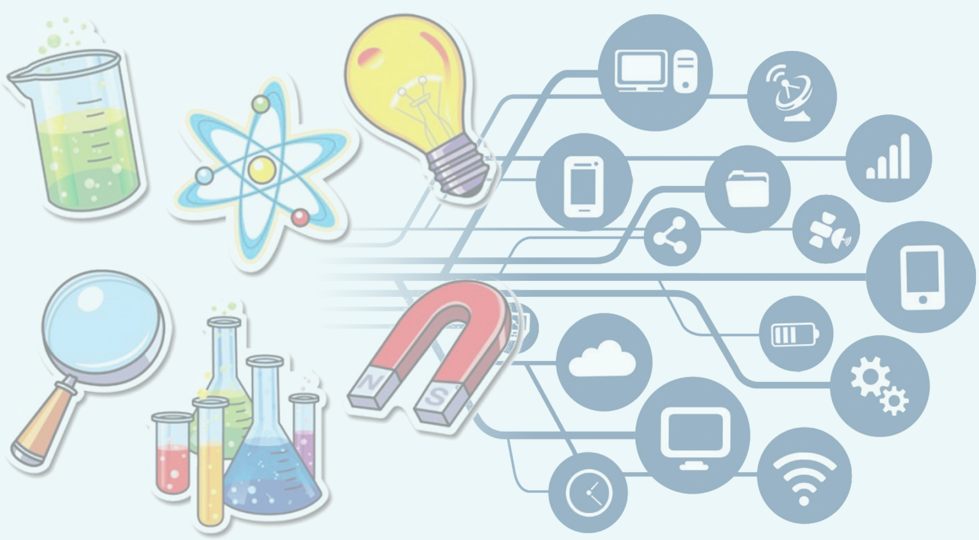
General Science & Technology

FIRST STEP

NCERT Based Course for **CSE**
after **Class 11**



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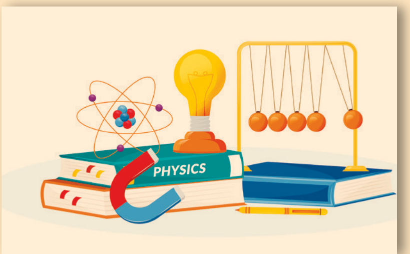
PART I

General Science

CHAPTER 1

PHYSICS



Physics is a branch of science which is concerned with all aspects of nature on both the microscopic and macroscopic level. Its scope of study encompasses not only the behavior of objects under the action of forces but also the nature of gravitational, electromagnetic, nuclear forces among others. The ultimate objective of physics is to formulate comprehensive principles that bring together and explain all such phenomena.

1.1 Units & Measurement

Measurement of any physical quantity involves comparison with a certain basic, arbitrarily chosen, internationally accepted reference standard called unit. The result of a measurement of a physical quantity is expressed by a number (or numerical measure) accompanied by a unit.

The units for the fundamental or base quantities are called fundamental or base units. The units of all other physical quantities can be expressed as combinations of the base units. Such units obtained for the derived quantities are called derived units. A complete set of these units, both the base units and derived units, is known as the system of units.

There are basically two types of unit:

1. **Fundamental Unit:** These units are a set of measurements, defined arbitrarily and from which other units are derived. Examples: meter, kilogram, second, etc.

   The fundamental units of some of the physical quantities are given below:

International System of Units (S.I.)

Parameters	Fundamental	Symbol
Mass	Kilogram	kg
Length	Meter	m
Time	Second	s
Temperature	Kelvin	K
Electric Current	Ampere	A
Luminous intensity	Candela	Cd
Quantity of matter	Mole	mol

2. **Derived Unit:** All the units which are expressed in terms of fundamental units are known as derived units. Examples: Newton, Joule, etc.

- Internationally, there are four types of unit systems. These are:

  1. **S.I. Units/System:** It is the modern form of the metric system, and is the most widely used system of measurement. It comprises

a coherent system of units of measurement built on seven base units namely kilogram, meter, second, candela, ampere, kelvin and mol.

2. **CGS System:** The centimeter-gram-second (CGS) system of units is a variant of the metric system based on centimetre as the unit of length, gram as unit of mass, and the second as the unit of time.
3. **FPS System:** The foot-pound-second (FPS) system is a system of units built on three fundamental units: the foot for length, the pound for mass and the second for time.
4. **MKS System:** The MKS system of units is a physical system of units that expresses any given measurement using base units of the metre, kilogram, and second.

Errors and Measurement

Measurement is the foundation of all experimental science and technology. The result of every measurement by any measuring instrument contains some uncertainty. This uncertainty is called error. Every calculated quantity which is based on measured values, also has an error.

The accuracy of a measurement is a measure of how close the measured value is to the true value of the quantity.

In general, the errors in measurement can be broadly classified as (a) systematic errors and (b) random errors. The systematic errors are those errors that tend to be in one direction, either positive or negative. Systematic errors can be minimised by improving experimental techniques, selecting better instruments and removing personal bias as far as possible.

The random errors are those errors, which occur irregularly and hence are random with respect to sign and size. These can arise due to random and unpredictable fluctuations in experimental conditions (e.g. unpredictable fluctuations in temperature, voltage supply, mechanical vibrations of experimental set-ups, etc).

NOTE The magnitude of the difference between the individual measurement and the true value of the quantity is called the absolute error of the measurement.

1.2 Basics of Motion

A body is said to be in motion if it changes its position with respect to its surroundings as time goes on. A body is said to be at rest if it does not change its position with time, with respect to its surroundings.

Types of Motion

(i) When a particle or a body moves along a straight path, its Motion is Rectilinear or Translatory Motion.

(ii) When a particle or a body moves in a circular path, its motion is Circular Motion. When a body spins about its own axis, it is said to be in Rotational Motion.

(iii) When a body moves to and fro or back and forth repeatedly about a fixed point in a definite interval of time, it is said to be in Vibrational or Oscillatory Motion.

The path travelled by an object during its motion is called trajectory. The actual path length during the motion is called distance and, the straight distance between the initial and final position of the motion in a particular direction is called displacement.

Speed

The time rate of change of position of an object in any direction i.e. the rate of change of distance of an object with respect to time is known as speed.

$$\text{Speed} = \frac{\text{distance}}{\text{time taken}}$$

Velocity

The rate of change of displacement of an object with respect to time is known as velocity.

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}}$$

Acceleration

The rate of change of velocity with respect to time is called acceleration.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{time taken}}$$

When a body completes equal displacement in equal interval of time, its velocity is constant and hence, it does not have an acceleration.

When a body shows equal change in velocity in equal interval of time its velocity is not constant but it has a constant acceleration.

Equations of Motion

For a Body Moving With a Uniform Velocity

If a body completes a displacement 'S' in time 't' with a uniform velocity 'V', then,

$$\text{Displacement} = \text{velocity} \times \text{time}$$

or $$S = vt \qquad \text{...(i)}$$

For a Body Moving With a Uniform Acceleration

If a body starting with an initial velocity 'u' moves with a uniform acceleration 'a' for a time 't' and attains a final velocity 'v' after travelling a displacement 's' then,

$$S = ut + \frac{1}{2}at^2 \qquad \text{....(ii)}$$

$$v^2 = u^2 + 2as \qquad \text{...(iii)}$$

When the velocity of a body increases, it has a positive acceleration and when the velocity decreases, it has a negative acceleration.

This negative acceleration is called deceleration or retardation.

NOTE

When a body is released from a height, its velocity increases by 9.8 m/s in every second and when a body is thrown above the earth's surface, its velocity decreases by 9.8 m/s in every second. This change in velocity every second is called acceleration due to gravity which is denoted by 'g'.

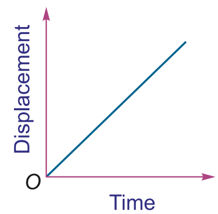
Its average value at the earth's surface is 9.8 m/s^2. It is always directed towards the centre of the earth because of the gravitational pull.

For a freely falling body, its acceleration is 9.8 m/s^2.

Displacement-Time Graphs

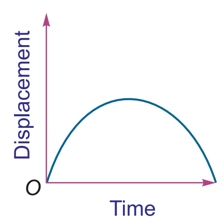
For a Body Moving With a Uniform Velocity

This graph comes as a straight line because in a uniform velocity the particle completes equal displacement in an equal interval of time.

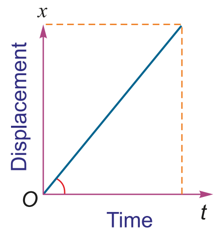


For The Motion of a Body Thrown Vertically Upwards

When the body moves up, its velocity continuously decreases due to gravity and finally becomes zero at the maximum height. Then, the body falls with an increasing velocity.



The slope of the position-time graph is equal to the uniform velocity.



$$\text{Slope} = \frac{\text{Displacement}}{\text{Time}}$$

or $V = \dfrac{x}{t}$

Velocity-Time Graph

For a uniformly accelerated motion the velocity-time graph is a straight line. The area under the velocity-time graph is equal to displacement.

$\therefore$ Displacement = Area under velocity-time graph

$$= \text{Area of } \Delta OAB = \frac{1}{2} \times AB \times OB$$

Where $\dfrac{AB}{2}$ = Average velocity (Var.)

$$= \frac{\text{Initial velocity} + \text{Final velocity}}{2}$$

or $V_{av} = \dfrac{u+v}{2}$ and OB = time (t)

$$\therefore \quad S = \left(\frac{u+v}{2}\right)t$$

$$\therefore \quad V = u + at$$

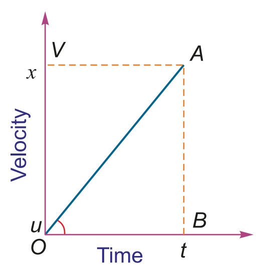
The slope of the velocity-time graph is equal to acceleration.

In the figure, Slope = $\dfrac{AB}{OB}$ = acceleration

and OB = time (t)

$$\therefore \quad a = \frac{v-u}{t}$$

or, $V = u + at$



Physical Quantities

Vectors

They have a definite magnitude and a definite direction, e.g. displacement, velocity, acceleration, force etc.

Scalars

They have definite magnitudes only and not direction. e.g. distance, speed, work, energy, power, electric charge etc.

Tensors

They have different magnitudes in different directions, e.g. Moment of interia, stress etc.

A physical quantity having direction may or may not be a vector e.g. time, pressure, current-electricity, surface-tension etc. They have direction but are not vectors.

Linear Momentum

It is the quantity of motion which a body possesses and is measured as the product of the mass and velocity of the body.

Linear momentum = mass × velocity

Impulse

The total change in momentum is called the impulse. If a very large force acts for a very small time, the product of force and the time is equal to the impulse.

Inertia

The inability of a body to change by itself its state of rest or state of uniform motion along a straight line is called inertia of the body.

The inertia of a body is measured by its mass. Heavier the body, greater is the force required to change its state and hence greater is its inertia. Inertia of a body may be inertia of rest, inertia of motion or inertia of direction.

Newton's Laws of Motion

First Law of Motion

Every body continues to be in a state of rest or uniform motion in a straight line, except in so far as it may be compelled by force to change that state. Newton's first law of motion defines inertia.

1. **Inertia of Rest :** The inability of a body to change by itself its state of rest.

   Example: When a branch of a fruit tree is shaken, the fruits fall down. This is because the branch comes in motion and the fruits tend to remain at rest. Hence, they get detached.

2. **Inertia of Motion :** The inability of a body to change by itself its state of uniform motion.

   Example: When an athelete takes a long jump, he runs first for a certain distance before the jump. This is because his feet come to rest on touching the ground and the remaining body continues to move owing to inertia of motion.

3. **Inertia of Direction :** The inability of a body to change by itself its direction of motion.

   Example: When a bus or a car rounds a curve suddenly, the person sitting inside is thrown outwards. It happens so because the person tries to maintain his direction of motion due to directional inertia while the vehicle turns.

Second Law of Motion

The rate of change of linear momentum of a body is directly proportional to the external force applied on the body and this change takes place always in the direction of the applied force.

The second law gives us a measure of force. When a force is applied on a body, its momentum and hence, velocity change. The change in velocity produces an acceleration in the body. The rate of change of linear momentum with time is equal to the product of the mass of the body and its acceleration which measures the magnitude of the applied force i.e.

$$\text{Force} = \frac{\text{Change in linear momentum}}{\text{time interval}}$$

$$= \text{mass} \times \text{acceleration}$$

or, $$F = ma$$

Third Law of Motion

"To every action, there is always, an equal and opposite reaction."

Here, the action is the force exerted by one body on the other body while the reaction is the force exerted by the second body on the first.

Significance of Third Law

It signifies that forces in nature are always in pairs. A single isolated force is not possible. Force of action and reaction act always on different bodies.

They never cancel each other and each force produces its own effect. The forces of action and reaction may be due to actual physical contact of the two bodies or even from a distance. But they are always equal and opposite. This third law of motion is applicable whether the bodies are at rest or they are in motion. This law is applied to all types of forces e.g. gravitational, electric or magnetic forces, etc.

Example: When a gun fires a bullet, it moves forward due to a force exerted by the gun. The bullet exerts a reaction due to which the gun recoils backward.

Principle of Conservation of Linear Momentum

The total sum of the linear momentum of all bodies in a system remains constant and is not affected due to their mutual action and reaction. It means in a system of the two bodies, the total momentum of the bodies before impact is equal to the total momentum of the two bodies after impact.

The law of conservation of linear momentum is universal i.e. it applies to both, the microscopic as well as macroscopic system.

Uniform Circular Motion

When a body moves along a circular path or a curve with a uniform circular speed, the body is acted upon by an inward acceleration. This acceleration acts towards the centre of a circular path or curve and is called as radial or centripetal acceleration which gives rise to the centripetal force. The centripetal force is an essential condition of the circular motion.

Centripetal force (F_c) = mass of the body (m) × centripetal acceleration (a_c)

or $$F_c = ma_c$$

Centripetal acceleration

$$a_c = \frac{v^2}{r} = r\omega^2$$

where v = linear speed, ω = angular speed or, r = radius of circular path or curve.

$$\therefore \quad F_c = ma_c = \frac{mv^2}{r} = mv\omega = mr\omega^2$$

The centripetal force acting on a body is an action and an equal and opposite force called centrifugal force appears as a reaction.

Example: A cyclist leans forward while going along a curve. By doing so, the ground provides him the centripetal force which he requires for turning. Hence, the cyclist leans inwards from his vertical position.

Rotational Motion

Torque (Moment of Force)

The product of force acting on a body and perpendicular distance of line of action of the force from the axis of rotation is called moment of force or torque.

Torque = Force × Perpendicular distance from axis rotation

Angular Momentum

It is equal to the product of linear momentum of a body and the perpendicular distance from the axis of rotation. It follows the principle of conservation. It means the total angular moment of an isolated system remains always constant.

Friction

When a body moves (slides or rolls) or even tries to move over the surface of another body a tangential force comes into action between their surfaces in contact, against their relative motion. This opposing force is termed as the force of friction.

The force of friction depends upon the mass of the body on a surface and roughness of the surfaces in contact between them and the magnitude of friction, which increases with increase in roughness and mass.

When a body is at rest on a surface, the friction is called static friction which is a self adjusting force. When the body is on the verge to move (slide or roll), the friction is called limiting friction but when the body moves, it gives rise to dynamic friction.

1.3 Work

When a force is applied on a body and a displacement is carried out in any direction except in a direction perpendicular to the direction of the force, an amount of work is done by the force.

The amount of work done is equal to the product of the force and the distance travelled in the direction of the applied force i.e.

Work = Force × distance travelled

or, $W = F \times S$

Unit of work is Joule 1 joule = 1 Newton × 1 Metre.

Work done by a force may be zero, positive or negative depending upon the direction of the applied force and displacement.

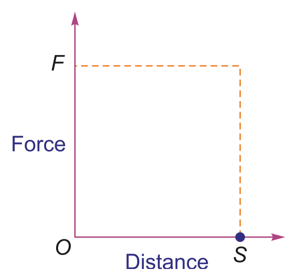
1.4 Power

The time rate of change of work is power. When a body takes less time to do a certain work, its power is said to be more and vice-versa.

$$\text{Power} = \frac{\text{work}}{\text{time}}$$

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

Its unit is Watt (W). One kilowatt (1 kW) is equal to 1000 watt. One horse power (h.p.) is equal to 746 Watt. Power of an agent measures how fast it can do the work.

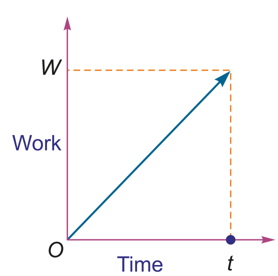


The area under the force versus distance graph is numerically equal to the work done by the agent.

Work = Force × Distance

$W = F \times S$

The area under power-time graph gives the work done while the slope of work versus time graph gives the power.



Work = power × time

= area under W-t graph

or, $W = Pt$

Power = Work/Time

or, $P = w/t$ = slope of W-t graph

1.5 Energy

The ability of a body to do work is called energy. When a body can do more work, it is said to have more energy and vice versa. Energy is different from power. Energy refers to the total amount of work a body can do and power determines the rate of doing work. Both the energy of a body and work done by the body are equivalent and are measured in Joule (J).

Kinetic Energy (K.E.)

It is the energy possessed by the body by virtue of its motion. The kinetic energy of a body is given as

$$\text{K.E.} = \frac{1}{2}mv^2$$

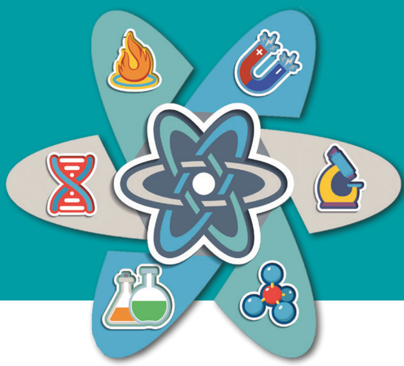
Where m = mass of the body and v = velocity of the body. Thus, K.E. of a body is equal to half the product of mass of the body and square of velocity of the body. The change in K.E. of a body measures the work done by the body.

Work = change in K.E. of the body

or, $$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

Where u and v are initial and final velocities respectively of the body of mass m.

Every moving system is associated with a definite amount of K.E. e.g. a moving vehicle, wind, water flow, etc.



Physics

PRACTICE QUESTIONS

1. Why are the inner lining of hot water geysers made up of copper?
(a) Copper has less heat capacity
(b) Copper has high electrical conductivity
(c) Copper does not react with steam
(d) Copper is good conductor of both heat and electricity

2. Hair of a shaving brush cling together when the brush is removed from water due to
(a) viscosity (b) elasticity
(c) friction (d) surface tension

3. Which one of the following forces lead to separation of the cream from the churned milk?
(a) Gravitational force
(b) Cohesive force
(c) Centripetal force
(d) Centrifugal force

4. Which one of the following common devices works on the basis of the principle of mutual induction?
(a) Tube light (b) Transformer
(c) LED (d) Photodiode

5. 'Mirage' is a phenomenon due to
(a) Reflection of light
(b) Refraction of light
(c) Total internal reflection of light
(d) Total diffraction of light

6. Which of the following has the most penetrating power?
(a) Alpha-particles
(b) Beta-particles
(c) Gamma-particles
(d) X-rays

7. The blackboard seems black because it
(a) reflects every colour
(b) does not reflect any colour
(c) absorbs black colour
(d) reflects black colour

8. A solid sphere, disc and solid cylinder all of same mass and made of same material are allowed to roll down (from rest) on incline plane then
(a) disc will reach the bottom first
(b) solid sphere will reach the bottom first
(c) solid cylinder will reach the bottom first
(d) All of them will reach the bottom at the same time

9. Which one of the following phenomena shows particle nature of light?
(a) Polarisation
(b) Photo-electric effect
(c) Interference
(d) Refraction

10. Which one of the following is deviated by an electric field?
(a) Alpha-rays (b) Beta-rays
(c) Neutrons (d) X-rays

11. The impurity atom with which pure silicon should be doped to make a p-type semiconductor are those of
(a) Phosphorus (b) Boron
(c) Antimony (d) Arsenic

42. Why the needle of iron swims on water surface when it is kept gently ?
(a) It will remain under the water, when it will displace more water than its weight
(b) the density of needle is less than that of water
(c) due to surface tension
(d) due to its shape

43. Which of the following statements is true when we see 'rainbow'?
(a) We face sun and raindrops
(b) The Sun remains behind us and we face raindrops
(c) In light rainfall, we face Sun
(d) The sky remains clear and the sun is at lower position in the sky

44. Surface tension in a liquid is due to :
(a) Adhesive force between molecules
(b) Cohesive force between molecules
(c) Gravitational force between molecules
(d) Electrical force between molecules.

45. The velocity of heat radiation in vacuum is
(a) Equal to that of light
(b) Less than that of light
(c) Greater than that of light
(d) Equal to that of sound

46. Which of the following is used for regulated electric supply ?
(a) Zener diode
(b) Junction diode
(c) Gun diode
(d) Tunnel diode

47. The substance which conducts current in the solid state is
(a) diamond (b) graphite
(c) iodine (d) sodium chloride

48. What is viewed through an electron microscope?
(a) Electrons and other elementary particles
(b) Structure of bacteria and viruses
(c) Inside of human stomach
(d) Inside of the human eye

49. Instrument used to measure the force and velocity of the wind is
(a) Ammeter (b) Anemometer
(c) Altimeter (d) Audiometer

50. A particle dropped from the top of a tower uniformly falls on ground at a distance which is equal to the height of tower. Which of the following paths will be traversed by the particle ?
(a) Circle (b) Parabolic
(c) Great circle (d) Hyper-parabolic

PHYSICS

ANSWER KEY

1. (d)	2. (d)	3. (d)	4. (b)	5. (c)	6. (c)	7. (b)	8. (b)
9. (b)	10. (a)	11. (b)	12. (c)	13. (b)	14. (c)	15. (b)	16. (a)
17. (b)	18. (c)	19. (b)	20. (c)	21. (c)	22. (d)	23. (d)	24. (c)
25. (a)	26. (c)	27. (b)	28. (b)	29. (d)	30. (a)	31. (b)	32. (c)
33. (d)	34. (a)	35. (c)	36. (d)	37. (a)	38. (b)	39. (b)	40. (d)
41. (b)	42. (c)	43. (b)	44. (b)	45. (a)	46. (a)	47. (b)	48. (b)
49. (b)	50. (b)						