pans are suspended from the bearings on these knife edges.

22. What is Mechanical platform balances?

A type of mechanical balance is used for weighing heavy items such as flour bags, cement bags, and steel bars.

23. What is an electronic balance?

An electronic balance does not require standard weights for measurement. It only needs to be connected to a power supply. Some models can also operate using dry cell batteries.

24. What is a force meter?

A force meter is a scientific instrument used to measure force. It is also called a newton meter or a spring balance. Digital force meters are now available for more precise measurements.

25. Why does a cricket ball stop moving after being hit by a bat?

When a cricket ball is hit, it moves with a high velocity. According to Newton's first law of motion, it should continue moving at a constant velocity. However, due to friction between the ball and the ground, the ball gradually slows down and stops.

26. What is 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.

27. Give an examples of energy dissipation due to friction.

Rubbing Hands: When we rub our hands together, heat is produced due to friction, making them warm.

28. What is the Sliding friction and its types?

The friction between two solid surfaces is called sliding friction.

Static Friction: The resisting force between the two surfaces before the motion starts is called the static friction.

Kinetic Friction: The friction during motion is called kinetic friction.

29. Define terminal velocity of an object.

Terminal velocity is the constant velocity an object attains when the upward force of air resistance balances the downward force of gravity, causing the object to stop accelerating and continue falling at a steady speed.

30. What is rolling friction?

Rolling friction occurs when an object rolls over a surface.

31. Why rolling friction is smaller than sliding friction?

Rolling friction is about one hundred times smaller than sliding friction because the body touches the surface only at a point and does not slide.

32. What are the methods to reduce friction?

- The parts which slide against each other are highly polished.
- Since the friction of liquids is less than that of solid surfaces, oil or grease is applied between the moving parts of the machinery.
- 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.
- 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.

33. Define momentum.

The momentum of a moving body is the product of its mass and velocity. **Mathematically:** $p = m \times v$
Momentum is a vector quantity, and its SI unit is kgms^{-1} or Ns .

34. Define Newton's Second Law in Terms of Momentum.

The rate of change of momentum of a body is equal to the force acting on it.

35. Define impulse of force.

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

36. State the 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.

Total momentum of the system before collision = Total momentum of the system after collision

$$m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$$

37. Where the principle of conservation of momentum is applicable?

The principle of conservation of momentum is applicable not only to macro-objects but also for micro-objects like atoms and molecules.

EXERCISE**Multiple Choice Questions:**

1	When we kick a stone, we get hurt. This is due to:	Inertia	velocity	momentum	reaction✓
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2	An object will continue its motion with constant acceleration until:	The resultant force on it begins to decrease.	The resultant force on it is zero. ✓	The resultant force on it begins to increase.	The resultant force is at right angle to its tangential velocity.
3	Which of the following is a non-contact force?	Friction	Air resistance	Electrostatic force ✓	Tension in the string
4	A ball with initial momentum p hits a solid wall and bounces back with the same velocity. Its momentum p' after collision will be:	$p' = p$	$p' = -p$ ✓	$p' = 2p$	$p' = -2p$
5	A particle of mass m moving with velocity v collides with another particle of the same mass at rest. The velocity of the first particle after collision is:	v	$-v$	0 ✓	$-\frac{1}{2}$
6	Conservation of linear momentum is equivalent to:	Newton's first law of motion	Newton's second law of motion	Newton's third law of motion ✓	None of these
7	An object with mass 5 kg moves at constant velocity of 10 ms^{-1} . A constant force acts for 5 s and gives it a velocity of 2 ms^{-1} in opposite direction. Force acting is:	5 N	-10 N	-12 N ✓	-15 N
8	A large force acts on an object for a short time. In this case, It is easy to determine:	magnitude of force	time interval	product of force and time ✓	none of these
9	A lubricant is usually introduced between two surfaces to decrease friction. The lubricant:	decreases temperature	acts as ball bearings	prevents direct contact of the surfaces ✓	provides rolling friction

Exercise Short Questions:**3.1. What kind of changes in motion maybe produced by a force?**

A force can change speed, direction and state of an object.

3.2. Give 5 examples of contact forces.

(i) Friction (ii) drag (iii) thrust (iv) Air resistance (v) elastic force

3.3. An object moves with constant velocity in free space. How long will the object continue to move with this velocity?

The object will move with constant velocity indefinitely or forever

3.4. Define impulse of a force.

See Q# 35.

3.5. Why has not Newton's first law been proved on Earth?

Because friction and resistance are always present on earth, so Newton's 1st law has not been proved on earth.

3.6. When sitting in the car which suddenly accelerates from rest, you are pushed back into the seat. Why?

It is due to inertia, as our body resists the change in motion and tends to remain at rest.

3.7. The force expressed in Newton's second law is a net force. Why is it so?

Yes, as net force is the sum of all forces acting on body. So it is important to consider net forces.

3.8. How can you show that rolling friction is lesser than sliding friction?

See Q# 31.

3.9. Define terminal velocity of an object.

See Q# 29.

3.10. An astronaut walking in space wants to return to his spaceship by firing a hand rocket. In what direction does he fire the rocket?

As according to Newton's third law of motion, so astronaut will fire rocket in opposite direction to the spaceship.

Constructed Response Questions:**3.1. Two ice skaters weighing 60kg and 80 kg push off against each other on a frictionless ice track. The 60 kg skater gains a velocity of 4ms^{-1} considering all the relevant calculations involved, explain how Newton's third law applies to this situation.**

Newton's third law state that for every action, there is an equal and opposite reaction. When the skater of mass 60kg applies a force on the skater of mass 80kg. The 80kg skater applies an equal and opposite force on the 60kg skater.

Mass of 1st person = $m_1 = 60\text{ kg}$

Velocity of 1st person = $v_1 = 4\text{ms}^{-1}$

Mass of 2nd person = $m_2 = 80\text{ kg}$

Velocity of 2nd person = $v_2 = ?$

$$m_1v_1 + m_2v_2 = 0 \Rightarrow m_2v_2 = -m_1v_1$$

$$v_2 = -m_1v_1/m_2 = -60/80 \times 4 = -3\text{ms}^{-1}$$

The negative sign shows that the other person pushes in the opposite direction

3.2. Inflatable air bags are installed in the vehicles as safety equipment. In terms of momentum, what is the advantage of air bags over seat belts?

Airbags reduces the risk of injury in accidents because they increase the time taken by humans inside to come to zero momentum and decreases the force that act on them.

3.3. A horse refuses to pull a cart. The horse argues, "according to Newton's third law, whatever force I exert on the cart, the cart will exert an equal and opposite force on me. Since the net force is zero, therefore I have no chance of acceleration (pulling) the cart." What is wrong with this reasoning?

The horse's argument is wrong. Because it ignores the ground force that helps it move forward.

3.4. When a cricket ball hits high, a fielder tries to catch it. While holding the ball he/she draws hands backward. Why?

The fielder pulls the hands back to reduce the ball's impact and prevent injury.

3.5. When someone jumps from a small boat onto the river bank, why does the jumper often fall into the water? Explain.

When a person jumps on the bank of a river that boat moves backward. As the person jumps forward, he loses his balance and falls into the water.

3.6. Imagine that if friction vanishes suddenly from everything, then what could be the scenario of daily life activities.

(1) We cannot walk or run. (2) Bikes, cars etc. cannot start or stop.

CH #4: TURNING EFFECTS OF FORCE**1. Define Parallel forces.**

All those forces which act parallel to one another are known as parallel forces.

2. Define like and unlike parallel forces.

Like Parallel forces: If the parallel forces are acting in the same direction, then they are called like parallel forces.

Unlike parallel forces: If their directions are opposite to one another, they are called unlike parallel forces.

3. What is a 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.

4. What is the axis of rotation?

During rotation, all the particles of the rigid body rotate along fixed circles. The straight line joining the centers of these circles is called the axis of rotation.

5. What is the line of action of a force?

The line along which the force acts is called the line of action of the force.

6. What is a 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.

7. What is the turning effect of a force?

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

Example: When we open or close a door, we apply force. This force rotates the door about its hinge.

8. Write the factors on which turning effect depends.

- The greater the force (**magnitude**), the greater is its turning effect.
- The larger the perpendicular **distance** of the force from the axis of rotation, the greater is its turning effect.

9. What is meant by the 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: $\tau = F \times l$

Unit: Newton metre (*Nm*).

10. When did Torque of force is Zero?

The torque of a force is zero when the line of action of the force passes through the axis of rotation, because its moment arm becomes zero.

11. What is positive and negative torque?

The torque is **positive** if the force tends to produce an anticlockwise rotation about the axis, and it is taken as **negative** if the force tends to produce a clockwise rotation.

12. What is a couple?

When two equal and opposite parallel forces act at two different points of the same body, they form a couple.

Examples: opening or closing a water tap, turning a key in a lock etc.

13. How is a force resolved into its components?

By the head-to-tail rule, two or more vectors can be added to form a resultant vector. The reverse process is also possible, where a given vector can be divided into two or more parts, called its **components**. The process of dividing a force into its components is known as the resolution of a force.

Horizontal components F_x : $F_x = F \cos \theta$ **Vertical components F_y :** $F_y = F \sin \theta$

14. How we determine a force from its perpendicular components?

$$F = \sqrt{F_x^2 + F_y^2}$$

The direction of **F**

$$\tan \theta = \frac{F_y}{F_x} \quad \text{or} \quad \theta = \tan^{-1} \left(\frac{F_y}{F_x} \right)$$

15. State the principle of moments.

When a body is in balanced position, the sum of clockwise moments about any point equals the sum of anticlockwise moments about that point.

16. What is meant by the center of gravity of a body?

Center of gravity is that point where total weight of the body appears to be acting.

17. What is meant by the center of mass?

The center of mass of a body is that point where the whole mass of the body is assumed to be concentrated.

18. What is meant by equilibrium? Explain its types.

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

There are two types of equilibrium:

Static Equilibrium: A body at rest is said to be in static equilibrium. **Example:** a book lying on a table, an electric bulb hanging from the ceiling of a room.

Dynamic Equilibrium: A body moving with uniform velocity is said to be in dynamic equilibrium. A good example is a paratrooper.

19. What is the 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:** $F = 0$ or $\sum F = 0$

20. What is the Second Condition of Equilibrium?

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

21. What are the steps to solve problems using the conditions of equilibrium?

To solve problems by applying the conditions of equilibrium, the following steps should be followed:

- Select the object(s).
- Draw a diagram.
- Choose a set of x and y axes.
- Resolve all the forces.
- Apply the first condition of equilibrium.
- If necessary, apply the second condition of equilibrium using.

22. Define the three states of equilibrium.

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.

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.

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

23. How can the stability of an object be improved?

Stability of an object depends on the position of its center of gravity.

24. What is centripetal force?

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

Example: Washing machine dryer, cream separator etc.

EXERCISE

Multiple Choice Questions:

1	A particle is simultaneously acted upon by two forces of 4 and 3 newtons. The net force on the particle is:	1 N	between 1 N and 7 N ✓	5 N	7 N
2	A force F is making an angle of 60° with x -axis. Its y -component is equal to:	F	$F \sin 60^\circ$ ✓	$F \cos 60^\circ$	$F \tan 60^\circ$
3	Moment of force is called:	moment arm	Couple	couple arm	torque ✓
4	If F_1 and F_2 , are the forces acting on a body and τ is the torque produced in it, the body will be completely in equilibrium, when:	$\sum F = 0$ and $\sum \tau = 0$ ✓	$\sum F = 0$ and $\sum \tau \neq 0$	$\sum F \neq 0$ and $\sum \tau = 0$	$\sum F \neq 0$ and $\sum \tau \neq 0$

5	A Shopkeeper sells his articles by a balance having unequal arms of the pans. If he puts the weights in the pan having shorter arm, then the customer:	loses✓	gains	neither loses nor gains	not certain
6	A man walks on a tight rope. He balances himself by holding a bamboo stick horizontally. It is an application of:	law of conservation of momentum	Newton's second law of motion	principle of moments✓	Newton's third law of motion
7	In stable equilibrium the center of gravity of the body lies:	at the highest position	at the lowest position✓	at any position	outside the body
8	The center of mass of a body:	lies always inside the body	lies always outside the body	lies always on the surface of the body	may lie within, outside or on the surface✓
9	A cylinder resting on its circular base is in:	stable equilibrium✓	unstable equilibrium	neutral equilibrium	none of these
10	Centripetal force is given by:	rF	$rF \cos \theta$	$\frac{mv^2}{r}$ ✓	$\frac{mv}{r}$

Exercise Short Questions:**4.1. Define Like and unlike parallel forces.**

See Q# 2.

4.2. What are rectangular components of a vector (or force) and their values?

The components of a vector which are perpendicular to each other are called rectangular components.

$$F_x = F \cos \theta \quad F_y = F \sin \theta$$

4.3. What is line of action of a force?

See Q# 5.

4.4. Define moment arm of force. Prove that $\tau = rF \sin \theta$. Where θ is angle between r and F .

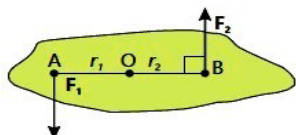
The product of force and its perpendicular distance from the axis of rotation is called moment of force.

Proof:

$$\tau = F \times l$$

$$\tau = F \sin \theta \times r \quad (\text{where } l = r \sin \theta)$$

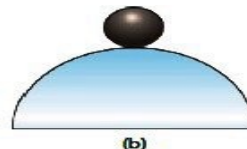
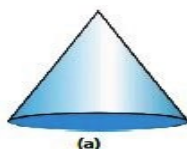
$$\tau = rF \sin \theta$$

4.5. With the help of a diagram, show that the resultant force is zero but the resultant torque is not zero.

Yes, it is possible the resultant force is zero but the resultant torque is not zero. They can occur when forces do not lie along the same line and cause rotation.

4.6. Identify the state of equilibrium in each case in the figure given below.

- (a) This object is in stable equilibrium.
 (b) This object is in unstable equilibrium.
 (c) This object is in neutral equilibrium.

**4.7. Give an example of the body which is moving yet in equilibrium.**

A paratrooper falling at constant velocity is in equilibrium.

4.8. Define center of mass and center of gravity of a body.

See Q# 16, 17.

4.9. What are two basic principles of stability physics which are applied in designing balancing toys and racing cars?

- Lowering the center of gravity
- Widening the base area

4.10. How can you prove that the centripetal force always acts perpendicular to velocity?

A body moves on a circular path only if a force acts on it perpendicular to its velocity. This force is always directed towards the center of the circle.

Constructed Response Questions:**4.1. A car travels at the same speed around two curves with different radii. For which radius the car experiences more centripetal force? Prove your answer.**

Because $F_c = mv^2/r$. Here centripetal force and radius are inversely proportional. Therefore the car experiences more centripetal force on the curve with the smaller radius.

4.2. A ripe mango does not normally fall from the tree. But when the branch of tree is shaken, the mango falls down easily. Can you tell the reason?

When the branch of a tree is shaken, a ripe mango falls because the stem becomes loose and earth's gravity pulls it down.

4.3. Discuss the concept of stability and center of gravity in relation to objects toppling over. Provide an example where an object's center of gravity affects in stability, and explain how altering its base of support can influence stability.

The balance of objects depends on their center of gravity and the support of their bases. If the center of gravity is low and lies within the base, the objects can move with great stability. **Example:** A narrow glass is less stable compared to a wide based bowl, because when it tilts, its center of gravity moves outside the base.

4.4. Why an accelerated body cannot be considered in equilibrium?

Because a net force is acting on it, causing a change in its velocity.

4.5. Two boxes of the same weight but different heights are lying on the floor of a truck. If the truck make sudden stop, which box is more likely to tumble over? Why?

A taller container is more likely to tip over because its center of gravity provides it with less stability.

CH #5: WORK, ENERGY AND POWER**1. Define work.**

Work is defined as the product of the magnitude of force and the distance covered in the direction of force.

Mathematically: Work = Force x Distance or $W = F \times S$

2. When is work done zero?

- If force is applied but no displacement occurs (e.g. pushing a wall that does not move), no work is done.
- If a force acting on the body is zero and the body is moving with uniform velocity, work will be zero.

3. What will be the work done when a force is acting on a body making an angle θ with the direction of motion?

When a force acts at an angle θ with the direction of motion, only the horizontal component of the force in the direction of motion does the work. This component is $F \cos \theta$. $W = FS \cos \theta$

Special cases:

If $\theta = 0^\circ$, then $\cos 0^\circ = 1$, so $W = FS$. Work is maximum.

If $\theta = 90^\circ$, then $\cos 90^\circ = 0$, so $W = 0$. No work is done.

4. What is the SI unit of work and defined it?

The SI unit of work is joule (J).

Joule: 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: **1J=1NM**, Bigger units of work $1 \text{ kJ} = 10^3 \text{ J}$ and $1 \text{ MJ} = 10^6 \text{ J}$.

5. What is energy?

Energy can be defined as the ability of a body to do work.

6. What is the SI unit of energy?

Energy, like work, is a scalar quantity. The SI unit of energy is the joule (J).

When one joule of work is done on a body, the amount of energy spent is one joule.

7. What are the basic forms of energy and define mechanical energy?

There are two basic forms of energy: Kinetic energy and Potential energy.

The combination of kinetic energy and potential energy is called mechanical energy.

8. What is kinetic energy?

Kinetic energy of a body is the energy that a body possesses by virtue of its motion. $E_k = \frac{1}{2}mv^2$

9. What is Potential Energy?

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

10. What are the different forms of potential energy?

There are many forms of potential energy. Some of the important ones are:

Gravitational Potential Energy: The energy possessed by an object due to its position relative to the Earth.

Elastic Potential Energy: The energy stored in a compressed or stretched spring.

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.

Thermal (Internal) Energy: This is the energy released by burning fossil fuels through chemical reactions.

Nuclear Energy: The energy stored in the nucleus of an atom.

11. What is meant by the 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.

12. What are Sources of Energy?

Sources of energy are the origins from which energy is obtained to perform various forms of work. These sources can be renewable or non-renewable.

13. What is Fossil Fuel Energy?

Fossil fuel energy comes out from burning of oil, coal and natural gas. These materials are known as fossil fuels.

14. What is Hydroelectric Energy?

Hydroelectric generation is the electricity generated from the power of falling water.

15. What is Solar Energy and how is it used?

Sun is the biggest source of energy. The energy obtained from sunlight is referred to as solar energy.

Uses of Solar Energy: Solar energy can be used in two ways. Heating System and Electricity Generation.

16. What is solar cell?

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

17. What is 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.

17. What is Nuclear Energy?

Nuclear energy is the heat energy released when the nucleus of an atom (e.g., uranium or plutonium) splits in a process called nuclear fission.

19. What is Geothermal Energy?

Geothermal energy is the heat energy of the hot rocks present deep under the surface of the Earth.

20. What is Wind Energy?

Wind energy is the electrical energy produced by using the kinetic energy of the fast- blowing wind.

21. What is 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.

22. What is Wave Energy and how can it be harnessed?

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

The method to harness wave energy is to use large floats which move up and down with the waves. One such device invented by Prof. Salter is known as Salter's duck.

23. What is Salter's duck?

It consists of two parts: Duck float and Balanced float.

The energy of the water waves causes duck float to move relative to the balance float. The relative motion of the duck float is used to drive the electricity generators.

24. What is Biofuel Energy?

It is that energy which is obtained from the biomass. Biomass consists of organic materials such as plants, waste foods, animals dung, sewage, etc.

25. Describe digester process and use of biogas.

The rotting of biomass in a closed tank called a 'digester' produces methane rich biogas. In this process, micro-organisms break down biomass material in the absence of oxygen. Biogas produced in the tank is piped out and can be used for heating and cooking like natural gas.

26. What is biofuel?

Biofuel such as ethanol (alcohol) can also be obtained from the biomass. It is a replacement of petrol. In this case, bacteria converts it into ethanol.

27. Differentiate between renewable and non-renewable sources of energy.

Renewable: The resources of energy which are replaced by new ones after their use are called renewable energy sources. Sources such as hydroelectricity, solar energy, wind energy, tidal energy, wave energy and geothermal energy are renewables.

Non-renewable: Non-renewable sources are those, which are depleted with the continuous use. Non-renewable sources include fossil fuels (coal, oil, natural gas) and nuclear energy.

28. What are the advantages and disadvantages of methods of energy production?

Advantages:

- The production of hydroelectric power is more economical and pollution free.
- The solar power, wind, tidal and wave power need more initial cost but do not produce pollution and are also economical as well.

Disadvantages:

- Power generation by fossil fuels and nuclear fuel adds to the pollution of environment.
- Burning of fossil fuels produces smoke, carbon dioxide gas and heat. They enhance direct pollution to atmosphere.
- Wind-mills are very noisy.
- Thermal pollution is increasing day by day, causing global warming.

29. Define power.

Power is defined as the time rate of doing work. **Formula:** Power = Work/time or $P=W/t$

30. What is SI unit of power?

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

Mathematically: $1W=1J/1s$ or $1Js^{-1}$

Bigger Units of Power: kilowatt (KW), megawatt (MW) etc. $1 \text{ kilo watt (kW)} = 10^3 W = 1000 W$

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

31. Define efficiency.

The ratio of useful output energy and the total input energy is called the efficiency of a working system.

Formula: Efficiency = Useful output energy / Total input energy

Efficiency is often multiplied by 100 to give percentage efficiency. Thus, **Percentage Efficiency** = Efficiency x 100.

32. Why a system cannot have 100% efficiency?

A system cannot have 100% efficiency because some energy is always wasted as heat due to friction and air resistance during energy conversion. This energy loss makes it impossible to convert all input energy into useful output energy.

33. Why is a perpetual machine not possible?

A perpetual machine cannot work because some energy is always lost as heat due to friction and air resistance. It would violate the principle of conservation of energy, which states that energy cannot be created or destroyed.

EXERCISE

Multiple Choice Questions:

1	Work done is maximum when the angle between the force F and the displacement d is:	$0^\circ \checkmark$	30°	60°	90°
2	A joule can also be written as:	$kg\ ms^{-2}$	$kg\ ms^{-1}$	$kg\ m^2s^{-3}$	$kg\ m^2s^{-2} \checkmark$
3	The SI unit of power is:	joule	newton	watt $\checkmark$	Second
4	The power of a water pump is 2KW. The amount of water it can raise in one minute to a height of 5 metres is:	1000 litres	1200 litres	2000 litres	2400 litres $\checkmark$
5	A bullet of mass 0.05 kg has a speed of $300\ ms^{-1}$. Its kinetic energy will be:	2250 J $\checkmark$	4500 J	1500 J	1125 J
6	If a car doubles its speed, its kinetic energy will be:	the same	doubled	increased to three times	increased to four times $\checkmark$
7	The energy possessed by a body by virtue of its position is:	kinetic energy	potential energy $\checkmark$	chemical energy	solar energy
8	The magnitude of momentum of an object is doubled, the kinetic energy of the object will:	Double	increase to four times $\checkmark$	reduce to one-half	remain the same
9	Which of the following is not renewable energy source?	Hydroelectric energy	Fossil fuels $\checkmark$	Wind energy	Solar energy

Exercise Short Questions:

5.1. What is the work done on an object that remains at rest when a force is applied on it?

The work done is zero. As $S = 0$, So $W = F \times S = F \times 0 = 0$

5.2. A slow-moving car may have more kinetic energy than a fast-moving motorcycle. How is this possible?

Because mass of a car is much larger than the motorcycles, so it has more kinetic energy.

5.3. A force F_1 does 5J of work in 10 s. Another force F_2 does 3J of work in 5 s. Which force delivers greater power?

For force F_1 .

By using formula of power: $Power = \frac{Work}{time} = P_1 = \frac{5}{10} = P_1 = 0.5\ watt$

For force F_2

By using formula of power: $Power = \frac{Work}{time} = P_2 = \frac{3}{5} = P_2 = 0.6\ watt$

Hence, force F_2 delivers more power.

5.4. A woman runs up a flight of stairs. The gain in her gravitational potential energy is 4500 J. If she runs up the same stairs with twice the speed, what will be gain in potential energy?

Potential energy does not depend on the speed of the body, so the potential energy will be the same.

5.5. Define work and its SI unit.

See Q# 1 and 4.

5.6. What is the potential energy of a body of mass m when it is raised through a height h ?

The potential energy of a body of mass m raised to a height h is given by the formula: $E_p = mgh$

5.7. Find an expression for the kinetic energy of a moving body.

The kinetic energy of a moving body is found by formula: $E_k = \frac{1}{2}mv^2$

5.8. Define efficiency of a working system. Why a system cannot have 100% efficiency?

See Q# 31, 32.

5.9. What is power? Define the unit used for it.

See Q# 29, 30.

5.10. Differentiate between renewable and non-renewable sources of energy

See Q# 27.

Constructed Response Questions:**5.1. Can the kinetic energy of a body ever be negative?**

No, kinetic energy cannot be negative. It is always positive or zero.

5.2. Which one has the greater kinetic energy; an object traveling with a velocity V or an object twice as heavy traveling with a velocity of $\frac{1}{2}V$?

The object travelling with velocity V has twice the kinetic energy of the twice as heavy object moving at V/2.

5.3. A car is moving along a curved road at constant speed. Does its kinetic energy change?

No, kinetic energy remains same, as speed is constant.

5.4. Comment on the statement. "An object has one joule of potential energy."

This statement is incomplete. Because it doesn't show the height of an object.

Correct statement: "An object has one joule of potential energy, having mass 'm' kg and height 'h' meter.

5.5. While driving on a motorway, tire of a vehicle sometimes bursts. What may be its causes?

The main reason for tire bursts is an increase in air pressure inside the tires. This happens because during travel, friction between tires and the road raises the tire's temperature, which causes the air inside to expand.

5.6. While playing cricket on a street, the ball smashes a window pane. Describe the energy changes in this event.

Ball's kinetic energy breaks window pane, energy transfers from ball to glass.

5.7. A man rowing a boat upstream is at rest with respect to the shore. Is he doing work?

Yes, he is doing work, by exerting force against water flow.

5.9. Is timber or wood a renewable source of heat energy? Comment.

Yes! Wood from trees is renewable energy, because planting more trees will provide us with wood for heating.

CH #6: MECHANICAL PROPERTIES OF MATTER**1. What is a 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. What is meant by elasticity?

An object is said to be elastic, if after removal of the deforming force, it restores to its original size and shape. This property of the material is known as elasticity.

Example: an appropriate force applied to a spring can increase its length called extension or cause compression thus reducing its length. If this force is removed, the spring will restore its original size and shape.

3. What is 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. What are 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. State Hooke's Law.

If a 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. This is known as Hooke's law.

Mathematically: $F = Kx$ Here, K is the constant of proportionality and is known as the spring constant.

6. Define spring constant.

Spring constant is defined as the ratio of applied force to the change in length of spring. Spring constant written as: $K=F/x$

In fact, it is a measure of stiffness of the spring. The greater the value of spring constant, the greater will be the stiffness or strength of the spring. Its unit is Nm^{-1} .

7. Describe Hooke's Law role in technology and engineering.

In the field of technology and engineering, springs in many devices rely on Hooke's law for their functions such as spring scales, balance wheel of the mechanical clocks, galvanometer, suspension systems in vehicles and motorbikes etc.

8. Describe three applications of Hooke's Law.

Spring scales: Spring scales use the extension or compression of a spring to determine the weight of objects.

Balance wheel of mechanical clocks: The balance wheel in mechanical clocks uses spring to control the back and forth motion that regulates the speed of the hands of a clock.

Galvanometer: A galvanometer is a current detecting device. It makes use of a tiny spring called hair spring which provides electrical connections to the galvanometer coil and also restores the pointer back to zero position.

9. What is meant by density?

Density of a substance is defined as its mass per unit volume. **Formula: Density = mass / volume** or $\rho = m/v$
Unit: Kg m^{-3} and also g cm^{-3} .

10. How can the density of a substance be determined?

The density of a substance can be determined by measuring its mass and volume. The mass can be measured using a physical balance.

11. Define pressure.

Pressure is defined as the force exerted normally on unit area of an object. **Formula: Pressure=Force/Area, $P=F/A$**
 Pressure is a scalar quantity. In SI units, the unit of pressure is Nm^{-2} also called Pascal (Pa).

12. How does pressure depend on area? Give daily life examples.

1. A **chopper's sharp blade** has a small area. When force is applied, pressure becomes high and it cuts easily.
2. A **thumb pin** has a sharp end. The small contact area creates high pressure, so it easily pierces a wooden board.
3. On a flat surface, our weight is spread over a larger area, so pressure is low. On pebbles, smaller area increases pressure and causes pain.
4. Elephants have large feet. This increases contact area and reduces pressure, protecting their legs from damage.

13. Define atmosphere and atmospheric pressure.

The Earth is surrounded by a layer of air called the **atmosphere**. The atmosphere exerts pressure on the surface of the Earth and on everything on the Earth. This pressure is called atmospheric pressure.

14. How atmospheric pressure is equal in all direction?

Because of the random motion of air molecules, atmospheric pressure acts equally in all directions.

15. Define a 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.

16. Can we use water in place of mercury to construct a barometer? Explain why.

No, we cannot use water in place of mercury in a barometer because water is much less dense. Since mercury is 13.6 times denser, a water barometer would need to be over 10 meters tall to measure the same air pressure. This makes it impractical to use.

17. How does atmospheric pressure used in weather forecasting?

The atmospheric pressure does not always remain uniform but fluctuates. By observing these variations, meteorologists can forecast weather conditions.

18. What is a simple 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.

19. What is 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.

20. What are the advantages of Pascal's Law?

- Liquids do not absorb any of the supplied energy.
- They can move heavy loads and produce great forces due to their incompressibility.

21. What are the applications of hydraulic systems?

- Hydraulic press.
- Car lift at service stations
- Hydraulic brakes in vehicles

22. How does a hydraulic press work?

A hydraulic press works on Pascal's Law. The object to be compressed (like a cotton bale) is placed on the larger piston. A force is applied on the smaller piston. The pressure generated lifts the larger piston and compresses the object. This principle is also used at service stations to lift cars for washing.

23. What is force multiplier?

A small force applied on the smaller area, results into a larger force on the larger area. Such a system is known as force multiplier.

24. How do hydraulic brakes work? Explain using Pascal's law.

When the brake pedal is pressed, the piston in the master cylinder applies pressure to the liquid. According to Pascal's law, this pressure is transmitted equally to all the larger pistons in the wheel cylinders. This causes the larger pistons to move outward, pressing the brake pads against brake discs or drums. The resulting friction slows down the vehicle. When the pedal is released, springs pull back the brake pads and the wheels move freely again.

EXERCISE

Multiple Choice Questions:

1	A wire is stretched by a weight W . If the diameter of the wire is reduced to half of its previous value, the extension will become:	one half	double	one fourth	four times✓
2	Four wires of the same material are stretched by the same load. Their dimensions are given below. Which of them will elongate most?	Length 1 m, diameter 1 mm	Length 2 m, diameter 2 mm	Length 3 m, diameter 3 mm	Length 4 m, diameter 0.5 mm✓
3	Two metal plates of area 2 and 3 square metres are placed in a liquid at the same depth. The ratio of pressures on the two plates is:	1:1 ✓	$\sqrt{2}:\sqrt{3}$	2:3	4:9
4	The pressure at any point in a liquid is proportional to:	density of the liquid	depth of the point below the surface of the liquid	acceleration due to gravity	all of the above✓
5	Pressure applied to an enclosed fluid is:	increased and applied to every part of the fluid	diminished and transmitted to the walls of container	increased in proportional to the mass of fluid and then transmitted to each part of the fluid	transmitted unchanged to every portion of the fluid and walls of containing vessel✓

6	The principle of a hydraulic press is based on:	Hooke's law	Pascal's law✓	Principle of conservation of energy	Principle of conservation of momentum
7	When a spring is compressed, what form of energy does it possess?	Kinetic	Potential✓	Internal	Heat
8	What is the force exerted by the atmosphere on a rectangular block surface of length 50 cm and breadth 40cm? The atmospheric pressure is 100 kPa.	20 kN ✓	100 kN	200 kN	500 kN

Exercise Short Questions:**6.1. Why heavy animals like an elephant have a larger area of the foot?**

Elephants have thick legs and large flat feet so that due to large contact area, pressure becomes less, otherwise, their bones would not tolerate the pressure.

6.2. Why animal like deer who run fast have a small area of the feet?

Because the pressure on the ground becomes high, which gives them a stronger grip and helps them to run quickly without slipping.

6.3. Why it is painful to walk bare footed on pebbles?

When we walk bare footed on pebbles, the contact area of our foot with the ground becomes small, so the pressure due to our weight becomes very high, and it becomes painful.

6.4. State Pascal's law. Give an applications of Pascal Law.

When pressure is applied at one point in an enclosed fluid, it is transmitted equally to all parts of the fluid without loss. **Applications:** 1. Hydraulic press 2. Hydraulic brakes 3. Water pumps

6.5. State what do you mean by elasticity of a solid?

The property of solid to restore its original size and shape when the deforming force ceases to act is called elasticity.

6.6 What is Hooke's Law? Does an object remain elastic beyond elastic limit? Give reason.

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.

No, after exceeding the elastic limit, the material is no longer elastic. It either breaks or undergoes permanent deformation.

6.7. Distinguish between force and pressure.

Force: Force is a push or pull acting on an object. It is measured in Newton (N). Formula: $F = ma$

Pressure: Pressure is the force applied per unit area. It is measured in Pascal (Pa). Formula: $P = \frac{F}{A}$

6.8. What is the relationship between liquid pressure and the depth of the liquid?

Liquid pressure increases with depth. The relationship is given by the formula: $P = \rho gh$

This means that the deeper you go in a liquid, the greater the pressure becomes.

6.9. What is the basic principle to measure the atmospheric pressure by a simple mercury barometer?

The basic principle is that atmospheric pressure is equal to the pressure exerted by the mercury column in the barometer.

6.10. State the basic principle used in the hydraulic brake system of the automobiles.

The hydraulic brake system works on Pascal's law, which states:

"When pressure is applied at one point in an enclosed fluid, it is transmitted equally to all parts of the fluid without loss."

Constructed Response Questions:**6.2. Springs are made of steel instead of iron. Why?**

Because steel is durable and has a higher elastic limit than iron.

6.3. Which of the following material is more elastic? (a) Iron or rubber (b) Air or water.

1. Rubber is more elastic than iron. 2. Air is more elastic than water.

6.4. How does water pressure one meter below the surface of a swimming pool compare to water pressure one meter below the surface of a very large and deep lake?

At a depth of one meter from the surface, the water pressure in a pond and a lake will be the same, because water pressure depends on depth rather than volume or size.

6.5. What will happen to the pressure in all parts of a confined liquid if pressure increase in one part. Give an example in your daily life by where principle is applied.

According to Pascal's law, if pressure is increased in one part of a confined liquid, the pressure will increase equally in all parts of the liquids.

Example: Hydraulic brake in vehicles, where pressure applied to brake pedal is transmitted equally to all four brakes.

6.6. If some air remains trapped within the top of the mercury column of the barometer which is supposed to be vacuum, how would it affect the height the mercury column?

Trapped air in the barometer will reduce the height of mercury column as the will exert pressure and oppose the weight of the mercury.

6.7. How does the long neck is not a problem to a giraffe while raising its neck suddenly?

Because the giraffe has a specialized circulatory system that maintains blood flow.

6.8. The end of glass tube used in a simple barometer is not properly scaled, some leak is present. What will be its effect?

Barometer will give incorrect readings due to air entering the tube through the leak.

6.9. Comment the statement. "Density is a property of a material not the property of an object made of that material."

Because density depends on an object's mass and volume, not on its size and shape.

6.10. How to load of a large structure is estimated by an engineer?

Engineer estimate the weight of large construction structures using material properties, structural design and the E.F.A method, which involves dividing the structure into small elements and analyzing the forces acting on each element.

CH #7: THERMAL PROPERTIES OF MATTER**1. What is Kinetic molecular theory?**

According to the kinetic molecular theory, matter is composed of very small particles called molecules, which are always in motion. Their motion may be vibrational, rotational, or linear.

2. What is intermolecular forces?

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.

3. How temperature of a substance depends on the kinetic energy of molecules?

When a substance is heated, its temperature increases and the molecular motion becomes more vigorous, increasing the kinetic energy. Thus, the temperature of a substance depends on the average kinetic energy of its molecules.

4. Why solids have a definite shape and volume?

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.

5. Why liquids have a definite volume but no definite shape?

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.

6. Why gas has no definite shape or volume?

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.

7. Define plasma as a fourth state of matter.

Plasma is a gas in which most of the atoms are ionized, containing positive ions and electrons.

Example: The Sun and most other stars, which are in the plasma state.

8. Why plasma is the conducting state of matter?

Because of the presence of freely moving charged particles, plasma is a conducting state of matter, allowing electric current to pass through it.

9. What is meant by temperature of a body?

Temperature of a body is defined as the degree of its hotness or coldness.

10. How can temperature be defined in terms of thermal energy?

Temperature can be defined as a physical quantity which determines the direction of flow of thermal energy.

11. Define heat as 'energy in transit'.

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

12. Define internal energy.

The sum of kinetic and potential energies of the molecules of an object is called its internal energy.

13. What is a thermometer?

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

14. What are the basic Thermometric Properties of a substance?

A thermometric property is a physical property of a substance that changes with temperature and is used in the construction of thermometers. Some thermometric properties are:

- It is a good conductor of heat.
- It gives quick response to temperature changes.
- It has uniform thermal expansion.
- It has high boiling point.
- It has low freezing point.
- It has large expansivity (low specific heat capacity).
- It does not wet glass.
- It does not vapourize.
- It is visible.

15. What is a liquid-in-glass thermometer and which liquids are used in it?

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. Mercury is commonly used in thermometers.

16. Why mercury is commonly used in thermometers not alcohol?

Because mercury is opaque and easily seen due to its silvery color. Alcohol can also be used, but it must be colored to make it visible. Also mercury has a very low freezing point and very high boiling point.

17. What are the three main types of temperature scales?

- Celsius or centigrade scale
- Fahrenheit scale
- Kelvin scale

18. Write about Celsius scale?

Lower fixed point: 0°C

Upper fixed point: 100°C

The scale is divided into 100 equal parts, each part representing 1°C.

19. Write about Fahrenheit scale?

Lower fixed point: 32°F

Upper fixed point: 212°F

The scale is divided into 180 equal parts, each part representing 1°F.

20. Write about Kelvin scale?

Lower fixed point: 273 K

Upper fixed point: 373 K

The scale is divided into 100 equal parts, with each part representing 1K, equivalent to 1°C.

21. What is absolute zero and its significance in the Kelvin scale?

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 **0K**, which is equivalent to **-273.15°C**. It is the lowest possible temperature in the universe.

22. Describe the conversion of temperature from one scale to another?

Relationship between Celsius and Fahrenheit scale: $T_F = \frac{9}{5} T_C + 32$

Relationship between Fahrenheit and Celsius scale: $T_C = \frac{5}{9} (T_F - 32)$

Relationship between Kelvin and Celsius scales: $T_K = T_C + 273$

23. What is a 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.

24. Write the use of thermocouple thermometer.

It is useful for very high temperatures and rapidly changing temperatures, as there is only a small mass of metal (the junction) to heat up.

25. What is meant by sensitive, range and linearity of thermometers?

Sensitivity: Sensitivity of a thermometer refers to its ability to detect small changes in the temperature of an object. **For example**, the minimum division on the scale of a thermometer is 1°C. The accuracy of its temperature measurement will be 1°C.

Range: This refers to the span of temperature, from low to high, over which the thermometer can measure accurately. **For example**, a clinical thermometer designed for human body temperature has a narrow or short range, say from 35°C to 45°C.

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

EXERCISE

Multiple Choice Questions:

1	How do the molecules in a solid behave?	Move randomly	Vibrate about their mean positions✓	Rotate and vibrate randomly at their own positions	Move in a straight line from hot to cold ends
2	What type of motion is of the molecules in a gas?	Linear motion	Random motion✓	Vibratory motion	Rotatory motion
3	Temperature of a substance is:	the total amount of heat contained in it	the total number of molecules in it	degree of hotness or coldness✓	dependent upon the intermolecular distance
4	Heat is the:	total kinetic energy of the molecules	the internal energy	work done by the molecules	the energy in transit✓
5	In Kelvin scale, the temperature corresponding to melting point of ice is:	Zero	32	-273	+273 ✓
6	The temperature which has the same value on Celsius and Fahrenheit scale is:	-40 ✓	+40	+45	-45
7	Which one is a better choice for a liquid-in-glass thermometer?	Is colorless	Is a bad conductor	Expand linearly✓	Wets glass

8	One disadvantage of using alcohol in a liquid-in-glass thermometer:	it has large expansivity	it has low freezing point (-112°C)	it wets the glass tube✓	its expansion is linear
9	Water is not used as a thermometric liquid mainly due to:	Colorless	a bad conductor of heat	non-linear expansion✓	a low boiling point (100°C)
10	A thermometer has a narrow capillary tube so that it:	quickly responds to temperature changes	can read the maximum temperature	gives a large change for a given temperature rise✓	can measure a large range of temperature
11	Which thermometer is most suitable for recording rapidly varying temperature?	Thermocouple thermometer ✓	Mercury-in-glass laboratory thermometer	Alcohol-in-glass thermometer	Mercury-in-glass clinical thermometer

Exercise Short Questions:**7.1. Why solids have a fixed volume and shape according to particle theory of matter?**

See Q# 4.

7.2. What are the reasons that gases have neither a fixed volume nor a fixed shape?

See Q# 6.

7.3. Compare the spacing of molecules in the solid, liquid and gaseous state.**Solid:** Very close (tightly packed, minimal space)**Liquid:** Close but slightly farther apart than solids (allows sliding)**Gas:** Very far apart (separated by large empty spaces)**7.4. What is the effect of raising the temperatures of a liquid?**

On raising temperature, liquid heats up, expands, and particles move faster very quickly.

7.5. What is meant by temperature of a body?

See Q# 9.

7.6. Define heat as energy in transit.

See Q# 11.

7.7. What is meant by thermometric property of a substance? List some thermometric properties.

See Q# 14.

7.8. State the main scales used for the measurement of temperature.

- **Celsius scale:** Water freezes at 0°C and boils at 100°C .
- **Fahrenheit scale:** Water freezes at 32°F and boils at 212°F .
- **Kelvin scale:** Water freezes at 273.15K and boils at 373.15K .

7.9. What is meant by sensitivity of a thermometer?

See Q# 25.

7.10. What do you mean by the linearity of a thermometer?

See Q# 25.

7.11. What makes the scale reading of a thermometer accurate?

Clear markings on the thermometer scale, high quality materials and consistent thermometric properties make the thermometer readings more accurate.

7.12. What does determines the direction of heat flow?

The flow of heat is determined by the temperature difference between two bodies. Heat always flows from a hot body to a cold body.

7.13. Distinguish between the heat and internal energy.**Heat:** Heat is energy transferred due to temperature difference from one object to another.**Internal Energy:** energy the total energy stored within a system.**7.14. When you touch a cold surface, does cold travel from the surface to your hand or does energy travel from your hand to cold surface?**

When we touched a cold object, heat is transferred from our body to that surface.

7.15. Can you feel your fever by touching your own forehead? Explain.

Yes! We can detect a fever by touching our forehead. Because when body temperature rises above normal, the forehead feels hot.

Constructed Response Questions:**7.1. Is kinetic molecular theory of matter applicable to the plasma state of matter?**

Yes this theory can be applied to the plasma state, but with some modifications and extensions.

7.2. Why mercury is preferred usually to alcohol as a thermometric liquid?

See Q# 16.

7.3. Why is water not suitable for use in thermometers? Without calculations guess what is equivalent temperature of 373 K on Celsius and Fahrenheit scales?

Water isn't suitable due to irregular expansion and high freezing point. 373 K is approximately 100°C and 212°F

7.4. Mention two ways in which the design of a liquid in glass thermometer may be altered to increase its sensitivity.

1. Increase the length of the thermometer bulb. 2. Use a liquid with higher coefficient of expansion.

7.5. One liter of water is heated by stove and its temperature rises by 2°C. If two liters of water is heated on the same stove for the same time. What will be then rise in temperature?

Since the amount of water has doubled but the amount of heat remains the same, the temperature will rise by one degree Celsius.

7.6. Why are there no negative number on the Kelvin scale?

Kelvin scale starts at absolute zero, so negative numbers aren't possible.

7.7. Comment on the statement. "A thermometer measure its own temperature."

This statement is correct because a thermometer measure the temperature of the liquid or gas inside it, which is in thermal equilibrium with its surrounding environment.

7.8. There are various objects made of cotton, wood, plastic, metals etc. in a winter night, compare their temperature with the air temperature by touching them with your hand.

At night, the temperature of cotton, plastic, wood, and metals will be close to the air temperature; however, due to differences in thermal conductivity and heat capacity, there may be slight variations in their actual temperatures. Metals will feel the coldest, plastic less cold than metals, cotton the least cold.

7.9. Which is greater an increase in temperature 1°C or on 1°F?

A 1°C increase in temperature is equal to 1.8°F. So a 1°C change is larger than a 1°F change.

7.10. Why would not you expect all the molecules in a gas to have the same speed?

This is because the speeds of molecules in a gas different due to collision and thermal motion; some molecules move fast, while others move slowly.

7.11. Does it make sense to talk about the temperature of a vacuum?

No, because temperature is a measure of the average kinetic energy of particles with a substance, whereas in a vacuum, there are no particles to measure kinetic energy.

7.12. Comment on the statement. "A hot body does not contain heat."

This is true statement. Heat is a form of energy transfer; a hot body possesses internal energy, not heat.

7.13. Discuss whether the Sun is matter.

Yes! The sun is matter. It is made up of hydrogen and helium gases, it occupies space and has weight.

CH #8: MAGNETISM**1. What is magnetism and magnetic materials?**

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

2. Write some materials are considered magnetic and non-magnetic?

Magnetic: Iron, nickel, and cobalt.

Non-magnetic: Brass, copper, wood, glass, and plastic.

3. What are the properties of magnets?

- Magnetic Poles
- Attraction and Repulsion of Magnetic Poles
- Identification of a Magnet
- Is Isolated Magnetic Pole Possible?

4. What are the 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).

5. What is property of attraction and repulsion magnetic poles?

When two freely suspended bar magnets are placed close to each other, like poles repel and unlike poles attract.

6. What is identification of magnet?

The repulsion between the like poles is a real test to identify a magnet.

7. Is Isolated Magnetic Pole Possible?

No, it is not possible. Each piece will have its two poles, i.e., N-Pole and S-Pole. Even if a magnet is divided into thousands of pieces, each piece will be a complete magnet with its N and S poles.

8. What is magnetization?

Magnetic material such as iron or steel can be made a magnet. This is known as magnetization. In other words, we can say that magnetism has been induced in the material.

9. Differentiate between temporary and permanent magnets.

Temporary magnets: Magnets that work only in the presence of a magnetic field of permanent magnets. Once the magnetic field vanishes, they lose their magnetic properties. **Example:** soft iron, Paper clips, office pins, and iron nails.

Permanent magnets: Magnets which retain their magnetic properties forever. **Example:** cobalt, alnico, and ferrite.

10. What is magnetic field?

A magnetic field is the region around a magnet where another magnetic object experiences a force on it.

11. What are magnetic lines of force?

Magnetic lines of force are imaginary curved paths used to represent a magnetic field. These lines appear to originate from the North Pole and end on the South Pole.

12. What about magnetic field lines direction and magnitude?

The magnetic field at a point has both a magnitude and a direction. The direction is indicated by the N-pole of a magnetic compass needle placed at that point.

13. Describe the strength of a magnetic field in terms of magnetic lines of force.

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. The field is stronger where the lines are close together and weaker where they are far apart.

14. What are the uses of permanent magnets?

- They are the essential parts of D.C motors, and A.C and D.C electric generators.
- Permanent magnets are used in the moving coil loud-speakers.
- These are very commonly used in door catchers.
- Magnetic strips are fitted to the doors of refrigerators and freezers to keep the door closed tightly.
- They are commonly used to separate iron objects from different mixtures.
- In the medical field, they are used to remove iron splinters from the eyes.
- A piece of permanent magnet is used to reset the iron pointer in a maximum and minimum thermometer.

15. Describe A.C Generator.

When a coil is rotated between the poles of a permanent magnet, the magnetic field through the coil changes, and an e.m.f is induced between the ends of the coil. On connecting these ends to an external circuit, an alternating current (A.C) flows through the circuit.

16. Describe Electric Motor.

It is the reverse process of an electric generator. When an A.C is passed through a coil placed between the poles of a permanent magnet, the coil starts rotating.

17. Describe shortly working of Loudspeaker.

A voice coil attached to the cone of the speaker is slipped over one pole (N) of a radial permanent magnet. The cone vibrates back and forth to produce sound in the air.

18. What is an electromagnet and how is it formed?

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. Once the current is stopped, it no longer remains a magnet.

19. What are the uses of electromagnets?

Electromagnets are used in many electrical and mechanical devices. Common uses of electromagnets include: Electric bell, Telephone receiver, Simple magnetic relay, Circuit breaker, Reed switches, Cranes, Tape recorder and Maglev trains

20. What is a 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.

21. What is a circuit breaker and how does it protect electric appliances?

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.

22. How are huge electromagnets used in cranes?

Huge electromagnets are used in cranes at scrapyards, steel works, and ships. These electromagnets are powerful enough to lift heavy iron and steel objects such as cars. After lifting and moving the objects to the required place, they are released easily by switching OFF the current, which turns off the magnetic field.

23. What is a Maglev train and how does it use electromagnets?

A Maglev train is a magnetically levitated train that floats above the track using electromagnets. It has no wheels and faces no friction, allowing it to reach speeds up to 400 Km h^{-1} .

24. What is the 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.

25. What is magnetic dipole?

If the spins and orbits of electrons in an atom align, the atom acts as a tiny magnet, known as a magnetic dipole.

26. What are 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 aluminum and lithium.

27. What are 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.

28. What are 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 neighboring 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.

29. What are 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.

30. How do soft iron and steel differ in terms of magnetic domain alignment?

In soft iron, the domains are easily oriented on applying an external field and return to random positions when the field is removed. In contrast, steel is not so easily oriented. It requires a very strong external field, but once aligned, it retains the alignment. That is why, steel is used to make permanent magnets.

31. What are the two methods for magnetizing a steel bar?

The two methods used for magnetizing a steel bar are: Stroking and Using a Solenoid

32. What is Stroking Method?

The steel bar is placed on a horizontal surface and stroked with a permanent magnet.

33. What are the two ways of stroking method?

Single Touch Method: A steel bar is placed on a horizontal surface. It is stroked from one end to the other several times in the same direction, using the same pole (e.g., North Pole) of the magnet. After each stroke, lift the magnet up before repeating.

Double Touch Method: Stroking is done from the center outward with the unlike poles of two magnets at the same time.

34. What is solenoid method for magnetizing?

In this method, a steel bar to be magnetized is placed inside a solenoid (a long coil of wire). The solenoid should have several hundred turns of insulated copper wire. When direct current is passed through the solenoid, the steel bar becomes a magnet.

35. What is 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.

36. How can a magnet be demagnetized?

Heating: Thermal vibrations tend to disturb the order of the magnetic domains. Therefore, if a magnet is heated strongly, it loses its magnetism very quickly.

Hammering: If we beat a magnet, the magnetic domains lose their alignment, and the magnet gets demagnetized.

Alternating Current: When an alternating current (A.C.) is passed through a long solenoid, and a magnet is slowly moved out from inside the solenoid, it becomes demagnetized.

37. In which recording mediums are electromagnets commonly used?

Electromagnets are widely used in recording technology. Such recording mediums are audio/video magnetic tapes, hard disks of computers and other data storing devices.

38. What is Magnetic tape recording?

Magnetic tape recording uses induced magnetism. The recording and playing head is a coil of wire wrapped around a horse-shoe shaped iron core with a narrow gap between its ends.

39. What is a 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.

40. What is a hard disk?

Hard disks are circular flat plates made of aluminum, glass, or plastic, coated on both sides with iron oxide. Hard disks can store terabytes of information.

41. What is the advantage of magnetic disks over tape recorders?

Magnetic disk devices can read or write data instantly, whereas finding desired information on a tape recorder may take many minutes.

42. How can electronic devices be protected from magnetic effects?

Electronic devices can be protected from strong magnetic effects by enclosing them in boxes made of soft iron.

43. Why is soft iron used as a magnetic shield and in electromagnets?

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.

EXERCISE

Multiple Choice Questions:

1	Which one of the following is not a magnetic material?	Cobalt	Iron	Aluminum✓	Nickel
2	Magnetic lines of force:	are always directed in a straight line	cross one another	enter into the north pole	enter into the south pole✓
3	Permanent magnets cannot be made by:	soft iron✓	steel	neodymium	Alnico
4	Permanent magnets are used in:	circuit breaker	loudspeaker✓	electric crane	magnetic recording
5	A common method used to magnetize a material is:	stroking✓	hitting	heating	placing inside a solenoid having A. C current
6	A magnetic compass is placed around a bar magnet at four points as shown in the figure below. Which diagram would indicate the correct directions of the field?				
7	A steel rod is magnetized by the double touch stroking method. Which one would be the correct polarity of the AB magnet? 				
8	The best material to protect a device from external magnetic field is:	Wood	plastic	steel	soft iron✓

Exercise Short Questions:

8.1. What are temporary and permanent magnet?

See Q# 9.

8.2. Define magnetic field of a magnet.

See Q# 10.

8.3. What are magnetic lines of force?

See Q# 11.

8.4. Name some uses of permanent magnets and electromagnets.

Uses of permanent magnets: Speakers, Electric motors, Freezer doors etc.

Uses of electromagnets: Electric bells, Cranes, Circuit breaker etc.

8.5. What are magnetic domains?

See Q# 29.

8.6. Which type of magnetic field is formed by a current carrying long coil?

A long current carrying coil produces a uniform magnetic field inside the solenoid. Outside the coil, the field lines are spread out and weak.

8.7. Differentiate between paramagnetic and diamagnetic materials.

See Q# 26, 27.

Constructed Response Questions:

8.4. Electric current or motion of electrons produce magnetic field. Is the reverse process true that is the magnetic field gives rise to electric current? If yes, give an example and describe it briefly.

Yes! The reverse is also true. A changing magnetic field induces an electric current. For example, generating electricity in a coil.

CH #9: NATURE OS SCIENCE

1. What is science?

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

2. Write the two 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. What is the scope of physics in everyday life?

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

4. What is Space?

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.

5. What is Time?

Time measures the sequence and duration of events. It is considered the fourth dimension.

6. How Physics explore the fundamental concepts are interconnected?

- Theory of relativity explains that space and time are not absolute, but are related to each other and are influenced by gravity and speed.
- Quantum mechanics explains the behavior of particles at the atomic and subatomic levels.

7. What are the main branches of Physics and their definitions?

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.

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.

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

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

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

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

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.

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

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

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

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

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

8. What is meant by interdisciplinary nature of Physics?

Interdisciplinary nature of Physics refers to integration and interaction of Physics with various other fields of study.

9. What are the main braches of interdisciplinary nature of Physics?

Biophysics: Some biological systems and processes are described using the principles and technique of physics under this field of Study. **Example:** the mechanics of biological structures, physical properties of cells, tissues and organs.

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

Example: imaging techniques such as X-rays, ultrasound, MRI and CT scan, and radiation therapy for cancer treatment.

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

Example: the interaction between matter and energy in space to understand the universe as a whole.

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

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

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

10. What is interdisciplinary research?

Interdisciplinary research involves collaboration between different scientific disciplines to address complex issues and challenges. It leads to greater breakthroughs and a deeper understanding of the natural and physical world.

11. Why is collaboration important in science?

Collaboration is important because:

(i) Solutions to complex issues require multifaceted expertise: Problems like climate change, disease prevention, and sustainable energy are diverse and require knowledge from multiple fields. **Example:** The COVID-19 pandemic required expertise from biology, chemistry, physics, medical technologies, and data science.

(ii) Interdisciplinary approaches foster innovation: Combining knowledge from different fields leads to innovative and novel solutions. **Example:** Nanotechnology blends physics, chemistry, materials science, and engineering to create nanoscale materials with medical and electronic applications.

(iii) Rapid sharing of knowledge across the globe: Global collaboration through the internet, conferences, and workshops allows scientists to share findings, discuss ideas, and cooperate on new approaches.

12. What is scientific method? Explain its main steps with the help of an example.

Scientific method is a systematic approach used to search for the truth of an issue and to solve problems related to the natural and physical world.

It is based on the following steps:

1-Observation: The first step is to observe natural processes and collect data. This can be done by simple observation or through experiments. **Example:** We commonly observe that a shadow is formed when an opaque object is placed in the path of light from the Sun or a lamp.

2-Hypothesis: A hypothesis is a possible explanation or guess based on observations. It is made to test logical results. **Example:** From the above observation, we assume that shadows are formed because light travels in a straight line.

3-Experiment: An experiment is a repeatable process used to test the truth of a hypothesis.

Example: Take four cardboards with holes and arrange them in a straight line in front of a torch. Light passes through all holes when aligned. If one cardboard is moved, the light is blocked. This proves that light travels in a straight line.

4-Theory: After successful experiments, the hypothesis becomes a theory. A theory explains the causes and effects of a natural event. **Example:** The above experiment proves that light travels in a straight line, so this assumption becomes a theory.

5-Prediction: Based on the theory, we can make predictions about other natural events. **Example:** We can predict that a ball will make a round shadow and a block will make a rectangular shadow when placed in light.

6-Falsifiability: A theory must make predictions that can be tested and possibly proven wrong. This helps to check if the theory is truly scientific and not based on vague ideas.

7-Law: After many successful tests and wide acceptance, a theory becomes a law. **Example:** The theory that light travels in a straight line becomes the law of light.

13. What is the conclusion of scientific method steps?

The theories or laws of physics are man-made ideas about the way the things work. They are liable to be disproved or modified with the future advances in science which brings fresh facts and new insights about the natural and physical world.

14. Differentiate the terms, science, technology and engineering.

1. Science: Science or to be more specific, physics plays a vital role being the core of each invention based on physical laws and principles.

2. Technology: Technology refers to the methods and techniques developed by using scientific knowledge. It may be a machine technology or a software programme of information technology. **Example:** Automobile technology is based on the principles of the thermodynamics.

3. 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.

Examples: A civil engineer designs a bridge that can withstand strong winds, earthquakes, intense weather conditions and heavy traffic. A software engineer designs a user friendly application of a smartphone.

EXERCISE

Multiple Choice Questions:

1	Physics is a branch of:	Social science	Life science	Physical science✓	Biological science
2	Which branch of science plays vital role in technology and engineering?	Biology	Chemistry	Geology	Physics✓
3	Automobile technology is based on:	Acoustics	electromagnetism	optics	thermodynamics✓
4	A user friendly software application of smart phone use:	laser technology	information technology✓	medical technology	electronic technology
5	The working of refrigeration and air conditioning involves:	electromagnetism	mechanics	climate science	thermodynamics✓
6	What is the ultimate truth of a scientific method?	Hypothesis	Experimentation	Theory	Law✓
7	The statement "If I do not study for this test, then I will not get good grade" is an example of:	Theory	observation	prediction✓	Law
8	Which of the following are methods of investigation?	Observation	Experimentation	Research	All of these✓
9	A hypothesis:	may or may not be testable	is supported by evidence	is a possible answer to a question	all of these✓
10	A graph of an organized data is an example of:	collecting data	forming a hypothesis	asking question	analyzing data✓
11	The color of a door is brown. It is an example of:	observation✓	hypothesis	prediction	law

Exercise Short Questions:

9.1. State in your own words, what is science? Write its two main groups.

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

Main two groups: 1-Biological science 2-Physical science

9.2. What is physics all about? Name some of its branches.

The branch of science which deals with matter, energy, space, time and their mutual relationship.

Branches: 1-Optics 2-Astronomy 3-Mechanics 4-Nuclear physics

9.3. What is meant by interdisciplinary fields? Give a few examples.

Interdisciplinary nature of Physics refers to integration and interaction of Physics with various other fields of study. **Example:** Biophysics, Geophysics.

9.4. List the main steps of scientific methods.

1-Observation 2-HYpothesis 3-Experiment 4-Theory 5-Prediction 6-Falsifiability 7-Law

9.5. What is hypothesis? Give an example.

Hypothesis: A hypothesis is a possible explanation or guess based on observations. It is made to test logical results. **Example:** From the above observation, we assume that shadows are formed because light travels in a straight line.

9.6. Distinguish between theory and law of Physics.

Theory: After successful experiments, the hypothesis becomes a theory. A theory explains the causes and effects of a natural event.

Law: After many successful tests and wide acceptance, a theory becomes a law.

9.7. What is the basis of laser technology?

Laser technology is based on the principles of atomic physics.

9.8. What is falsifiability concept? How is it important?

This condition ensures that theories are not based on vague, non-specific, or untestable claims.

Constructed Response Questions:

9.1. Is the theory of science an ultimate truth? Describe briefly.

No! A scientific theory is not an absolute truth. Scientific theories can change with new inventions and discoveries.

9.2. Do you think that the existing laws of nature may need a change in future? Describe briefly.

Yes, Current laws are based on existing evidence. New discoveries may reveal situations where these laws do not fully apply. Science and our understanding of it can change over time.

9.3. Describe three jobs that need the use of scientific knowledge.

- 1-Doctor uses medical science to treat patients.
- 2-Engineer applies physics and math to design.
- 3-Researcher conducts scientific experiments daily.

9.4. Describe when a theory is rejected or needs modification.

A theory is rejected or modified when new evidence does not support it or is inconsistent with the facts.

9.5. Comment on the statement. "A theory capable of being proved right but not being proved wrong is not a scientific theory."

This is incorrect statement. A scientific theory must be testable and falsifiable.

9.6. What has been the general reaction to new ideas about established truths?

New theories regarding established truths often face skepticism and resistance. Over time, if supported by evidence, these new theories gradually gain acceptance.

9.7. If a hypothesis is not tested, is the hypothesis wrong? Explain.

No, if a hypothesis is not tested, it cannot be called wrong. It simply remains uncertain until we test it.

9.8. Explain how a small amount of data cannot prove that a prediction is always correct but can prove it is not always correct.

A small amount of data cannot prove that a prediction is always accurate, because it cannot cover all scenarios.

9.9. What is relationship between an experiment and a hypothesis?

An experiment tests a hypothesis to confirm or refuse it. The results indicate whether the idea is correct or not.

9.10. Describe why the solution of complex problems need interdisciplinary research and collaboration.

No single branch of science can provide a solution to complex problems; only by working together can all branches of science represent an effective course of action to address them.