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"Success (S) in any exam is directly proportional to your Hard Work (H), Dedication (D), Notes Preparation (N) & Revision (R). While it is inversely proportional to your Care Less (C) attitude towards studies. While your Dheetpan (D) remains constant."
(Bilal's Law of Success)

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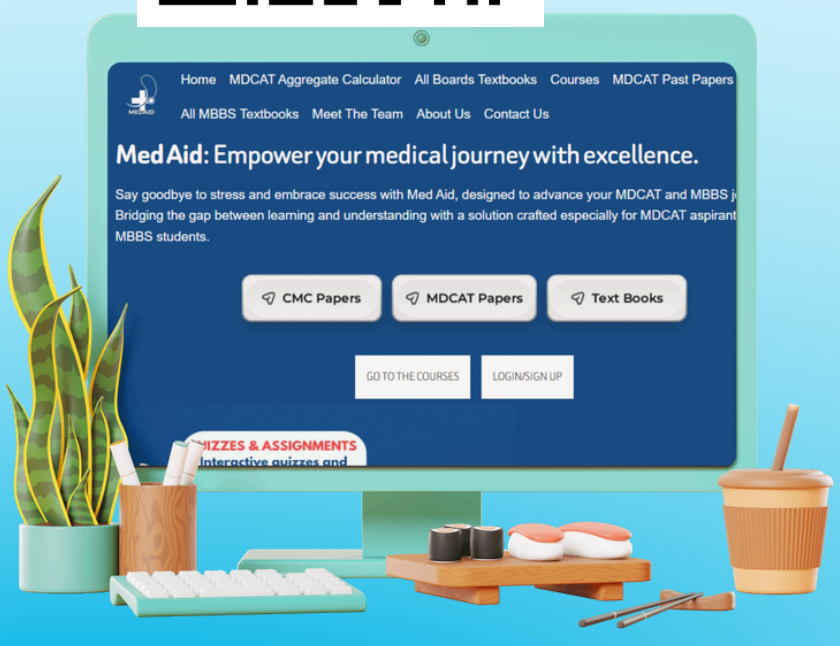
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CHAPTER 1
MEASUREMENTS

PHYSICS:

Physics is the branch of science which deals with the study of matter and energy and the relationship between them.

It has many branches, some of these are:

- Nuclear Physics:
  It deals with atomic nuclei.
- Particle Physics:
  It deals with the ultimate particles of which the matter is composed.
- Relativistic Mechanics:
  It is that branch of physics which deals with velocities approaching that of light.
- Solid State Physics:
  It concerned with the structure and properties of solids.
- Mechanics:
  The branch of physics which deals with the study of the behavior of physical systems under the action of forces.
- Fluid Dynamics:
  The branch of physics which deals with the study of fluids in motion is called fluid dynamics. Newton's laws and law of conservation of energy are used to analyze fluid dynamics.
- Acoustic:
  The application of the scientific study about the sound in designing a building, halls, concert rooms etc. is called acoustics.
- Optics:
  It is the science of light and vision.
- Heat and Thermodynamics:
  Thermodynamics deals with various phenomena of energy and related properties of matter, especially the transformation of heat into other forms of energy.
- Electrostatics:
  Electrostatics is a branch of physics in which we deal with the study of electric charges at rest under the act of electric forces. An electric force is the force in which holds the positive and negative charges that make up atoms and molecules.
- Electrodynamics:
  The study of the relations between electrical, magnetic, and mechanical phenomenon.
- Magnetism:
  Phenomena involving magnetic fields and their effects on materials.
- Electronics:
  The branch of physics which deals which principles and ways by which the flow of electrons is controlled, is called "Electronics".

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INTERNATIONAL SYSTEM OF UNITS:

In 1960, an international committee agreed on a set of definitions and standard to describe the physical quantities. The system that was established is called the System International (SI).

The system international (SI) is built up from three kinds of units, supplementary units and derived units.

(I) Base Units:

There are seven base units for various physical quantities, the names of base units for these physical quantities together with symbols are listed in table:

	Physical Quantity	SI Units	Symbol
(1)	Length	metre	m
(2)	Mass	kilogram	kg
(3)	Time	second	s
(4)	Electric current	ampere	A
(5)	Thermodynamic temperature	kelvin	K
(6)	Intensity of light	candela	cd
(7)	Amount of substance	mole	mol

(II) Supplementary Units:

The General conference on weights and measures has not yet classified certain units of the system international under either base units of derived units. These units are called as supplementary units. These are units of plane angle and units of solid angle.

The names of supplementary units for these physical quantities together with symbols are listed in table:

	Physical Quantity	SI Units	Symbol
(1)	Plane angle	radian	rad
(2)	Solid angle	steradian	sr

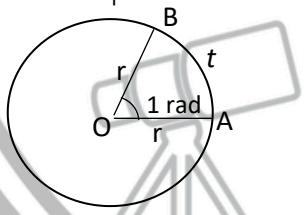
DEFINITIONS OF RADIAN AND STERADIAN:

Radian:

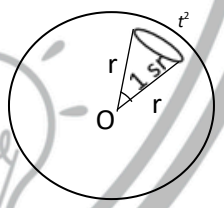
The radian is the plane angle between two radii of a circle which cut off on the circumference, where an arc length AB is equal to the radius of the circle as shown in figure (a).

Steradian:

The steradian is the solid angle (three-dimensional angle) subtended at the centre of a sphere by an area of its surface equal to the square of radius of sphere as shown in figure (b).



$Fig.\ (a)$



$Fig.\ (b)$

(III) DerivedUnits:

SI unitsfor measuring all otherphysical quantities arederived from thebaseand supplementary units. Some ofthe derived units are given in table as follows:

	Physical Quantity	SI Units	Symbol	In termsofbase units
(1)	Force	newton	N	$kgms^{-2}$
(2)	Work	joule	J	$nm=kgm^2s^{-2}$
(3)	Power	watt	W	$JS^1=kgm^2s^{-3}$
(4)	Pressure	pascal	Pa	$Nm^{-2}=kgm^{-1}s^{-2}$
(5)	Electric charge	coulomb	C	As

SCIENTIFIC NOTATION:

Numbers are expressed in standard form called scientific notation, which employs power of ten. The internationally accepted practice is that there should be only one non-zero digit left of decimal. For example,

(i) The number 134.7 should be written as 1.347×10^2.

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(ii)

Note: The number 0.0023 should be expressed as 1.3×10^{-3}.

Following points should be kept in mind while using units:

(i) Full name of the unit does not begin with a capital, even if named after a scientist e.g., newton.
(ii) The symbol of unit named after a scientist has initial capital letters such as N for newton.
(iii) The prefix should be written before the unit without any space, such as 1×10^{-3} m is written as 1 mm.
(iv) A combination of base units is written each with one space apart. For example, newton metre is written as N m.
(v) Compound prefixes are not allowed. For example, 1μμ may be written as 1 p.
(vi) A number such as 5.0×10^{4} cm may be expressed in scientific notation as 5.0×10^{2}m.
(vii) When a multiple of a base unit is raised to a power, the power applies to the whole multiple and not the base unit alone. Thus, 1 km^2 = 1 $(km)^2$ = $1\times10^{6}m^2$
(viii) Measurement in practical work should be recorded immediately in the most convenient unit, e.g., micrometer screw gauge measurement in mm, but before calculation for the result, all measurements must be converted to the appropriate SI base units.

STANDARD PREFIXES:

Some standard prefixes are given in the table as:

Factor	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c
10^{-1}	deci	d
10^{1}	deca	da
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E

SIGNIFICANT FIGURES:

In any measurement, the accurately known digits and the first doubtful digit are called significant figures.

Explanation:

Suppose that we want to measure the length of a straight line with the help of a metre rod calibrated in millimeters. The position of the edge of a line recorded as 12.7 cm with the help of a meter rod, may lie between 12.65 cm and 12.75 cm.

Thus, in this example the maximum uncertainty is ±0.05 cm.

The uncertainty or accuracy in the value of a measured quantity can be indicated conveniently by using significant figure. The recorded value of the length of the straight line, i.e., 12.7 cm contains three digits (1, 2, 7) out of which two digits (1 and 2) are accurately known while the third digits i.e., '7' is a doubtful one.

Rules for deciding the number of significant figures in a measured quantity:

(1) All non-zero digits (1, 2, 3, 4, 5, 6, 7, 8, 9) are significant.

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(2) Zero between non-zero digits are significant. E.g., 4003 kg has four significant figures, and 8.07 kg has three significant figures.

(3) Zero to the left of the first non-digits are not significant. E.g., none of the zeros in 0.00467 or 02.59 is significant.

(4) Zero to the right of a significant figure may or may not be significant.

Zero to the right of a significant figure are significant. E.g., all the zeros in 3.570 or 7.4000 are significant. However, in integers such as 8,000 kg, the number of significant zeros is determined by the accuracy of the measuring instrument.

If the measuring scale has a least count of 1 kg then there are four significant figures written in scientific notation as 8.000×10^3 kg.

If the least count of the scale is 10 kg, then the number of significant figures will be 3, written in scientific notation as 8.00×10^3 kg and so on.

(5) When a measurement is recorded in scientific notation, the figures other than the powers of ten are significant figures, e.g., 8.70×10^4 kg has three significant figures.

Rules for Rounding of Numbers:

(1) If the first digit dropped is less than '5', the digit retained should remain unchanged, e.g., 13.3 is rounded to 13.

(2) If the first digit dropped is more than 5, the digit to be retained is increased by one, e.g., 1.6 is rounded to 14.

(3) If the digit to be dropped is 5, the previous digit which is to retained is increased by one if it is odd and retained as such if it is even. For example, the following number are rounded off to three significant figures as follows. The digits are deleted one by one.

43.75 is rounded off as 43.8

73.650 is rounded off as 73.6

64.350 is rounded off as 64.6

Example:

The computation of the following using a calculator, gives

$$\frac{5.348\times10^{-2}\times3.64\times10^{4}}{1.336}=1.45768982\times10^{3}$$

Thus, the correct answer of the computation is 1.46×10^3.

PRECISION AND ACCURACY:

Precision:

A precise measurement is the one which has less precision or absolute uncertainty. The precision of a measurement is determined by the instrument being used.

Accuracy:

An accurate measurement is the one which has less fractional or percentage uncertainty or error. The accuracy of a measurement concerns how close a measurement is to the true value of the quantity measured.

ASSESSMENT OF TOTAL UNCERTAINTY THE FINAL RESULT:

To assess the total uncertainty or error, it is necessary to evaluate the likely uncertainties in all the factors involved in that calculation. The maximum possible uncertainty or error in the final result can be found as follows.

(i) Addition and Subtraction:

For addition and subtraction absolute uncertainties are added.

For example, the distance 'x' determined by the difference between two separate position measurements,

$x_1 = 10.5\pm0.1$ cm and $x_2 = 26.8 \pm 0.1$cm is recorded as,

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(ii) $x = x_2 - x_1 = 16.3 \pm 0.2$ cm

Multiplication and Division:

To get total uncertainty, when observed quantities are either multiplied or divided, the percentage uncertainties are added.

For example, we have to find,

$$R = \frac{V}{I}$$

Where

$V = 5.2 \pm 0.1$ V.

And $I = 0.84 \pm 0.05$ A

The %age uncertainty for V is

$$= \frac{0.1V}{5.2V} \times \frac{100}{100} = \frac{1.92}{100} = \text{about } 2\%$$

The %age uncertainty for I is:

$$= \frac{0.05A}{0.84A} \times \frac{100}{100} = \frac{5.95}{100} = \text{about } 6\%$$

Hence total uncertainty in the value of 'R' when 'V' is divided by I is 8%.

The result is thus quoted as

$R = \frac{5.2V}{0.84A} = 6.19\ VA^{-1} = 6.19$ ohms with a %age uncertainty of 8%.

i.e, $R = 6.2 \pm 0.5$ ohms

(iii) Power Factor:

To get total uncertainty for power factor we multiply the percentage uncertainty by that power.

For example, in the calculation of the volume of a sphere using,

$V = \frac{4}{3}\pi r^3$

If the radius of a small sphere is measured as 2.25 cm by Vernier calipers with least count 0.01 cm, then the radius r is recorded as,

$r = 2.25 \pm 0.01$ cm

%age uncertainty in

$$r = \frac{0.01cm}{2.25cm} \times \frac{100}{100} = 0.4\%$$

Total %age uncertainty in 'V'

= 3 × %age uncertainty in 'r'

= 3 × 0.4% = 1.2%

Thus volume,

$V = \frac{4}{3}\pi r^3$

$V = \frac{4}{3}(3.14)(2.25\ cm)^3$

$V = 47.689\ cm^3$ with 1.2% uncertainty

Thus, the result should be recorded as,

$V = 47.7 \pm 0.6 cm^3$

(iv) Average Value of many Measurements:

The uncertainty for average value of a number of different of same experiment is equal to mean of deviation of different readings.

For example, the six reading of the micrometer screw gauge to measure the diameter of a wire in mm are,

1.20, 1.22, 1.23, 1.19, 1.22, 1.21

Then,

$$\text{Average} = \frac{1.20+1.22+1.23+1.19+1.22+1.21}{6}$$

= 1.21 mm

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The deviation of the reading, which are the difference (without regards to the sign) between each reading and average value are,

0.01, 0.01, 0.02, 0.02, 0.01, 0

Mean of deviations = $\frac{0.01+0.01+0.02+0.02+0.01+0}{6}$

= 0.01 mm

Thus, uncertainty in the mean diameter (1.21 mm) is 0.01 mm recorded as 1.21±0.01mm.

(v) Uncertainty in Timing Experiment:

The uncertainty in the time period of a vibrating body is found by dividing the last count of timing device by the number of vibrations.

For example, the time of 30 vibrations of a simple pendulum recorded by a stopwatch accurate upto one tenth of a second is 54.6 s, the period,

$T = \frac{54.6s}{30}$

T = 1.82 s with uncertainty $(\frac{0.1s}{30} = 0.003s)$

Thus, period T is quoted as

T = 1.82±0.003s

DIMENSIONS OF PHYSICAL QUANTITIES:

It stands for the qualitative nature of the physical quantity. It is an expression which tells the involvement of the fundamental units in physical quantity.

Each base quantity is considered a dimension denoted by a specific symbol written within square brackets. For example, different quantities such as length, breadth, diameter, light year which are measured in metre denote the same dimension and has the dimension of length [L].

Similarly, the mass and time dimensions are denoted by [M] and [T], respectively.

The dimensions of other quantities may be combination of these,

For example,

Dimensions of speed = $\frac{\text{Dimension of length}}{\text{Dimension of time}}$

$[V] = \frac{[L]}{[T]} = [L][T^{-1}] = [LT^{-1}]$

Similarly, the dimensions of acceleration are

$[a] = [L][T^{-2}] = [LT^{-2}]$

And that of force are,

$[F] = [m][a] = [M][LT^{-2}] = [MLT^{-2}]$

Use of dimensional analysis:

Using the method of dimensions called the dimensional analysis, we can check the correctness of a given formula or an equation, and can also derive it.

Limitation of dimensional analysis:

- Dimensional analysis does not give any information about the constant of proportionality.
- It does not give any information about trigonometric function.
- This method fails when a physical quantity depends upon base quantities other than mass, length and time.

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DIMENSIONAL FORMULAE OF PHYSICAL QUANTITIES

S.No.	Physical Quantity	Relationship with other physical quantities	Dimensional Formula
1.	Area	Length × breadth	$[M^0L^2T^0]$
2.	Volume	Length × breadth × height	$[ML^3T^0]$
3.	Mass density	Mass/volume	$[ML^{-3}T^0]$
4.	Frequency	I/time period	$[M^0L^0T^{-1}]$
5.	Velocity, speed	Displacement/time	$[M^0LT^{-1}]$
6.	Acceleration	Velocity/time	$[M^0LT^{-2}]$
7.	Force	Mass × acceleration	$[MLT^{-2}]$
8.	Impulse	Force × time	$[MLT^{-1}]$
9.	Work, energy	Force × Distance	$[ML^2T^{-2}]$
10.	Power	Work/time	$[ML^2T^{-3}]$
11.	Momentum	Mass × velocity	$[MLT^{-1}]$
12.	Pressure, stress	Force/Area	$[ML^{-1}T^{-2}]$
13.	Strain	$\frac{\text{change in dimension}}{\text{origonal dimension}}$	$[M^0L^0T^0]$
14.	Modulus of elasticity	Stress/Strain	$[ML^{-1}T^{-2}]$
15.	Surface tension	Force/Length	$[ML^0T^{-2}]$
16.	Surface energy	Energy/Area	$[ML^0T^{-2}]$
17.	Velocity gradient	Velocity/distance	$[M^0L^0T^{-1}]$
18.	Pressure gradient	Pressure/distance	$[ML^{-2}T^{-2}]$
19.	Pressure energy	Pressure × volume	$[ML^2T^2]$
20.	Coefficient of viscosity	Force/area × velocity gradient	$[ML^{-1}T^{-1}]$
21.	Angle, Angular displacement	Arc/radius	$[M^0L^0T^0]$

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22.	Trigonometric ratio (sinθ, cosθ, tanθ etc)	Length/length	$[M^0L^0T^0]$
23.	Angular velocity	Angle/time	$[M^0L^0T^{-1}]$
24.	Angular acceleration	Angular velocity/time	$[M^0L^0T^{-2}]$
25.	Radius of gyration	Distance	$[M^0LT^0]$
26.	Moment of inertia	Mass × (radius of gyration)^2	$[ML^2T^0]$
27.	Angular momentum	Moment of inertial × angular velocity	$[ML^2T^{-1}]$
28.	Moment of force, Moment of couple	Force × distance	$[ML^2T^{-2}]$
29.	Torque	Angular momentum/time Or Force × distance	$[ML^2T^{-2}]$
30.	Angular frequency	2π × Frequency	$[M^0L^0T^{-1}]$
31.	Wavelength	Distance	$[M^0LT^0]$
32.	Hubble constant	Recession speed/distance	$[M^0L^0T^{-1}]$
33.	Intensity of wave	(energy/time)/area	$[ML^0T^3]$
34.	Radiation pressure	Intensity of wave/speed of light	$[ML^{-1}T^{-2}]$
35.	Energy density	Energy/volume	$[ML^{-1}T^{-2}]$
36.	Critical velocity	$\frac{\text{Reynold's number} \times \text{coefficient of viscosity}}{\text{Mass density} \times \text{radius}}$	$[M^0LT^{-1}]$
37.	Escape velocity	(2 × acceleration due to gravity × earth's radius)$^{1/2}$	$[M^0LT^{-1}]$
38.	Heat energy, internal energy	Work = force × distance	$[ML^2T^{-2}]$
39.	Kinetic energy	(1/2)mass × velocity^2	$[ML^2T^{-2}]$
40.	Potential energy	Mass × acceleration due to gravity × height	
41.	Rotational kinetic energy	½ × moment of inertia × (angular velocity)^2	$[ML^2T^{-2}]$
42.	Efficiency	$\frac{\text{output work of energy}}{\text{input work of enegy}}$	$[M^0L^0T^0]$
43.	Angular impulse	Torque × time	$[ML^2T^{-1}]$
44.	Gravitational constant	$\frac{\text{Force} \times \text{distance}^{\,2}}{\text{mass} \times \text{mass}}$	$[M^{-1}L^3T^{-2}]$
45.	Plank constant	Energy/frequency	$[ML^2T^{-1}]$

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46.	Heat capacity, entropy	Heat energy/temperature	$[ML^2T^{-2}K^{-1}]$
47.	Specific heat capacity	Heat energy/(Mass × temperature)	$[M^0L^2T^{-2}K^{-1}]$
48.	Latent heat	Heat energy/mass	$[M^0L^2T^{-2}]$
49.	Thermal expansion coefficient or thermal expansion expansivity	$\frac{\text{change in dimension}}{\text{original dimension} \times \text{temperature}}$	$[M^0L^0K^{-1}]$
50.	Thermal conductivity	$\frac{\text{Heat energy} \times \text{thickness}}{\text{area} \times \text{temperature} \times \text{time}}$	$[MLT^{-3}K^{-1}]$
51.	Bulk modulus or (compressibility)$^{-1}$	$\frac{\text{volume} \times (\text{change in pressure})}{\text{change in volume}}$	$[ML^{-1}T^{-2}]$
52.	Centripetal acceleration	$(\text{Velocity})^2/\text{radius}$	$[M^0LT^{-2}]$
53.	Stefan constant	$\frac{(\text{Energy} \div \text{area} \div \text{time})}{(\text{Temperature})^2}$	$[ML^0T^{-3}K^{-4}]$
54.	Wien constant	Wavelength × temperature	$[M^0LT^0K]$
55.	Boltzmann constant	Energy/temperature	$[ML^2T^{-2}K^{-1}]$
56.	Universal gas constant	$\frac{\text{Pressure} \times \text{volume}}{\text{mole} \times \text{temperature}}$	$[ML^2T^{-2}K^{-1}$ $mol^{-1}]$
57.	Charge	Current × time	$[M^0L^0TA]$
58.	Current density	Current/area	$[M^0L^{-2}T^0A]$
59.	Voltage, electric potential, electromotive force	Work/charge	$[ML^2T^{-3}A^{-1}]$
60.	Resistance	Potential difference/Current	$[ML^2T^{-3}A^{-2}]$
61.	Capacitance	Charge/potential difference	$[M^{-1}L^{-2}T^4A^2]$
62.	Electrical resistance or (electrical conductivity)$^{-1}$	$\frac{\text{Resistance} \times \text{area}}{\text{length}}$	$[ML^3T^{-3}A^2]$
63.	Electric field	Electrical force/charge	$[MLT^3A^{-1}]$
64.	Electric flux	Electric field × area	$[ML^3T^{-3}A^{-1}]$
65.	Electric dipole moment	Torque/electric field	$[M^0LTA]$
66.	Electric field strength or electric intensity	$\frac{\text{Potential difference}}{\text{distance}}$	$[MLT^{-3}A^{-1}]$

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67.	Magnetic field, magnetic flux density, magnetic induction	$\frac{\text{Force}}{\text{Current} \times \text{Length}}$	$[ML^0T^2A^{-1}]$
68.	Magnetic flux	Magnetic field× area	$[ML^2T^{-2}A^{-1}]$
69.	Inductance	~~Magnetic flux / Current~~	$[ML^2T^{-2}A^{-2}]$
70.	Magnetic dipole moment	Torque/magnetic field or Current × area	$[M^0L^2T^0A]$
71.	Magnetic field strength, magnetic intensity or magnetic moment density	$\frac{\text{Magnetic moment}}{\text{Volume}}$	$[M^0L^{-1}T^0A]$
72.	~~Permittivity constant~~ (or free space)	$\frac{\text{charge} \times \text{charge}}{4\pi \times \text{electric force} \times (\text{distance})^2}$	$[M^{-1}L^{-3}T^4A^2]$
73.	Permeability constant (or free space)	$\frac{2\pi \times \text{force} \times \text{distance}}{\text{current} \times \text{current length}}$	$[MLT^{-2}A^{-2}]$
74.	~~Refractive index~~	$\frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}}$	$[M^0L^0T^0]$
75.	Faraday constant	Avogadroconstant×elementarycharge	$[M^0L^0TA\ mol^{-1}]$
76.	Wave number	2π/wavelength	$[M^0L^{-1}T^0]$
77.	Radiant flux, Radiant power	Energy emitted/time	$[ML^2T^{-3}]$
78.	Luminosity of radiant flux or radiant intensity	$\frac{\text{Radiant power or radiant flux}}{\text{solid angle}}$	$[ML^2T^{-3}]$
79.	Luminous power or luminous flux of source	$\frac{\text{Luminous energy emitted}}{\text{time}}$	$[ML^2T^{-3}]$
80.	Luminous intensity of illuminating power of source	Luminous flux/Solid angle	$[ML^2T^{-3}]$
81.	Intensity of illumination or luminance	Luminous intensity / (distance)2	$[ML^0T^{-3}]$
82.	Relative luminosity	$\frac{\text{Luminous flux of a source of given wavelength}}{\text{luminous flux of peak sensitivity wavelength (555nm) source e ofsame power}}$	$[M^0L^0T^0]$
83.	Luminous efficiency	$\frac{\text{total luminous flux}}{\text{total radiant flux}}$	$[M^0L^0T^0]$
84.	Illuminance or illumination	Luminousfluxincident / area	$[ML^0T^{-3}]$

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85.	Mass defect	(sum of masses of nucleons) – (mass of the nucleus)	$[ML^0T^0]$
86.	Binding energy of nucleus	Mass defect × (speed of light in vacuum)2	$[ML^2T^{-2}]$
87.	Decay constant	0.693/half life	$[M^0L^0T^{-1}]$
88.	Resonant frequency	(inductance × capacitance)1/2	$[M^0L^0T^{-1}A^0]$
89.	Quality force or Q-factor of coil	$\frac{\text{Resonant frequency} \times \text{inductance}}{\text{Resistance}}$	$[M^0L^0T^0]$
90.	Power of lens	$(\text{Focal length})^{-1}$	$[M^0L^{-1}T^0]$
91.	Magnification	$\frac{\text{Image distance}}{\text{object distance}}$	$[M^0L^0T^0]$
92.	Fluid flow rate	$\frac{(\pi/8)(\text{pressure}) \times (\text{radius})^2}{(\text{viscosity coefficient}) \times (\text{length})}$	$[M^0L^3T^{-1}]$
93.	Capacitive reactance	Angular frequency × capacitance	$[ML^2T^{-3}A^{-2}]$
94.	Inductive reactance	Angular frequency × Inductance	$[ML^2T^{-3}A^{-2}]$

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PRACTICE SHEET

1. While measuring acceleration due to gravity by a simple pendulum, a student makes a positive error of 1% in the length of the pendulum and a negative error of 3% in the value of time period. The percentage error in the measurement of g is:
   a. 2% b. 4% c. 7% d. 10%

2. A force F is applied on a square plate of side L. If the percentage error in the determination of L is 2% and that in F is 4%, then permissible error in pressure is:
   a. 2% b. 4% c. 6% d. 8%

3. If length (L) mass (M) and force(F) are taken as fundamental quantities, then the dimensions of time will be:
   a. $M^{1/2}L^{1/2}F^{-1/2}$ b. $M^{-1/2}L^{1/2}F^{1/2}$ c. $M^2L^2T^{-2}$ d. $MLF^{-1/2}$

4. If pressure P, velocity v and time T are taken as fundamental physical quantities, then dimensional formula of force is:
   a. Pv^2T^{-2} b. $P^{-1}v^2T^{-2}$ c. PvT^2 d. $P^{-1}vT^2$

5. The length, breadth and thickness of sheet are 3.233m, 2.105m and 1.05 m respectively. Volume of sheet up to the appropriate significant digits is:
   a. 7.25 m^3 b. 7.5 m^3 c. 7.15 m^3 d. 7.1 m^3

6. If the error in the measurement of radius of a circle is 1% then the error in the measurement of its area will be:
   a. 1.1% b. 2% c. 5% d. 8%

7. Which is a base unit?
   a. newton b. steradian c. second d. pascal

8. In scientific notation 0.0001 will be written as:
   a. 1×10^4 b. 1×10^5 c. 10^4 d. 10^{-4}

9. Radian is unit of:
   a. Plane angle b. Solid angle c. Area d. Radius

10. One (atto) is equal to:
    a. 10^{-18} b. 10^{-15} c. 10^{18} d. 10^{-12}

11. One milli is equal to:
    a. 10^3 b. 10^{-3} c. 10^5 d. 10^{-6}

12. Significant figures in 0.00467 are:
    a. one b. two c. three d. five

13. Candela is the unit of:
    a. acoustic intensity b. electric intensity c. luminous intensity d. magnetic intensity

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14. Significant figures in 0.0322 are:

a. one b. two c. three d. four

15. The fundamental quantities which form the base for the SI system are:

a. mass, energy and time b. mass, force and time
c. mass, length and time d. force, length and time

16. Which of the following is derived quantity?

a. force b. velocity c. acceleration d. all of these

17. Total fractional uncertainty in the period $T = 2\pi\sqrt{\frac{\ell}{g}}$ will be equal to the:

a. sum of fractional uncertainty b. difference of uncertainties
c. product of uncertainties in ℓ and g d. none of these

18. Number of significant figures with increasing accuracy of the measuring instrument:

a. decreases b. increases c. remains unchanged d. none of these

19. A science student takes 100 observations in an experiment. Second time he takes 500 observations in the same experiment. By doing so the possible error becomes:

a. 5 times b. 1/5 times c. unchanged d. none of these

20. Density of a liquid is 13.6 gcm^{-3}. Its value in SI units is:

a. 136.0 kgm^{-3} b. 13600 kgm^{-3} c. 13.6 kgm^{-3} d. 1.36 kgm^{-3}

21. Given that v is the speed, r is radius and g is acceleration due to gravity. Which of the following is dimensionless?

a. v^2g/r b. v^2rg c. vr^2g d. v^2/rg

22. Dimensions of power are:

a. ML^2T^{-3} b. M^2LT^{-2} c. ML^2T^{-1} d. MLT^{-2}

23. Which of the following is a derived quantity?

a. mass b. velocity c. length d. time

24. Which of the following is not a unit of energy?

a. kilowatt b. erg c. joule d. kilowatt-hour

25. The dimensions of the quantities in one (or more) of the following pairs are the same. Identify the pairs.

a. Torque and work b. Angular momentum and work
c. Energy and Young's modulus d. Light year and wavelength

26. Which of the following pairs of physical quantities have the same dimension?

a. work & power b. work & energy c. force & power d. momentum & power

27. One nanometer is equal to:

a. 10^9 mm b. 10^{-6} cm c. 10^{-7} cm d. 10^{-9} cm

28. Which of the following quantities has not been expressed in proper units:

a. Young's Modulus = Nm^{-2} b. Surface tension = Nm^{-1}

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c. Pressure = Nm^{-2} d. Energy = $kgms^{-1}$

29. The percentage errors in the measurement of mass and speed are 2% and 3% respectively. The maximum error in the estimation of kinetic energy will be:
a. 1% b. 5% c. 8% d. 11%

30. A physical quantity X has the dimensional formula $M^a L^b T^{-c}$. If the percentage errors in the measurement of mass, length and time are **α%,β% and γ%** respectively, then the maximum percentage error on the measurement of X is:
a. $(\alpha+\beta+\gamma)\%$ b. $(\alpha+\beta-\gamma)\%$ c. $(a\alpha+b\beta+c\gamma)\%$ d. $(a\alpha+b\beta-c\gamma)\%$

31. The error in the measurement of the radius of a sphere is 1%. The error in the measurement of volume is:
a. 1% b. 3% c. 5% d. 8%

32. The dimensions of gravitational constant G are:
a. MLT^{-2} b. ML^3T^{-2} c. $M^{-1}L^3T^{-2}$ d. $M^{-1}LT^{-2}$

33. The dimensions of "light-year" are:
a. LT^{-1} b. T c. ML^2T^{-2} d. L

34. The dimensions of torque are:
a. ML^2T^{-2} b. MLT^{-2} c. MLT^{-1} d. MT^{-2}

35. Candela is the unit of:
a. acoustic intensity b. electric intensity c. luminous intensity d. magnetic intensity

36. Which of the following is a dimensionless quantity?
a. momentum/acceleration b. volume/area
c. energy/work d. force/power

37. Light year is a unit of:
a. distance b. time c. linear speed d. angular speed

38. The branch of physics which deals with the atomic nuclei is called:
a. solid state physics b. medical physics
c. nuclear physics d. mechanics

39. In scientific notation 0.0003 will be written as:
a. 3×10^4 b. 3×10^3 c. 3×10^{-4} d. 3×10^{-3}

40. According to Einstein equation, $E = mc^2$. E for one kilogram is equal to:
a. 10×10^{21} J b. 9.5×10^{16} J c. 9×10^{16} J d. 9×10^{18} J

41. The international accepted scientific notation of a number 123.4 is:
a. 12.34×10^1 b. 1.234×10^2 c. 0.1234×10^3 d. 123.4×10^2

42. The relative error is defined as the ratio of the error to the:
a. standard number b. measured number c. given number d. all of the above

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43. The number of significant figures in 8.80×10^{4} kg is:

a. 4 b. 3 c. 2 d. 1

44. The number 54.350 is rounded off as:

a. 4.36 b. 4.35 c. 54.46 d. 54.4

45. The number of significant zeros in 0.0001 are:

a. zero b. one c. two d. three

46. Ratio of dimensions of velocity to acceleration is:

a. $[LT^{-1}]$ b. [T] c. [L] d. $[LT^{-2}]$

47. Dimensional analysis helps:

a. to find relationship between quantities b. to convert one system of unit into another
c. to confirm correctness of any physical equation d. all of these

48. A basic physical quantity represented by a specific symbol written within square brackets is called:

a. Acceleration b. Impulse c. Dimension d. Units

49. Which physical quantity is measured in meters?

a. Light year b. Breadth c. Diameter d. All of these

50. Which of the following is a main frontier fundamental science?

a. The world of the extremely large things b. The world of the extremely small things
c. The world of middle size things d. All of the above

51. Which is not a base unit?

a. metre b. ampere c. candela d. radian

52. The branch of physics which is concerned with the ultimate particles of which the matter is composed is called:

a. atomic physics b. nuclear physics c. plasma physics d. particle physics

53. The branch of physics which deals with velocities approaching the velocity of light is called:

a. quantum mechanics b. relativistic physics
c. classical mechanics d. wave mechanics

54. Silicon can be obtained from:

a. metals b. chemicals c. sand d. stones

55. The rest mass of a proton is $1.67\times\mathbf{10}^{-27}$Kg. Its mass in gm is:

a. 1.67×10^{-30} b. 1.67×10^{-24} c. 1.67×10^{-28} d. 1.67×10^{-29}

56. SI unit of amount of substance is:

a. ampere b. candela c. mole d. joule

57. Significant figures in 0.00034 are:

a. five b. six c. two d. three

58. Significant figures in 8.70×10^{4} kg is:

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a. 1 b. 2 c. 3 d. 4

59. The dimensions of the relation $\sqrt{\frac{F \times l}{m}}$ are equal to the dimensions of:
a. force b. momentum c. acceleration d. velocity

60. The dimensions of the relation mc^2 are equal to the dimensions of:
a. force b. momentum c. energy d. torque

61. $M^0L^0T^{-1}$ refer to quantity:
a. velocity b. time period c. frequency d. force

62. The fundamental unit which has same power in the dimensional formula of surface tension and viscosity is:
a. mass b. length c. time d. none

63. The dimensional formula of WORK is:
a. $[ML^2T^{-2}]$ b. $[MLT^{-2}]$ c. $[ML^{-1}T^{-2}]$ d. $[ML^{-2}T^{-2}]$

64. The period T of a soap bubble under S.H.M. is given by: $T = P^a D^b S^c$, where P is pressure, D is density and S is surface tension. Then the value of a, b and c are:
a. $-\frac{3}{22}, \frac{1}{2}$ b. -1, -2, 3 c. $\frac{1}{22}, \frac{3}{2}, \frac{1}{2}$ d. 1, 2, $\frac{1}{3}$

65. The surface tension of a liquid is "70 dynes/cm". In M.K.S system it may be expressed as:
a. $70Nm^{-1}$ b. $7\times10^{2}Nm^{-1}$ c. $7\times10^{-2}Nm^{-1}$ d. $7\times10^{3}Nm^{-1}$

66. The density of a cube is measured by measuring its mass and the length of its side. If the maximum errors in the measurement of mass and length are 3% and 2%, respectively, then maximum error in the measurement of density is:
a. 1% b. 5% c. 7% d. 9%

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ANSWER KEY

SERIAL #	ANSWER	SERIAL #	ANSWER	SERIAL #	ANSWER
1.	C	31.	B	61.	C
2.	D	32.	C	62.	A
3.	A	33.	D	63.	A
4.	A	34.	A	64.	A
5.	C	35.	C	65.	C
6.	B	36.	C	66.	D
7.	C	37.	A	67.	
8.	D	38.	C	68.	
9.	A	39.	C	69.	
10.	A	40	C	70	
11.	B	41.	B	71.	
12.	C	42.	D	72.	
13.	C	43.	B	73.	
14.	C	44.	D	74.	
15.	C	45.	A	75.	
16.	D	46.	B	76.	
17.	A	47.	D	77.	
18.	B	48.	C	78.	
19.	B	49.	D	79.	
20.	B	50.	D	80.	
21.	D	51.	D	81.	
22.	A	52.	D	82.	
23.	B	53.	B	83.	
24.	A	54.	C	84.	
25.	A & D	55.	B	85.	
26.	B	56.	C	86.	
27.	C	57.	C	87.	
28.	D	58.	C	88.	
29.	C	59.	D	89.	
30.	C	60.	C	90.	

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CHAPTER # 02
VECTORS AND EQUILIBRIUM

VECTORS

"The physicalquantitieswhichcanbecompletelydefinedbymagnitudewith proper units and particulardirection arecalled vectorquantities."

Examples: Velocity,weight,force,torque,displacement,accelerationetc.

UNITVECTOR: Avectorwhosemagnitudeisoneiscalledunitvector.Itisgenerally used to indicate the directionofvector.Aunitvectorinagivendirectionisrepresentedbyanyalphabetical letter with a capuponite.g.

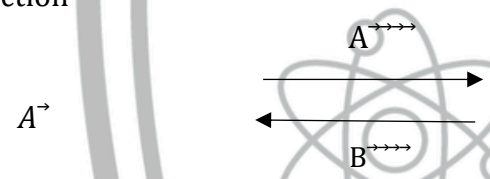
Consider a vector $\vec{A}$, its unitvector $\hat{A}$ will be,

$$\hat{A} = \frac{\vec{A}}{|\vec{A}|}$$

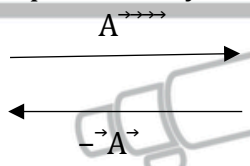
NULLVECTOR(ORZEROVECTOR): Itisavectorofzeromagnitudeandarbitrary direction. e.g. the sum, of a vector and its negative vector is a null vector.

$$\vec{A} + (-\vec{A}) = \vec{O}$$

EQUALVECTOR(ORZEROVECTOR): Twoormorevectorsaresaidtobeequal,if they have same magnitudeanddirection.Vectors $\vec{A}$ and $\vec{B}$ areequalvectors,becausetheyhavesame magnitude and direction

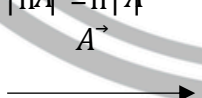


NEGATIVEOFAVECTOR: Avectorhavingthesamemagnitudebutoppositeindirection to the originalvectoriscallednegativeofavectore.g.Consideravector $\vec{A}$ isrepresented by straight line. The negativeofavectorisrepresentedby $-\vec{A}$,asshowninfigure.

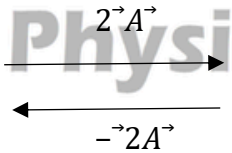


MULTIPLICATIONOFAVECTORBYASCALAR: Whenavector $\vec{A}$ ismultipliedby a number n > 0, thenanewvectorn $\vec{A}$ isobtainedhavingthesamedirectionasthatof $\vec{A}$,butamagnitude n times the magnitude of $\vec{A}$,i.e.

$$|n\vec{A}| = n|\vec{A}|$$



When'n'isthepositivenumber,thedirectionofthevectorisnotchanged,butitis reversed when 'n' is negative.



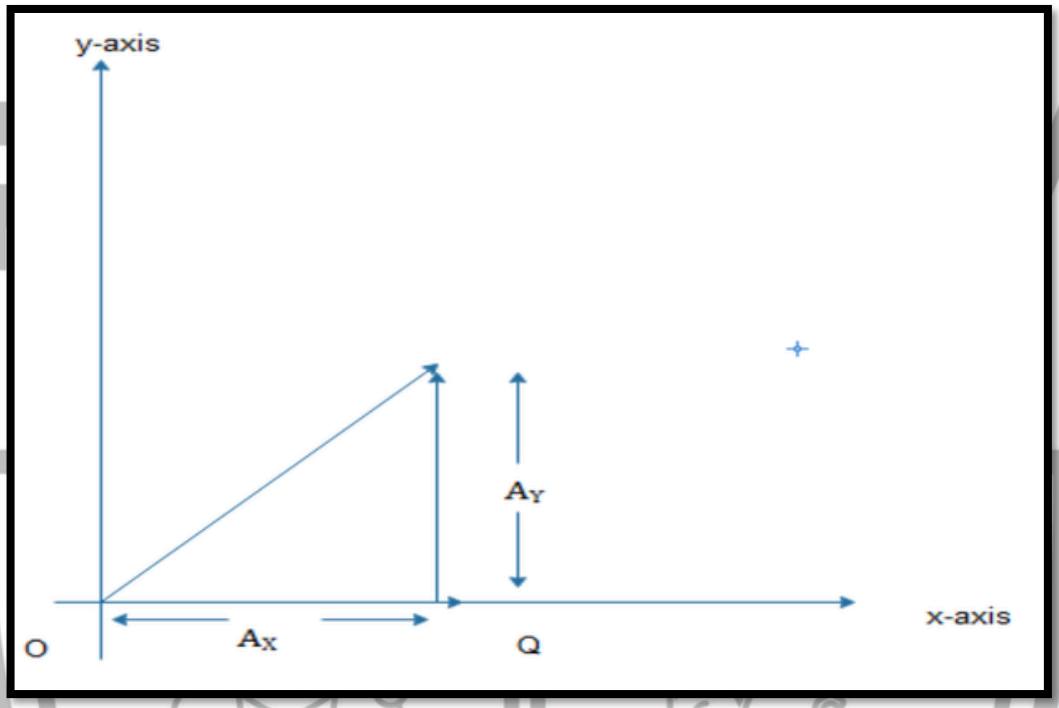
RECTANGULARCOMPONENTSOFAVECTOR

It is possibletosplitupanyvectorintotwoormoreparts.Theseareknownas**"Components".** If the componentsofthevectoraremutuallyperpendiculartoeachother,thentheseare called rectangular components

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Explanation: Let a vector $\vec{A}$ represented by $\vec{OP}$ making an angle θ with the x axis. In a plane a vector has two rectangular components, one may be x components along x axis and the other y component along y-axis.

To find value of these components, draw the given vector $\vec{A}$ in xy-plane such that its tail lies at origins. From the head of vector $\vec{A}$ a perpendicular is drawn on x-axis. The length of this perpendicular is value of y component of vector $\vec{A}$ and denoted by A_1



The length of line between foot of perpendicular and the origin is the vector of x component of vector $\vec{A}$. It is denoted by A_x.

Or $A_x = A \cos\theta$ ..... (i)

Or $A_y = A \sin\theta$ ..... (ii)

DETERMINATION OF MAGNITUDE OF THE RESULTANT VECTOR

$A = \sqrt{A_x^2 + A_y^2}$

This is the formula for magnitude of a vector in terms of its rectangular components.

DETERMINATION OF DIRECTION OF RESULTANT VECTOR

$\theta = \tan^{-1}\left(\frac{A_y}{\quad}\right)$

For any number of coplanar vectors $\vec{A}, \vec{B}, \vec{C}$, ..., we can write

$R = \sqrt{(A_x+B_x+C_x...)^2 + (A_y+B_y+C_y...)^2}$

And $\theta = \tan^{-1}\left(\frac{Ay+B_y+C_y...}{Ax+Bx+Cx...}\right)$

$\theta = \tan^{-1}\left(\frac{R_y}{\quad}\right)$

The exact value of **'θ'** can calculated by the help of rectangular components. The sign of R_x and R_y determine the quadrant in which the resultant vector lies. Irrespective of the sign of R_x and R_y determine the value of,

$\tan^{-1}\left(\frac{R_y}{R_x}\right) = \Phi$

Knowing the value of Φ, angle θ is determined

(a) If both R_x and R_y components are positive, then the resultant lies in the first quadrant and the direction is $\theta = \phi$.

(b) If R_x is negative and R_Y component is positive, the resultant lies in the second quadrant and its direction is $\theta = 180° - \phi$.

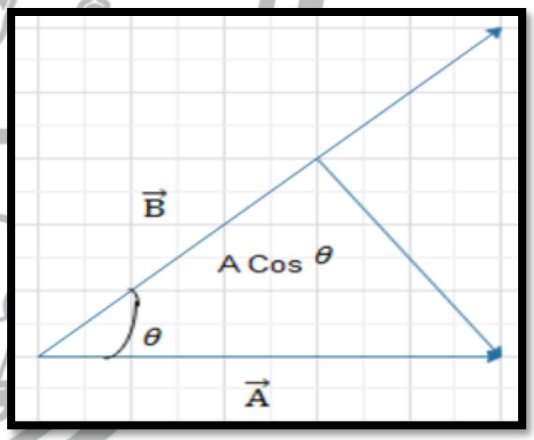
(c) If both R_x and R_y components are negative, the resultant lies in the third quadrant and its direction is $\theta = 180° + \phi$.

(d) If R_x is positive R_y is negative, the resultant lies in the fourth quadrant and its direction is $\theta = 360° - \phi$

SCALAR PRODUCT OR DOT PRODUCT:

"Whenaproductoftwovectorsresultsinascalarquantity, such type of product is called scalar productordotproductoftwo vectors."

Considertwovectors$\vec{A}$and$\vec{B}$,andθistheanglebetweenthem.
Their scalar product is defined as,
$\vec{A} \cdot \vec{B} = ABCos\theta$.....(i)
Where, A and B are magnitudes of vector $\vec{A}$ and $\vec{B}$
Explanation: As weknow,
$\vec{A} \cdot \vec{B} = ABCos\theta$.....(i)
Considertwovectors$\vec{A}$and$\vec{B}$asshowninfig(a).Drawaperpendicular from head of vector $\vec{B}$ on vector$\vec{A}$thentheR.H.S.oftheequation(i)canbestatedas,
$\vec{A}.\vec{B} = A(BCos\theta)$
$\vec{A}.\vec{B} = A(ProjectionofB\ onA)$
$\vec{A}.\vec{B} = A(ComponentofB\ onthedirectionofA)$
Similarly, from fig (b)
$\vec{B}.\vec{A} = BACos\theta$
$\vec{B}.\vec{A} = B(ProjectionofA\ onB)$
$\vec{B} \cdot \vec{A}$ = B (Component of $\vec{A}$ on the direction of $\vec{B}$



Characteristicof ScalarProduct:

I. Thescalarproductiscommutative,

i.e.$\vec{A}.\vec{B} = \vec{B}.\vec{A}$

II. Thescalarproductoftwomutuallyperpendicularvectors is zero,

i.e. $\vec{A} \cdot \vec{B} = ABCos90° = 0$

III. The scalarproductoftwoparallelvectorsisequaltothe product of magnitudes.
Thus,forparallelvectors($\theta = 0°$),
i.e.$\vec{A}.\vec{B} = ABCos0° = AB$
and foranti-parallelvectors ($\theta = 180°$)
i.e.$\vec{A}.\vec{B} = ABCos180° = -AB$

IV. Theself-productofavector$\vec{A}$isequaltosquareofitsmagnitude
$\vec{A}.\vec{A} = AACos0° = A^2$

V. Scalarproductoftwovectors$\vec{A}$and$\vec{B}$intermsoftheirrectangular component is written as,
$\vec{A}.\vec{B} = (A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}).(B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k})$
OR$\vec{A}.\vec{B} = A_xB_x + A_yB_y + A_zB_z$

VI. Scalarproductobeysthedistributivelaw,
$\vec{A}.(\vec{B} + \vec{C}) = \vec{A}.\vec{B} + \vec{B}.\vec{C}$

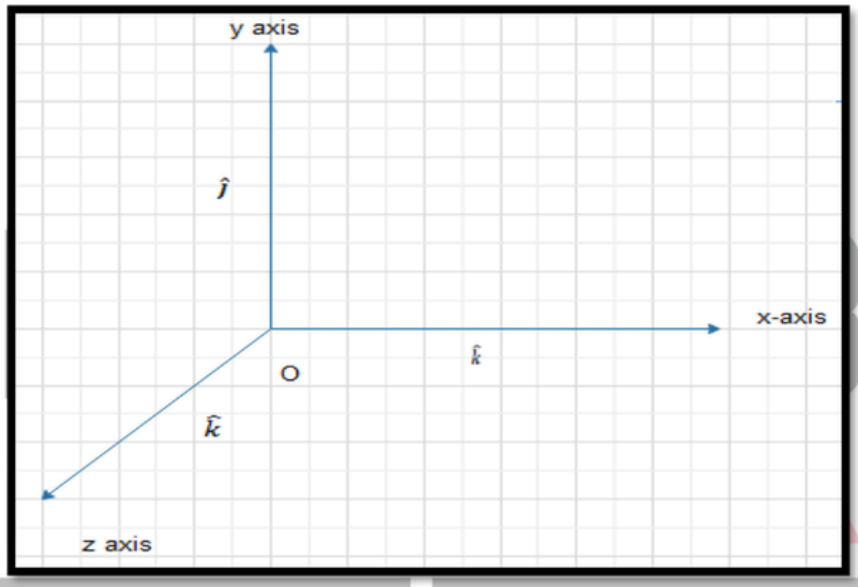
VII. In thescalarproductoftwovectors,theproductofunitvectors $\hat{\imath}$, $\hat{\jmath}$and $\hat{k}$ is

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$\hat{\imath}.\hat{\imath} = \hat{\jmath}.\hat{\jmath} = \hat{k}.\hat{k} = 1$

$\hat{\imath}.\hat{\jmath} = \hat{\jmath}.\hat{\imath} = \hat{k}.\hat{\imath} = 0$

(Where, $\hat{\imath}$, $\hat{\jmath}$ and $\hat{k}$ are unit vectors along x axis, y axis and z axis respectively).



VECTOR PRODUCT OR CROSS PRODUCT:

"The vector product of two vectors result into a vector quantity, the productis called vector product."

The vector product of two vectors $\vec{A}$ and $\vec{B}$ is written as, $\vec{A} \times \vec{B}$. Thus, the vector product is also ca as cross product.

Let two vectors $\vec{A}$ and $\vec{B}$ are making an angle 'θ' with each other, then their vector product is equal to another vector $\vec{C}$, which is given by the relation as,

$\vec{A} \times \vec{B} = \vec{C} = AB \sin\theta\, \hat{n}$

Where (AB Sin θ) is the magnitude of vector $\vec{C}$,

i.e. C = AB Sin θ

and $\hat{n}$ is a unit vector perpendicular to the plane containing $\vec{A}$ and $\vec{B}$ and it shows the direction of $\vec{C}$, which is found out by **"Right hand rule".**

RIGHT HAND RULE:

Let two vectors $\vec{A}$ and $\vec{B}$, their tails are joined. If fingers of right hand are stretched along first written vector, so that these can be easily curled towards the 2nd vector. The thumb of right hand indicates the direction of $(\vec{A} \times \vec{B})$.

Characteristic of Cross Product

I Cross product of two vectors do not obey commutative law.

$\vec{A} \times \vec{B} = \vec{B} \times \vec{A}$

But $\vec{A} \times \vec{B} = -(\vec{B} \times \vec{A})$

II The cross product of two perpendicular vectors has maximum magnitude

i.e. $\vec{A} \times \vec{B} = AB \sin 90° \hat{n} = AB\, \hat{n}$

III The cross product of two parallel vectors is null vector, because for such vectors θ = 0° or 180°. Hence,

$\vec{A} \times \vec{B} = AB \sin 0° \hat{n} = 0$

or $\vec{A} \times \vec{B} = AB \sin 180° \hat{n} = 0$

IV Cross product of two vectors $\vec{A}$ and $\vec{B}$ in terms of their rectangular components is:

$\vec{A} \times \vec{B} = (A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}) \times (B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k})$

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$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & Az \\ B_X & B_Y & AZ \end{vmatrix}$$

$$\vec{A} \times \vec{B} = (A_yB_Z - A_ZB_Y)\hat{i} + \hat{j}(A_XB_Z - A_ZB_X) + \hat{k}(A_XB_y - A_yB_X)$$

V The magnitude of $\vec{A} \times \vec{B}$ is equal to area of the parallelogram formed with $\vec{A}$ and $\vec{B}$ as two adjacent sides.

Note: In vector product,

$\hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 0$

$\hat{i} \times \hat{j} = \hat{k}$ $\quad \hat{j} \times \hat{i} = -\hat{k}$

$\hat{j} \times \hat{k} = \hat{i}$ $\quad \hat{k} \times \hat{j} = -\hat{i}$

$\hat{k} \times \hat{i} = \hat{j}$ $\quad \hat{i} \times \hat{k} = -\hat{j}$

TORQUE

"Turning effect of the force about an axis of rotation is called torque or moment of the force."

If $\vec{F}$ be the force and $\vec{r}$ be the position vector, then mathematically torque is written as ,

$$\tau = \vec{r} \times \vec{F}$$

Torque is a vector quantity , the SI unit for torque is newton meter

Example: When a nut is tightened with a spanner a force is applied perpendicular to the moment arm. The turning effect is produced which depends upon the magnitude of the applied force and length of moment arm.

The larger the handle of the spanner, greater will be the turning effect produced. The distance **'OP'** is called moment arm **'l'.** Thus, the magnitude of torque is represented by **'t'** is,

$$\tau = \vec{r} \times \vec{F}$$

When the applied forces pass through the pivot point (axis of rotation), the moment arm l = 0, so in this case torque is zero.

Note:

1. Torque is the analogous of force for rotational motion. Just as the force determines the linear acceleration produced in a body, the torque acting on a body determines its acceleration
2. Torque is written with negative signs when it rotates or tries to rotate a body in clockwise direction. And torque is written with positive sign when it rotates or tries to rotate a body in anti-clockwise direction.

EQUILIBRIUM:

A body is said to be in equilibrium if it as at rest or moving with uniform velocity (acceleration is ZERO).

FIRST CONDITION OF EQUILIBRIUM:

If upward forces are equal to downward forces and the leftward forces are equal to the rightward forces. This statement is called as first condition of equilibrium.

First condition of equilibrium may be expressed as the sum of all forces directed along x axis is zero sum of all y directed forces are also zero.

Mathematically, we can write

$$\sum F_x = 0$$
$$\sum F_y = 0$$

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Note: If rightward forcesaretaken as negative and leftward forces are taken as negative. Similarly, if upward forces are takenaspositive then downward forces are taken as negative.

SECOND CONDITIONOFEQUILIBRIUM:

The vector sum ofallthetorquesacting upon the body about an arbitrary axis is zero. This is called second conditionofequilibrium.

$\sum\vec{\tau} = 0$

By convention, thecounterclockwise torques are taken as positive and clockwise torques are taken as negative.

Important Note:

1. When first conditionissatisfied, there is no linear acceleration and body will be in translational equilibrium.
2. When secondconditionissatisfied, there is no angular acceleration and body will be in rotational equilibrium.
3. If a body is atrest,itissaidtobe in static equilibrium.
4. If the body ismovingwithuniform velocity and rotating with uniform angular velocity, it is said to be in dynamicequilibrium.
5. A body is saidtobeinequilibrium when both conditions of equilibrium (first and second) are satisfied.

TRIGONOMETRICRATIOS:

	0°	**30°**	**45°**	**60°**	**90°**
Sin	$\frac{\sqrt{0}}{2}$ = 0	$\frac{\sqrt{1}}{2}$ = 0.5	$\frac{\sqrt{2}}{2}$ = 0.707	$\frac{\sqrt{3}}{2}$ = 0.866	$\frac{\sqrt{4}}{2}$ = 1
Cos	$\frac{\sqrt{4}}{2}$ = 1	$\frac{\sqrt{3}}{2}$ = 0.866	$\frac{\sqrt{2}}{2}$ = 0.707	$\frac{\sqrt{1}}{2}$ = 0.5	$\frac{\sqrt{0}}{2}$ = 0

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PRACTICE SHEET

1. Two forces of magnitudes 8N and 15N act at a point. If the resultant force is 17N, the angle between the force has to be:

a. 30° b. 45° c. 60° d. 90°

2. If two forces $\vec{F}$ and $\vec{G}$ act at right angles to each other, their resultant has the magnitude:

a. $\sqrt{F^2+G^2}$ b. F + G c. $\frac{F+G}{2}$ d. $\sqrt{F^2-G^2}$

3. One of two forces is double the other and their resultant is equal to the greater force. The angle between them is:

a. $\cos^{-1}\frac{1}{2}$ b. $\cos^{-1}(-)\frac{1}{2}$ c. $\cos^{-1}\frac{1}{4}$ d. $\cos^{-1}(-)\frac{1}{4}$

4. The scalar product of two vectors is $2\sqrt{3}$ and the magnitude, of their vector product is 2. The angle between them is:

a. 30° b. 45° c. 60° d. 90°

5. If $\vec{A}=\vec{B}+\vec{C}$ and the magnitudes of $\vec{A}$, $\vec{B}$ and $\vec{C}$ are 5, 4 and 3 units, respectively. The angle between A and C is:

a. $\cos^{-1}\frac{3}{5}$ b. $\cos^{-1}\frac{4}{5}$ c. $\sin^{-1}\frac{3}{4}$ d. $\frac{\pi}{2}$

6. If $|\vec{F}_1\times\vec{F}_2|=|\vec{F}_1.\vec{F}_2|$ then $|\vec{F}_1+\vec{F}_2|$ is:

a. $|\vec{F}_1|+|\vec{F}_2|$ b. $\sqrt{|\vec{F}_1|^2+|\vec{F}_2|^2}$

c. $\sqrt{|\vec{F}_1|^2+|\vec{F}_2|^2+\frac{|\vec{F}_1||\vec{F}_2|}{\sqrt{2}}}$ d. $\sqrt{|\vec{F}_1|^2+|\vec{F}_2|^2+\sqrt{2}|\vec{F}_1||\vec{F}_2|}$

7. Two forces of the same magnitude act at a point. The square of their resultant is 3 times the product of their magnitudes. The angle between them is:

a. 0° b. 30° c. 60° d. 90°

8. Two forces (P+Q) and (P – Q) acting at a point have their resultant $\sqrt{2(P^2+Q^2)}$. Then the angle between them must be:

a. 90° b. 180° c. 0° d. 45°

9. Two forces of magnitude 7N and 5N Newton act on a particle at an angle θ to each other, θ can have any value. The minimum magnitude of the resultant force is:

a. 12N b. 8N c. 2N d. 5N

10. Angle between the vectors $(\vec{i}+\vec{j})$ are $(\vec{j}+\vec{k})$ is:

a. 60° b. 90° c. 180° d. 0°

11. Two forces of magnitudes F_1 and F_2 acting at right angle to each other have the resultant of magnitude:

a. $\sqrt{F_1^2+F_2^2}$ b. $\sqrt{F_1^2-F_2^2}$ c. $F_1 + F_2$ d. zero

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12. The F_x component of a force vector 'F' of magnitude 30N making an angle of 60° with x-axis:

a. 7N b. 15N c. 5N d. 10N

13. The resultant of two forces 3N and 4N making an angle 90° with each other is:

a. 1.0N b. 7N c. 5N d. 3.5N

14. Two forces each of 10N magnitude act on a body. If the forces are inclined at 30° and 60° with x-axis, then the x-component of their resultant is:

a. 20N b. 1.366N c. 13.66N d. 136.6N

15. Two forces of magnitude F act perpendicular to each other. The angle made by resultant force with the horizontal will be:

a. 90° b. 60° c. 30° d. 45°

16. If $|\vec{a}+\vec{b}|=|\vec{a}-\vec{b}|$, then the angle between $\vec{a}$ and $\vec{b}$ is:

a. 90° b. zero c. 180° d. 45°

17. To get a resultant displacement of 10 cm, two displacement vectors one of magnitude 6 m and another of 8m should be combined:

a. at an angle 60° b. Perp. to each other c. parallel d. anti-parallel

18. Torque acting on a body determines its:

a. linear acceleration b. angular acceleration c. linear momentum d. impulse

19. The rotational analogue of force is:

a. angular momentum b. moment of inertia c. inertia d. torque

20. Torque is also known as:

a. moment of inertia b. moment of force c. angular velocity d. moment arm

21. If direction of the applied force $\vec{F}$ is reversed then:

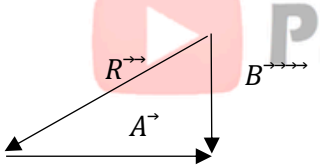
a. The magnitude of torque remains unchanged
b. There is change in magnitude and direction of the torque
c. The magnitude and direction of the torque remains constant
d. The magnitude of torque remains same but the direction reverses

22. If both R_x and R_y are negative, the resultant lies in the:

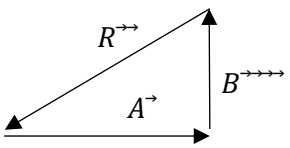
a. 1st quadrant b. 2nd quadrant c. 3rd quadrant d. 4th quadrant

23. Which diagram correctly shows the addition of $\vec{A}$ and $\vec{B}$ vectors?

a.

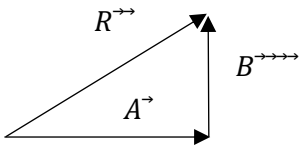


b.

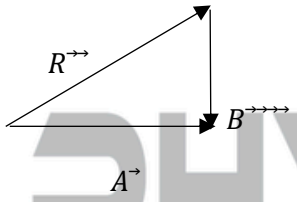


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c.



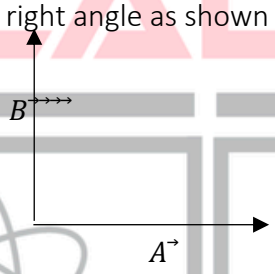
d.



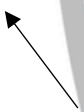
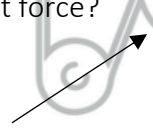
24.If $\mathbf{A}^{\rightarrow\rightarrow\rightarrow\rightarrow}=A\hat{\mathbf{i}}$ and $\mathbf{B}^{\rightarrow\rightarrow\rightarrow\rightarrow}=\hat{\mathbf{j}}$ A then:

a. $A^{\rightarrow\rightarrow\rightarrow\rightarrow}\times B^{\rightarrow\rightarrow\rightarrow\rightarrow}=0$ b. $A^{\rightarrow\rightarrow\rightarrow\rightarrow}\times B^{\rightarrow\rightarrow\rightarrow\rightarrow}=A^2\hat{i}\hat{j}$ c. $A^{\rightarrow\rightarrow\rightarrow\rightarrow}\times B^{\rightarrow\rightarrow\rightarrow\rightarrow}=A^2\hat{k}$ d. $A^{\rightarrow\rightarrow\rightarrow\rightarrow}\times B^{\rightarrow\rightarrow\rightarrow\rightarrow}=A^2$

25.Two vectors $\mathbf{A}^{\rightarrow\rightarrow\rightarrow\rightarrow}$ and $\mathbf{B}^{\rightarrow\rightarrow\rightarrow\rightarrow}$ are acted at right angle as shown in the figure:



Which of the following shows the direction of the resultant force?

a.  b.  c.  d.

26. Let $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$ be two vectors are two adjacent sides of a parallelogram, then area of the parallelogram is equivalent to:

a. $|A^{\rightarrow\rightarrow\rightarrow\rightarrow}|\times|B^{\rightarrow\rightarrow\rightarrow\rightarrow}|$ b. $|A^{\rightarrow\rightarrow\rightarrow\rightarrow}\times B^{\rightarrow\rightarrow\rightarrow\rightarrow}|$ c. $A^{\rightarrow\rightarrow\rightarrow\rightarrow}\times B^{\rightarrow\rightarrow\rightarrow\rightarrow}$ d. $A^{\rightarrow\rightarrow\rightarrow\rightarrow}\cdot B^{\rightarrow\rightarrow\rightarrow\rightarrow}$

27. When two vectors $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$ of magnitude a and b are added, the magnitude of the resultant vector is always:

a. greater than (a+b) b. not greater than (a+b) c. equal to (a+b) d. less than (a+b)

28. Two forces of 4 dyne and 3 dyne acts upon a body. The resultant force on the body can only be:

a. between 3 dyne and 4 dyne b. between 1 and 7 dynes
c. more than 3 dynes d. more than 4 dynes

29. A force $\vec{\mathbf{F}}=6\hat{\mathbf{i}}-8\hat{\mathbf{j}}+10\hat{\mathbf{k}}$ newton produces an acceleration of $1ms^{-2}$ in a body the body would be:

a. $10\sqrt{2}$ kg b. $6\sqrt{2}$ kg c. 20 kg d. 200 kg

30. The sum of two or more vectors is equal to a single vector which is called:

a. component vector b. product vector c. resultant vector d. position vector

31. Position vector of point in x-z plane is given by:

a. $r^{\rightarrow\rightarrow}=y\hat{i}+z\hat{k}$ b. $r^{\rightarrow\rightarrow}=x\hat{i}+y\hat{k}$ c. $r^{\rightarrow\rightarrow}=x\hat{i}+z\hat{k}$ d. $r^{\rightarrow\rightarrow}=x\hat{i}+y\hat{j}+z\hat{k}$

32. The minimum number of un-equal forces whose vector sum can be zero is:

a. 1 b. 2 c. 3 d. 4

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33. Two forces of magnitude F_1 and F_2 act on a body at an angle 'θ' to each other the magnitude of resultant force is:

a. $\sqrt{F^2_1+F_2}$

b. $\sqrt{F^2_1+F_2+2F_1F_2}$

c. $\sqrt{F^2_1+F^2_2+2F_1F_2\,cos\theta}$

d. $\sqrt{F^2_1+F^2_2+F_1F_2\,cos\theta}$

34. Two forces of 10N and 8N are applied simultaneously to a body. The maximum value of their resultant is:

a. 10N b. 18N c. 28N d. 15N

35. If two forces of 20N and 60N are acting on a body and are directed in same direction, then the net force is:

a. 80N b. 40N c. 1200N d. 8N

36. The direction of a vector $\vec{A}$ can be found out by its x and y-components by the following relation:

a. $\theta = \tan^{-1}(y/x)$ b. $\tan\theta = (A_x/A_y)$ c. $\tan\theta=(A_y/A_x)$ d. $\theta = \tan(x/y)$

37. The vector in space has:

a. 2 components b. 1 component c. 4 components d. 3 components

38. Which (one or more) of the following quantities is a vector?

a. pressure b. power c. current d. angular momentum

39. Two forces equal in magnitude have a resultant with its magnitude equal to either. The angle between them is:

a. 45° b. 60° c. 90° d. 120°

40. When three forces acting at a point are in equilibrium, then:

a. Each force is numerically equal to the sum of the other two
b. Each force is numerically greater than the sum of the other two
c. Each force is numerically greater than the difference of the other two
d. None of the above

41. The work done by a force is defined as $W = \vec{F}\cdot\vec{S}$. In a certain situation $\vec{F}$ and $\vec{S}$ are not zero but the work done is zero. From this we conclude that:

a. $\vec{F}$ and $\vec{S}$ are in the same direction
b. $\vec{F}$ and $\vec{S}$ are in the opposite direction
c. $\vec{F}$ and $\vec{S}$ are at right angles
d. None of the above is true

42. The scalar product of vectors $\vec{A}=2\hat{i}+5\hat{k}$ and $\vec{B}=3\hat{j}+4\hat{k}$ is:

a. 20 b. 23 c. $5\sqrt{33}$ d. 26

43. Two vectors $\vec{A}$ and $\vec{B}$ are at right angles to each other, when:

a. $\vec{A}+\vec{B}=0$ b. $\vec{A}+\vec{B}=0$ c. $\vec{A}\times\vec{B}=0$ d. $\vec{A}\cdot\vec{B}=0$

44. In the self-cross product, the angle is:

a. 0° b. 45° c. 90° d. 180°

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45. If $\vec{A}=5\hat{i}+7\hat{j}-3\hat{k}$ and $\vec{B}=2\hat{i}+2\hat{j}-a\hat{k}$ are perpendicular vectors, then vector of 'a' is:

a. -2 b. 8 c. -7 d. -8

46. The angle between the vector $2\hat{i}+3\hat{j}$ and the y-axis is:

a. $\tan^{-1}\left(\frac{3}{2}\right)$ b. $\tan^{-1}\left(\frac{2}{3}\right)$ c. $\sin^{-1}\left(\frac{2}{3}\right)$ d. $\cos^{-12}\left(\frac{}{3}\right)$

47. Three vectors $\vec{A},\vec{B}$ and $\vec{C}$ satisfy the relation $\vec{A}\cdot\vec{B}=0$ and $\vec{A}\cdot\vec{C}=0$. The vector $\vec{A}$ is parallel to:

a. $\vec{B}$ b. $\vec{C}$ c. $\vec{B}\cdot\vec{C}$ d. $\vec{B}\times\vec{C}$

48. Which of the following vectors is/are perpendicular to the vector $4\hat{i}-3\hat{j}$?

a. $4\hat{i}+3\hat{j}$ b. $6\hat{i}$ c. $7\hat{k}$ d. $3\hat{i}-4\hat{j}$

49. The angle between the two vectors $-2\hat{i}+3\hat{j}+\hat{k}$ and $\hat{i}+2\hat{j}-4\hat{k}$ is:

a. 0° b. 90° c. 180° d. none of these

50. The angle between the two vectors $\vec{A}=3\hat{i}+4\hat{j}-5\hat{k}$ and $\vec{B}=6\hat{i}+8\hat{j}-10\hat{k}$ is:

a. 0° b. 90° c. 180° d. 45°

51. Find the torque of a force $\vec{A}=-3\hat{i}+\hat{j}+5\hat{k}$ acting at point $\vec{r}=7\hat{i}+3\hat{j}+\hat{k}$.

a. $14\hat{i}-38\hat{j}+16\hat{k}$ b. $4\hat{i}+4\hat{j}+6\hat{k}$ c. $21\hat{i}+4\hat{j}+4\hat{k}$ d. $-14\hat{i}+38\hat{j}-16\hat{k}$

52. Two forces, each of magnitude F, acting on a particle yield a resultant force of magnitude F. The angle between the forces is:

a. 0° b. 30° c. 90° d. 120°

53. By decreasing the value of angle between the two given vectors, their cross product:

a. increases b. decreases c. remains constant d. none of these

54. The unit vector parallel to the resultant of the vectors $\vec{A}=4\hat{i}+3\hat{j}+\hat{k}$ and $\vec{A}=-\hat{i}+3\hat{j}-3\hat{k}$ is:

a. $\frac{1}{}(3\hat{i}+6\hat{j}-2\hat{k})$ b. $\frac{1}{}(3\hat{i}+6\hat{j}+2\hat{k})$

c. $\frac{1}{49}(3\hat{i}+6\hat{j}-2\hat{k})$ d. $\frac{1}{49}(3\hat{i}-6\hat{j}+2\hat{k})$

55. The minimum number of equal forces whose vector sum can be zero is:

a. 2 b. 3 c. 1 d. 4

56. The reverse process of vector addition is called:

a. resolution of a vector b. subtraction of vector
c. multiplication of vector d. negative of vector

57. A vector in plane has:

a. 1 component b. 3 component c. 2 component d. 0 component

58. If a vector A makes an angle θ with the x-axis its x-component is given by:

a. A sin θ b. A tan θ c. A cos θ d. A sin x

59. Dot product of two non-zero vectors is zero $(\vec{a}\cdot\vec{b}=0)$ when the angle between them is:

a. 30° b. 45° c. 60° d. 90°

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60. If $\vec{A}.\vec{B}=0$ and also $\vec{A}\times\vec{B}=0$, then:

a. $\vec{A}$ and $\vec{B}$ are parallel to each other
b. $\vec{A}$ and $\vec{B}$ are perpendicular to each other
c. $\vec{A}$ and $\vec{B}$ are anti-parallel
d. Either $\vec{A}$ or $\vec{B}$ is a null vector

61. Area of the parallelogram in which the two adjacent sides are $\vec{A}$ and $\vec{B}$ is given by:

a. AB sin θ b. A . B c. B cos θ d. AB cosθ

62. If $\vec{A}=A\hat{i}$ and $\vec{B}=B\hat{j}$ then:

a. $\vec{A}.\vec{B}=A$ b. $\vec{A}.\vec{B}=0$ c. A . B = A^2 d. $\vec{A}.\vec{B}=B$

63. Which of the following is correct?

a. $\vec{A}\times\vec{B}=-\vec{B}\times\vec{A}$ b. $\vec{A}\times\vec{B}=\vec{B}\times\vec{A}$ c. $\vec{A}\times\vec{B}=\vec{B}\times\vec{A}$ d. $\vec{A}.\vec{B}\neq\vec{B}.\vec{A}$

64. The cross product $\hat{j}\times\hat{k}$ is equal to:

a. 0 b. i c. 1 d. -i

65. Position vector of point in yz-plane is given by:

a. $\vec{r}=y\vec{i}+z\vec{k}$ b. $\vec{r}=x\hat{i}+y\hat{k}$ c. $\vec{r}=y\hat{j}+z\hat{k}$ d. $\vec{r}=x\hat{i}+y\hat{j}+z\hat{k}$

66. The direction of the torque $\vec{\tau}=\vec{r}\times\vec{F}$ is found out by:

a. left hand rule b. knowing the direction of r c. head to tail rule d. right hand rule

67. If the line of action of the $\vec{F}$ passes through the axis of rotation or origin then its torque is:

a. maximum b. unity c. zero d. RF sin θ

68. The angle between $\vec{A}$ and $\vec{B}$ is θ The value of the triple product $\vec{A}$. ($\vec{B}$ × $\vec{A}$) is:

a. A^2B b. A^2B sin θ c.Zero d. A^2B Cos θ

69. Torque produced by a force depends upon:

a. magnitude of the force and angular velocity
b. magnitude of the force and displacement
c. magnitude of the force and moment arm
d. force and acceleration of the body

70. If $\vec{A}=2\hat{i}+\hat{j}+2\hat{k}$ the $|\vec{A}|$ is:

a. = 0 b. = 3 c. = 5 d. = 9

71. Which of the following lists of physical quantities consists only of vectors:

a. time, temperature, velocity
b. force, volume, momentum
c. velocity, acceleration, mass
d. force, acceleration, velocity

72. A force of 10N is acting along y-axis. Its component along x-axis is:

a. 10N b. 20N c. 100 N d. 0 N

73. Two forces are acting together on an object. The magnitude of their resultant is minimum when the angle between the force is:

a. 0° b. 60° c. 120° d. 180°

74. Two forces of 10N and 15N are acting simultaneously on an object in the same direction. Their resultant is:

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a. zero b. 5N c. 25N d. 150N

75. If the dot product of two non-zero vectors vanishes, the vectors will be:
a. in the same direction b. opposite to each other
c. perpendicular to each other d. zero

76. The dot product of two vectors is negative when:
a. they are parallel vectors b. they are anti-parallel vectors
c. they are perpendicular vectors d. none of the above is correct

77. If three vectors $\vec{A},\vec{B}$ and $\vec{C}$ are 12, 5 and 13 in magnitude such that $\vec{C}=\vec{A}+\vec{B}$, then the angle between $\vec{A}$ and $\vec{B}$ is:
a. 60° b. 90° c. 120° d. none of these

78. Torques has zero value if angle between $\vec{r}$ and $\vec{F}$ is:
a. 0° b. 30° c. 45° d. 90°

79. Which of the following is a scalar quantity?
a. Displacement b. Electric field c. Acceleration d. Work

80. If A . B = 4 and A . C = 6 then A . (B+C) =
a. 6 b. 10 c. 100 d. 2

81. If a vector $\vec{A}=\hat{i}+\hat{j}+\hat{k}$, then its magnitude will be:
a. 3 b. $3\sqrt{3}$ c. $\sqrt{3}$ d. $\frac{\sqrt{3}}{3}$

82. The resultant of two forces 6N and 8N making an angle 90° with each other is:
a. 1.0N b. 10N c. 3N d. 101N

83. If a force of 10N makes an angle of 60° with y-axis, its x-component is given by:
a. 1.866N b. 0.89N c. 8.66N d. 0.866N

84. If the vectors $\vec{A}$ and $\vec{B}$ are parallel to each other, then:
a. $\vec{A}\cdot\vec{B}=0$ b. $\vec{A}\cdot\vec{B}=1$ c. $\vec{A}\cdot\vec{B}=AB$ d. $\vec{A}\cdot\vec{B}=-AB$

85. Two forces act together on an object. The magnitude of their resultant force is maximum when they act at:
a. 0° b. 90° c. 45° d. 180°

86. Null vector is a vector having zero magnitude and:
a. specific direction b. arbitrary direction c. no direction d. opposite direction

87. Two equal and opposite forces acting on a body form a:
a. couple b. torque c. impulse d. momentum

88. Unit vector is used to specify:
a. magnitude of a vector b. dimensions of a vector
c. direction of a vector d. position of a vector

89. The cross product of two vectors is a negative vector when:
a. they are parallel b. they are anti-parallel vectors

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c. they are rotated by 270 ° d. none of these

90. Three forces 9, 12 and 15 N acting on a point are in equilibrium. The angle between 9 N and 15 N is:
a. $\cos^{-13}\theta$ b. $\cos^{-14}(\frac{}{5})$ c. $\pi-\cos^{-13}(\frac{}{5})$ d. $\pi-\cos^{-14}(\frac{}{5})$

91. If a force of 50N is acting along x-axis, then its component along y-axis will be:
a. the same b. of the half magnitude c. zero d. none of these

92. The vector product of two equal vectors i.e., $\vec{A}\times\vec{A}$ is equal to:
a. a vector b. null vector c. square of vector d. unit vector

93. If two non-zero vectors are perpendicular to each other than their scalar product is equal to:
a. 1 b. 2 c. constant d. 0

94. A boat which has a speed of 5km/h in still water crosses a river of width 1km along the shortest path in 15 minutes. The velocity of the river in km/hr is:
a. 1 b. 3 c. 4 d. $\sqrt{41}$

95. Torque has maximum value if angle between $\vec{r}$ and $\vec{F}$ is:
a. 0° b. 90° c. 180° d. 360°

96. Which of the following is correct?
a. $\hat{i}\cdot\hat{j}=\hat{k}$ b. $\hat{i}\cdot\hat{j}=\hat{i}$ c. $\hat{i}\cdot\hat{j}=1$ d. $\hat{i}\cdot\hat{j}=0$

97. The cross product $\hat{j}\times\hat{i}$ is equal to:
a. $\hat{k}$ b. $-\hat{k}$ c. 1 d. −1

98. Five equal forces of 10N each are applied at one point and all are lying in one plane. If the angles between them are equal the resultant force will be:
a. Zero b. 10N c. 20N d. 10 $\sqrt{2}$N

99. The sum of two forces acting at a point is 16N. If the resultant force is 8N and its direction is perpendicular to minimum force then the forces are:
a. 6N and 10N b. 8N and 8N c. 4N and 12N d. 2N and 14N

100. A boy walks uniformly along the sides of a rectangular park of size 400 m x 300 m, starting from one corner to the other corner diagonally opposite. Which of the following statements is incorrect?
a. He has traveled a distance of 700 m
b. His displacement is 700 m
c. His displacement is 500 m
d. His velocity is uniform throughout the walk

101. A man can swim in still water with a speed of 4 km/h. The time taken by him to cross a 1 km wide River flowing at 3 km/h, if he makes his strokes normal to the river current, is:
a. 10 min b. 15 min c. 30 min d. 45 min

102. In Question # 101, how far down the river does the man go when he reaches the other bank?
a. 500m b. 750m c. 1 km d. 1.5 km

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103. Three vectors $\vec{P}$, $\vec{Q}$ and $\vec{R}$ are such that $|\vec{P}| = |\vec{Q}|$, $|\vec{R}| = \sqrt{2}|\vec{P}|$ and $\vec{P} + \vec{Q} + \vec{R} = 0$. The angles between $\vec{P}$ and $\vec{Q}$, $\vec{Q}$ and $\vec{R}$, $\vec{P}$ and $\vec{R}$ are

a. 90, 135°, 135° b. 90°, 45°, 45° c. 45°, 90°, 90° d. 45°, 135°, 135°

104. Two balls are rolling on a flat surface. One has velocity component 1 m/s and $\sqrt{3}$ m/s along the rectangular axis x and y, respectively, and the other has components 2 m/s and 2 m/s, respectively. If both the balls start moving from the same point, the angle between their directions of motion is:

a. 15° b. 30° c. 45° d. 60°

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ANSWER KEY

SERIAL #	ANSWER	SERIAL #	ANSWER	SERIAL #	ANSWER	SERIAL #	ANSWER
1.	D	31.	C	61.	A	91.	C
2.	A	32.	C	62.	B	92.	B
3.	D	33.	C	63.	A	93.	D
4.	A	34.	B	64.	B	94.	B
5.	A	35.	A	65.	C	95.	B
6.	D	36.	C	66.	D	96.	D
7.	C	37.	D	67.	C	97.	B
8.	A	38.	D	68.	C	98.	A
9.	C	39.	C	69.	B	99.	A
10.	A	40	C	70	D	100.	B
11.	A	41.	A	71.	D	101.	B
12.	B	42.	D	72.	D	102.	B
13.	C	43.	A	73.	C	103.	A
14.	C	44.	D	74.	C	104.	A
15.	D	45.	B	75.	B	105.	
16.	A	46.	D	76.	B	106.	
17.	B	47.	C	77.	A	107.	
18.	B	48.	B	78.	D	108.	
19.	D	49.	A	79.	B	109.	
20.	B	50.	A	80.	C	110.	
21.	D	51.	D	81.	B	111.	
22.	C	52.	B	82.	C	112.	
23.	C	53.	A	83.	C	113.	
24.	C	54.	A	84.	A	114.	
25.	C	55.	A	85.	B	115.	
26.	B	56.	C	86.	A	116.	
27.	B	57.	C	87.	C	117.	
28.	B	58.	D	88.	C	118.	
29.	A	59.	D	89.	C	119.	
30.	C	60.		90.		120.	

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CHAPTER # 03
MOTION AND FORCE

REST

"If a body is not changing its position according to its surrounding then it is said to be in the state of REST."

MOTION

"If a body is changing its position according to its surrounding then it is said to be in the state of MOTION."

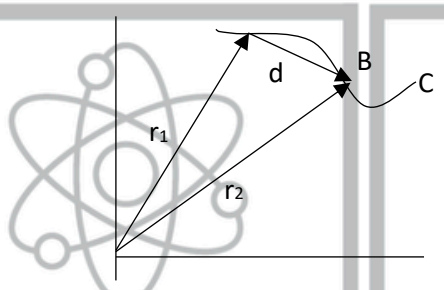
DISPLACEMENT:

When a body moves from one point to another, the minimum distance between initial and final positions of the body is called displacement.

Displacement is a vector quantity, and its unit is meter **(m)**.

Explanation:

The displacement can be represented as a vector, which describes how far and in what direction the body has been displaced from its original position. The tail of the displacement vector lies at the initial position and its tip or arrowhead is located at the final position where the displacement ended.



e.g.,Considerabody is moving from point A, to another point B, along the curve as shown in figure. Thenthedisplacement d of the body is represented by A B .

If $\vec{r}_1$ isthepositionvector of A and $\vec{r}_2$ that of point B then by the head to tail rule we can write,

$$\vec{O}\vec{A}+\vec{A}\vec{B}=\vec{O}\vec{B}$$

Or

$$\vec{r}_1+\vec{d}=\vec{r}_2$$

$$\boxed{\vec{d}=\vec{r}_2-\vec{r}_1}$$

Thedisplacement is thus a change in the position of body from its initial position to its final position.

VELOCITY:

Thetimerate of change of displacement of a moving body is called its velocity. Itisavectorquantity and its direction is along the direction of displacement. The unit velocity is ms^{-1}. Mathematicallyitcan be written as,

$$\vec{v}=\frac{\vec{\Delta d}}{\Delta t}$$

Dimensions:

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

$$[v] = \frac{[L]}{[T]}$$

$$= [LT^{-1}]$$

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Thus, dimensions of velocity are $[LT^{-1}]$.

Uniform Velocity:

When a body covers equal displacement in equal intervals of time then the body is said to move with uniform velocity.

Non-uniform Velocity:

When a body covers different displacements in equal intervals of time, then the body is said to move with non-uniform velocity.

AverageVelocity:

Itis defined as the ratio of total displacement to the time taken by the body to cover its displacement.

Ifa bodycovers a displacement $\vec{d}$, during the time 't', then its average velocity is mathematically written as,

$$\vec{v}_{av} = \frac{\vec{d}}{t}$$

Instantaneous Velocity:

The velocity of a body at any instant of time is called Instantaneous Velocity.

OR

The instantaneous velocity is defined as, the ratio of small displacement covered by a body to very small interval of time i.e., $(\Delta t \rightarrow 0)$.

Mathematically it can be written as follows:

$$\vec{v}_{av} = \lim_{\Delta t \to 0} \frac{\Delta \vec{d}}{\Delta t}$$

Where " $\lim_{\Delta t \to 0}$ " shows thatthe time interval is as small as possible.

NOTE:

The instantaneous velocity and average velocity are same when the body moves with uniform velocity.

ACCELERATION:

"The time rate of change of velocity of a body is called acceleration."

Mathematically it can be written as,

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

Acceleration is a vector quantity, and its unit is ms^{-2}.

Dimensions:

$$\text{Acceleration} = \frac{\text{Change of velocity}}{\text{Time}}$$

$$= \frac{\text{Distance}}{(\text{Time})(\text{Time})}$$

$$= \frac{[L]}{[T^2]}$$

$$= [LT^{-2}]$$

Thus, dimensions ofacceleration are $[LT^{-2}]$.

Positive Acceleration:

The acceleration will be positive when the velocity of the body is increasing. Its direction is same as direction of body's motion.

Negative Acceleration:

The acceleration will be negative when the velocity of the body is decreasing. Its direction is opposite to the direction ofbody's motion.

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The negative acceleration is also called Retardation of deceleration.

AverageAcceleration:

Itis defined as,the total change in velocity divided by the total time for this change. Mathematically we canwrite,

$$\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t}$$

Instantaneous Acceleration:

It is defined as the acceleration of a body at any instant of time

OR

It isdefined as the smallchange in velocity $\Delta \vec{v}$ divided by a very small interval of time i.e. $(\Delta t \to 0)$. Mathematically, it can be written as,

$$\vec{a}_{ins} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t}$$

Note:

When instantaneousacceleration and average acceleration becomes equal to each other, the body will move with uniform acceleration.

Uniform Acceleration:

When the velocity of the body changes in equal interval of time by equal amount the body is said to have uniform acceleration.

Non-uniform Acceleration:

When the change in the velocity is unequal for equal intervals of time, the body is said to have variable or non-uniform acceleration.

NOTE:

(1) The acceleration produced due to magnitude of the velocity is parallel or anti-parallel to the direction of motion.

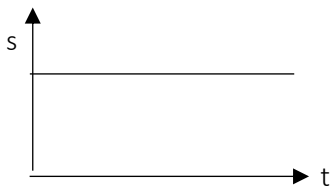
(2) If the direction of the velocity is changing acceleration will right angle to the direction of motion.

GRAPHICAL REPRESENTATION

The displacement-time graph and velocity-time graphs are quite useful in analyzing the motion of a particle. The slope of the displacement-time graph at any instant gives the velocity of the particle at that instant and the slope of the velocity-time graph at any instant gives the acceleration of the particle at that instant.

SOME TYPICAL DISPLACEMENT-TIME GRAPHS

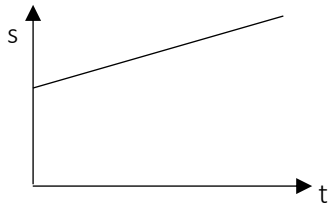
(a)



The graph is a straight line parallel to the time axis, *i.e.,* *s* does not change with time. Hence the body is at rest; velocity is zero.

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(b)



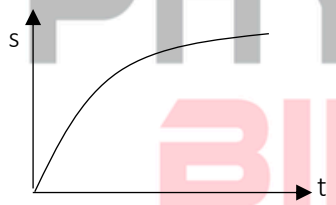
The graph is a straight line inclined to the time axis. Thus *ds/dt* is constant and hence the particle moves with a constant velocity; acceleration is zero.

(c)



ds/dt and hence the velocity increases; acceleration is positive.

(d)



ds/dt and hence the velocity decreases with time; acceleration is negative.

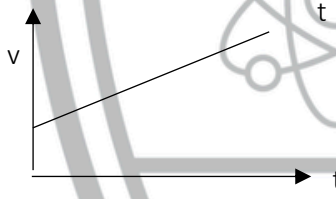
SOME TYPICAL VELOCITY-TIME GRAPHS

(a)



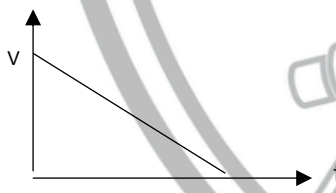
Velocity remains constant with time; acceleration is zero

(b)



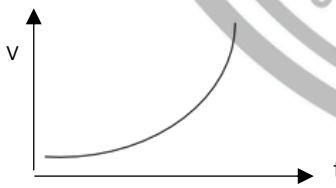
Velocity increases linearly with time; acceleration is constant and positive.

(c)



Velocity decreases linearly with time; motion is uniformly retarded.

(d)



$\frac{ds}{dt}$ increases with time; thus, acceleration is variable.

Graph	Slope	Area under the graph
position vs. time	velocity	-----
velocity vs. time	acceleration	displacement
acceleration vs. time	-----	change in velocity

REVIEW OF EQUATIONS OF UNIFORMLY ACCELERATED MOTION

Suppose an object is moving with uniform acceleration 'a' along a straight line. If the initial velocity of the object us v_i and final velocity is v_f, after a time interval 't' during which distance covered is 's', then equations of motion are:

1) $v_f = v_i + at$
2) $s = v_i t + \frac{1}{2}at^2$
3) $2as = v_f^2 - v_i^2$

For vertical motionin downward direction these equations are written as,

1) $v_f = v_i + gt$
2) $s = v_i t + \frac{1}{2}gt^2$
3) $2gs = v_f^2 - v_i^2$

For vertical motionin upward direction these equations become,

1) $v_f = v_i - gt$
2) $s = v_i t - \frac{1}{2}gt^2$
3) $-2gs = v_f^2 - v_i^2$

FRAME OF REFERENCE:

A co-ordinate system which is used to get some information about the position of particle in a plane or in a space.

There are two types of frame of reference one is called inertial frame of reference and the other is called non-inertial frame of reference.

Inertial Frame of Reference:

A non-accelerated frame of reference which may be at rest or moving with uniform velocity is called Inertial Frame of Reference.

Newton's first law of motion holds good in inertial frame of reference.

Non-inertial Frame of Reference:

An accelerated frame of reference which has non-uniform motion is called non-inertial frame of reference.

Newton's first law of motion does not hold in non-inertial frame of reference.

NEWTON'S LAWS OF MOTION:

These laws were stated by Newton in 1687 in his famous book "Principia Mathematica". Newton's laws were not derived laws but deduced from experiments, therefore these are also called empirical laws.

Newton's 1st Law of Motion:

This law states that, a body at rest remains at rest, and a body moving with uniform velocity continue to do so, unless acted upon by some un-balanced external force.

This is known as law of inertia.

Inertia:

The property of an object tending to maintain the state of rest or state of motion is referred to as the objects' inertia.

The inertia of the body is directly proportional to the mass of the body.

Newton's 2nd Law of Motion:

This law states that when an external un-balanced force is applied on a body an acceleration is produced in the direction of force, which is directly proportional to the applied force and inversely proportional to the mass of the body.

Mathematically we can write,

$$\vec{a} \propto \vec{F} \quad \text{. . . . . (i)}$$

And $$\vec{a} \propto \frac{1}{m} \quad \text{. . . . . (ii)}$$

Combining eq. (i) & (ii) we get

$$\vec{a} \propto \frac{\vec{F}}{m}$$

Or

$$\vec{a} = (\text{Constant}).\frac{\vec{F}}{m}$$

Here constant of proportionality is unity, therefore

$$\vec{a} = \frac{\vec{F}}{m}$$

Or

$$\boxed{\vec{F} = m\,\vec{a}}$$

Newton's 3rd Law of Motion:

This law states that for every action there is always a reaction equal in magnitude but opposite in direction.

Each force in action-reaction pair acts on one of the two bodies, the action and reaction forces never act on the same body.

MOMENTUM (LINEAR MOMENTUM)

The momentum is defined as the quantity of motion possessed by the body and it is equal to the product of mass and velocity of a moving body.

Linear momentum is denoted as **P** .

If 'm' is the mass and **v** is the velocity of a body along a straight line, then we write linear momentum of the body mathematically as,

$$\vec{P} = m\vec{v}$$

Momentum is a vector quantity; its direction is along the direction of velocity.

Unit:

SI unit of momentum is kg ms^{-1}.

Or Ns $(\therefore N = kgms^{-1})$

Dimensions:

$[MLT^{-1}]$

Newton's 2nd Law of Motionin terms of Momentum:

Newton's second lawof motion in terms of momentum is defined as, the time rate of change of momentum of a body equalsthe applied force.

$$\boxed{\vec{F} = \frac{m\vec{v}_f - m\vec{v}_i}{t}}$$

Where'$m\vec{v}_f$' is the final momentum and '$m\vec{v}_i$' is the initial momentum.

Hencelast expression shows that, the time rate of change of momentum of a body is equal to the applied force.

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Impulse:

When a force acts on a body for a short interval of time and changes its momentum, the product of force and time is called Impulse.

Mathematically,

$$\text{Impulse} = \vec{I} = \vec{F} \times t$$

Impulse is a vector quantity.

Unit:

The SI unit of impulse is 'Ns' are the same as that of momentum.

Impulsive Force:

A large force acting upon a body for a small interval of time is called an Impulsive force.

Impulse is Equal to Change in Momentum:

As we know by Newton's second law of motion in terms of momentum that time rate of change of momentum of a body equals the applied force.

Or $$\vec{F} = \frac{m\vec{v_f} - m\vec{v_i}}{t}$$

Thus $$\vec{F} \times t = m\vec{v_f} - m\vec{v_i}$$

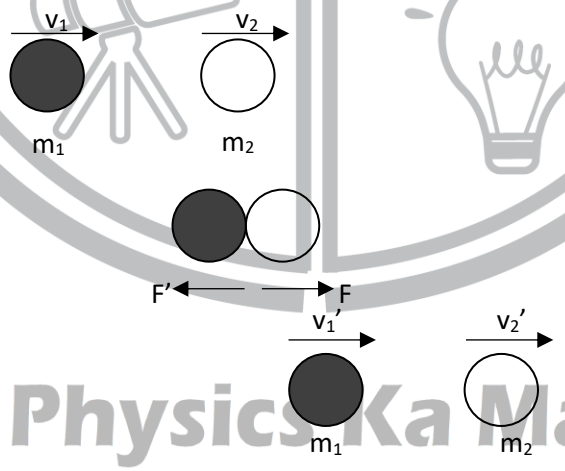
Hence impulse is equal to change in momentum.

Law of Conservation of Momentum:

It states that, the total linear momentum of an isolated system remains constant.

Consider an isolated system of two smooth hard interacting balls of masses m_1 and m_2 moving along the same line, in the same direction with velocities $\overrightarrow{v_1}$ and $\overrightarrow{v_2}$ respectively.

Both the balls collide after the collision, ball of mass m_1 moves with velocity $\overrightarrow{v_1}'$ and m_2 moves with velocity $\overrightarrow{v_2}'$ in the same direction as shown in figure.



$$m_1\overrightarrow{v_1} + m_2\overrightarrow{v_2} = m_1\overrightarrow{v_1}' + m_2\overrightarrow{v_2}'$$

$$\begin{bmatrix} Total\ momentum\ of \\ system\ before\ collision \end{bmatrix} = \begin{bmatrix} Total\ momentum\ of \\ the\ system\ after\ collision \end{bmatrix}$$

Isolated System:

A system in which a number of particles exerting a force upon one another but no external force acts upon it is called an isolated system.

e.g., System of gas molecules enclosed in a cylinder at constant temperature exerting a force upon each other but no external force act on them.

Collision:

When two or more objects came close to each other and there is interaction between them, with or without the presence of an external force then we say that collision has taken place between them.

There are two types of collision:

(i) Elastic Collision (ii) Inelastic Collision

(i) Elastic Collision:

The collision in which kinetic energy of colliding bodies before and after collision remain constant is called Elastic Collision.

For example, when a hard ball is dropped onto a marble floor, it rebounds to very nearly the initial height. Thus, the ball losses negligible amount of energy in the collision with the floor, so the K.E of the ball remains constant.

(ii) Inelastic Collision:

The collision in which the K.E of the system does not remain constant before and after the collision.

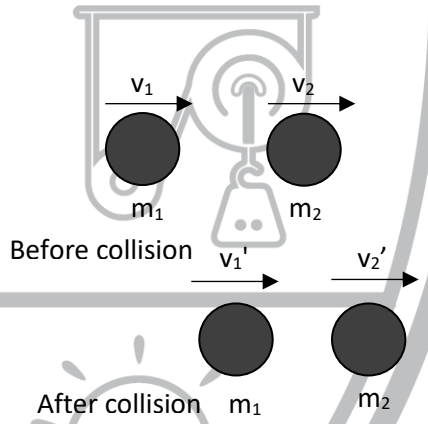
e.g. When two tennis balls collide, then after collision they will rebound with velocities less than the velocities before the collision. During this process, a portion of K.E is lost, partly due to friction (as the molecules in the ball move past one another when the balls distort) and partly due to its change into heat and sound energies.

ELASTIC COLLISION IN ONE DIMENSION:

Consider two smooth, non-rotating balls of masses m_1 and m_2 moving initially with velocities v_1 and v_2 respectively, in the same direction.

They collide elastically and after collision the final velocity of these masses is denoted by v_1' and v_2'.

There is a special case that before and after the collision the direction of motion of these masses remains along same straight line (say along x-axis). Therefore, it is called elastic collision in one dimension.



$$v_1' = \frac{(m_1 - m_2)v_1}{m_1 + m_2} + \frac{2m_2 v_2}{m_1 + m_2}$$

$$v_2' = \frac{2m_1 v_1}{m_1 + m_2} + \frac{(m_2 - m_1)v_2}{m_1 + m_2}$$

Here v_1' and v_2' are the final velocities of bodies of mass m_1 and m_2 respectively after elastic collision in one dimension.

NOTE:

In elastic collision magnitude of relative velocity of approach is equal to the magnitude of relative velocity of separation.

CASES OF ELASTIC COLLISION

Case I: If $m_1 = m_2$ & $V_2 \neq 0$

Then $V'_1 = V_2$ & $V'_2 = V_1$

Case II: If $m_1 = m_2$ & $V_2 = 0$
Then $V'_1 = 0$ & $V'_2 = V_1$

In both cases I & II due to the sane masses of the colliding bodies the velocities after collision got interchanged.

Case III: If $m_1 \gg m_2$ & $V_2 = 0$
Then $V'_1 = V_1$ & $V'_2 = 2V_1$

Case IV: If $m_1 \ll m_2$ & $V_2 = 0$
Then $V'_1 = -V$ & $V'_2 = 0$

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FORCE DUE TO WATER FLOW:

Let us consider, water is flowing through a horizontal pipe, and it strikes with a wall normally and exerted a force on the wall.

The force exerted by the water on the wall is given by:

$$F = -\left(-\frac{mv}{t}\right)$$

$$F = \frac{mv}{t}$$

RELATIVE VELOCITY:

The velocity of a body A as seen by an observer B which is also moving is known as the Relative Velocity of A with respect to B.

If body A is moving with velocity (Va) and body B is moving with velocity (Vb) (on parallel tracks), then the relative velocity of A with respect to B is

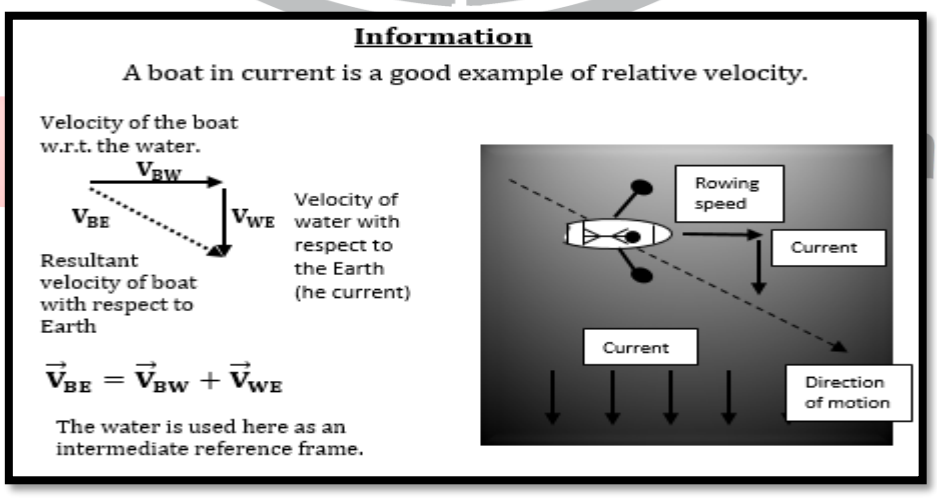
$$V_{ab} = V_a - V_b$$

(i) If both are moving in opposite directions, then

$$V_{ab} = V_a - (-V_b) = V_a + V_b$$

(ii) If both are moving in same direction, then

$$V_{ab} = V_a - V_b$$



PROJECTILE MOTION

When a body is thrown with certain initial velocity, making an angle ($0° < \theta < 90°$) with horizontal and moves freely under the action of gravity, then it is said to be perform "projectile motion".
The path followed by the projectile is called its trajectory.

OR

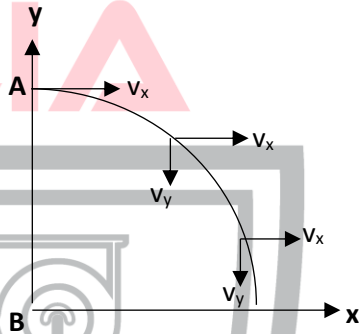
If a body is falling freely under the action of gravity in such a way that it has a constant velocity in horizontal direction and a constant acceleration in vertical direction, then its motion is known as Projectile Motion.

Assumptions for the Derivation of Equations of Projectile

- Earth is assumed to be flat over the whole trajectory of projectile.
- The acceleration due to gravity remains constant over the whole trajectory of projectile.
- Neglecting the aerodynamics effects.
- Considering the horizontal thrust force as zero i.e. assuming horizontal velocity to be constant.

Explanation:

Suppose a ball is thrown from point "A" with certain horizontal velocity v_x. It is observed that the ball travels forward as well as falls downwards under the action of gravity. Thus, the motion of ball does not remain in one dimension but its path becomes curved (to dimensional) as shown in figure.



Such combined (horizontal and vertical) motion is called Projectile motion.
According to Newton's 1st law of motion there will be no acceleration in horizontal direction unless a horizontally directed force acts on the ball. Since zero acceleration mean constant velocity.
Horizontal distance is covered by constant component of velocity v_x, whose value after any time 't' is written as,

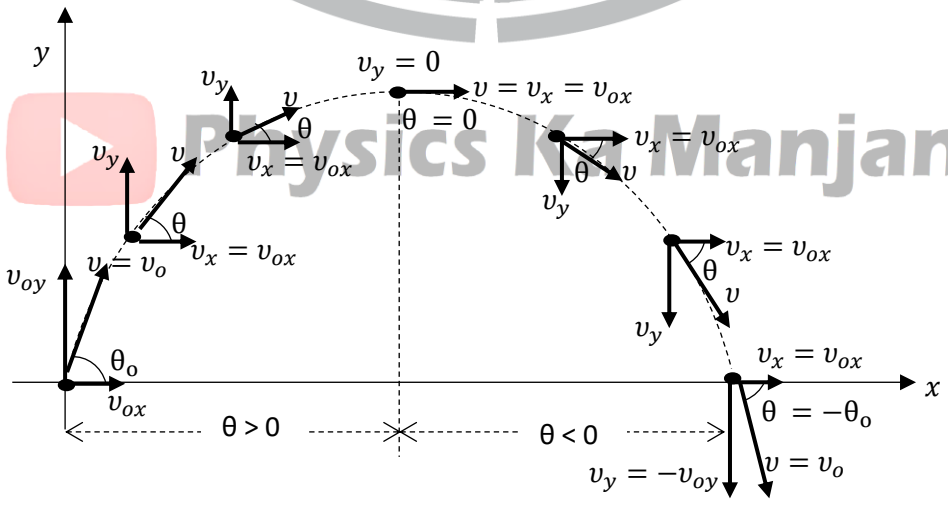
$$x = v_x t$$

The vertical motion of the ball is free falling motion, so acceleration $\vec{a} = \vec{g}$.
Since initial vertical velocity is zero, hence vertical distance 'y' is given by, using the following equation.

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

$$y = 0 + \frac{1}{2} g t^2$$

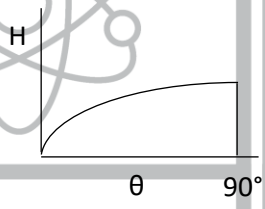
$$y = \frac{1}{2} g t^2$$



Physics Ka Manjan

- Horizontal and vertical coordinates of projectile at time 't' are given as:
  $x = V_o \cos\theta_o \, t$
  $y = V_o \sin\theta_o \, t - 1/2gt^2$
- Trajectory of projectile is parabola in the absence of air friction. In the presence of air friction, it is like parabola.
- If two identical balls are thrown simultaneously from same height, one vertical and other horizontal, then both falls to the earth simultaneously.
- Time to reach maximum height is given as:
  $t = V_o \sin\theta_o/g$
- Total time of flight is given as:
  $T = 2V_o \sin\theta_o/g$
- Vertical range (height) is given as:
  $H = V_o^2 \sin^2\theta_o/2g$
- Range (horizontal) is a distance between point of projection and point at which it comes back to its level of projection. It is given as:
  $R = V_o^2 \sin 2\theta_o/g = V_o^2(2\sin\theta_o\cos\theta_o)/g$
- Maximum horizontal range is at angle θ = **45°** and given as:
  $R = V_o^2/g$
- The relation between range and the height of the projectile is
  $R \tan\theta = 4H$

- ***Variation of height of the projectile with angle***

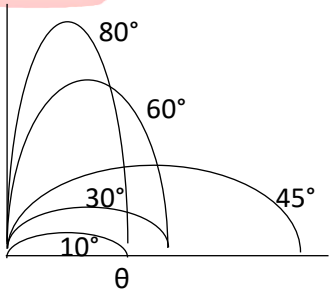


- Instantaneous velocity is maximum at point of projection and at the landing point and minimum at maximum height as $V_y = 0$.
- Horizontal component of projectile velocity remains constant throughout the projectile motion.
- Vertical component decreases, becomes zero at maximum height and then increases till projectile hits the ground.

Note that
$\overrightarrow{a_x} = 0$
$\overrightarrow{a_y} = \pm g$

R = Range of projectile
H = Maximum Height of Projectile

- With same initial velocity the range of projectile for two angles of projection will be equal if sum of the angles is equal to 90° i.e., $\theta_1 + \theta_2 = 90°$.
- Variation in the range and height with angle is shown with the following sketch



Do you know?

When angle of projection is 76° then range and height of projectile are equal to each other.

FORCES IN NATURE

There are four basic forces in nature – gravitational, electromagnetic, strong (nuclear) and weak. All other forces are manifestations of these forces. While considering macroscopic phenomena, we are concerned with only gravitational and electromagnetic forces.

FRICTION

The force which opposes relative motion between two bodies in contact is called the *Frictional force;* each body applies a force on the other opposite to the direction of relative motion along the common surface.

The magnitude of the frictional force depends on the nature of the two surfaces in contact. The origin of friction is due to the surface irregularities at molecular scales. Even a highly polished surface has such irregularities. When two surfaces are placed together, there occurs same sort of interlocking or "welding" of the uneven portions due to the interaction between the molecules. The frictional force is associated with the rupturing of these welds when one body is pulled over another body.

STATIC FRICTION

Suppose a body is placed on a horizontal surface and a horizontal force *F* is applied to it. If *F* is small then the body may not move. This is because an equal and opposite frictional force comes into play. If *F* is increased slightly, the body may not still move showing that the frictional force has also increased. However, if *F* is continuously increased then, at a certain value the body just starts sliding. This shown that the frictional force cannot increase beyond a certain value. This is called ***maximum force of static friction (F_s)*** or ***limiting friction.***

Laws of Friction

1. F_s is independent of the area of contact.
2. F_s is proportional to the normal reaction N, i.e.,

$$F_s \propto N \quad or \quad \boxed{F_s = \mu_s N}$$

Where μ_s is called ***coefficient of static friction***.

Kinetic Friction

If a body is sliding over a surface, the frictional force is less than the maximum force of static friction. This is called kinetic friction (F_k). This law of kinetic friction is exactly similar to those of static friction. We can write

$$\boxed{F_k = \mu_k N}$$

Where μ_k is the ***coefficient of kinetic friction***. Since $F_k < F_s$, we have $\mu_k < \mu_s$.

Rolling Friction

When a body rolls over a surface, the frictional force developed is called *rolling friction*. Rolling friction is much smaller as compared to sliding friction. That is why wheels are so useful in everyday life.

Total Reaction

The resultant of the normal reaction (N) and the limiting friction force (F_s) is called total reaction.

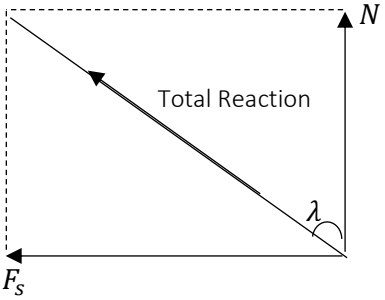
Angle of Friction

The angle between the normal reaction and the total reaction is called the angle of friction. If λ is the angle of friction, then we have

$$\tan\lambda = \frac{F_s}{N} = \mu$$

Or

$$\boxed{\lambda = \tan^{-1}\mu}$$



PRACTICE SHEET

1. The decrease in velocity per unit time is called:
   a. acceleration b. variable acceleration c. average acceleration d. retardation

2. When the values of average and instantaneous velocities are equal, the body is said to be moving with:
   a. uniform speed b. uniform acceleration c. uniform velocity d. average velocity

3. When the values of average and instantaneous acceleration are equal, the body is said to be moving with:
   a. average acceleration b. uniform acceleration
   c. positive acceleration d. negative acceleration

4. The force which produces an acceleration of $1ms^{-2}$ in a body of mass 1 kg is equal to:
   a. one slug b. one-pound c. one dyne d. one newton

5. The laws of motion show the relation between:
   a. velocity and acceleration b. mass and velocity
   c. mass and acceleration d. force and acceleration

6. The quantity of matter in a body is called:
   a. momentum b. mass c. velocity d. force

7. Laws of motion are valid in a system which is:
   a. non-inertial b. at rest c. inertial d. in the space

8. Acceleration of $1.5ms^{-2}$ expressed in kmh^{-2} is:
   a. 324 b. 5.4 c. 5400 d. 19440

9. Pull of earth on a mass of 20kg on the surface of earth is:
   a. 20N b. 196N c. 19.6N d. 1960N

10. The motion of the rocket in the space is according to the law of conservation of:
    a. energy b. linear momentum c. mass d. angular momentum

11. In an inelastic collision:
    a. Kinetic energy is more after collision b. kinetic energy is less after the collision
    c. momentum is more after the collision d. momentum is less after the collision

12. A bullet fired into a fixed wooden block loses half its velocity after penetrating 60 cm. It comes to rest after penetrating a further distance of:
    a. 10 cm b. 20 cm c. 40 cm d. 60 cm

13. The dimension of velocity is:
    a. LT^{-1} b. LMT c. LMT^{-1} d. $LM^{-1}T^{-1}$

14. If the velocity of a body is decreasing its acceleration is:
    a. positive b. negative c. both a & b d. none of these

15. From the top of a building, 16 m high, water drops are falling at equal intervals of time such that when the first drop reaches the ground, the fifth drop just starts. The distance between the successive drops, in meters, at that instant is:
a. 8, 4, 2, 1 b. 7, 5, 3, 1 c. 7.5, 5, 2.5, 1 d. None

16. When the body moves with constant acceleration, the velocity time graph is:
a. straight line b. hyperbola c. parabola d. circular

17. When the body moves with increasing acceleration, the velocity time graph is:
a. straight line b. curve c. parabola d. hyperbola

18. The area between the velocity and time axis in the velocity time graph is numerically equal to the:
a. speed of the object b. acceleration of the object
c. momentum of the object d. distance covered by the object

19. A force is applied on a body produces in its "own direction". This is the statement of:
a. Newton's first law b. Newton's third law
c. Newton's law of gravitation d. Newton's 2nd law

20. A collision in which the K.E of the system is not conserved is called:
a. inelastic collision b. elastic collision
c. one dimensional collision d. none of these

21. Distance covered by a freely falling body in 2 sec will be:
a. 4.9m b. 19.6m c. 28m d. 10m

22. One dyne is equal to:
a. 10^3 N b. 10^5 N c. 10^{-5} N d. 10^7 N

23. During the projectile motion, the horizontal component of velocity:
a. changes with time b. becomes zero
c. remains constant d. increases with time

24. The range of a projectile is directly proportional to:
a. $\sin^2 \theta$ b. $\sin 2\theta$ c. $\sin \theta$ d. $2 \sin \theta$

25. If the slope of a velocity time graph gradually decreases then the body is said to be moving with:
a. positive acceleration b. negative acceleration
c. uniform acceleration d. zero acceleration

26. The change in the magnitude of displacement or direction or both give rise to:
a. speed b. velocity c. acceleration d. impulse

27. A football is kicked vertically upwards with a velocity of 19.6m/s. It rises to a height of:
a. 49.9m b. 39.2m c. 19.6m d. 9.8m

28. Dimensions of impulse is similar to the dimensions of:
a. torque b. work c. force d. momentum

29. The horizontal range of a moving projectile depends upon:

a. the mass of projectile
b. the angle of launch
c. the velocity of projectile
d. both the velocity and angle

30. All objects in free fall near the surface of earth move towards the earth with:
a. uniform acceleration
b. variable acceleration
c. no acceleration
d. negative acceleration

31. The weight of a body of mass 1 kg is:
a. 1N b. 980N c. 98N d. 9.8N

32. A body of mass 5 kg starts from rest and falls freely. The distance covered by it in one second is:
a. 9.8m b. 980m c. 49m d. 4.9m

33. When a force is applied on an object, it gains momentum:
a. in the direction of applied force
b. opposite to applied force
c. perpendicular to applied force
d. none of these

34. The projectile motion is composed of:
a. horizontal motion only
b. vertical motion only
c. two independent horizontal and vertical motions
d. motion along straight line

35. The velocity of a projectile is maximum:
a. At middle of the height
b. At one-fourth of the height
c. Just before striking the ground and at the point of projection (Launching Point)
d. None of these

36. A particle moves with constant velocity of $10ms^{-1}$. It covers a distance of 20m along a straight line in two seconds. What is acceleration of the particle?
a. $20ms^{-2}$ b. $10ms^{-2}$ c. $1\ ms^{-2}$ d. zero

37. Which of the following can be zero if the particle is in motion for some time?
a. speed b. displacement c. distance covered d. none of these

38. If the distance covered by a particle is zero, then what can we say about its displacement?
a. it is negative
b. it may or may not be zero
c. it must be zero
d. it cannot be zero

39. The velocity-time graph of a motion starting from rest with uniform acceleration is a straight line:
a. not passing through origin
b. parallel to time axis
c. parallel to velocity axis
d. none of these

40. A train takes 1 hour to go from one station to the other. It travels at a speed of 30 kmh^{-1} for the first half hour and at a speed of 50 kmh^{-1} for the next half hour. The average speed of the train is:
a. 45 km/h b. 35 km/h c. 40 km/h d. none of these

41. Change of momentum is called:
a. force b. pressure c. tension d. impulse

42. Dimensions for the impulse are given by:
a. $[ML^2T^{-1}]$ b. $[ML^2T]$ c. $[ML^2T^{-2}]$ d. $[MLT^{-1}]$

43. A particle, dropped from a height h, travels a distance 9h/25 in the last second. If g = 9.8m/s^2, then h is:
a. 100 m b. 122.5 m c. 145 m d. 16705 m

44. A body is thrown vertically upward with initial velocity 9.8m/s. It will reach the height:
a. 19.8m b. 29.4m c. 9.8m d. 4.9m

45. Motion of projectile is:
a. one dimensional b. two dimensional c. three dimensional d. four dimensional

46. The maximum range of projectile is:
a. $R_{max} = v_i^2/g$ b. $R_{max} = 2v/g$ c. $R_{max} = v_i/g$ d. $2v_i^2/g$

47. The horizontal component of a projectile moving with the initial velocity of 500m/s at an angle 30° to y-axis is equal to:
a. 500m/s b. 1000m/s c. 250m/s d. zero

48. Time taken by the projectile to reach its maximum height:
a. $\frac{v_i \sin\theta}{g}$ b. $\frac{v_i \cos\theta}{g}$ c. $\frac{2v_i \sin\theta}{g}$ d. $\frac{v_i^2 \sin^2\theta}{g}$

49. The velocity of a particle at an instant is 10m/s and after 5s the velocity of the particle is 20m/s. The velocity 3s before in m/s is:
a. 8 b. 4 c. 6 d. 7

50. A train of 150m length is going towards north direction at a speed of 10m/s. A parrot flies at a speed of 5m/s towards south direction parallel to the railway track. The time taken by the parrot to cross the train is equal to:
a. 12 s b. 8 s c. 15 s d. 10 s

51. A body is dropped from a tower, with zero velocity, reaches ground in 4 s. The height of the tower is about:
a. 80 m b. 20 m c. 160 m d. 40m

52. Which of the following four statements is false?
a. A body can have zero velocity and still be accelerated.
b. A body can have a constant velocity and still have a varying speed.
c. A body can have a constant speed and still have varying velocity.
d. The direction of the velocity of a body can change when its acceleration is constant.

53. If the horizontal range of a projectile is four times its maximum height, the angle of projection is:
a. 30° b. 45° c. $\sin^{-1}\left(\frac{1}{4}\right)$ d. $\tan^{-1}(4)$

54. When two bodies move towards each other with constant speeds, the distance between them decreases at the rate of 6m/s. if they move is the same direction with the same speeds, the distance between them increases at the rate of 4m/s. Then their speeds are:

a. 5m/s & 1m/s b. 3m/s & 3m/s c. 4m/s & 2m/s d. none of these

55. Starting from rest and moving with a constant acceleration, a body covers a certain distance in time t. It covers the second half of the distance in time:
a. $\frac{t}{\sqrt{2}}$ b. $\frac{t}{\sqrt{3}}$ c. $t\left(1-\frac{1}{\sqrt{2}}\right)$ d. $t\left(1-\frac{1}{\sqrt{3}}\right)$

56. A body of mass 2kg, moving on a horizontal surface with an initial velocity of 4m/s, comes to rest after 2 seconds. If one wants to keep this body moving on the same surface with a velocity of 4m/s, the force required is:
a. zero b. 2 N c. 4 N d. 8 N

57. The range of a projectile when launched at an angle of 15° with the horizontal is 1.5 m. Its range, when launched at 45° with the same speed is:
a. 3.0 m b. 1.5 m c. 6.0 km d. 0.75 km

58. A bomb of mass 12 kg, initially at rest, explodes into two pieces of masses 4kg and 8 kg. The speed of the 8 kg mass is 6m/s. The kinetic energy of the 4 kg mass is:
a. 32 J b. 48 J c. 114 J d. 288 J

59. A stone is thrown vertically upwards with a velocity of 30m.s^{-1}. If the acceleration due to gravity is 10m/s^2, what is the distance travelled by the particle during the first second of its motion:
a. 30m b. 25m c. 10m d. none of these

60. Two bodies start falling freely from rest from the same height at an interval of 1 s. How long after the first body begins to fall will the two bodies be 10 m apart? (g = 10 m/s^2)
a. 0.5 s b. 1.0 s c. 1.5 s d. 2.0 s

61. A cricket ball is hit so that it travels straight up in air and it acquires 3 seconds to reach the maximum height. Its initial velocity is:
a. 10m/s b. 15 m/s c. 29.4 m/s d. 12.2 m/s

62. Distance covered by a freely falling body in 1 second will be:
a. 14.9 m b. 4.9 m c. 39.2 m d. 44.1 m

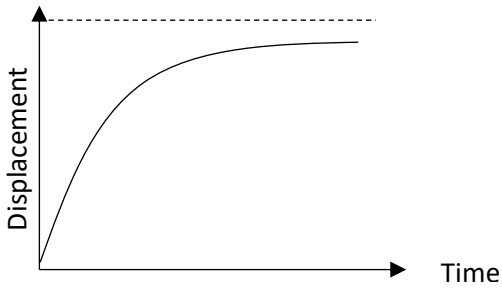
63. The distance covered by a body in time t starting from rest is:
a. $at^2/2$ b. Vt c. $a^2t/2$ d. at^2

64. An object with constant speed:
a. is not accelerated b. might be accelerated
c. is always accelerated d. also has a constant velocity

65. When a body is accelerated:
a. its velocity always changes b. its speed always changes
c. its direction always changes d. its speed may or may not change

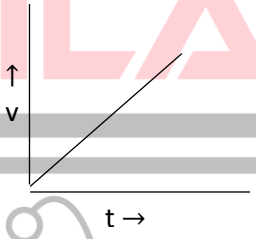
66. A car starts from rest and attains a speed of 40ms^{-1} in 20 sec. Its average acceleration in ms^{-2} is:
a. 0.5 b. 2 c. 4 d. 8

67. The displacement-time graph of a particle is as shown below. It indicates that:

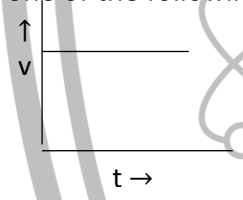


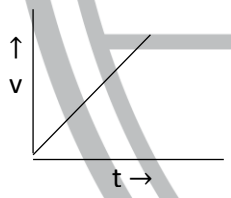
a. The particle starts with a certain velocity, but the motion is retarded and finally the particle stops.
b. The velocity of the particle is constant throughout.
c. The acceleration of the particle is constant throughout.
d. The particle starts with a velocity, the motion is accelerated and finally the particle moves with a constant velocity.

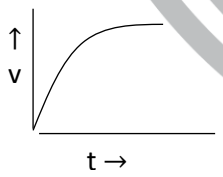
68. The velocity-time graph of a body moving in a straight line is shown below:

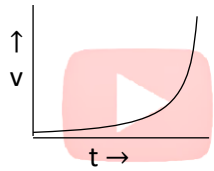


Which one of the following represents its acceleration-time graph?

a. 

b. 

c. 

d. 

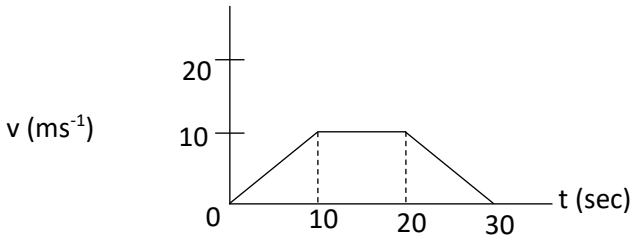
69. A car moves with a speed of 40 kmh^{-1} for the first half time and with a speed of 60 km/h for the second half time. The average speed during the whole journey is:

a. 45 kmh^{-1} b. 48 kmh^{-1} c. 50 kmh^{-1} d. 50m/s

70. A body dropped from a tower with zero velocity, reaches the ground in 3 sec. The height of the tower is about:

a. 45m b. 20m c. 160m d. 40m

71. In the following time velocity graph, the distance travelled by the meters is:



a. 200 b. 250 c. 300 d. 400

72. A body moves from rest with a constant acceleration of 5 m/s^2. Its instantaneous speed in m/s at the end of 10 seconds is:
a. 50 b. 5 c. 2 d. 0.5

73. When a force of 1N acts on a 1kg body that is able to move freely, the body receives:
a. a speed of 1 m/s b. an acceleration of 1 m/s^2
c. an acceleration of 980 cms^{-2} d. an acceleration of 10 ms^{-2}

74. A force of 12N gives an acceleration of $4ms^{-2}$ to an object. The force required to give it an acceleration of 10 ms^{-2} is:
a. 15N b. 20N c. 25N d. 30N

75. A ball is projected at an angle of 45° to the horizontal. If the horizontal range is 20m, the maximum height to which the ball rises is ($g = 10ms^{-2}$)
a. 2.5m b. 5.0m c. 7.5m d. 10m

76. A man in a train moving with a constant velocity drops a ball on the platform. The path of the ball as seen by an observer standing on the platform is:
a. a straight line b. a circle c. a parabola d. none of these

77. The range of a projectile launched at an angle of 15° to the horizontal is 2.5 km. What will be its range if it is projected at an angle of 45° to the horizontal?
a. 0.75 km b. 5.0 km c. 1.5 km d. none of these

78. The angle of projection for which the maximum height and the horizontal range of a projectile are equal is:
a. 45° b. 60° c. $\tan^{-1}(1/4)$ d. $\tan^{-1}(4)$

79. The maximum range of a gun on a horizontal terrain is 16 km. The muzzle velocity of the shell is ($g = 10ms^{-2}$)
a. 200m/s b. 256 m/s c. 400 m/s d. 800 m/s

80. For a projectile, the ratio of maximum height reached to the square of flight time is ($g = 10ms^{-2}$)
a. 5 : 4 b. 5 : 2 c. 5 : 1 d. 10 : 1

81. In an elastic collision:
a. Momentum is conserved but energy is not
b. Both momentum and energy are conserved
c. Neither momentum nor energy is conserved
d. Energy is conserved but momentum is not

82. When two bodies stick together after the collision, the collision is said to be:
a. Elastic b. Both c. Inelastic d. none of these

83. A bullet hits and gets embedded in a solid block resting on a horizontal frictionless table. What is conserved?
a. momentum and kinetic energy b. momentum only
c. kinetic energy only d. neither momentum nor kinetic energy

84. A car is waiting at a traffic signal and when the signal turns green, the car starts ahead with a constant acceleration of 2 m/s^2. At the same time a bus travelling with a constant speed of 10 m/s overtakes and passes the car. How far beyond it's starting point will the car overtake the bus?
a. 40 m b. 30 m c. 90 m d. 100 m

85. What will be the ratio of the distances moved by a freely falling body from rest in 4^{th} and 5^{th} seconds of journey?
a. 4 : 5 b. 7 : 9 c. 16 : 25 d. 1 : 1

86. Bullet having a mass of 0.005 Kg is moving with a speed of 100 m/s. It penetrates into a bag of sand and is brought to
rest after moving 25 cm into the bag, the decelerating force (in Newtons) on the bullet and the time (in seconds) in which it is brought to rest is;
a. 100,0.005 b. 120,0.05 c. 10,0.05 d. None

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ANSWER KEY

1.	D	31.	D	61.	C
2.	C	32.	D	62.	B
3.	B	33.	A	63.	A
4.	D	34.	C	64.	B
5.	D	35.	C	65.	A
6.	B	36.	D	66.	B
7.	C	37.	B	67.	A
8.	D	38.	C	68.	A
9.	B	39.	D	69.	C
10.	B	40	C	70	A
11.	B	41.	D	71.	A
12.	B	42.	D	72.	A
13.	A	43.	B	73.	B
14.	B	44.	D	74.	D
15.	B	45.	B	75.	B
16.	A	46.	A	76.	C
17.	B	47.	C	77.	B
18.	D	48.	A	78.	D
19.	D	49.	B	79.	C
20.	A	50.	D	80.	A
21.	B	51.	A	81.	B
22.	C	52.	B	82.	C
23.	C	53.	B	83.	B
24.	B	54.	A	84.	D
25.	B	55.	C	85.	B
26.	C	56.	C	86.	A
27.	C	57.	A	87.	
28.	D	58.	D	88.	
29.	D	59.	B	89.	
30.	A	60.	C	90.	

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CHAPTER 4
WORK AND ENERGY

WORK DONE BY CONSTANT FORCE:

The work done on a body by a constant force is defined as, "The product of the magnitude of the displacement and the component of the force in the direction of the displacement".

Explanation:

If a constant force $\vec{F}$ acts upon a body and that body is displaced from its initial position to a final position (through a displacement $\vec{d}$). Then work done is given by the following formula.

Work = W = $\vec{F} \cdot \vec{d}$

= Fd cos θ

= $(F \cos\theta)(d)$

Where F cos θ is the component of the force $\vec{F}$ in the direction of the displacement $\vec{d}$.

Positive Work:

The work is positive when force and displacement are in same direction, or when the angle between force and displacement is less than 90°, i.e., θ < 90°.

The work has maximum value when θ = 0°.

i.e., Work = Fd cos0°

= Fd

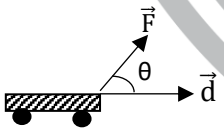
Negative Work:

The work is negative when force and displacement are in opposite direction, or when the angle between force and displacement is greater than 90°, i.e., θ > 90°.

Zero Work:

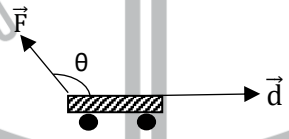
The work is zero when force and displacement are perpendicular to each other, or when the angle between force and displacement is 90°, i.e., θ = 90°.

Examples: (Different forms of work)



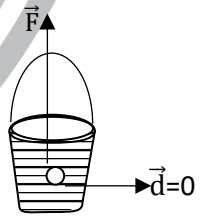
Body is moving toward right in the direction of force.

$Fig.(1)$



Body is moving toward right in the opposite direction of force.

$Fig.(2)$



A pail is lifting up.

$Fig.(3)$

Positive, negative and zero work are illustrated in figure 1, 2 and 3 respectively.

Q. Show that work done on a body against gravity is negative.

Ans. Work done on a body against gravity is negative, in this case θ = 180° i.e., force and displacement are anti-parallel. Therefore.

Work = Fd cos 180°

= −Fd

Hence it proved.

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Unit of Work:

SI unit of work is Nm known as joule (J).

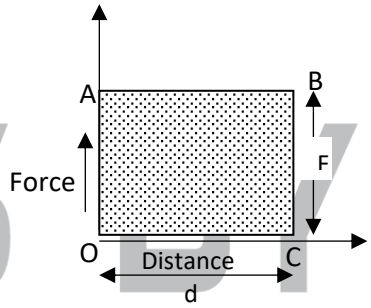
Dimension of Work:

Dimensions of work are $[ML^2T^{-2}]$.

Graphical Method of Calculation of Work Done by a Constant Force:

The value of work done by a constant force can also be calculated by graphical method.

If we plot a graph between various values of displacement and corresponding value of force.



The shape of graph is shown in figure. It is a straight line (AB). The are under this straight line is in shape of rectangle OABC. This area is given by (OA)(OC).

Here 'OA' represents value of force applied F and 'OC' represents the value of displacement d.

Hence, we get

Area (OABC) = Work done

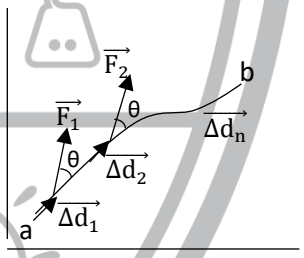
It must be noted that,

(i) If the constant force $\vec{F}$ and the displacement $\vec{d}$ are in the same direction, then the work done is Fd (joule), as clearly shaded area in fig.

(ii) When the force $\vec{F}$ makes a certain angle with the displacement ($\theta \neq 0°$), then graph is plotted between various values of displacement and the component of force along direction of displacement (F cos θ).

Work Done by Variable Force:

There are many cases in which the value of the applied force does not remain constant throughout the total displacement. For example, as a rocket moves away from the earth, work is done against the force of gravity, which varies as the inverse square of the distance from the Earth's centre. Then work done by this variable force is calculated as follows:



Consider a particle is moved from point 'a' to 'b' by the action of a variable force.

Let us divide the total displacement into n short intervals of displacement, $\overrightarrow{\Delta d_1}, \overrightarrow{\Delta d_2}, \ldots \overrightarrow{\Delta d_n}$ and $\overrightarrow{F_1}$, $\overrightarrow{F_2}, \ldots, \overrightarrow{F_n}$ are the forces acting during these intervals as shown in figure.

During each small interval, the force is supposed to be constant, work done for the first interval is

$$\Delta W_1 = \overrightarrow{F_1} . \overrightarrow{\Delta d_1} = F_1 \cos\theta_1 \Delta d_1$$

Work done for the second interval is

$$\Delta W_2 = \overrightarrow{F_2} . \overrightarrow{\Delta d_2} = F_2 \cos\theta_2 \Delta d_2$$

Similarly so on,

$$\Delta W_n = \overrightarrow{F_n} . \overrightarrow{\Delta d_n} = F_n \cos\theta_n \Delta d_n$$

Therefore

$$W_{total} = \Delta W_1 + \Delta W_2 + \cdots + \Delta W_n$$

Or $$W_{total} = F_1 \cos\theta_1 \Delta d_1 + F_2 \cos\theta_2 \Delta d_2 + \cdots + F_n \cos\theta_n \Delta d_n$$

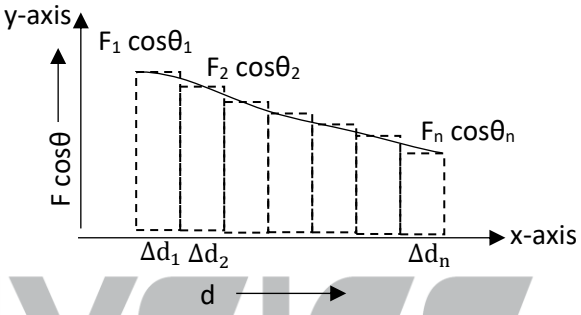
$$\boxed{W_{total} = \sum_{i=1}^{n} F_i \cos\theta_i \Delta d_i}$$

It is formed for the work done by variable force.

Graphical Method of Calculation of Work Done by Variable Force:

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If graph is plotted between various values of (F cos θ) and corresponding values of displacements then we get a graph of irregular shape as shown in figure.



To find area under curve of the graph we draw perpendiculars from beginning and end of the curve on horizontal axis and we get large number of vertical strip as shown in figure. Each strip can be taken approximately as a thin rectangle. The length of any one of these may be represented by (F cosθ) and small breadth is represented by (Δd). Then area of one of the strip can be written as,

$$\begin{pmatrix}\text{Area of one}\\ \text{rectangular strip}\end{pmatrix} = (F\cos\theta)(\Delta d)$$

Where Δd is so small that it approaches to zero. This area is equal to work done during small displacement.

The sum of area of all thin strips is equal to total work done, i.e.,

$W_{total} = F_1 \cos\theta_1\Delta d_1 + F_2 \cos\theta_2\Delta d_2 + \ldots + F_n \cos\theta_n\Delta d_n$

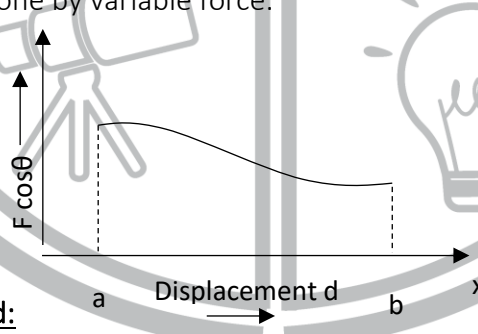
$$W_{total} = \sum_{i=1}^{n}(F_i\cos\theta_i)\Delta d_i$$

Note:

As Δd is so small that it approaches to zero, therefore we can write above expression as,

$$W_{total} = \lim_{\Delta d\to 0}\sum_{i=1}^{n}(F_i\cos\theta_i)\Delta d_i$$

Hence the total area under the curve of graph, between various different values of $(F\cos\theta)$ and the displacement is equal to work done by variable force.



Work Done in Gravitational Field:

"Work done by gravitational field of earth is independent of the shape of path followed and it depends only on initial and final positions". Such a field is called conservative field.

Closed Path:

A path in which bodies after passing through several points reach the starting point is called closed path.

CONSERVATIVE FIELD:

Conservative field is defined as, "the field in which work done by gravitational field is independent of the shape of path followed and it depends only on the initial and final positions".

OR

"A field in which the work done by the gravitational field of earth along closed path is zero".

POWER:

The amount of work done by a body in unit time, is called Power.

OR

The rate of doing work of a body is called as Power.

Mathematically.

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

or $$P = \frac{W}{T}$$

Unit of Power:

The SI unit of power is watt.

Watt:

The watt is defined as, "if one joule of work is done in one second then power will be one watt".

$$\text{Watt} = \frac{\text{Joule}}{\text{sec}}$$

Kilowatt Hour:

If a power of one kilowatt is maintained for one hour, the work done is one kilowatt hour.

This unit of energy is also known as Board of trade unit.

1 kWh = 1 kilowatt × 1 hour

= 1000 W × 3600 sec.

= 36×10^5 Ws

= 36×10^5 J $\left(\therefore 1\ W = \frac{1\ J}{s}\right)$

= 3.6×10^6 J

= 3.6 MJ $(\therefore \text{One megawatt} = 10^6 W)$

Dimension of Power:

The dimensions of power are $[ML^2T^{-3}]$.

Power in Terms of Force and Velocity:

$$\boxed{P = \vec{F}.\vec{v}}$$

ENERGY:

The capacity or ability of doing work of a body is called its energy.

Mechanical Energy:

The energy possessed by a body due to its state of rest or motion is called Mechanical Energy.

There are two types of mechanical energy:

(i) Kinetic Energy (K.E)

(ii) Potential Energy (P.E)

KINETIC ENERGY (K.E):

"The energy possessed by a body due to its motion is called Kinetic Energy".

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

GRAVITATIONAL POTENTIAL ENERGY (P.E):

It is defined as the energy possessed by a body due to its position. This energy is always due to an external field (e.g. gravitational field, elastic field, magnetic field, etc.)

$$\boxed{P.E = (mg)(h)}$$

It is formula for gravitational P.E.

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ELASTIC POTENTIAL ENERGY:

The P.E possessed by a spring due to its compressed or stretched state is called elastic potential energy.

Note:

1) As K.E = $\frac{1}{2}mv^2$
   Or $\mathrm{K.E} \propto v^2$
   i.e., K.E is directly proportional to the square of the velocity. If v is doubled, K.E becomes four times.

2) K.E = $\frac{1}{2}mv^2$
   K.E = $\frac{1}{2}m(\vec{v}.\vec{v})$
   Hence, kinetic energy is a scalar quantity due to scalar or dot product.

WORK ENERGY PRINCIPLE:

This principle states that work done on a body, by an applied force, is equal to change of its kinetic energy.

i.e., $(\mathrm{Final\ K.E}) - (\mathrm{Initial\ K.E}) = \mathrm{Work\ done}$

ABSOLUTE POTENTIAL ENERGY:

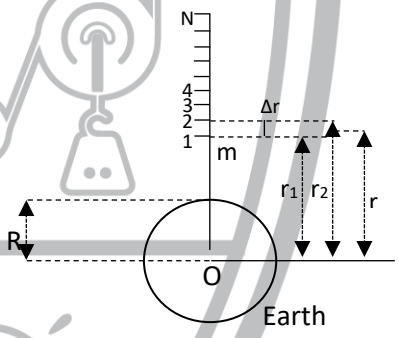
It is defined as "the amount of work done in moving a body from earth's surface to a point at infinite distance". (Where the value of g is negligible)

Explanation:

In the gravitational potential energy we have a formula, (P.E = mgh) which is the formula for difference of gravitational P.E with respect to a reference point of another point 'h' distance above it.

$$U = -\frac{GmM}{r}$$

Here U is symbol for absolute value of gravitational (P.E) due to earth at distance r, from the centre of the earth.



Due to –ve sign we say that, when r decreases, the body falls towards the earth, the work is positive and P.E decrease (i.e. becomes more negative). When r increases, the gravitational force does negative work and 'U' increases, (i.e., becomes less negative). And 'U' is zero when r = ∞.

ESCAPE VELOCITY:

"The minimum initial velocity of a body that thrown vertically upward, from surface of earth, due to which it crosses the earth's gravitational field, is called escape velocity". It is denoted by v_{esc}.

$$\boxed{v_{esc} = \sqrt{\frac{2GM}{R}}}$$

Or $\boxed{v_{esc} = \sqrt{2gR}}$

The value of v_{esc} comes out to be approximately by putting values of g and R, (i.e., g = 9.8 m/s and R = 6.4×10^6 m)

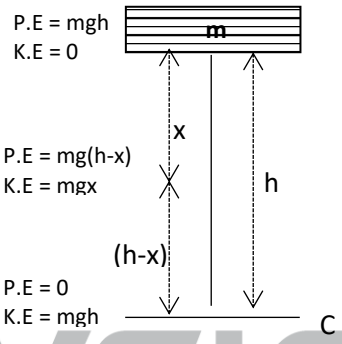
v_{esc} = 11.2 km/s

INTERCONVERSION OF P.E AND K.E:

The inter-conversion of P.E and K.E confirmed that one form of mechanical energy can be converted into its other form, so that total mechanical energy remains constant. It is true when there is no loss of energy.

Hence, we P.E = mgh conclude that total K.E = 0 mechanical energy remains constant at position A, B and C. But decrease in (K.E) so that their sum remains constant.

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Thus, we see that during the free fall of a body.

$$(\textbf{Loss of P.E}) = (\textbf{Gain in K.E})$$

When Air Friction is Present During the Download Motion:

Then the part of P.E is used in doing work against friction equal to "fh". Thus remaining P.E = mgh – fh is converted into (K.E).

Hence,

$mgh - fh = ½\ mv^2$

$$\boxed{mgh = \frac{1}{2}mv^2 + fh}$$

Thus, Loss of P.E = Gain in K.E + Work done against friction.

Note:

If the body is moving up

Less of K.E = Gain in P.E + Work done against friction.

Or $\frac{1}{2}\ mv^2 = mgh + fh$

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PRACTICE SHEET

1. The unit of power SI (watt) is equivalent to:
   a. kg m^2s^{-3} b. kg ms^{-2} c. kg m^2s^{-2} d. none of these

2. The work done in moving a body from one place to another in a gravitational field is independent of:
   a. force of gravity b. the applied force
   c. the path followed by the body d. the power consumed

3. Which of the following types of force can do no work on the particle on which it acts:
   a. frictionless forces b. gravitational force
   c. elastic force d. centripetal force

4. When a body is lifted through a height 'h', the work done on the body appears in the form of:
   a. kinetic energy b. potential energy c. force d. work

5. One erg is equal to:
   a. 10^5 J b. 10^7 J c. 10^{-5} J d. 10^{-7} J

6. The work needed to lift a body of mass 'm' from the surface of earth to an infinite distance is:
   a. kinetic energy of the body b. absolute potential energy of the body
   c. potential energy of the body d. elastic potential energy

7. One mega watt-hour is equal to:
   a. 36×10^6 J b. 36×10^{12} J c. 36×10^9 J d. 36×10^8 J

8. A body of mass 3 kg lies on the surface of the table 2 m high. It is moved on the surface by 4 m. The change of P.E will be:
   a. zero b. 9.8J c. 19.6 J d. 329 J

9. The consumption of energy by a 60-watt bulb in 2 sec is:
   a. 120 J b. 60 J c. 30 J d. 0.02 J

10. The P.E of an object on the surface of earth is equal to:
    a. mgh b. 2 mgh c. ½ mgh d. zero

11. The escape velocity of a body depends upon:
    a. the mass of the body b. the mass of the planet (earth etc)
    c. density of the planet d. volume of the planet

12. The source of geothermal energy is:
    a. the fusion in sun b. the radioactive decay in the earth's interior
    c. the rotation of earth around the sun d. the rotation of earth around its own axis

13. Solar cells are made up from the material called:
    a. iron b. hydrocarbons c. carbon d. silicon

14. Work done under a force is negative if the force and displacement are:
    a. At the right angle to each other b. In the same direction
    c. In opposite direction d. None of these

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15. In a power of 1 kW is maintained for 1 second, the work done is equal to:
a. 10^3 J b. 10^5 J c. 10^6 J d. 3.6×10^6 J

16. Which one is the biggest unit of energy:
a. erg b. joule c. watt-hour d. kilo-watt hour

17. A body moves a distance of 10 m along a straight line under the action of a force of 5N. If the work done is 25 joules, the angle which the force takes with is the direction of motion of the body is:
a. 0° b. 30° c. 60° d.90°

18. How much water a pump of 2 kW can raise in one minute to a height of 10 m, take g=10ms^{-2}
a. 1000 liters b. 1200 liters c. 100 liters d. 2000 liters

19. A loaded bus and an unloaded bus are both moving with the same kinetic energy. The mass of the former is twice that of the latter. Brakes are applied to both so as to exert equal retarding forces. If S_1 and S_2 are the distances covered by the two buses, respectively, before coming to rest, then:
a. $S_1 = S_2$ b. $2S_1 = S_2$ c. $S_1 = 2S_2$ d. $S_1 = 4S_2$

20. The kinetic energy of a body of mass m is E. Its momentum is:
a. $\sqrt{2mE}$ b. 2mE c. $\sqrt{\frac{mE}{2}}$ d. $\frac{2E}{m}$

21. A body of mass 2kg is thrown up vertically with a kinetic energy of 490 J. If g = 9.8 m/s, the height at which the kinetic energy becomes half its original value:
a. 10 m b. 12.5 m c. 25 m d. 50 m

22. Water from a stream is falling on the blades of a turbine at the rate of 100 kg/s. If the height of the stream is 100m then the power delivered to the turbine is:
a. 1 kW b. 100 W c. 10 kW d. 100 kW

23. The retarding force required to reduce velocity of a 3 kg body from 0.75m/s to 0.25 m/s in 0.02 seconds will be:
a. 100N b. 75 N c. 50 N d. 25 N

24. The momentum of particle is numerically equal to its kinetic energy. What is the velocity of the particle?
a. 9m/s b. 3m/s c. 2m/s d. 1m/s

25. If moon's radius is 1600 km and 'g' on its surface is 1.6 ms^{-2}, then the escape velocity on the moon is:
a. 1600m/s b. 50.6 m/s c. 50.6 m/s d. 2263 m/s

26. Two masses of 1 g and 4 g are moving with equal kinetic energies. The ratio of the magnitudes of their linear momenta is:
a. 4 : 1 b. $\sqrt{2}$: 1 c. 1 : 2 d. 1 : 16

27. A body of mass 2 Kg is thrown up vertically with K.E of 980 J. If the acceleration due to gravity is 9.8 m/s^2, the height at which the K.E of the body becomes half its original value is given by:
a. 50 m b. 12.5 m c. 25 m d. 10 m

28. Two bodies of masses m_1 and m_2 have equal momentum their kinetic energies E_1 and E_2 are in the ratio:

a. $\sqrt{m_1} : \sqrt{m_2}$ b. $m_1 : m_2$ c. $m_2 : m_1$ d. $m_1^2 : m_2^2$

29. A 2kg body and a 3 kg body have equal momentum. If the kinetic energy of 3 kg body is 10J, the K.E of 2 kg body will be:
a. 6.66 J b. 15 J c. 22.5 J d. 45 J

30. A child on a swing is 1 m above the ground at the lowest point and 6 m above the ground at the highest point. The horizontal speed of the child at the lowest point of the swing is approximately:
a. 8 m/s b. 10 m/s c. 12 m/s d. 14 m/s

31. When the velocity of a body is doubled:
a. its K.E is doubled b. its P.E is doubled
c. its momentum is doubled d. its acceleration is doubled

32. A moving body need not have:
a. Kinetic energy b. Potential energy c. momentum d. velocity

33. Two spheres of same size, one of mass 5 kg and the other of mass 10kg, are dropped simultaneously from a tower. When they are about to touch the ground, they have the same:
a. momentum b. kinetic energy c. potential energy d. acceleration

34. If momentum is increased by 20% the K.E. increases by:
a. 44% b. 55% c. 66% d. 77%

35. The work done in holding a mass of 50 kg at a height of 2 m above the ground is:
a. 0 J b. 25 J c. 100 J d. 980 J

36. Work done in earth's gravitational field is:
a. $\vec{F} \cdot \vec{d}$ b. zero
c. Dependent on path followed d. Independent of path followed

37. A 1kg mass has a K.E of 1 joule when its speed is:
a. 0.45 m/s b. 1 m/s c. 1.4 m/s d. 4.4 m/s

38. A 1kg mass has a P.E of 1 joule relative to the ground when it is at a height of:
a. 0.102 m b. 1 m c. 9.8 m d. 32 m

39. If R is the radius of a planet and the value of acceleration due to the gravity is 'g' on it, then the escape velocity from the planet is:
a. $v_{esc} = 2Rg$ b. $v_{esc} = \sqrt{2R/g}$ c. $v_{esc} = \sqrt{2Rg}$ d. $v_{esc} = \sqrt{2g/R}$

40. A light body A and a heavy body B have equal kinetic energies of translation. Then:
a. A has larger momentum than B.
b. B has larger momentum than A.
c. A and B have same momentum.
d. Nothing can be said about their momentum relationship unless actual masses are known.

41. One watt-hour equal:
a. 3.6×10^3 J b. 3.6×10^3 cal c. 3.6×10^6 J d. 3.6×10^6 cal

42. A bullet of mass 10g hits the target and penetrates 2cm into it. If the average resistance offered by the target is 100N, then the velocity with which the bullet hits the target is:
a. 10m/s b. $10\sqrt{2}$m/s c. 20m/s d. $20\sqrt{2}$m/s

43. A body of 5kg, initially at rest, is moved by a force of 2N on a smooth horizontal surface. The work done by the force in 10sec is:
a. 20 J b. 30 J c. 40 J d. 60 J

44. The time taken by an engine of power 10kW to lift a mass of 200 kg to a height of 40 m is ($g = 10ms^{-2}$)
a. 2 sec b. 4 sec c. 8 sec d. 16 sec

45. A body of mass 10 kg is dropped to the ground from a height of 10m. The work done by the gravitational force is ($g = 9.8ms^{-2}$)
a. – 490 J b. 490 J c. – 980 J d. 980 J

46. The decrease in the potential energy of a ball of mass 20 kg which falls from a height of 50 cm is:
a. 968 J b. 98 J c. 1980 J d. none of these

47. The kinetic energy of a body of mass 2kg and momentum 2 Ns is:
a. 1 J b. 2 J c. 3 J d. 4 J

48. A body of mass 5 kg is moving with a momentum of 10 kg ms^{-1}. A force of 0.2 N acts on it in the direction of motion of the body for 10 seconds. The increase in its K.E is:
a. 2.8 J b. 3.2 J c. 3.8 J d. 4.4 J

49. A force $\vec{F} = 5\hat{\imath} + 6\hat{\jmath} - 4\hat{k}$ acting on a body, produces a displacement $\vec{S} = 6\hat{\imath} + 5\hat{k}$. Work done by the force is:
a. 10 units b. 18 units c. 11 units d. 15 units

50. A particle moves with a velocity $6\hat{\imath} - 4\hat{\jmath} + 3\hat{k}$ ms^{-1} under the influence of a constant force $\vec{F} = 20\hat{\imath} + 15\hat{\jmath} - 5\hat{k}$ N. The instantaneous power applied to the particle is:
a. 45 J/s b. 35 J/s c. 25 J/s d. 195 J/s

51. A body is falling freely from A to B, the total energy of the body at point C (Somewhere between A and B) is:
a. equal to the total energy at point A.
b. less than the total energy at point A
c. greater than the total energy at point A
d. one fourth of the total energy at point A

52. The component of the force in the direction of the displacement $\vec{d}$ is:
a. Fd cosθ b. Fd sinθ c. 0 d. F cosθ

53. The kinetic energy of a 100gm bullet moving at a speed of 100 m/s is:
a. 2500 J b. 500 J c. 1250 J d. 250 J

54. The kinetic energy acquired by a body of mass m in travelling a certain distance starting from rest, under a constant force is:
a. directly proportional to m
b. directly proportional to $\sqrt{m}$
c. inversely proportional to $\sqrt{m}$
d. independent of m

55. The dimensions of Kinetic energy are:
a. ML^2T^{-2} b. $ML^{-2}T^2$ c. $ML^{-1}T^{-2}$ d. $ML^{-1}T^{-1}$

56. The dimensions of potential energy are:
a. ML^2T^{-2} b. $ML^{-1}T^{-2}$ c. $ML^{-1}T^{-1}$ d. $ML^{-2}T^2$

57. An electric motor creates a tension of 45 N in a hoisting cable and reels it in at the rate of 2 m/s, the power of the motor is:
a. 15 kW b. 90-watt c. 225 W d. 9000 H.P.

58. A solar cell is a device which converts solar energy into:
a. heat energy b. chemical energy c. nuclear energy d. electrical energy

59. If the angle between force $\vec{F}$ and displacement $\vec{d}$ is zero, then the work done will be:
a. minimum b. maximum c. negative d. none of these

60. The work done is said to be negative if:
a. $\theta = 0$ b. $\theta = \infty$ c. $\theta < 90°$ d. $\theta > 90°$

61. The area under the force displacement curve represents:
a. work done by the force b. acceleration produced by the force
c. impulse of the force d. motion produced by the force

62. The dimensions of work are:
a. MLT b. MLT^{-1} c. ML^2T^{-1} d. ML^2T^{-2}

63. Work done against the force of friction is the example of:
a. positive work b. negative work c. maximum work d. zero work

64. The force which can do no work on the body on which it acts is:
a. frictional force b. elastic force c. gravitational force d. centripetal force

65. The space (or region) around the Earth within which a body can experience a force of attraction due to earth is called:
a. electric field b. magnetic field
c. electromagnetic field d. gravitational field

66. The work done by the gravitational force is negative if the displacement of the object and the gravitational force are:
a. in same direction b. in opposite direction
c. perpendicular d. making an angle of 60°

67. A field in which the work done in moving a body along a closed path is zero is called:
a. electromagnetic field b. nuclear field
c. conservative field d. resistive field

68. The field in which the work done is independent of the path followed is called:
a. nuclear field b. conservative field
c. resistive field d. gravitational field

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69. Which of the following is not a conservative force?
a. elastic force b. elastic spring force
c. frictional force d. gravitational force

70. The rate at which work is done is called:
a. energy b. work c. power d. momentum

71. Which of the following defines the power?
a. $p = \vec{F} \cdot \vec{v}$ b. $p = \vec{F} \cdot \vec{d}$ c. $p = \vec{W} \cdot \vec{d}$ d. $p = \vec{F} \times \vec{v}$

72. The kinetic energy of a body depends upon:
a. its mass b. its velocity c. both a & b d. none of these

73. Kinetic energy is:
a. vector quantity b. scalar quantity c. variable quantity d. none of these

74. Which of the following gives rise to tides in the sea?
a. gravitational force of Earth b. gravitational force of Moon
c. gravitational force of Jupiter d. gravitational force of Sea

75. The escape velocity at the surface of earth is given by:
a. $V_{esc} = \sqrt{gR}$ b. $V_{esc} = \sqrt{2g/R}$ c. $V_{esc} = \sqrt{Rg/2}$ d. $V_{esc} = \sqrt{2gR}$

76. Which of the following is not a biomass?
a. crop residue b. animal dung c. coal d. sewage

77. While passing through the atmosphere, the total solar energy is reduced due to:
a. reflection b. absorption c. scattering d. all of above

78. Watt is the unit of power; kilowatt-hour is the unit of:
a. force b. power c. momentum d. energy

79. The kinetic energy of a body becomes four times its initial value. The new linear momentum will be:
a. thrice the initial value b. four times the initial value
c. same as the initial value d. twice the initial value

80. Two bodies of masses m and 5m are dropped from the top of a tower. When they reach the ground, their kinetic energy will be in the ratio:
a. 1 : 2 b. 2 : 1 c. 1 : 5 d. 5 : 1

81. Energy required to accelerate a car from 10m/s to 20m/s compared with, that required to accelerate is from 0 to 10m/s is:
a. twice b. three times c. four times d. same

82. The work is done at the rate of 1000 joules per second, then the power of machine is:
a. One-watt b. One kilo-watt c. Half watt d. One megawatt

83. An electric motor creates a tension of 35 N in a hoisting cable and reels it in at the rate of 2 m/s, the power of the motor is:
a. 15 kW b. 70-watt c. 225 W d. 9000 H.P.

84. The Kinetic energy of a 200gm bullet moving at a speed of 100 m/s is:
a. 2500 J b. 1000 J c. 1250 J d. 250 J

85. Electron volt is the unit of:
a. Power b. Energy c. Voltage d. Momentum

86. Two bodies of masses m and 4m are dropped from the top of a tower. When they reach the ground, their Kinetic Energy will be in the ratio:
a. 1 : 2 b. 2 : 1 c. 4 : 1 d. 1 : 4

87. A 500g body has a velocity $v = 3\hat{\imath} + 4\hat{\jmath}$ m/s at a certain instant. Its kinetic energy is:
a. 6.25 J b. 62.5 J c. 6.25×10^3 J d. 62.5×10^3 J

88. A body of mass 10kg at rest is acted upon simultaneously by two forces 4 N and 3 N at right angles to each other. The kinetic energy of the body at the end of 10 sec is:
a. 300 J b. 50 J c. 20 J d. 125 J

89. A bullet is shot from a rifle. As a result, the rifle recoils. The kinetic energy of rifle as compared to that of bullet is:
a. Less b. Greater c. Equal d. Cannot be concluded

90. A man pushes a wall but fails to displace it. He does:
a. Negative work b. Maximum positive work
c. Positive work but not maximum d. No work

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ANSWER KEY

1.	A	31.	C	61.	A
2.	C	32.	B	62.	D
3.	D	33.	D	63.	B
4.	B	34.	A	64.	D
5.	D	35.	A	65.	D
6.	B	36.	D	66.	B
7.	D	37.	C	67.	C
8.	A	38.	A	68.	B
9.	A	39.	C	69.	C
10.	D	40	B	70	C
11.	B	41.	A	71.	A
12.	B	42.	C	72.	C
13.	D	43.	C	73.	B
14.	C	44.	C	74.	B
15.	A	45.	D	75.	D
16.	D	46.	B	76.	C
17.	C	47.	A	77.	D
18.	B	48.	D	78.	D
19.	A	49.	A	79.	D
20.	A	50.	A	80.	C
21.	B	51.	A	81.	B
22.	D	52.	D	82.	B
23.	B	53.	B	83.	B
24.	C	54.	D	84.	B
25.	D	55.	A	85.	B
26.	C	56.	A	86.	D
27.	B	57.	B	87.	A
28.	C	58.	D	88.	D
29.	B	59.	B	89.	A
30.	B	60.	D	90.	D

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CHAPTER 5
CIRCULAR MOTION

Angular Motion:

When a body moves in circular path (curved path) then its motion is called angular motion of circular motion.

In circular motion the direction of motion of body continuously change.

Example:

1) Moon revolves around the earth
2) Motion of wheels
3) Electron revolves around the nucleus.

Angular Displacement:

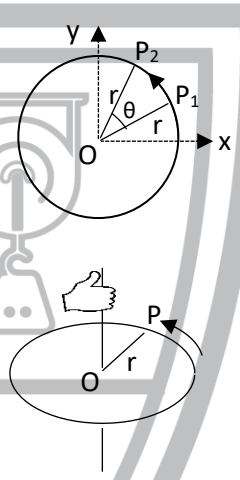
It is defined as "the displacement covered by a body moving in a circle is called angular displacement".

OR

It is defined as "the angle subtended at the center of the circle by an arc along which it moves".

Explanation:

Let a particle p moves along the circular path then we denote P_1 and P_2 as initial and final positions of this particle. The angle θ between the lines OP_1 and OP_2 is called angular displacement.



Angular displacement is a vector quantity and its direction is along axis of rotation, which determined by right hand rule, i.e.,

Curling of right-hand fingers along the direction of circular motion of particle, then thumb points in the direction of angular displacement.

Hence the plane of circle in xy-plane and axis of rotation is along z-axis, as shown in figure below.

Units of Angular Displacement:

The SI unit of angular displacement is radian but it is also measured in "degree" and "revolution".

Radian:

The angular displacement is one radian when length of arc is equal to radius of that circle. i.e., s = r.

Note:

The relation (s = rθ) is valid only when θ is measured in radian.

1 radian = 57.3°

It is the relation between radian and degree.

Angular Velocity:

The rate of change of angular displacement is called angular velocity. It is a vector quantity and its direction is along axis of rotation, which can be determined by right hand rule.

Mathematically it can be written as,

$$\vec{\omega} = \frac{\overrightarrow{\Delta\theta}}{\Delta t}$$

Unit:

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The SI unit of angular velocity is radian per second or $rads^{-1}$. Sometimes it is also given in terms of revolution per minute.

Note:

When the average angular velocity and instantaneous angular velocity are equal to each other then the body will move with uniform angular velocity.

Angular Acceleration:

Time rate of change of angular velocity is called angular acceleration. It is denoted as α.

Mathematically it can be written as,

$$\vec{\alpha} = \frac{\overrightarrow{\Delta\omega}}{\Delta t}$$

It is a vector quantity. Its direction is along axis of rotation, given by right hand rule.

Unit:

The SI unit of angular acceleration is radian/sec^2 or rad s^{-2}.

Note:

(1) When the instantaneous angular acceleration and average angular acceleration will become equal to each other, the body will move with uniform angular acceleration.

(2) If $\vec{\omega}$ is increasing then $\vec{\alpha}$ is in the direction of $\vec{\omega}$ and if $\vec{\omega}$ is decreasing then $\vec{\alpha}$ is opposite to the direction of $\vec{\omega}$.

Relation between Linear and Angular Velocity:

$v = r\omega$

Note:

In the expression $(v = r\omega)$ the angular speed ω must be expressed in radian measure.

Since all points within the rigid body have the same angular speed "ω", points with greater radius r have greater linear speed v.

The linear velocity is always tangent to the circular path as shown in figure, (above)

In vectorial form we can write,

$$\vec{v} = \vec{\omega} \times \vec{r}$$

Relation between Angular and Linear Acceleration:

$a = r\alpha$

Equations of Angular Momentum:

As we know equations of linear motion, i.e.,

$$v_f = v_i + at$$
$$s = v_i t + \frac{1}{2}at^2$$
$$2as = {v_f}^2 - {v_i}^2$$

Similarly, equation of angular motion are

$$\omega_f = \omega_i + \alpha t$$
$$\theta = \omega_i t + \frac{1}{2}\alpha t^2$$
$$2\alpha\theta = {\omega_f}^2 - {\omega_i}^2$$

Note:

The angular equations of motion hold true only in the case when the axis of rotation is fixed, so that all the angular vectors have the same direction hence they can be manipulated as scalars.

Centripetal Force:

"The force required to keep the body moving in the circular path and directed towards the center of the circular path is called Centripetal Force". It is denoted by $\overrightarrow{F_c}$.

Examples:

(i) A ball is whirling in a horizontal circle at the end of a string. The tension in the string provides the centripetal force.

(ii) Wheels spinning on the shafts is due to centripetal force.

Centripetal Acceleration:

The acceleration towards the center of circular path covered by an object is called centripetal acceleration. It is denoted by $\overrightarrow{\alpha_c}$.

Formula for Centripetal Force:

$$F_c = \frac{mv^2}{r}$$

The alternative form of centripetal force is

$$F_c = mr\omega^2 \qquad \because (v = r\omega)$$

The centripetal acceleration is denoted as a_c.

i.e., $$a_c = \frac{v^2}{r}$$

Note:

The direction of $\overrightarrow{a_c}$ is along the direction of $\overrightarrow{\Delta v}$. Hence $\overrightarrow{a_c}$ is also directed towards the center of circle.

Moment of Inertia:

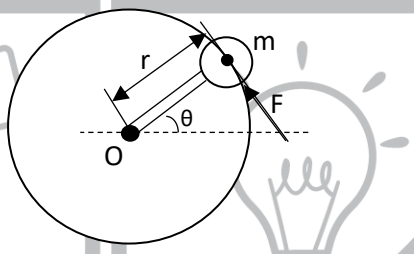
The inertia due to rotation is called rotational inertia or moment of inertia. It is defined as, "the product of the mass of the body and square of the distance from the axis of rotation."

Mathematically we can write,

(Moment of Inertia) $I = mr^2$

Moment of inertia is scalar quantity and its SI units are kgm^2.

Explanation:



Consider a point mass m is rotated in a horizontal circle. This mass is supposed to be attached to one end of the rod of a negligible mass, whose other end is attached to a bearing at the pivot point O.

A force F is applied which produces torque and the mass m starts rotating. This force is acting on the mass perpendicular to the rod, or tangent to the circle as shown in figure.

This force will accelerate the mass according to F = ma.

Here $a = a_T$ (tangential acceleration)

$= r\alpha$

Therefore we get

$F = m(r\alpha)$

Multiplying both sides of the above equation by r, we have,

$rF = mr^2\alpha$

or $\boxed{\tau(\text{torque}) = I\alpha}$ $\qquad \because (I = mr^2)$

Here I is called moment of inertia of rotating body.

By comparing above equation with [F=ma] we see, "the moment of inertia plays the same role in angular motion as the mass in linear motion".

Dimensions:

The dimension of moment of inertia is $[ML^2]$.

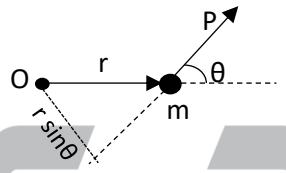
Angular Momentum:

The momentum of a body is due to its circular motion is called angular momentum. It is defined as, the cross product of position vector $\vec{r}$ of the particle and linear momentum $\vec{P}$.

Mathematically we can write,

Angular momentum $\vec{L} = \vec{r} \times \vec{P}$

Angular momentum is vector quantity and its direction is along axis of rotation given by right hand rule.



Units:

According to SI system the units of angular momentum are kgm^2s^{-1} or Js.

$\because \quad (kgm^2s^{-1} = (kgms^{-2})ms = Nms = Js)$

Or $\boxed{L = I\omega}$

Law of Conservation of Angular Momentum:

"It states that total angular momentum of a system remains constant if no external torque acts upon the system".

If we denote I_1 and I_2 as moment of inertia of a body before and after change of mass distribution and ω_1 and ω_2 are their corresponding angular velocities then according to law of conservation of angular momentum we can write,

$$I_1\omega_1 = I_2\omega_2$$

Note:

The axis of rotation of an object will not change its orientation unless an external torque causes it to do so.

Rotational Kinetic Energy:

"The energy of a body due to its spinning motion is called rotational kinetic energy."

$$K.E_{rot} = \frac{1}{2}I\omega^2$$

Rotational Kinetic Energy of a Disc and a Hoop:

For Disc:

The rotational kinetic energy is given as

$$K.E_{rot} = \frac{1}{2}I\omega^2$$

The moment of inertia of a disc is

$$I = \frac{1}{2}mr^2$$

Therefore $K.E_{rot}$ of a disc is given by

$$K.E_{rot} = \frac{1}{2}\left(\frac{1}{2}mr^2\right)\omega^2$$

$$K.E_{rot} = \frac{1}{4}mr^2\omega^2$$

Since $r^2\omega^2 = v^2$

Therefore

$$\boxed{K.E_{rot} = \frac{1}{4}mv^2}$$

is the expression of rotational kinetic energy of a disc.

For Hoop:

For hoop the moment of inertia is

$$I = mr^2$$

Therefore $K.E_{rot}$ for a hoop is given as

$$K.E_{rot} = \frac{1}{2}(mr^2)\omega^2$$
$$K.E_{rot} = \frac{1}{2}m(r^2\omega^2)$$
$$K.E_{rot} = \frac{1}{2}mv^2$$

Is the rotational K.E of a hoop.

Velocity of a Disc and Hoop on Reaching Lower End of Inclined Plane:

When both (disc and hoop) start moving down and inclined plane of height 'h' their motion consist of both rotational and translational motions.

If no energy is lost against friction, the total K.E of the disc or hoop on reaching the bottom of the incline must be equal to its potential energy at the top.

$$P.E = K.E_{translational} + K.E_{rotational}$$

For Disc:

$$mgh = \frac{1}{2}mv^2 + \frac{1}{4}mv^2$$
$$mgh = mv^2 \times \left(\frac{1}{2} + \frac{1}{4}\right)$$
$$v^2 = \frac{4gh}{3}$$
$$\boxed{v = \sqrt{\frac{4gh}{3}}}$$

It is formula for the velocity of disc on reaching the lower end of inclined plane.

For Hoop:

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$$
$$mgh = mv^2$$
$$\boxed{v = \sqrt{gh}}$$

It is formula for the velocity of hoop on reaching the lower end of inclined plane.

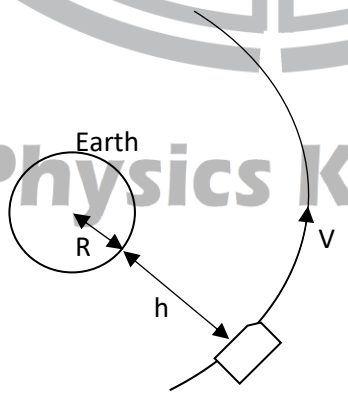
Note:

Moment of inertia of solid sphere $= \frac{2}{5}mr^2$

And; Moment of inertia of hollow sphere $= \frac{2}{3}mr^2$

Artificial Satellites:

Satellites are objects that revolve round the earth in circular orbits. They are put into orbit by rockets and are held in orbits by the gravitational pull of earth. The acceleration for satellites with small height from surface of earth is, ($g = 9.8\ ms^{-2}$) and this acceleration is directed towards center of earth. This is equal to centripetal acceleration whose formula is



$$a_c = \frac{v^2}{R}$$

If $a_c = g$, then we get

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$$g = \frac{v^2}{R}$$

$$v = \sqrt{gR}$$

Here $R = 6.4\times10^6$ m

And $g = 9.8$ m.s^{-2}

Therefore, we have

$$v = \sqrt{(9.8 ms^{-2})(6.4 \times 10^6 m)}$$

$$v = 7.9\ kms^{-1}$$

This is minimum velocity to put a satellite into the orbit and called "critical velocity of satellite".

The time period 'T' (time required to complete one revolution) is given by

$$T = \frac{2\pi R}{v}$$

Putting values, we get,

$$T = \frac{2\times3.14\times6.4\times10^6 m}{7.9\times10^3 m/s}$$

T = 50605 sec ≅ 84 min.

Hence a satellite orbiting near the earth would have a velocity of 7.9 Km/s and it take 84 minutes to orbit the earth.

Note:

(i) The gravitational acceleration decreases inversely as the square of the distance from the center of the earth.

(ii) The higher the satellite the slower will they require speed and longer time required to complete one revolution around the earth.

(iii) The close orbiting satellites are about 400 km height from surface of earth. A set of twenty-four such satellite forms the global positioning system.

Real and Apparent Weight:

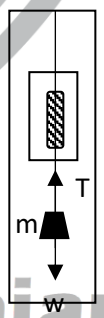
The gravitational pull of earth acting on a body is called weight. It is real when body lies on surface of earth.

The weight appears to be changed when the body lies in a lift, moving up or down with certain acceleration. It is called its apparent weight.

Usually weight is directly measured by using a spring balance.

Conditions of Weightlessness in a Lift:

Consider a body of mass m suspended by a spring balance which is attached to the ceiling of the lift or elevator as shown in the figure.



The spring balance indicates the tension in the string which is equal to the weight of the body represented by "T".

Case 1:

When the lift is at rest or moving with uniform velocity, the resultant acting on the body suspended with spring balance is given by,

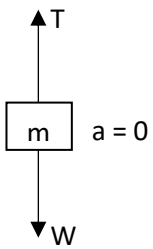
$$F = T - w$$

$$ma = T - w$$

As $a = 0$ so

$$0 = T - w$$

$$\boxed{T = w}$$



In this case value of T gives the real weight of body.

Case 2:

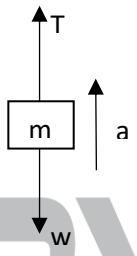
When lift moves up with an acceleration 'a' then resultant force acting on the body suspended with spring balance is given by,

$F = T - w$

$ma = T - w$

$ma + mg = T$

$\boxed{T = m(a+g)}$



In this case the value of T gives the apparent weight, which is greater than real weight.

Case 3:

When lift moves down with an acceleration 'a', then w > T so we write the resultant force as,

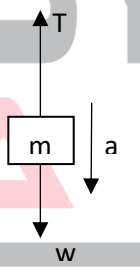
$F = w - T$

$ma = w - T$

$T = w - ma$

$T = mg - ma$

$\boxed{T = m(g - a)}$



In this case the value of T gives apparent weight, which is less than real weight.

Case 4:

When the lift is falling freely, i.e., when the supporting rope of the lift or elevator breaks then lift is falling freely under the action of gravity, then (a = g), therefore

$F = w - T$

Or $mg = w - T$

Or $T = w - mg$

Or $T = mg - mg$

$\boxed{T = 0}$

In this case the apparent weight of the object is zero.

From above observations it is clear that apparent weight of the object is not necessarily equal to its true weight in an accelerating system.

Orbital Velocity:

$$v = \sqrt{\frac{GM}{r}}$$

It is the formula for orbital velocity of satellite.

The minimum distance of a satellite from earth is 400 km therefore radius of earth is

$r = R + h = 6400 + 400 = 6800$ km

$r = 6.8\times10^{6}$ m

and $G = 6.67\times10^{-11}$ Nm^2/kg^2 and mass of earth $M = 6\times10^{24}$ kg therefore orbital velocity of satellite is given as,

$$v = \sqrt{\frac{(6.67\times10^{-11}\,Nm^2kg^{-2})(6\times10^{24}\,kg)}{6.8\times10^{6}\,m}}$$

$$\boxed{v = 7.67\times10^{3}\,m/s}$$

It is value of orbital velocity of satellite.

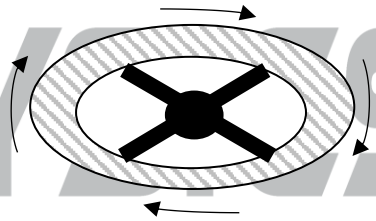
Its value depends on r (distance of satellite from center of earth).

Any speed less than this will bring the satellite tumbling back to earth.

Artificial Gravity:

When a satellite is revolving around the earth, the astronauts with respect to their satellites are in the state of weightlessness. The weightlessness creates a lot of problems for astronauts and may affect the performance of the astronauts, present in that space craft. To overcome this difficulty, an artificial gravity is created in the satellite.

This is done by the help of spin motion of satellite (rotating around its own axis). The astronauts then are pressed towards the outer rim and exerts a force on the floor of the spaceship in much the same way as on the earth.



To get artificial gravity equal to gravity on surface of earth we have to adjust the frequency of spin motion of satellite.

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$$

this is the formula to calculate spin frequency of a satellite due to which artificial gravity becomes equal to gravity on surface of earth.

Geostationary Orbits:

Geostationary orbit is such an orbit in which as artificial satellite remains at rest with respect to earth, such type of satellite is called geostationary satellite.

Since this type of motion is synchronized with the rotation of the earth, so the satellite may be called Geo-synchronous satellite. In this way the synchronous satellite remains always over the same point on the equator as the earth spins on its axis.

Geostationary satellites are very useful for worldwide communications, navigations, and other military uses.

$$r = \left(\frac{GMt^2}{4\pi^2}\right)^{1/3}$$

is the formula for the radius of geostationary orbit.

Putting values of G, M and t we get

$r = 4.23\times10^4$ Km

Note:

The height of satellite in its geostationary orbit from equator is about 36000 km.

A satellite at this height will always stay directly above a particular point on the surface of the earth.

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PRACTICE SHEET

1. When a body is whirled in a vertical circle at the end of the string tension in the string is maximum:
   a. at the top
   b. at the bottom
   c. at the horizontal
   d. at every position

2. Angular acceleration is produced by:
   a. power
   b. pressure
   c. torque
   d. force

3. When a body moves along a circular path, its velocity:
   a. remains the same
   b. becomes zero
   c. changes continuously
   d. sometimes changes

4. An orbiting satellite around the earth receives centripetal force from:
   a. The gravitational pull of the moon on the satellite.
   b. Gravitational pull of the sun on the satellite.
   c. The rocket engine attached to the satellite.
   d. The gravitational pull of the earth on satellite.

5. The necessary centripetal force to the moving car around a corner track is provided by:
   a. the coulomb's force
   b. gravitational force
   c. the force of friction
   d. centrifugal force

6. Angular momentum of a body under a central force is:
   a. zero
   b. maximum
   c. minimum
   d. constant

7. The rate of change of angular momentum of a body is:
   a. the applied force
   b. the moment of inertia
   c. the applied torque
   d. impulsive force

8. The moment of linear momentum is called:
   a. impulse
   b. torque
   c. angular momentum
   d. couple

9. As we go below the surface of the earth, the value of g:
   a. increase
   b. decreases
   c. remains constant
   d. reduces to zero

10. A man in an elevator descending with an acceleration will conclude that his weight has:
    a. increased
    b. decreased
    c. remained constant
    d. reduce to zero

11. Einstein's theory states that bodies and light rays move along:
    a. geodesics
    b. force of gravity
    c. both a & b
    d. circular path

12. A body moving in circular motion with constant speed has:
    a. constant velocity
    b. none
    c. constant kinetic energy
    d. constant displacement

13. Angular momentum is:
    a. vector (axial)
    b. vector (polar)
    c. scalar
    d. none of these

14. What remains constant in the field of central force:
    a. potential energy
    b. kinetic energy
    c. angular momentum
    d. linear momentum

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15. What remains constant when the earth revolves around the sun:
a. angular momentum b. linear momentum
c. angular kinetic energy d. linear kinetic energy

16. A person standing on a rotating platform has hands lowered. He suddenly outstretches his arms. The angular momentum:
a. becomes zero b. increases c. decreases d. remains same

17. A body of mass m is moving in a circle of radius r with a constant speed v. The work done by the centripetal force in moving the body over the half the circumference of the circle is:
a. $\frac{mv^2}{r} \times 2r$ b. $\frac{mv^2}{r} \times \pi r$ c. $\frac{mv^2}{r} \times r$ d. zero

18. A car of mass 1000 kg moves on a circular road with a speed of 20 m/s. Its direction changes by 90° after travelling 628 m on the road. The centripetal force acting on the car is:
a. 500 N b. 750 N c. 1000 N d. 1500 N

19. The moments of inertia of two spheres of equal masses about their respective diameters are same. One of them is solid and the other is hollow. The ratio of the diameter of the solid sphere to that of the hollow sphere is:
a. $\sqrt{3} : \sqrt{5}$ b. $\sqrt{5} : \sqrt{3}$ c. 5 : 3 d. 3 : 5

20. Two bodies with moments of inertia I_1 and I_2 ($I_1 > I_2$) have equal angular momenta. If E_1 and E_2 are their rotational kinetic energies respectively, then:
a. $E_1 > E_2$ b. $E_1 = E_2$
c. $E_1 < E_2$ d. the one which has larger mass has larger K.E

21. If the radius of the earth suddenly contracts to $\frac{1}{n}$ of its present value without any change in its mass, the duration of one day will become approximately:
a. $\frac{24}{n}$ hours b. $\frac{24}{n^2}$ hours c. 24n hours d. $24n^2$ hours

22. The moment of inertia of a solid cylinder about its axis is I. It is allowed to roll on a surface without slipping. If its angular velocity is ω, then its K.E is:
a. $\frac{3}{2} I\omega^2$ b. $I\omega^2$ c. $\frac{1}{2} I\omega^2$ d. $2 I\omega^2$

23. If R is the radius of the earth and g is the acceleration due to gravity on the surface of the earth, the mean density of the earth is:
a. $\frac{3\pi R}{4gG}$ b. $\frac{4\pi G}{3gR}$ c. $\frac{4RG}{3\pi g}$ d. $\frac{3g}{4\pi RG}$

24. If 'g' is the acceleration due to gravity at the surface of the earth, then the energy required to launch a satellite of mass m from the surface of the earth into circular orbit at an altitude of 2R, R being the radius of the earth, is:
a. $\frac{mgR}{6}$ b. $\frac{mgR}{3}$ c. $\frac{2mgR}{3}$ d. $\frac{5mgR}{6}$

25. A point on the rim of wheel moves 0.2m when the wheel turns through an angle of 0.25 rad. The radius of wheel:
a. 0.65m b. 0.125m c. 0.8m d. 0.35m

26. The angular speed of the minute hand of the clock in degrees per second is:

a. 1.0 b. 0.1 c. 0.001 d. none of these

27. The angular speed for daily rotation of earth in rad/s is:
a. 2π b. π c. 7.3×10^{2} rad/s d. 7.3×10^{-5} rad/s

28. A man of mass 100kg is standing in an elevator. The net force on man when elevator is going up with acceleration of $4m/s^2$ would be:
a. 908N b. 490N c. 100N d. 1380N

29. What will be the duration of the day and night (in hour) if the diameter of the earth is suddenly reduced to half its original value, the mass remaining constant:
a. 12 b. 6 c. 3 d. 2

30. What will be the duration of the day and night (in hour) if the diameter of the earth is suddenly reduced to One third of its original value, the mass remaining constant:
a. 12 b. 2.67 c. 3.77 d. 2

31. The dimensions of impulse are same as those of:
a. momentum b. velocity c. force/time d. none of above

32. Joule-second is a unit of:
a. energy b. momentum c. power d. angular momentum

33. Newton-second is a unit of:
a. force b. impulse c. moment of inertia d. energy

34. The SI unit of angular momentum is:
a. kg m^2s^{-1} b. kg m^2s^{-2} c. kg ms^{-2} d. kg ms^{-1}

35. The dimensions of the ratio of angular to linear momentum is:
a. $M^0L^1T^0$ b. $M^1L^1T^1$ c. $M^1L^2T^{-1}$ d. $M^{-1}L^{-1}T^{-1}$

36. Select the only correct statement from the following:
a. The orbital velocity of a satellite increases with the radius of the orbit.
b. Escape velocity of a particle from the surface of the earth depends on the speed with which it is fired.
c. The time period of a satellite does not depend on the radius of the orbit.
d. The orbital velocity is inversely proportional to the square root of the radius of the orbit.

37. A particle revolves round a circular path with a constant speed. The acceleration of the particle is:
a. along the circumference of the circle b. along the tangent
c. along the radius d. zero

38. If a body moves with a constant speed in a circle:
a. no work is done on it b. no force acts on it
c. no acceleration is produced in it d. its velocity remains constant

39. For a particle moving in uniform circular motion:
a. velocity is transverse and acceleration is radial
b. velocity is radial and acceleration is transverse

c. both velocity and acceleration are radial
d. both velocity and acceleration are transverse

40. A wheel rotates about an axis passing through the center and perpendicular to the plane with slowly increasing angular speed. Thus, it has:
a. radial velocity and radial acceleration
b. tangential velocity and radial acceleration
c. tangential velocity and tangential acceleration
d. tangential velocity but acceleration having both components (Radial as well as Transverse)

41. A body is moving in a circle with a constant speed. It has:
a. A constant velocity
b. A constant acceleration
c. A velocity of constant magnitude and a variable acceleration
d. Both velocity and acceleration of constant magnitude

42. The work done by the centripetal force F when a body completes one revolution around a circle of radius R is:
a. 2πRF b. 2RF c. RF d. zero

43. A stone of mass 16 kg is attached to a string 144 m long and is whirled in a horizontal circle. The maximum tension the string can stand is 16 N. The maximum velocity of revolution that can be given to the stone without breaking the string is:
a. 20 m/s b. 16 m/s c. 14 m/s d. 12 m/s

44. A particle of mass m is executing uniform circular motion on a path of radius r. If P is the magnitude of its linear momentum, then the radial force acting on the particle is:
a. Pmr b. $\frac{rm}{P}$ c. $\frac{mP^2}{r}$ d. $\frac{P^2}{rm}$

45. A hollow sphere and a solid sphere, having the same mass, are released from rest simultaneously from the top of an inclined plane. Which of the two will reach the bottom first?
a. Solid sphere b. Hollow sphere
c. The one which has the greater density d. Both will reach the bottom simultaneously

46. Angular momentum of a body is defined as the product of:
a. mass and angular velocity b. centripetal force and radius
c. linear velocity and angular velocity d. moment of inertia and angular velocity

47. A ring, a disc and a solid sphere, all having the same mass and radius, roll down an inclined plane from the same height. Which of the three will reach the bottom first?
a. Ring b. Disc
c. Solid sphere d. All of them will reach simultaneously

48. If the distance between two masses is doubled, the gravitational attraction between them:
a. is doubled b. becomes four times
c. is reduced to half d. is reduced to a quarter

49. A car moving on a horizontal road may be thrown out of the road in taking a turn:
a. By the gravitational force
b. Due to the lack of proper centripetal force

c. Due to the rolling frictional force between the tyre and the road
d. by the reaction of the ground

50. The intensity of the earth's gravitational field is maximum at:
a. the center of the earth
b. the equator
c. the poles
d. none of the above

51. Which of the following statements about the motion of an earth-satellite is/are correct?
a. The satellite is always accelerating towards the earth.
b. There is no force acting on the satellite
c. The acceleration and the velocity of the satellite are in the same direction
d. The satellite must fall back to earth when its fuel is consumed

52. The relay satellite transmits the T.V. programme continuously from one part of the world to another because its:
a. Period is greater than the period of rotation of the earth about its axis.
b. Period is less than the period of rotation of the earth about its axis
c. Period is equal to the period of rotation of the earth about its axis
d. Mass is less than the mass of the earth

53. An artificial satellite orbiting around the earth does not fall down because the attraction of the earth:
a. vanishes at such distances
b. is balanced by the attraction of the moon
c. is balanced by the centrifugal force
d. provides the necessary acceleration for its motion in a curved path

54. A satellite is revolving around the earth in a circular orbit with a uniform speed v. If the gravitational force suddenly disappears, the satellite will:
a. Continue to move in the same orbit with speed v.
b. Move tangentially to the orbit with speed v.
c. Move away from the earth normally to the orbit.
d. Fall down on the earth

55. A body is moving in a circle of radius 'r' with constant angular speed "ω". Its centripetal acceleration is:
a. $\frac{\omega}{r}$
b. ωr
c. $\omega^2 r$
d. $\frac{\omega^2}{r}$

56. Two isosceles triangles are similar if:
a. The angles between their unequal arms are equal
b. The angles between their equal arms are equal
c. The angles between their unequal arms are unequal
d. All of the above

57. When a body moves along a circular path, its velocity:
a. remains constant
b. becomes zero
c. changes continuously
d. always increases

58. Correct relationship between torque and moment of inertia is:
a. $\tau = I\theta$
b. $\tau = Ia$
c. $\tau = I\omega$
d. $\tau = I\alpha$

59. The diver spin faster when moment of inertia becomes:
a. greater
b. smaller
c. remains constant
d. zero

60. Rotational K.E for a hoop can be represented by formula:
a. $K.E_{rot} = ¼ mv^2$ b. $K.E_{rot} = ½ mv^2$ c. $K.E_{rot} = ¼ m^2v$ d. $K.E_{rot} = ½ m^2v$

61. The magnitude of the centripetal force on a mass 'm' moving with angular speed 'ω' in a circle of radius 'r' is:
a. $mr^2\omega$ b. $\frac{m\omega^2}{r}$ c. $mr\omega^2$ d. $mr^2\omega^2$

62. The angle subtended at the centre by a body moving along a circle is called:
a. angular speed b. angular velocity
c. angular displacement d. angular acceleration

63. The rotational analogue of the Newton's second law of motion (F=ma) is:
a. torque = $mr^2\alpha$ b. angular momentum = Iw
c. centripetal force = $\frac{mv^2}{r}$ d. moment of inertia = mr^2

64. A disc, starting from rest, rolls down a hill of height h, its speed at the bottom is given by:
a. $v = \sqrt{gh}$ b. $v = \sqrt{4gh}$ c. $v = \sqrt{\frac{gh}{3}}$ d. $v = \sqrt{\frac{4gh}{3}}$

65. The angular momentum of a rigid body in terms of moment of inertia I and angular velocity ω is:
a. $L = I\omega$ b. $L = I\omega^2$ c. $L = I^2\omega^2$ d. $L = ½ I\omega^2$

66. The artificial satellites are held in orbit by the:
a. gravitational pull of the sun b. gravitational pull of the moon
c. gravitational pull of the earth d. none of these

67. The apparent weight of a body of mass m suspended by a spring balance that is attached to a ceiling of a lift moving downward with an acceleration 'a' is given by:
a. T = W b. T = W – ma c. T = W + ma d. T = ma

68. A body falling freely is in the state of:
a. increasing weight b. decreasing weight
c. weightlessness d. maximum weight

69. The artificial gravity is created in the satellite to:
a. increase the orbital speed of the satellite
b. keep the satellite in its orbit
c. keep the orbital radius of the satellite constant
d. overcome the weightlessness experienced by the astronauts

70. The orbital speed of a satellite orbiting at distance r from the center of earth is given by:
a. $v = \sqrt{\frac{GM}{r}}$ b. $v = \frac{GM}{r}$ c. $v = G\sqrt{\frac{M}{r}}$ d. $v = \frac{\sqrt{GM}}{r}$

71. The Einstein's theory predicted the bending of light due to gravity as compared to that due to Newton's theory, as:
a. the same b. twice c. thrice d. half

72. The value of 'g' at the centre of the earth is:

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a. double b. zero c. infinite d. same

73. A particle starts from rest with acceleration 2 $rads^{-2}$ in a circle of radius 2m. Find its linear speed after 6 s.
a. 12m/s b. 24 m/s c. 4 m/s d. none of these

74. A particle moves in a circular path of radius r. In half the period of revolution its displacement and distance covered are:
a. 2r, πr b. r, πr c. 2r, 2πr d. $r\sqrt{2}$, πr

75. The angular acceleration of a article moving along a circular path with uniform speed is:
a. zero b. variable
c. uniform but non-zero d. incomplete information

76. Radian is defined as the angle subtended at the centre of a circle by:
a. an arc length equal to its radius b. an arc of length equal to double its radius
c. an arc of length equal to 2.5 times its radius d. an arc of length equal to thrice its radius

77. When a body moves in a circle, the angle between its linear velocity 'v' and the angular velocity 'ω' is always:
a. 180° b. 0° c. 90° d. 45°

78. The dimensions of angular acceleration are:
a. T^{-1} b. T^{-2} c. T^{-3} d. $L\,T^{-2}$

79. When an object moves with uniform speed in a circular orbit, its centripetal acceleration must be directed:
a. along the direction of motion b. towards the centre along the radius
c. perpendicular to the centre of circle d. away from the centre along the radius

80. When a body is whirled in a horizontal circle by means of a string, the centripetal force is supplied by:
a. mass of a body b. velocity of body
c. tension in the string d. centripetal acceleration

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ANSWER KEY

1.	B	31.	A	61.	C
2.	C	32.	D	62.	C
3.	C	33.	B	63.	A
4.	D	34.	A	64.	D
5.	C	35.	A	65.	A
6.	D	36.	D	66.	C
7.	C	37.	C	67.	B
8.	C	38.	A	68.	C
9.	B	39.	A	69.	D
10.	B	40	D	70	A
11.	A	41.	D	71.	B
12.	C	42.	D	72.	B
13.	A	43.	D	73.	B
14.	C	44.	D	74.	A
15.	A	45.	A	75.	A
16.	D	46.	D	76.	A
17.	D	47.	C	77.	C
18.	C	48.	D	78.	B
19.	B	49.	B	79.	B
20.	C	50.	C	80.	C
21.	B	51.	A		
22.	C	52.	C		
23.	D	53.	D		
24.	D	54.	B		
25.	C	55.	C		
26.	B	56.	B		
27.	D	57.	C		
28.	D	58.	D		
29.	B	59.	B		
30.	B	60.	B		

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CHAPTER 6
FLUID DYNAMICS

VISCOUS DRAG AND STROKES LAW

- Viscosity is the measure of the force required to slide one layer of a liquid over another.
- SI unit of coefficient of viscosity is $kgm^{-1}s^{-1}$and dimension $ML^{-1}T^{-1}$.
- Substance that flows easily like water etc has lesser coefficient of viscosity.
- The force experienced by an object while moving in a viscous medium is called drag force.
- The drag force in a medium depends on the profile of the object and velocity of the same object and nature of medium.

Mathematically Drag force can be related with above stated factors using Strokes' Law

$$F_D = 6\pi\eta r v$$

The strokes' law holds well at low speeds only for spherical bodies.

DO YOU KNOW?
When an object is moving in a fluid at considerably higher speed than the force of drag is no more proportional to speed.

TERMINAL VELOCITY

When a spherical object falling gains constant speed medium than a net force acting on it is zero and the corresponding speed is called Terminal Velocity represented as V_1.

$$V_1 = 2gr^2\rho / 9\eta \Rightarrow V_1 \propto r^2$$

Where η is the coefficient of viscosity of fluid.

FLUID FLOW

- In a fluid if every particle that passes a particular point, moves along exactly the same path as followed by particles which passed that point earlier than flow is called STREAMLINE or LAMINAR.

- Irregular or unsteady flow of the fluid is called TURBULENT FLOW.
- **Characteristic of ideal fluid**
  - i It is non viscous
  - ii It is incompressible
  - iii Its motion is steady

DO YOU KNOW?
At higher velocities of fluid flow the flow is turbulent and, in this condition, the exact path of fluid particles cannot be predicted

EQUATION OF CONTINUITY

$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$ is called equation of continuity

- The law of conservation of mass gives us the equation of continuity
- For ideal fluid, it becomes; $A_1V_1 = A_2V_2 = \text{Constant}$
- The constant in equation of continuity is equal to the volume of the fluid flows per second or flow rate.

BERNOUILLI'S EQUATION

Bernoulli's equation is derived from conservation of energy

- Bernoulli's equation is $P + \frac{1}{2}\rho V^2 + \rho gh = \text{constant}$
- Fluid have three types of energy-

1) Potential Energy = mgh or potential energy per unit volume = ρgh
2) Kinetic Energy = $\frac{1}{2}$ mv^2 or kinetic energy per unit volume = $\frac{1}{2}$ ρV^2
3) Pressure Energy = PV or pressure energy per unit volume = P

APPLICATIONS:

(1) SPEED OF EFLUX

- Speed of efflux is determined by Torricelli's theorem $V = \sqrt{2g(h_1 - h_2)}$
- Speed of efflux depends upon the height through which fluid falls under the action of gravity.
- Pressure of fluid increases if the speed of fluid decreases and vice versa.
- An aero plane lifts due to the difference of pressure on its wings.
- Swing in cricket and tennis ball is also due and difference of pressure on its two sides.
- There is a danger that a person standing near a fast-moving train to fall towards it.
- Venturi meter is a device used to measure the speed of liquid flow.
- Venturi meter works according to venturi relation which is

$$P_1 - P_2 = \frac{1}{2}\rho V^2$$

- Mixing of petrol with air in carburetor is according to the Bernoulli's equation.

(2) BLOOD PRESSURE

- Instrument used to measure blood pressure is called sphygmomanometer. It measures blood pressure dynamically.
- Blood pressure is measured in the unit torr, 1 torr = 133.3 N/m^2 = 1mm of Hg
- For normal healthy person the systolic pressure is 120 and diastolic pressure is 75 to 80 torr.
- At systolic pressure the blood flow is turbulent while it switches from turbulent to laminar at si-systolic pressure.

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PRACTICE SHEET

1. High concentration of red blood cells increases the viscosity of blood from:
   a. 2 – 3 times that of water
   b. 3 – 4 times that of water
   c. 3 – 5 times that water
   d. 4 – 5 times that water

2. The working of carburetor or car uses:
   a. equation of continuity
   b. gravitational law
   c. Bernoulli's theorem
   d. Stroke's theorem

3. In the equation of continuity, ρAv =
   a. mass/time
   b. density/time
   c. volume/time
   d. density×time

4. If a raindrop with a mass of 0.05g falls with constant velocity, the retarding force of atmospheric friction is (neglect density of air):
   a. zero
   b. 49 dynes
   c. 490 N
   d. 49 N

5. A two-meter-high tank is filled with water. If a hole appears at its middle then the speed of efflux is:
   a. 5.6m/s
   b. 9.8m/s
   c. 4.42m/s
   d. zero

6. An incompressible fluid flows steadily through a cylindrical pipe which has a radius 2r at a point A and radius r at B farther along the flow direction. If the velocity at point A is v, the velocity at point B will be:
   a. 4v
   b. v
   c. 2v
   d. $\frac{v}{2}$

7. The velocity of falling raindrops attains limited value because:
   a. Up thrust of air
   b. Viscous force exerted by air
   c. Both A and B
   d. Air currents atmosphere

8. Ball pen functions on the principle of:
   a. Viscosity
   b. Boyle's law
   c. Gravitational force
   d. Surface tension

9. An atmosphere:
   a. is a unit of pressure
   b. is a unit of force
   c. gives us an idea of composition of air
   d. is the height above which there is no atmosphere

10. Two light balls are suspended. When a stream of air passes through the space between them, the distance between the balls will:
    a. increase
    b. decrease
    c. remain the same
    d. may increase or decrease depending on the speed of air

11. When a fluid passes through the constricted part of a pipe, its:
    a. velocity and pressure decrease
    b. velocity and pressure increases
    c. velocity decreases and pressure increase
    d. velocity increases and pressure decreases

12. The rate of leak from a hole in a tank is:

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a. independent of its height from the bottom
b. more if situated near the bottom
c. more if situated near its top
d. more at midway between top and bottom

13. An ideal liquid flows through a horizontal tube of variable diameter. The pressure is lowest where the:
a. velocity is highest
b. velocity is lowest
c. diameter is largest
d. all of these

14. Bernoulli's equation is applicable in the case of:
a. streamlined flow of compressible fluids
b. streamlined flow of incompressible fluids
c. turbulent flow of compressible fluids
d. turbulent flow of incompressible fluids

15. A cylinder is filled with a non-viscous liquid of density d to a height h_0 and a hole is made at a height h_1 from the bottom of the cylinder. The velocity of the liquid issuing out of the hole is:
a. $\sqrt{2gh_0}$ b. $\sqrt{dgh_0}$ c. $\sqrt{dgh_1}$ d. $\sqrt{2g(h_0 - h_1)}$

16. The velocity of flow of a liquid through an orifice at the bottom of a tank depends on the:
a. density of the liquid
b. area of cross-section of orifice
c. height of liquid above the orifice
d. height of the orifice from the ground

17. When the terminal velocity is reached, the acceleration of a body moving through a viscous medium is:
a. zero
b. positive
c. negative
d. depends on other factors

18. The velocity of rain drop attains constant value because of:
a. Both C and B
b. up thrust of air
c. viscous force exerted by air
d. air currents

19. Rain drops are spherical because of:
a. gravitational force
b. surface tension
c. low viscosity of water
d. air resistance

20. Stroke's law holds for:
a. cubical bodies b. cylindrical bodies c. spherical bodies d. elliptical bodies

21. According to Stroke's law drag force depends on:
a. coefficient of viscosity
b. radius of the spherical body
c. terminal velocity of the body
d. all of these

22. Two boats moving parallel in a river:
a. Are pulled towards each other due to less pressure in between them
b. Get part due to increase in pressure in between them
c. Remain always parallel as there is no change in pressure
d. None of these

23. In the formula for velocity of efflux v = $\sqrt{2gh}$, (h) is the:
a. height of liquid column
b. Height of orifice from the bottom of the vessel
c. Height of liquid column above the orifice

d. Height of the vessel

24. The drag force increases as the speed of object:
a. increases b. decreases c. remains constant d. none of these

25. When the velocity of a liquid flowing steadily in a tube increases, its pressure:
a. increases b. decreases c. remains constant d. becomes zero

26. According to Bernoulli's theorem velocity and pressure:
a. are directly proportional b. are inversely proportional
c. have no relation d. are equal

27. Density of blood is:
a. equal to water b. greater than water c. lesser than water d. zero

28. Viscosity of liquids with rise in temperature:
a. remains constant b. increases c. decreases d. none of these

29. Drag force between two layers depends upon:
a. surface area of layer b. distance between the two layers
c. relative velocity between two layers d. all of these

30. If the area of the pipe decrease, the speed of fluid must increase according to:
a. Bernoulli's equation b. Bilal's equation
c. Venturi relation d. General Gas Equation

31. Dimensions of pressure are same as that of:
a. Force per unit area b. P.E per unit volume
c. K.E per unit volume d. all of these

32. Dimensions of coefficient of viscosity are:
a. $ML^{-1}T^{-2}$ b. $ML^{-2}T^{-1}$ c. $ML^{-1}T^{-1}$ d. $ML^{-2}T$

33. If air blows from place A to place B:
a. temperature is higher at place B b. temperature is higher at place A
c. temperature is same at both places d. none of these

34. Maximum drag force on a body falling in a viscous medium is 19.6 N. Its mass is:
a. 1 kg b. 2 kg c. 3.5 kg d. 4 kg

35. Pressure on the upper side of the wing of an aero plane:
a. is greater than that on its underside b. is same as that on its underside
c. is less than that on its underside d. none of these

36. The viscous drag on a small spherical body moving with a speed v is proportional to:
a. v b. $\sqrt{v}$ c. $\frac{1}{\sqrt{v}}$ d. v^2

37. Bernoulli's theorem is applicable to:
a. flow of liquids b. viscosity c. surface tension d. non-viscous static

38. Water is flowing through a pipe of uniform cross section under constant pressure, at some place the pipe becomes narrow, the pressure of water at this place:
a. depends on several factors
b. increases
c. decreases
d. remains unchanged

39. What makes the hair shaving brush cling together when taken out of water:
a. viscosity
b. attraction between the air
c. gravity
d. surface tension

40. The viscous force acting on a body falling under gravity in a viscous fluid will be:
a. $\frac{6\pi\eta r}{v}$ b. $\frac{rv}{6\pi\eta}$ c. $\frac{6\pi v}{\eta r}$ d. $6\pi\eta rv$

41. Why are the aero planes made to run on the runway before takeoff?
a. it decreases atmospheric pressure
b. it decreases friction
c. it provides required lift to the aero plane
d. it decreases viscous drag of the air

42. When the temperature decreases, the viscosity:
a. remains constant b. increases c. decreases d. doubles

43. Drag force between two layers under consideration depends upon:
a. distance between the layers
b. surface area of layer
c. relative velocity between them
d. all of the above

44. A fog droplet falls vertically through air with an acceleration:
a. less than g b. greater than g c. equal to g d. equal to 0

45. The product of cross-sectional area of the pipe and the fluid velocity at any point along the pipe is:
a. zero b. variable c. flow rate d. none of these

46. The SI units of flow rate are:
a. m^2s^{-1} b. m^3s^{-2} c. m^3s^{-1} d. m^2s^{-2}

47. Velocity of efflux is measured by the relation:
a. $\sqrt{gh}$ b. $\sqrt{gh/2}$ c. $\sqrt{2gh}$ d. $\sqrt{\frac{4}{3}gh}$

48. At high altitude, the blood flows out of nose and ear because:
a. The blood pressure increases at high altitudes
b. The percentage of oxygen in the air increases
c. The atmospheric pressure decreases there
d. The density of blood decreases at high altitudes

49. The terminal velocity of a drop of water of radius 1×10^{-3} m moving through air is: (Given that $\eta=19\times10^{-6}$ $kgm^{-1}s^{-1}$ and Density of water = 997 Kg/m^3)
a. $114.6ms^{-1}$ b. $114.6\ kms^{-1}$ c. $11.46ms^{-1}$ d. $1.146\ ms^{-1}$

50. One torr in Nm^{-2} is expressed as:
a. 1 torr = $133.3Nm^2$
b. 1 torr = $1.33Nm^{-2}$
c. 1 torr = $133.3Nm^{-2}$
d. 1 torr = $13.33Nm^{-2}$

51. The blood pressure of about 120 torr (Upper reading) is called the:

a. diastolic pressure
b. systolic pressure
c. minimum diastolic pressure
d. dangerous blood pressure

52. The blood pressure of about 80 torr (Bottom reading) is called:
a. systolic pressure
b. diastolic pressure
c. minimum systolic pressure
d. maximum systolic pressure

53. The maximum drag force on a falling sphere is 9.8N, its weight is:
a. 1 N
b. 5 N
c. 9.8 kg
d. 9.8 N

54. Which is the equation of continuity:
a. $\rho_1 A_1 v_1 = \rho_2 A_2 v_2$
b. $A_1 v_2 = A_2 v_1$
c. $\rho_1 A_2 v_2 = \rho_2 A_1 v_1$
d. none of these

55. When the velocity of an object moving through a fluid becomes maximum it is called:
a. initial velocity
b. final velocity
c. terminal velocity
d. variable velocity

56. With increase in temperature the viscosity of:
a. a gas decreases and liquid increases
b. a gas increases and liquid decreases
c. both gases and liquids decrease
d. both gases and liquids increase

57. Bernoulli's equation is based upon:
a. law of conservation of mass
b. law of conservation of momentum
c. law of conservation of energy
d. law of conservation of charge

58. Two water pipes of diameter 2cm and 4cm are connected with main supply line. The velocity of flow of water in the pipe 2cm diameter is:
a. 4 times
b. ¼ times
c. 2 times
d. ½ times

59. A small and a large rain drops are falling through air:
a. the large drop moves faster
b. the small drop moves faster
c. both move with the same speed
d. no conclusion can be drawn

60. As the speed of the object moving through a fluid, increases, the upward drag force experienced by it:
a. decreases
b. increases
c. remains constant
d. becomes zero

61. The net force acting on the droplet moving through the fluid is:
a. F = weight – drag force
b. F = weight + drag force
c. F = drag force – weight
d. F = zero

62. Bernoulli's equation establishes a relation between:
a. pressure and speed of fluid
b. pressure and height of fluid
c. pressure speed and height of fluid
d. pressure and mass of fluid

63. As compared to external atmospheric pressure the pressure of blood inside vessels is:
a. greater
b. lesser
c. zero
d. none of these

64. The terminal velocity of a tiny droplet of radius 'r' falling vertically downward through air is given as:
a. $v_t \propto r$
b. $v_t \propto r^2$
c. $v_t \propto r^3$
d. $v_t \propto \frac{1}{r}$

65. If the radius of the sphere falling vertically is doubled, its terminal velocity:

a. becomes double b. becomes four times c. becomes zero d. becomes half

66. An object moving through a fluid experiences a retarding force known as:
a. centripetal force b. drag force c. accelerating force d. gravitational force

67. When a fog droplet moves vertically downward, it is subjected to:
a. force of gravity b. drag force only c. both a and b d. no force at all

68. An object moving through a fluid experience:
a. no force b. a retarding force c. accelerating force d. none of these

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ANSWER KEY

1.	C	31.	D	61.	A
2.	C	32.	C	62.	C
3.	A	33.	A	63.	A
4.	B	34.	B	64.	B
5.	C	35.	C	65.	B
6.	A	36.	A	66.	B
7.	C	37.	A	67.	C
8.	A	38.	C	68.	B
9.	A	39.	D	69.	
10.	B	40	D	70	
11.	D	41.	C	71.	
12.	B	42.	B	72.	
13.	A	43.	D	73.	
14.	B	44.	D	74.	
15.	D	45.	C	75.	
16.	C	46.	C	76.	
17.	A	47.	C	77.	
18.	A	48.	C	78.	
19.	B	49.	A	79.	
20.	C	50.	C	80.	
21.	D	51.	B	81.	
22.	A	52.	B	82.	
23.	C	53.	D	83.	
24.	A	54.	A	84.	
25.	B	55.	C	85.	
26.	B	56.	B	86.	
27.	A	57.	C	87.	
28.	C	58.	A	88.	
29.	D	59.	A	89.	
30.	C	60.	B	90.	

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CHAPTER 7
OSCILLATIONS

SIMPLE HARMONIC MOTION

- Vibratory motion is that in which a body moves to and fro about the fixed position along same path. E.g.
    1. Motion of Simple Pendulum
    2. Motion of molecules of a solid
- Simple Harmonic Motion (SHM) is a special type of vibratory motion in which:
    1. $a \propto -x$
    2. a is directed towards mean position
- Restoring force is always directed towards mean position hence assigned negative sign.
- Periodic motion is that which repeats itself after equal time intervals.
- Vibration is one complete round trip of a body about its mean position.
- Time period is defined as time taken by vibrating body to complete its one vibration and denoted by T.
- Frequency is number of vibrations per second and denoted by f
  $f = 1/T$
  Its unit is Hz, other units are vibration/s, cycle/s, rev/sec
- `Amplitude is maximum distance from mean position.
- Angular frequency is $\omega = 2\pi/T \rightarrow \omega = 2\pi f$
- Phase is angle which specifies the displacement and direction of motion of the point executing SHM phase = $\theta = \omega T$.
- Initial angle at t = 0 is called phase constant and denoted by Φ.
- If phase constant $\Phi = 90°$, then displacement $X = X_0 \text{ Sin } (\omega T + 90°) = X_0 \text{ Cos } \omega T$.
-

A HORIZONTAL MASS SPRING SYSTEM

- For spring, Hooke's Law states that
  Strain $\propto$ Stress
  $F = kx$
  Where $k = F/x$ is called spring constant or force constant

If a spring is cut into two parts then spring constant of each spring is doubled.

- Mass attached to spring has SHM. We get-
  $a = -k/mx$
  $a \propto -x$

- Mass spring system has S.H.M and we can trace its waveform (pictorial display between time displacement for S.H.M.) by following relation:
  $X = X_0 \text{ Sin } [2\pi/T \times t]$

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Time t	POSITION x(t)	VELOCITY v(t)	ACCELERATION a(t)	KE	PE
0	x_{max}	0	$-a_{max}$	0	PE_{max}
$\frac{T}{4}$	0	$-v_{max}$	0	KE_{max}	0
$\frac{T}{2}$	$-x_{max}$	0	a_{max}	0	PE_{max}
$\frac{3T}{4}$	0	v_{max}	0	KE_{max}	0
T	x_{max}	0	$-a_{max}$	0	PE_{max}

SPRING IN SERIES

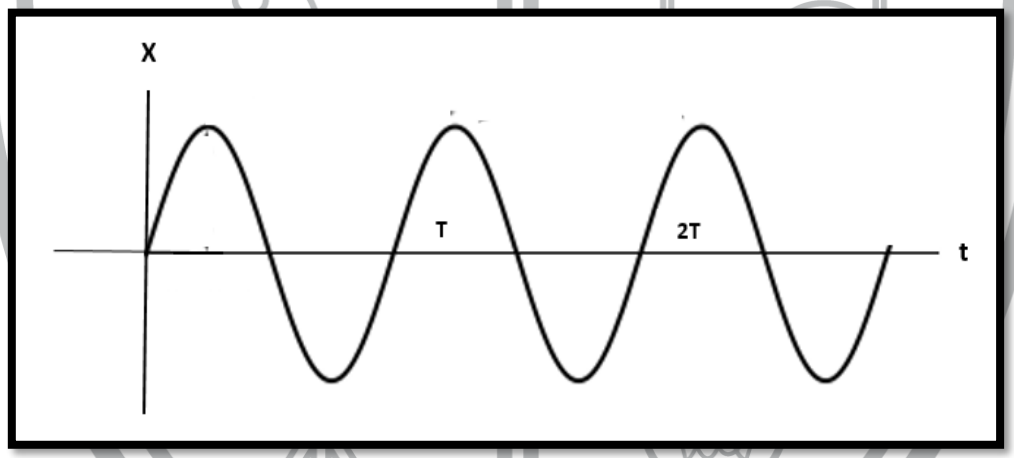
The resultant of spring constant in case of the series combination is

$$1/K = 1/K_1 + 1/K_2 + \ldots\ldots\ldots$$

SPRING IN PARALLEL

The resultant of spring constant in case of the parallel combination is

$$K = K_1 + K_2 + \ldots\ldots\ldots$$



- Time period of single mass attached to spring is given as:

$$T = 2\pi\sqrt{m/k}$$

$$T \propto \sqrt{m} \quad T \propto 1/\sqrt{k}$$

Its displacement is given as:

$$X = X_0 \text{ Sin } \omega t$$

- Instantaneous velocity of mass "m" attached to spring is given as:

$$V_{inst} = \sqrt{\frac{k}{m}\left(1 - \frac{x^2}{x_0^2}\right)}$$

- Maximum speed of mass attached to spring is given as:

$$V_0 = x_0\sqrt{k/m}$$

- Instantaneous and maximum speed of mass attached to spring is related as:

$$V_{inst} = V_0\sqrt{\frac{(1-x^2)}{x_0^2}}$$

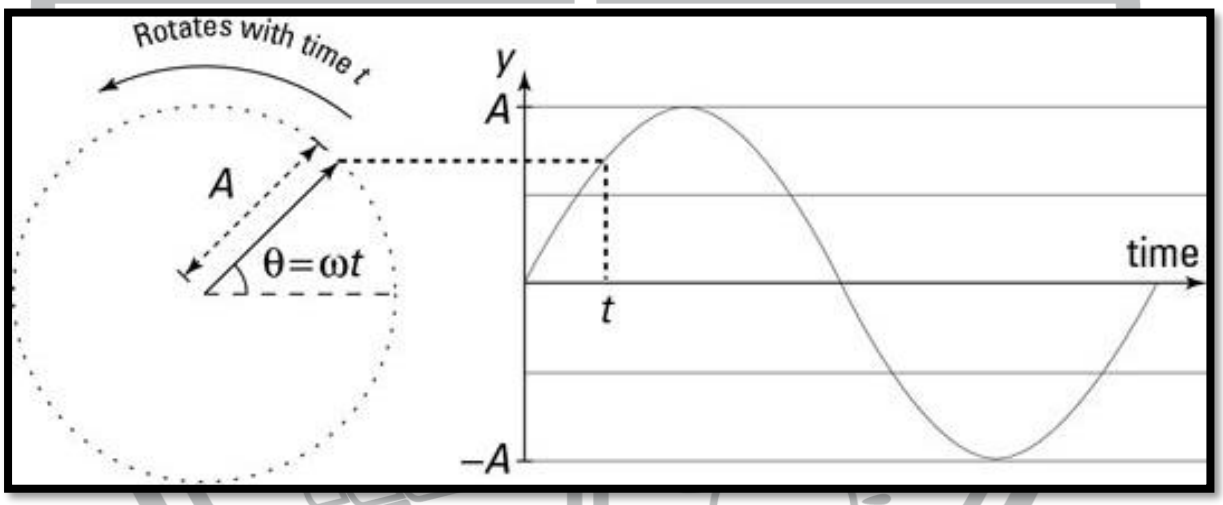
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velocity	At mean position max	At extreme position zero
Acceleration	At mean position minimum	At extreme position maximum

DO YOU KNOW?
In a one complete vibration a body covers a distance equal to four times of the amplitude.

MOTION OF A PROJECTION OF A BODY MOVING IN A CIRCLE DIAMETER

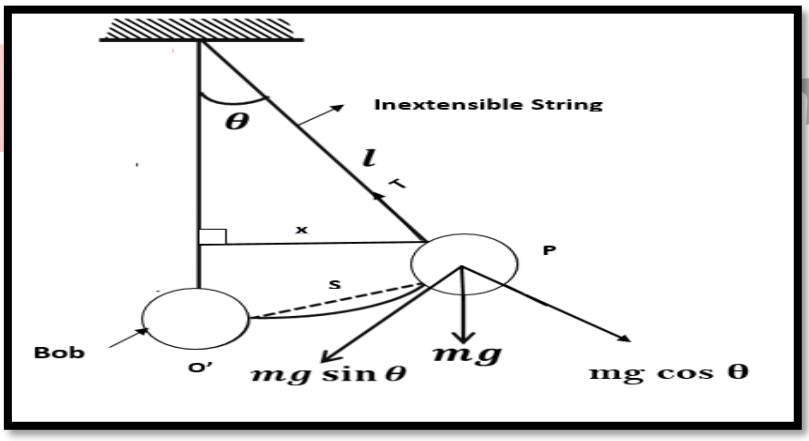
- Motion of a projection of a body moving in a circle on diameter with constant speed on S.H.M.
- Its acceleration is given as:
  $a = -\omega^2 x$
- Time period of projection is given as:
  $T = 2\pi/\omega$
- Speed of projection is given as:
  $V = \omega\sqrt{r^2 - x^2}$ Where, r = radius of the circle = amplitude of SHM
- Projection speeds up when moving towards the center of circle.
- Projection slows down when moving away from the centre of circle.
- If speed ω of body is not constant then projection does not have SHM but has vibratory motion, which is non SHM.



SIMPLE PENDULUM

It consists of a heavy point mass suspended from a rigid support by means of almost weightless and inextensible string.

- Galileo invented simple pendulum.
- Motion of simple pendulum is S.H.M if there is no damping.
- Damping force reduces the amplitude of simple pendulum continuous and finally its motion is stopped.



- In absence of damping force, restoring force on simple pendulum is given as:

$$F_r = -mg \sin\theta$$

- Equation of acceleration of simple pendulum for small amplitude is:

$$a = -(g/I)x$$

- Time period and frequency of simple pendulum are given as:

$$T = 2\pi\sqrt{l/g} \text{ and } f = {}^{1}/_{2}\ \pi\sqrt{g/l}$$

- If amplitude and simple pendulum is not small then, It has non-SHM as $a = -g \sin\theta$ and we know that $\sin\theta = \theta$ only when θ is small.

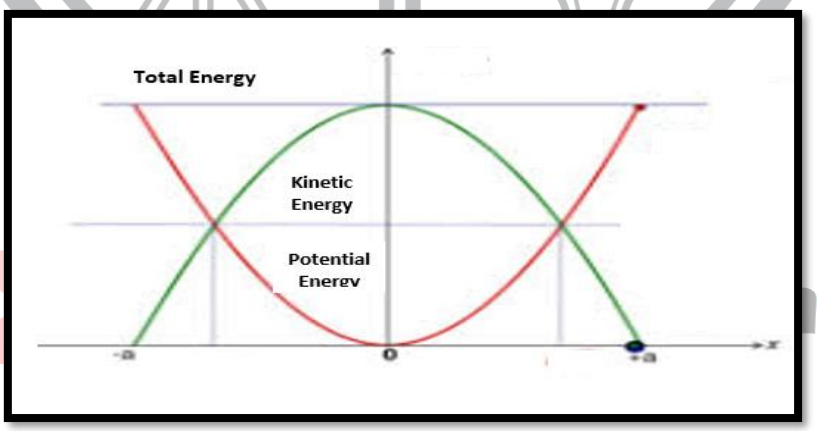
POINT TO PONDER
The time period of simple pendulum is independent of mass and its amplitude.

- **Kinds of Pendulum**
  a) Simple Pendulum
  b) Compound Pendulum or Physical Pendulum
  c) Torsion Pendulum
- A second pendulum has following characteristics:
-

Time Period	2 seconds
Frequency	0.5 Hz
Length	0.99 or 1 meter

ENERGY CONSERVATION IN SHM

- Its K.E, is given as:
  $KE_{inst} = {}^{1}/_{2}\ kx_0^2\ (1 - x^2/x_0^2)$
  $(KE)_{max} = kx_0^2/2$ It is at mean position
  $(KE)_{min} = 0$ It is at extreme position
  $KE_{inst} = (K.E.)_{max}\ (1 - x^2/x_0^2)$
- Its P.E. is given as:
  $P.E._{inst} = kx^2/2$
  $(P.E.)_{max} = kx_0^2/2$ It is at extreme position
  $(P.E.)_{min} = 0$ It is at mean position
- Total energy of system = $\frac{1}{2}\ kx_0^2$
  Energy remain conserve in SHM



In one vibration KE attains its maximum value twice.

FREE & FORCED OSCILLATIONS

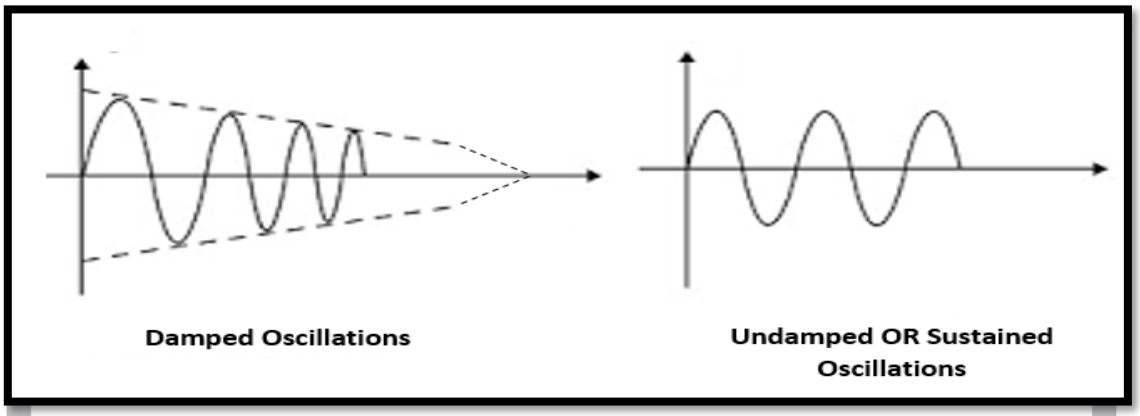
- Oscillation of a system is called free vibration if it oscillates without the interference of an external force.
- Frequency of free oscillation is called natural frequency of the system.

- When a system performs oscillation only in the presence of external periodic force its vibration is called forced oscillation.
- A physical system under going forced vibration is known as driven harmonic oscillator.

DAMPED OSCILLATION

Such oscillations in which the amplitude decreases steadily with time are called as damped oscillations.

- In shock absorber of a car critical damping is applied.



RESONANCE

A phenomenon of increase in amplitude of a body (capable of vibrating) under the action of a periodic force whose time period is equal to natural time period of body.

OR

Specific resonance of a system to external periodic force whose time period is equal to natural time period of a body.

OR

Process in which one body transfers its vibration to nearby body whose natural time period is agreeable to it.

- For tuning circuit of TV or radio or mobile phone, electrical resonance takes place at following frequency:

$$f = 1/2\pi\sqrt{LC}$$

- Magnetic resonance (MRI) is a process of getting images of internal origins of human body due to incidences of photo from time varying magnetic field. It is less damaging than X rays imaging process.
- Suspension bridge may break down due to vibration with increased amplitude caused by resonance.
- We get tired on walking briskly because of force oscillations fed our legs for resonance
- Loose parts of car produce resonance noise at specific due to resonance.

SHARPNERS OF RESONANCE

- Amplitude of vibration decreases with damping force.
- Amplitude of vibration remain constant with undamped force.
- Smaller damped force, sharp is the amplitude frequency curve.
- Sharpness of resonance is inversely proportional to the damped force.

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PRACTICE SHEET

1. Resonance is said to be taken place when:
   a. Forcing power is maximum
   b. Forcing amplitude is maximum
   c. The damping coefficient of the forces body is minimum
   d. Forced frequency is equal to natural frequency of the forced body

2. A force is 20 N is applied on an elastic spring. If the extension produced in the spring is 10 cm, the spring constant of the spring is:
   a. 14 Nm^{-1} b. 18 Nm^{-1} c. 200 Nm^{-1} d. 200 Nm

3. If a point mass 'm' is moving on a circle of radius x_0 with a constant angular velocity 'ω', where the period of oscillation is $2\pi\sqrt{\frac{m}{k}}$ and the displacement is 'x' then the kinetic energy of particle at any instant is:
   a. $\frac{1}{2}kx^2$ b. $\frac{1}{2}kx_0{}^2$ c. $\frac{1}{2}k(x_0{}^2 - x^2)$ d. None of these

4. The time period of a simple pendulum of length ℓ is given by $T = 2\pi\sqrt{\frac{\ell}{g}}$. If the length of pendulum is increased by four times its initial length. Then the new time period will be:
   a. $2\pi\sqrt{\frac{\ell}{g}}$ b. $4\pi\sqrt{\frac{\ell}{g}}$ c. $2\pi\sqrt{\frac{\ell}{4g}}$ d. $2\pi\sqrt{\frac{g}{4\ell}}$

5. We can increase the time period of mass-spring system:
   a. By decreasing the length of spring
   b. By decreasing the mass of bob attached to spring
   c. By increasing the mass of bob attached to spring
   d. All of the above

6. How long must be the length of a simple pendulum in order to have a period of one second
   a. 0.25 m b. 0.50 m c. 1 m d. 0.25 cm

7. A spring of harmonic oscillator is cut into two equal halves. If the same force is applied on a full and a half spring respectively, then the spring constant of halved spring will:
   a. increase by two times that of first spring c. remains constant
   c. decrease by half time that of first spring d. increase by half time that of first spring

8. If a hole is bored along a diameter of the earth and a stone is dropped into the hole it will:
   a. Reach the center of the earth and stop there
   b. Reach the other side of the earth and stop there
   c. Execute S.H.M about the center of the earth
   d. None

9. The length of a second's pendulum on the surface of the moon, where g is $1/6^{th}$ of the value of g on the surface of the earth is:
   a. 1/36 m b. 1/6 m c. 6 m d. 36 m

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10. A particle of mass 200g executes S.H.M. The restoring force is provided by a spring of force constant 80 Nm^{-1}. The time period of oscillation is:
a. 0.31 sec b. 0.15 sec c. 0.05 sec d. 0.02 sec

11. The total energy of a particle executing S.H.M is proportional to:
a. frequency of oscillation
b. maximum velocity of motion
c. amplitude of motion
d. square of amplitude of motion

12. The restoring force is directly proportional to the displacement of the system from its equilibrium position, it is called:
a. Newton's first law b. Bilal's law c. Hook's Law d. Stroke's Law

13. When simple pendulum swings, which of the following quantity does not become zero throughout the oscillation:
a. mass of pendulum
b. momentum of pendulum
c. acceleration of pendulum
d. velocity of pendulum

14. Wave form of S.H.M is:
a. sine wave b. pulsed wave c. square wave d. saw tooth wave

15. The time period of simple pendulum depends upon:
a. length of the pendulum
b. mass of pendulum
c. mass of the thread
d. volume of the bob

16. If the mass of a simple pendulum is reduced to half, its time period:
a. becomes double b. reduces to half c. becomes $1/4^{th}$ d. remains same

17. At extreme position during the vibration of a body executing S.H.M:
a. P.E is maximum and K.E is minimum
b. P.E is minimum and K.E is maximum
c. Both P.E and K.E are maximum
d. Both P.E and K.E are minimum

18. Which of the following law remains valid in a vibratory motion (S.H.M)?
a. law of conservation of momentum
b. law of conservation of energy
c. law of conservation of angular momentum
d. law of conservation of charge

19. When quarter of the cycle is completed by a body in a circular motion, the phase of vibration is:
a. 0° b. 90° $\left(\frac{\pi}{2}\text{ radian}\right)$ c. 180°(π radian) d. 270° $\left(\frac{3\pi}{2}\text{radian}\right)$

20. The time period of simple pendulum is independent from its:
a. mass
b. length
c. restoring force
d. acceleration due to gravity

21. In a simple harmonic motion, which of the following does not hold:
a. The force on the particle is maximum at the ends
b. The acceleration is maximum at the mean position
c. The potential energy is maximum at the mean position
d. The kinetic energy is maximum at the mean position

22. In a simple harmonic motion, the kinetic energy and the potential energy, are such that throughout the motion:

a. K.E remains constant
b. P.E remains constant
c. K.E/P.E is constant
d. K.E + P.E remains constant

23. The total energy of a particle executing S.H.M of amplitude A is proportional to:
a. A^2 b. A^{-2} c. A d. $\frac{1}{A}$

24. A simple pendulum is oscillating in a lift. If the lift starts moving upwards with a uniform acceleration, the period will:
a. Remain unaffected
b. Be shorter
c. Be longer
d. May be shorter or longer, depending on the magnitude of acceleration

25. A body of mass 5g is executing S.H.M with amplitude 10 cm. Its maximum velocity of 100 cm/s. Its velocity will be 50 cm/s at a displacement from the mean position equal to:
a. 5 cm b. $5\sqrt{3}$ cm c. 10 cm d. $10\sqrt{3}$ cm

26. A particle executing S.H.M has an acceleration of $64cm/s^2$ when its displacement is 4cm. Its time period, in seconds is:
a. π/2 b. π/4 c. π d. 2π

27. The frequency of the second pendulum is:
a. 0.5 Hertz b. 1 Hertz c. 1.5 Hertz d. 2 Hertz

28. If a given spring of spring constant (k) is cut into three identical segments, the spring constant of each segment is:
a. k/2 b. k/3 c. 3k d. 4k

29. A particle of mass 0.5 kg executes S.H.M. Its energy is 0.04J. If its time period is π seconds, its amplitude is:
a. 10 cm b. 15 cm c. 20 cm d. 40 cm

30. When a body attached with a spring has no displacement from its mean position then that position of the body is known as:
a. Extreme position
b. Equilibrium position
c. Zero position
d. Initial position

31. A particle executing S.H.M has an amplitude of 6 cm. its acceleration at a distance of 2 cm from the mean position is $8cms^{-2}$. The maximum speed of the particle is:
a. 8 cms^{-1} b. 12 cms^{-1} c. 16 cms^{-1} d. 24 cms^{-1}

32. The kinetic energy and potential energy of a particle executing SHM will be equal when displacement (amplitude = a) is:
a. $a\sqrt{2/3}$ b. a/2 c. $a/\sqrt{2}$ d. $a\sqrt{2}$

33. What is the length of second's pendulum where g is 980 cms^{-2}?
a. 102.4 cm b. 99.2 cm c. 88 cm d. 78 cm

34. The displacement of a particle in SHM in one time period is:
a. zero b. a c. 2a d. 4a

35. The phase angle between the projection of uniform circular motion on two mutually perpendicular diameter is:
a. π/2 b. 3π/4 c. π d. zero

36. The maximum distance of vibrating body from the mean position when the body is executing S.H.M is called:
a. Displacement b. Time period c. Frequency d. Amplitude

37. The relation between frequency and time period T is:
a. f = 1/T b. f = 2πT c. f = 1/2πT d. f = T/2π

38. The angular speed of the mass attached to a spring is:
a. $\omega = 1/2\pi\sqrt{m/k}$ b. $\omega = 2\pi\sqrt{m/k}$ c. $\omega = \sqrt{k/m}$ d. $\omega = 2\pi\sqrt{k/m}$

39. In S.H.M, the velocity of particle is minimum at:
a. Extreme position
b. Mean position
c. Between mean and extreme position on the right side
d. Between mean and extreme position on the left side

40. Total energy of a body executing S.H.M is directly proportional to:
a. Square root of amplitude b. The amplitude
c. Reciprocal of amplitude d. Square of amplitude

41. The force responsible for the vibratory motion of the simple pendulum is:
a. mg cosθ b. mg sinθ c. mg tanθ d. mg

42. The SI unit of spring constant is identical with that of:
a. Force b. Pressure c. Surface tension d. Loudness

43. In the equation of S.H.M, $a = -\omega^2 x$ negative sign indicates the direction of motion of particle is always:
a. away from mean position b. perpendicular to mean position
c. towards mean position d. towards or away from mean position

44. When the bob of a simple pendulum is at the mean position, its K.E is:
a. negative b. Maximum c. Minimum d. Zero

45. The oscillations in which the amplitude decreases steadily with time are called:
a. Simple oscillations b. Damped oscillation
c. Undamped oscillations d. Forced oscillations

46. The type of vibratory motion whose instantaneous acceleration at any distance x from the mean position is proportional to x and always directed towards the mean position is called:
a. None b. Torque
c. Oscillatory motion d. Simple harmonic motion

47. Frequency and time period are related as:
a. $fT^{-1} = 1$ b. $fT^{-2} = 1$ c. $f^{-1}T = 1$ d. $fT = 1$

48. The dimensions of spring constant are:

a. MLT^{-2} b. MT^{-2} c. MLT^{-1} d. ML^2

49. Which one of the following is a simple harmonic motion?
    a. Wave moving through a string fixed at both ends
    b. Earth spinning around its own axis
    c. Ball bouncing between two rigid vertical walls
    d. Particle moving in a circle with uniform speed

50. If the period of oscillation of mass (M) suspended from a spring is 2s, then the period of mass 4M will be:
    a. 1 s b. 2 s c. 3 s d. 4 s

51. The time period of a simple pendulum is 2 seconds. If its length is increased by 4 times, then its period becomes:
    a. 16 s b. 12 s c. 8 s d. 4 s

52. To make the frequency double of an oscillator (mass spring system), we have to:
    a. Double the mass b. half the mass
    c. Quadruple the mass d. Reduce the mass to one-fourth

53. A physical system under going forced vibrations is known as:
    a. driven harmonic oscillator b. vibrational harmonic oscillator
    c. frequency harmonic oscillator d. free oscillator

54. The projection of a particle moving in a circle executes:
    a. rotatory motion b. angular motion c. S.H.M d. circular motion

55. For a mass body executing S.H.M, its:
    a. momentum remains constant b. kinetic energy remains constant
    c. potential energy remains constant d. total energy remains constant

56. Which of the following does not exhibit S.H.M?
    a. A mass attached to a spring when released
    b. A train shunting between two terminals
    c. The projection of a point describing uniform circular motion
    d. A simple pendulum

57. When a body is pulled away from its mean position and then released, it oscillates due to:
    a. a restoring force b. force of gravity
    c. acceleration due to gravity d. driven force

58. The relation between time period T of a body executing S.H.M and its angular frequency ω is
    a. $T = \frac{2\pi}{\omega}$ b. $T = 2\pi\omega$ c. $T = \frac{\omega}{2\pi}$ d. $T = \pi\omega$

59. When a body is performing S.H.M, its acceleration is:
    a. Inversely proportional to the displacement
    b. Directly proportional to the applied force
    c. Directly proportional to the amplitude
    d. Directly proportional to the displacement and oppositely directed

60. When a mass attached to one end of a spring is displaced through a distance x, then the force F exerted on the spring varies as:
a. $F \propto x^2$ b. $F \propto \frac{1}{x^2}$ c. $F \propto \frac{1}{x}$ d. $F \propto x$

61. Resonance phenomena in a vibrating body may:
a. increases the amplitude b. decrease the amplitude
c. not affect the amplitude d. both (a) & (b)

62. In the case of forced oscillations, the frequency of oscillation is:
a. the natural damped frequency b. the natural undamped frequency
c. The frequency of the external periodic force d. zero

63. Energy of a free harmonic oscillator is:
a. Totally potential at either extreme position
b. Totally kinetic at the mean position
c. Partly potential and partly kinetic in between the mean position and either extreme position
d. All of these

64. In an isolated spring-mass system total energy is:
a. variable b. constant c. low d. high

65. A simple harmonic oscillator has a period of 0.01 sec and an amplitude of 0.2m. The magnitude of the velocity in m/s at the center of oscillation is:
a. 20π b. 40π c. 60π d. 80π

66. The formula $T = 2\pi\sqrt{\frac{\ell}{g}}$ of a simple pendulum holds only if:
a. length of pendulum is large b. length of pendulum is small
c. mass of pendulum is large d. amplitude of motion should be small

67. Instantaneous acceleration of a system executing S.H.M is directed:
a. towards the mean position b. away from the mean position
c. perpendicular to the mean position d. none of these

68. For a simple pendulum the graph between L and T^2 is:
a. Straight line b. Parabola c. Curve d. Ellipse

69. An example of forced oscillations is:
a. the pendulum of a clock b. the windscreen-wiper
c. a plucked sonometer wire d. a sonometer wire excited by a tuning fork

70. The process whereby energy is dissipated form the oscillating system is called:
a. oscillation b. resonance c. damping d. reflection

71. The maximum velocity of 1kg mass attached to a spring constant of 1 Nm^{-1} up to the displacement of 5cm is:
a. 1m/s b. 0.01m/s c. 5m/s d. 0.05 m/s

72. If the length of a simple pendulum at a place is made nine times, then the new time period:
a. increases by four times b. increases by three times

c. decreases by four times
d. decreases by two times

73. When a particle executing S.H.M passes through the mean position, it has:
a. minimum K.E and maximum P.E
b. maximum K.E and maximum P.E
c. maximum K.E and minimum P.E
d. minimum K.E and minimum P.E

74. In order to double the period of a simple pendulum:
a. its length should be doubled
b. its length should be quadrupled
c. the mass of is bob should be doubled
d. the mass of its bob should be quadrupled

75. A simple pendulum is vibrating in an evacuated chamber. It will:
a. Come to rest eventually
b. Oscillate forever with the same amplitude and frequency
c. Oscillate with the same frequency but amplitude will decrease with time
d. Oscillate with the same amplitude but frequency will decrease with time

76. If the period of oscillation of mass M suspended from a spring is 1 sec, then the period of mass 4M will be:
a. ¼ sec
b. ½ sec
c. 2 sec
d. 4 sec

77. The displacement of a particle in S.H.M is given by y = A sinωt + B cosωt. The amplitude of oscillation is:
a. $\frac{A+B}{2}$
b. $\sqrt{AB}$
c. $\sqrt{A^2+B^2}$
d. $\sqrt{\frac{A^2+B^2}{2}}$

78. The ratio of the amplitudes of the simple harmonic oscillations given by y_1 = A sinωt and $y_2 = \frac{A}{2}\sin\omega t + \frac{A}{2}\cos\omega t$, is:
a. 1
b. 2
c. $\frac{1}{\sqrt{2}}$
d. $\sqrt{2}$

79. The velocity of a particle, undergoing S.H.M is v at the mean position. If its amplitude is doubled, the velocity at the mean position will be:
a. 2v
b. 3v
c. $2\sqrt{2}$v
d. 4v

80. A girl is swinging on a swing in the sitting position. How will the period of swing be affected if she stands up?
a. the period will now be shorter
b. The period will now be longer
c. The period will remain unchanged
d. The period may become longer or shorter depending upon the height of the girl

81. A simple harmonic oscillator has time period T. The time taken by it to travel from the extreme position to half the amplitude is:
a. $\frac{T}{6}$
b. $\frac{T}{4}$
c. $\frac{T}{8}$
d. $\frac{T}{2}$

82. The frequency of oscillation of a simple pendulum of length L, mounted in a cabin that is falling freely under gravity is:
a. infinity
b. zero
c. $\sqrt{\frac{g}{2L}}$
d. $\sqrt{\frac{g}{L}}$

83. The Time Period of oscillation of a simple pendulum of length L, mounted in a cabin that is falling freely under gravity is:

a. infinity b. zero c. $\sqrt{\frac{g}{2L}}$ d. $\sqrt{\frac{g}{L}}$

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ANSWER KEY

1.	D	31.	B	61.	A
2.	C	32.	C	62.	C
3.	C	33.	B	63.	D
4.	B	34.	A	64.	B
5.	C	35.	A	65.	B
6.	A	36.	D	66.	D
7.	A	37.	A	67.	A
8.	C	38.	C	68.	A
9.	B	39.	A	69.	B
10.	A	40	D	70	C
11.	D	41.	B	71.	D
12.	C	42.	C	72.	B
13.	A	43.	C	73.	C
14.	A	44.	B	74.	B
15.	A	45.	B	75.	B
16.	D	46.	D	76.	C
17.	A	47.	D	77.	C
18.	B	48.	B	78.	D
19.	B	49.	A	79.	A
20.	A	50.	D	80.	A
21.	C	51.	D	81.	A
22.	D	52.	D	82.	B
23.	A	53.	A	83.	A
24.	B	54.	C	84.	
25.	B	55.	D	85.	
26.	A	56.	B	86.	
27.	A	57.	A	87.	
28.	C	58.	A	88.	
29.	C	59.	D	89.	
30.	B	60.	D	90.	

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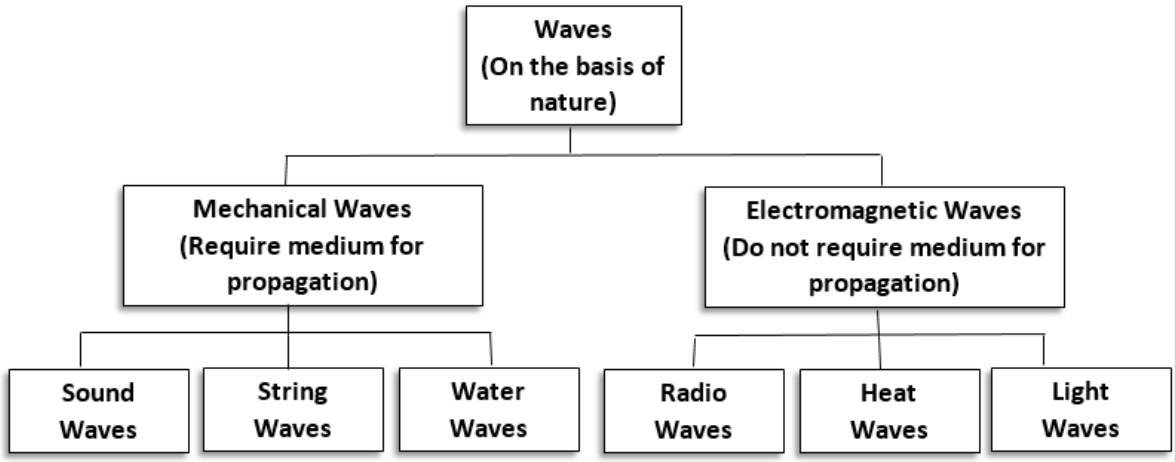
CHAPTER 8
WAVES

INTRODUCTION

- Wave is due to disturbance created in medium
- Waves transport energy without transporting matter.

CLASSIFICATION OF WAVES

DO YOU KNOW?
In case of mechanical waves, we deal with the cooperative motion of a collection of particles



PROGRESSIVE/TRAVELLING WAVES

- Traveling wave is that which propagates or distributes its pulses in space along specific direction.
  e.g.

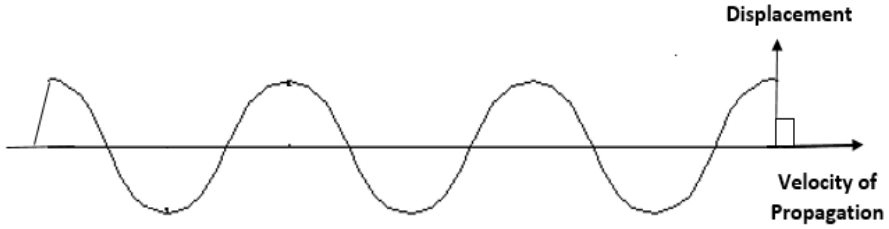
1. Waves on string
2. Waves on water surface

PERIODIC WAVES

Periodic waves are those, which are repeated in regular interval of time.

- Periodic waves may be transverse may be longitudinal.

For transverse waves the displacement of the medium is perpendicular to the direct propagation of wave. A ripple on a pond and a wave on a string are easily visualized transverse waves.



Transverse waves may occur on a string on the surface of a liquid, and throughout a solid.

Transverse waves cannot propagate in a gas or a liquid because there is no mechanism for driving motion perpendicular to the propagation of the wave.

In longitudinal waves the displacement of the medium is parallel to the propagation of the wave. A wave in a "slinky" is a good visualization. Sound wave in air are longitudinal waves.



In fluids waves die out very quickly and usually cannot be produced at all.

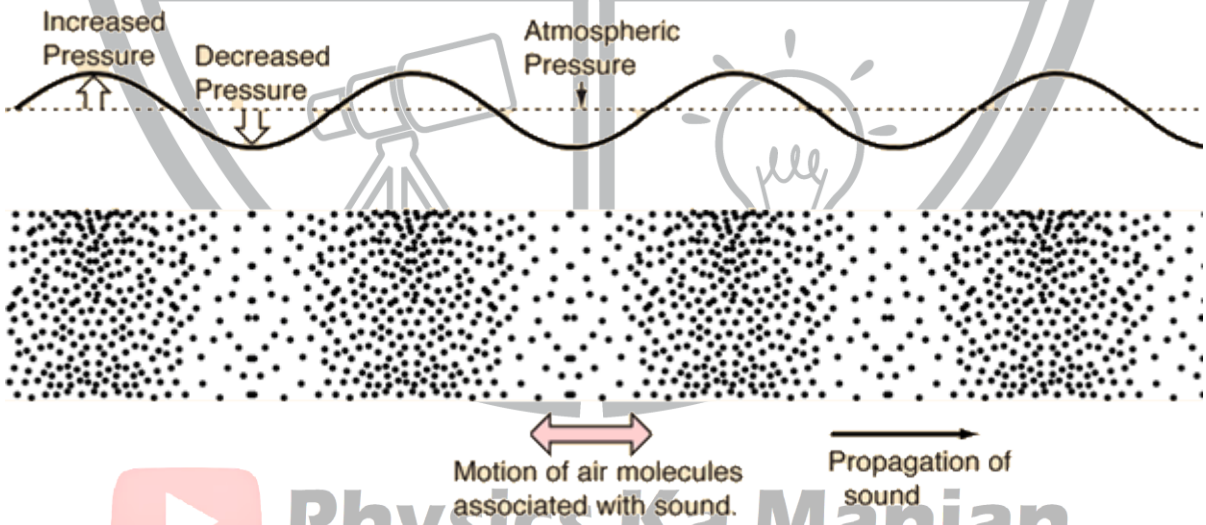
DO YOU KNOW?
The waves transport both energy and momentum in a medium

TRANSVERSE PERIODIC WAVES

- In a time-interval equal to time period a particle in the wave travels a distance equal to wavelength.
- The particles in the wave separated by a distance integral multiple of λ i.e. nλ are in phase motion with each other.
- The particles separated by a distance odd multiple of λ i.e. (n + 1/2) λ are out phase to each other.

SOUND

- A vibrating body produces sound waves (λ = 1m Approximately).
- Three things are essential for the detection of sound.
    1. Vibrating body for production of sound.
    2. Medium for propagation of sound.
    3. Listener (ear) for the detection of sound.



- Sound waves are longitudinal waves having three dimensional propagation in air.
- Longitudinal sound waves consist of compression and refraction.
- Compression is region where crowding of particles of medium is

Wave	Speed (m/s)
EM Waves	3,00,000,000

Sound in air	340
Sound in water	1,500
Sound in steel	5,000

- Refraction is a region where crowding of a particles of medium is minimum.
- Sound waves produce Reflection, Refraction, Diffraction, Interference but not polarization because sound waves are longitudinal.

SOUND INTENSITY

Sound intensity is defined as the sound power per unit area. The usual context is the measurement of sound intensity in the air at a listener's location. The basic units are watts/m^2 or watt/cm^2.
The most common approach to sound intensity measurement is to use the decibel scale:

$$I(dB) = 10 \log_{10} \left[\frac{I}{I_0}\right] \text{ intensity in decibel}$$

VELOCITY OF SOUND IN AIR

- Newton was the first to derive a formula for speed of sound in any medium. Its base was that sound waves travel in air isothermally.

$$V = \sqrt{E/\rho}$$

Where, E = modulus of elasticity of medium
ρ = density of medium

- In gases, sound travels in the form of compressional wave; and gases have bulk modulus of elasticity. So, for gases we get

$$V = \sqrt{E_{bulk}/\rho}$$

- Bulk modulus of elasticity is ratio of stress to volume strain

$$E_{bulk} = P/(\Delta V/V)$$

- Newton proved that for air $E_{bulk} = P$, so that at S.T.P.

$$V = \sqrt{P/\rho}$$

$V = \sqrt{hdg/\rho}$ Where d is density of mercury

$$V = \sqrt{76 \times 13.6 \times \frac{981}{0.001293}}$$

$$V = 28{,}100 \text{ cm/s}$$

$$V = 281 \text{ m/s}$$

- Percentage error in Newton's calculation was 16% because of assumption that sound propagates through air isothermally.
- Laplace corrected Newton's formula by proposing that "sound wave does not propagate in air isothermally but adiabatically, as air is a thermal insulator".
- Laplace's formula is given as:

$$V = \sqrt{\gamma P/\rho}$$

$$\gamma = C_p/C_v$$

$\gamma = 1.42$ (for air)

- Experimentally it is found that speed of sound increases by 0.61 m/s or 61 cm/s for each 1°C rise in temperature.

EFFECT OF MOISTURE

Water vapors are lighter than air thus the presence of moisture in air reduces density hence the speed of sound increases in such cases.

- **Dependence of velocity of sound**
  1. V is independent of pressure
  2. $V \propto 1/\sqrt{P}$
  3. $V \propto \sqrt{T}$

DO YOU KNOW?
The speed of sound in hydrogen is four times more than the speed of sound in oxygen at same.

4. $V_1/V_2 = \sqrt{T_1/T_2}$
5. $V_1 = V_0 + 0.61\ t$

PRINCIPLE OF SUPERPOSITION

The resultant displacement of a point of medium is equal to sum of individual displacement produced by each move. This is called principle of superposition.

$$Y_{total} = Y_1 + Y_2 + Y_3 + \ldots\ldots\ldots + Y_n$$

APPLICATIONS

1. **Interference:** It is produced by two waves of same frequencies, which are traveling in the same direction.
2. **Beats:** These are produced by two waves of slightly different frequencies in the same direction.
3. **Stationary Waves:** These are produced by two waves of equal frequency and equal amplitude traveling along same line in opposite direction.

INTERFERENCE OF SOUND

Superposition (mixing up) of two identical sound waves while passing through same medium propagating along same direction is called interference.

- **Conditions for interference**
  1. Coherent Waves
  2. Same Medium
  3. Same Direction
  4. Identical Waves
  5. Source of sound should be close to each other
- In constructive interference, two interfering sound waves reinforce each other, so that a resultant is a louder sound.

CONDITION FOR CONSTRUCTIVE INTERFERENCE

Path difference = $n\lambda$ where n = 0, ±1, ±2 ……

- In destructive interference, two interfering sound cancel each other's effect so that the resultant loudness of sound is become fainter.

CONDITION FOR DESTRUCTIVE INTERFERENCE

Path difference = $(n + ½)\lambda$ where n = 0, ±1, ±2 ……

- Echoing zone is region of constructive interference.
- Silence zone is region of destructive interference.
- Path difference is the difference between lengths of paths traveled by two waves.

BEATS

The periodic alteration of sound between maximum and minimum loudness are called beats.

- Beats are produced by the interaction of two waves having slightly different frequencies traveling in same medium along same direction.
- Beat frequency is number of beats per second.
- Different between frequencies of two tuning forks producing beat is given as:

$$f_{beat} = f_A - f_B$$

Maximum beat frequency for normal ears is 10 Hz.

- Beats are used to

1. Determine unknown frequencies
2. Tune musical instruments

REFLECTION OF WAVES

- All kind of wave shows reflection i.e. reflection is wave characteristic.

- When reflection of wave takes place from denser boundary, the phase of wave reverses. In this case, reflection co-efficient is maximum and transmission coefficient is almost zero except for quantum mechanical transmission of particle from potential barrier.
- When reflection takes place from rare boundary, there is no phase reversal. In this case, reflection co-efficient and transmission coefficient have considerable values.

DO YOU KNOW?
The reflected wave has the same wavelength and frequency but its phase may change depending on the nature of medium.

TRANSMISSION OF WAVES

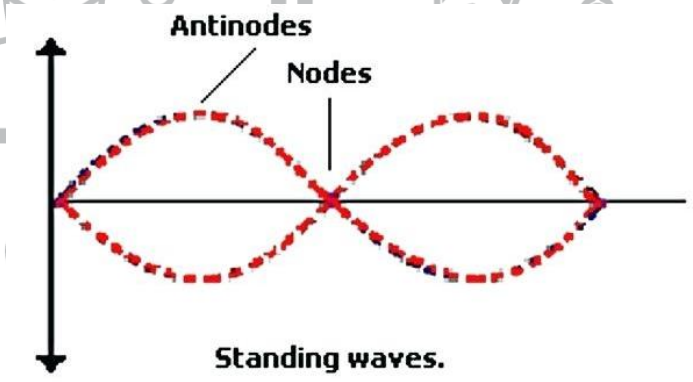
- Amplitude of transmitted wave is less than that of incident wave because some of energy of incident wave is wasted at point of discontinuity.
- Frequency transmitted wave is same as that of incident wave but its velocity depends on density of medium as given below:

$$V \propto 1/\sqrt{\rho}$$

- Since velocity of transmitted wave is different from original wave therefore, wave length (λ) changes as frequencies of both waves are equal.

STANDING WAVES

- Interaction of two identical waves traveling opposite to each other in the same medium, gives rise stationary or standing waves.
- Both constructive and destructive interference takes place in formation of stationary waves.
- Points of constructive interference are called antinodes while points of destructive interference are called nodes as shown



- Amplitude is maximum at antinodes and minimum (zero) at nodes.
- Nodes are stationary points whereas antinodes are points that vibrate with maximum amplitude.
- Two consecutive nodes or antinodes are separated by a distance equal to $\lambda/2$ and an antinode and its consecutive node by $\lambda/4$

DO YOU KNOW?
The energy stored in antinodes at their extreme position is wholly potential while at equilibrium position the energy stored is usually kinetic but total energy remains the same.

STANDING WAVES IN STRECHED STRINGS

- At fixed end of string always node is formed while at free end of string always antinode is formed.

- If string fixed at both ends, the number of nodes is one greater than no of antinodes.
  N = A + 1
- If string is free at one end, the no of antinodes is equal that of nodes.
  A = N
- Speed of string wave is
  $V = \sqrt{T/m} = \sqrt{F/m}$
  m is called linear mass density
- Frequency of stationary wave is
  $f_n = n f_1$
  Where $f_1 = \frac{1}{2l}\sqrt{\frac{T}{m}}$
- Stationary waves obey quantization of frequency
  $f_n = n f_1$; n = 1, 2, 3, ……
  Where f_1 is the lowest frequency (fundamental or basic frequency) at which first stationary wave is formed.
  All other frequencies (f_2, f_3 ,…… f_n) which are integral multiple of fundamental frequencies are called overtones or harmonics.

DO YOU KNOW?
The speed of stationary waves is independent of the No of loops.

STANDING WAVES IN AIR COLUMNS
FREQUENCIES OF STANDING WAVES

	Pipes open or closed at both sides string fixed at both ends	Pipes open at one end
Length L	$L = n\lambda/2$	$L = (2n-1)\,\lambda/4$
Fundamental	f = v/2l	f = v/4l
Harmonics	2f	3f
	3f	5f
	…..	…..
	nf	(2n -1) f

Where n = 1, 2, 3, ……

- Fundamental frequency of open pipe = 2 × fundamental frequency of closed pipe.
- No of harmonics in open pipe = 2 × no of harmonics in closed pipe

DOPPLER'S EFFECT

Apparent change in pitch (frequency) of sound is due to relative motion of source and observer.

- Doppler's Effect was discovered by Doppler, an Australian physicist, in 1845.
- Apparent frequency of sound heard by **stationary listener**, due to source **moving towards** him at speed 'u' is given as;
  $f' = (v/v-u) f$ $f' > f$
- Apparent frequency of sound heard by **stationary listener** due to source **moving away** from him at speed 'u' is given as;
  $f' = (v/v+u) f$ $f' < f$
- Apparent frequency of sound heard by a **person moving towards** a **stationary source** with speed 'u' is given as;
  $f' = (v+u/v) f$ $f' > f$
- Apparent frequency of sound heard by a listener **moving away from a stationary source with** speed 'u' is given as;

$$f' = (v-u/v)\, f \qquad f' < f$$

- When source and listener move in same direction, then frequency of sound heard by listener is given as;

$$f' = (v-u_0/v+u_s)f$$

where v = True speed of sound u_0 = Speed of listener u_s = Speed of source

- When source and observer are moving away from each other, then frequency of sound heard by listener id given as;

$$f' = (v+u_0/v-u_s)f$$

- Light observes Doppler's Effect too

APPLICATION OF DOPPLER'S EFFECT

1. Ships and submarines (sonar devices)
2. Bats (for travelling)
3. Radar (for detection)
4. Determining velocity of a star w.r.t earth
5. To monitor blood flow in major arteries

- When a start is moving away from earth then wavelength of light increases and red shift of spectrum is observed.
- When a start is moving toward the earth then wavelength of light decreases and blue shift of spectrum is observed.

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PRACTICE SHEET

1. Mechanical waves:
   a. are longitudinal only
   b. are transverse only
   c. can be both transverse and longitudinal
   d. require no medium for propagation

3. The speed of sound waves having a frequency of 256 Hz, compared with the speed of sound waves having a frequency of 512 Hz is:
   a. half as great
   b. twice as great
   c. 4 times as great
   d. same

4. The formula for speed of wave on a string is given by $v = \sqrt{\frac{F}{m}}$, here m is equal to:
   a. mass of string
   b. mass of rigid body
   c. length of the string
   d. mass per unit length of the string

5. Choose the correct statement:
   a. sound waves are transverse waves
   b. sound travels fastest through vacuum
   c. sound travels faster in solids than in gases
   d. sound travels faster in gases than in liquids

6. Transverse waves can propagate:
   a. both in a gas and in a metal
   b. in a gas but not in a metal
   c. not in a gas but in a metal
   d. neither in a gas nor in a metal

7. A string of length ℓ, fixed at both ends, is vibrating in two segments. The wave length of the corresponding wave is:
   a. $\frac{\ell}{4}$
   b. $\frac{\ell}{2}$
   c. ℓ
   d. 2ℓ

8. Passage of waves from one medium into another is called:
   a. reflection
   b. refraction
   c. transmission
   d. diffraction

9. Mark the correct statement:
   a. Apparent frequency increases when the source approaches the observer at rest
   b. Apparent frequency increases when the listener approaches the source at rest
   c. No change in frequency occurs if both source and listener are moving with the same speed
   d. All of them

10. In relation for over tones produced by an open-end organ pipe $f_n = n\left(\frac{v}{2\ell}\right)$, the value of integer n are:
    a. 1, 2, 3, ...
    b. – 1,– 2,– 3, ...
    c. 0, 1, 2, 3, ...
    d. $\frac{1}{2}, \frac{3}{2}, \frac{5}{2}$, ...

11. Overtones produced by a closed-end organ pipe are:
    a. f, 3f, 5f, ...
    b. 2f, 3f, 4f, ...
    c. 3f, 5f, 7f, ...
    d. f, 2f, 3f, ...

12. Beats occur because of
    a. Interference
    b. Reflection
    c. Refraction
    d. Doppler effect

13. The expression $v = f\lambda$ is valid for all types of:
    a. linear motion
    b. angular motion
    c. rotatory motion
    d. wave motion

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14. Path difference for constructive interference is:

a. $\Delta s = n \lambda$ b. $\Delta s = ½ n \lambda$ c. $\Delta s = \frac{\lambda}{n}$ d. $\Delta s = n/ \lambda$

15. When a sound source moves towards a stationary observer there is:

a. an apparent increase in wavelength
b. an apparent increase in frequency
c. an apparent decrease in frequency
d. a decrease in pitch

16. Which of the following statement is correct?

a. Both sound and light waves in air are longitudinal
b. Both sound and light waves in air are transverse
c. Sound waves in air are transverse and light waves are longitudinal
d. Sound waves in air are longitudinal and light waves are transverse

17. The speed of sound wave in a medium depends upon:

a. elasticity of medium
b. density of medium
c. amplitude of particle in medium
d. both density and elasticity of medium

18. Velocity of second in vacuum is:

a. 332m/s b. zero c. 320m/s d. 322m/s

19. It is a common characteristic of all types of wave motion that:

a. Particles move up and down
b. Particles move back and forth
c. Energy is transferred without the transport of particles
d. Energy is transferred with the transport of particles

20. When two identical traveling waves are superposed, the velocity of the resultant wave:

a. decreases b. increases c. remains same d. becomes zero

21. Identify the waves, which do not need any medium for its propagation:

a. electromagnetic wave
b. water wave
c. sound wave
d. waves on string of guitar

22. If a wave oscillator vibrates 10 times in one second with a speed of 10m/s. Then the correct wavelength of the wave is:

a. 1m b. 30m c. 50m d. 10m

23. The amplitude of a wave indicates the:

a. height of crest b. depth of trough c. intensity of a wave d. all of above

24. The fundamental frequency of stationary wave is:

a. the maximum frequency
b. the minimum frequency
c. the average frequency
d. all of the above

25. If the number of loops of a stationary wave are increasing then:

a. wavelength gets higher
b. wavelength gets shorter
c. wavelength becomes constant
d. none of these

26. In order to produce beats, the two waves must have:

a. similar frequency
b. similar amplitude

c. slightly different frequency d. slightly different amplitude

27. Frequencies less than 20 hertz are called:
a. Ultrasonic b. Supersonics c. Infrasonic d. None of these

28. The distance between two consecutive antinodes is:
a. $\lambda/4$ b. $\lambda/2$ c. λ d. 2λ

29. A stationary wave is set up in the air column of a closed pipe. At the closed end of the pipe:
a. Always a node is formed
b. Always antinode is formed
c. Neither node nor antinode is formed
d. Sometimes a node and sometimes an antinode is formed

30. In a stationary wave, the particle velocity at the node is:
a. Maximum b. minimum c. zero d. constant

31. The velocity of a transverse waves along a string of mass per unit length m and stretched with tension F is:
a. v = F/m b. v = m/F c. $v = F/(m)^2$ d. $v = \sqrt{F/m}$

32. A set of frequencies which are multiplies of the fundamental frequency are called:
a. Doppler frequencies b. Nodal frequencies c. Beat frequencies d. Harmonics

33. Sound waves do not travel in vacuum because:
a. They are transverse waves b. They are stationary waves
c. They require material medium for propagation d. They do not have enough energy

34. The velocity of sound in air at 0°C is:
a. 224 ms^{-1} b. 322 ms^{-1} c. 300 ms^{-1} d. 332 ms^{-1}

35. How many anti-nodes must be there between two nodes?
a. 3 b. 2 c. 1 d. zero

36. Which one of the following properties of sound is affected by change in air temperature?
a. Frequency b. Amplitude c. Intensity d. velocity

37. Beats are the results of:
a. Diffraction of sound waves b. Constructive and destructive interference
c. Polarization d. Destructive interference

38. Doppler's Effect applies to:
a. Sound waves only b. Light waves only
c. Both sound and light waves d. Neither sound nor light waves

39. The number of nodes between two consecutive antinodes is:
a. zero b. 3 c. 2 d. 1

40. The path difference is an odd integral multiple of half the wave length in:
a. Constructive interference b. Destructive interference

c. Constructive and destructive interference d. Only interference

41. Path difference for constructive interference is given by:
a. $\Delta s = (2n + 1)\,\lambda/2$ b. $\Delta s = n\,\lambda$ c. $\Delta s = n/\lambda$ d. $\Delta s = n\lambda/2$

42. If an aero plane approaches towards the radar, then the wavelength of the wave reflected from aeroplane would be:
a. Shorter b. Larger c. The same d. None of these

43. Detection and location of submarines can be detected by:
a. Bernoulli's effect b. Photoelectric effect c. Compton Effect d. Doppler Effect

44. When sound waves travel from air to water which of these remains' constant:
a. Velocity b. Frequency c. Wavelength d. All of above

45. For production of beats the two sources must have:
a. Different frequencies and same amplitude
b. Different frequencies
c. Different frequencies, same amplitude and same phase
d. Different frequencies and same phase

46. The temperature at which the speed of sound in air becomes double its value at 0°C is:
a. 1092°C b. 819 K c. 819°C d. 546°C

47. The frequency of the whistle of an engine is 600 Hz. It is moving with a speed of 30m/s towards a stationary observer. The apparent frequency is (speed of sound = 330m/s)
a. 630 Hz b. 660Hz c. 570 Hz d. 540 Hz

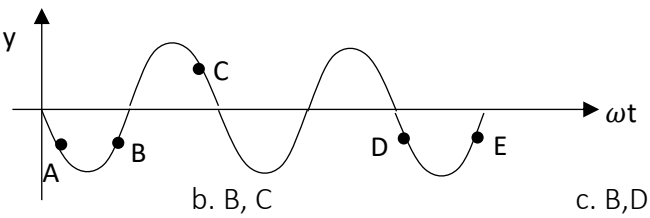
48. A stretched string of length 1m has mass per unit length 0.5g. The tension in the string is 20N. It if is plucked at a distance of 25 cm from one end, the frequency of vibration will be:
a. 200 Hz b. 100Hz c. 300Hz d. 400Hz

49. A stretched string of length 2m vibrates in 4 segments. The distance between consecutive nodes is:
a. 0.5 m b. 0.25 m c. 1.0 m d. 0.75 m

50. An air column in a pipe, which is closed at one end, will be in resonance with a vibrating tuning fork of frequency 256 Hz, if the length of the column in cm is (velocity of sound in air= 340 m/s):
a. 21.25 b. 125 c. 62.50 d. 33.2

51. The distance between two consecutive antinodes is 0.5m. The distance traveled by the wave in half the time period is:
a. 2m b. 1m c. 0.5m d. 0.25 m

52. The diagram shows the profile of a wave. Which of the following pairs of points are in phase?



a. A, B b. B, C c. B,D d. B,E

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53. Ultrasonic waves are those waves which:
a. human beings cannot hear
b. human beings can hear
c. has high velocity
d. have large amplitude

54. The ripple tank is used to study various features of:
a. particle phenomenon
b. wave phenomenon
c. light phenomenon
d. solids

55. Laplace's correction in the formula for the speed of sound given by Newton was needed because sound waves:
a. are longitudinal
b. propagate isothermally
c. propagates adiabatically
d. have long wavelength

56. With the rise of temperature, the speed of sound in a gas:
a. increases
b. decreases
c. remains constant
d. may increase or decrease depending on the corresponding change in pressure

57. The speed of sound in air at STP is 300 m/s. If the air pressure becomes double, the temperature remaining the same, the speed of sound would become:
a. 1200 m/s
b. 600 m/s
c. $300\sqrt{2}$ m/s
d. 300 m/s

58. When a source of sound is in motion towards a stationary observer, the effect observed is:
a. increase in the velocity of sound only
b. decrease in the velocity of sound only
c. increase in frequency of sound only
d. increase in velocity and frequency both

59. The velocity of sound is generally greater in solids than in gases because:
a. The density of solids is high and the elasticity is low
b. Both the density and the elasticity of solids are very low
c. The density of solids is low and the elasticity is high
d. The elasticity of solids is very high

60. As a wave strikes against a wall:
a. Its phase changes by 180°, but velocity does not change
b. Its phase does not change, but velocity changes
c. Its velocity changes and phase too change by 180°
d. Nothing can be predicted about changes in its velocity and phase

61. The Doppler effect is applicable for:
a. light wave
b. sound wave
c. space wave
d. both (a) & (b)

62. Velocity of sound in air:
(i) Increases with temperature
(ii) decreases with temperature
(iii) Increases with pressure
(iv) is independent of pressure
(v) Decreases with pressure
(vi) is independent of temperature
Choose the correct answer:
a. only (i) and (ii) are true
b. only (i) and (ii) are true
c. only (i) and (v) are true
d. only (i) and (iv) are true

63. The speed of sound in air is 350m/s. The frequency of the fundamental note emitted by a tube of length 50cm open at both ends is:
a. 50 Hz b. 175 Hz c. 350 Hz d. 700 Hz

64. If the speed of sound is v, then the frequency of the fundamental note emitted by a closed pipe of length $\mathcal{l}$ is:
a. $v/2\mathcal{l}$ b. v/4 $\mathcal{l}$ c. 3v/4 $\mathcal{l}$ d. 4v/ $\mathcal{l}$

65. The velocity of sound in air is 330 m/s. The fundamental frequency of an organ pipe, open at both ends and of length 0.3m, will be:
a. 200Hz b. 550Hz c. 300Hz d. 275 Hz

66. The frequency of fundamental note emitted by a string of length $\mathcal{l}$, clamped at both ends is (v is the velocity of waves in the string)
a. v/ $\mathcal{l}$ b. 2v/ $\mathcal{l}$ c. v/2 $\mathcal{l}$ d. v/4 $\mathcal{l}$

67. An aero plane is heading towards airport, its frequency picked at the radar:
a. decreases b. increases
c. may increase or decrease d. remain unchanged

68. Which one of the following is carried (transported) from one place to the other by the waves?
a. mass b. momentum c. weight d. energy

69. Which of the following are longitudinal waves?
a. light waves b. stationary waves c. X-rays d. sound waves

70. Sound waves in air are produced as a result of:
a. reflection and refraction b. up and down motion of air particle
c. compressions and rarefactions d. electromagnetic waves

71. The speed of sound waves in a medium depends upon:
a. elastic modulus of medium only b. density of medium only
c. both elastic modulus and density d. pressure

72. A silence zone occurs due to:
a. resonance b. polarization
c. constructive interference d. destructive interference

73. Which of the following employs the Doppler Effect?
a. monitoring of blood flow through arteries b. determination of speed of satellites
c. detection and location of submarines d. all of the above

74. The amplitude and frequency of a sound wave are both increased. How are the loudness and pitch of the sound affected?
a. loudness is increased and pitch is raised b. loudness is increased and pitch is lowered
c. loudness is decreased and pitch is lowered d. loudness is decreased and pitch is raised

75. A guitar string is made to vibrate. What would make the pitch of the note rise?
a. a decrease in the amplitude of vibration b. an increase in the amplitude of vibration

d. an increase in the frequency of vibration

c. a decrease in the frequency of vibration

76. Intensity level in decibels if intensities I and $\mathbf{I_0}$ is given by

a. $10\log_{10}(\frac{I}{I_0})$ b. $10\ln(\frac{I}{I_0})$ c. $10\ln(\frac{I_0}{I})$ d. $10\log_{10}(\frac{I_0}{I})$

77. An engine is moving on a circular track with a constant speed. It is blowing whistle of frequency 500Hz. The frequency received by an observer standing stationary at the center of the track is:

a. 500 Hz b. more than 500 Hz

c. less than 500Hz d. more or less than 500Hz depending on the actual speed of engine

78. Doppler shift in frequency does not depend upon:

a. the actual frequency of the wave b. the distance of the source from the listener

c. the velocity of the source d. the velocity of the observer

79. If the velocity of sound in air is 340m/s, a person singing a note of frequency 250 Hz is producing sound waves with a wavelength of:

a. 0.7 m b. 1.36 cm c. 1.36 m d. 85 km

80. A whistle giving put 450Hz approaches a stationary observer at a speed of 33m/s. The frequency heard by the observer in Hz is:

a. 409 b. 429 c. 517 d. 500

81. If F is restoring force, k is force constant and y is displacement, which of the following expression represent the equation of simple harmonic motion

a. F = –ky b. $F = \sqrt{ky}$ c. F = ky d. none of these

82. The number of beats produced per second by two tuning forks when sounded together is 4. One of them has a frequency of 250Hz. The frequency of the other cannot be less than:

a. 254 Hz b. 252 Hz c. 248 Hz d. 246 Hz

83. The first resonance length in a closed organ piper is 50cm. Then the second resonance length will be:

a. 50cm b. 100 cm c. 150 cm d. 200 cm

84. The waves which do not require any medium for their propagation are called:

a. Mechanical waves b. Matter waves

c. Light waves d. Compressional waves

85. Mechanical waves are those which:

a. Do not need medium

b. Need medium but do not carry energy from one place to the other

c. Need medium

d. Carry energy but do not need medium

86. When the amplitude of a wave become double, its energy becomes:

a. Double b. Four times c. One half d. Nine times

87. A source of sound is moving towards a stationary observer with a speed of 50 m/s. The observer measures the frequency of the source as 1000Hz. The speed of sound is 350m/s. The apparent frequency measured by the observer when the source is moving away after crossing the observer is:

a. 750 Hz b. 850 Hz c. 1150 Hz d. 1250 Hz

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88. A source of sound is moving with a constant speed of 20m/s emitting a note of fixed frequency. The ration of the frequencies observed by a stationary observer when the source is approaching him and after it has crossed him is:

a. 9 : 8 b. 8 : 9 c. 10 : 9 d. 9 : 10

89. Speed of sound in a gas is proportional to:

a. square root of isothermal elasticity b. square root of adiabatic elasticity
c. isothermal elasticity d. adiabatic elasticity

90. Newton formula estimated the speed of sound:

a. 282 m/sec b. 333 m/sec c. 340 m/sec d. all of above

91. The temperature at which the speed of sound in air becomes double of its value at 27°C is:

a. 54°C b. 327°C c. 927°C d. -123°C

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ANSWER KEY

1.	C	31.	D	61.	D
2.	D	32.	C D	62.	C
3.	D	33.	C	63.	B B
4.	C	34.	D	64.	C
5.	C	35.	B	65.	B
6.	C	36.	C	66.	D
7.	C	37.	D	67.	D
8.	D	38.	B	68.	C
9.	A	39.	B	69.	C
10.	A	40	A	70	D
11.	A	41.	D	71.	D
12.	D	42.	B	72.	A
13.	A	43.	B	73.	D
14.	B	44.	C	74.	
15.	D	45.	B	75.	A A
16.	D	46.	B	76.	B
17.	B	47.	A	77.	C
18.	C	48.	D	78.	D
19.	C	49.	C	79.	A
20.	A	50.	D	80.	D
21.	A	51.	A	81.	C
22.	D	52.	B	82.	C
23.	B	53.	C	83.	C
24.	B	54.	A	84.	B
25.	C	55.	D	85.	A
26.	C	56.	C	86.	A
27.	B	57.	D	87.	B
28.	A	58.	A	88.	A
29.	C	59.	D	89.	C
30.	D	60.		90.	

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CHAPTER 9
PHYSICAL OPTICS

WAVE FRONT AND RAYS

- Wave front is a locus of points which have same phase of vibrations.
- Following are the types of wave front:

1. SPHERICAL WAVE FRONT

Set of points, which determine the surface of sphere.

2. CYLINDERICAL WAVE FRONT

Set of points, which determine the surface of cylinder.

3. PLANE WAVE FRONT

A small part of spherical or cylindrical wave front at very large distance from source of light.

- Point of light produce spherical wave fronts.
- When a point source is at focus of converging lens, plane wave fronts are obtained.
- Plane wave fronts reach from the sun to the earth, as the earth is far off from the sun.
- The distance between consecutive wave fronts is one wavelength.

A line normal to the wave front including the direction of motion is called a ray of light.

DO YOU KNOW?
A point source of light is placed at principle focus of convex lens will produce a plane wave.

HUYGEN'S PRINCIPLE

1. Every point on wave front act as a source of secondary wavelets, which propagates in forward direction with speed of light.
2. Position of new wave front of all secondary wavelets is tangent envelope to all of them.
3. Radius of hemisphere = $c\Delta t$

- There is an infinite number of secondary wavelets present on wave front.
- Light ray is associated with direction of flow of light energy.
- In a homogenous medium, the energy of wave is transmitted equal in all sides and wave front remains spherical for long distance.

INTERFERENCE OF LIGHT

Interference is a superposition of two light waves of same frequency and same amplitude propagating in same medium along same direction very close to each other.

- For constructive interference, light wave reaches a point in phase and their path difference = $n\lambda$.
- For destructive interference, light wave reaches a point in out of phase and their path difference = $(2n + 1)\ \lambda/2$.
- **Conditions for interference of light**
  1. Monochromatic (Having single wave length)
  2. Coherence (Having constant phase difference)
  3. Same direction
  4. Same medium
  5. Very close to each other
- There is no perfect monochromatic source, but by using filters it is possible to produce a source that gives light whose wavelength differ by $\pm 5 \times 10^{-10}$ m.
- If phase difference between two waves remains constant, then interference pattern will be stationary on screen otherwise it will change continuously.

- For two ordinary sources, no interference pattern is obtained, because the phase changes rapidly and irregularly (that's why to get two coherent waves a single source of light is split into two).
- Optical path is equal to product of refractive index of medium and distance covered in air.

Optical Path = nd

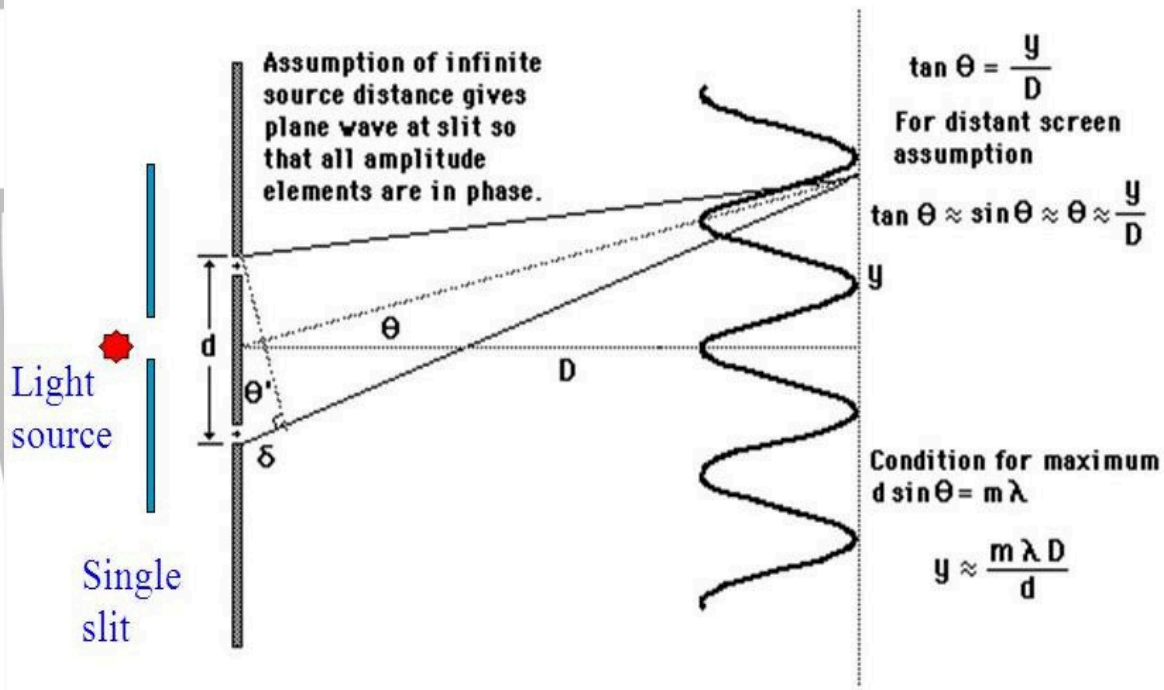
Where 'n' is refractive index and 'd' is path in air.

YOUNG'S DOUBLE SPLIT EXPERIMENT

- Path difference = d Sin θ
- For bright fringes:

  d Sin θ = m λ 1st bright fringe at m = 0
- For dark fringes:

  d Sin θ = (2m + 1) λ/2 1st dark fringe at m = 0



- $y_m = m\lambda D/d$ (Position of m^{th} bright fringes)
- $y_m = (2m + 1)\lambda D/2d$ (Position of m^{th} dark fringes)
- $\lambda = y_m d/mD$ (Wavelength from bright fringes)
- $\lambda = 2 y_m D/(2m + 1) d$ (Wavelength from dark fringes)
- Distance between centers of two consecutive dark fringes or bright fringes is called fringe width.

  F.W = λD/d (Applicable both for bright dark fringes)
- **Suggestions to widen interference fringes**

  F.W α λ (To increaseλ)

  F.W α D (To increase D)

  F.W α 1/d (To decrease d)

INTERFERENCE IN DIFFERENT TYPES OF FILMS

- Thin film of refracting medium having thickness comparable to the wavelength of light rays e.g.
  1. Oil film on water
  2. Soap film
  3. Air film
- When exposed to white light, thin film produces colorful pattern due to interference.

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- When exposed to monochromatic light, only bright and dark fringes are obtained.
- Classification of thin films

1. Uniform or parallel thin films

Whose thickness is uniform? It gives straight interference pattern

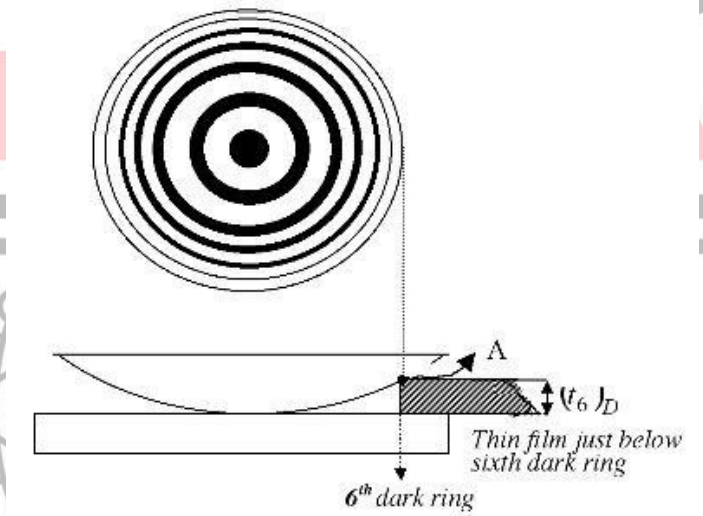
2. Wedge-shaped films

Whose thickness is zero at one end and then increase uniformly. Its interference pattern comprises a set of parallel fringes all parallel to the edge of wedge.

- Wedge shaped films can be obtained using a spacer between the two slides of glass.
- The thinnest part of wedge film shaped is always dark, due to additional path difference of $\lambda/2$, caused by phase reversal, at denser medium.

NEWTON'S RINGS

- Newton's ring are practical study of interference in wedge shaped thin films.



1. When sodium light is incident on the Plano convex lens system, lightray reflect from upper and lower layers of the air present between lens and the glassplate. The sodium light source is almost monochromatic.

   There is no phase change at the lens-air surface, because the wave if going from higher to a lower refraction index medium. At the air-plate surface, however, there is a phase shift of p with the reflection from medium of higher refractive index.

   Waves reflected from these two surfaces interfere, forming bright bands where the path length in air produces two waves in phase and dark bands where the waves are in antiphase.

   The center of the pattern is black. There is no reflection because there is no air gap here.
2. The thickness of the thin film is equal to the thickness of the airfilm adjacent to it.
3. The fringes are circular as the locus of points of equal thickness of air is a circle.

- Conditions of interference are reversed for Newton's rings as;

  Path difference = mλ (for dark ring)

  Path difference = (2m + 1) $\lambda/2$ (for bright ring)

  This is due to **Phase reversal by 180°** and extra path difference of $\lambda/2$.
- Point of contact is always dark due to **Phase reversal** at point of contact.

PRIMARY AND SECONDARY COLOURS

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Red, Green and blue colors are called primary colors. Complementary colors of white light are those two colors of white light are those two colors, whose combined effect is to produce white light on eye. They are;

1. Red and blue – green
2. Yellow and blue – violet
3. Green and purple (mixture of red and blue)

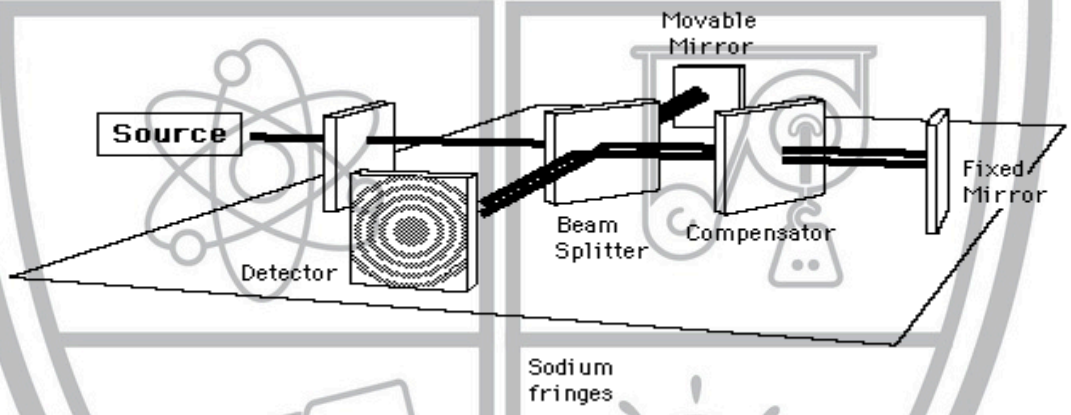
If two primary colors of white light are mixed, we get complementary colors, e.g. red and green primary colors are mixed, we get yellow, which is complementary colors of blue-violet.

DIFFERENCE BETWEEN LUMINOUS, NON-LUMINOUS AND INDECENT OBJECTS

→ A luminous object is one that emits its own light e.g. sun.
→ A non-luminous object is that which is visible by light it reflects e.g. moon.
→ Incandescent objects are that which emit light due to heating e.g. filament of electric bulb.

MICHELSON INFEROMETER

- Michelson Inferometer is an optical instrument used for following purposes;
  1. Testing lenses, mirrors and prisms
  2. Measurement of refractive indices
  3. Thickness of plate



- Inferometers are based upon the principle of division of wave front.
- Michelson's inferometer consists of following essential parts;
  1. Diffused source of monochromatic light.
  2. Beam splitter (semi silvered glass).
  3. Plane mirrors held to each other, one is fixed and the other is movable.
  4. Micrometer (It is attached to movable mirror).
  5. Compensator (Glass plate equal in thickness to beam splitter).
  6. Telescope (To observe interference fringes).
- If mirror is moved by a distance of $\lambda/2$, with **dark fringes in view**, then fringe of same kind is observed because **total path difference is λ**.
- If mirror is moved by a distance of $\lambda/4$, then **alternatively, dark** and bright fringes can be observed because **total path difference is $\lambda/2$.**
- If mirror is moved through distance P, then 'm' fringes pass before eye.

$$P = m\,\lambda/2$$

- Inferometer can be used:
  1. To determine refractive index
  2. To test planes of glass slabs and lenses
  3. To determine wavelength of light

DIFFRACTION OF LIGHT

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Bending of light around edges of a slit is called diffraction or the spreading of light waves into geometrical shadow of an obstacle and redistribution of light intensity resulting in dark and bright fringes is called diffraction of light.

• The smaller is size of diffracting object (obstacle), the higher degree of diffraction is observed.

Interference	Diffraction
Superposition of few secondary wavelets involved.	Superposition of large number of secondary wavelets is involved.
Interference fringes are equal in size.	Diffraction fringes wide near diffracting object and become small as one move away from it.
Interference fringes are equally spaced.	Diffraction fringes become narrow as distance from diffracting object decreases.
Points of destructive interference are perfectly dark.	Points of maximum intensity are not perfectly dark.

DIFFRACTION DUE TO NARROW SLIT

• Diffraction due to a narrow slit has central maxima and alternative minima and maxima on either side.

• Condition for mth order minima on either side of center is given by

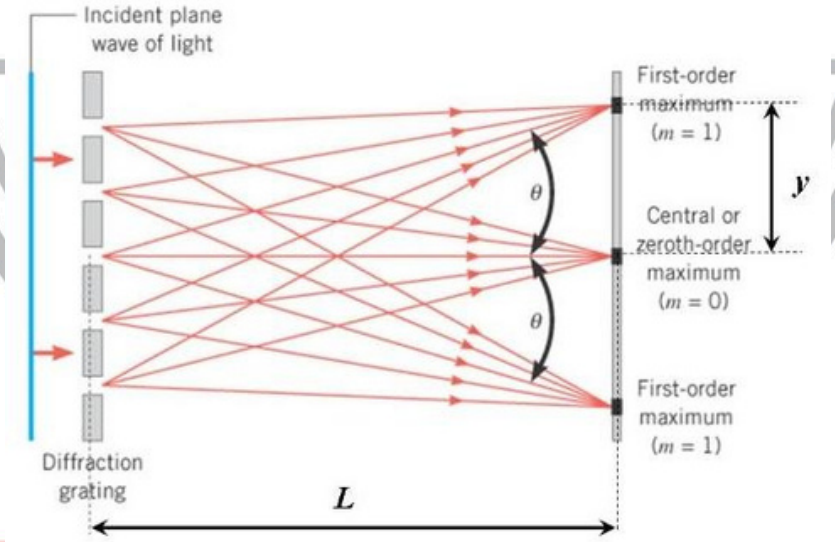
$$D \sin\theta = m\lambda$$

Where m = 1, 2, 3, ...

DIFFRACTION GRATING

Diffraction grating is a multi-slit arrangement of parallel and equally spaced slits.

Suppose monochromatic light is directed at the grating parallel to its axis as shown. Let the distance between successive slits be d.



The diffraction pattern on the screen is the result of the combined effects of diffraction and interference. Each slit cause diffraction, and the diffracted beams in turn interferewith one another to produce the pattern. The path difference between waves from any two adjacent slits can be found by dropping a perpendicular line between the parallel waves. By geometry, this pathdifference is d Sin θ.

If the path difference equals one wavelength or some integral multiple of a wavelength, waves from all slits will be in phase and a bright line will be observed at that point. Therefore, thecondition for maxima in the interference pattern at the angle θ is

$$d \sin\theta = m\lambda$$

where n = 0, 1, 2, 3,....

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Because d is very small for diffraction grating, a beam of monochromatic light passing through a diffraction grating is splitted into very narrow maxima (bright fringes) at large angles θ.

- Lines are opaque while separation between them are transparent, so space between two engraved lines behave as slits.
- Distance between two slits is called grating element.
  d = 1/N
  Where 'N' is the number of lines in one unit length.
- Grating equation is given as;
  $d \sin\theta = m\lambda$
  Where 'm' is called the order of diffraction pattern.
- For white light, we see colored fringes.
- Resolving power of grating is its ability to separate to wavelengths of light in given order of of their spectrum.
  Resolving Power = $\lambda/\Delta\lambda$ = N × m
  N = Number of lines ruled on grating
  m = Order of diffraction

DIFFRACTION OF X-RAYS BY CRYSTALS

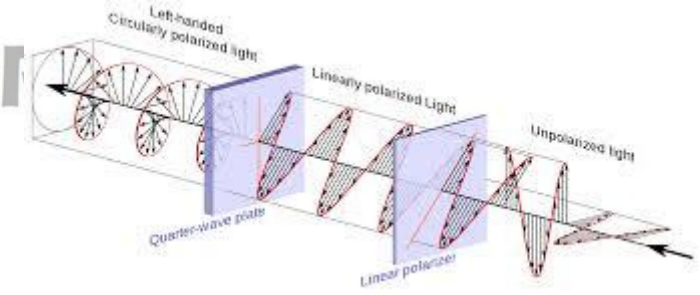
- Bragg's law is given as
  $2 d \sin\theta = m\lambda$
  Where 'd' is called lattice spacing and θ is called angle of diffraction.
- Solid crystal behaves as very good natural diffraction gratings and incident ultraviolet light is diffracted from layers of atoms.
- Inter atomic layer distance is called lattice constant.
- In 1913, Max Von Laue suggested that since atomic layers in solid NaCl have layer separation of 10^{-10} m, therefore, **X-rays can be diffracted**.
- Max Von Laue pattern on films is in the form dark spots/bright spots.
- Analysis of the relative intensity of dark spots/bright spots.
- Analysis of the relative intensity of dark/bright spots gives rise to crystal structure of solid.

DO YOU KNOW?
Diffraction proves the wavelength of light is smaller than that of sound.

POLARIZATION

Confinement of electric vectors of light into one plane is called polarization.

- The material which produces polarization, is called polarizer, e.g. tourmaline crystal is a polarizer.



- Polaroid (polarizer) absorbs all magnetic vectors as well as randomly oriented electric vectors leaving only those electric vectors, which are in one plane.

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- Tourmaline crystal has internal molecular structure such that their interaction with incident light is to:
  1. Absorb all magnetic vectors
  2. Put (confine) all electric vectors in one plane.
- Polarization is possible only in EM waves because their electric and magnetic vectors are perpendicular to each other as well as to direction of propagation. **Thus, polarization has established that light is a transverse wave**.
- Analyzer is used to test plane polarization.
- Plane determined by direction of propagation and polarized electric vectors of light is called
- plane of polarization.
- Plane determined by direction of propagation and polarized electric vectors of light is called plane of polarization.
- Different methods for producing plane polarized light are given below;
  1. Polarizer (e.g. tourmaline crystal, calcite, crystal).
  2. Polarization by reflection.

Uses of polarized light

- 1. Determine of optically active substance e.g. sugar in blood & urine
  2. Curtain less window
  3. To enhance effect of clouds & sky in photograph.
  4. Headlights of vehicles to control the glare in night driving

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PRACTICE SHEET

1. While carrying out Young's Double Slit experiment for interference of light with two slits, maxima occur at angles for which ($\sin\theta = \frac{m\lambda}{d}$) Here d is:
   a. distance of slits from screen
   b. distance between dark and bright fringes
   c. distance between slits
   d. width of m^{th} fringe

2. Conclusion of Young's experiment establishes that:
   a. light consists of wave
   b. light consists of particles
   c. light is neither particle nor wave
   d. light is both particle and wave

3. Colors of thin film are due to:
   a. dispersion of light
   b. interference of light
   c. absorption of light
   d. scattering of light

4. When viewed in white light, soap bubbles show colors because of:
   a. interference b. scattering c. diffraction d. dispersion

5. A thin air film between a plane glass plate and a convex lens is irradiated with parallel beam of monochromatic light and is observed under a microscope. We see:
   a. uniform brightness
   b. complete darkness
   c. field crossed over by concentric bright and dark rings
   d. field crossed over by a straight bright and dark fringe.

6. The central part of Newton's rings is dark due to the reason that:
   a. The part of the ray reflected from upper surface of plane convex lens undergoes a phase shift of 180°
   b. The reflection from the upper surface of sir film undergoes a phase shift of 180°
   c. The reflection from the lower surface of sir film undergoes a phase shift of 180°
   d. None of the above

7. One cannot see through fog because:
   a. Fog absorbs light
   b. The refractive index of fog is infinity
   c. Light suffers total reflection at the droplet in a fog
   d. Light is scattered by the droplets in fog

8. Stars Twinkle due to:
   a. The fact that stars do not emit light continuously
   b. The refractive index of the earth's atmosphere fluctuates.
   c. Intermittent absorption of star light by its own atmosphere.
   d. None of these

9. A diffraction grating has 500 lines per mm. Its slit spacing (grating element) will be:
   a. 5×10^{3} mm b. 5×10^{-3} mm c. 2×10^{3} mm d. 2×10^{-3} mm

10. What is the frequency of light whose wavelength is 5×10^{-7} m?
    a. 5×10^{-7} Hz b. 3×10^{8} Hz c. 6×10^{-4} Hz d. 6×10^{14} Hz

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11. How many fringes will pass a reference point if the moveable mirror of a Michelson's interferometer is moved 0.06 mm? The wavelength of light used is 6×10^{-3} mm.
a. 200 b. 300 c. 20 d. 203

12. Two waves originating from sources S_1 and S_2 having zero phase difference and common wavelength λ will show completely destructive interference at a point P if $S_1P - S_2P$ is:
a. 5λ b. $3\lambda/4$ c. 2λ d. $11\lambda/2$

13. Two coherent sources of wavelength 6.2×10^{-7} m produce interference. The path difference corresponding to 10^{th} order maximum will be:
a. 12.4×10^{-6} m b. 6.2×10^{-6}m c. 3.1×10^{-6} m d. 1.5×10^{-6} m

14. Light appears to travel in straight lines since:
a. It is not absorbed by the atmosphere b. It is reflected by the atmosphere
c. Its wavelength is very small d. Its velocity is very large

15. If yellow light emitted by sodium lamp in Young's double slit experiment is replaced by monochromatic blue light of the same intensity:
a. Fringe width will decrease b. Fringe width will increase
c. The fringe width will remain unchanged d. Fringes will become less intense

16. Huygens's conception of secondary waves:
a. Helps us to find the focal length of a thick lens
b. Is a geometrical method to find wave-fronts
c. Is used to determine the velocity of light
d. Is used to explain polarization of light

17. The fringe width in Young's double slit experiment can be increased by decreasing:
a. separation of the slits b. distance between slit and stress
c. wavelength of the source of light d. all of these

18. In Young's double slit experiment the separation between the slits is doubled and the distance between the slit and screen is halved. The fringe width becomes:
a. one-fourth b. half c. double d. quadruple

19. The fringe pattern observed in Young's double slit experiment is:
a. A diffraction pattern
b. An interference pattern
c. A combination of diffraction and interference patterns
d. Neither a diffraction nor an interference pattern

20. The phenomenon of interference is shown by:
a. longitudinal mechanical waves only b. transverse mechanical waves only
c. non-mechanical transverse waves only d. all of the above types of waves

21. Polarization of light proves the:
a. corpuscular nature of light b. quantum nature of light
c. transverse wave nature of light d. longitudinal wave nature of light

22. Longitudinal waves do not exhibit:

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a. refraction b. reflection c. diffraction d. polarization

23. Two sources of waves are called coherent is:
a. Both have the same amplitude of vibrations.
b. Both produce waves of the same wavelength.
c. Both produce waves of the same wavelength having a constant phase difference.
d. Both produce waves having the same velocity.

24. In Young's experiment of one source and two slits, one of the slits is covered with black paper. Then:
a. The fringes will be darker.
b. The fringes will be narrower
c. The fringes will be broader
d. No fringe pattern will be obtained and the screen will have uniform illumination

25. In Young's interference experiment with one source and two slits, one slit is covered with a cellophane sheet (A transparent wrapping material) which absorbs half the intensity. Then:
a. No fringes are obtained.
b. Bright fringes will be brighter and dark fringes will be darker
c. All fringes will be darker
d. Bright fringes will be less bright and dark fringes will be less dark.

26. Oil floating on water appears colored due to interference of light. The approximate thickness of oil for such effect to be visible is:
a. 1 cm b. 1 mm c. 10,000 Å d. 100 Å

27. Candela is a unit of:
a. acoustic intensity b. electric intensity c. magnetic intensity d. luminous intensity

28. In Huygens's wave theory, the locus of all the points in the same state of vibration is called a:
a. half period zone b. vibrator c. wave-front d. ray

29. In a Young's double-slit experiment the distance between slits id d, distance of the screen from the slits is D and the wavelength of light is λ. The expression for the Fringe Spacing is:
a. $\frac{\lambda d}{D}$ b. $\frac{\lambda D}{d}$ c. $\frac{2\lambda D}{d}$ d. $\frac{3\lambda D}{d}$

30. Light from the sun reaches the Earth in:
a. spherical wave-fronts b. plane wave-fronts
c. packets d. all of these

31. Interference and diffraction of light support the:
a. electromagnetic nature of light b. wave nature of light
c. quantum nature of light d. longitudinal nature of light waves

32. Which one of the following properties of light does not change with the nature of medium?
a. velocity b. wavelength c. frequency d. amplitude

33. Huygens's principle is used to explain the:
a. speed of light b. dispersion of light c. propagation of light d. reflection of light

34. Polarized sun glasses decreases glare on a sunny day because they:

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a. completely absorb the light
b. block a portion of reflected light
c. have a special color
d. refract the light

35. The central part of Newton's rings is dark due to the reason that:
a. The reflection from the lower surface of sir film undergoes a phase shift of 180°
b. The part of the ray reflected from upper surface of plane convex lens undergoes a phase shift of 180°
c. The reflection from the upper surface of air film undergoes a phase shift of 180°
d. All of the above.

36. Laser light is considered to be coherent because it consists of:
a. Many wavelength
b. Uncoordinated wavelength
c. Coordinated waves of exactly the same wavelength
d. Divergent beams

37. Optically active substances are those substances which:
a. Produce polarized light
b. Rotate the plane of polarization of polarized light
c. Produce double refraction
d. Convert a plane polarized light into circularly polarized light

38. The illumination from the sun is greater at noon than in the evening because:
a. The sun is brighter at noon
b. The sun is nearer to the earth at noon
c. The rays of the sun are less oblique at noon that in the morning
d. The atmosphere is thinner at noon than in the morning

39. If a torch is used in place of monochromatic light in Young's experiment:
a. Fringes will appear as for monochromatic light
b. Fringes will appear for a moment and then they will disappear
c. No fringes will appear
d. Only bright fringes will appear

40. For which of the following colors will the fringe-width be minimum in the double-slit experiment:
a. violet b. red c. green d. yellow

41. Formation of fringes in Young's double slit experiment is due to:
a. Both a and d b. interference c. refraction d. diffraction

42. If in a Young's double slit experiment, the distance between the slits is halved and the distance between slit and screen is doubled, then the fringe width will become:
a. four times b. unchanged c. half d. double

43. If the path difference between the interfering waves is $n\lambda$ then the fringes obtained on the screen will be:
a. coloured b. white c. bright d. dark

44. According to Bragg's Law
a. $d \sin\theta = \frac{m}{}\lambda$
b. $2d \sin\theta = m\lambda$
c. $d \sin\theta = m\lambda^{3}$
d. $d \sin\theta = (m+)\lambda \ \frac{1}{2}$

45. The wave nature of light was proposed by:
a. Thomas young b. Fresnel c. Maxwell d. Huygen

46. Electromagnetic waves transport:
a. Energy only b. Momentum only
c. Both energy and momentum d. Momentum and disturbance

47. According to modern idea about the nature of light, light shows:
a. particle nature only b. wave nature c. dual nature d. none

48. The danger signals are red while the eye is more sensitive to yellow because:
a. Scattering in yellow color is less than that of red
b. Red light is longer in wave length than yellow light
c. Scattering in red is less than in yellow
d. Red color has greater frequency than yellow light

49. In young's double slit experiment, the condition for constructive interference (or bright fringes) is:
a. $d \sin\theta = (m + ½)\lambda$ b. $d \sin\theta = m\lambda$
c. $d \sin\theta = (m - ½)\lambda$ d. $2d \sin\theta = m\lambda$

50. In Young's double slit experiment, the fringe spacing (or fringe width) is equal to:
a. $d/\lambda L$ b. $2\lambda d/L$ c. $\lambda L/d$ d. $\lambda d/L$

51. The interference fringe spacing depends upon:
a. the wavelength of light used b. the distance of source from the coherent source
c. separation between sources d. All the three factors

52. Newton's rings are formed due to:
a. Diffraction of light b. Interference of light
c. Polarization of light d. Reflection of light

53. In the diffraction of X-rays from crystals by Bragg's Law, the condition for constructive interference is given by:
a. $d \sin\theta = n\lambda$ b. $d \sin\theta = 2n\lambda$ c. $2d \sin\theta = n\lambda$ d. $2d \sin\theta = n/\lambda$

54. Which one of the following cannot be polarized?
a. Radio waves b. Ultraviolet rays c. X-rays d. Sound waves

55. The distance between two consecutive wave fronts is called:
a. Time period b. Frequency c. Wavelength d. Displacement

56. Longitudinal waves do not exhibit:
a. refraction b. reflection c. diffraction d. polarization

57. The splitting up of white light into component colors is called:
a. refraction b. interference c. reflection d. dispersion

58. The interference fringe spacing depends upon:
a. the wavelength of light used b. separation between the source

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the distance of screen from the coherent sources d. all of these

59. Newton's rings are experimentally derived from the phenomena of:
a. polarization of light b. resolution of light
c. interference of light d. diffraction of light

60. The interference can occur only if the two sources of light:
a. have same frequency b. have different frequency
c. have frequency very close to each other d. none of these

61. The path difference between rays from two sources at a point of maxima is:
a. odd multiple of $\frac{\lambda}{2}$ b. even multiple of $\frac{\lambda}{2}$
c. integral multiple of $\frac{\lambda}{2}$ d. none of these

62. To observe diffraction, the size of the obstacle:
a. should be of the same order as the wavelength
b. should be much larger than the wavelength
c. has no relation to wavelength
d. should be exactly half the wavelength

63. In Young's double slit experiment the condition for dark fringes or destructive interference is:
a. $d \sin\theta=(m+)\lambda \frac{1}{2}$ b. $d \sin\theta= \frac{m}{\lambda}$
c. $d \sin\theta=m\lambda$ d. $2d \sin\theta=m\lambda$

64. In Young's double slit experiment, if white light is used:
a. bright fringes will be seen b. dark fringes will be seen
c. alternate dark and bright fringes will be seen d. no interference fringes will be seen

65. In Young's double slit experiment the condition for bright fringes or constructive interference is:
a. $d \sin\theta=(m)\lambda\frac{1}{2}$ b. $d \sin\theta=m\lambda$
c. $d \sin\theta= \frac{m}{\lambda}$ d. $\lambda \sin\theta=md$

66. Interference and diffraction of light support the:
a. wave nature of light b. quantum nature of flight
c. transverse nature of light d. complex nature of light

67. The path difference between rays from two sources at a point of minima is:
a. odd multiple of $\frac{\lambda}{2}$ b. even multiple of $\frac{\lambda}{2}$
c. integral multiple of $\frac{\lambda}{2}$ d. none of these

68. The equation for Michelson's interferometer is:
a. $L=2m\lambda$ b. $L= \frac{1}{2}m\lambda$ c. $Lm =2\lambda$ d. $\lambda L=2m$

69. The wavelength of x-rays is of the order of:
a. 10Å b. 1000Å c. 1Å d. 100 Å

70. A diffraction grating has 1000 lines per mm. Its slit spacing or grating element will be:

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a. 5×10^{-3} mm b. 1×10^{-3} mm c. 2×10^{-3} mm d. 500 mm

71. Expression for path difference during constructive interference by grating plate is:

a. $d \sin\theta = \frac{m}{\lambda}$ b. $d \sin\theta = \frac{\lambda}{m}$

c. $d \sin\theta = m\lambda$ d. $d \sin\theta = (m+)\lambda \frac{1}{2}$

72. A limited region taken on the wave-front formed at a very large distance from a source can be regarded as:

a. spherical wave-front b. plane wave-front

c. cylindrical wave-front d. none of these

73. Two light sources (beams) obtained from a single source are called:

a. non-coherent source b. coherent source

c. monochromatic sources d. spherical sources

74. If the movable mirror M_1 in Michelson interferometer moves a distance $\frac{\lambda}{2}$, the path difference introduced is:

a. λ b. $\frac{\lambda}{2}$ c. $\frac{3\lambda}{2}$ d. $\frac{\lambda}{4}$

75. In an interference pattern:

a. bright fringes are wider than dark fringes

b. dark fringes are wider than bright fringes

c. both dark and bright fringes are of equal width

d. bright fringes are narrower than dark fringes

76. If the movable mirror M_1 in Michelson interferometer moves a distance $3\frac{\lambda}{4}$, the path difference introduced is:

a. λ b. $\frac{\lambda}{2}$ c. $\frac{3\lambda}{2}$ d. $\frac{\lambda}{4}$

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ANSWER KEY

1.	C	31.	B	61.	B
2.	A	32.	C	62.	A
3.	B	33.	C	63.	A
4.	A	34.	B	64.	D
5.	C	35.	A	65.	B
6.	C	36.	C	66.	A
7.	D	37.	B	67.	A
8.	B	38.	C	68.	B
9.	D	39.	C	69.	C
10.	D	40	A	70	B
11.	C	41.	A	71.	C
12.	D	42.	A	72.	B
13.	B	43.	C	73.	B
14.	C	44.	B	74.	A
15.	A	45.	D	75.	C
16.	B	46.	C	76.	C
17.	A	47.	C	77.	
18.	A	48.	C	78.	
19.	C	49.	B	79.	
20.	D	50.	C	80.	
21.	C	51.	D	81.	
22.	D	52.	B	82.	
23.	C	53.	C	83.	
24.	D	54.	D	84.	
25.	D	55.	C	85.	
26.	C	56.	D	86.	
27.	D	57.	D	87.	
28.	C	58.	D	88.	
29.	B	59.	C	89.	
30.	B	60.	A	90.	

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CHAPTER 10
OPTICAL INSTRUMENTS

LENS

- Lens is a piece of transparent medium bounded by two surfaces at least one is curved.
- Every lens is a part of some sphere.

TYPES OF LENSES

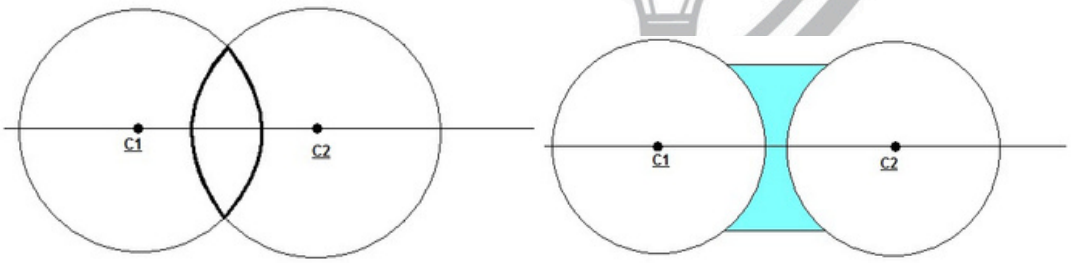
1. Convex Lens: It is thicker at the middle and the thinner of the edges
2. Concave Lens: It is thinner at the middle and thicker at the edges.

TYPES OF CONVEX AND CONCAVE LENS

Convex Lens	Concave Lens
Double Convex	*Double Concave*
Plano Convex	*Plano Concave*
Concavo Convex	*Convexo Concave*

IMPORTANT DEFINITIONS

- **Center of Curvature:** Center of sphere from which spherical surface of lens is obtained.



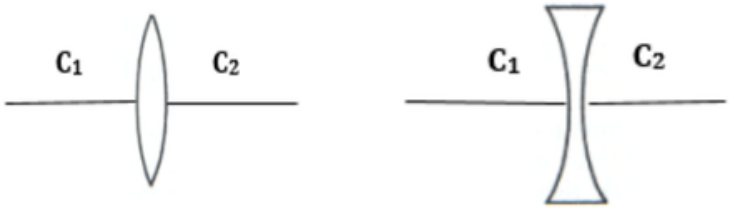
Every lens has two center of curvature.

- **Radius of Curvature:** Radius of sphere form which spherical surface of lens is obtained.



Every lens has two radii of curvature that may not be equal

- **Principle Axis:** is the line joining its two centers of curvature.



- **Principle Focus:**
  a) Forconvexlens,principlefocusisapoint of convergence of refracted light ray. It is a real point.
  b) Forconcavelens,principlefocusisapoint of divergence of refracted light rays. It is imaginarypoint.

Everylens hastwo focii oneachside.

- **OpticalCentre:**isapointinsidethebodyof lens through light rays pass, undeviated.
- **FocalLength:**isadistancebetweenprinciple focus and optical centre. It is positive for convex lens and negative for concave lens.
  Note:Itisnecessarythattwofocallengthsare equal.
- **Aperture:** is the size of diameter oflens
- **Powerofalens:**isitsabilitytodeviatelight ray from its original path.
  P = 1/f
  Where,'f'isafocallengthinameter.
  If 'f' is in cm, then-
  P = 100/f
- SI unit of power of lens is diopter.
  P =1D if f=1m

GENERALRULEFORCOMBINATIONOF'n'LENSES

Generalrule forcombinationof'n'lenses is

$P = P_1 + P_2 + P_3 \ldots\ldots\ldots + P_n$

EXAMPLES

Fortwodouble convex lenses:

$P = P_1 + P_2$

$1/f = 1/f_1 + 1/f_2$

$1/f = f_1 + f_2 / f_1 f_2$

$f = f_1 f_2 / f_1 + f_2$

Thus, combination behaves as convex lens.

Fortwoconcave lenses:

$1/f = - 1/f_1 - 1/f_2$

$1/f = - (f_1 + f_2)/f_1 f_2$

$f = - f_1 f_2 / f_1 + f_2$

Thus, combination behaves as a concave lens

For one concave and another convex lens:

$1/f = 1/f_1 - 1/f_2$

$1/f = - (f_2 - f_1)/f_1 f_2$

$f = f_1 f_2 / f_2 - f_1$

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Thus, combination behaves as a concave or convex lens.

DO YOU KNOW?
Positive sign is used where rays actually intersect. If not then we can use negative sign.

LENS FORMULA

- General lens formula is given as:

  $1/p + 1/q = 1/f$

  p is positive for real object and negative for virtual object.
  q is positive for real image and negative for virtual image.
  f is positive for convex lens and negative for concave lens.

- For different cases, we have to modify it

Examples

For a virtual object;
$1/p + 1/-q = 1/f$
For concave lens
$1/p + 1/-q = 1/-f$

POSITION AND NATURE OF IMAGE FOR CONVEX LENS

Position of Object	Position of Image	Nature of Image
Beyond 2F	Between F and 2F	Real, inverted, small
At 2F	At 2F	Real, inverted, equal
Between F and 2F	Beyond 2F	Real, inverted, enlarged
At F	At infinity	Real, inverted, enlarged
Inside F	On same side further away from lens than the object	Virtual, erect, enlarged

MAGNIFICATION OF LENS

- Linear magnification is givenas;

  $M = q/p = h_1/h_0 =$ Sizeofimage/Sizeofobject

- Angular magnification is givenas;

  $M = \theta_1/\theta_0$ = Angle formedataided eye/Angle formed at naked eye.

- For real image;

  $M = q/p$

- For virtual image;

  $M = -q/p$

DO YOU KNOW?
Forverysmallangleswecanequate linearandangularmagnifications

VISUAL ANGLE

- Visual angle is made by object at observer's eye.
- Apparent size of object varies with visual angle.

Apparent size ∝ visual angle

RESOLVING POWER

The resolving power of an instrument is its ability to reveal the minor details of the object under examination.

ANGLE OF RESOLUTION

The minimum angle that allows two-point sources to appear distinct is called angle of resolution it is expressed as ∝min

$$\propto min = 1.22\frac{\lambda}{D}$$

Raleigh shows that resolving power of lens of aperture D, under a light source of wavelength λ is.

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LENS ABERRATIONS

$$R = \frac{1.22\lambda}{D}$$

1. **Spherical Aberration**
   It is the formation of blurred image due to size of lens because outer rays undergo more refraction than the inner ones.
2. **Color (Chromatic)**
   It is inability of lens to bring all light rays (all colors) at single focus. Multicolored blurred image is formed.

REMEDY
Provide such constraints on the lens that allows only paralaxical rays to enter the lens.

REMEDY
Use the combination of concave and convex lenses called as achromatic lenses.

LEAST DISTANCE OF DISTINCT IMAGE
It is minimum distance up to which a normal eye can see an object clearly.

d = 25 cm

To see an object near d, we have to use a convex lens.

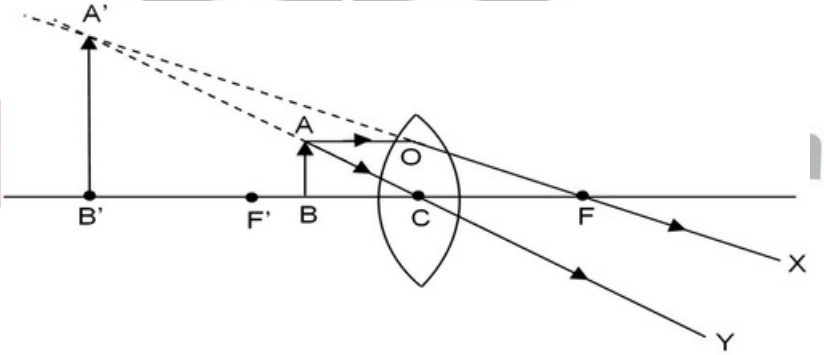
DO YOU KNOW?
As the get over the years up to old age the value of least distance of distinct vision is drastically effect.

OPTICAL INSTRUMENTS
Optical instruments are those, which use light for their operation e.g.

1. Simple Microscope
2. Compound Microscope
3. Telescope
4. Camera
5. Michelson Inferometer
6. Spectrometer
7. Periscope

SIMPLE MICROSCOPE
Simple microscope/magnifier is a double convex lens of short focal length.

- Its magnifying power;
  M = 1 + d/f
  d = 25 cm
  f = focal length
- It forms virtual, erect and magnified image at d.
  $M \propto 1/f$

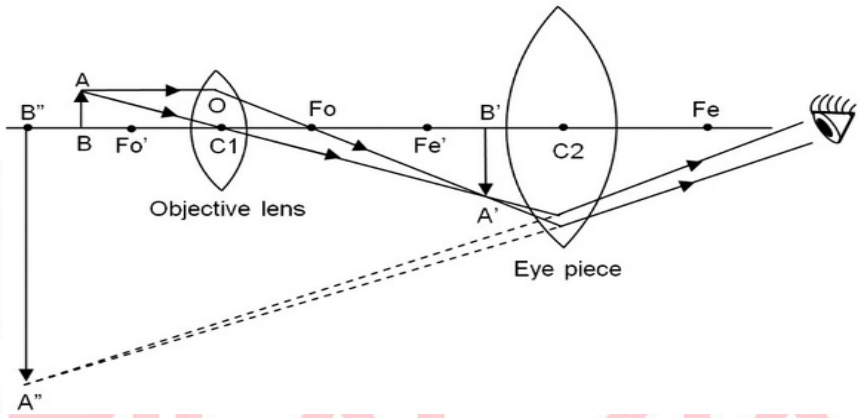


COMPOUND MICROSCOPE
Compound Microscope consists of two convex lenses

a) **Objective Lens** of small size and short focal length.
b) **Eyepiece Lens** of large size and large focal length.

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A compound microscope uses a very short focal length objective lens to form a greatly enlarged compound. This image is then viewed with a short focal length eyepiece used as a simple magnifier. The image should be formed at infinity to minimize eyestrain.
The general assumption is that the length of tube L is large compared to either f_0 or f_e so that the following relationships hold.



$$M = L/f_0\ (1 + d/f_e)$$

DO YOU KNOW?
A wider objective and use of blue light of short wavelength produces less diffraction and allows more details to be seen.

Note:

1. $f_0 < f_e$ always otherwise it will become astronomical telescope.
2. In case of expensive microscopes, eyepiece and objectives are combination of lenses to reduce lens defect.
3. Objective forms real image while eyepiece forms virtual image.
4. Magnification of objective = L/f_0.
5. Magnification of eyepiece = $1 + d = f_e$

TELESCOPE

Telescope is an optical instrument, which enables the observer to see fine details of a far off object.

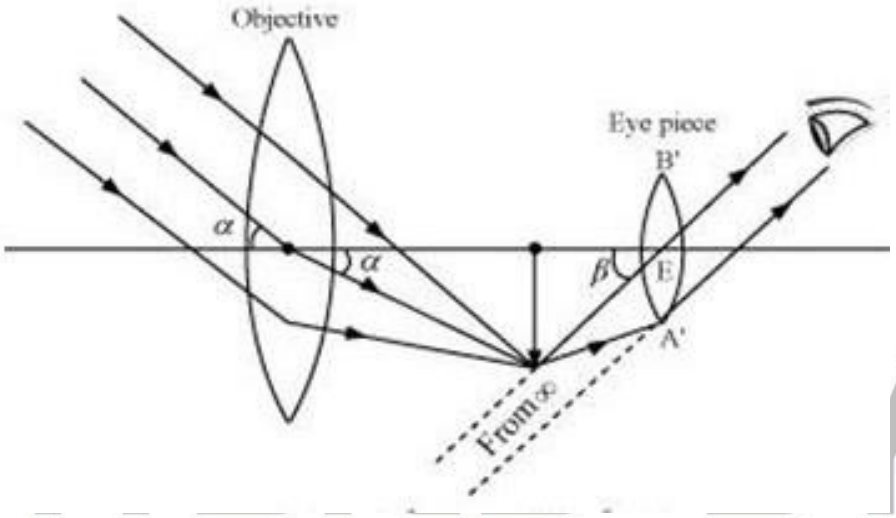
- Two major classes of telescopes are given below:
  1. Reflecting telescopes
  2. Refracting telescopes

ASTRONOMICAL TELESCOPE

- It is used to see images of heavenly bodies.
- It consists of two lenses.
  a) **Objective** is double convex lens of large focal length and large size.
  b) **Eyepiece** is a double convex lens of short focal length and small size.

1. When set for ∞, then-

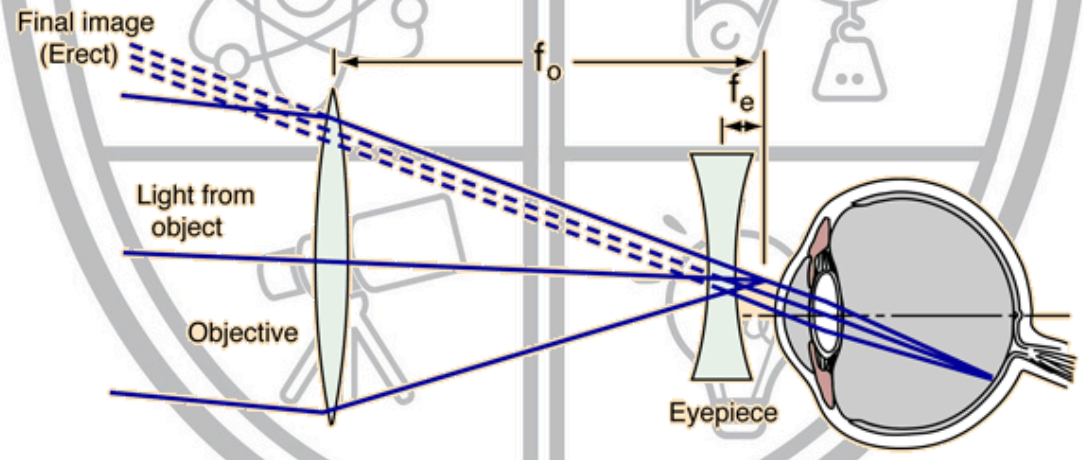
$$L = f_0 + f_e$$



- **Advantages:**
  1. High magnifying power
     $M = f_0 + f_e$
  2. Large field of view
- **Disadvantages:**
  Final image is inverted

GALILEAN TELESCOPE

The Galilean or terrestrial telescope uses a positive object and a negative eyepiece. It gives erect images and is shorter than the astronomical telescope with the same power. Its angular magnification is $-f_0/f_e$.



SPECTROMETER

It is an optical instrument used to study spectra

- It has following parts
  1. **Collimator:** It has slit at focus of double convex lens to get a parallel beam of light.
  2. **Telescope:** It is an astronomical telescope
  3. **Turn Table:** Prism or diffraction grating is placed on table called turn table.
  4. **Leveling Screws**
- **Working**
  1. Telescope is set for infinity and fixed.
  2. Source of monochromatic light is placed in front of slit and and collimator is adjusted for parallel rays.
  3. Angle of min minimum deviation (D_m) is experimentally determined.
     Then refractive index of prism is given as;
     $\mu = \text{Sin}\,(A + D_m/2)/\text{Sin}\,(A/2)$

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Where 'A' is angle of prism or angle or apex prism.

4. Forwavelengthofmonochromaticlightdiffractiongratingisused.
   $d\sin\theta = m\lambda$
   $\lambda = d\sin\theta / m$
   Usually m = 1 (first order diffraction grating)
   d =gratingelement
   d = 1/N

SPEED OFLIGHT

- Firstattempttomeasurethespeedoflightwasmade**byGalileo**.
- Firsttimespeedoflightmeasuredaccuratelyby Michelson.
- TheMichelson'sformulafordeterminationofspeedoflightis.

$$C = 16fd$$

Wherefisthefrequencyofrotationofoctagonalmirroranddisdistancebetweenplane mirror and octagonal mirror.

INTRODUCTION TO FIBER OPTICS

- GrahamBellinvented**photophone**totransmitvoicemessageviabeamoflight.
- In opticalfiber,lightisusedasa**transmissioncarrierwave**.
- The principleoftransmittingsignalsthroughopticalfiberis
  1. Totalinternalreflection
  2. Continuousrefraction
- Opticalfiberisafineglassrodhavingcentralportionofhighrefractiveindexcalledcore, which is surroundedbyglasslayerhavinglowrefractiveindexthatiscalled**cladding**.
- Lightpassesthroughcoreduetointernalreflectionorcontinuousrefraction.

CLASSIFICATION OF OPTICAL FIBERS

Single modestepindexfiber

It is also calledmonomodefiber&hasverynarrowcoreofdiameterabout5μm.

Multimode step index fiber

It has largercore(50μm)ofconstantrefractiveindex.Refractiveindexchangesattheboundary of core and cladding.Itisusefulforashortdistanceonly.Themodeoftransmissioninitistotal internal reflection.

Multimode gradedindexfiber

In it, core has a diameterfrom50to1000μm.Thereisnonoticeableboundarybetweencore and cladding. The modeoftransmissionoflightinitiscontinuousrefraction.Itissuitableforlong distance transmissioninwhichlightisused.

SIGNAL COMMUNICATION

- Fiber optic communicationsystemconsistsofthreeparts
  1. Transmitter:Toconvertelectricalsignalstolightsignals.
  2. Optical Fiber:Toguidethelightsignals.
  3. Receiver: Tocapturethelightsignalandconvertthemtoelectricsignals.
- Light signals travelthroughfiberin'on'or'off'.Alightpulse**represents,1and**absence of light **represents '0'**
- **Advantages ofcommunicationthroughopticalfiber**
  1. Light signalsinglasstravelfasterthanelectricsignalsincoppercable.
  2. More massagespercablelength.(Highsignalstrength).
  3. Clear soundisreceived.

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LOSSES OF POWER

- Power is lost in optical fiber is due to scattering of light from impurities atoms in glass.
- Due to dispersion of light, signal also gets errors.
- Error due to dispersion are reduced by using graded index fiber.
- Repeaters are used at suitable distance to overcome the power loss due to scattering from impurities atoms.

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PRACTICE SHEET

1. Two plane mirrors are placed perpendicular to each other. A ray strikes one mirror and after reflection falls on the second mirror. The ray after reflection from the second mirror will be:
   a. perpendicular to the original ray
   b. parallel to the original ray
   c. at 45° to the original ray
   d. can be at any angle to the original ray

2. An object is placed between two parallel mirrors. The number of images formed is:
   a. 2 b. 4 c. 8 d. infinite

3. A monochromatic beam of light passes from a denser to a rarer medium. As a result, its:
   a. velocity increases
   b. velocity decreases
   c. frequency decreases
   d. wavelength decreases

4. When light passes from one medium to another, the physical quantity that remains unchanged is:
   a. velocity b. wavelength c. frequency d. none

5. A diver in a lake wants to signal his distress to a person sitting on the edge of the lake flashing his water proof torch. He should direct the beam:
   a. Vertically upwards
   b. Horizontally
   c. At angle to the vertical which is slightly less than the critical angle
   d. At an angle to the vertical which is slightly more than the critical angle

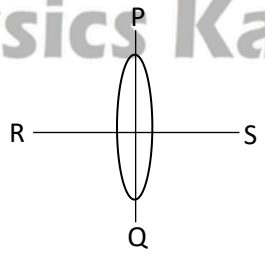
6. To increase the magnification of a telescope:
   a. The objective lens should be of large focal length and eyepiece should be of short focal length
   b. The objective and eyepiece both should be of large focal lengths
   c. Both the objective and eyepiece should be of smaller lengths
   d. The objective should be small focal length and eyepiece should be of large focal length

7. The distance between an object and its real image formed by a convex lens cannot be:
   a. greater than 2f b. less than 2f c. greater than 4f d. less than 4f

8. The index of refraction of diamond is 2.0. Velocity of light in diamond in cms^{-1} is approximately:
   a. 6×10^{10} b. 3×10^{10} c. 2×10^{10} d. 1.5×10^{10}

9. The power of a lens is 4 diopters. Its focal length is:
   a. 20 cm b. 25 cm c. 50 cm d. 400 cm

10. The figure shows an equiconvex lens of focal length f. If the lens is cut along PQ, the focal length of each half will be:



   a. $\frac{f}{2}$ b. f c. 2f d. $\frac{3f}{2}$

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11. A compound microscope has a magnification of 30. The focal length of the eye-piece is 5cm. If the final image is formed at the least distance of distinct vision (25cm), the magnification produced by the objective is:
a. 5 b. 7.5 c. 10 d. 12

12. For an astronomical telescope $f_o+f_e=105cm$, $\frac{f_o}{f_e}=20$, focal lengths of objective and eye-piece are:
a. 200cm, 20cm b. 50cm, 5cm c. 100cm, 5cm d. none of these

13. An astronomical telescope has an angular magnification of magnitude 5 for distant objects. The separation between the objective and the eyepiece is 36 cm and the final image is formed at infinity. The focal length f_o of the objective and f_e of the eyepiece are:
a. f_o = 45cm and f_e = –9cm b. f_o = 50cm and f_e = 10cm
c. f_o = 6cm and f_e = 30cm d. f_o = 30cm and f_e = 6cm

14. What is the time taken by light to travel 4 mm in a material of refractive index 3?
a. 4×10^{-11} sec b. 2×10^{-11} sec c. 16×10^{-11} sec d. 8×10^{-10} sec

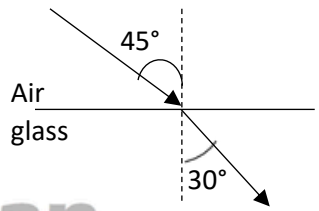
15. Distance of distinct vision is 25 cm. The focal length of the convex lens is 5 cm. It can act as a magnifier of magnifying power:
a. 6 b. less than5 c. 5 d. more than 6

16. Total internal reflection of a ray of light is possible when the ray goes from:
a. Denser to rarer medium and the angle of incidence is greater than the critical angle
b. Denser to rarer medium and the angle of incidence is less than the critical angle
c. Rarer to denser medium and the angle of incidence is greater than the critical angle
d. Rarer to denser medium and the angle of incidence is less than the critical angle

17. Which of the following produce a virtual image longer in size than the object?
a. concave lens b. convex lens c. none d. convex mirror

18. The least distance of distinct vision is 22.5cm. The focal length of a convex lens is 7.5cm. It can act as a simple microscope of magnifying power.
a. 4 b. 5 c. 3 d. None of these

19. A ray of light travels from air to glass as shown in the figure. The speed of light in air is 3.0×10^{8} ms^{-1}. What is the speed of light in glass?
a. 2.00×10^{-6} m/s
b. 2.12×10^{-8} m/s
c. 2.12×10^{8} m/s
d. 3.25×10^{8} m/s



20. Two convex lenses of equal focal length 'f' are placed in contact, the resultant focal length is:
a. zero b. f c. 2f d. $\frac{f}{2}$

21. For normal adjustment, length of astronomical telescope is:
a. $f_0 + f_e$ b. $f_0 - f_e$ c. $\frac{f_0}{f_e}$ d. $\frac{f_e}{f_0}$

22. When an object is placed within the principal focus of a convex lens, the image is:
a. virtual b. erect c. magnified d. all of these

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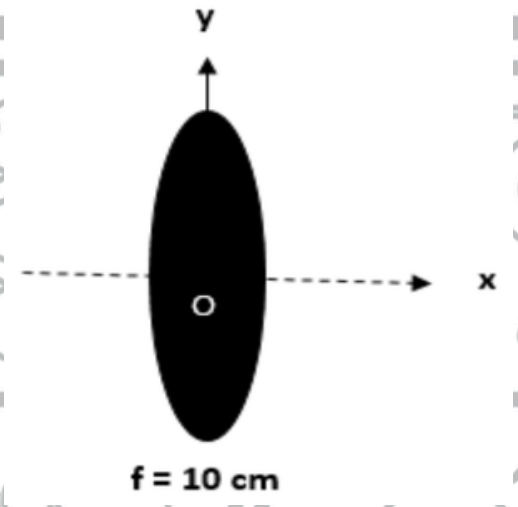
23. In spectrometer, the function of collimator is to produce:
a. diverging beam of light b. converging beam of light
c. parallel beam of light d. none of these

24. Television signals are converted into light signals by:
a. decoder b. transistor c. photodiode d. optical fibre

25. In the small angles' approximation:
a. sin θ ~ tanθ ~ θ b. sinθ ~ cosθ ~ 1 c. cosθ ~ tanθ ~ θ d. none of these

26. Power of a lens of focal length 1 m is:
a. 0.5 dioptre b. 1.5 dioptre c. 1 dioptre d. 2 dioptre

27. Consider the situation shown in the figure. P is an object whose coordinates are (-20 cm, -2 cm). Determine the coordinates of the image with respect to origin O.



a. (-20 cm, 2 cm) b. (20 cm, -2 cm)
c. (20 cm, 2 cm) d. (-20 cm, -2 cm)

28. Nature of image in compound microscope is:
a. real and inverted b. virtual and inverted c. real and erect d. virtual and erect

29. The image obtained in case of a simple microscope is:
a. virtual & erect b. real & erect c. real & inverted d. none

30. Transmitter converts:
a. light signal to electrical signal b. electrical signals to light signals
c. mechanical energy to electrical energy d. none of these

31. The speed at which light enters into a material depends upon:
a. frequency b. refractive index c. wavelength d. velocity

32. The instruments which are based upon the principle of reflection and refraction are:
a. magnifying glass b. compound microscope c. telescopes d. all of the above

33.Ifaconvex lens has focal length f = 5cm, placed at a distance of 25cm than the magnification will be:

a.2.5 b. 6 c. 7.5 d. 10

34.Theimage formed by a concave lens is:
a. Real and lies on the other side of the lens
b. Virtual and lies on the same side of the lens as the object
c. Diminished
d. Both (b) and (c)

35. The ratio of the angle subtended by the image as seen through the optical device to that subtended by the object at the unaided eye is called:
a. None b. resolving power
c. magnifying power d. critical angle

36. A well-cut diamond appears bright because:
a. it emits light b. it is radioactive c. of dispersion d. of total reflection

37. Water has refractive index $\frac{4}{3}$. The speed of light in water in m/s is:
a. 2.25×10^8 b. 1.78×10^8 c. 1.50×10^8 d. 2.67×10^8

38. The speed of light in vacuum is 3×10^8 ms^{-1}. Its speed in a medium of refractive index 1.5 will be:
a. 6.5×10^8 b. 2×10^8 m/s c. 4.5×10^8 cm d. 5.5×10^8

39. If f_o and f_e be the lengths of the objective and eye piece of in astronomical telescope, the length of the tube is:
a. $f_o - f_e$ b. $\sqrt{f_o f_e}$ c. $f_o f_e / f_o + f_e$ d. $f_o + f_e$

40. Why one cannot see through the fog?
a. fog refracts light b. fog scatters light c. fog polarizes light d. fog reflects light

41. When light passes from one medium to another, it is bent to or away from the normal. This phenomenon is known as:
a. Diffraction b. Dispersion c. Refraction d. Polarization

42. In going from a denser to rarer medium, a ray of light is:
a. Undeviated b. Bent away from normal
c. Ben towards the normal d. Diffracted

43.The focal length of a concave lens is:
a.Negative b. Positive
c.Positive and negative d. Neither positive nor negative

44.Incase of a concave lens, the image of the real object in any position is:
a.Virtual, magnified and erect b. Virtual, diminished and erect
c.Real, magnified and inverted d. Real, diminished and inverted

45.Ifan object is placed away from 2f of a converging (convex) lens, then the image will be:
a.Real & erect b. Virtual & erect c. Real & inverted d. Virtual

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46. If an object is placed within the foal length of a converging lens, the image formed will be:

a. Virtual, erect & magnified in front of lens
b. Real, inverted & magnified in front of lens
c. Virtual, erect & magnified behind the lens
d. Real, inverted & magnified behind the lens

47. If an object is placed between f and 2f of a convex lens, then the image will be:

a. Virtual, erect & diminished
b. Virtual, erect & magnified
c. Real, inverted & magnified
d. Real, erect & magnified

48. Convex lens forms:

a. Real & inverted imaged image if p > f
b. Always virtual and inverted image
c. Always real and inverted image
d. Always real and erect image

49. The image of distant object as seen through an astronomical telescope is:

a. Real & inverted b. Virtual & inverted c. Real & erect d. Virtual & erect

50. Critical angle of a medium depends upon the:

a. Refractive index of the denser medium
b. Relative refractive index of the two mediums
c. Speed of light in air
d. Intensity of the beam of light

51. For glass – air boundary, the value of critical angle θ_c, is:

a. 41.5° b. 41° c. 41.8° d. 41.2°

52. Multimode graded index fiber core has diameter of range:

a. 50–100 µm b. 50–3000µm c. 50–1000µm d. 50–2000µm

53. A fly is sitting on the objective of a telescope pointed towards the moon. What effect is expected on the photography of the moon taken through the telescope?

a. The entire field of view blocked
b. There is an image of the fly on the photography
c. There is no effect at all
d. There is a reduction in the intensity of the image

54. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen:

a. Half the image will disappear
b. No change either in size or in intensity
c. Intensity of image will increase
d. Intensity of the image will decrease

55. When the length of a microscope tube increases, its magnifying power:

a. Decrease
b. Increase
c. Does not change
d. May increase or decrease depending on the observer and the place of observation

56. The ratio of the distance of the image to the distance of the object from the lens is called:

a. angular magnification
b. magnifying power
c. resolving power
d. magnification (linear)

57. In modern optical fibers, repeaters are usually laid down after every:

a. 10 km b. 100 km c. 1000 km d. 100 m

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58. The optical fiber in which central core has high refractive index and over it a layer is lower refractive index is called:
a. single mode step index fibre
b. multi-mode step index fibre
c. multi-mode graded index fibre
d. none of these

59. If the refractive index of water is 1.33, then the speed of light in water will be:
a. 225000 km/s
b. 300000 km/s
c. 299999 km/s
d. 333 m/s

60. Light can be totally confined within the fibre by:
a. total internal reflection
b. continuous refraction
c. both total internal reflection and continuous refraction
d. dispersion

61. The equation used to determine the speed of light by Michelson was:
a. c = 16 fd
b. $c = \frac{16}{d} f$
c. $c = \frac{1}{16 \times fd}$
d. $c = 2\pi fd$

62. We use driving mirror to be convex instead of plane mirrors because:
a. they give exact idea of distant object
b. they produce magnified image
c. their field of view is wider
d. they are beautiful

63. An object at the bottom of water appears to be near the upper surface due to:
a. diffraction
b. interference
c. refraction
d. reflection

64. The power of a converging lens is 2 diopters. Its focal length will be:
a. 2m
b. 2 cm
c. 5 m
d. 0.5 m

65. A spectrometer is used to measure:
a. refractive index of material of glass prism
b. deviation of light by a glass prism
c. wavelength of the light
d. all of these

66. The minimum angle between two-point sources that allow the images to be resolved as two distinct spots of light rather than one is called:
a. resolving power
b. angular magnification
c. magnifying power
d. linear magnification

67. In a compound microscope, the focal length of the objective is:
a. equal to that of eye-piece
b. greater than that of eye-piece
c. smaller than that of eye-piece
d. very large than that of eye-piece

68. If two-point sources lying very close to each other are observed by an optical instrument of high resolution, then the point source appears as:
a. two separate sources
b. one source
c. three sources
d. none of the above

69. Which of the following is used so that a compound microscope resolves more details?
a. a wider objective only
b. blue light of short focal length only
c. both wider objective and blue light
d. none of the above

70. The distance between the objective and eye-piece of a telescope (astronomical) in normal adjustment is equal to:
a. focal length of objective
b. length of the telescope

c. magnifying power of telescope
d. aperture of the objective

71. The image formed by the objective in an astronomical telescope is:
a. real, erect and magnified
b. real, inverted and diminished
c. virtual, inverted and magnified
d. virtual, erect and diminished

72. The final image seen through the eye-piece, in astronomical telescope, is:
a. virtual, enlarge and erect
b. real, diminished and inverted
c. virtual, enlarge and inverted
d. real, diminished and erect

73. Use of outer layer in optical fibers called cladding is mainly to:
a. scatter the light
b. absorb unwanted light
c. transmit the light
d. produce total internal reflection

74. Total internal reflection occurs when the angle of incidence is:
a. greater than the angle of refraction
b. equal to the critical angle
c. greater than the critical angle
d. greater than 42°

75. An observer moves towards a plane mirror with a speed of 2m/s. The speed of the image with respect to the observer is:
a. 1m/s
b. 2m/s
c. 4m/s
d. 8m/s

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ANSWER KEY

SERIAL #	ANSWER	SERIAL #	ANSWER	SERIAL #	ANSWER
1.	B	31.	B	61.	A
2.	D	32.	D	62.	C
3.	A	33.	B	63.	C
4.	C	34.	D	64.	D
5.	C	35.	C	65.	D
6.	A	36.	D	66.	A
7.	D	37.	A	67.	C
8.	D	38.	B	68.	A
9.	B	39.	D	69.	C
10.	C	40	B	70	B
11.	A	41.	C	71.	B
12.	C	42.	B	72.	C
13.	D	43.	A	73.	D
14.	A	44.	B	74.	C
15.	A	45.	C	75.	C
16.	A	46.	A	76.	
17.	B	47.	C	77.	
18.	C	48.	A	78.	
19.	C	49.	A	79.	
20.	D	50.	B	80.	
21.	A	51.	C	81.	
22.	D	52.	C	82.	
23.	C	53.	D	83.	
24.	A	54.	D	84.	
25.	A	55.	B	85.	
26.	C	56.	D	86.	
27.	C	57.	B	87.	
28.	B	58.	B	88.	
29.	A	59.	A	89.	
30.	B	60.	C	90.	

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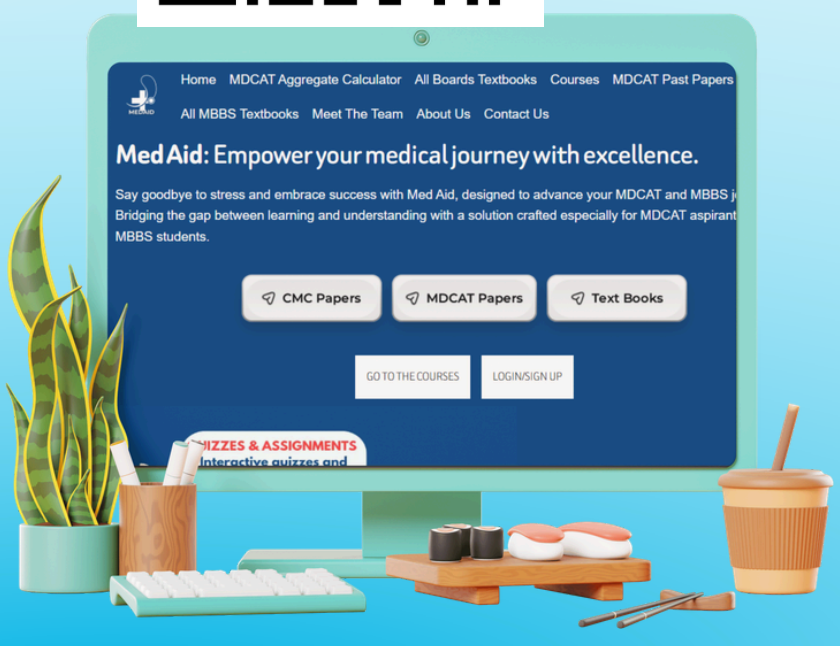
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