TEACHING / TRAINING MODULE

PHYSICS

CLASS - XI & XII

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ST & SC DEVELOPMENT DEPARTMENT
GOVERNMENT OF ODISHA
BHUBANESWAR

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FOREWORD

The ST and SC Development Department, Government of Odisha, has initiated an innovative effort by setting up an ***Academic Performance Monitoring Cell*** (APMC) in Scheduled Castes and Scheduled Tribes Research and Training Institute (SCSTRTI) to monitor the Training and Capacity Building of teachers of SSD Higher Secondary Schools and Ekalabya Model Residential Schools (EMRS) under the administrative control of the ST & SC Development Department. This innovative program is intended to ensure quality education in the Higher Secondary Level of the schools of the ST & SC Development Department.

The modules and lesson plans are prepared for the +2 Science and Commerce stream' in all the subjects such as Physics, Chemistry, Botany, Zoology, Mathematics, Information Technology, Odia, English and Commerce for both the years in line with the syllabus of Council of Higher Secondary Education (CHSE).

These modules/lesson plans are self contained. The subiect experts who are the best in their respective subjects in the State have been roped in for the exercise. They have given their precious time to make the module as activity based as possible.

I hope, this material will be extremely useful for the subject teachers in effective class room transactions and will be helpful in improving the quality education at the Higher Secondary Level. I also take this opportunity to thank all the subject experts of different subjects for rendering help and assistance to prepare the modules/lesson notes and lesson plans within a record time.

Prof. (Dr.) A.B.Ota
Director and Special Secretary,
SCSTRTI

Contents

CLASS - XI

PHYSICS

LESSON PLAN – 2018-19

Class - XI

Unit	Lect No.	TOPIC	Date of Completion	
I	**PHYSICAL WORLD AND MEASUREMENT**			
	L-l	Physics and its scope, Physics-Technology and Society		
	L-2	Measurement, need for measurement, units of measurement, fundamental and derived units		
	L-3	The international system (SI) Units		
	L-4	Measurement of length- Macroscopic length and Microscopic length, Measurement of mass and time		
	L-5	Accuracy and precision of measuring instruments, errors in measurement		
	L-6	Absolute error, relative error, percentage of error		
	L-7	Combination of errors		
	L-8	Significant figures		
	L-9	Dimensions of Physical quantities		
	L-10	Dimensional analysis and its applications		
	L-ll	Application of dimensional analysis		
II	**KINEMATICS**			
	1	**Motion in a straight line**		
	L-12	Rest and motion, Frame of reference, motion in a Straight line		
	L-13	Concept of differentiation for describing motion		
	L-14	Concept integration for describing motion		
	L-15	Position, Path length and displacement, speed and velocity		
	L-16	Uniform and non-uniform motion, average speed and Velocity, Instantaneous speed and velocity		

Unit	Lect No.	TOPIC	Date of Complation	
	L-17	Uniformly accelerated motion, velocity - time and position -time graph		
	L-18	Relation for uniformly accelerated motion (graphical treatment)		
	L-19	Relation for uniformly accelerated motion (graphical treatment)		
	2	**Motion in a plane**		
	L-20	Scalars and vectors, general vectors and their notations, position and displacement vectors, equality of vectors		
	L-21	Unit vectors, multiplication of vectors by a real number		
	L-22	Addition and subtraction of vectors		
	L-23	Relative velocity		
	L-24	Resolution of a vector in a plane, rectangular components		
	L-25	Dot products of two vectors		
	L-26	Cross products of two vectors		
	L-27	Motion in a plane, cases of uniform velocity and uniform acceleration		
	L-28	Projectile motion: Equation of trajectory, range, time of flight, maximum height		
	L-29	Projectile motion: Equation of trajectory, range, time of flight, maximum height		
	L-30	Uniform circular motion		
III	**LAWS OF MOTION**			
	L-31	Concept of force, Newton's first law, inertia		
	L-32	Momentum and Newton's 2nd law of motion		
	L-33	Impulse, Impulse-momentum theorem		
	L-34	Newton’s 3rd law of motion, Law of Conservation of linear momentum		

Unit	Lect No.	T O P I C	Date of Complation	
	L-35	Application of law of conservation of linear momentum. Equilibrium of Concurrent forces		
	L-36	Static and Kinetic friction, laws of friction, rolling friction, lubrication		
	L-37	Dynamics of uniform circular motion, Centripetal force		
	L-38	Motion of a vehicle on a level circular road and on a banked road		
IV	**WORK, ENERGY AND POWER**			
	L-39	Work done by a Constant force and variable force		
	L-40	kinetic energy		
	L-41	work- energy theorem, power		
	L-42	Notion of potential energy		
	L-43	Potential energy of a spring, conservative and non-conservative forces		
	L-44	Conservation of mechanical energy (Kinetic and Potential energies)		
	L-45	Motion in a vertical circle		
	L-46	Elastic and in-elastic collisions in one and two dimensions		
	L-47	Elastic and in-elastic collisions in one and two dimensions		
V	**MOTION OF SYSTEM OF PARTICLES AND RIGID BODIES**			
	L-48	System of Particles and Rotational Motion : Centre of mass of a two-particle system		
	L-49	Momentum of conservation and centre of mass motion		
	L-50	Centre of mass of rigid bodies, Centre of Mass of a uniform rod		
	L-51	Angular velocity and its relation with linear velocity, Angular acceleration		

Unit	Lect No.	TOPIC	Date of Complation	
	L-52	Moment of a force, Torque, angular momentum		
	L-53	Conservation of angular momentum		
	L-54	Applications of law of conservation of angular momentum		
	L-55	Equilibrium of rigid bodies		
	L-56	Equation of rotational motion, comparison of linear and rotational motions		
	L-57	Moment of inertia, radius of gyration		
	L-58	Moment of inertia of simple geometrical objects (no derivation)		
	L-59	Parallel axis theorem and their applications		
	L-60	Perpendicular axis theorem and their applications		
VI	**GRAVITATION**			
	L-61	Newton's law of gravitation		
	L-62	Kepler's laws of planetary motion (only statements)		
	L-63	Gravitational field and Potential, gravitational potential energy		
	L-64	Acceleration due to gravity and its variation with altitude		
	L-65	Variation of acceleration due to gravity with depth		
	L-66	Escape velocity of a satellite		
	L-67	Orbital velocity of a satellite		
	L-68	Geostationary satellites		
VII	**PROPERTES OF BULK MATTER**			
	1	**Mechanical properties of Solids**		
	L-69	Elastic Behaviours, Stress, Strain, Hookes' Law, Stress-Strain diagram		
	L-70	Young's modulus, Bulk modulus, Shear modulus of rigidity		

Unit	Lect No.	T O P I C	Date of Complation	
	L-71	Poisson's ratio, elastic energy		
	2	**Mechanical properties of fluids**		
	L-72	Pressure due to a fluid column, Pascal's law		
	L-73	Applications of Pascal's Law - Hydraulic lift and hydraulic brakes, effect of gravity on fluid pressure		
	L-74	Surface energy and surface tension		
	L-75	Angle of contact, excess pressure across a curved surface		
	L-76	Application of surface tension ideas to drops, bubbles		
	L-77	Capillary rise		
	L-78	Viscosity, Stoke's law, terminal velocity		
	L-79	Streamline and Turbulent flow		
	L-80	Equation of continuity and critical velocity		
	L-81	Bernoulli's theorem		
	L-82	Applications of Bernoulli's theorem		
	3	**Thermal properties of matter**		
	L-83	Concepts of heat and temperature, Thermal expansion of solids		
	L-84	Thermal expansion of liquids and gases, anomalous expansion of water		
	L-85	Specific heat capacity : Cp, Cv, Calorimetry		
	L-86	Change of state, latent heat capacity		
	L-87	Heat transfer: Conduction, Convection and radiation, thermal conductivity		
	L-88	Qualitative ideas of black body radiation		
	L-89	Wien's displacement law, Stefan's law, Greenhouse effect		

Unit	Lect No.	TOPIC	Date of Complation	
VIII	**THERMODYNAMICS**			
	L-90	Thermal equilibrium, definition of temperature (Zeroth law of thermodynamics) heat, work and internal energy		
	L-91	First law of thermodynamics		
	L-92	Isothermal process		
	L-93	Adiabatic process, Second law of thermodynamics		
	L-94	Reversible and Irreversible processes		
	L-95	Heat Engine, Carnot's engine		
	L-96	Carnot Engine, Efficiency of Carnot's engine (no derivation)		
	L-97	Refrigerator		
IX	**KINETIC THEORY OF GASES**			
	L-98	Equation of state of a perfect gas, work done in compressing a gas		
	L-99	Kinetic theory of gases- Postulates, concept of pressure		
	L-100	kinetic interpretation of temperature, mean and RMS speed of gas molecules		
	L-101	degrees of freedom, law of equipartition of energy (statement only) and its applications to specific heat of gases		
	L-102	concept of mean freepath and Avogadro's number		
X	**OSCILLATION AND WAVES**			
	1	**Periodic Motion**		
	L-103	Periodic motion: Period, Frequency, displacement as a function of time, periodic function		
	L-104	Simple harmonic motion and its equation, phase		

Unit	Lect No.	TOPIC	Date of Complation	
	L-105	Oscillation of a spring, Restoring force and force constant		
	L-106	kinetic and potential energy in SHM, simple pendulum		
	L-107	Simple pendulum, derivation of expression for its time period		
	L-108	Free, damped and forced oscillation (qualitative idea only), resonance		
	2	**Wave**		
	L-109	Wave motion		
	L-110	Transverse and longitudinal wave		
	L-111	Speed of wave motion, displacement relation for a progressive wave		
	L-112	speed of longitudinal wave in an elastic medium		
	L-113	Speed of transverse wave in a stretched string (qualitative idea only)		
	L-114	Principle of superposition of waves		
	L-115	Reflection of waves, standing waves in strings		
	L-116	Organ pipes, fundamental mode and harmonics		
	L-117	Organ pipes, fundamental mode and harmonics		
	L-118	Beats		
	L-119	Doppler's effect		
	L-120	Doppler's effect		

UNIT-I

Physical World and Measurement

Structure

Introduction

Meaning and scope of Physics

Technology and Society

Objectives

Measurement and its need

Units of Measurement Types

Accuracy and precision of instruments

Errors

Introduction – Science means knowledge. The main idea of this unit is to illustrate how scientific knowledge grows on the basis of human curiosity as well as human need. Physics is a branch of science which deals with the physical world, with the events of surrounding. Physics gives answer to the questions "why", "what", "when" and "how" regarding the events occurring around us qualitatively and quantitatively. The development of physics and technology is an integral part of human endeavour to overcome difficulties of existence in society and to satisfy natural curiosity. The unit appreciates the inter dependence of science and society. The development of science influences the shape and dynamics of a society which in turn leads to a change in the level of scientific and technological developments. Science is a social institution. It has cumulative tradition of knowledge. The stock of previous knowledge forms the basis of new knowledge. Science is influenced by prevailing social thoughts and in turn scientific ideas influence the general attitude of the society. Physics is the science or knowledge of the physical world. It deals with matter and energy. Physics also called as the science of measurement.

Scope of physics is unbounded Physics has contribution to every moment of society and every moment of human existence. Starting from creation of universe to existing state physics explains everything. It also gives idea about the future.

Objectives –

To prepare a student to

(a) appreciate the scope of science basically physics for upliftment of society.

(b) know that measurement is the key note to study the events.

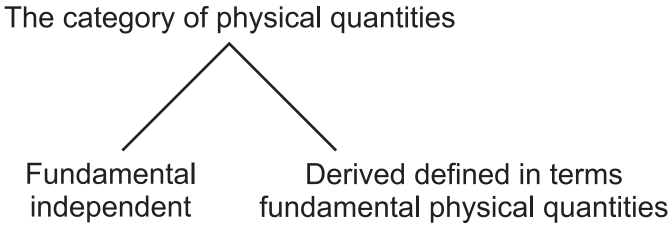
(c) get the process of measurement through units.

(d) know about dimensional analysis.

(e) appreciate that all measurements are inexact and are expressed in numbers resulting from approximation.
(f) distinguish between precision and accuracy.
(g) express measurement in scientific notation.

Measurement

Scientific truths are based on experimental observations. So measurement is the most important part of physics. To observe means to measure “when you can measure what you are speaking about and express it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind” – Lord Kelvin



Operational definition of measurement is the procedure in which the physical quantity may be measured.

Measurement done by the devices which interact and quantifies the physical quantity.

Idea about fundamental or base quantities

Length, Mass, Time, Thermodynamic Temperature, Electric Current, Amount of substance and luminous intensity.

Derived quantities – Defined in terms of fundamental quantities.

Relationship is defined by means of equation.

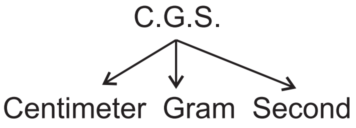
Examples : [Volume in terms of length V = ℓ^3 for cube]

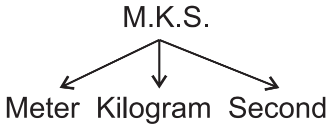
Units

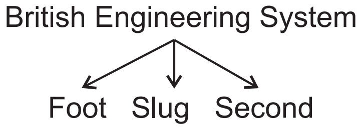
Measurement of a physical quantity involves its comparison with a similar physical quantity of suitable chosen value. This chosen value is the unit the ratio of value of the physical quantity and that of the unit is a pure number or it gives how many times the value of physical quantity is that of unit.

Example should be given (wall in terms of no of bricks)

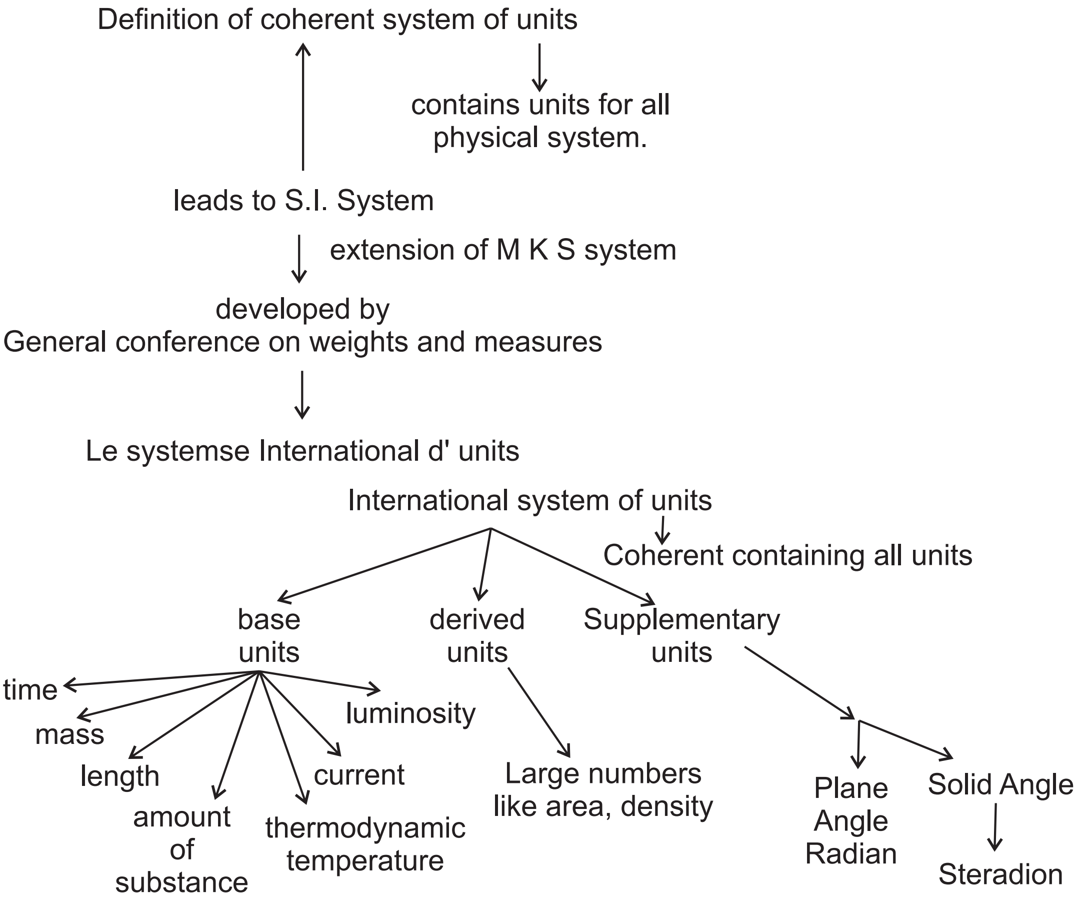
Set of Units







for all Mechanical systems.



Description of base units and their definitions

Time – Second
Mass – Mole
Meter – Length
Kelvin – Temperature
Ampere – Current

} Definition in terms S.I. Standards

(1) Idea about S.I. derive units with specific names

Example – Force – Newton
Energy – Joule

(2) Rules of writing and using symbols and prefixes of units should be described.

(3) Advantages of S.I. Unit
Comprehension, coherence, rationality, brevity
Some concrete examples for conversion of units from one system to other.

(4) Discussion of criteria to choose the unit standards
(with idea about previous standards) as Meter bar – atomic standard – speed of light (for length unit)

(5) Idea of different unit scale for measurement of mini, micro, macro scales as light year, Angstrom, parsec, termi, astronomical units, light year.

Some problems on conversion of units.

(1) Express how many cm^2 are there in a square kilometer.

(2) Express speed of light in parsec/year

$1\ pc = 3.08 \times 10^{15} m$

Significant digits

The number of digits used in reporting a measurement have significance.

All the digits which are known reasonably are significant.

All non zero digits are significant

A digit is significant if and only if it affects the relative error.

Measurement	unit of measurement	Possbile error	relative error
0.5 m	0.1 m	0.05 m	0.1
0.05 m	0.01 m	0.005 m	0.1
0.005 m	0.001 m	0.0005 m	0.1
0.00005 m	0.00001 m	0.000005 m	0.1

In above example unit of measure and possible error are different but relative error is same.

Thus zeros following the decimal points are not significant. So digits are significant if they affect relative error.

Rules governing significant digit

(1) All non zero digits in a number are significant

(2) Zeros lying between non-zero digits are significant.

(3) Final zeros after decimal points are significant.

(4) If number is less than 1 zeros after decimal point are not significant but zeros following non-zero digits are significant.

$$0.\underbrace{00}_{\text{non significant}}58\underbrace{000}_{\text{significant}}$$

Measurement	possible error	relative error
0.2 m	0.05 m	$\frac{0.05}{0.2} = 0.25$
0.20 m	0.005 m	$\frac{0.005}{0.20} = 0.025$
25 m	0.5 m	0.02 m
250 m	0.5 m	0.002 m
102 m	0.5 m	0.0049 m
1002 m	0.5 m	0.000499 m

Show how the positions of zeros affect relative error so they are significant.

Rules for determining significant figures in algebraic operation.

Result → Smallest number of decimal spaces in the operation.

$$3.23 + 4.013 + 5.7 = 12.943 = 12.9$$

Some more examples to be given and preliminary idea about order of magnitude should be given.

Dimensions

It indicates how a physical quantity is related to the base quantities.

Dimensions of base quantities

[Length] = L   [Mass] = M
[Time] = T   [Temperature] = K
[Electric Current] = A   [Amount Substance] = N
[Luminous Intensity] = J

Students should be given idea about dimensions of known quantities but after words teacher should indicate unit and dimensions of any new physical quantity a student encounters

↓

idea about dimension less physical quantity as pure number

↓

idea about constants with dimension.

Properties of dimensions –

(i) non dependency on system of units
(ii) treated as algebraic quantities
(iii) tracing of dimension from units
(iv) more than one physical quantity may have same dimension
  Examples – torque, work

Dimensional analysis –

Equation in physics must be dimensionally homogeneous

Uses of dimensional analysis

(1) derivation of formula like velocity in a longitudinal wave
(2) checking the validity of equation

This portion may be explained with small known examples but in every chapter whenever an equation is derived should be shown that this is dimensionally homogeneous.

Limitations of dimensional analysis

(1) no information about dimensionless constants
(2) no correct guess for presence of all dimensional variables
(3) it does not distinguish between different physical quantity with same dimension (work, torque)

Idea about scientific notations.

All the rules to express the numbers (both large and small number) in exponential notations should be taught to the students

Unit of measure says about the quantity of measuring Instrument are having lower unit of measurement is more precise

[example screw gauge least count 0.01 cm and 0.005 cm]

Relative error

When two measurements [one small, one big] are done by same instrument the possible error in both is same. In order to compare such measurements one has to define relative error.

$$\boxed{\text{Relative error} = \frac{\text{Possible error}}{\text{Total measurement}}}$$

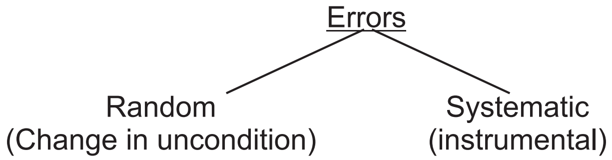
Measurement	unit of measurement	Possbile error	relative error
0.2 m	0.1 m	0.05 m	0.05 / 0.2 = 0.1
0.20 m	0.01 m	0.005 m	0.025
0.2000 m	0.0001 m	0.00005 m	0.00025

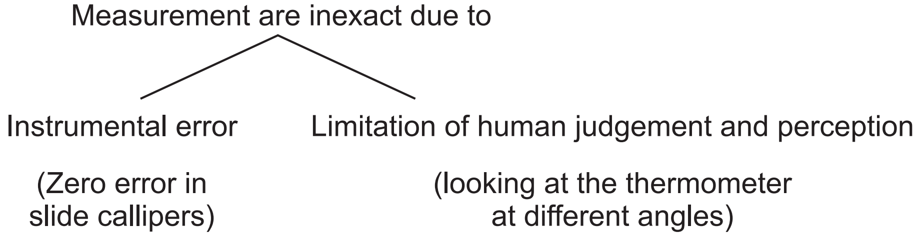
Similarly

Ask students to find relative error of 25m, 250m, 2500m

Where unit of measurement is 1M for each.

So relative error measures the error in measurement of different objects though the instrument is having same least count. So instrument is more precise and accurate when the least count is less.





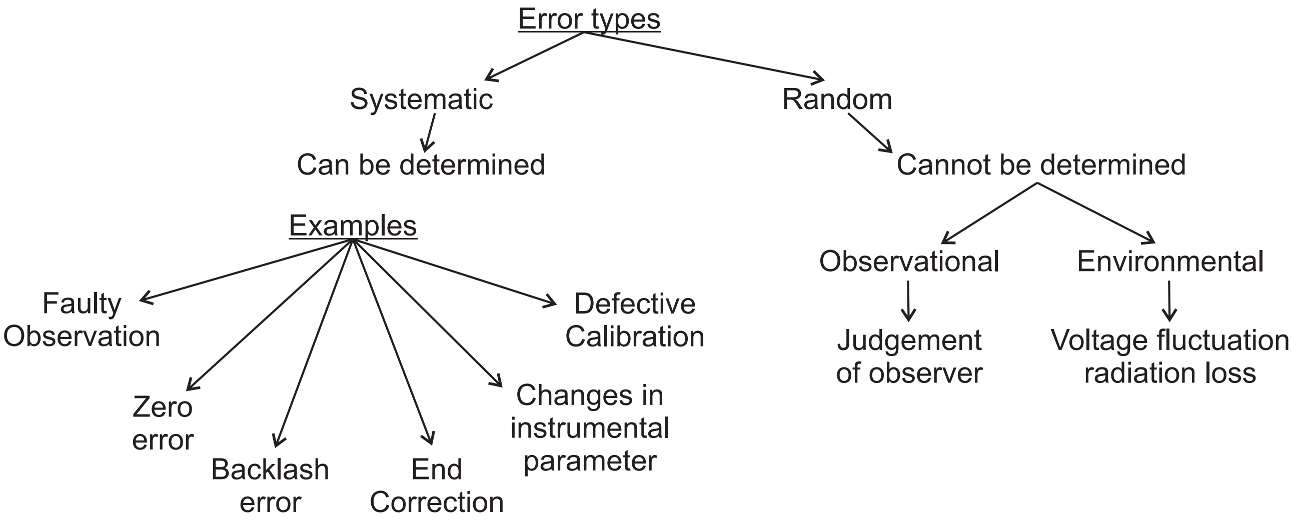
Sometimes the measuring instrument is unable to measure accurately

Example length measurement by a meter scale where length is in between say 5.1 cm and 5.2 cm

So if one reports it to be 5.1 then last digit is in error.

Possible error and precision

Without any mistake in measuring, maximum possible error is ½ of the unit of measurement which is due to inherent imprecision in measuring device. So possible error is proportional to unit of measure.



Error Propagation

Error calculation in addition, subtraction, multiplication and division

Addition } → Sum of individual error
Subtraction }

More Correct $\delta Q = \sqrt{(\delta A)^2 + (\delta B)^2 + (\delta C)^2}$

Multiplication } → Fractional error = Sum of fractional errors in individual
Division }

Statistical $\frac{\delta Q}{Q} = \sqrt{\left(\frac{\delta A}{A}\right)^2 + \left(\frac{\delta B}{B}\right)^2}$

Error in exponential quantity

Fractional error in A^n = n x fractional error in A

Determining the size of error

(i) Take number of observations

(ii) Find the average

(iii) Determine the deviation of each observation from the average value

(iv) Average out the deviations

(v) Precision index = $\frac{\text{average deviation}}{\sqrt{\text{No. of observations}}}$

Error can be obtained in slopes of graphs, error in slope = $\frac{\text{maximum slope} - \text{minimum slope}}{2}$

To avoid curved graphs one can draw semi-log or log graphs

Summery – Knowledge about

(1) Measurement (2) Units
(3) Dimension (4) Significant number
(5) Error

Assignments

What is meant by unit of measurement ?

What are base units ?

What is precision ?

What is significant number ?

State utility of dimensional analysis

Problems – The number of significant figures in 10.07 m is _______ Ans. (4)

The errors in measurement of length breadth and width of a parallopipedare

1% 2% and 2%

The error in volume of the parallelopipe is _________ Ans. 5%

UNIT-II

Kinematics

Introduction

Objective

Rest and Motion

Frame of reference

Language for describing motion

Concept of variation of one variable with respect to others (differentiation)

Concept of continuous sum (integration)

Vectors, scalars, their properties and operations, position, path length, distance & displacement, Velocity, Speed (average, instantaneous), acceleration, graphical and mathematical relations between displacement, velocity and acceleration.

Motion in a plane

(i) Circular motion

(ii) Projectile motion

Relative motion

Introduction :

Motion is part and parcel of daily life. In school level motion along straight line was taught. This chapter extends to two dimensional planar motion with description for language needed to explain motion by knowing vector treatment, differentiation, integration, position, displacement, velocity and acceleration and relative motion.

Objectives :

Student going through this unit should be able to

(i) specify appropriate frame of reference for a given physical situation.

(ii) Express the vectors and know operations done on vectors.

(iii) Describe the different motion parameters in terms of vectorial representations.

(iv) distinguish between average and instantaneous velocity and acceleration.

(v) extend the knowledge to describe planar motion.

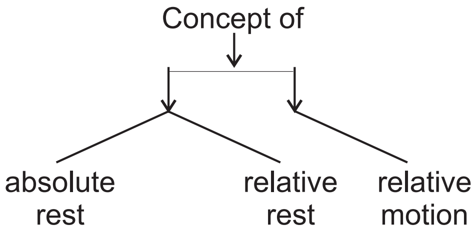
(vi) determine the relative velocity and acceleration.

Motion :

Positions alter with time, how to measure positions ?

The study of motion deals with the questions where ? and when ?

To determine the position there is need of a reference. Thus to specify a physical quantity each observer has to choose a zero of time scale, an origin in space and an appropriate coordinate system. All these collectively is frame of reference.



Language for describing motion

(i) Definition of scalars and vectors.

(ii) Representation of a vector in one and two dimensions.

(iii) geometrical representation of vector both in magnitude and direction.

(iv) Concept of vectors are not localised

(v) Concept of null vector, unit vector and negative vector

(vi) operation on vectors

  (a) equality of vectors (magnitude direction both same)

  (b) multiplication of vector with a scalar

  (c) Addition of vectors and subtraction as addition with a negative vector.

    Triangle law of vector addition

    Parallelogram method of vector addition

    Polygon method of vector addition

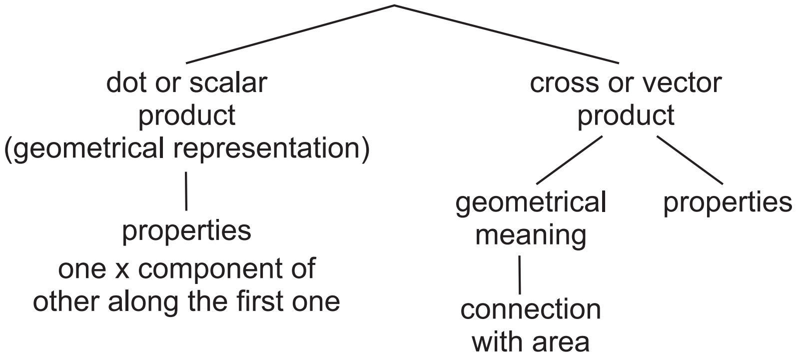
    Complete proof and discussion

    properties (associative law, distributive laws and commutative laws).

  (d) Components of vectors

  Rectangular components

  (e) Multiplication of vectors



  (f) Derivative of a vector with respect to a scalar.

(vii) Representation of position by position vector with reference point and reference axis graphically

Distance

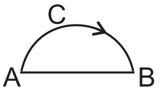
Distance travelled is measured from initial position to final position along the path followed.

Definition of displacement

Distinguish displacement from distance

Shortest distance → Displacement

Displacement may be zero but not the distance



Distance = Displacement

For A → B

Distance ≠ Displacement

For ACB path

Distance Time graphs (D ~ t graph)

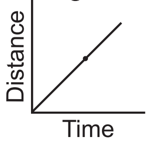
Student should be impressed D ~ t graph that can be plotted for a curvilinear path as well as rectilinear path.

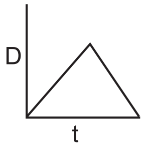
Example

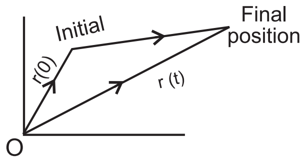
(1) Bats man taking a single run

D ~ t and position vs time graph

(2) Bats man taking two runs







Displacement $= \vec{r}(t) - \vec{r}(0)$

$\vec{r}(t)$ → position vector at time t

$\vec{r}(0)$ → position vector a time t = 0

Magnitude of displacement can be plotted against time.

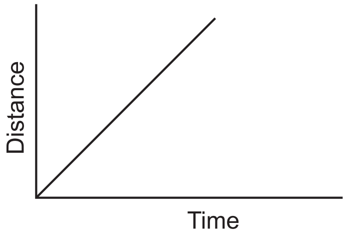
$$\text{Speed} = \frac{\text{Total Distance}}{\text{Total time}} = \text{average speed}$$

Instantaneous speed : speed at particular time

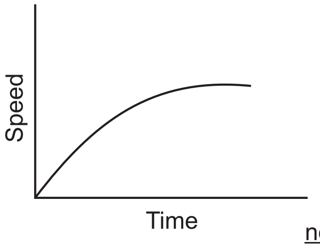
$$\underset{\Delta t \to 0}{\text{Lt}} \frac{dD}{dt} = \text{instantaneous speed}$$

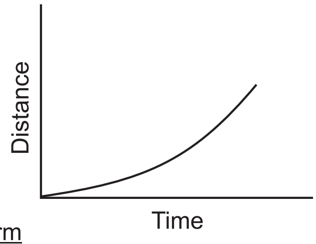
idea of instantaneous speed may be equal to average speed $\xrightarrow{\text{in}}$ uniform motion may not be equal to average speed $\xrightarrow{\text{in}}$ non uniform motion.

Speed timegraph



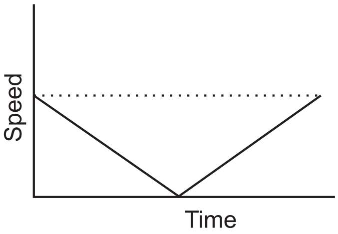
uniform Speed



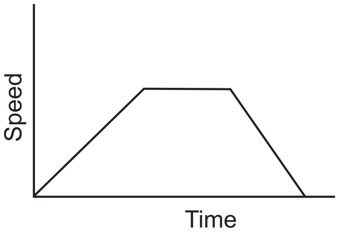


<u>nonuniform</u>

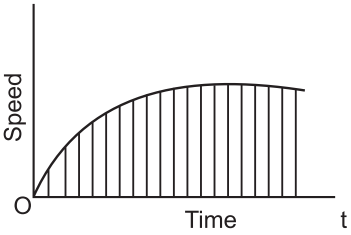
Relation of slope of Distance time curve with speed should be explained and area of speed time graph gives distance. <u>A ball thrown upwards then returns to ground.</u>



Car starting from rest attains a speed at constant rate then travels at a constant speed then comes to rest at a decrease of speed at a constant rate



Idea of integration as a continuous sum should be utilised to calculate area of speed time graph to get distance (only magnitude is considered)



Velocity : Motion with constant speed or non uniform speed with same direction or different direction some times changes in both leads to define velocity.

Speed in particular direction $< v > = \frac{\Delta s_1}{\Delta t} + \frac{\Delta s_2}{\Delta t} + \frac{\Delta s_3}{\Delta t} + \ldots$

$$= \frac{\Delta s_1 + \Delta s_2 + \Delta s_3 + \ldots}{n \; \Delta t} = \text{average velocity}$$

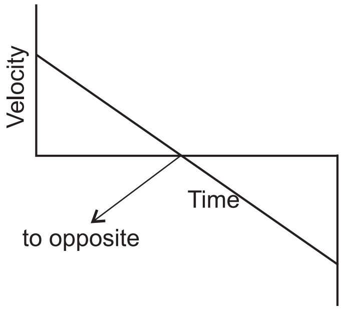
if $\Delta t \longrightarrow$ time interval is very small

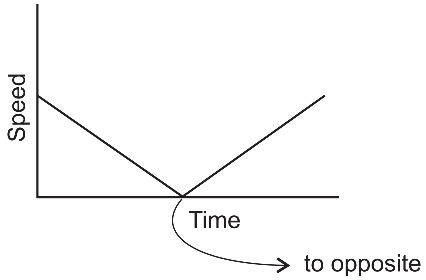
$$\underset{\Delta t \to 0}{Lt} \frac{\Delta s}{\Delta t} = \text{instantaneous velocity}$$

$$< v > \neq v_{average}$$

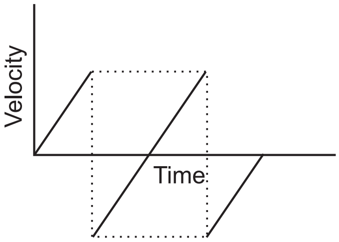
Velocity time graph → magnitude part versus time (with opposite direction to -ve magnitude)

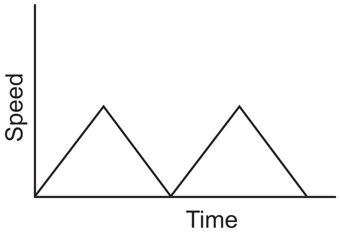
A ball thrown upwards which comes downward.





Graphical representation of ping-ping ball falling from a height.





Displacement can be calculated from above graph.

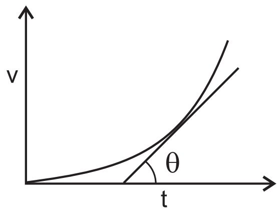
+ve area -ve area cancels and displacement is zero

Distance is not zero

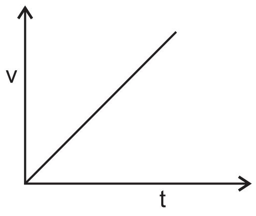
Acceleration : $< a > = \frac{v_1 - v_2}{t_1 - t_2}$ — average

$$\underset{dt \to 0}{Lt} \frac{ds}{dt} = \vec{a} \quad \text{— instantaneous}$$

Slope of v ~ t curve gives acceleration.



Non-uniform Acceleration



Uniform Acceleration

Deduction of equations of motion by calculus method for uniformly accelerated motion with different initial conditions.

Motion in a plane

Expression for displacement, velocity and acceleration in two dimension.

$$\vec{r} = \hat{i}\,x + \hat{j}\,y + \hat{k}\,z$$

$$\vec{s} = \hat{i}\,s_x + \hat{j}\,s_y$$

$$\vec{v} = \hat{i}\,v_x + \hat{j}\,v_y$$

$$\vec{a} = \hat{i}\,a_x + \hat{j}\,a_y$$

$$|\vec{r}| = \sqrt{x^2 + y^2 + z^2}$$

Projectile Motion → Definition -

Force Acting → gravitational + air friction

if air friction neglected only gravitational force

Key points to remembers

(1) g is uniform if height is small

(2) air resistance negligible if velocity of projection small

(3) No effect of earth's rotation

(4) Horizontal component of velocity not affected due to absence of force.

(5) vertical component decreases to zero then increases.

(6) no where velocity is zero.

Derive expressions :

(1) position, velocity at any point of the path

(2) path equation

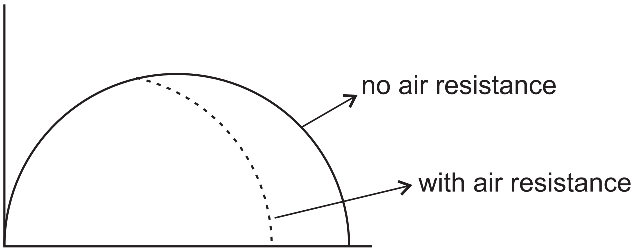
(3) time of flight

(4) Height of flight

(5) range

Discuss about their dependency of velocity of projection, angle of projection with horizontal direction.

If there is some air resistance the path gets deviated



Circular motion as a planar Motion → Express

$$\vec{r} = r\,\hat{i}\cos\theta + r\,\hat{j}\sin\theta = \hat{i}\,r\cos\omega t + \hat{j}\,r\sin\omega t$$

$$\vec{v} = -\hat{i}\,r\,\omega\sin\omega t + \omega\,\hat{j}\cos\omega t$$

$$\vec{v}\,.\,\vec{v} = \omega^2 r^2 \qquad \vec{v}\,.\,\vec{r} = 0$$

Idea of acceleration and force

Assignments

Problems

(I) A particle moves along the curve $y = Ax^2$ $x = Bt$ A, B are constants.

Express the position vector and velocity at any point at time t.

Assignments

(1) Define unit vector, null vector, line of action of a vector, sense of vector.

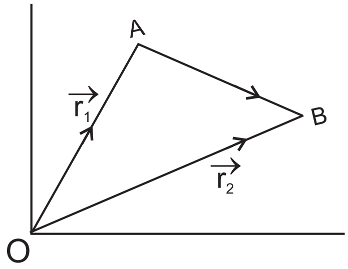
(2) Find minimum and maximum of $\vec{A}\,.\,\vec{B}$

(3) A particle is acted upon by 15 N towards east 15 Newton towards west and 25 Newton towards south. What is the resultant force.

(4) Two projectiles launched with same speed v_0 but an angle at $45^0 + \Phi$ and $45^0 - \Phi$ with the horizontal direction. If the range is same what will be the difference in their flight time ?

Description of relative motion

Concept of relative displacement



$\vec{r}_1$ Position of A with respect to origin

$\vec{r}_2$ – that of B w.r.t. origin but coordinate of B with respect to A

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

or that of A w.r.t. B $(-\vec{r}_2)$

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

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

$$\frac{d\vec{r}}{dt} = \frac{d\vec{r}_2}{dt} - \frac{d\vec{r}_1}{dt} \quad \rightarrow \text{velocity of B w.r.t. A}$$

$$\frac{d\vec{r_2}}{dt} = \frac{d\vec{r}}{dt} + \frac{d\vec{r_1}}{dt}$$

$$\frac{d\vec{r_1}}{dt} = \frac{d\vec{r_2}}{dt} - \frac{d\vec{r}}{dt}$$

$$v_{BA} = v_{B0} - v_{A0} = \frac{d\vec{r}}{dt}$$

$$v_{AB} = v_{A0} - v_{B0} = -\frac{d\vec{r}}{dt}$$

Relative Velocity

Give the example of two trains moving in same direction and moving in opposite direction

UNIT-III

Laws of Motion

Structure

Introduction

Objective

Dynamics

    (Cause, effect)

Conception of force

    Definition of force from observations
    Observations leading to different laws of motion

Application

Linear momentum related to second law

Impulse

Conservation of linear momentum and application

    Equilibrium under different forces
    Opposing force to motion
        (Static and Kinetic friction)
    Dynamics of uniform circular motion leading to concept of centripetal force
    Motion of vehicles on a level circular road and banked road

Introduction

A motion is described by a particle in terms of its displacement, velocity and acceleration. These are observed facts and can be measured. But if one asks why this motion has happened then the answer is given by this unit. The cause of motion is force. The way force controls motion qualitatively and quantitatively is obtained from Newton's laws of motion. Which in turn gives idea of momentum, impulse and its conservation. This unit also deals with the opposing force to the motion.

The discussion on linear motion is not sufficient. So one has to also think over the motion in a curved path which leads to study of uniform angular motion in a horizontal plane.

Objective

After studying this unit a student should be able to –

(1) apply Newton's laws of motion

(2) solve problems using equilibrium condition

(3) be conversant with conservation of linear momentum and solve problems

(4) know about friction

(5) study circular motion and know centripetal force.

Dynamics of motion

What makes things to move ?

Aristotle's conception push or pull was needed to keep something moving Galileo critically examined the statement of Aristotle but modified that any body in motion, if not obstructed will continue to move with a constant speed along a horizontal line.

Activity to illustrate

Examples of a toy car resting on a smooth and level surface

		Activity	**Observation**
1.		No push	Car at rest
2.	(i)	A push or pull	Car starts motion in direction of push or pull
	(ii)	a continuous push or pull	motion with increasing speed
	(iii)	push or pull stopped	motion continues with acquired velocity,
	(iv)	some other toyes are tied up with car	provided surface is smooth,
		same push or pull continued for some time	motion attains less velocity with some time
3.		A larger push but car is same	Velocity increase
4.		Same push. Car is overloaded	no motion

Conclusions

(a) These observations leads to definition of force. The force is that quantity which applied on a body changes or tends to change its state from rest to motion or if it is in motion then force changes the state of motion already existing.

(b) Unless a net push is applied from outside a body continues to be in state of rest or existing state of uniform motion.

(c) Larger the force, object being same larger is the change in velocity (acceleration)

(d) Force being same if the object is massive acceleration is less.

All these conclusions leads to Newton's laws of motion.

1st law → Every body continues in state of rest or of uniform motion along a straight line until and unless it is acted upon by an external resultant force to do so.

Example → Force may be acting but if resultant is zero then no change in state.

Thus the observations $\xrightarrow{\text{leads}}$ to the first law which implies that

(i) definition of force (external agent which can or tend to disturb the inertia (acceleration)

(ii) qualitative aspect of effect due to cause (force)

(iii) Inertia (inertness to interact) is an inherent property of all bodies and depends upon the mass observation (mass changes acceleration changes) ⟶ **law of inertia**

inertia of rest ↙ ↘ inertia of motion

Explanation with examples

(iv) In first law concept of frame of reference (inertial and non inertial frame of references) is there, as the quantity of observed effect (acceleration) depends upon the reference from which to which it is measured.

(v) (a) The law does not distinguish between states of a body at rest or in uniform motion.

(b) It also fails to make distinction between no force and no net resultant force.

(vi) Ideas about inertial observer and inertial mass

Second Law

This gives idea about the quantitative aspect of cause and effect

Observation leads to conclusions

$$\text{acceleration} \propto \text{applied force}$$

$$\text{acceleration} \propto \frac{1}{\text{mass of the body}}$$

$$\left.\begin{matrix} a \propto F \\ a \propto \dfrac{1}{m} \end{matrix}\right\} \rightarrow a \propto \frac{F}{m} \rightarrow F = kma$$

Implications

(a) Forces acting on a body are independent of one another.

(b) Force is quantitatively defined by this law.

(c) The value of k leads to choice of unit of force and definition of unit of force.

Unit of force is that force which produces unit acceleration on a body of unit mass then k = 1 and dimension less.

Net external force $\vec{F}$ = mass (m) x acceleration $\left(\frac{d^2\vec{r}}{dt^2}\right)$

$$= m\vec{a}, \quad \vec{a} = \frac{d^2\vec{r}}{dt^2}$$

with assumption m → constant for slow velocity

The three equations of motions are $F_x = ma_x \quad F_y = ma_y \quad F_z = ma_z$

Three component equations of motion

(d) $\vec{F}^{net} = 0 \qquad \frac{d^2\vec{r}}{dt^2} = 0 \qquad \frac{d}{dt}\left(\frac{d\vec{r}}{dt}\right) = 0$

$\frac{d\vec{r}}{dt}$ → constant → asserted by 1st law

(e) 1st law is quite independent of 2nd law

The equation of motion not derived from first principle but predicted from experimental observations so a very good postulate → basic equation of classical mechanics.

Dimension and units of force may be explained. Definition of newton, dyne and poundal and their inter relationship.

Third Law

To every action there is an equal and opposite reaction.

F_{AB} → Force due to A on B

F_{BA} → Force due to B on A

$\vec{F}_{AB} = -\vec{F}_{BA}$ one action other reaction.

Explanation with examples

[Earth and falling apple]

$|\vec{F}_{AB}| = |\vec{F}_{BA}|$ magnitude same, direction opposite

Implications

(i) Action and reaction act on different bodies

(ii) Single isolated force does not exist, forces occur in pair

(iii) Action and reaction force do not balance each other. F_{AB} has no effect on A

(iv) This law holds good for bodies in contact or at a distance.

(v) This is valid in inertial frames of reference.

Examples should be given

Limitations of Newton's Law

(i) can not be applied in non inertial frame.

(ii) mass is taken to be constant

(iii) For many particle system Newtonian mechanics is different → which tends to Lagrangian formulation.

(iv) Laws are not applicable to subatomic particles.

(v) 3rd law can not be applied to moving charged particles.

Definition of weight (effective and apparent)

↓

Knowledge of gravitational system of units

Algorithm to apply Newton's Law

(i) Identify systems

(ii) Identify the forces on each system

(iii) Make a free body diagram

(iv) Choose axes and write down equation with proper sign and solve with given conditions.

Conservation of linear momentum

↓

Statement →

When no net external force $\Sigma \vec{F}_{ext} = 0$

$\vec{P} \rightarrow$ Constant

Implications

(i) centre of mass of a body moving with constant velocity

(ii) conservation of linear momentum

Equilibrium

Equilibrium of body under application of forces (zero acceleration) → equilibrium under action of force

static body at rest

transnational body in uniform rectilinear motion

when vector sum of forces acting

$$\sum_i \vec{F}_i = 0 \qquad \sum_i F_{ix} = 0 \qquad \sum_i F_{iy} = 0 \qquad \sum_i F_{iz} = 0$$

Key notes

under equilibrium condition

Forces may be → Concurrent

→ represented by sides of closed polygon in cyclic order

↓

concept of free body diagram

Friction

Force of Friction : Force between two surfaces in contact and acts as an opposing force to relative motion

Types : (i) Dry friction; (ii) fluid friction

Origin due → interlocking of peaks and troughs of surfaces in contact.

Demonstration and example

Friction

static no relative motion

kinetic relative motion between layers in contact

bodies are at rest

Sliding friction

Rolling friction → How it is of less effect

Static Friction

(i) self adjusting

(ii) $f_{max} = \mu_s N$ $\mu_s \rightarrow$ coefficient of static friction N - normal reaction.

(iii) Direction of force adjusted to keep body at rest

(iv) does not depend on area of contact but on the nature of surfaces

(ii) and (iv) states laws of friction

Kinetic Friction

(I) $f_K = \mu_K N$

(ii) direction of f_K opposite to direction of motion

(iii) does not depend on area of contact but nature of surfaces in contact.

$$\mu_K < \mu_S$$

Laws of friction from observations

Definition of angle of friction (Figure)

If R → resultants of limiting friction

f_{max} and N (normal reaction)

angle of friction (θ) → angle between N and R

$$\tan\theta = \frac{f_{max}}{N} \quad \text{(derivation)}$$

Angle of repose : Angle that inclined plane makes with horizontal so that the body starts sliding

Proof of Angle of friction = Angle of repose

Advantage and disadvantages of friction. Necessity of Lubrication for minimisation of friction.

Dynamics of Circular motion

(a) Uniform → Uniform angular velocity

(b) Non-uniform → Non-uniform angular velocity

Uniform Circular Motion – as a planar motion

Requirement – axis and origin of circle on the axis

Examples

(1) Tips on hands of clock

(2) Artificial Sattelite

Idea about (1) angular displacement, angular velocity and angular acceleration, Time Period, Explain graphically and Mathematically their units, dimensions and directions.

(2) angular velocity at right angles to the plane of circular path along the axis of rotation.

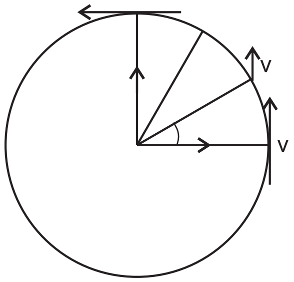
(3) Corresponding linear velocity is non-uniform.

(change in magnitude = 0
by establishing relation $|\vec{v}| = |\vec{w}|\,|r|$
for uniform circular motion)

but direction change is there

To show $\vec{v} \perp^{r} \vec{r}$ at every point on the circular path by showing

$$\vec{v} \,.\, \vec{r} = 0$$



as $\vec{r}$ magnitude does not change

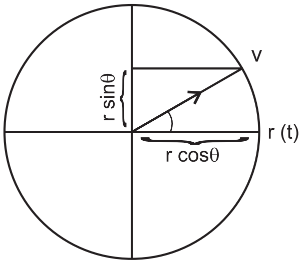
$$\vec{r} \,.\, \vec{r} = r^2$$

$$\frac{d(\vec{r} \,.\, \vec{r})}{dt} = \frac{dr^2}{dt} = 2r\frac{dr}{dt} = 0 \qquad r \text{ constant}$$

$$= \vec{r} . \frac{d\vec{r}}{dt} + \frac{d\vec{r}}{dt} . \vec{r} = 2\,\vec{r} . \frac{d\vec{r}}{dt} = 2\vec{r}.\vec{v}$$

so $\vec{r}$ and $\vec{v}$ are at right angles

Vectorial representation of position of particle on the circular path at any time with reference to cartesian axis whose origin coincides with the centre of the circular path.



$\theta \rightarrow \omega t$

$$\vec{r}(t) = \hat{i}\,x(t) + \hat{j}\,y(t)$$

$$r(t) = \hat{i}\,r\cos\theta + \hat{j}\,r\sin\theta$$

$$\vec{r}(t) = \hat{i}\,r\cos\omega t + \hat{j}\,r\sin\omega t$$

$$\vec{v} = \frac{d\vec{r}}{dt} \quad \text{and} \quad \vec{v}.\vec{v} = \omega^2 r^2$$

$$|v| = \omega r \rightarrow \text{magnitude constant}$$

$$\vec{v} = -i\,r\omega\sin\omega t + j\,r\omega\cos\omega t$$

$$\vec{r}.\vec{v} = 0$$

$$\vec{a} = \frac{d\vec{v}}{dt} = -\omega^2(\hat{i}\,r\cos\omega t + \hat{j}\,r\sin\omega t)$$

$$= -\omega^2\vec{r} = -\omega^2 r\,\hat{r}$$

$$\vec{a} = -\frac{v^2}{r}\hat{r} \qquad \text{as } |v| = |\omega r|$$

$$|a| = \frac{v^2}{r} \quad \text{directing towards the centre of the circular path}$$

as a is centre seeking so

Centripetal

Show that average acceleration and velocity over a cycle is zero. Presence of acceleration leads that there is a force as per the Newtons law.

That force which is necessary for centripetal acceleration is the centripetal force.

$$\vec{Fc} = m\vec{a} = -m\frac{v^2}{r}\hat{r}$$

directed towards the centre

$\vec{Fc}$ depends on mass, velocity and radius

$$|Fc| \propto m$$

$$|Fc| \propto \frac{1}{r}$$

$$|Fc| \propto v^2$$

- This force causes deviation from linear path to curved path
- The body is not in equilibrium
- Change in kinetic energy from point to point is constant as $|v| \rightarrow$ constant
- This force is provided by relevant type of force at different situation.

  It is not a different force

(a) whirling of stone → Tension in the string is centripetal force

(b) orbiting of earth → gravitational force

(c) orbiting of electron around neucleus electrostatic attraction

(d) car rounding a curve on road → frictional force

Concept of Centrifugal force

Not a reaction force to Centripetal. Idea of inertial and non inertial frame of reference.

It is a fictitious force acting on the body observed by an observer who is in a non inertial frame of reference.

It is a fictitious or pseudo force. Give some illustrations like passenger moving in an accelerated car and car is negotiating a curve or an observer siting on a turntable looking at an object at rest on the turntable and tied to the centre by a string.

Banking of tracks

Motion on a level road

force on automobile

(1) force of Gravity (2) normal reaction exerted by road, (3) side wise frictional force exerted by road on tyre.

1st and second force balance

$\vec{F} = f_{\text{friction}} = -\frac{mv^2}{r}\hat{r}$ provides the Centripetal force to keep mobile on circular track.

So $v \rightarrow v_{max}$ so that f_{friction} can provide necessary centripetal force

$$\frac{mv^2_{max}}{r} = \mu s \text{ x normal reaction}$$

$$= \mu s\ mg$$

$mv^2_{max} = \mu s \ mg \times r$

if $v > v_{max} \rightarrow$ skidding

so to avoid skidding

road is banked outer edge, higher sloping towards the centre of path. so that part of normal reaction balances gravitational force and part gives rise to centripetal force.

θ is governed by

$$\tan\theta = \frac{v^2}{rg}$$

Some examples :

Assignment -

1) Define coefficient of static and kinetic friction.
2) Is the force of static friction is a self adjusting force ?

Problem

A 20 kg block is at rest on a horizontal surface. It is at the verge of sliding when a force is applied to it at a direction 60^0 upward from the horizontal. Find the coefficient of static friction ?

UNIT-IV

Work Energy Power

Structure

1. Introduction
    Objective
2. Work
    (i) work done by a constant force
    (ii) work done by a variable force
3. Energy
    (I) kinetic energy and work energy theorem
    (ii) power
    (iii) conservative force and non conservative forces
    (iv) conception of potential energy
        potential energy of a spring
    (v) conservation of energy
    (vi) Energy diagrams
    (vii) Motion in a vertical circle
    (viii) Elastic and non-elastic collisions
    (ix) problems
    (x) questions

Introduction

In the previous section students have studied the dynamics of motion or cause behind the motion. In day to day activities people utter word work. We have done some work we have lost some amount of energy to do the work. But the word 'work' has a special meaning for physicists. A teacher standing near a table delivering one hour lecture has done no work as per a physicist. A porter walking on the platform having a heavy box on his head also does not do any work. In this unit we will learn the physicist's interpretation of work and energy. The conservation of energy and the application of principles to events will be discussed.

Objective

After studying this unit one will be able to –

(1) compute work of different types of forces
(2) apply work energy theorem
(3) solve problems on the principle of conservation of energy
(4) compute power in mechanical systems
(5) solve problems based on elastic and inelastic collisions

Work

Definition of work $w = \vec{F} . \vec{\Delta\ell}$

unit, dimensions of work = $M L^2 T^{-2}$

$\downarrow$

newton meter (Joule)

Work product of component of $\vec{F}$ or $\vec{S}$ in direction of $\vec{S}$ or $\vec{F}$

Role of angle between $\vec{F}$ and $\vec{\Delta\ell}$

θ → acute → work is said to be done by force

(Example with figure)

θ → obtuse → work done against the force

(Example with figure)

θ → = 90 → no work is done

Example reaction of the ground on a man when he walks. Torsion on the string of a pendulum

$\theta = 0$ Maximum work

Work done by a constant force

F constant, $\Delta\ell \rightarrow \vec{\Delta\ell_1} + \vec{\Delta\ell_2} + \vec{\Delta\ell_3}$ ...... (figure)

successive displacement

$$W = \vec{F} . \vec{\Delta\ell} = \vec{F} . \vec{\Delta\ell_1} + \vec{F} . \vec{\Delta\ell_2} \ ......$$

Work done by several forces (constant)

$$(\vec{F_1} + \vec{F_2} + ...) . \vec{\Delta\ell}$$

Work done by a constant force for a succession of displacements is the sum of work done in individual displacements.

if force is position dependent (variable force)

Example – Coulomb force

Gravitational force

$$\vec{F} \simeq \vec{F}(r)$$

$$W = F(\vec{r_1}) . \vec{\Delta\ell_1} + F(\vec{r_2}) . \vec{\Delta\ell_2} + ...$$

$$= \sum_i F(r_i) . \Delta\ell_i$$

$$W = \lim_{\Delta\ell_i \to 0} \sum_i \vec{F}(\vec{r_i}) . \vec{\Delta\ell_i}$$

As $\Delta\ell_i$ is made smaller and smaller

$$W = \int_A^B \vec{F}(r) . \vec{d\ell} \qquad \text{line integral}$$

if $\vec{F} = \hat{i}\,F_x + \hat{j}\,F_y$ (figure)

$$\vec{d\ell} = \hat{i}\,d\ell_x + \hat{j}\,d\ell_y$$

$$\vec{F}\,.\,\vec{d\ell} = F_x d\ell_x + F_y d\ell_y$$

Energy — Mechanical

Kinetic , Potential

by virtue of motion

by virtue of position, configuration

$$\vec{F} = \frac{\vec{dp}}{dt} = m\frac{dv}{dt}$$

$$v = \frac{d\ell}{dt} \qquad d\ell = v\,dt$$

$$\vec{F}\,.\,\vec{d\ell} = m\frac{\vec{dv}}{dt}\,.\,\vec{v}dt = m\,\vec{v}\,.\,\vec{dv}$$

$$\frac{d}{dt}(\vec{v}\,.\,\vec{v}) = 2\,\vec{v}\,.\,\frac{\vec{dv}}{dt}$$

$$\vec{v}\,.\,\frac{\vec{dv}}{dt} = \frac{d}{dt}\,\frac{1}{2}\,(\vec{v}\,.\,\vec{v})$$

$$\vec{F}\,.\,\vec{d\ell} = m\frac{d}{dt}\{\frac{1}{2}(\vec{v}\,.\,\vec{v})\}\,dt$$

$$= \frac{m}{2}\,d(\vec{v}\,.\,\vec{v})$$

$$W = \int_A^B \vec{F}\,.\,\vec{d\ell} = \int_{V_A}^{V_B}\frac{m}{2}\,d(\vec{v}\,.\,\vec{v})$$

$$= \frac{1}{2}\,m\,(v_B^2 - v_A^2) = T_B - T_A$$

T → K.E

leads to work energy theorem

Line integral of a force between two positions is equal to change in kinetic energy of the particle in coming from initial to final position, which is work energy theorem.

Work = +ve → Kinetic Energy increases

Work = 0 → Kinetic Energy constant

Work = –ve → Kinetic Energy decreases

Kinetic Energy of particle = work that a particle can perform against the net force which causes it to come to rest.

Conservative Force

The force for which the work done is independent of the path followed and depends on the initial and final positions of the particle. Derivation to prove the statement.

Example → Gravitational force, Electro Static Force, Spring - Mass system.

Work done around a closed path is zero.

Deduction should be done to show this

Let $\vec{F} = -k_0 x \hat{i}$ $\vec{d\ell} = \hat{i}\, dx$

$\vec{F} \cdot \vec{d\ell} = -k_0 x\, dx$ (spring mass system)

$$W = -\int_{x_1}^{x_2} k_0 x\, dx = -\frac{k_0}{2}(x_2^2 - x_1^2) = -(u_2 - u_1)$$

Let $\frac{k_0}{2} x_2^2 \rightarrow u_2$

$\frac{k_0}{2} x_1^2 \rightarrow u_1$

For Gravitational force $w = -(mgy_2 \;\; mgy_1) = -(u_2 - u_1)$

where $u \rightarrow mgy$

this x, y gives the configuration or position of the body

$x \rightarrow$ stretching in spring

$y \rightarrow$ height of the body

Thus u is a quantity that depends on the configuration of system and $u \rightarrow$ potential energy

Potential Energy of a particle at any point in a conservative force field is equal to the negative of work done on it by the conservative force, when a particle moves from a point at zero potential energy level to that point or work done in taking system from that configuration to some standard configuration.

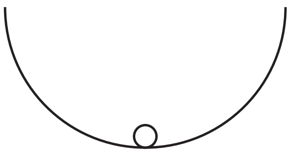
Potential Energy is related to conservative force

$$du = -\vec{F} \cdot \vec{dx}$$

$$|F| = -\frac{du}{dx}$$

Conservation force is negative rate of change of potential energy with respect to the position variable.

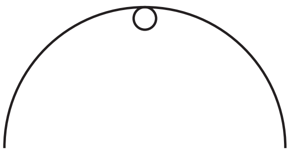
$$\frac{du}{dx} = 0 \left\} \begin{array}{l} u - \text{minimum} \\ u - \text{maximum} \\ u - \text{constant} \end{array} \right.$$



(1) minimum

↓

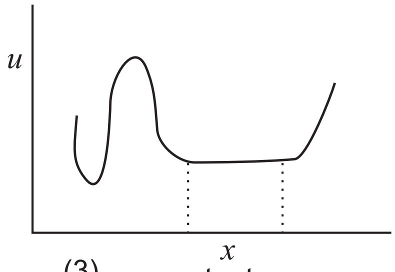
stable equilibrium



(2) maximum

↓

unstable



(3) constant

↓

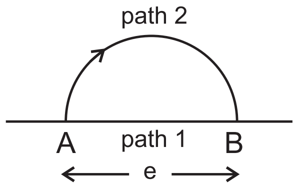
neutral equilibrium

Non conservative force

A force is non conservative if the work done by it on a particle moving from point A to B is dependent on path

$$\int \vec{F} \cdot \vec{ds} \neq 0 \text{ for a closed path}$$

Example friction



$$w_1 = {}_0\int^{\ell} f_k \,.\, ds = -{}_0\int^{\ell} f_k \, ds = f_k \ell$$

along path 1

along path 2 $\quad w_2 = - f_k \pi r$

$\ell \neq \pi r \quad r \to$ radius

$\ell = 2r$

$\pi r \neq 2r$

$\longrightarrow$ friction direction changes
$\longleftarrow$

so total work on closed path $\neq 0$

Principle of energy conservation

Total Mechanical Energy is constant

P.E + K.E. = constant

loss in P.E. = gain in K.E. (Example, body falling from a height under gravity)

when a body moves on a horizontal plane

P.E. → constant

P.E. + K.E. + work done against friction = constant

Energy conservation leads to

(i) Energy can neither be created nor destroyed and can be transformed from one type to another with exact equivalence.

(ii) Total amount of energy in the universe or any isolated system is constant.

Power

Rate of doing work

$$\vec{P} = \frac{dw}{dt} = \vec{F} \cdot \vec{v}$$

Unit - watt (Joules/sec) and dimensions ML^2T^{-3} should be mentioned.

Conversion of hp to watt should be told to students.

1 hp → 746 watt

Motion in a vertical circle

The points to be noted :

First of all the difference between the motion of a body on horizontal plane in circular path and motion on a vertical circle should be mentioned.

Role of gravitational potential energy and pull of the earth should be explained.

Tension of the string when the body is at lowermost position is maximum.

This should be explained with figures and some examples.

Elastic and Inelastic collisions

Principle → (i) Conservation of momentum

Definition → Kinetic Energy unchanged — Elastic
Kinetic Energy not constant — Inelastic
(along with linear momentum conservation)

Collisions can be illustrated by taking a drawing board, paper, with some coins and carbon sheet.

Deriving expression for velocities after collision, the dependence on different initial velocities and mass ratio should clearly be explained.

Inelastic Collision — example, ballistic pendulum, collision between two macroscopic bodies.

Problems on each unit should be done

Assignment :-

(1) State and prove work energy theorem.

(2) Differentiate between conservative and non conservative force.

(3) What is the maximum velocity of particle moving in a vertical circle ? How it is different from motion in a horizontal circle ?

UNIT-V

Structure

1. Introduction
    - Objectives
2. System of particles
    - (i) Centre of mass, reduced mass conception
    - (ii) Equation of motion in CM and relative coordinate
3. Conception of rotation
4. Kinematics of angular motion
    - (i) Angular displacement
    - (ii) Angular velocity and angular acceleration
    - (iii) Relating the linear and angular kinematical variables
5. Dynamics of angular motion
    - (i) Angular motion in general
    - (ii) Torque (Moment of force)
    - (iii) Kinetic energy of rotation
6. Angular momentum
    - (i) Conservation and application with examples
7. Equations of rotational motion comparison with linear equation motion
8. Equilibrium of rigid bodies with different examples.
    - (i) Linear momentum conservation and angular momentum conservation
9. Concept of moment of inertia
    - (i) Moment of inertia of simple bodies, axis transfer theorems

Introduction

Previously the problem of uniform circular motion has already been dealt with. But world is full of rotating objects (rotating galaxies, orbiting of planets, merry go round, bicycle wheels and fly wheels, acrobats and ballerians (dancers)). One can analyse all such motions using Newton's law by applying it to each particle undergoing rotation but bodies are not point particles, they are extended objects so it is necessary to find a simple method for treating the angular motion of an object as a whole as if it behaves like a point particle rotating around an axis. So it is necessary to find the point whose motion is equivalent motion of the entire body. So we have to introduce the concept of centre of mass and motion of a rigid body (linear and angular) in terms of CM and relative coordinates. As rotation deals with angular motion so kinematics and dynamics of rotational motion is to be studied. Comparison of both type of motion to be dealt with.

Objective

After studying this unit a student should be able to –

(1) define the centre of mass, relative corodinates and reduced mass of system of particles.

(2) solve problems involving motion of two body system by knowledge of its CM and relative coordinates.

(3) Compute the motion of system of particles in terms of motion of its centre of mass and relative coordinates.

(4) Express the angular displacement, angular velocity, angular acceleration, rotational kinetic energy of a particle undergoing angular motion.

(5) Relate the kinemetical variables of angular motion and linear motion in their vector forms.

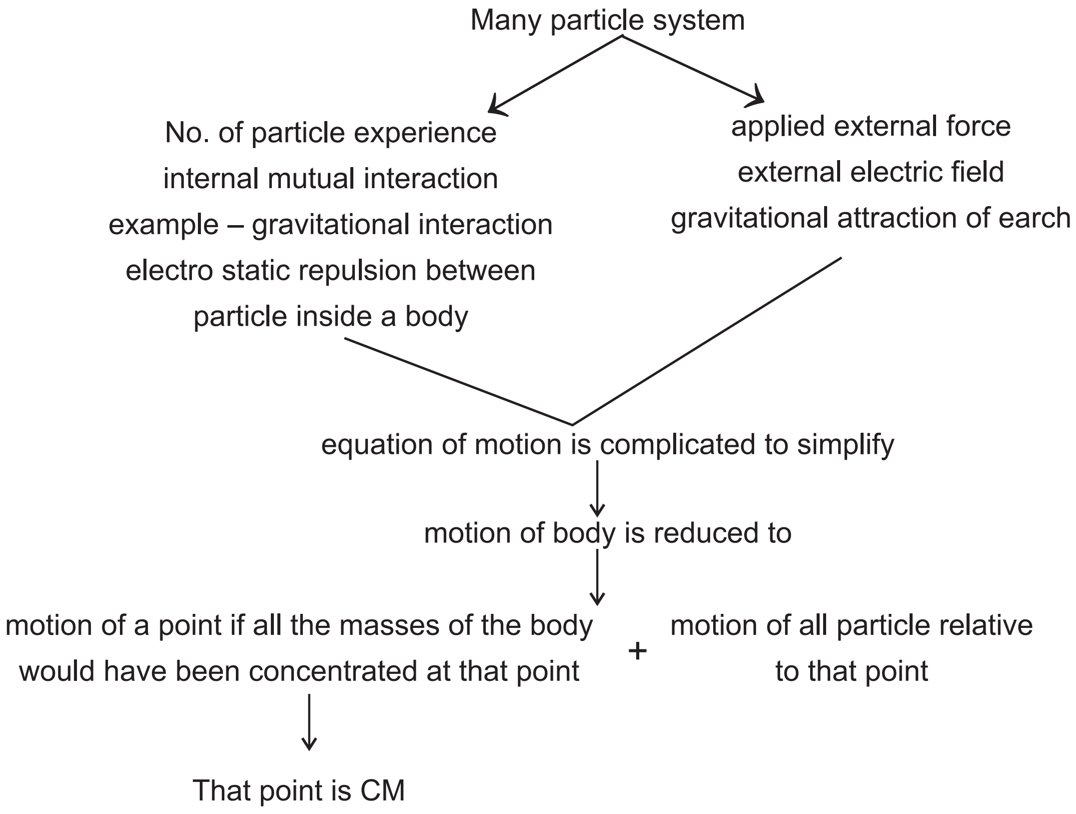
(6) Solve problems relating to the concept of torque, rotational kinetic energy and angular momentum of the particle.

(7) Apply the law of conservation of angular momentum.

(8) Express moment of inertia for different bodies and its role equivalent to mass in linear motion.

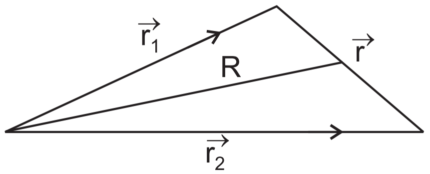
System of particle

Motion of an extended body can be explained by knowing the individual motion which is complicated. So equivalent point particle, of many particles to be taken → idea of centre of mass



This leads to definition of CM

Calculation of coordinates of CM and relative coordinates of particles with respect to CM for two body system



$$R = \frac{M_1 r_1 + M_2 r_2}{M_1 + M_2}$$

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

$$\vec{r}_1' = r_1 - R = \frac{M_2 \vec{r}}{M_1 + M_2}$$

$$\vec{r}_2' = r_2 - R = -\frac{M_1}{M_1 + M_2}\vec{r}$$

$$\ddot{r} = \left(\frac{1}{M_1} + \frac{1}{M_1}\right)\vec{F}_{21}$$

$\mu \rightarrow$ reduced mass $= \dfrac{M_1 M_2}{M_1 + M_2}$

as $\vec{F}_{21} = -\vec{F}_{12}$

So $\dfrac{d^2}{dt^2}(MR) = 0$

MR = constant

C.M. moves with constant velocity

$\boxed{\mu \ddot{r} = F_{21}} \longrightarrow$ as it is only one equation to be solved

↓

reduces the task of solving two second order differential equation

↓

as if it is equivalent to one body

Conception of rotation

(i) necessity of an axis

(ii) individual particle moving in a circular path around axis

(iii) rigid body definition (distance between two particles constant)

(iv) every particle on the axis, if axis is on the body is having zero velocity

(v) concept of angular displacement on rotation

(vi) relation of angular displacement with the radius of circular path

(vii) vector nature of angular displacement

(viii) Angular speed, angular velocity in vectorial form and direction specification

$$w = \hat{k}\frac{d\theta}{dt}$$

$\hat{k} \rightarrow$ unit vector along axis if rotation is about axis in anticlockwise direction.

(ix) angular acceleration as a vector α is in direction of Δw if w is having change in magnitude only then α direction is parallel or anti-parallel to axis direction but if w is having change only in direction then α direction is perpendicular to w direction. when w is angular velocity.

(x) relation between linear and angular kinematical variables.

Dynamics of angular motion

Role of only radial force → uniform circular motion

Role of radial and transverse force → non uniform circular motion giving rise to finite angular acceleration.

Torque – definition

Examples –

Analogy of torque and force → in angular motion and linear motion, Torque provides relation between applied force and tendency of a body to rotate. Torque depends on origin but force does not. For same force torque may be more for greater r. For fixed r, F maximum torque is with r, F are at right angles to each other.

Definition of kinetic energy → Kinetic Energy of only rotating body

Kinetic Energy of body slipping as well as rotating.

Angular momentum definition, relation with linear momentum.

Angular momentum of system of particles.

Conservation of angular momentum and relation between torque and angular momentum.

Application → (i) Steer a satellite

(ii) student on a frictionless turnable.

(iii) A boy diving into water

Equilibrium of right body

$$\Sigma F = 0 \qquad \Sigma \tau = 0$$

$$\Sigma F_x = 0 \qquad \Sigma \tau_x = 0$$

$$\Sigma F_y = 0 \qquad \Sigma \tau_y = 0$$

$$\Sigma F_z = 0 \qquad \Sigma \tau_z = 0$$

Conception of moment of inertia analogy with mass, definition, expression for simple objects. Parallel axis theorem, perpendicular axis theorem, statements, some small problems.

Problems

(1) What would be the magnitude and direction of angular displacement in a clockwise rotation of a hand of a clock from 5 to 9

(Answer - $\theta = 2\pi/3$ rad perpendicular to face of ...... away from the holder)

(2) Show that angular acceleration is perpendicular to angular velocity if

$$|w| = \text{constant}$$

$$\frac{dw^2}{dt} = \frac{d(w \,.\, w)}{dt} = w \,.\, \frac{dw}{dt} + \frac{dw}{dt} \,.\, w$$

$$\text{but } \frac{dw}{dt} = \alpha \qquad w \,.\, \alpha + \alpha \,.\, w = 0$$

$$w \,.\, \alpha = 0$$

w perpendicular to α

(3) problems relating to application of parallel axis and perpendicular axis theorem :

Find the expression of moment of inertia of a disc about an axis which is tangent to side and in the plane of disc.

(4) Assignment -

(a) State parallel and perpendicular axis theorem for moment of inertia.

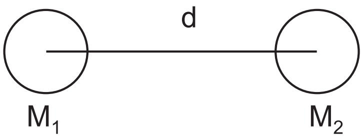
(b) Define centre of mass

UNIT-VI

Gravitation

What is gravitation ?

Newton's Law of gravitation



$$F = G \frac{M_1M_2}{d^2}$$

Definition of G.

Unit of G

C.G.S. System – $\frac{\text{dyne x Cm}^2}{\text{Gm}^2}$

M.K.S. System – $\frac{\text{N x m}^2}{\text{Kg}^2}$

Dimension of G

$[G] = [M^{-1} L^3 T^{-2}]$

Value of G :–

$G = 6.67 \times 10^{-8}$ C.G.S. Unit

$= 6.67 \times 10^{-11}$ M.K.S. Unit

Kepler's Laws of Planetary motion

1st Law :– Every planet revolves round the sun in a fixed elliptic orbit with sun situated at one focus.

2nd Law :– A real velocity of the planet is constant.

3rd Law :– The square of time period of revolution of a planet around the sun is directly propotional to the cube of semi major axis of the elliptic orbit.

$$T^2 \propto a^3$$

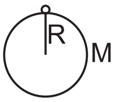
$$\frac{T^2}{a^3} = \text{constant}$$

Definition of Gravitational field, potential and potential energy

Gravitational potential $= -\frac{GM}{r}$

Gravitational potential energy $= -\frac{GMm}{r}$

Relation between g and G :-



M = Mass of earth

R = Radius of earth

$$\frac{GM\cancel{m}}{R^2} = \cancel{m}g$$

$$\boxed{g = \frac{GM}{R^2}}$$

Variation of g with altitude :-

Value of g decreases at a height above the surface of earth.

$$g' = g(1 - \frac{2h}{R})$$ h = Height above the earth surface

Variation of g with depth :-

Value of g decreases at a depth below the surface of earth.

$$g'' = g(1 - \frac{h}{R})$$ h = Depth below the earth surface.

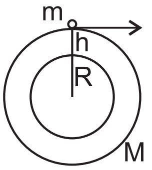
Value of g at the centre of earth :-

For the centre, $h = R$

Hence $g'' = g(1 - \frac{R}{R}) = 0$

Since g = 0 at the centre of earth, everything becomes weightless at the earth centre.

Orbital Velocity :-



M = Mass of earth

R = Radius of earth

m = Mass of revolving body

h = Height at which the body revolves

$$\frac{GMm}{(R+h)^2} = \frac{mv^2}{R+h} = \text{Centripetal force}$$

$$v^2 = \frac{GM}{R+h} \qquad v = \sqrt{\frac{GM}{R+h}}$$

When the satelite is very close to the earth surface, h is neglected

$$v = \sqrt{\frac{GM}{R}} = \sqrt{\frac{GM}{R^2} \times R}$$

$$= \sqrt{Rg} = 8.4 \text{ km/sec.}$$

Escape Velocity :-

It is the velocity with which a body is projected so that it will never come back to the surface of earth.

$$v_e = \sqrt{2Rg} = 11.2 \text{ km/sec.}$$

$$\boxed{v_e = \sqrt{2} \times v}$$

Escape Velocity = √2 x Orbital Velocity

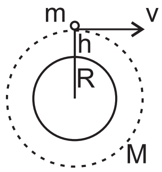
Geo - Stationary Satelite :-

Definition :- It is the satelite which appears to be stationary when viewed from the surface of earth.

Time period of a geo-stationary satelite

$$T = 24 \text{ hrs.}$$

Height at which a geo-stationary satelite revolves



$$\frac{GMm}{(R+h)^2} = \frac{mv^2}{R+h}$$

$$v = \sqrt{\frac{GM}{R+h}}$$

$$\text{But} \quad v = \frac{2\pi(R+h)}{T}$$

$$\frac{2\pi(R+h)}{T} = \sqrt{\frac{GM}{R+h}}$$

$$\frac{4\pi^2(R+h)^2}{T^2} = \frac{GM}{R+h}$$

$$T^2 = \frac{4\pi^2(R+h)^3}{GM}$$

$$(R+h)^3 = \frac{GMT^2}{4\pi^2}$$

$$R+h = \left(\frac{GMT^2}{4\pi^2}\right)^{1/3}$$

$$\boxed{h = \left(\frac{GMT^2}{4\pi^2}\right)^{1/3} - R} \qquad T = 24 \times 60 \times 60 \text{ Seconds}$$

Assignment :-

Objective questions

1. Fill in the blanks
   (a) Value of g at the centre of earth is ________.
   (b) Value of g is maximum at the ________ of earth.
   (c) Time period of a geo-stationary satelite is ________ .
   (d) ________ is the dimension of G.
   (e) Expression for escape velocity is __________.
2. (a) Define gravitational potential and potential energy.
   (b) Mass of earth is 80 times that of moon and radius is 4 times. Calculate the value of g on the surface of moon if that on the surface of earth is 9.8 m/sec^2.

(c) State Kepler's Laws of planetary motion.

(d) If Kinetic Energy of satelite revolving close to the surface of earth is suddenly doubled what happens to the satelite ?

(e) Calculate the density of earth.

(f) Calculate the gravitational force of attraction between two masses 5 gms and 10 gms separated by a distance of 25 cm. Given G = 6.67×10^{-11} M.K.S. units.

(g) How far from the earth surface does the acceleration due to gravity become 16% of its value on the surface of earth ? Given R = 6400 km.

(h) Moon has no atmosphere. Why ?

(i) What are the different uses of a satelite ?

(j) A satelite of mass (m) revolves around a planet of mass (M) in an orbit of radius (r). What is the total energy of the satelite ?

UNIT-VII

Properties of Matter

Elastic Behaviours

Stress

Definition, Unit and dimension

Different types of stress

Strain

Definition, Unit and dimension

Different types of strain

Stress - Strain Diagram

Hook's Law

Modulus of Elasticity

Definition, Unit and dimension

Different types of elastic modulus

Young's Modulus (Y)

Bulk Modulus (B or K)

Rigidity Modulus (n)

Poisson's Ratio (σ)

Definition, Unit and dimension

Limiting values of Poisson's Ratio

$-1 \leq \mu \leq .5$ $\mu \rightarrow$ poisson's ratio

Relation between elastic constant

$$\frac{9}{Y} = \frac{3}{K} + \frac{1}{n}$$

Expression for elastic energy

W = ½ Force x Extension

Energy per unit volume

$$= \frac{W}{AL} = \frac{1}{2}\frac{F\ell}{A \times L}$$

$$= \frac{1}{2}\left(\frac{F}{A}\right) \times \left(\frac{\ell}{L}\right)$$

$$= \frac{1}{2} \text{ Stress} \times \text{Strain}$$

Assignment :-

1. (a) Stress is defined as ________ per unit ________.

   (b) Steel is ________ elastic than rubber.

   (c) Dimensional formula for modulus of elasticity is ________.

   (d) Values of poision's ratio lies between ________ and ________.

   (e) Energy density of a wire is ________ times the product of tension and extension.

2. (a) What is elastic fatigue ?

   (b) What force is required to stretch a steel wire of cross wire of 1 sq.cm to double its length ?

   $$(Y = 2 \times 10^{11} N/m^2)$$

   (c) State Hook's Law.

   (d) Why is steel said to be more elastic than rubber ?

   (e) Write the relation between elastic constants.

Mechanical Properties of Fluids

Pressure due to a fluid column

$$= P = h\rho g$$

Unit and dimension of pressure

Statement of Pascal's Law

Application of Pascal's Law

Hydraulic lift and hydraulic brakes.

Definition of surface energy and surface tension.

Units and dimensions of surface tension and surface energy. Cohesive force and Adhesive force.

Relation between surface tension and surface energy.

Variation of surface tension with temperature.

Definition of angle of contact

Excess pressure across a curved surface.

Excess pressure across a soap bubble = $\frac{4T}{R}$

Excess pressure across a liquid drop = $\frac{2T}{R}$

Capillary Rise

Expression for Capillary rise in terms of surface tension

$$T = \frac{rh\rho g}{2\cos\theta}$$

Viscosity

Idea of Viscosity

Statement of Stoke's Law

$$F = 6\pi\eta rv$$

Expression for terminal velocity

$$v = \frac{2}{9}\frac{r^2 g(\rho - \sigma)}{\eta} = \frac{2}{9} r^2 g(\rho - \sigma)$$

Distinction between stream line motion and turbulent motion.

Idea of Critical Velocity

Equation of Continuity

$$av = \text{constant}$$

$$v \propto \frac{1}{a}$$

Bernoulli's Theorem

Statement

$$p + h\rho g + \tfrac{1}{2}\rho v^2 = \text{constant}$$

Some applications of Bernoulli's Theorem.

Venturi meter, Spray atomiser

Definition of co-efficient of viscosity.

Unit and dimension of co-efficient of viscosity.

Assignment :-

1. (a) Unit of surface tension is ________.
   (b) What is the dimension of Co-efficient of viscosity.
   (c) What is Cohesive force ?
   (d) Pressure difference across a liquid drop is ________.
   (e) Work done is blowing a soap bubble is ________.
   (f) Define angle of contact.
   (g) What is the expression for terminal velocity ?
   (h) State Pascal's Law.
   (i) Expression for pressure due to a liquid column is ________.
   (j) Surface tension of a liquid ________ for the rise in temperature.
2. (a) Water wets glass, but Hg does not. Why ?
   (b) Distinguish between stream line flow and turbulent flow.
   (c) Calculate the pressure difference across a soap bubble of diameter 4mm. Surface tension of soap solution = 30 dynes/cm.

(d) Calculate the work done is enlarging a soap bubble from diameter 4 mm to 8 mm. Surface tension of soap solution = 30 dynes/cm

(e) Shape of a small drop is spherical. Why ?

(f) Roofs of mud house are blown off during storm. Why ?

(g) Deep water runs slow. Why ?

(h) How does co-efficient of viscosity of a liquid change with temperature ?

(i) Explain the significance of Reynold number.

(j) A liquid is flowing through a horizontal pipe of varying cross section. The velocity of flow is 25 cm/sec. at a point where the diameter of the pipe is 5 cm. What will be the velocity of flow at another point where the diameter is 1 cm.

Thermal Properties of Matter

Heat and Temperature

Heat is a form of energy. Temperature is the external manifestation of heat. It gives the degree of hotness or coldness of a body.

Different scales of temperature

Conversion of one scale to another.

$$\frac{C}{5} = \frac{F - 32}{9}$$

$$T^0K = (t^0 + 273^0)$$

Thermal Expansion

Linear Expansion, Superficial Expansion and Cubical Expansion.

Co-efficient of Linear Expansion (α) or Linear Expansivity

Co-efficient of Superficial Expansion (β) or Area Expansivity

Co-efficient of Cubical Expansion (γ) or Volume Expansivity

$$\alpha = \frac{\ell_t - \ell_0}{\ell_0 \times t} \quad \text{or} \quad \alpha = \frac{\ell_2 - \ell_1}{\ell_1 (t_2 - t_1)}$$

$$\beta = \frac{A_t - A_0}{A_0 \times t} \quad \text{or} \quad \beta = \frac{A_2 - A_1}{A_1 (t_2 - t_1)}$$

$$\gamma = \frac{V_t - V_0}{V_0 \times t} \quad \text{or} \quad \gamma = \frac{V_2 - V_1}{V_1 (t_2 - t_1)}$$

Units and dimensions of α, β and γ

Relation between α, β and γ

$$\alpha : \beta : \gamma :: 1 : 2 : 3$$

Anomalus Expansion of water

Specific Heat

$$Q = m c t$$

$$C = \frac{Q}{mt}$$

Definition of specific heat

Unit and dimension of specific heat

Specific heat of water = 1 cal/gm x 1^0C

Definition of 1 calorie

Two specific heats of a gas

c_p = Specific heat at constant pressure

c_v = Specific heat at constant volume

C_p = Molar Specific heat at constant pressure

C_v = Molar Specific heat of constant volume

$C_p = M \times C_p$ M = Molecular weight of the gas.

$C_v = M \times C_v$

$$\boxed{C_p - C_v = R}$$

Thermal Capacity

Its definition, unit and dimension

Water Equivalent

Definition, unit and dimension

Heat lost = Heat gained

Latent Heat

Definition of Latent heat. Its unit and dimension

Latent Heat of Fusion of Ice

Its value = 80 cal / gm.

Latent heat of vaporisation of heat

Its value = 540 cal / gm.

Heat of work

$W = JH$ J = 4.2 Jouls / Cal or 4.2×10^7 Ergs / Cal

Heat Transfer

Idea of conduction, convection and radiation. Conduction takes place due to vibration of molecules.

Convection takes place due to motion of molecules.

For radiation no medium is necessary.

Thermal Conductivity

Co-efficient of thermal Conductivity

Its definition, unit and dimension.

$$Q = \frac{KAt\,(\theta_1 - \theta_2)}{\ell}$$

Black Body radiation

Idea of absorptive power, reflecting power and transmitting power.

Definition of Emissive Power

Idea of perfect black body.

Statement of Stefan's Law

Definition of Stefan's constant. Its value

Statement of Wien's Law and Wien's constant

Idea of Green house effect

Assignment :-

1. (a) What is the relation between α, β and γ ?
   (b) Normal human body temperature is ________ ^{0}C.
   (c) The temperature for which both Centigrade and Fahrenheit scales give the same reading is ________.
   (d) Between C_p and C_v, which is more and why ?
   (e) A solid or liquid has one specific heat, but a gas has two specific heats. Why ?
   (f) Unit of Specific Heat is ________.
   (g) What is the relation between thermal capacity and water equivalent ?
   (h) Latent Heat of Vaporisation of steam is ________.
   (i) Express 5 calories of heat in Joules.
   (j) Write the unit of co-efficient of thermal conductivity.
   (k) What is the speed of radiant energies ?
   (l) Absorptive power of a perfect black body is ________.
   (m) State Wien's displacement law.
   (n) State Stefan's Law.
   (o) Write the unit of Stefan's constant.
2. (a) A piece of copper wire has a length of 2 meter at 0^0C. Find its length at 100^0C. Given α for Copper $= 17 \times 10^{-6}\ {}^0C^{-1}$.
   (b) Calculate the amount of heat required to convert 10 grams of ice at 0^0C to water at 10^0C.
   (c) 10 grams of water at 8^0C is mixed with 1 gram of ice at 0^0C. What will be final temperature of the mixture ?

(d) Co-efficient of volume expansion of a solid is 0.000054 / ^{0}C. What is its linear expansivity ?

(e) Specific heat of water is 1 Cal/ gm x ^{0}C. Why ?

(f) Temperature is a microscopic or macroscopic quantity ?

(g) If 10 grams of steam condenses on a block of ice at 0^{0}C. How much of ice will be converted into water at 0^{0}C ?

(h) What is green house effect ?

(i) Why is ice packed in gunny bags ?

(j) Why do animals curl in order to save themselves from extreme cold ?

(k) What is a perfect black body ?

(l) An iron rod and a wooden rod are placed in same temperature during winter. On touching, we find iron rod colder than wooden rod. Why ?

(m) Discuss the statement “good absorbers must be good radiators”.

(n) Why are the two pieces of rail track separated by a small distance in between ?

(o) A bullet of mass 10 grams moving with a velocity of 210 m/sec is suddenly stopped. If its kinetic energy is totally converted into heat, calculate the amount of heat generated.

UNIT-VIII

Thermodynamics

What is thermal equilibrium ?

Condition of thermal equilibrium.

Definition of Temperature.

Statement of Zeroth Law of thermodynamics.

Conclusion from Zeroth Law.

Thermodynamic variables.

Internal Energy.

Work done during expansion.

Statement of 1st law of thermodynamics.

$$dQ = dU + dW = dU + P.dV$$

1st law of thermodynamics is a statement of principle of conservation of energy.

Definition of isothermal process.

$$dQ = dU + dW$$

For isothermal process temperature remains constant.

So dU = Change of internal energy = 0

Hence for isothermal process,

$$\boxed{dQ = dW}$$

i.e. total heat supplied to an isothermal process is spent in doing external work.

Definition of adiabatic process

For adiabatic process, $dQ = 0$

$$\text{So} \quad dU + dW = 0$$

$$\text{i.e.} \quad dW = -dU$$

So during adiabatic expansion, temperature decreases. i.e. Adiabatic expansion causes cooling. Similarly adiabatic compression causes heating.

For adiabatic process,

$$PV^{\gamma} = \text{Constant} \quad \text{where} \quad \gamma = \frac{C_p}{C_v}$$

Expression for work done during isothermal expansion,

$$W = \int_{V_1}^{V_2} P\,.\,dv = 2.303\,RT\log_{10}\left(\frac{v_2}{v_1}\right)$$

Expression for work done during adiabatic expansion

$$W = \int_{V_1}^{V_2} P\,dv = \frac{R\,(T_1 - T_2)}{\gamma - 1}$$

Idea of indicator diagram or P ~ V diagram.

Importance of indicator diagram in thermodynamics.

Definition of reversible process and irreversible process.

Statement of Second Law of thermodynamics.

Concept of heat engine.

Carnot's engine is an ideal heat engine

Efficiency of Carnot's engine = $= 1 - \frac{T_2}{T_1}$

Idea of refrigerator.

Assignment :-

1. (a) Amount of heat supplied in all adiabatic process is ________.
   (b) What is the change of internal energy in an isothermal process ?
   (c) Concept of ________ is obtained from Zeroth law of thermodynamics.
   (d) What is thermal equilibrium ?
   (e) Which is the necessary and sufficient condition for thermal equilibrium ?
   (f) Cooling is produced during adiabatic ________.
   (g) Write adiabatic gas equation in terms of volume and temperature.
   (h) Distinguish between a refrigerator and heat engine.
   (i) Distinguish between reversible and irreversible process.
   (j) State 2nd law of thermodynamics.
   (k) What is an adiabatic process.
   (l) Where from a gas gets energy when it undergoes adiabatic expansion ?
   (m) What are the minimum requisites for operation of Carnot's engine.
   (n) Define efficiency of a heat engine.
   (o) If the door of an operating refrigerator in a room is opened, the temperature of the room will ________.
2. (a) Calculate efficiency of Carnot's engine working between 0^0C and 100^0C.
   (b) Show that C_p is more than C_v.
   (c) Can the efficiency of Carnot's engine be 100% ? Explain.
   (d) What is the necessity of sink in heat engine ?
   (e) Can the total amount of heat drawn from a source be converted to work.
   (f) Is Cp – Cv of Co_2 is equal to that of N_2 gas ?
   (g) If Carnot's engine is working between temperature 27^0C and 227^0C, what is its efficiency ?
   (h) What remains constant in an adiabatic process ?
   (i) Distinguish between isothermal and isobaric process.
   (j) Can two isothermals intersect each other ?

UNIT-IX

Kinetic Theory of Gases

Basic postulates of Kinetic theory of gasses.

Expression for pressure exerted by a gas.

$$P = \frac{1}{3} p (\bar{c})^2$$

c = RMS velocity of gas molecules

$$= \sqrt{\frac{c_1^2 + c_2^2 + ... + c_n^2}{n}}$$

Difference between mean velocity and rms velocity

$$\text{Mean velocity} = \frac{c_1 + c_2 + c_3 .... + c_n}{n}$$

$$\text{RMS velocity} = \sqrt{\frac{c_1^2 + c_2^2 + ... + c_n^2}{n}}$$

Definition of Boyl's Law, Charle's Law, Pressure law Avogvadro's hypothesis, Graham's Law of diffusion from Kinetic Theory.

Kinetic interpretation of temperature

$$\bar{c} \propto \sqrt{T}$$

Kinetic Energy per gm-molecule of a gas = $\frac{3}{2}$ RT.

Kinetic Energy per molecule of a gas = $\frac{3}{2} \frac{RT}{N} = \frac{3}{2} KT$

[N = Avogadro's Number = 6.023×10^{23} K = Boltzman Constant]

Degree of Freedom :-

Definition

Degree of freedom for a monoatomic gas = 3

Degree of freedom for a diatomic gas = 3 at low temperature

Degree of freedom for a diatomic gas = 5 at medium temperature

Degree of freedom for a diatomic gas = 6 at high temperature

Law of Equipartition of energy :

Statement

Energy per molecule per degree of freedom = $\frac{1}{2}$ KT

Gram-molecular energy of a monoatomic gas = $\frac{3}{2}$ RT

Gram-molecular energy of a diatomic gas = $\frac{5}{2}$ RT

Gram-molecular energy of a triatomic gas = 3 RT

$$C_p - C_v = R$$

For a Monoatomic Gas :

$$U = \frac{3}{2} RT$$

$$C_v = \frac{dU}{dT} = \frac{3}{2} R$$

$$C_p = C_v + R = \frac{3}{2} R + R = \frac{5}{2} R$$

$$\gamma = \frac{C_p}{C_v} = \frac{5}{2} R \Big/ \frac{3}{2} R = \frac{5}{3} = 1.67$$

For a diatomic Gas :

$$U = \frac{5}{2} RT$$

$$C_v = \frac{dU}{dT} = \frac{5}{2} R$$

$$C_p = C_v + R = \frac{5}{2} R + R = \frac{7}{2} R$$

$$\gamma = \frac{C_p}{C_v} = \frac{7}{2} R \Big/ \frac{5}{2} R = \frac{7}{5} = 1.4$$

For a triatomic Gas :

$$U = 3RT$$

$$C_v = \frac{dU}{dT} = 3R$$

$$C_p = C_v + R = 3R + R = 4R$$

$$\gamma = \frac{C_p}{C_v} = \frac{4R}{3R} = \frac{4}{3} = 1.33$$

Idea of free path and mean free path.

Avogadro's Number

Number of molecules present in a gram-molecule of a gas

$$N = 6.023 \times 10^{23}$$

Equation of state for a perfect gas

$PV = RT$ for 1 gm-molecule.

for n gm-molecule.

$PV = nRT \qquad R = 8.311$ J/mole/^{0}K

Work done in Compressing gas

$$dW = P . dV$$

Assignment :-

1. (a) Degree of freedom for a diatomic gas molecule at medium temperature is ________.
   (b) What is the value of Avogadro's number ?
   (c) Energy per molecule per degree of freedom is ________.
   (d) State Avogadro's hypothesis.
   (e) How does rate of diffusion of a gas depend on density of the gas ?
   (f) Value of γ for monoatomic gas is ________.
   (g) Mean velocity of gas molecule is same as r.m.s. velocity. (Correct the statement if necessary)
   (h) Write real gas equation.
   (i) What is the relation between pressure and r.m.s. velocity of a gas.
   (j) Find the dimension of R (Universal gas constant).
2. (a) Calculate the temperature at which r.m.s. velocity of a gas becomes double of its value at NTP.
   (b) Write basic postulates of Kinetic theory of gases.
   (c) State the law of equipartition of energy.
   (d) Find out an expression for gram-molecular energy of a diatomic gas.
   (e) What is a perfect gas ?
   (f) Distinguish between real gas equation and ideal gas equation.
   (g) What is Kinetic interpretation of temperature.
   (h) Deduce Charle's Law from Kinetic Theory of gas.

UNIT-X

Oscillation and Waves

Oscillations

Definition of periodic motion and example.

Simple harmonic motion

$$a \propto -y$$

Definition of time period, frequency, phase

Expression for displacement

$$y = r \sin wt$$

Expression for velocity and acceleration in S.H.M.

$$V = w\sqrt{r^2 - y^2}$$

Velocity is maximum at the mean position and zero at the extreme position.

Acceleration $= a = -w^2 y$

Acceleration is zero at the mean position maximum at the extreme position.

Expression for Kinetic Energy and Potential Energy in S.H.M.

Kinetic Energy $= E_k = \frac{1}{2} m w^2 (r^2 - y^2)$

It is maximum at the mean position and zero at the extreme position.

Potential Energy $= E_p = \frac{1}{2} m w^2 y^2$

It is maximum at the extreme position and zero at the mean position.

Total Energy $= E = E_k + E_p$

$$= \frac{1}{2} m w^2 y^2 + \frac{1}{2} m w^2 (r^2 - y^2) = \frac{1}{2} m w^2 r^2$$

Total energy of a body executing S.H.M. remains constant. So it obeys principle of conservation of energy.

Definition of simple pendulum.

Length of a simple pendulum.

Motion of a simple pendulum is simple harmonic

$$\text{Acceleration} = -\frac{g}{\ell} \times \text{ displacement}$$

Definition of time period of a simple pendulum and its expression

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

What is a second's pendulum ?

Length of a second's pendulum = 99.4 cm.

Variation of time period of a simple pendulum with length, acceleration due to gravity, mass and nature of material of the bob.

Loss or Gain of time by a pendulum clock.

Oscillation of a spring

$$T = 2\pi\sqrt{\frac{m}{k}} \qquad k = \text{force constant}$$

Springs in Series

$$T = 2\pi\sqrt{\frac{m\,(k_1 + k_2)}{k_1\,k_2}}$$

Springs in Parallel

$$T = 2\pi\sqrt{\frac{m}{k_1 + k_2}}$$

Idea of free vibration, damped vibration and forced vibration with example.

Idea of resonance and condition of resonance.

i.e. Natural frequency of vibration of the body = Frequency of the applied periodic force.

Waves :-

Wave motion with example. (Ripples on the surface of water)

Longitudinal wave and Transverse wave.

Idea of compression and rarefaction

Crest and Trough.

Examples of longitudinal wave and Transverse wave.

Characteristics of wave motion.

Definition of terms associated with wave motion

Wave length, wave number, velocity of a wave.

Relation between velocity, wave length and frequency.

Definition of phase, phase difference and path difference.

Relation between phase difference and path difference.

$$\text{Phase difference} = \frac{2\pi}{\lambda} \times \text{Path Difference}$$

Velocity of longitudinal wave in an elastic medium.

$$V = \sqrt{\frac{E}{\rho}}$$

Velocity of Transverse wave in a stretched string

$$V = \sqrt{\frac{T}{m}}$$

Frequency of Transverse vibration

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}}$$

Laws of Transverse Vibration

i) $n \propto \frac{1}{\ell}$, T and m are constant

ii) $n \propto \sqrt{T}$, ℓ and m are constant

iii) $n \propto \sqrt{\frac{1}{m}}$, ℓ and T are constant

Principle of superposition

Organ Pipe

Open organ pipe and closed organ pipe.

Harmonics of open and closed organ pipe. Fundamental note and overtones.

Idea of beats

What is Doppler's effect ?

Examples of Doppler's effect.

Expression for apparent frequency

Source in motion and Listener at rest.

Listener in motion and Source at rest.

Both Source and Listener are in motion.

Limitation of Doppler's effect.

Application of Doppler's effect

Expansion of the Universe.

Assignment :-

1. (a) Define frequency.
   (b) What is a second's pendulum ?
   (c) What is the time period of a simple pendulum in a artificial satelite ?
   (d) Marching men are asked not to march on an old bridge. Why ?
   (e) What is the condition of resonance.
   (f) Distinguish between free vibration and damped vibration.
   (g) What is force constant ?
   (h) A particle executes S.H.M. of period 10 seconds and amplitude 5 cm. Calculate its maximum velocity and maximum acceleration.
   (i) What is the force constant of a spring which stretches by 0.1 m when a mass of 0.5 kg is hung from it ?
   (j) Starting from mean position draw the acceleration - time graph for oscillation of a simple pendulum.

(k) A particle is executing S.H.M. of amplitude (a) at what distance from the mean position is its Kinetic Energy equal to its Potential Energy.

(l) What is the condition of resonance ?

(m) Distinguish between forced vibration and resonance.

(n) What is the phase difference between velocity and acceleration in S.H.M. ?

2. (a) Write the relation between phase difference and path difference.

(b) What type of waves are the ripples on a pond of water ? Longitudinal or Transverse ?

(c) Define wave length and wave number.

(d) Which characteristic of a wave does not change when it travels from one medium to another.

(e) What is the distance between two consecutive crests ?

(f) Distinguish between wave velocity and particle velocity.

(g) An observer moves towards a stationary source of sound with a velocity one-fifth of velocity of source. Calculate of change in frequency.

(h) What is echo ?

(i) A man has a frequency 400 while that of a women is 200. What is the ratio of their wave length ?

(j) Two sound waves of frequencies 135 and 140 cycles/sec. are superposed on each other. What is the no. of beats produced per second ?

(k) Distinguish between nodes and anti-nodes.

(l) Explain why music produced by open organ pipe is sweeter than that produced by closed organ pipe.

(m) Explain how stationary waves are formed.

(n) How does frequency of vibration of a stretched string depend upon its tension ?

(o) Prove that second resonant length of a closed organ pipe is three times its first resonant length.

CLASS - XII

Contents

CLASS - XII

PHYSICS
LESSON PLAN – 2018-19
(2nd Year)

Unit	Lect. No.	Topic	Date of Completion
I	**ELECTROSTASTICS**		
		1-Electric charges and fields	
	L-1	Electric charge and its quantization	
	L-2	Conservatinon of charge, Coulomb's law, force between two point charges	
	L-3	Coulomb's law, force between two point charges, Force between multiple charges	
	L-4	Superposition principle, Continuous charge distribution, Electric field due to a point charge	
	L-5	Electric field lines/ electric field due to a dipole at any point	
	L-6	Electric field due to a dipole at any point on the axial line.	
	L-7	Electric field due to a dipole at any point on the equitorial line.	
	L-8	Torque on a dipole in uniform electric field	
	L-9	Electric flux, Gauss's theorem (statement only), Its applications to find field due to uniformly charged infinite plane sheet	
	L-10	Its applications to find field due to infinitely long straight wire	
	L-11	Its applications to find field due to uniformly charged thin spherical shell (field inside, outside & on the surface).	
		2 - Electrostatic potential and capacitance:	
	L-12	Electric potential, potential difference, Electric potential due to a point charge	
	L-13	Potential due to a dipole	
	L-14	Potential due to a system of charges. Equipotential surfaces, Electrical potential energy of a system of two point charges.	
	L-15	Electrical potential energy of electric dipole in an electrostatic field, Conductors, insulators, free charges and bound charges inside a conductor	
	L-16	Dielectrics and electric polarization, Capacitors and capacitance	
	L-17	Capacitance of a parallel plate capacitor with and without dielectric medium between the plates	
	L-18.	Combintaion of capacitors in series & in parallel, energy stored in a capacitor.	
II	**CURRENT ELECTRICITY**		
	L-19	Electric current	
	L-20	Drift velocity	
	L-21	Mobility and their relation with electric current, Ohm's law	
	L-22.	Electrical resistance, conductance, resistivity, conductivity, Effect of temperature on resistance, V-I characteristics (linear and non-linear)	
	L-23	Electrical energy and power. Carbon- resistors, colour code of carbon resistors	
	L-24	Combinations of resistors in series &. in parallel.	
	L-25	EMF and potential difference, internal resistance of a cell,	
	L-26	Combination of cells in series &. in parallel	
	L-27.	Kirchhoffs laws and simple applications, Wheatstone bridge and meter bridge.	

	L-28.	Potentiometer-Principle and its applications to measure potential difference and comparing EMF of two cells;	
	L-29	Its applications for measurement of internal resistance of a cell	
III.	**MAGNETIC EFFECT OF CURRENT AND MAGNETISM**		
		1- Moving Charges and Magnetism	
	L-30	Concept of magnetic field, Oersted's experiment, Biot-Savart iaw and its application to find magnetic field at the centre of a current carrying circular loop.	
	L-31	Its application to find magnetic field on the axis of a current carrying circular loop	
	L-32	Ampere's law and its application to infinitely long straight wire, Straight and toroidal solenoid (qualitative treatment only)	
	L-33	Force on a moving charge in uniform electric field & magnetic field .	
	L-34	Cyclotron.	
	L-35	Force on a current carrying conductor in a uniform magnetic field/ Force between two parallel current carrying conductors- definition of ampere	
	L-36.	Torque experienced by a current loop in uniform magnetic field	
	L-37	Moving-coil galvanometer its current, sensitivity. Conversion of galvanometer to ammeter and voltmeter	
		2- Magnetism and Matter	
	L-38	Current loop as a magnetic dipole and its magnetic dipole moment, magnetic dipole moment of a revolving electron	
	L-39	Magnetic field intensity due to a magnetic dipole (bar magnet) along its axis	
	L-40	Magnetic field intensity due to a magnetic dipole (bar magnet) along perpendicular to its axis	
	L-41	Torque on a magnetic dipole (bar magnet) in a uniform magnetic field, bar magnet as an equivalent solenoid, magnetic field lines	
	L-42	Earth's magnetic fieid and magnetic elements.	
	L-43	Para- dia- and ferro- magnetic substances with examples, Electromagnets and factors affecting their strengths, permanent magnets.	
IV	**ELECTROMAGNETIC INDUCATION AND ALTERNATING CURRENT**		
		1-Electromagnetic Induction	
	L-44	Faraday' iaws of electromagnetic induction, induced EMF and current, Lenz's law, Eddy currents	
	L-45	Self and mutual induction	
		2-Alternating Current	
	L-46	Alternating currents, peak value of alternating current / voltage, RMS value of alternating current / voltage	
	L-47	Reactance and impedance, AC voltage applied to a resistance	
	L-48	AC voltage applied to a inductor & a capacitor	
	L-49	LCR series circuit	
	L-50	LCR series circuit	
	L-51	Resonance, Power in AC circuits, wattles current	
	L-52	LC oscillation (qualitative idea only),	
	L-53	A.C. generator	
	L-54	Transformer	

VI	**OPTICS**		
		1-Ray Optics and Optical instruments	
	L-55	Reflection of light, spherical mirrors. Mirror formula	
	L-56	Lateral and longitudinal magnification, refraction of light. Refractive index, its relation with velocity.of light (formula only)	
	L-57	Total internal reflection and its applications, optical fibre	
	L-58	Refraction at spherical surfaces. Thin fens formula, lens makers formula	
	L-59	Magnification, power of lenses, Combination of two thin lenses in contact, combination of a lens and a mirror	
	L-60	Refraction and dispersion of light through prism, Scattering of light: blue colour of sky and reddish appearance of sun at sunset and sunrise	
	L-61	Microscopes (Simple & Compound.)	
	L-62	Telescopes (reflecting and refracting) and their magnifying powers.	
	L-63.	Telescopes (reflecting and refracting) and their magnifying powers. ‘	
		2- Waves Optics	
	L-64	Wave front, Huygen’s principle. Reflection of plane wave at a plane surface using wavefronts, proof of laws of reflection using Huygen’s principle	
	L-65	Refraction of plane wave at a plane surface using wavefronts, proof of laws of refraction using Huygen’s principle	
	L-66	Interference, Young’s double slit experiment, Coherent sources, sustained interference of light	
	L-67	Expression for fringe width	
	L-68	Diffraction due to a single slit, width of a central maximum	
	L-69	Resolving power of microscope & astronomical teelescope, (qualitative idea). Polarization, plane polarized light, Brewster’s law	
	L-70	Uses of plane polarized light and polaroids	
VII	**DUAL NATURE OF RADIATION AND MATTER**		
	L-71	Dual nature of radiation	
	L-72	Photoelectric effect, Hertz and Lenard’s observations	
	L-73	Einstein’s photoelectric equation, particle nature of light	
	L-74	Matter waves- wave nature of particles, de-Broglie relation, Davisson- Germer experiment, (only conclusions should be explained)	
VII	**ATOMS AND NUCLEI**		
		1-Atoms	
	L-75	Alpha- particle scattering experiment	
	L-76	Rutherford’s model .of atom, its limitations.	
	L-77	Bohr model	
	L-78	Energy levels, hydrogen spectrum.	
		2-Nuclei	
	L-79	Atomic nucleus, its composition, size, nuclear mass, nature of nuclear force/ Mass defect, binding energy per nucleon and its variation with mass number	
	L-80	Nuclear fission. Nuclear fusion	
	L-81	Radioactivity, alpha, beta and gamma particles/ rays and their properties	
	L-82	Radioactive decay law, half life and decay constant.	

IX	**SEMICONDUCTOR ELECTRONICS**		
	L-83	Energy bands in conductors, Semiconductors and insulators (qualitative idea -only)/ p-type, ntype semiconductors	
	L-84	Semiconductor diode, V-I characteristics in forward and reverse bias	
	L-85	Diode as a half wave rectifier, efficiency (no derivation), Diode as full wave rectifier (centre tap), efficiency (no derivation).	
	L-86	Special purpose p-n junction diodes: LED, photodiode, solar cell	
	L-87	Zener diode and their characteristics, Zener diode as a voltage regulator	
	L-88	Junction transistor, transistor action, Characteristics of transistor	
	L-89	transistor as an amplifier (CE configuration)	
	L-90	Basic idea of analog and digital signals. Logic gates (OR/ AND/ NOT, NAND/ and NOR)	
V	**ELECTROMAGNETIC WAVES**		
	L-91	Basic idea or displacement current; Qualitative idea about characteristics of electromagnetic waves, their transverse nature.	
	L-92	Electromagnetic spectrum (radio waves, microwaves, infrared/ visible, Ultra violet. X-ray and gamma rays), including elementary ideas about their uses.	
X	**COMMUNICATION SYSTEM**		
	L-93	Elements of a communication system (block diagram only), Bandwidth of signals (speech, TV and digital data), bandwidth of transmission medium	
	L-94	Propagation of electromagnetic waves in the atmosphere, sky and-space wave propagation, satellite communication, Need for-modulation, qualitative idea about amplitude modulation	
	L-95	Qualitative idea about frequency modulation, Advantages of frequency modulation over amplitude modulation	
	L-96	Basic idea about internet, mobile telephony and global positioning system (GPS).	

Unit - I
ELECTROSTATICS

Electric charges and fields

A charge is a fundamental cherterstics property of elementry particles of matter It is a scalar quantity.

Two types of charges

i. Type of charge acquired by a glass rod when rubbed with silk is called positive charge.

ii Type of charge aqquired by amber when rubber with wollen cloth is called Negative charge.

One unit of charge is qual to $1.6 \times 10^{-19} C$

Charge quatisation

q= ne

Where $e = 1.6 \times 10^{-19} C$

$n = \pm 1, \pm 2, \pm 3............$

Colomb's Law

Statement :-

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \frac{N \times m^2}{c^2}$$

$\in_0$ = Permitivity of free space

$$= 8.854 \times 10^{-12} \frac{c^2}{N \times m^2}$$

Dimenstion of charge : [q] = [AT]

Dimension of $[\varepsilon_0] = \left[M^{-1}L^{-3}T^4A^2\right]$

Units of Charge:-

C.G.S system - stat . colomb

M.K.S System - colomb

C.G.S (emu) unit - ab conlarb

1 conlumb = 3×10^9 stat -coulomb

1 colomb $= \frac{1}{10}$ ab- conlomb

Principle of superposition :-

It states that all the charges when placed near each other behave independent of each other and the net force on one charge due to all other charges is equal to the vector sum of all forces produced by them on the first in accordance with coloumb's law .

Continous charge distribution :-

Linear charge distribution

Surface charge distribution.
Volume charge distribution
Elecric field due to a point charge
Definition of electric field intensity.
Unit of electric field intensity.
Dimension of electric field intensity.
Electric lines of force
Its defination
Properties of electric lines of force .
Two lines of force will never intersect .

Definition of elecctric dipole .

Dipole moment , Its unit and dimension . Dipole moment is a vector quantity. Electric field intersity due to a dipole at end -on position, broad side on position and at any position.

Torque on a dipole in uniform electric field .

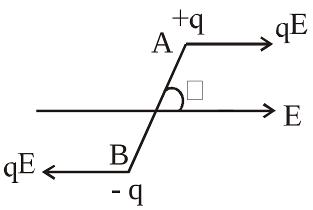
$$\vec{\tau} = \vec{p} \times \vec{E}$$

Potential energy of an electric dipole is an electric field

$$W = -PE\cos\theta$$

Definition of electric flux

Statement of Gauss theorem



$$\phi = \frac{q}{\varepsilon_0}$$

Electric field due to uniformly charged infinite plane sheet.

For non-conducting sheet $E = \frac{\delta}{2t_0}$

For conducting sheet $E = \frac{\delta}{\varepsilon_0}$ Field due to infinitely long straight line electric field due to uniformly charged this spherical shell.

Field inside and field outside

Electro-static potential and capacitance :-

Definition of electic potential
Its unit and dimension
SI Unit → Volt
C.G.S Unit → Stat -volt

1 volt $= \frac{1}{300}$ stat-volt

Potential due to a point charge:-

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

Potential due to a dipole at end on position and broad side on position.
Potential due to a system of charges, principle of superposition of potential .

Equipotential Surface :-

Work done in moving a charge on an equipotential surface.

K.E of a charged particle moving through a potential difference

$$\frac{1}{2}mu^2 = eV$$

Definition of Electron-volt

$$1eV = 1.6 \times 10^{-19} \text{ Joules}$$

Idea of conductors and insulators. Free charges and bound chargs.

Polarisation of a dielectric .

Definition of capacity :

$$C = \frac{q}{V}$$

Unit and dimension of capacity

C.G.S. system -stat-Farad

M.K.S system -Farad

1 Farad $= 9 \times 10^{11}$ stat -Farad

$$[C] = \left[M^{-1}L^{-2}T^4A^2\right]$$

Capacitance of a parallel plate capacitor without dielectric medium in between the plats .

$$C = \frac{\varepsilon_0 A}{d}$$

Capacitance with dielectric medium

$$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{\varepsilon_r}}$$

Energy stored in a condenser

$$W = \frac{1}{2}CV^2 = \frac{1}{2}qV = \frac{1}{2}\frac{q^2}{c}$$

Condensers joined in series

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

Condensers joined in parallel $C = C_1 + C_2$

ASSIGNMENT

1. a. State coulomb's Law.
   b. Dipole moment is a scalar quantity (Write true or false).
   c. One unit of charge is ______ coulomb.
   d. Unit of electric field intensity is ____
   e. What is an equipotential surface?
   f. How much work is done in moving a charge on an equipotential surface?

g. Define electro-static potential .

h. 1 volt = ______stat volt.

i. Field intensity due to an electric dipole at end -on position is _____

j. 1 electron-Volt = ________Joules.

k. Define capacity.

l. Write the dimension of capacity.

m. What is the energy stored in a condenser.

n. Can two electric lines of force intersect?

o. 1 stat-fard = _______ Farad.

2. a Calculate the electric field intensity in air at a distance of 2 cm from a charge of $3\mu c$.

b. Two point charges $4\mu c$ and $25\mu c$ are placed 20cms apart . At which point on the line joining them electric field will be Zero.

c. A region in electric field is specified by the potential function.

$$V(x) = 4x^2$$

Find the electric field at the point X=2 located in the region.

d. A parallel plate condensor with oil between the plates (K=2) has a capacitance C. What will be the capacitance when the oil is removed?

e. A condenser of capacity $5\mu c$ is charged to 50 volts. Calculate the energy stored in the condenser.

UNIT - II
CURRENT ELECTRICIY

Definition of electric current

$$i = \frac{q}{t}$$

$$i = \lim_{\Delta t \to 0} dt \frac{\Delta q}{\Delta t} = \frac{dq}{dt}$$

Unit S.I unit $\longrightarrow \frac{\text{Coulomb}}{\text{Sec}} = \text{Ampere}$

C.G.S esu $\longrightarrow$ stat ampere

C.G.S emu $\longrightarrow$ ab ampere

$$1 \text{ amp} = \frac{\text{Coulomb}}{\text{Sec}} = 3 \times 10^9 \text{ stat ampere} = \frac{1}{10} \text{ab} - \text{ampere}$$

Dimension of Current - [A]

Difference between steady Current and variable current.

Direction of current

Direction of current is taken to be the direction of flow of +ve charge.

Definition of Drift velocity.

Expression for drift velocity

$$\nu = \frac{eV}{ml} \tau$$

Order of drift velocity is 1mm/sec.

Relation between drift velocity and electric Current :

$$i = n A \nu e$$

$$i \propto v$$

Current $\propto$ drift velosity

Mobility

$$\text{Mobility} = \mu = \frac{V}{E}$$

V = Drift veloctity

E = Strength of electric field.

$$i \propto \mu$$

Electric Current $\propto$ mobility of electron.

Ohm's Law :-

Statement $i \propto V$

$\frac{V}{i}$ condition = R.

Distinguish between ohmic conductor on non-ohmic conductor with examples.

Resistance of a conductor.

$$V = i R$$

Definition of resistance.

Units S. I. unit → ohm

$$\text{ohm} = \frac{\text{volt}}{\text{ampere}}$$

C. G. S. esu → stat - ohm

C. G. S. emu → ab – ohm

Dimension of resistance :-

$$[R] = \left[\frac{V}{I}\right]$$

$$= \left[\frac{W}{q \times I}\right] = \left[\frac{W}{I^2 t}\right]$$

$$= \left[\frac{M L^2 T^{-2}}{A^2 T}\right]$$

$$= \left[M L^2 T^{-3} A^{-2}\right]$$

Variation of resistance with temperature :-

Resistance of a conductor increases with increase in temperature.

$$R_t = R_0 (1 + \propto t)$$

α = Temp. Co-efficient of resistane

Uni of $\alpha \rightarrow (O_C)^{-1}$

Resistance of a semi conductor decreases with increases in temperature.

Specific Resistance or Resistivity.

$$R = \rho \frac{\ell}{A}$$

Definition of ρ :

Specific resistance of a material is defined as the resistance of unt cube of the material.

Unit of ρ : $\rho = \frac{R \times A}{\ell} = \frac{\text{ohm} \times \text{m}^2}{\text{m}} = \text{ohm} \times \text{metre}$

Dimension of ρ :-

$$[\rho] = \left[\frac{R \times A}{\ell}\right]$$

$$= \left[\frac{M L^2 T^{-3} A^{-2} \times L^2}{L}\right] = \left[M L^3 T^{-3} A^{-2}\right]$$

Conductivity :- (σ)

It is defined as the reciprocal of resistivity.

$$\sigma = \frac{1}{\rho}$$

Its unit Ohm^{-1} metre $^{-1}$

Dimension of σ :-

$$[\sigma]=\left[\frac{1}{\rho}\right]=\left[M^{-1}L^{-3}T^{3}A^{2}\right]$$

Conductance

Unit :- $\frac{1}{\text{ohm}}$ or mho

$$[\text{Conductance}]=\left[\frac{1}{\text{Resistance}}\right]=\left[M^{-1}L^{-2}T^{3}A^{2}\right]$$

Current Density $(\vec{J})$

$$\vec{J}=\lim_{\Delta A\to 0}\frac{\Delta I}{\Delta A}=\frac{dI}{dA}$$

Unit of $\vec{J}$ $\frac{\text{amp}}{m^2}$

Dimension of $\vec{J}$ $\left[\frac{A}{L^2}\right]=\left[AL^{-2}\right]$

Relation between Current density and electric field

$$\vec{j}=\sigma\vec{E}$$

σ = Conductivity of the material

Combination of resistance :-

(i) Series combination

$$R = R_1 + R_2 + R_3.$$

(ii) Parallel combination

$$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$$

Grouping of cells

(i) **Cells in series** $i=\frac{nE}{R+nr}$

R = External resistsnace the circuit

n = No of the cells in series

E = e. m. f of each cell

r = Internal resistance of the cell

(ii) **Cells is parallel** $i=\frac{nE}{nR+r}$

(iii) **Mixed grouping of cells**

$$i=\frac{mnR}{mR+nr}$$

n = No of cells is a row

m = No. of rows is parallel.

Condition for maximum current :-

$$R = \frac{nr}{m}$$

Electro-motive force (E. M. F).

Definition E M F = $\frac{w}{q}$

Unit → $\frac{\text{Joule}}{\text{Coulomb}}$

Electro-motive force and Potential Diff.

$$E = V + ir$$

$$i = \frac{E - V}{r}$$

Difference between E. M. F and P. D.

Heating of effect of electric current -

Heat produced is a conductor carrying current.

$$H = \frac{I^2 R t}{J}$$

Joule's Laws

$H \propto I^2$ when R and t are cond.

$H \propto R$ when I and t are cond.

$H \propto t$ when I and r are cond.

Electrical Power

Work done = $W = VIt$

Power = $\frac{W}{t} = VI$

Distinction between watt and watt hour

Watt is the unit of power watt-hour is the unit of energy..

1 watt-hour = $1 \text{watt} \times 3600$ sec

= 3600 Joules.

Distinction between killowatt and killowatt hour.

Killowatt is the unit of power. Killowatt hour is the unit of energy.

1 K W H = $1000 \, \text{watt} \times 3600 \, \text{sec.} = 36 \times 10^5$ Joules

1 Commercial unit of electricity = 1 killowatt hour.

Kirchoff's Rules

1st Rule $\sum I = 0$

2nd rule $\sum E = \sum IR$.

Condition of balance of Wheat stone's bridge

$$\frac{P}{Q} = \frac{R}{S}$$

Principle of a potertiometer meter.

Measurement of potential difference.

Comparison of e. m. f of two cells.

Measurement of internal resistance of a cell.

ASSIGNMENT

1. (a) State ohm's Law.
   (b) Define drift velocity.
   (c) What is charge quantisation?
   (d) Charge of electron is __________ .
   (e) Unit of specific resistance is __________.
   (f) How does resistance of a conductor charge with temperature ?
   (g) Define mobility.
   (h) Dimension of resistance is __________ .
   (i) Distinguish between e. m. f and P. D.
   (j) What is the condition of balance of wheat stone's bridge ?
   (k) What is a potentis meter ?
   (l) Define temperature co-efficient of resistance of a conductor.

2. (a) Tick out the current answer.
   Electric current is given by
   (i) Charge per unit area
   (ii) Charge per unit volume
   (iii) Charge per unit lime
   (iv) None of the above
   (b) Unit of specific resistance is S. I. system is
   (i) $\text{Ohm} \times \text{m}^{-1}$ (ii) ohm . m (iii) ohm. cm^{-1} (iv) Amp. m.
   (c) A wire of resistance 4 ohms is doubled on itself. Its resistance will be
   (i) 1 ohm (ii) 2 ohms
   (iii) Δ ohms (iv) None of the above
   (d) A metallic wire of resistance 40 ohms is stretched to twice its length. Its new resistance world be approximately.
   (i) 20 ohms (ii) 80 ohms (iii) 120 ohm (iv) 160 ohms
   (e) The resistance of a conductor increases with
   (i) increase in length (ii) increase in temperature
   (iii) Decrease is area (iv) all of these .
   (f) Three resistance each of 4Ω are connected to form a triangle. The resistance between any two terminals is
   (i) 12 ohms (ii) 2 ohms (iii) 6 ohm (iv) $\frac{8}{3}\text{ohm}$.

(g) Three resistances $\Delta\Omega$, 6Ω or $12\,\Omega$ are connected is parallel and the combination is connected is series with a 4 V battery with interval resistance of 2 ohms. The battery current is

(i) 0.5 A (ii) 1 A (iii) 2 A (iv) 10 A

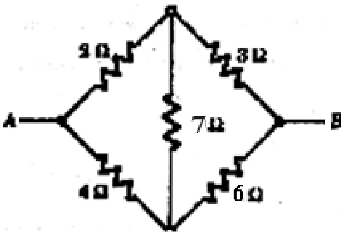
(h) Two cells of e. m. f 1.25 V and .75 V are connected in paralel. The effective voltage is

(i) 075 V (ii) 1.25 V (iii) 2V (iv) .5 V

(i) A cell of e. m. f E is connected accross a resistance r. The potential difference between the liminals is found to be V. The internal resistance of the cell must be

(i) $r\,V(E-V)$ (ii) $r(E-V)$ (iii) $\left(\frac{E-V}{V}\right)r$ (iv) $\left(\frac{E-r}{V}\right)r$

(j) Five resistance are connected as shown in the figure. The effective resistance between the points A and B is

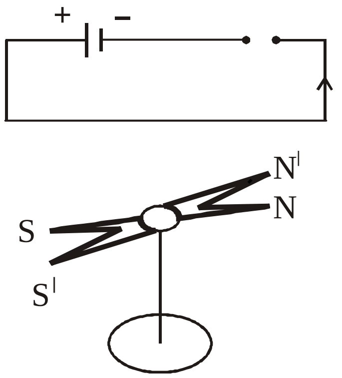


(i) $\frac{10}{3}\Omega$ (ii) $\frac{20}{3}\Omega$ (iii) 15 Ω (iv) 6 Ω

UNIT - III
MAGNETIC EFFECT OF ELECTRIC CURRENT

Oersted's experiment :

A conductor carrying current behaves like a magnet associated with a magnetic field. This is proved from Orested experiment



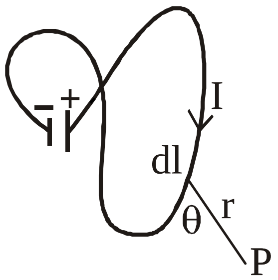
Rules for direction deflection of N-pole

(i) SNOW Rule.

(ii) Ampere;s swiming Rule.

Biot Sawart's Law

$$d\beta \propto I$$
$$\propto d\ell$$
$$\propto \sin\theta$$
$$\propto \frac{1}{r^2}$$



$$d\beta \propto \frac{Id\ell\sin\theta}{r^2}$$

$$d\beta = \frac{KId\ell\sin\theta}{r^2}$$

In SI unit, $K = \frac{\mu_0}{4\pi}$ μ_0 = permeability of free space

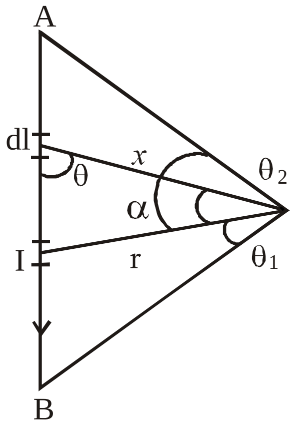
$$d\beta = \frac{\mu_0}{4\pi}\frac{Id\ell\sin\theta}{r^2} \qquad \mu_0 = 4\pi\times10^{-7}\frac{\text{Weber}}{\text{amp}\times\text{metre}}$$

Biot-Savart Law in Vector form :-

$$d\beta = \frac{\mu_0}{4\pi} I \frac{\left(\vec{d}\ell\times\vec{r}\right)}{r^3}$$

Magnetic field due to a straight conductor carrying current

$$d\beta = \frac{\mu_0 I}{4\pi r}\left(\sin\theta_2 - \sin\theta_1\right)$$



If the conductor is of infinte length

$$\theta_1 = -90^0,\ \theta_2 = 90^0$$

$$\beta = \frac{\mu_0 I}{4\pi r}\left[\sin 90^0 - \sin(-90^0)\right]$$

$$= \frac{\mu_0 I}{4\pi r}(1+1)$$

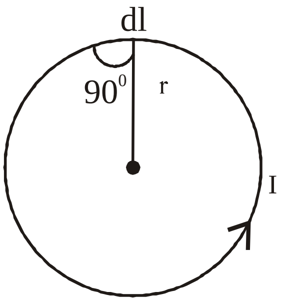
$$B = \frac{\mu_0 I}{2\pi r}$$

Magnetic field at the centre of a circular coil. carrying current

$$d\beta = \frac{\mu_0}{4\pi}\frac{Id\ell \sin\theta}{r^2}$$

$$= \frac{\mu_0}{4\pi}\frac{Id\ell \sin 90^{23}}{r^2}$$

$$= \frac{\mu_0}{4\pi}\frac{Id\ell}{r^2}$$



$$B \quad = \int_0^{2\pi r}\frac{\mu_0}{4\pi}\frac{Id\ell}{r^2}$$

$$= \frac{\mu_0 I}{4\pi r^2}\times 2\pi r$$

$$\boxed{B = \frac{\mu_0 I}{2r}}$$

for n - turns, $B = \frac{\mu_0 nI}{2r}$

Magnetic field on the axis of acircular coil carrying current.

$$B = \frac{\mu_0}{4\pi}\frac{2\pi N i a^2}{\left(a^2+x^2\right)^{3/2}}$$

N = No of turns

i = Current

a = Radius of the coil

$$B = \frac{\mu_0}{2}\frac{N i a^2}{\left(a^2+x^2\right)^{3/2}}$$

x = Distance from the centre of the coil on the axis.

Magnetic field at the centre.

x = 0

$$\boxed{B = \frac{\mu_0 N i}{2a}}$$

Magnetic field at a point situated at large distance away from the axis

In this case x >> a.

So a^2 is neglected.

$$B = \frac{\mu_0}{4\pi}\frac{2\pi N i a^2}{x^3} = \frac{\mu_0}{4\pi}\frac{2 N i A}{x^3} \quad \left[A = \pi a^2\right]$$

$$= \frac{\mu_0}{2\pi}\frac{N i A}{x^3}$$

For a single turn , N = 1

$$B = \frac{\mu_0}{2\pi}\frac{i A}{x^3}.$$

Statement of Amperes law.

Its application to infinitely long straight wire, straight and toroidal solenoid.

Force on a charge moving in a magnetic and electric field.

$\vec{F} = q\vec{E}$ (q = charge, $\vec{E} = \text{Electric field}$)

$\vec{F} = q\left(\vec{v} \times \vec{B}\right)$ $\vec{B}$ = Magnetic flux density

$\vec{V}$ = Velocity of teh charge.

If $\vec{V} = 0$, $\vec{F} = 0$

No force is exerted on a charge at rest in a magnet field.

Lorentz Force :-

When a charge (q) is subjected to both electric and magnetic field simultaneously the resultant force exerted on the charge is called Lorentz force.

$$\vec{F} = q\vec{E} + q\left(\vec{V} \times \vec{B}\right)$$

Force on a current carrying conductor in a magnetic field.

$$\vec{F} = i\left(\vec{\ell} \times \vec{B}\right)$$

Fleming Left Hand Rule :-

Stretch the force finger, the middle finger and thumb of the left hand in such a manner that they are perpendicular to each other. If the fore finger represents the direction of magnetic field, the middle finger represents current. then the thumb represents the direction of force.

Force between two parallel conductors carrying currents

$$F = \frac{\mu_0 i_1 i_2 \ell}{2\pi r}$$

Force per unit length = $\frac{F}{\ell} = \frac{\mu_0 i_1 i_2}{2\pi r}$

If current flows is the same direction the conductors will attract each other.

If current flows in opposite direction the conductors will repel each other.

Definition of ampere :

$$\frac{F}{\ell} = \frac{\mu_0 i_1 i_2}{2\pi r}$$

If $i_1 = i_2 = i$, r = 1m $\ell = 1\text{m}$

then $F = \frac{4\pi \times 10^{-7} i^2}{2\pi} = 2 \times 10^{-7} i^2$

If i = 1 amp, $F = 2 \times 10^{-7}$ N

One ampere is defined as the current maintained in two parallel straight conductors of infinite length and negligible cross section separated by a distance 1 m in vacuum would produce a force of 2×10^{-7} per metre length of the conductors.

Cyclotron :

What is a cyclotron ?

Its construction and working.

Maximum K.E. acquired by a charged particle. Limitations of cyclotron.

Torque experienced by a current loop in a magnetic field.

$C = i\ell bB\cos\theta$ A = Area of the loop

$= i\,AB\,\cos\theta$ B = Magnetic flux density

For n - turns θ = Angle which the plane of the loop makes with lines of force.

$C = i\,n\,A\,B\,\cos\theta$

Torque in vector form :

If α = Angle between normal to the plane of the loop and magnetic field.

$$\alpha = \pi/2 - \theta .$$

So $\cos\theta = \sin\alpha$

$C = i\,n\,A\,B\sin\alpha$ iA = M = Magnetic moment of the magnetic diople to which the current carrying loop is equivalent.

$$C = n\,M\,B\sin\theta$$

$$\vec{C} = n\left(\vec{M}\times\vec{B}\right)$$

Moving coil galvanometer :-

What is a moving coil galvanometer ? Its construction and theory.

$$i = \frac{C}{n\,B\,A}\theta$$

C = Torsional conple per unit angular twist of the suspension fibre.

A = Area of the coil.

B = Magnetic flux density

n = No of turns

$\frac{C}{n\,B\,A}$ = K = Reduction factor of the galvanometer

$$\boxed{i = K\theta}$$

Definition of K :-

When $\theta = 1$, i = K.

The reduction factor of a moving coil galvan ometer is defined as the current required to produce unit deflection in the galvanometer.

Conversion of galvanometer to an ammeter.

A galv can be converted to an ammeter by joining a low resistance in parallel i.e. by joining a shunt.

An ammeter is always joined in series in a circuit.

Conversion of galvanometer into voltmeter :-

A galvanometer can be converted to a voltmeter by joining a high resistance in series.

A galvanometer is always joined is parallel in a circuit.

Magnetism and Matter

Definition of magnetic dipole.

Dipole moment.

Magnetic dipole moment of a revolving electron.

Magnetic field intersity due to a magnetic dipole at end-on position

$$F = \frac{\mu_0}{4\pi}\frac{2Mr}{\left(r^2 - \ell^2\right)^2} \qquad M = 2ml$$

$$= \text{Magnetic moment}$$

In case of dipole, ℓ is very small.

$$F = \frac{\mu_0}{4\pi}\frac{2Mr}{r^4}$$

$$= \frac{\mu_0}{4\pi}\frac{2M}{r^3}\cdot \text{ along the direction of M.}$$

Magnetic lines of force.

Properties of magnetic lines of force.

Magnetic field, field intensity.

Permeability, Intersity of magnetic sation.

Magnetic susceptibility.

Earth Magnetism.

Magnetic elements of earth.

(Declination, Dip and Horizontal intensity).

Properties of dia, para and ferromagnetic substance with examples.

Ferromagnetic domain.

Idea of electromagnets.

Torque on a magnetic dipole in uniform magnetic field.

$$\vec{C} = \vec{M} \times \vec{B}$$

$\vec{M}$ = Magnetic moment

$\vec{B}$ = Magnetic flux density

$\vec{C}$ = Torque exerted.

ASSIGNMENT

1. (a) State ampere's swimming rule.
   (b) What is the force exerted on a charge at rest in a magnetic field ?
   (c) State Fleming's left hand rule.
   (d) What is the nature of force between two parallel wives carrying current in the same direction ?
   (e) State Biot-Savart law.
   (f) Write Biot - Savart Law in vector form.

(g) How can you convert a galvanometer to an ammeter ?

(h) How can you convert a galvanmeter to a voltmeter ?

(i) What is Lorentz force ?

(j) Define reduction factor of a galvanometer.

(k) What are magnetic elements of earth ?

(l) Can two magnetic lines of force intersect ?

(m) What is sureptibility of a diamagnetic substance ?

(n) State Curie law.

(o) What is the value of Dip at the poles ?

(p) What is the relation between permeability and susceptibility.

(q) What are ferromagnetic domains ?

(r) Define a magnetic dipole.

2. (a) A circular coil of 2mm diameter carries a current of 5 amp. Calculate the magnetic flux density at the centre of the coil.

(b) A long straight conductor carries a current of 2 amp. Calculate the magnetic flux density at a distance of 10 cm from the conductor.

(c) It is desired to pass 2% of the main current through a galvanometer of resistance 98 ohms. How can this be done ?

(d) An electron moves with a velocity of 2×10^6 m/sec enters a magnetic field of intersity 340 Wb/m^2 at right angles to it. Calculate the magnitude of force exerted on the electron.

(e) Why the magnet in a galvanometer has concave pole pieces ?

UNIT - IV
ELECTRO-MAGNETIC INDUCTION

Explanation of electro-magnetic induction.
Faraday's Laws of electro-magnetic induction Lenz's Law.
Lenz's Law obeys principle of conservation of energy.
Experimental demonstration of faraday's Law.
Self - induction and self - inductance.

$$E = -L\frac{dI}{dt}$$

Mutual induction and mutual inductance.

$$E = -M\frac{dI}{dt}$$

Units of magnetic flux and flux derxty

$$\text{Tesla} = \frac{\text{Weber}}{m^2}$$

$$\text{Gauss} = \frac{\text{Maxwell}}{cm^2}$$

1 Tesla = 10^4 Gauss.

Energy stored in an induction

$$W - \frac{1}{2}LI_0^2$$

Fleming's Right Hand Rule.
E. M. F induced is a coil rotating is a magnetic field.
Idea of eddy current.
Some applications of eddy current.
Self- inductance of a solenoid.

$$L = \mu_0\mu_r\, n\, N\, A$$

Unit → Henry

Dimension $\rightarrow \left[ML^2T^{-2}A^{-2}\right]$

Mutual inductance of two long solenoids

$$M = \mu_0\mu_r\frac{N_1N_2}{\ell}A$$

ASSIGNMENT

Answer the following MCQ.

1. (a) Lenz's Law is a consequence of law of conservation of
(i) Charge (ii) Momentum
(iii) Mass (iv) energy

(b) A magnet is allowed to full through a metal ring. Thenduring the fall, it acceleration is
(i) Equal to g (ii) Less than g
(iii) Greater than g (iv) Equal to zero

(c) In an inductior of inductance 100 mH a current 10 amp is flowing. The energy stored in the inductor is

(i) 5 Joules	(ii) 10 Joules
(iii) 100 Joules	(iv) 1000 Joules

(d) Current is a coil charges from 5 a to 10 A in 0.2 seconds. If the co-efficient of self-induction is 10 henry, then the induced e.m.f is

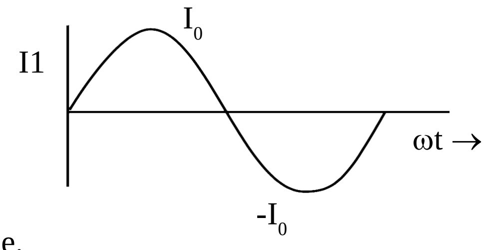
(i) 120 V	(ii) 150 V
(iii) 200 V	(iv) 250 V

(e) SI unit of self-inductance is

(i) farad	(ii) faraday
(iii) Henry	(iv) Tesla

2. (a) What is eddy Current ?
   (b) Define self inductance.
   (c) State Fleming's right hand rule.
   (d) What is the relation between weber and Maxwell.
   (e) Write the dimension of magnetic flux.
   (f) Distinguish between magnetic flux and flux density.
   (g) Prove that Lenz's Law obeys principle of conservation of energy.
   (h) When the current changes from 2A to –2A in .05 seconds, an induced e.m.f of 8 volts induced in the coil. Calculate the co-efficient of self induction.
   (i) A 100mH coil carries a current of lamp. Calculate the energy stored in the inductor.
   (j) A loop of wire is placed in a magnetic field B = 0.2 i Tesla. Find the flux through the loop if the area vector is $\vec{A} = \left(3\hat{i} + 6\hat{j} + 2\hat{k}\right) m^2$.
   (k) The magnetic flux through a coil perpendicular to its plane is varrying according to the relation $\phi = \left(5t^3 + 4t^2 + 2t - 5\right)$ weber. Calculate the induced Current through the coil at t = 2 second if the resistance of thecoil is 5 ohms.

UNIT - V
ALTERNATING CURRENT



Definition of a.c

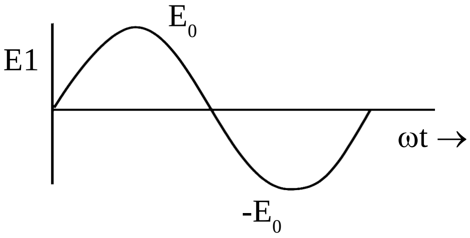
$I=I_0 \sin \omega t$

Def^n of alternating e.m.f

$E=E_0 \sin\omega t$

Peak values of a.c. and alternating voltage.

Defination of time period, frequency and phase of a.c.



Mean value of a.c.

Definition. Mean value of a.c. is defined as as that value of steads current which sends the same amount of charge through a circuit in same time as is done by a.c. in a half cycle.

$$I_{mean} = \frac{2I_0}{\pi} = .637\, I_0$$

RMS value of a.c.

Definition : Root mean square value of a.c. is defined as that value of steady current which produces the same heating effect is a resistance is a certain time as is produced by alternating current in the same resistance in same time.

It is also called virtual value of a.c.

$$I_{rms} = \frac{I_0}{\sqrt{2}} = .7\, I_0$$

Similarly rms value of alternating e.m.f

$$= E_{rms} = \frac{E_0}{\sqrt{2}} = .7E_0$$

Average value of a.c. in a complete cycle

$I_{an} = O$

Circuit elements

resistance(R) inductance (L) and Capacitance (C)

Inductive Reactance

$X_L = Lw = 2\pi fL$ [f = frequency of a.c.]

Capacitance Reactance

$$\mathbf{X_C =} \frac{1}{CW} = \frac{1}{2\pi f\ c}$$

Unit of X_C and X_L

ohm.

Impedance :- (Z)

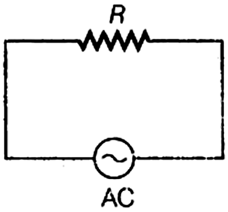
It is defined as the net opposition offered by all circuit elements in an a.c.

circuit.

Unit of impedance :

ohm

A.C Voltage applied to a resistance :



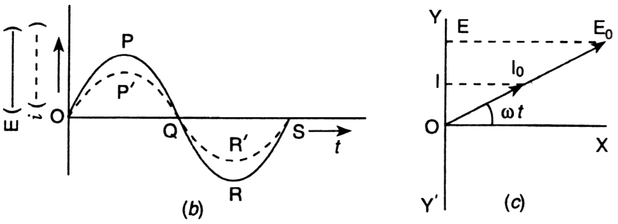
$$E = E_0 \sin \omega t$$

$$I = \frac{E_0}{R} \sin \omega t$$

Peak value of e.m.f. = E_0

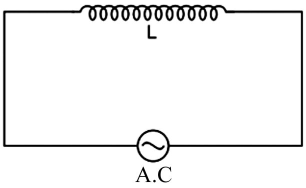
Peak value of Current = $\frac{E_0}{R}$.

Both e.m.f. and Current are in phase.



A.C. circuit containing pure inductance :

$$E = E_0 \sin \omega t$$



$$I = \frac{E_0}{Lw} \sin\left(\omega t - \pi/2\right)$$

Peak value of e.m.f = E_0

Peak value of a.c. = $\frac{E_0}{L\omega}$

Phase of e.m.f = ωt

Phase of current = $\omega t - \pi/2$.

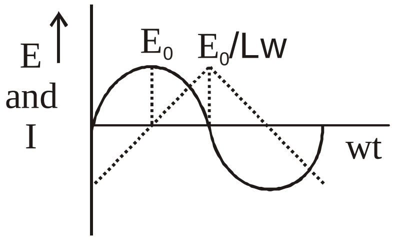
So is an a.c. unit containing pure inductance current lags behind the e.m.f by a phase of $\pi/2$.

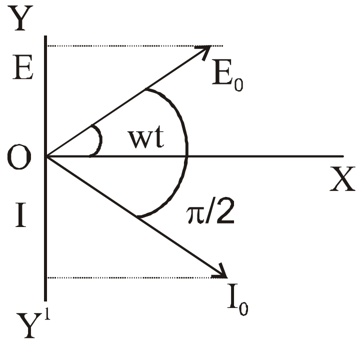
Peak value of e.m.f = E_0

Peak value of current = $\frac{E_0}{L\omega}$

$$\frac{\text{Peak value of e.m.f}}{\text{Peak value of current}} = \frac{E_0}{\left(\frac{E_0}{L\omega}\right)} = L\omega$$

= Inductive is a = X_L





Power factor of the circuit

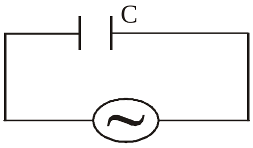
$$\cos\theta = \cos \pi/2 = 0$$

Since power factor is zero, current is called wattless current.

A.C. circuit containingcapacitance only.

$$E = E_0 \sin \omega t$$

$$I = E_0 c\omega \sin\left(\omega t + \pi/2\right)$$



Peak value of e.m.f = E_0

Peak value of current = E_0 cω

$$\frac{\text{peak value of e.m.f}}{\text{Peak value of current}} = \frac{E_0}{E_0 c\omega} = \frac{1}{\omega} = X_C$$ = Capacitive Reactance.

Phase of e.m.f = ωt

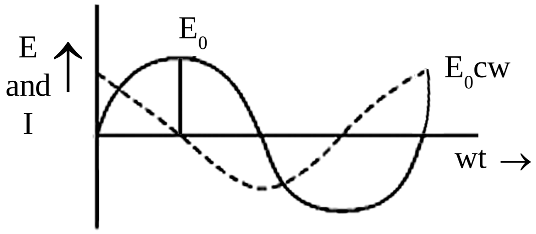
Phase of current = $\omega t + \frac{\pi}{2}$

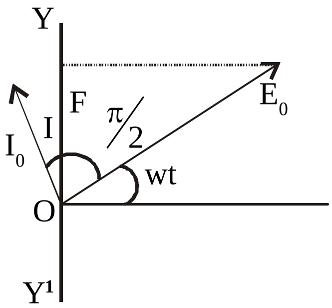
Phase diff between e.m.f. and current = $\pi/2$

The current leads over the e.m.f by a phase of $\pi/2$.

Power factor = $\cos\theta = \cos\frac{\pi}{2} = 0$

Since power factor is zero, current is called wattless current.





Impedance of a.c. circuit containing R, C and L

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega c}\right)^2}$$

Unit of Z = ohm.

Power factor of a.c. circuit :

Power factor = $\cos\theta$

Where θ = phase diff between e.m.f and current.

For pure inductive and pure capacitive.

Circuit, $\theta = \pi/2$

Hence power factor = $\cos\pi/2 = 0$

So current is these circuits is called wattless current.

Resonance :-

Condition of resonance

$$L\omega = \frac{1}{c\omega}$$

$$\omega^2 = \frac{1}{Lc}$$

$$\omega = \frac{1}{\sqrt{Lc}}$$

$f = \frac{\omega}{2\pi} = \frac{1}{2\pi\sqrt{LC}}$ = permant frequency.

Transformar :

Step up transformer

Step down transformer

Loss of energy is a transformer

(i) Copper Loss

(ii) Iron Loss or Eddy Current Loss

(iii) Loss due to flux leakage.

(iv) Hysteresis Loss.

A.C. generator

Construction working principle.

Uses of a.c. generator.

ASSIGNMENT

1. Answer the following MCQ.

(i) A transformer is used in

(a) A.C supply (b) D.C supply

(c) Both A.C and D.C supply (d) None of the above

(ii) The core of a transformer is laminated to

  (a) increase the output voltage
  (b) decrease the output voltage
  (c) reduce the eddy current loss
  (d) reduce the residual magnetism in the core.

(iii) The frequency of a.c. mains in India is

  (a) 30 cycles/sec (b) 50 cycles/sec
  (c) 60 cycles/sec (d) 120 cycles/sec

(iv) In purely inductive circuit the current

  (a) lags behind the voltage by $\pi/2$
  (b) leads the voltage by $\pi/2$
  (c) is in phase with the voltage
  (d) None of the above

2. **Answer the following questions :**

(a) What are the different losses in a transformer ?

(b) What is the peak voltage of 220 volt a.c. supply ?

(c) How much power is consumed by a pure inductive circuit ?

(d) A circuit contains an inductance of 50 mH. What is the reactance of the circuit ?

(e) What type of transformers are used for transmission of current from a power house.

(f) What is virtual ampere ?

(g) Define impedance of an a.c. circuit.

(h) Between A.C. and D.C. at the same voltage. Which is more dangerous and why ?

(i) What is resonant frequency ?

(j) Define power factor.

UNIT - VI
OPTICS

Structure :

Introduction :

Objective

Ray optics	(i)	Reflection	(ii)	total internal reflection
	(iii)	refraction	(iv)	dispersion

Optical instruments

Wave optics

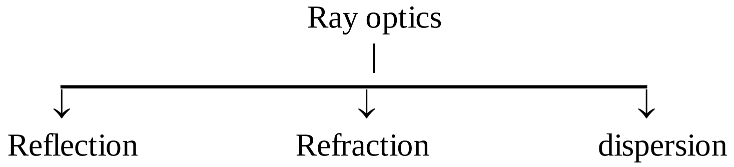
(i)	Huygen's principle	(ii)	interference
(iii)	diffraction	(iv)	Resolving power (v) Polarisation

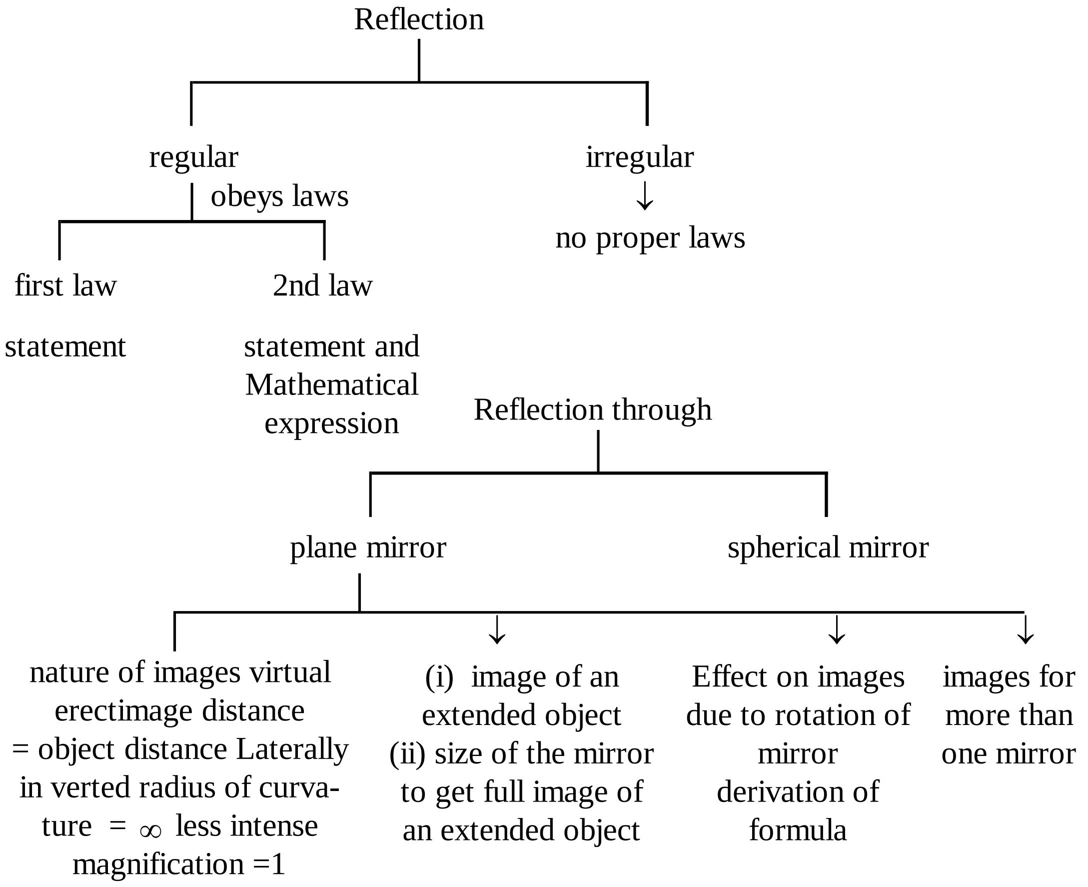
Introduction - Optics is the branch of physics which deals with light. The geometrical and physical optics deals with geometrically explanation of light propagation and effects and wave nature of light is used to explain the optical phenomena respectively. The instruments used to visualise the optical effects are optical instruments.

Objectivess :- After going through this unit a student should have the conception of light propagation and phenomenona due to it. A student also visualises the application of these phenomenon in day to day life.

Ray optics

This branch deals with optical phenomena without taking into account the nature of light.





Images due to more than one plane mirror

Derivation of formula of no of images depending on the angle between two mirrors facing each other.

If $\frac{360}{\theta}$ is even

No of image is given by $n = \frac{360}{\theta}$

If $\frac{360}{\theta}$ is odd

Situation

(i) If the object lies symmetrically between two mirrors.

$$n = \frac{360}{\theta} - 1$$

(ii) If the object is placed assymetrically then $n = \frac{360}{\theta}$

panes are parallel $n = \frac{360}{o} = \infty$

Conceptual - (1) To have full image of a person what should be minimum size of the plane mirror ?

2. A man is running away from the plane mirror at the rate of 5m s^{-1}, with what speed he is receding from his own image ?

Every thing should be explained with ray diagram and proper ray direction.

Reflection from spherical mirrors

↓

Definition and construction of spherical mirror

↓

Definition of pole, focus centre of curvature principal axis, radius of curvature, focal length, relation between f and R.

↓

mirror types

↓ difference in construction

Derivation of mirror formula with sign convention.

↓

Definition of magnification lateral and longitudinal

↓

characteristics of image in both mirrors with ray diagrams.

↓

applications of mirrors both concave and convex

Concave
nature vary with
object distance

Convex
virtual erect
diminshed

Application

Convex
for rear view and
wide field of view

Concave
(i) table lamp
(ii) astromical telescope
(iii) shaving mirror
(iv) in ophthalomo scope
(v) in solar application

REFRACTION

Idea of deviation of original path of light rays for different media.

laws of refraction

↓

1st law and 2nd law (snell's law)

↓

Bending in interface of different media

↓

idea of refractive index

formula

μ is small for rarer medium   greater in denser medium

relation with velocity of light

↓

principle of reversibility of light

$${}^a\mu_b \times {}^b\mu_a = 1$$

(proof) with ray diagram

↓

refraction through a parallel slab.

↓

expression for lateral displacement

lateral shift increases, with (1) thickness of slab. (2) angle of incidence

(3) refractive index of slab

It will be maximum when light is incident on the glass at an angle 90^0.

↓

Refraction through a compound slab.

↓

Apparent depth, real depth, their relation with refractive index

Refraction from denser to rarer medium idea of total internal reflection

Condition →

(1) incident light in denser medium

(2) idea of critical angle

i > critical angle

(3) $r \geq 90^0$

relation between critical angle and refractive index.

$$^g\mu_a = \frac{\sin i_C}{\sin 90} = \sin i_C$$

$$^g\mu_a \times {}^a\mu_g = 1 \text{ so } {}^a\mu_g = \frac{1}{\sin i_C}$$

↓

for diamond mirage in desert, totally reflecting prisms, sparkling of diamonds ($i_C = 24^0$)

application

↓

Optical fibers.

Principle and uses.

Some examples of phenomena observed due to refraction.

Refraction through lens (spherical surfaces)

↓

Refraction at surface convex (i) towards rarer
(ii) towards denser.

at surface concave towards (i) rarer (ii) towards denser

Derivation of formula

$$\frac{\mu_1}{-u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$$

object is in rarer medium

$$\frac{\mu_2}{-u} + \frac{\mu_1}{v} = \frac{\mu_1 - \mu_2}{R}$$ object in denser medium

↓

Definition of 1st and 2nd principal focal length of spherical surfaces

Lens.

How it is constructed (types , focus, pole, centre of curvature)

↓

Derivation of thin lens and Lens maker's formula
for both convex and concave lens

↓

characteristics of images in both type of lenses.

Problems : should be gibe on basis of lens formula.

Lirear magnification = $\frac{V}{U} = \frac{f - V}{f}$

power of lens $P = \frac{1}{f}$ but should be expressed in meter

$$P = \frac{100}{f} \text{ dioptre}$$

+ve power for converging lens

–ve power for diverging lens.

Lens maker's formula $P = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Derivation of focal length of combination of two thin lenses in contact

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$P = p_1 + p_2$$

Power is sum of two powers. For combination of two thin concave lens. If both focal lengths are equal numerically.

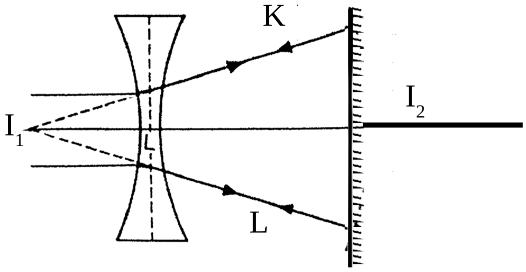
$$\frac{1}{F} = \frac{1}{f} - \frac{1}{f} = 0$$

Power = 0

Given combination behaves like plane glass slab

Some examples of mirror lens combination

(1) Problem



object is at infinity

focal length of concave lens = 10 cm

Separation between plane mirror and lens is 10 cm, light comes from infinity so parallel ray after refraction they will appear to diverge from focus. So I_1 is at focus of lens. I_1 is at distance 20cm from plane mirror so image due to mirror is at 20 cm from the plane mirror in the back.

So I_2 is at a distance of 30 cm from

So $U = -30$ cm

$$\frac{1}{V}-\frac{1}{-30}=\frac{1}{-10}$$

$$\frac{1}{V}=\frac{1}{-10}-\frac{1}{30}=-\frac{4}{30},\ V=-7.5$$

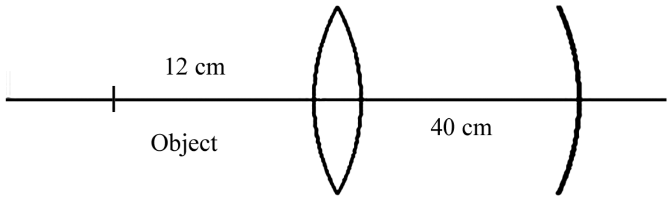
7.5 cm from lens 2.5 cm in front of mirror.

2nd example should be given.

Convex lens plane mirror in contact and object is at focus of convex lens.

Where the image will be formed ?

Combination convex lens and concave mirror



f_{lens} = 15 cm

If final beam comes out as paralle.

What is the focal length of mirror ?

refraction of lens

$$\frac{1}{f_L}=\frac{1}{v_1}-\frac{1}{u} \qquad u=-12\,\text{cm} \quad f=15\,\text{cm}$$

$$\frac{1}{15}=\frac{1}{v_1}+\frac{1}{12}$$

v_1 = – 60 cm

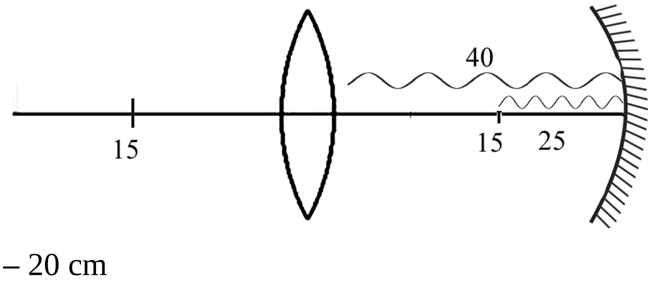
reflection from mirror.

object distance 60 + 40 = 100 cm

$$\frac{1}{f_m}=\frac{1}{u}+\frac{1}{v}=\frac{1}{f_m}=-\frac{1}{100}-\frac{1}{25}$$

as parallel rays are coming out means.

image is at focus of lens.



So f_m = – 20 cm

Dispersion and refraction through prism

Definition of (1) prism
(2) refracting faces
(3) refracting edge
(4) Angle of prism

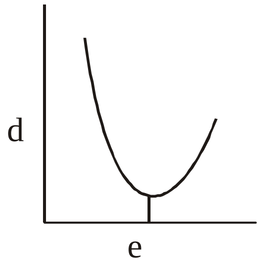
Different types of prism

Rays diagram showing refraction through prism.

Definition of (1) angle of emergence (e)
(2) angle of deviation. (d)

Relation between e and derivation of i + e = d + A

d = –A + i + e graphical variation of d with i.



Minimum deviation definition.

Expression for μ of material of prism in terms of d_{minimum} by calculus method.

proof of $i = e$
$r_1 = r_2$

$$\mu = \frac{\sin\left(\frac{A + d_m}{2}\right)}{\sin A/2}$$

Condition for no emergence of light from prism if A > 2 i_C ($i_C \rightarrow$ critical angle)
condition for grazing emergence – d = 90^0.
and $r_2 = i_C$ that leads to condition

$$\sin i = \sqrt{\mu^2 - 1}\ \sin A - \cos A$$

Condition for maximum deviation i = 90^0

$$d_{\max} = 90^0 + \sin^{-1}\left[\mu \sin\left(A - i_C\right) - A\right]$$

Prism with non monochromatic light

↓

deviation

$$d = (\mu - 1)A$$

↓

dispersion (definition) as μ^1s are different

Which is unaltered during dispersion (f or λ)

Proof of $d_{violet} - d_{red} = (\mu_v - \mu_r)A$.

dispersive power definition

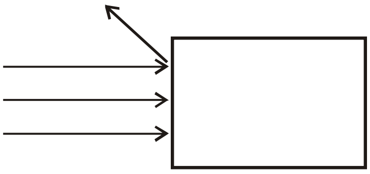
$$dw = \frac{\mu_v - \mu_r}{\mu - 1}$$

Scattering of light

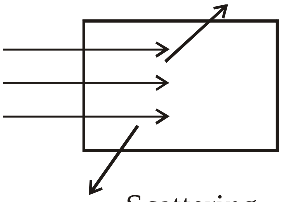
Phenomenon where light is redirected in many different direction when interact with non uniformities in medium through which it passes.

It is a form of particle interaction → light gets absorbed then emitted →

In reflection light does not interact just gets reflected from surface.



reflection



Scattering

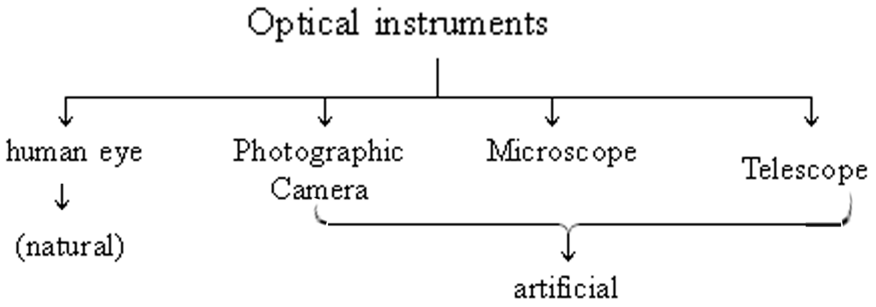
Scattering → photon gets absorbed electron gets excited then jumps back emitting enegy.

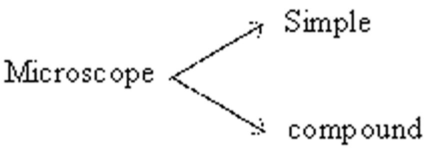
Sun set → Sunlight travels a longer path short wave lengths are removed (much more light is scattered) So left with mixture of yellow orange and red. Sun light scattered by air molecule, shorter wavelengths are more scattered so sky is blue.

Little bit idea of Rayleigh scattering

$$\text{Scattering} \propto \frac{1}{\lambda^4}$$

Thus Sun light interacts with air molecule and shorter wavelengths are more scattered





Simple microscope – Convex lens of short focal length, object distance less than f, virtual, erect, magnified image at least distance of distinct vision from eye.

↓

ray diagram of simple microscope.

Angular magnification magnifying power = $\beta/\alpha = \frac{\text{Tan}\,\beta}{\text{Tan}\,\alpha}$ for small β, α

Where $\beta \longrightarrow$ angle subtended at the eye by the image at least distance of distinct vision (near point)

α – angle substended by object at eye when object is placed at near point

Derivation of

↓

D → Least distance of distinct vision

Magnification $M = 1 + \frac{D}{f}$

f → focal length

If eye is at a distance a from the eye

$$M = 1 + \frac{D - a}{f}$$

2nd case object at f, image is at ∞

$$M = D/f \rightarrow \text{Minimum}$$

$$M = 1 + \frac{D - a}{f} \rightarrow \text{Maximum}$$

Use → In, watch and Laboratory.

Compound microscope

(1) Description of construction (may be made up of two lenses)

(2) Ray diagram

(3) Formation of images

objective, eye piece

↓ may be single lens

may be → Combination of no of lenses.

Calculation of magnification

$$M = M_e \times M_0$$

$$M_e = 1 + D/f_e$$

$$M_0 = \frac{v_0}{u_0} \qquad M = (1 + D/f_e)\frac{v_0}{u_0} = \frac{-L}{f_0}\left(1 + D/fe\right)$$

If f_0 and f_e less → M is more

L → Microscope tube length

If imge formed at ∞

$$M = \frac{-L}{f_0} \times \frac{D}{f_e}$$

Telescope
- Astronomical, refracting
- Terrestrical, refracting
- reflecting

Astronimal Refracting Telescope

↓

Construction

↓

image formation with ray diagram.

Derivation of magnifying power of telescope in normal adjustment

$$M = {}^{\beta}\!/_{\alpha} = \frac{\operatorname{Tan}\beta}{\operatorname{Tan}\alpha}$$

β → angle subtended by the image at ∞ at eye.

α —— angle subtended by object when both are at ∞.

$$M = \frac{-\frac{1}{fe}}{\frac{1}{f_0}} = \frac{-f_0}{f_e}$$

Derivation of magnification when object at ∞, image is at near point ↓

Ray diagram.

Calculation of $M = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$

Terrestrial Telescope
- construction
- Ray diagram
- image formation

Work of auxillary lens

Derivation of $M = -\frac{f_0}{f_e}$ or $\frac{f_0}{f_0}\left(1 + \frac{f_e}{D}\right)$

Galilean type

Difference of Galilean telescope from normal terrestrial telescope with ray diagram.

Reflecting telescope

Some astronomical telescope use mirrors insted of lens.

Mirrors are parabolic and used as objective.

Description of mirror.

Ray diagram

Advantages of reflecting telescope.

(i) free of colour defect

(ii) removes spherical aberration..

(iii) brighter image

(iv) large diameter of mirror so high resolving power

(v) It has greater stability

(vi) less costly

(vii) high M

(viii) high light gathering power.

First designed by James Gregory in 1733. Cassegrainian telescope is another reflecting telescope.

Questions – why the objective and eye peice have short focal length in case of compound microscope ?

Wave optics

Geometrical or ray optics doesnot take consideration of light as a wave

↓

Little discussion about the development of Newton's corpscular theory and its limits

↓

Dutch physicist christian Huygens theory

↓

idea of light as a form of energy which advances forward as wave motion from the luminous source

↓

How it overcome the limits of Newton's theory ?

↓

Idea of wave front and its definition

↓

locus of points having same phase of oscillation

↓

Ray → line perpendicular to wave front

→

Different geometrical shape of wave front
depending on the source of distance

↓ ↓ ↓

spherical	Cylindrical	Plane
(point source)	↓	source is at ∞

source of light is a line source

↓

Hugen's construction of primary and secondary wave fronts

Why backward wave front is rejected,

Stoke's law

Internsity $\propto (1+\cos\theta)$

Proper figures of wave fronts (secondary and primary)

Proof of Laws of reflection and refraction by Huygen's theory with proper ray diagrams

↓

Idea of super position of two waves with idea of wave fronts (crest and trough) graphically as well as analytically)

Interference

↓

Condition ⟶ coherent source (definition)

Same amplitude frequency, wavelength phase difference constant

↓

production of coherent sources

By division of wave front by using mirror, lens prism.

By division of amplitude

Partial reflection or refraction (thin film)

Example - Young's double slit experiment

Interference of waves Analytical treatment, Super position of two waves with constant phase difference.

[effect of non constancy in phase difference]

Expression of resultant amplitute and phase

$$A=\sqrt{a_1^2+a_2^2+2a_1a_2\cos\phi} \qquad \text{Tan}\,\theta=\frac{a_2\sin\phi}{a_1+a_2\cos\phi}$$

$\phi \longrightarrow \text{phase diff.}$

Discussion with different ϕ

↓

Derivation of expression for maximum and minimum intensity

↓

condition for destructive and constructive interference (graphically and analytically)

$\Delta = n\lambda,\ \phi = 2n\pi$ ———— constructive

$\Delta = \lambda/2\,(2n+1)\phi = (2n+1)\pi$ ———— destructive

Comparison of I_{max} and I_{min}

Young's double slit Experiment

Description of experimental arrangement virtual source

↓

Ray diagram

↓

super position of crests and troughs

Analytical method to find the position of dark and bright fringe

↓

fringe width calculation dependence of fringe width on λ, d, D.

↓

Intensity distribution pattern.

↓

Description of use of experiment to find the wavelength of the source

↓

Condition for sustained interference pattern

↓

Discussion of conservation of energy in interference pattern.

↓

Problem → (1) λ, D, d given. To find fringe width
(2) D, d, fringe width given find λ
(3) varying D or d or λ how fringe width varies ?

Difraction

Wave theory demands light bends round the corner

↓

but not visible as λ small

↓

passing through aperature comparable to λ light is observed to diverge

↓

Phenomenon of bending of light round the corner and encroachment of light into geometrical shadow region

↓

observable

↓

[Luminous border sorrounding the profile of a mountain just before the sun rises.]

First observed by
Garibaldi in 1665

↓

Newton and Hooke

↓

Thomas Young

Diffraction

Fresnel source and screen are close to obstacle

Fraun hoffer
Source and screen are at a large distance

Diffraction at single slit experimental arrangement

↓

Ray diagram

↓

observation of fringe pattern

Diffraction

↓

definition - with example

↓

diffraction due to single slit

Explain with qualitative description by division of single slit into small segments.

↓

width of central maximum

↓

$$\theta n = \frac{n\lambda}{d}$$

width of central maximum = $2\left(\frac{nD\lambda}{d} - \frac{(n-1)D\lambda}{d}\right) = \frac{2D\lambda}{d}$

figures of maxima's. Intensity distribution.

Resolving power →

general Definition

Rayleigh's criterion

↓

Formula for resolving power of Telescope

It is reciprocal of smallest angular separation between two distance objects whose images are separated in telescope

formula $d\theta = \frac{122\lambda}{a}$

$d\theta$ = angle subtended by object at telescope objective.

λ → wavelength of source.

a → diameter of telescope objective

Resolving power of microscope →

least distance between two objects which can be distinguished

least distance → $\Delta d = \dfrac{\lambda}{2\mu \sin\theta}$

λ - wavelength

μ - refractive index of medium

θ → half angle of cone of light from the point object.

Resolving power = $\theta\dfrac{1}{\Delta d} = \dfrac{2\mu \sin\theta}{\lambda}$

Polarisation

Meaning of polarisation

↓

Possible for transverse wave, explain with cardboard, thread experiment

↓

plane of vibration, plane of polarisation definition

↓

polarisation types

↓

plane, circular, elliptical (qualitative idea)

↓

plane polarised light due to reflection with figure

↓

Brewster law

figure

Proof of Tan $i_p = \mu$

Idea of nicol prism and polaroid.

Its use.

Difference between Interference and diffraction

	Interference		**Diffraction**
(1)	super position of two primary wave fronts coming from two coherent sources	(1)	Superposition of secondary wavelets coming from single wavefront
(2)	Fringe width constant	(2)	fringe width is variable
(3)	Intersity distribution uniform	(3)	non uniform
(4)	good contrast in maxima, minima	(4)	poor contrast

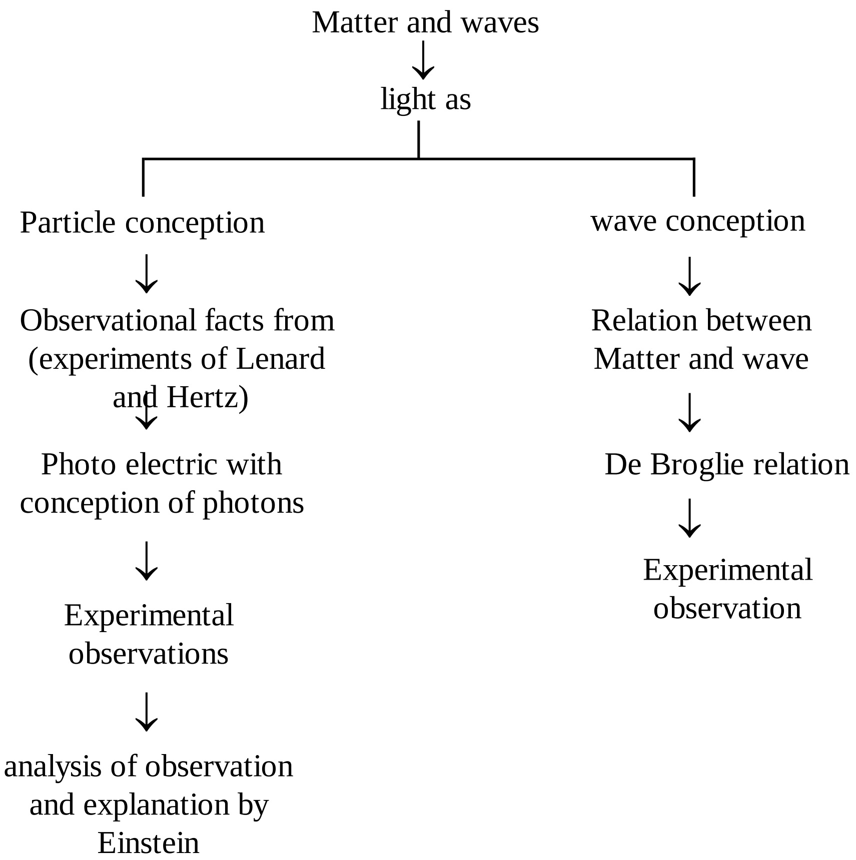
UNIT - VII
DUAL NATURE OF RADIATION AND MATTER

Structure

(1) **Introduction :**

Objective

(2) Dual nature conception

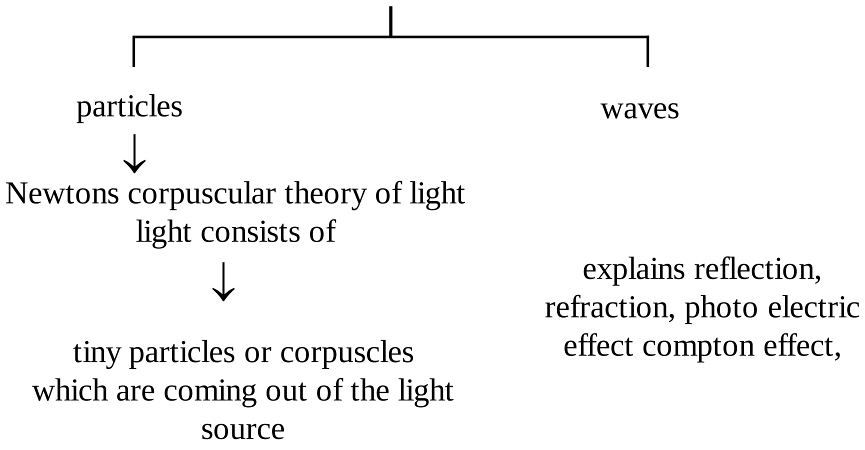


Introduction →

In this unit a student will learn about the dual nature of light as a wave and as a particle and relation between matter and wave.

Dual nature of radiation

Explanation of radiation consists of (?) to explain experimental observations.



Limitations :-

(1) no explanation regarding the similarity in corpuscles though the sources may be different.

(2) No explanation for diffraction, interference, polarisation.

(3) no explanation regarding velocity of light in different media.
(Newton's theory $V_{denser} > V_{rarer}$)
actually velocity in rarer medium is more

(4) Explanation of reflection is based on repulsion between corpuscles of incident light and reflecting surface.

(5) At the time of refraction a part is reflected and a part is refracted How their will be simultaneous attraction and repulsion of light corpuscles in the medium ?

(6) Colours of thin film was not explained

Next is Huygen's wave conception.

↓

An illuminated body spreads disturbance in form of waves

↓

existence of hypothetical medium ether to allow passage of light waves.

↓

Max well modified concept of medium

↓

For light, and electro magnetic wave no need of medium for passage.

↓

Could explain all phenomenon
(linear propagation, reflection, refraction, interference, diffraction, polarisation)
Wave theory could not explain

↓

spectroscopy and photoelectricity.

↓

(1) Spectros copy gave idea of radiation of energy when electron changes its energy level.
(2) radiated energy is in form of definite frequency in packets.
(3) Photoelectricity

↓

A definite quantum of light radiation falling on surface ejects electron.

These two phenomenan explained by the idea that light contains packet of energy called photon

Properties of photon

(1) Source of radiation emits energy in forms of photons
(2) Photons travel in straight line
(3) Velocity is that of light
(4) It is not material particle. It is packet of energy
(5) Enegy of photon depends on its frequency which does not change with medium
(6) Speed and wavelength change with different media
(7) electrically neutral
(8) Rest mass is zero.

(9) Intensily of light $\propto$ no of photons present.

(10) $E = mc^2 = hf$

$$m = \frac{hf}{c^2} = \frac{h}{c\lambda}$$

(11) Momentum $[P = mC = \frac{h}{c\lambda}C = \frac{h}{\lambda}]$

All these facts lead to confusion regarding the nature of radiation, so light was taken to have both particle and wave nature some experiments explained on basis that light is particle like, some experiments are dealt with wave nature of light.

But no experiment is found where light behaves in both ways. It is either this or that given by Bohr's complimentary principle.

Radiation (1) emitted in quanta (2) transmitted in wave form (3) absorbed in quanta.

Dual aspect of radiation leads to

Particle nature	wave nature
↓	↓
mass, momentum, energy Einsten's equation $E = mC^2$	energy, wavelength frequency

In 1924. de-Broglie's argument → (1) Nature loves symmetry"
(2) Dual nature of radiation

mass energy symmetry for both particle and wave.

↓

Connection between mass energy of both from Einstein planck's expression for energy

$E = h\ \ f = m c^2$

$c = f\ \lambda$

$$E = \frac{hc}{\lambda} = mc^2$$

$$\lambda = \frac{h}{mc}$$

mc = p = momentum

$$\lambda = \frac{h}{p}$$

A quantum having momentum p is associated with wavelength

For material particle

$$\lambda = \frac{h}{mv}$$

This is de-Broglie wave equation

(i) $\lambda \propto \frac{1}{v}$ if particle is in motion

(ii) $\lambda \propto \frac{1}{m}$, small mass, large λ

(iii) $\lambda \propto \frac{1}{p}$ larger is momentum smaller λ

(iv) λ is independent of charge

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

$$\frac{p^2}{2m} = K.E$$

$$P = \sqrt{2m \times K.E}$$

$$\lambda = \frac{h}{\sqrt{2m} \times \sqrt{\text{kinetic energy}}}$$

Problem → λ for an accelerated electron through a potential difference of v volts.

work done = ev = gain in K.E.

$$KE = eV$$

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

$$\text{velocity} = u = \sqrt{\frac{2eV}{m}}$$

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2meV}}$$

$h = 6.62 \times 10^{-34}$ Js $\qquad M = 9.1 \times 10^{-31}$ kg

$e = 1.6 \times 10^{-19}$ C

$$\lambda = \frac{12.27}{\sqrt{V}} A^0$$

for protons $m_p = 1.67 \times 10^{-27}$ kg

$$\lambda = \frac{0.286}{\sqrt{V}} A^0$$

$$\lambda \text{ deutron} = \frac{0.202}{\sqrt{V}} A^0$$

$$\lambda \propto \text{particle} = \frac{0.101}{\sqrt{V}} A^0$$

$$\lambda \text{ neutron} = \frac{6.62 \times 10^{-34}}{\sqrt{2 \times 1.67 \times 10^{-27} E}}$$

For thermal neutrons

$E = KT$ K Boltzman constant

$T \rightarrow$ absolute temperature

$$\lambda = \frac{30.835}{\sqrt{T}} \; A^0$$

For gas molecules at T^0K temp

$$E = {}^{3}\!/\!_{2}\; KT, \quad \lambda = \frac{h}{\sqrt{3m\,KT}}$$

properties of matter wave

(1) Mater waves are different from electromagnetic wave.

Mater waves are related to particles in motion (charged or uncharged)

(2) In Ordinary situation, wave length is small can not be detected.

Example say a body, wt = 50 gm

speed 30 m s^{-1}

Calculate λ which will be order of 10^{-34}m

(3) Matter wave velocity is more than C (light velocity)

$$\underset{\substack{\text{mater}\\ \text{wave}}}{V = f\lambda} \quad \lambda = \frac{E}{h} \times \frac{h}{P} = \frac{E}{P} \quad \frac{MC^2}{mV} = \frac{C^2}{V_{particle}}$$

$V_{particle} < C \qquad V_{materwave} > C$

Actually matter waves travel with the body in a group.

Group velocity = velocity of particle.

but individual waves of the group travel theoretically with higher speed than C.

(4) Both aspect wave and particle nature can not be observed simultaneously which nature will dominate depends on the de-Broglie wave length compared with dimension of the body and dimension of the body it interacts with.

(5) Square of amplitude of the de-Broglie wave at any point is proportional to the probability of finding the particle at that point.

Application →

(1) electron microscope

(2) quantisation of orbit of electron

To have a standing wave

$$2\pi r = \text{circumference} = n\lambda$$

$$= \frac{nh}{P} = \frac{nh}{mv}$$

$$mvr = \frac{nh}{2\pi} - n\hbar$$

Problem :

(1) A photon and electron have same de-Broglie wave length which has greater energy ?

(2) For what K.E of neutron

$$\lambda = 1.4 \times 10^{-10} \text{ m.}$$

(3) Find the ratio of Hydrogen λ and helium λ if they are at 27^0C and 127^0C respectively.

Davison Germer experiment.

Description of experimental setup.

Observation –

(1) Intensity $\propto$ no of electrons

(2) More no of electrons are received at a particular voltage for a particular angle of scattering.

(3) de-Broglie wave length was calculated for electron at that particular voltage v = 54 volt.

$$\lambda = 1.67\,A^0 \qquad \lambda = \frac{h}{[2meV]^{1/2}}$$

(4) It was same as the λ value of calculated from x-ray diffraction.

(5) Conclusion is that electrons are diffracted in the same way as de-Broglie.

Photo electric effect

Hertz in 1887 observed

(1) Electric discharge in a cathode ray tube is facilitated when tube is exposed to ultra violet ray. Air in the spart gap became a better conductor.

Hall wachs in 1888 observed.

(1) Ultra violet ray being incident on neutral zinc plate the plate becomes positively charged.

(2) U-V ray incident on negatively charged zinc plate, it loose the negativity.

(3) U - V ray incident on positively charged zinc plate makes it more positive.

Conclusion

negatively charged particles are emitted by surface of a metal under the action of U-V ray.

In 1898 Thomson conclusion e/m value of emitted particle

$= e/m$ value of cathode rays.

In 1916 Einstein studied the effect of visible light of a range of frequencies on sodium, potassium etc and electrons were emitted.

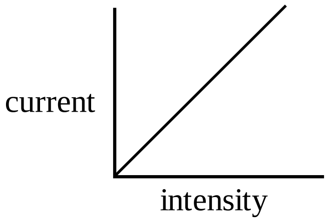
So it was concluded that when electro magnetic radiation of suitable frequency are incident on metalic surface then electrons are emitted. The ejected electrons are photo electrons and the effect is photo electric effect. Hence the current drawn is photo current.

Describe experiment with circuit diagram

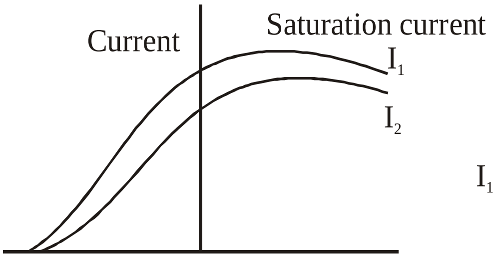
↓

observations from experiment

(i) effect of intensity of the incident radiation (with potential and frequency constant)

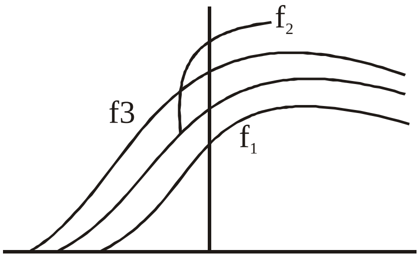


(ii) Effect of potential with intensity and frequency constant



I_1 (intensity) $I_2 < I_1$
I_2 intensity

lower intensity lower saturation current
at v = 0, also some current
v = $-v_0$ current is zero
idea of stopping potential where current = 0
V_0 is independent of frequency

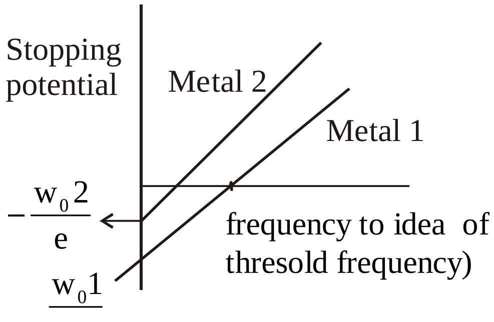


$f_3 > f_2 > f_1$

v_3 v_2 v_1 v_3 is more negative

Effect of frequency

Stopping potential is dependent on frequency



Laws of photo electric emission

(a) Instantaneus.
Time lag between incidence of light and ejection of electron is 10^{-9} sec
Energy from photon supplied and electron gets ejected.

(b) The no of electrons emitted persec $\propto$ intensity.

(c) The lower limit of frequency is called thresold frequency

(d) Above thresold frequency the maximum velocity of electron depends only on frequency not on intensity.

Einstein's interpretation

Energy of incident beam

= energy required to make electron free + K.E of electrom.

Energy required to make electron free → work function dependent on nature of material.

hf = wo + K.E.

hf → quantum of energy (energy of Photon) absorbed by electron.

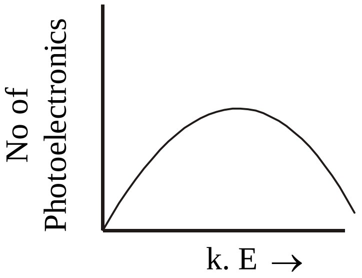
One to one correspondence electron ejected

Kinetic energy = Energy obtained – energy required to over come the binding = hf – wo

if no loss in collision

K.E (maximum) = hf – wo = $hc\left(\frac{1}{\lambda}-\frac{1}{\lambda_0}\right)$

Where wo = hfo = $\frac{hc}{\lambda o}$



electrons may have K.E = 0 to K.E (maximum)

Stopping potential → V_0

then eV_0= K.E $(maximum)_2$

$$eV_0 = \frac{1}{2}\ m\,v^2_{max}$$

$$= h\,(f - f_0)$$

$$V_0 = \frac{h}{e}(f - f_0)$$

$$= \frac{hf}{e} - \frac{hf_0}{e}$$

$$= \frac{hf}{e} - \frac{wo}{e}$$

Description of the experimental observations which can be explained by Einstein's photo electric equations.

Failure of clasical wave theory to explain photo electric effect

(1) The intensity problem →

If intensity of incident e.m wave is increased according to classical wave theory amplitude of oscillating electric wave vector $\vec{E}$ of light wave increases in amplitude.

The force $e\vec{E}$ applied to electron will be more. So kinetic energy should increase due to increase of intensity which is contrary to observation where maximum K.E. is independent of light intensity

(2) The frequency problem →

Classically photoelectric effect should occur for any frequency provided intensity should supply energy to over come binding. Observation is such that for a particular metal the effect occurs after certain frequency no matter the intensity of lower frequency is used.

(3) Time delay problem

Classically the light energy is uniformly distributed over the wave

So energy of incident light will not go entirely to a particular electron rather it will be distributed the electron will take some time to accu mulate energy. So there must be a time lag between incidence and ejection - but ejection and incidence are instantaneous

Solution by quantum theory

(1) I $\rightarrow$ intensity, A-area of exposure

IA = energy

N $\rightarrow$ no of photons / time

IA = N h f $\quad \frac{IA}{hf} = N$

Intensity doubled.

N will be doubled but hf will not change

So K. E_{max} of electron non-changed

(2) If K.E = 0 hf_0 = wo

Photon has just enough to eject not imparting any K.E.

$f < f_0$ no ejection

$f > f_0$ ejection + K.E.

(3) Quantum mechamically photon is concentrated bundle or packet of energy, so it does not get distributed one photon interacts with one electron if photon energy $\geq$ work function of electron, electron gets ejected immidiately

Application of photo electric effect

Photo cells.

Application of photo current

(1) Reproduction of sound in cinema films
(2) Television
(3) Astronomy
(4) Solar batteries
(5) Temperature control
(6) Fire alarm
(7) Burglar alarm
(8) Automatisation of street light
(9) Automatic oponing of garage door.

Problems

(1) Wavelength $\lambda = 5000\,A^0$

Work function 1.2 eV

Calculate the value of stopping potential.

(2) Speed of electron = 10^4 m/sec

Work function = 2.3 eV

What will be frequency of incident light ?

(3) If the work function is 2.3 eV.

What is the largest wavelength light that can cause photo electric emission ?

UNIT -VIII
ATOMS AND NUCLI

Structure

1. Introduction
   - Objective
   - Atom and atomic models
   - Rutherford scattering experiment
   - Bohr model
   - Hydrogen spectrum
   - Nucleus (Characteristics, composition)
   - Fission, Fusion
   - Radioactivity

Introduction :- This unit deals with the smallest constituent of matter which takes part in chemical reaction, that is atom. The different types of atomic models are explained with their limitations to explain the structure of an atom. The structure of atom leads to idea of subatomic core that is nucleus. further the idea about constituent behaviour of nucleus, disintegration of nucleus and the reunion of nucleus are dealt in this unit. Some nuclei are more reactive and their decay process is analysed in this unit.

Objective :-

After going through this unit a students should have knowledge about

1. Smallest unit of matter that takes part in chemical reaction.
2. Its structure
3. Sub stomic core of atom.
4. behaviour of nucleus.

Atom and atomic models

matter consists of atoms (prout's Idea that matter consists of hydrogen atoms)

↓

different models

↓

↓ Thomson model ↓ Rutherford model ↓ Bohr model

(1) electrical neutrality of atom
(2) atom full of +ve fluid like pudding evenly distributed
(3) electron are plums embeded in pudding. through out the fluid
(4) +ve charged sphere of radius 10^{-10}m
(5) No of electrons are such that –ve - charge equal to +ve charge.
(6) It explained demand of e.m theory, limitation – It could not explain the experimental observations of Rutherford's experiment.
(7) It could not explain observed line spectrum of hydrogen atom.

↓

Rutherford's

1. α particle scatting experiment
2. Observations
3. Conclusion

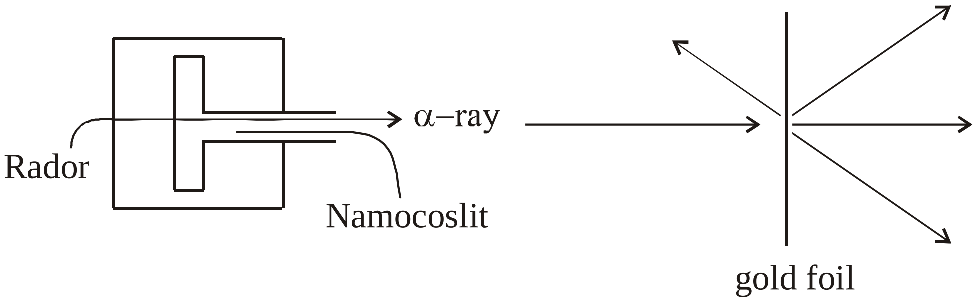
Rutherford's α particle scattering .

Aim → to study inner core of atom a source of α particle Radon placed in a load box .

α particle ${}_2He^4 \rightarrow$ charge +2e, velocity 10^7 and having highly penetrating energy around $\rightarrow$5.5mev

Figure of the experiment should be given .

Arrangement of experiment should be explained .



Entire apparatus is enclosed in an evacuated chamber capable of rotating around a vertical axis.

Observations:-

i. Most α particles undeviated.

ii. Some deviated at angles less than 90^o

iii. Some at very high angle even at 180^o.

iv. $N\alpha \frac{1}{\sin^4 \theta/2}$ where θ- scattering angle.

v. $\frac{\mathrm{M}}{\mathrm{t}}$ constant for one θ value

t → thickness of gold foil.

vi. The α particles pass at a greater distance are deflected less. The distance of closest approach or impact parameter → perpendicular distance of the velocity vector from the point where all +ve charges are supposed to be concentrated as to Rutherford.

Conclusion :-

1. Undeviated α particles $\xrightarrow{\text{suggest}}$ most space is vacuum.
2. heavier $\rightarrow \alpha$ particle → large angle scattering only if large e.s. repulsion.
   So +ve charge is concentrated at a very small space.
3. Effect of impact parameter.
4. Distance of closest approach leads to idea of radius of the spherical space where +ve charge is concentrated.

Calculation of $b = \frac{Ze^2 \cot \theta/2}{4\pi\varepsilon_0 \left(\frac{1}{2} m v_i^2\right)}$

$r_0 = \frac{1}{4\pi\varepsilon_0}\frac{4Ze^2}{mv_i^2}$ problems should be discussed.

Explanation → Ruther ford explained → atom consisting of nucleus where all +ve charges concertrated in a sphere of $r_0 \approx 10^{-15} m$ entire space empty, electrons move in orbits.

Failure →(1) classically a charged body orbiting around is accelerated so it will emit radiations so radius of orbit will be smaller so electron will drop into nucleus which is not true.

2. The line spectrum of atoms were not expained as electron radiate energy of all frequencies as per Rutherford .

Bohr's model

Failure of Rutherford leads to Bohr model postalates -

1. Atom has → nucleus → small → contains entire +ve charge and mass.
2. Eletrons orbit around nucleus the orbit is fixed and circular .
3. The eletrostatic altraction supplies centripetal force.
4. Angular mometum is quantised $mvr = \frac{nh}{2\pi} = n\hbar$
5. Electrons donot radiate energy but radiate energy when jump from one orbit to other.

Bohr's theory

1. Derivation of nth orbit radius $r_n = \frac{1}{4\pi\varepsilon_0}\frac{n^2h^2}{4\pi^2ml^2}$. So $r_n \alpha n^2$
2. Derivation of velocity of electron in nth orbit $V_n = \frac{1}{4\pi\varepsilon_0}\frac{2\pi e^2}{nh}$

$$V_n = \frac{c}{n}\frac{1}{4\pi\varepsilon_0}\frac{2\pi e^2}{ch}$$

$$V_n = \frac{c}{n}\frac{e^2}{4\pi\varepsilon_0 \frac{h}{2\pi} c}$$

$$= \frac{c}{n}\frac{1}{137} = \frac{c\alpha}{n}$$

$$\frac{e^2}{4\pi\varepsilon_0 hc} = \frac{1}{137} \left[\text{fine structure} = \text{constant } \alpha\right]$$

for n = 1

$V_1 = \frac{c}{137}$ c light velocity

$$V_n \alpha \frac{1}{n}$$

Outer orbit $\rightarrow$ slower velocity

3. Energy of electron

$$E = E_k + E_p$$

derivation $E_n = \frac{-K^2 2p^2 me^4}{n^2 h^2} \rightarrow k = \frac{1}{4\pi\varepsilon_0}$

$$E \alpha \frac{1}{n^2}$$

-ve sign $\rightarrow$ attractive bound to nucleus

n = 1 more negative energy

n = 2 less negative energy

$$E_{n2} = \frac{-k^2 c^2 2\pi^2 me^4}{n^2 h^2 c^2} = -\frac{1}{2}\frac{mc^2}{n^2}\left[\frac{e^2}{4\pi\varepsilon_0 hc}\right]^2$$

$$= -\frac{1}{2}\frac{mc^2}{n^2}\alpha^2$$

$$E_1 = -13.6eV$$

$$E_n = \frac{-13.6ev}{n^2}$$

While jumping the energy difference

$$E_f - E_i$$

$$= -\frac{k^2 2\pi^2 me^4}{n_f^2 h^2} + \frac{k^2 2\pi^2 me^4}{ni^2 h^2}$$

$$= \frac{k^2 2\pi^2 me^4}{h^2}\left(\frac{1}{ni^2} - \frac{1}{nf^2}\right)$$

Hydrogen spectrum

$$h\nu = E_f - E_c$$

$$\nu = \frac{E_f - E_i}{h}$$

$$\frac{c}{\lambda} = \frac{E_f - E_i}{h}$$

Wavenumber $= \bar{\nu} = \frac{1}{\lambda} = \frac{k^2 2\pi^2 me^4}{ch^3}\left[\frac{1}{ni^2} - \frac{1}{nf^2}\right]$

$\bar{\nu} = R\left[\frac{1}{ni^2} - \frac{1}{nf^2}\right]$, R is Rydberg constant.

Transition-

Transistor from higher orbits to inner most orbit

Lyman series

$$\bar{v} = R\left[\frac{1}{1^2} - \frac{1}{nf^2}\right] \quad \text{nf = 2, 3, ...}$$

Maximum corresponds to ultraviolet region

$$\bar{\text{v}} \text{ minimum} = \text{R}\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$

For Balmer ni = 2 , nf= 3, 4, 5,

$$\bar{v} = R\left[\frac{1}{2^2} - \frac{1}{nf^2}\right]$$

Around 29 lines have been detected

1st to 4 lines → visible region . rest → $u-v$ region

$$\bar{v}\,\text{max}^m = \frac{R}{4}$$

$$\bar{v}\,\text{min} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

For Paschen ni = 3, nf = 4,5,6,...

$$\bar{v} = R\left[\frac{1}{3^2} - \frac{1}{nf^2}\right]$$

$$\bar{v}_{mzx} = R\left(\frac{1}{3^2}\right)$$

$$\bar{v}_{\min} = R\left(\frac{1}{4^2} - \frac{1}{nf^2}\right)$$

Series is in infrared region.

For Bracket - ni = 4, nf = 5,6,7.

$$\bar{v} = R\left[\frac{1}{4^2} - \frac{1}{nf^2}\right]$$

infrared region.

For Pfund ni = 5 , nf = 6,7

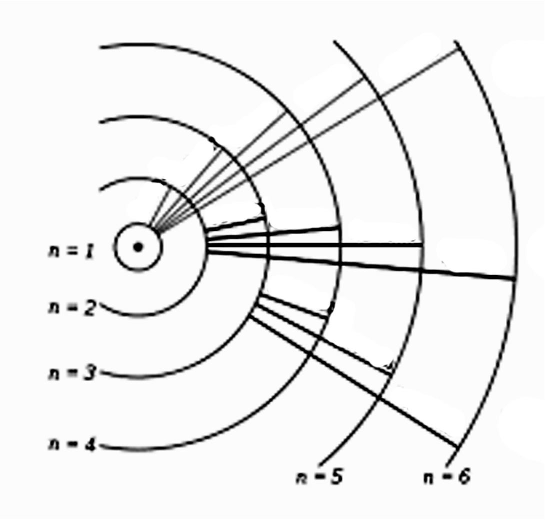
$$\bar{v} = R\left[\frac{1}{5^2} - \frac{1}{nf^2}\right]$$

far infrared region.

Hamphry series

$n_1 = 6, \ n_2 = 7, 8.......$

Spectral series should be shown in diagram



Horizontal energy level diagram should be given

Orgin of spectra - Energy supplied - electron jumps to outer orbit but pauli's exclusion principle debars its stay there, so jumps back to orginal orbit emitting energy .

Just reter that - Hydrogen spectra considers (i) Nucleus to be at rest

(ii) electron to move.

(iii) electron have negligible mass.

But practically these are not true .

So spectrum is affected by finite mass and motion of nucleus.

Limitations of Bohr's theory :-

i. It is only appreciable for hydrogen like atoms.
ii. It could not explain hyperfine structure of spectral lines.
iii. This theory does not give any idea about the intersitaies of spectral lines.
iv. No indication about the arrangement of electrons.
v. It does not tell anything about wave nature of electron.
vi. It does not tell about the time span of stay of electron in an orbit.

Problems- (i) Radius of first electron orbit of hydrogen is $5\times10^{-11}m$ what will be radius of third orbit $\left(r_n \alpha n^2\right)$?

(2) If total energy of first excited state is -3.4 ev what is its potential energy?

3. Calculate the shortest wavelength of Paschen series.

<u>Conclusion from Rutherford's experiment</u>

Nucleus $\underrightarrow{contains}$ +ve charge and whole mass of the atom .

Mass number of atom and electrical neutrality demands no of +ve charge = no of -ve change .

no of proten = electron .

Mass no demands → there must be some other particle of same mass as proton, electrical neutrality demands the other one must be charge less that is neutron.

Why neutrons should be inside nucleus why not electron ?

Dimension of nucleus is of 1 Fermi

Mass of protron $=1.67\times10^{-27}kg$

charge $=1.6\times10^{-19}kg$

Mass of neutron $1.675\times10^{-27}kg$

charge =0

Uncertainty principle demands

$\Delta p\Delta x \rightarrow ƛ$

$\Delta x \approx 10^{-15}m$

$\Delta p = ƛ\times10^{-15}$

As per energy of electron - 200mev

but emitted electron

has energy $\rightarrow$4 mev

So electrons are not inside nucleus .

De Broglie hypothesis also demands that value of angular momentum and magnetic momentum does not suggest that electrons are inside nucleus.

size $\rightarrow$ $R = R_0A^{1/3}$

$R_0 = 1.2\times10^{-15}m$

A $\rightarrow$ mass number of nucleus

volume $=\frac{4}{3}\pi R^3 = \frac{4}{3}\pi R^3{}_0A$

volume αA Density $=\frac{Mass}{Volume} = \frac{A\ amu}{\frac{4}{3}\pi R_0^3 A}$ $= 2.29\times10^{17}\ {}^{kg}\!/\!{}_{m^3}$

(conversion of Amu should be explained)

Density is (1) independent of A

(2) very large

(3) non uniform

(4) nuclear radius is the distance from the centre where density is half of that at centre.

How $\rightarrow$so many +ve charges are inside nucleus $\rightarrow$

Idea $\rightarrow$ coulomb repulsion is there but over powered by attractive strong force (nuclear force)

Nuclear force $\approx 10^{36}$ x coulomb force

Nature (i) attractive , strong

(ii) charge independent

(iii) short ranged present upto 1.5 fermi then zero

(iv) spin dependent

(v) saturation property

The nuclear reaction is due to meson exchange $\left(\pi^o, \pi^+, \pi^- \ mesons\right)$

(vii) Time involved in exchange process is very small

(viii) $p \to n$ and $n \to p$ inside nucleus

Binding energy

Def^n- Mass defect $\to \Delta m$

Zmp + (A-Z)mn -M

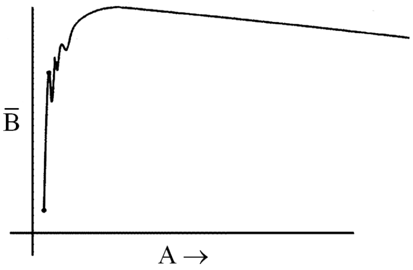
Why there is mass defect?

Relation between binding energy and mass defect $B = B.F = \Delta mc^2$

Binding energy per nucleon

$$\overline{B} = \frac{B}{A}$$

Conversion -Amu , Mev, Joule should be explained



Features -(1) $\overline{B}$ increases with A upto certain no of A→ steep rise.

(2) cyclic recurrence of peaks for ${}_2He^4$ ${}_4Be^8$ and ${}_{10}Me^{20}$ → which shows stability

3. Gradual increase after A = 20
4. Maximum at A=56 $\overline{B} = 8.8 mev$
5. $\overline{B}$ for A 40 to 120 nearly same close to $\overline{B}$ max - suggests stability of these elements.
6. Continuous decrease in $\overline{B}$, for A >120 (due to more protons so coulomb repulsion is more which reduces $\overline{B}$)
7. A>238 rapid decrease in $\overline{B}$

Conclusion

In the low limit of A, $\overline{B}$ graph suggests that fusion of two light elements gives rise to stable nuclus with emission of energy .

In the higher limit of A it suggests that elements are more stable when they break up.

Problem 1. Calculate density of carbon and lead nuclei.

$M_c = 19.92 \times 10^{-27} kg \quad R_c = 2.7 \times 10^{-15} m$

$M_{pb} = 34 \times 10^{-25} kg \quad R_{pb} = 7 \times 10^{-15} m$

What conclusion you got?

2. Calculate to binding energy of ${}^{4}_{2}He$

$m_n = 1.00865 amu$

$m_H = 1.007825 amu$

$M\left({}^{4}He\right) = 4.002604\, amu$

Fission

Due to increasing role of electrostatis repuesion (presence of more protons) in highest A value $\xrightarrow{get\,into}$ more stable ones on breaking . This is nuclear fission.

Slow neutrons bombared to uranium ${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{30}Kr + 3{}^{1}_{0}n^{+200}$ energy time span is 10^{-17} seconds for neutron capture $10^{-14}\sec s$ time for emission of 3 neutrons.

Fission fragments of unequal mass → assymmetric fission.

Heavier in between 125<A<150

lighter is in between 80<A<110

Maximum probability is 140 and 95.

Problem - Calculate the energy liberated in above reaction.

${}_{92}U^{235} = 235.043\, amu$

${}^{1}_{0}n = 1.0087 amu$

${}_{36}Kr^{92} = 91.8973\, amu$

Liberated neutron can bombard further the uranium . So it is a chain reaction . Give schematic diagram. Uncontrolled chain reaction leads - Bomb. Controlled chain reaction is utilised in requiredment of society.

A little idea of reactor.

Fusion → lighter nuclei merge to form a heavier nucleus but more stable with emission of energy.

2 deutron → Helium

$\Delta m \rightarrow$ 0.02554 amu

energy released → 24 mev

1 kg of uranium and 1 kg of hydrogen.

Where there will be more energy liberated ?

Fusion is not possible in normal condition it needs high temp to reunite two +ve protons by overcoming the repulsive force.

(Idea of magnetic bottling)

Fusion in core of sun .

$\left.\begin{matrix} P-P\,cycle \\ C-N\ cycle \end{matrix}\right\} with\ equations$

Energy source of stars - fusion process

Radio activity

In 1896 Becquerel gave idea about spontaneous emission of radiation . The particle emitted will be treated as tools to probe matter.

Little idea about the history of discovery .

Exposure of photo graphic plate in presence of uranium salt.

The emission of ionising and penetrating radiations from uranium was named as radio activity .

Madame curie → radioactivity in thorium , polonium and radium.

Rutherford established existrence of two components α ray , β ray

P villars gave the idea of γ -ray

Radio active elements used as probing tools.

$\alpha\ ray \xrightarrow{used}$ for discovery of nucleus .

Artificial transmutation →

Production of transuranic elements →

radio isotopes

carbon dating

discovery of neutrino

Different types of radiations can be differentiated by making them to pass throgh a strong electricfield . γ -ray was unaffected.

Properties -

α ray	β ray	γ -ray
+vely charge	-vely charge	no charge like
+2c change	-e	em wave
Mass $= 4\times$ Hydrogen mass	mass=mass of electron	energy high
		$\lambda - less$
deflected by	deflected by	not affected
em field	em field	by em field
Affects photographic plate	same as α ray	same as α ray
causes fluoroscence		
strong ionising power	less power than α	no ionisation
small peretrating power	large penetrating	Strongest penetrating
	power $> \alpha$ particle	power
Small velocity	greater velocity	velocity of light

Soddy's displacement law

Nucleus ejects α particle ${}_zY^A \xrightarrow{\alpha} {}_{z-2}Y^{A-4}$

$\beta\ particle\ {}_zY^A \xrightarrow{\beta} {}_{z+1}Y^{A-4}$

γ rays not affected.

Decay continues until a stable isotope is reached.

$$^{238}Ls \xrightarrow{\alpha} {}^{234}Th\underline{\beta}\ {}^{234}\mathrm{Pr}\,\underline{\beta}\ {}^{234}U\,\frac{\alpha}{206}\,{}^{234}Th \to ....$$

Rutherford and Soddy's Radio activity decay law

1. Distintegration is a random process
2. Rate of decay independent of physical composition and chemical condition.
3. The rate of decay α quantity of material [present at that instant. $-\frac{dN}{dt}\alpha N$

-ve sign suggests number decreasing $\frac{dN}{dt} = -\lambda N$

$\lambda \to$ decay constant

$M \rightarrow No\,e^{-\lambda t}$ Number at t=0

$\lambda \rightarrow$relative no of atoms decaying per second.

$\frac{dN}{N} = -\lambda$ if dt = 1 sec

$\lambda \rightarrow$ reciprocal of time when $\frac{N}{N_0}$ falls to $\frac{1}{e}$

Half life period $T_{1/2}$

Time required to disintegrate half of the amount of the radio active substance initially present .

$$\frac{N}{N_o} = \frac{1}{2} = e^{-\lambda T 1/2}$$

$$T_{1/2} = \frac{\log_2}{\lambda} = \frac{0.6931}{\lambda}$$

$$\lambda = \frac{0.6931}{T\,1/2}$$

any time $t = 3.323 T_{1/2} \log_{10} \frac{N_0}{N_C}$ replacing value of λ interms of $T_{1/2}$

$$N = N_o \left(\frac{1}{2}\right)^n$$

if the decay is observed after n half lives.

$$t = nT\,1/2$$

$$n = \frac{t}{T_{1/2}}$$

$$N = N_o \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$$

Units of Radioactivity (Ci)

1. One curie if it undergoes 3.7×10^{10} disintegration per second
2. Rutherford (Rd) if it undergoes 10^6 disintgration / sec
3. Becquerel if it goes under 1 disintegration / sec

1 curic $= 3.7 \times 10^4$ rutherford.

$= 3.7 \times 10^{10}$ becquerl

Problems - Half life of radium is 1600 years. After how many years 25% of radium remains undecayed $N = \frac{N_0}{4} = N_0 \left(\frac{1}{2}\right)^{\frac{t}{T_{\frac{1}{2}}}}$

$$\frac{t}{T_{1/2}} = 2, \quad t = 2\,T_{1/2}$$

Unit -IX
SEMI CONDUCTOR ELECTRONICS

Structure

Introduction

Objective

1. Solids and semiconductor devices
    i. Energy bonds, classification of solids.
    ii. Semi conductor (types) and characteristics
    iii. Application
    iv. Special purpose junction diodes.
    v. Transistors.
2. Digital electronic
    i. Analog, digital signals
    ii. Logic gates

Introduction

This unit is meant for describing the importance of semiconductor in modern life. The semiconductors have important property like their ability to function as rectifier and amplifier of electrical voltage, current and power . Most of electrical devices need dc current to operate. The semiconductor devices are used to convert line ac current to d.c. so one should have basic knowledge about semiconductor and their applications. Dgital electronic is the basi of computer , mobile and operation of day to day appliances. This unit frames a fundamental picture of basic of digital electronics.

Objectie :- After going through this unit a student should

a. Differentiate between metals (conductors) semiconductors and insulators.
b. Know to construct a pn junction from extrensic semiconductors. After knowning difference between intrinsic and extrinsic semiconductors.
c. Be used to p-n junction , junction diodes and transistors.
d. Know about special type of junction didoes.
e. Be able to use basics of digital electronics.

Conception of energy bonds:-

Starting from single atom energy levels (discrete)

↓

Pauli exclusion principle

↓

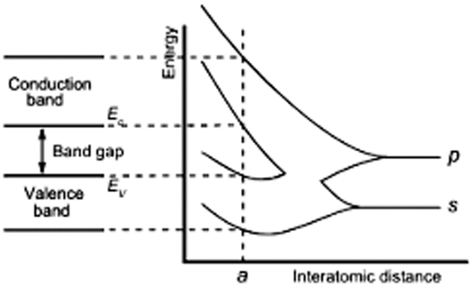
In a solid presence of infinite number of atoms.

↓

Splitting of energy levels due to presence of sorrounding atoms.

↓

outer orbitals overlap



Examples

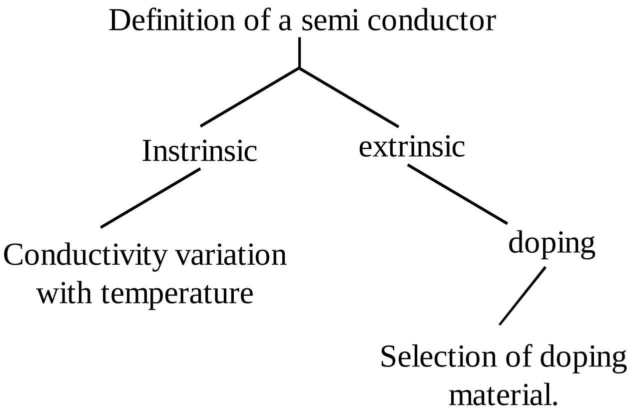
An example of any solid should be explained and how the outer orbits overlap and splitting

↓

reduction of energy gap in comparison to single atom (gap between valence and conduction band).

INSERT DIAGRAM

Differentiation with respect to energy gap



If semiconductor of valence 4 doping to be with material of valancy 3 → p type.
valancy 5 → n type.

Concption of electron moving which consequently gives rise to movement of hole.

No confusion regarding hole it is not a proton rather it is absence of electron, holes are created due to motion of electron.

Student should know that for P.N. junction there is no sandwitching of p type and N type , rather . One semi conductor one side is doped to be p type other side is doped to be n type.

p-n junction → movement of electrons should be clearly taught , potential barrier and idea of depletion region - recombination and space of charge free region

At the sides

Idea of different biasing

↓

V-I, curves

definition of knee voltage voltage at sharp increase of current

↓

reverse saturation current, Current limiting resistance to control current in ammeter.

↓ ↓

constant current in reverse bias Circuit digram of both biasing

↓ reason for less current in reverse bias ↓

Resistance of diode

Static $\frac{V}{I}$

dynamic $\frac{\Delta v}{\Delta I}$

Use as rectifier

Half wave , full wave (centre tap)

Circuit diagram along with input and output wave forms

Expression for efficiency $= \frac{40.6}{1+\frac{rd}{RL}}$ for single diode.

Expression for current

$$I_D = I_s\left[e^{KV_D/T} - 1\right]$$

$K = 11,\ 600/n$

n= 1 for Ge

=2 for silicon at low I_D value

n = 1 for both for high level value

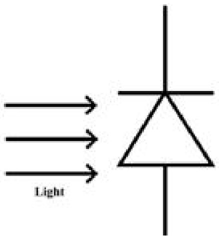
Limitations of diode - it can not amplify

Problem - If for a half wave rectifier dynamic forward resistance 50Ω and load resistance 500Ω find the efficiency ?

Different types of diodes

1. **Photo diode** made up of photo sensitive semiconductor.

Principle → electron get energy from light falling on the junction.



Reverse bias → current increases

with increase in intensity of incident light

Forward bias - current increases

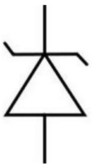
Dark current → current flowing through the diode without light.

Zcener diode → Designed to work in reverse bias condition and in reverse breakdown condition.

↓

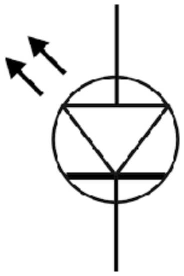
highly doped

symbl and circuit



Principle → Large current change associated with small voltage change in the reverse breakdown region, works as a voltage stabiliser.

LED → In forward bias the energy produced by recombination of electron and holes at the junction emmitted as light . So it is light emmitting diode. Brightness of light (if energy is in visible range) can be controlled by load resistance.



Solar cell

One of P or N is very thin in this type of diode.

light falls → but less absorbed due to diode.

Light energy $\xrightarrow{\text{converted to}}$ electrical energy such diodes are solar cells.

thin region → emitter

thicker one → base

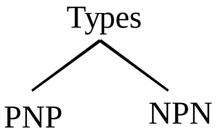
Difference between photo diode and solar cell.

ADD DIAGRAM

When light of suitable frequency is made incident on an open circuited solar cell, an emf is produced across its terminals $\xrightarrow{so}$ photovoltaic effect.

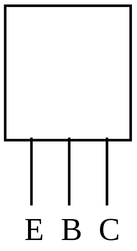
Junction transistor

Transistor → combination of Transfer + Resistor



Symboles of both, idea of emitter , base and collector .

representation of transistor →



→ red dot at side of collector

E → emitter
B → base
C - Collector

Biasing of Junctions -

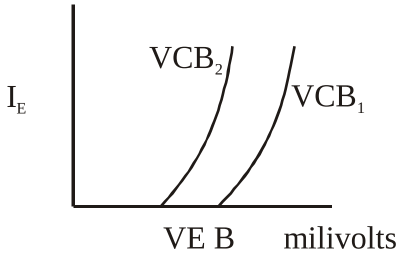
P.N.P → emitter base junction for ward biased collector base junction - reverse biased description of working and movement of holes and electrons in the junction

Circuit diagram

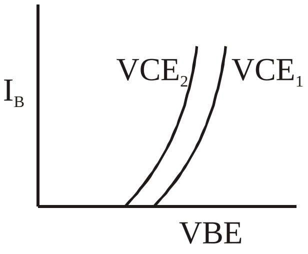
Working in details

NPN → emmitter junction forward biased, collector junction reverse biased . Working and circuit diagram .

$I_E = I_B + I_C$



Common base



Common emmiter

(Input characteristics)

Fror Common collector

Output characteristic resembles that of above input characteristic and vice versa.

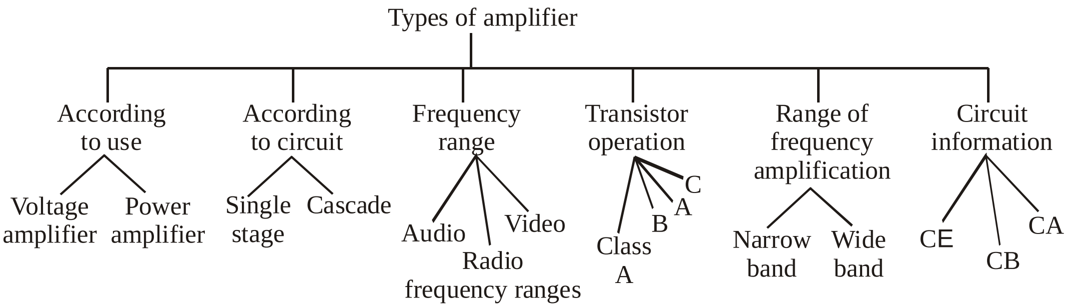
as input V_{CB} reverse biased.

input impedance high.

Output section - for ward bias output impedence low.

Amplifier

Amplification is the process to increase the strength of a weak signal.



Discussion of operation of amplification in CE mode

1) Input inpedance low.

2. $I_E >> I_B$

$I_{in\,put} \times Z_{in\,put}$ = Input signal

$I_C \approx 95\% I_E$

I_B less

Thus input cureent I_B or I_E is treated as controller of I_C

Transistor - current controlled device

Vacuum tube → voltage controlled device

Current amplification factor

$\alpha \rightarrow$ emitter -collector gain factor

$$\alpha = \left(\frac{\Delta I_C}{\Delta I_E}\right) V_{CB} \text{ constant}$$

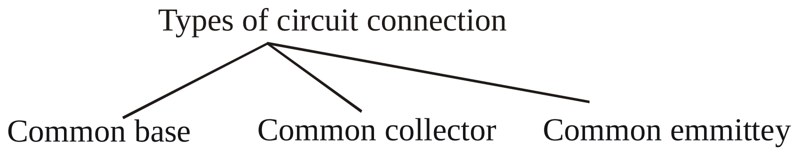
$\alpha \approx 0.95$ to 0.99

Base collector current gain factor

$$\beta = \left[\frac{\Delta I_C}{\Delta I_B}\right] V_{CE} \text{ constant}$$

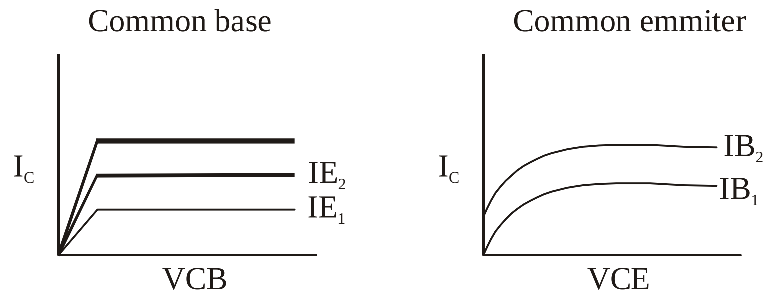
Proof of $\beta = \dfrac{\alpha}{1-\alpha}$

$$\alpha = \frac{\beta}{1+\beta}$$



Circuit diagrams in each case

The output and input characterstic curves for each arrangement .



Output characteristics

Z output >> Z input

but $I_C \approx I_E$

So V_{out} is more than V_{in}

Circuit diagram for C.E amplifier .

plot of input and output voltage waveform plot of $I_C \propto V_{CE}$ at different I_B .

Voltage gain (example)

If $\alpha = 0.99$

$\beta = \dfrac{\alpha}{1-\alpha} = 99$. If $Zi = 2000\Omega$

$R_L = 10000\Omega$

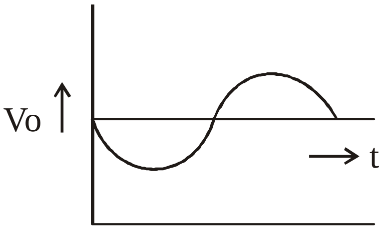
$$\text{Voltage gain} = \frac{V_{out}}{V_{in}} = \frac{I_C R_L}{I_b R_{in}}$$

$$= \beta \frac{R_L}{R_{in}} = 495$$

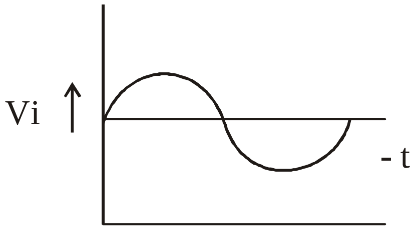
$$\text{Power gain} = \frac{I_C^2 \ R_L}{I_\beta^2 \ R_{in}} = \beta^2 \frac{R_L}{R_{in}} = 49{,}005$$

CE transistor has higher power gain

Phase of output signal is opposite to the phase of input signal.



Out put



In put

Digital electronics

Definition and Difference between Analog and digital

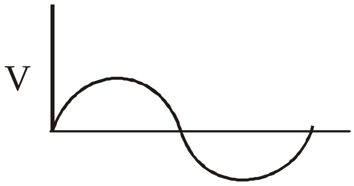
Analog - What we see and can measure height , width , age ...

Amplifiers are analog as they measure amplification factor. These applications do not have their own discriminating power . But certain applications require logical decission (example traffic light when to be red, when to be yellow and when to be blue, based on certain in put condition . Such circuits are digital circuits . gate is a digital circuit that follows certain logical relationship between input and output. Voltage and are called logical gates

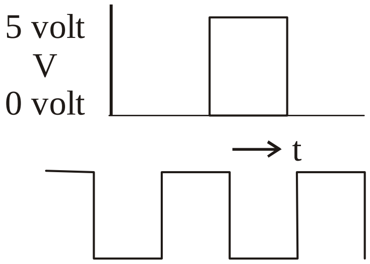
Gate → building block of logical circuits.

Analog → signals are continuous

digital → signal are dis crete, off or on, high or low.



analog



Digital

High or on → logic → 1

low or off → logic → 0

only two values 0, 1 → of the voltage permissible.

Little idea (refreshing) of binary algebra and conversions.

Boolean operations → which gives relation between output and input variables.

Different gates

1. Circuit diagram
2. Truth table
3. Symbols
4. Pratical applications
5. Realisation of gates.

Combination of gates.

Why Nand gate is a universal gate?

ASSIGNMENT

1. Determine the value of β when $\alpha = 0.95$.
2. In CE transistor $I_B = 50\mu A$, $\beta = 100$ calculate I_E
3. In a centre tap rectifier if $rd = 50\Omega$, $R_L = 500\Omega$ then what will be the efficiency ?
4. What is the type of bias used in zener diode?
5. Explain working of PN junction diode.
6. Explain depletion layer.
7. What is break down voltage?
8. Draw input and output characterstic curves for common emitter transistor.

UNIT - X
COMMUNICATION SYSTEM

Communication is transfer of information from one to other.

Communication deals with

↓ Transmission

↓ needs a channel or medium

↓ reception.

Example Sound transmission, oral conversation

vocal chord/lip / tongue ⟶ transmitts sound

air — channel.

ear — receiver.

This chapter deals with communication system where the information is inform of electrical current or voltage.

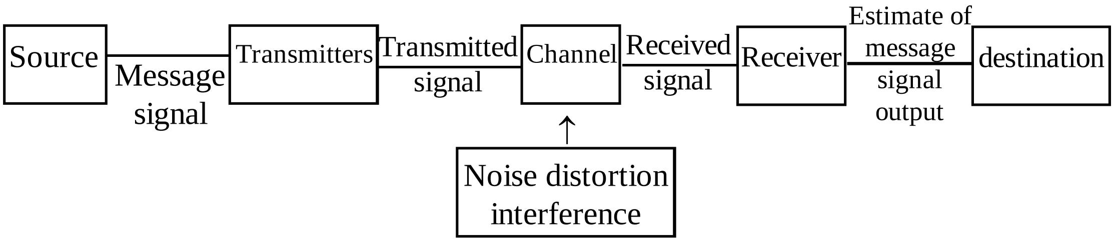
Example :- microphone converts speech ⟶ electrical signal

$$\text{Transducers}\begin{cases}\text{pie z. electric sensors} \rightarrow \text{pressure} \rightarrow \text{signal} \\ \text{Photo det ectors} \longrightarrow \text{light signal}\end{cases}$$

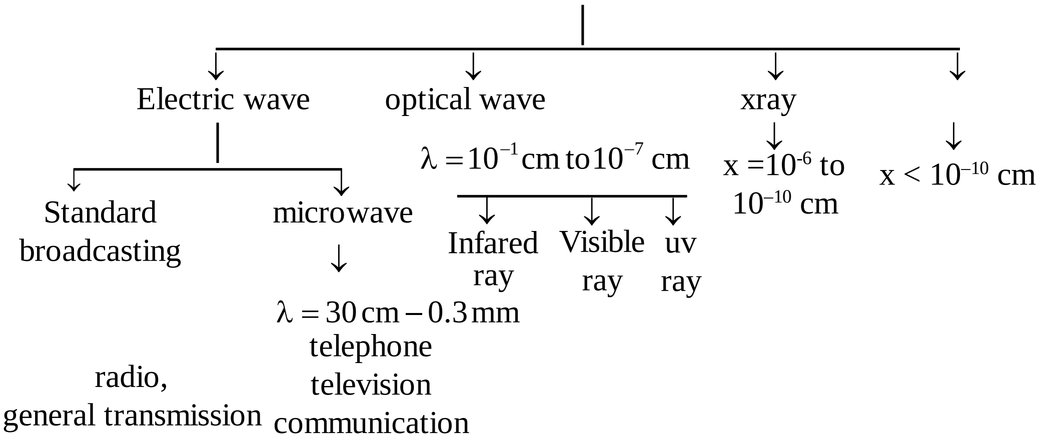
Signal contains information — defined as single valued function of time and it has a unique value at every instant of time

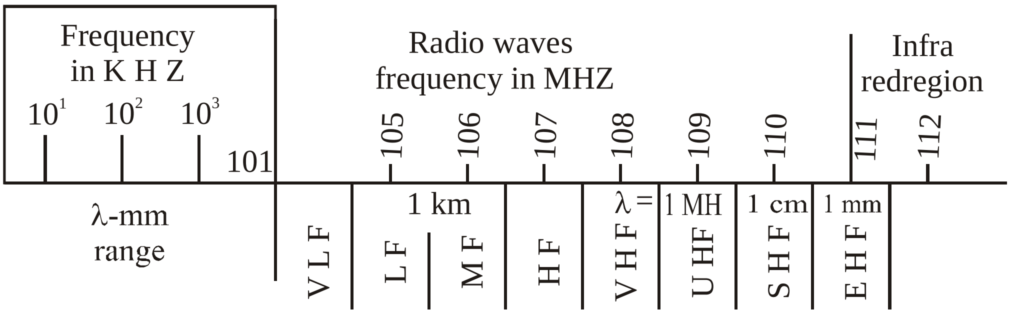
Transducer → device which converts information to electrical signals.

Block diagram



Idea about complete electromagnetic spectrum of transmission



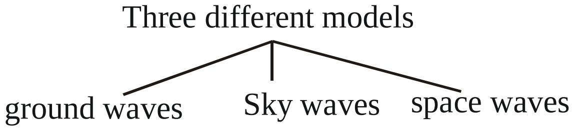


Band names should be explained

Idea about earth's atmosphere →

(1) Idea of Tropo, stato, Meso and Iono spheres.

(2) Propagation of radio waves.



HF waves → space waves → travel in troposphere.

Frequency < H F waves travel around earths curvature → ground waves.

All broad cast radio signals received in day time propagate by surface waves.

Waves in H F range reflected by the ionised layers – are – sky waves

$ELF \rightarrow f < \quad 3KHZ \qquad \lambda > 100\,km$

(extremely low frequency)

V L F $\qquad$ f = 3 – 30 Hz $\qquad \lambda = 10 - 100\,km$

(very low frequency)

Low frequency

L F $\qquad f = 30 - 300\,KHz \qquad \lambda \rightarrow 1 - 10\,km$

Medium frequency

M F $\qquad f = 300\,KHz - 3MHz \qquad \lambda 100\,km - 1km$

High frequency $\qquad f = 3 - 30\,MHz \qquad \lambda - 10 - 100\,m$

H F

V H F

(very H F)

$f - 30 - 300\,MHz \qquad \lambda 1 \rightarrow 10m$

Ultra H F $\qquad f = 300\,MHz - 2GHz \qquad \lambda = 10cm - 1meter$

superhigh frequency $\qquad f = 3 - 30\,GHz \qquad \lambda = 1 - 10\,cm$

S H F

Extremely high frequency $\qquad f = 30 - 300\,GHz \qquad \lambda = 1mm - 1cm$

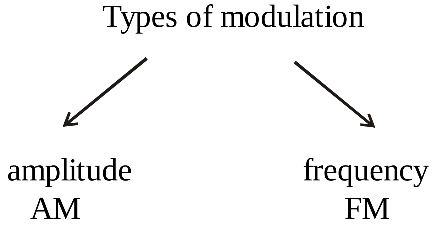
E H F

(frequency bands of radiowave communication)

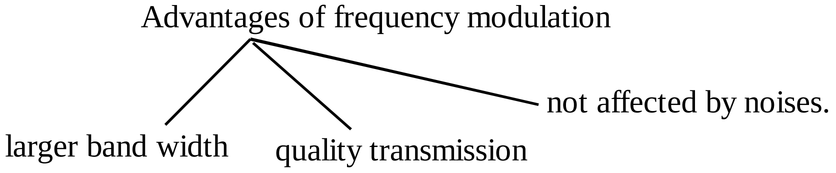
Description of wave propagation in different spheres of atmospheres of earth.

Modulation

The process of changing the characteristics of signal by carier wave is called modulation



Necessity of modulation. Definition of both type of modulation.



$$\text{FM radio} \longrightarrow \begin{matrix}\text{frequency band}\\ 88-108\,\text{z}\end{matrix}$$

$$\text{TV} \longrightarrow \begin{matrix}47-230\,\text{MHz (VHF)}\\ 470-960\,\text{MHz}\left(\text{UHF}\right)\end{matrix}$$

Little idea of modems and its reference to computer.

↓

Modem (Modulation and demodulation)

(Block diagram)

↓

Mobile telephone

Mobile telephone service is V H F radio system linked to the public switched telephone net work.

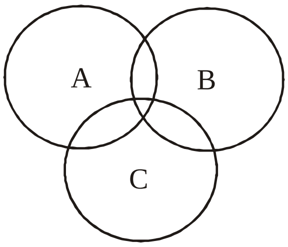
Qualitative discussion about internet.

GPS

GPS is a net work of 30 satellities orbiting around earth at an height of 20000 k m. Where ever one may be on planet at least four satellities are visible at any time. Each one transmitor information about its position and current time at regular intervals. These signals are intercepted by GPS receiver, which calculates the distance of each satellite basing on the time to receive and the message to arrive. If distance of at least three satellites are known then the position is pin pointed by GPS receiver. This process is

Trilaternation

Meeting point of three satellite is the position.



There is synchronisation of clock of sattellites with ground clock. If there is error then there will be error in knowing the position.