HIGHER SECONDARY FIRST YEAR
PHYSICS VOLUME –I
LAWS AND DEFINITIONS

Force:
"Force is the external agency applied on a body to change its state of rest and motion".

Fundamental quantities

Fundamental quantities are quantities which cannot be expressed in terms of any other physical quantity

derived quantities

Quantities that can be expressed in terms of fundamental quantities are called derived quantities

Unit

unit of a physical quantity is defined as the established standard used for comparison of the given physical quantity The units in which the fundamental quantities are measured are called fundamental units and the units used to measure derived quantities are called derived units.

One standard metre is equal to 1 650 763.73 wavelengths of the orange − red light emitted by the individual atoms of krypton − 86 in a krypton discharge lamp.

The kilogram is equal to the mass of the international prototype of the kilogram (a plantinum − iridium alloy cylinder) kept at the International Bureau of Weights and Measures at Sevres, near Paris, France.

One standard second is defined as the time taken for 9 192 631 770 periods of the radiation corresponding to unperturbed transition between hyperfine levels of the ground state of cesium – 133 atom.

Ampere

The ampere is the constant current which, flowing through two straight parallel infinitely long conductors of negligible cross-section, and placed in vacuum 1 m apart, would produce between the conductors a force of 2 × 10 -7 newton per unit length of the conductors.

Kelvin

The Kelvin is the fraction of 1/273.16 of the thermodynamic temperature of the triple point of water*.

Candela

The candela is the luminous intensity in a given direction due to asource, which emits monochromatic radiation of frequency 540×10^{12} Hz and of which the radiant intensity in that direction is 1/683 watt per steradian.

Mole

The mole is the amount of substance which contains as many elementary entities as there are atoms in 0.012 kg of carbon-12.

Rules and conventions for writing SI units and their symbols

1. The units named after scientists are not written with a capital initial letter.
For example : newton, henry, watt
2. The symbols of the units named after scientist should be written by a capital letter.
For example : N for newton, H for henry, W for watt
3. Small letters are used as symbols for units not derived from a proper name.
For example : m for metre, kg for kilogram
4. No full stop or other punctuation marks should be used within or at the end of symbols.
For example : 50 m and not as 50 m.
5. The symbols of the units do not take plural form. For example : 10 kg not as 10 kgs
6. When temperature is expressed in kelvin, the degree sign is omitted.
For example : 273 K not as 273° K
(If expressed in Celsius scale, degree sign is to be included. For example 100o C and not 100 C)
7. Use of solidus is recommended only for indicating a division of one letter unit symbol by another unit symbol. Not more than one solidus is used.
For example : m s−1 or m / s, J / K mol or J K^{-1} mol^{-1} but not J / K / mol.
8. Some space is always to be left between the number and the symbol of the unit and also between the symbols for compound units such as force, momentum, etc.
For example, it is not correct to write 2.3m. The correct representation is 2.3 m; kg m s^{-2} and not as $kgms^{-2}$.
9. Only accepted symbols should be used. For example : ampere is represented as A and not as amp. or am ; second is represented as s and not as sec.
10. Numerical value of any physical quantity should be expressed in scientific notation.
For an example, density of mercury is 1.36 × 104 kgm^{-3} and not as 13600 kg m^{-3}.

Astronomical unit

Astronomical unit is the mean distance of the centre of the Sun from the centre of the Earth.

1 Astronomical unit (AU) = 1.496×10^{11} m

The error in the use of any instrument is normally taken to be half of the smallest division on the scale of the instrument. Such an error is called instrumental error
If the error in the measured value is expressed in fraction, it is called fractional error and if expressed in percentage it is called percentage error

Significant figures

the number of meaningful digits in a number is called the number of significant figures

Principle of homogeneity of dimensions

An equation is dimensionally correct if the dimensions of the various terms on either side of the equation are the same. This is called the principle of homogeneity of dimensions

Uses of dimensional analysis

The method of dimensional analysis is used to
(i) convert a physical quantity from one system of units to another.
(ii) check the dimensional correctness of a given equation.
(iii) establish a relationship between different physical quantities in an equation.

Limitations of Dimensional Analysis

(i) The value of dimensionless constants cannot be determined by this method.
(ii) This method cannot be applied to equations involving exponential and trigonometric functions.
(iii) It cannot be applied to an equation involving more than three physical quantities.
(iv) It can check only whether a physical relation is dimensionally correct or not. It cannot tell whether the relation is absolutely correct or not. For example applying this technique $s = ut + 1/4at^2$ is dimensionally correct whereas the correct relation is $s = ut + 1/2at^2$.

Particle

A particle is ideally just a piece or a quantity of matter, having practically no linear dimensions but only a position.

Rest and Motion

When a body does not change its position with respect to time, then it is said to be at rest.Motion is the change of position of an object with respect to time.

Speed

It is the distance travelled in unit time. It is a scalar quantity.

Velocity

The velocity of a particle is defined as the rate of change of displacement of the particle. It is also defined as the speed of the particle in a given direction. The velocity is a vector quantity. It has both magnitude and direction.
Velocity =displacement/time taken
Its unit is m s−1 and its dimensional formula is LT^{-1}.

Uniform velocity

A particle is said to move with uniform velocity if it moves along a fixed direction and covers equal displacements in equal intervals of time, however small these intervals of time may be.

Acceleration

If the magnitude or the direction or both of the velocity changes with respect to time, the particle is said to be under acceleration. Acceleration of a particle is defined as the rate of change of velocity. Acceleration is a vector quantity

Retardation or deceleration

If the velocity decreases with time, the acceleration is negative. The negative acceleration is called retardation or deceleration.

Uniform motion

A particle is in uniform motion when it moves with constant velocity (i.e) zero acceleration

Triangle law of vectors

If two vectors are represented in magnitude and direction by the two adjacent sides of a triangle taken in order, then their resultant is the closing side of the triangle taken in the reverse order.

Parallelogram law of vectors

If two vectors acting at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram, then their resultant is represented in magnitude and direction by the diagonal passing through the common tail of the two vectors.

Resolution of vectors and rectangular components

A vector directed at an angle with the co-ordinate axis, can be resolved into its components along the axes. This process of splitting a vector into its components is known as resolution of a vector.

Projectile motion

A body thrown with some initial velocity and then allowed to move under the action of gravity alone, is known as a projectile.

Angle of projection

The angle between the initial direction of projection and the horizontal direction through the point of projection is called the angle of projection.

Velocity of projection

The velocity with which the body is projected is known as velocity of projection.

Range

Range of a projectile is the horizontal distance between the point of projection and the point where the projectile hits the ground.

Trajectory

The path described by the projectile is called the trajectory.

Time of flight

Time of flight is the total time taken by the projectile from the instant of projection till it strikes the ground.

Newton's first law of motion

It states that every body continues in its state of rest or of uniform motion along a straight line unless it is compelled by an external force to change that state.

Inertia of rest

It is the inability of the body to change its state of rest by itself.

Inertia of motion

Inertia of motion is the inability of the body to change its state of motion by itself.

Inertia of direction

It is the inability of the body to change its direction of motion by itself.

This inability of a body to change by itself its state of rest or of uniform motion along a straight line or direction, is known as inertia. The inertia of a body is directly proportional to the mass of the body.

Force is defined as that which when acting on a body changes or tends to change the state of rest or of uniform motion of the body along a straight line.

The momentum of a body is defined as the product of its mass and velocity.

Newton's second law of motion

According to this law, the rate of change of momentum of a body is directly proportional to the external force applied on it and the change in momentum takes place in the direction of the force

Impulsive Force

An impulsive force is a very great force acting for a very short time on a body, so that the change in the position of the body during the time the force acts on it may be neglected.

(e.g.) The blow of a hammer, the collision of two billiard balls etc.

Impulse of a force

The impulse J of a constant force F acting for a time t is defined as the product of the force and time.(i.e) Impulse = Force × time $J = F \times t$

Principle of impulse and momentum

the total change in the momentum of a body during a time interval is equal to the impulse of the force acting during the same interval of time. This is called principle of impulse and momentum.

Newton's third Law of motion

for every action, there is an equal and opposite reaction.

Law of conservation of momentum

the total momentum of the system is always a constant (i.e) when the impulse due to external forces is zero, the momentum of the system remains constant. This is known as law of conservation of momentum.

Parallelogram law of forces

If two forces acting at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram, then their resultant is represented in magnitude and direction by the diagonal passing through the point.

Triangle law of forces

if a body is in equilibrium under the action of three forces acting at a point, then the three forces can be completely represented by the three sides of a triangle taken in order.

Lami's theorem

if three forces acting at a point are in equilibrium, then each of the force is directly proportional to the sine of the angle between the remaining two forces.

Angular velocity

The rate of change of angular displacement is called the angular velocity of the particle

Centripetal acceleration

the acceleration of the particle producing uniform circular motion is equal to v^2/r and is along AO (i.e) directed towards the centre of the circle. This acceleration is directed towards the centre of the circle along the radius and perpendicular to the velocity of the particle. This acceleration is known as centripetal or radial or normal acceleration

Centripetal acceleration

for circular motion, a constant force should act on the body, along the radius towards the centre and perpendicular to the velocity of the body. This force is known as centripetal force.

joule.

One joule is defined as the work done by a force of one newton when its point of application moves by one metre along the line of action of the force.

Energy

Energy can be defined as the capacity to do work

Principle of work and energy (work – energy theorem)

Statement

The work done by a force acting on the body during its displacement is equal to the change in the kinetic energy of the body during that displacement.

Law of conservation of energy

The law states that, if a body or system of bodies is in motion under a conservative system of forces, the sum of its kinetic energy and potential energy is constant

Power

It is defined as the rate at which work is done.

power =work done/time

Its unit is watt and dimensional formula is $ML^2 T^{-3}$.

Power is said to be one watt, when one joule of work is said to be done in one second.

Collisions

A collision between two particles is said to occur if they physically strike against each other or if the path of the motion of one is influenced by the other.

Elastic collision

If the kinetic energy of the system is conserved during a collision, it is called an elastic collision. (i.e) The total kinetic energy before collision and after collision remains unchanged

Inelastic collision

During a collision between two bodies if there is a loss of kinetic energy, then the collision is said to be an inelastic collision

A point in the system at which whole mass of the body is supposed to be concentrated is called centre of mass of the body.

3.1.3Centre of gravity

A body may be considered to be made up of an indefinitely large number of particles, each of which is attracted towards the centre of the Earth by the force of gravity.

The centre of gravity of a body is the point at which the resultant of the weights of all the particles of the body acts, whatever may be the orientation or position of the body provided that its size and shape remain unaltered.

Equilibrium is thus stable, unstable or neutral according to whether the potential energy is minimum, maximum or constant.

Rigid body

A rigid body is defined as that body which does not undergo any change in shape or volume when external forces are applied on it.

A rigid body is said to have pure rotational motion, if every particle of the body moves in a circle, the centre of which lies on a straight line called the axis of rotation

Parallel axes theorem

Statement

The moment of inertia of a body about any axis is equal to the sum of its moment of inertia about a parallel axis through its centre of gravity and the product of the mass of the body and the square of the distance between the two axes.

Perpendicular axes theorem

Statement

The moment of inertia of a plane laminar body about an axis perpendicular to the plane is equal to the sum of the moments of inertia about two mutually perpendicular axes in the plane of the lamina such that the three mutually perpendicular axes have a common point of intersection.

Moment of a force

The magnitude of the moment of force F about a point is defined as the product of the magnitude of force and the perpendicular distance of the point from the line of action of the force

Two equal and opposite forces whose lines of action do not coincide are said to constitute a couple in mechanics. The two forces always have a turning effect, or moment, called a torque.

The product of the forces forming the couple and the arm of the couple is called the moment of the couple or torque

Angular momentum of a particle

The angular momentum of a particle is defined as the moment of linear momentum of the particle.

The sum of the moment of the linear momenta of all the particles of a rotating rigid body taken together about the axis of rotation is known as angular momentum of the rigid body.

when no external torque acts on the body, the net angular momentum of a rotating rigid body remains constant. This is known as law of conservation of angular momentum.

Newton's law of gravitation

every particle of matter in the universe attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Gravitational field

A particle or a body placed at a point modifies a space around it which is called gravitational field The gravitational field is defined as the space around a mass in which it can exert gravitational force on other mass.

Gravitational field intensity

Gravitational field intensity or strength at a point is defined as the force experienced by a unit mass placed at that point. It is denoted by **E.** It is a vector quantity. Its unit is N kg^{-1}.

Gravitational potential difference

Gravitational potential difference between two points is defined as the amount of work done in moving unit mass from one point to another point against the gravitational force of attraction

Gravitational potential

Gravitational potential at a point is defined as the amount of work done in moving unit mass from the point to infinity against the gravitational field. It is a scalar quantity. Its unit is N m kg^{-1}.

Gravitational potential energy

The gravitational potential energy of a mass m at a distance r from another mass M is defined as the amount of work done in moving the mass m from a distance r to

infinity. Intertial mass of a body is a measure of the ability of a body to oppose the production of acceleration in it by an external force.

Gravitational mass

Gravitational mass is the mass of a body which determines the magnitude of gravitational pull between the body and the Earth

Escape speed

The escape speed is the minimum speed with which a body must be projected in order that it may escape from the gravitational pull of the planet.

Orbital velocity

The horizontal velocity that has to be imparted to a satellite at the determined height so that it makes a circular orbit around the planet is called orbital velocity

Geo–stationary satellites

A number of communication satellites which appear to remain in fixed positions at a specified height above the equator are called synchronous satellites or geo-stationary satellites

Kepler's laws of planetary motion

(i) The law of orbits

Each planet moves in an elliptical orbit with the Sun at one focus

The law of areas

The line joining the Sun and the planet (i.e radius vector) sweeps out equal areas in equal interval of times.

The law of periods

The square of the period of revolution of a planet around the Sunis directly proportional to the cube of the mean distance between the planet and the Sun.

Conditions for life on any planet

The following conditions must hold for plant life and animal life to exist on any planet.

(i) The planet must have a suitable living temperature range.

(ii) The planet must have a sufficient and right kind of atmosphere.

(iii) The planet must have considerable amount of water on its surface.

The forces acting between the atoms due to electrostatic interaction between the charges of the atoms are called interatomic forces. Thus, interatomic forces are electrical in nature

Elasticity

The property of a material to regain its original state when the deforming force is removed is called elasticity.

Stress and strain

This restoring force per unit area of a deformed body is known as stress.

strain produced in a body is defined as the ratio of change in dimension of a body to the original dimension

Hooke's law

Within the elastic limit, strain produced in a body is directly proportional to the stress that produces it.

(i.e) stress α strain

Stress/Strain= a constant, known as modulus of elasticity.

Its unit is N m-2 and its dimensional formula is ML-1T-2.

Young's modulus of elasticity

Young's modulus of the material of the wire is defined as the ratio of longitudinal stress to longitudinal strain. It is denoted by q.

Young's modulus =longitudinal stress/longitudinal strain

Bulk modulus of elasticity

Bulk modulus of the material of the object is defined as the ratio bulk stress to bulk strain. It is denoted by k.

∴ Bulk modulus =Bulk stress/Bulk strain

Shear modulus or rigidity modulus of the material

Shear modulus or rigidity modulus of the material of the object is defined as the ratio of shear stress to shear strain. It is denoted by n. Rigidity modulus =shear stress/shear strain

Pascal's law

Pascal's law states that if the effect of gravity can be neglected then the pressure in a fluid in equilibrium is the same everywhere

Viscosity

Viscosity is the property of the fluid by virtue of which it opposes relative motion between its different layers. Both liquids and gases exhibit viscosity but liquids are much more viscous than gases

The coefficient of viscosity of a liquid is numerically equal to the viscous force acting tangentially between two layers of liquid having unit area of contact and unit velocity gradient normal to the direction of flow of liquid.

The unit of η is N s m^{-2}. Its dimensional formula is $ML^{-1}T^{-1}$.

Streamline flow

The flow of a liquid is said to be steady, streamline or laminar if every particle of the liquid follows exactly the path of its preceding particle and has the same velocity of its preceding particle at every point.

Critical velocity of a liquid can be defined as that velocity of liquid upto which the flow is streamlined and above which its flow becomes turbulent.

Stoke's law (for highly viscous liquids)

When a body falls through a highly viscous liquid, it drags the layer of the liquid immediately in contact with it. This results in a relative motion between the different layers of the liquid. As a result of this, the falling body experiences a viscous force

F. Stoke performed many experiments on the motion of small spherical bodies in different fluids and concluded that the viscous force F acting on the spherical body depends on

(i) Coefficient of viscosity η of the liquid

(ii) Radius a of the sphere and

(iii) Velocity v of the spherical body.

Dimensionally it can be proved that F = k ηav Experimentally Stoke found that k = 6π ∴ F = 6π ηav This is Stoke's law.

Terminal velocity of a body is defined as the constant velocity acquired by a body while falling through a viscous liquid.

Cohesive force

Cohesive force is the force of attraction between the molecules of the same substance. This cohesive force is very strong in solids, weak in liquids and extremely weak in gases.

Adhesive force

Adhesive force is the force of attraction between the moelcules of two different substances. For example due to the adhesive force, ink sticks to paper while writing. Fevicol, gum etc exhibit strong adhesive property.

Surface tension of a liquid

Surface tension is defined as the force per unit length acting perpendicular on an imaginary line drawn on the liquid surface, tending to pull the surface apart along the line. Its unit is N m^{-1} and dimensional formula is MT^{-2}.

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Angle of contact

The angle between the tangent to the liquid surface at the point of contact of the liquid with the solid and the solid surface inside the liquid is called angle of contact

Bernoulli's theorem

. According to Bernoulli's theorem, for the streamline flow of a non-viscous and incompressible liquid, the sum of the pressure energy, kinetic energy and potential energy per unit mass is a constant.

(i.e)

$\rho /P + v^2/2 + gh$ = constant

This equation is known as Bernoulli's equation.