INTERMEDIATE STAGE FUNDAMENTAL OF PHYSICS

BOOK ONE

FOR CLASS XI

For

Sindh Textbook Board, Jamshoro.

CONTENTS

Chapter 1

THE SCOPE OF PHYSICS

DEFINITION OF PHYSICS:

Physics is the branch of science that deals with the study of Properties of matter, Energy and their mutual interactions.

HISTORY OF PHYSICS:

- The people of Euphrates and Tigris valley were aware of calendar and they had the knowledge of geometry.
- The people of Indus valley were pioneers of decimal system.
- The Greeks are accepted as pioneers of physics as a systematic knowledge.
- Chinese were first to make papytue (paper).

The glorious Islamic era was between the eight to thirteenth century AD
The achievements of well known scientists of splendid age are:

IBN-UL-HAISHAM:

- Discover the nature of light, declared it as a form of light.
- Presented two laws of reflection of light.
- Constructed a pin hole camera.
- Gave description of luminous, non luminous, opaque and transparent object.
- The remarkable discovery was "**The ray of light passing through a medium takes a path which takes the least time to transverse**". This principle is called as Fermate principle of least time.
- The first comprehensive book on light was his book "**Kitab-ul-Manazir**".

AL-BERUNI:

- Gave the conclusion that speed of light is greater as compare to the sound.
- His book "**Kitab-ul-Masoodi**" is considered as encyclopedia of astronomy.
- He was the first who calculated the diameter of earth.

AL-KHAWARZINI:

- Was the founder of algebra and wrote first book in the world on Algebra known as "**Hisabul-jabr-wal-Muqabla**"
- He gave geometrical solution of linear and quardratic equations.
- He invented "**Monograph**" named **"Hisab"** in which he introduced the method of counting based on numerals.
- Invented the term "**logarithm**".

YAQOOB-AL-KINDI:

- The first Arab philosopher.
- Wrote research monograph on "**Metrology**", "**specific gravity**" and "**Tides**".

- Explained the appearance of blue color on the sky.

AL-RAZI:

- The prominent and best physician about 200 original monographs, most of them pertained to medicine.

IBN-E-SINA:

- Discovered use of catheters.
- Gave intravenous injections by means of silver syringe.
- "**Al-Qanoon-Fil-tib**" is famous book of medicine.
- **"Al-shifa**" an encyclopedia of philosophy.

UMAR KHAYYAM:

- He was one of the well-known mathematicians.
- He was an outstanding poet of Islamic world.

AL-BATTANI:

Made calculations in connection with solar system change in seasons, eclipses of moon and sun and other astronomical phenomenon.

BRANCHES OF PHYSICS:

The main branches of Physics are as under
i) Particle Physics
ii) Nuclear Physics
iii) Molecular and Atomic Physics
iv) Plasma Physics
v) Astro Physics
vi) Medical Physics
vii) Solid state Physics

UNITS AND MEASURMENTS:

Physics is a quantitative science concerned with relations between careful measurements of well defined physical quantities.
The basic quantities are mass length time electric current temperature amount of substance and luminous intensity.

MEASURMENTS:

The comparison of unknown quantity with some standard quantity is called comparison.

UNITS:

The standard with which the things are compared is called Unit.

Measurement has basic importance in our daily life. We cannot buy or sale any thing until and unless we measure it and for measurement a common standard is needed, that is called Unit.

SYSTEM OF UNITS:

There are four systems of units
Centimeter- Gram- Second (C.G.S)
Foot-Pound-Second (F.P.S)
Meter-Kilogram-Second (M.K.S)

FUNDAMENTAL UNITS:

The units used to measure the basic or fundamental quantities are called fundamental units.
International system (S.I) of units was implemented to overcome the difficulties of large numbers of multiple and submultiples units and due to large conversion of factors.

This system is called as MKSA (Meter-Kilogram-Second-Ampere) system
The table for the fundamental units is given below.

Physical Quantities	**S.I units**	**Abbreviation**
Length	Meter	M
Mass	Kilogram	Kg
Time	Second	Sec
Temperature	Kelvin	K
Current	Ampere	A
Luminous intensity	Candela	Cd
Amount of substance	Mole	Mol

DERIVED UNITS:

The units which are obtained with the help of two or more fundamental or basic units are called as derived units.

Physical Quantity	Unit	Symbol	In terms of base units
Force	Newton	N	Kg ms-2
Work	Joule	J	Nm=kg m2 s -2
Power	Watt	W	Js-1=kg m2 s-3
Electric charge	Coulomb	C	As
Potential Difference	Volt	V	J A-1 s -1
Pressure	Pascal	Pa	N m2= kgm-1 s-2

SUPPLEMANTARY UNITS:

The units which are simple but can be derived from the combinations of other units are called as supplementary units.

RADIAN:

The angle formed at the center of the circle equal to the radius of the circle.
The S.I unit of the plane angle is called as radian.

DIMENSION AND SEGNIFICANT FIGURES:

Dimension is the power to which a fundamental quantity is raised.

Dimensional formula is an expression which tells the involvement of the fundamental units in a physical quantity. In general for a physical quantity a dimension in mass, b in length and c in time then
X= M^a * L^b * T^c

- Principle of homogeneity of dimensional equation is states that the dimensions on both sides of the equation must be equal.
- Dimensional equation is used for the following reasons
  - To check the correctness of physical relation.
  - To convert one system of units into another.
  - To derive various physical relations.
- Dimension less numbers: these numbers are power number like 1,2,3,………pie
- Significant figures are reliable digits known with certainty in a given number.
- The number of significant figure refers to the precision and accuracy of measured quantity, in this numbers the last digit may not be precisely mentioned, the value of last digit is uncertain.
- Rules for determining significant figures.
  - All non zeros are significant. E.g. 789 has 3 significant figures
  - Zero between non significant digits are significant. e.g. 4002 has 4 significant figures
  - Zero locating the decimal point in number, less than 1 is not significant. E.g. 0.065 has 2 significant figures
  - Final zeros to the right of the decimal point are significant. E.g. 4.000 have 4 significant figures.
  - Zeros that locate the decimal point in numbers larger than one are not necessarily significant. e.g. 40 have one significant figure.

Chapter 2

SCALARS AND VECTORS

In every life we deals with some physical quantities, such as time temperature, mass and electric charge, can be described completely by a single number with a unit. But many others important quantities have direction associated with them and can not be described by a single number. When a physical quantity is described by a number, called Scalar in contrast it is called Vectors.
In this chapter we explore some of the properties and uses of vectors and we introduce the Mathematical operations that involve vectors.

SCALAR:

The Physical quantities which are completely specified by its magnitude are called as Scalars.

Examples:

The examples of scalars are; power; temperature; electrical, resistance, electric current and Energy. Scalar quantities are added, subtracted, multiplied, and divided by ordinary arithmetic.

VECTOR:

Those physical quantities which are specified by a magnitude as well as direction are called as Vectors.

Examples:

The examples of vectors are; Displacement, velocity, acceleration, force, momentum and torque etc. the addition, subtraction and multiplication of vectors have their own algebra different from scalars.

RECTANGULAR COORDINATE SYSTEM AND VECTORS REPRESENTATION:

The reference system consists of two mutually perpendicular reference lines X'X, Y'Y, and called as rectangular coordinate system.
The one of the lines is named as x-axis and other is y-axis. The direction of a vector is specified with respect to a certain reference direction, i.e. denoted by teetha (angle) in the x y -plane.
Angle teetha is considered positive in anti-clockwise sense and negative, in the clockwise sense from x-axis. Along the x-axis, teetha= 0o, called Cartesian or Rectangular coordinate system.

VECTOR REPRESENTATION:

Symbolic:

Vectors can be represented symbolically by a letter with an arrowhead above or below with bold face letters. I.e. A, A, A.
Vectors have different properties from scalar quantities; the arrow is reminded that vectors have direction.
The magnitude of a vector is denoted by |A| (A modulus) or A with no arrow.
While, the direction by A^ read as "A hat". Magnitude of A = |A| = A
Direction of A = A^ (A hat)
Thus

A = |A| A^ or A = A A^

GRAPHICAL REPRESENTATION:

A vector is represented graphically by a directed line segment with an arrow head. The length of the line segment represents the magnitude of the vector which is chosen according to scale. While arrowhead on the line represents its direction of that given vector.

VECTOR MULTIPLIED BY A SCALAR (NUMBER):

When a vector A is multiplied by a scalar or number n, then the magnitude of the product becomes n^. The direction of the product vector remains the same if n is positive i.e. n>0 and reversed if n is negative i.e. n<0.
If the n=0, then the resultant vector becomes Null vector, having zero magnitude.

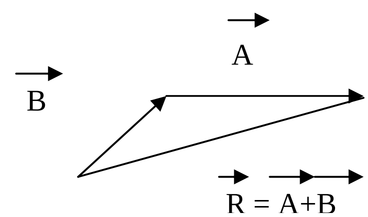
ADDITION OF VECTORS:

Vectors can be added by graphical and geometrical method.
Addition of vectors means to get a single vector by adding two or more vectors.
The single vector obtained by the addition of the two or more vectors is called as resultant vector.
For example

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

SUBTRACTION OF VECTORS:

The subtraction of vector B from A means the addition of (-B) to a called Vector subtraction."
R = A – B
R = A + (-B)
Note that in vector subtraction the order is not important.



HEAD TO TAIL RULE:

Head to tail rule states that
Two or more than two vectors can be added to form resultant vectors. The sum or resultant of two vectors A and B is a vector R which is obtained by placing the tail of B on the head of A and then joining the tail of A to the head of B. the sum is defined by

$\vec{R} = \vec{A} + \vec{B}$.

PARALLELOGRAM LAW OF VECTOR:

This law states that
If two vectors initiate from a same point then we consider them two adjacent sides of parallelogram. Then complete the parallelogram and their diagonals will be resultant vector.

LAW OF COSINE:

Magnitude of resultant can be obtain by

$$\sqrt{A^2 + B^2 + 2AB\cos\ \theta}$$

Where A and B are the vectors and θ is the angle between them.
If the angle between two vectors is 0 degree their resultant will be maximum.
If the angle between two vectors is 180 degree their resultant will be minimum.

TYPES OF VECTOR:

There are following types of vector

1. **Unit vector:** The vector whose magnitude is unit or 1 is called as unit vector.
2. **Free vector:** a vector that is displaced parallel to itself is called as free vector.
3. **Position vector:** The vector that specifies the position of a 2^{nd} point with respect to the origin of first point is called as position vector.
4. **Null vector:** When a vector has a zero magnitude and no particular direction then this type of vector is called as null vector or zero vectors.

PROPERTIES OF VECTOR ADDITION:

There are two laws of vector addition.

Commutative law of vector addition:

According to this law
Two vectors initiate from a same point, we consider them two adjacent sides of parallelogram. Then complete the parallelogram and their diagonals will be resultant vector.

Associative law of vector:

This law based on head to tail rule of addition. According to this law.
Two or more than two vectors can be added to form resultant vectors. The sum or resultant of two vectors A and B is a vector R which is obtained by placing the tail of B on the head of A and then joining the tail of A to the head of B.

RESOLUTION AND COMPOSITION OF RECTANGULAR COMPONENT:

The process of replacing one vector by two or more than two vectors in called as Resolution of vectors.

If the components of a vector are mutually perpendicular, then they are called as Rectangular components of the original vector.

ADDITION OF A VECTOR BY RECTANGULAR COMPONENT:

The addition of vectors by rectangular components method is more suitable as compared to head to tail rule because it provide less chances of error.

Now consider two vectors A and B we are required to add by rectangular components method.

$$\vec{R} = \vec{A} + \vec{B} --------- eq1$$

Where R is a resultant vector, makes an angle θ with x –axis.
If two vectors A + B are equal, then they must have the same magnitude as well as same direction. Hence we come to the conclusion that

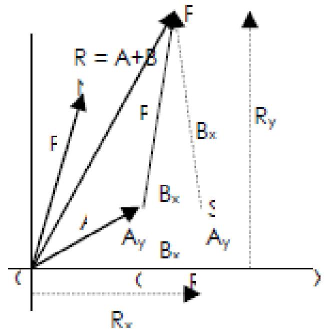
The two vectors are equal to each other only if their corresponding components are equal."
So it is evident from the given figure that the sum of x – component of A and B are related to the components of R as;

$$\overrightarrow{Rx} = \overrightarrow{Ax} + \overrightarrow{Bx}$$

$$\overrightarrow{Rx} = \overrightarrow{Axi} + \overrightarrow{Bxi}$$

$$\overrightarrow{Rx} = (\overrightarrow{Ax} + \overrightarrow{Bx})i --------eqII$$

Similarly, the sum of the magnitude of their y – components is equal to the y – Component of the resultant is;



$$\overrightarrow{Ry} = \overrightarrow{Ay} + \overrightarrow{By}$$

$$\overrightarrow{Ry} = \overrightarrow{Ayi} + \overrightarrow{Byi}$$

$$\overrightarrow{Ry} = (\overrightarrow{Ay} + \overrightarrow{By})i --------eqIII$$

Rx and Ry are the rectangular components of R. hence

$$\vec{R} = \overrightarrow{Rx} + \overrightarrow{Ry}$$

$$\vec{R} = (\overrightarrow{Ax} + \overrightarrow{Bx})i + (\overrightarrow{Ay} + \overrightarrow{By})j$$

The magnitude of resultant vector is;

$$R = \sqrt{Rx^2 + Ry^2}$$

$$R = \sqrt{(\overrightarrow{Ax} + \overrightarrow{Bx})^2 + (\overrightarrow{Ay} + \overrightarrow{By})^2}$$

The direction θ of the resultant is;

$$Tan\theta = Ry / \mathrm{Rx}$$

$$\theta = Tan^{-1}(\mathrm{Ry/\,Rx})$$

$$\mathrm{Tan}\,\theta = Ay + By / Ax + Bx$$

$$Tan^{-1}(\mathrm{Ay+By/\,Ax+Bx})$$

Similarly for any number of coplanar vectors A, B, C…,.
Then the magnitude and direction of the resultant vector R is;

$$\mathrm{R} = \sqrt{(\mathrm{Ax+Bx+Cx+.....})^2 + (\mathrm{A}\,y + \mathrm{B}\,y + \mathrm{C}\,y + ...)^2}$$

And

$$Tan\theta = ((\mathrm{A}\,y + \mathrm{B}\,y + \mathrm{C}\,y + ...) / (\mathrm{Ax+Bx+Cx+.....})$$

STEPS FOR VECTOR ADDITION BY RECTANGULAR COMPONENTS:

The vector addition by rectangular components consists of the following steps.
(i) Draw the axes and vectors which are required to be added.
(ii) Find x and y-components of the given vectors.

(iii) Find the x-component of R i.e. Rx.
(iv) Find the y-component Ry of the resultant.
(v) Using the formula to find the resultant magnitude of R.

THE DOT PRODUCT OR SCALAR PRODUCT:

When two vectors are multiplied together and their resultant vector is the scalar quantity then the product is called as dot product or scalar product.
The dot product of two vectors will be

$\vec{A} \,.\vec{B} \;= AB\cos\theta$

Where θ is the angle between A and B.

COMMUTATIVE LAW FOR DOT PRODUCT:

Commutative law states that if the order of multiplied vector changed then this will not change the result. For example
A . B = B . A

DITRIBUTIVE LAW FOR DOT PRODUCT:

Consider three vectors A B and C
To prove: $\vec{A} \,.\, \left(\vec{B} \,+\, \vec{C}\right) \;=\; \vec{A} \,.\, \vec{B} \,+\, \vec{A} \,.\, \vec{C}$

B(A) = Projection of B on A
C(A) = Projection of C on A
(B + C)A = Projection of (B + C) on A
Therefore
A . (B + C) = A [(B + C}A] {since A . B = A B(A)}
= A [B(A) + C(A)] {since (B + C)A = B(A) + C(A)}
= A B(A) + A C(A)
= A . B + A . C
Therefore,
B(A) = B cos θ => A B(A) = A B cos θ = A . B
And C(A) = C cos θ => A C(A) = A C cos θ = A . C
Combining both relations.

$\vec{A} \,.\, \left(\vec{B} \,+\, \vec{C}\right) \;=\; \vec{A} \,.\, \vec{B} \,+\, \vec{A} \,.\, \vec{C}$

Thus dot product obeys distributive law.

THE CROSS PRODUCT:

When two products get multiplied by each other and their result is another vector than is called as a vector product or a cross product.

$\overline{A} X \overline{B} = AB\sin\;\theta$

CHARACTERISTICS OF SCALAR PRODUCT:

(i) **COMMUTATIVE PROPERTY:**

Scalar product is the simplest product of two vectors. The order of multiplication does
not effect the product. i.e.
A . B = AB cos teetha
B . A = BA cos teetha
Since A, B and cos teetha are real numbers and they commute therefore,

A . B = B . A
Which means that the scalar product obeys the commutative Law.

(ii) **DISTRIBUTIVE PROPERTY:**

If A, B and C are the three vectors, then the scalar product is distributive by addition. i.e.

A . (B + C) = A . B + A . C
PROOF:-
Let B + C = R
Now
A . R = AR cos teetha
A . R = A (OP) .: Rcos teetha = OP
A . R = A (OQ + QP) .: OP = OQ + QP
A . R = A (OQ) + A (QP)
A . R = ABcos teetha 1 + AC cos teetha^2
A . (B + C) = A . B + A . C

(iii) **ASSOCIATIVE PROPERTY:**

Scalar product is associative. If we interchange the numbers in dot product the result will remains the same.

nA. mB = nm A . B
=> nA .mB = A . nmB
=> nA .mB = mA . nB
Where n and m are numbers.

PROPERTIES OF VECTOR PRODUCT:

$\overline{A} X \overline{B} = AB\sin \ \theta$

$\vec{A} x \vec{B} = -(\vec{A} x \vec{B})$

$\vec{A} x (\vec{B} + \vec{C}) = (\vec{A} x \vec{B}) + (\vec{A} x \vec{C})$

$(\vec{A} + \vec{B}) \mathrm{X} \vec{C} = (\vec{A} x \vec{B}) + (\vec{A} x \vec{C})$

If $\vec{A} \neq 0, \vec{B} \neq 0$ and $(\vec{A} x \vec{B}) = 0$

Then $(\vec{A} x \vec{B})$ are parallel.

$i * i = 0$

$j * j = 0$

$k * k = 0$

$i * j = k$

$j * k = i$

$k * i = j$

$i * j = -j * i = k$

$j * k = -k * j = i$

$k * i = -i * k = j$

If $\vec{A} = A_1 i + A_2 j + A_3 k$

$\vec{B} = B_1 i + B_2 j + B_3 k$

The cross product of vector will be

$$\vec{A} x \vec{B} = \begin{pmatrix} i & j & k \\ A_1 & A_2 & A_3 \\ B_1 & B_2 & B_3 \end{pmatrix}$$

Chapter 3

MOTION

MOTION:

An object is said to be in motion if it changes its position with respect to its surrounding.
For example:
motion of car, flying birds.

DISPLACEMENT:

The minimum distance between the initial and final point is called as displacement.
OR
The shortest distance between two points is called as displacement.

S.I UNIT:

Meter (m)

VELOCITY:

The change in its position in a unit time or 1 second is called as velocity.
FORMULA:

Velocity = distance/time
V= S/t

S.I UNIT:

Meter/second (m/sec)

AVERAGE VELOCITY:

The average of two or more than two velocities is called as average velocity.

FORMULA:

V= V1+V2+V3/3

INSTANTANEOUS VELOCITY:

The velocity of an object at a particular instant of time is called as instantaneous velocity.

ACCELERATION:

The change in velocity in a unit time or 1 second is called as acceleration.

FORMULA:

Acceleration=velocity/time
A = v/t

S.I UNIT:

Meter/second (m/sec)

UNIFORM ACCELERATION:

When the velocity of a body changes at equal interval of time it is called as uniform acceleration.

AVERAGE ACCELERATION:

The average of two or more than two accelerations is called as average acceleration.

FORMULA:

A= A1+A2+A3/3

INSTANTANEOUS ACCELERATION:

The acceleration of an object at a particular instant of time is called as instantaneous velocity.

EQUATIONS OF UNIFORMLY ACCELERATED RECTILINEAR MOTION:

There are three equations of linear motion.

$$v_f = vi + at$$

$$S = vit + 1/2at^2$$

$$v_f^2 = vi^2 + 2aS$$

These are three equations for motion under gravity.

$$v_f = vi + gt$$

$$h = vit + 1/2gt^2$$

$$v_f^2 = vi^2 + 2gh$$

NEWTON'S LAW OF MOTION:

FIRST LAW OF MOTION:

First law of motion states that,
A body remains in rest or continue to move until or unless an external force acted upon it.
It is also called as law of inertia. Because a body can maintain its state of rest or uniform motion due to its principle feature inertia.

INERTIA:

The state maintaining property of a body is called as inertia.

2^{nd} LAW OF MOTION:

Second law of motion states that,
When an unbalanced force is applied on a body some acceleration will produce it will cover some distance which is directionally proportional to the applied force and it will produce an acceleration in the direction of motion.

First consider that the force is directly proportional to the mass and acceleration.

$$F \propto m - - - - - - - eqi$$
$$F \propto a - - - - - - - eqii$$

By combining relation i and ii

$$F \propto ma$$
$$F = kma - - - - - - k = 1$$
$$F = ma$$

THIRD LAW OF MOTION:

Third law of motion states that,
Every action having an equal reaction but opposite in direction.
For example:

- Walking on ground.
- Launching of rocket.

MOTION OF BODIES CONNECTED BY STRING:

CASE 1

EXPLANATION:

Consider two bodies of unequal masses m1 and m2 connected by a string which passes through a frictionless pulley.
Let m1 is greater than m2. Body A has greatest mass than body B.
First consider the motion of body A. There are two forces acting on it

1. Weight on the body acting downward w=mg
2. Tension on the string.

We have the equation of motion for the body A.
m1g - T=m1a------- eq1
Now consider the body B. here forces will act on the body B
The tension of string acting upward and the weight acting vertically downward.
So the relation become
T- m2g = m2a-----eqII

By adding both equations
m1a+m2a = m1g – m2g

a = (m1-m2/m1+m2)g

Now tension in the string can be calculated as
M1g – T/T-m2g = m1/m2
Now we will cross multiply
M1m2g – m2T = m1T – m1m2g
Or T (m1+m2) = 2m1m2g

T= (2m1m2/m1+m2)g

CASE II

When one body moves vertically and the other moves on a smooth horizontal surface.

Consider two bodies A and B of masses m1 and m2 respectively. This passes through a frictionless pulley. The body A is hanging over a string with acceleration a. and body B moves on the horizontal surface with the same acceleration.

From the above relation
m1g - T=m1a------- eq1
Now consider the body B. here forces will act on the body B
The tension of string acting horizontally toward pulley.
The weight acting vertically downward.
The reaction R of the smooth horizontal surface on the body which acts vertically upward.

So the relation become
T = m2a-----eqII
To obtaining the value of a
M1g – T = m1a

T= m2a/m1g= (m1a +m2a)
Or (m1+m2)a = m1g
Therefore
A = (m1/m1+m2)g
Putting this value of a in eq II
T = (m1*m2/m1+m2)g

MOMENTUM OF A BODY:

The quantity of motion is called as momentum.
OR
The product of mass and velocity is called as momentum.

UNITS OF MOMENTUM:

Momentum = mass * velocity
= kg*meter /sec
We get,
Momentum = kg *meter/second* second/ second
= kilogram * (meter/(seconds)2)* second
= kilogram * (meter/(seconds)2) = 1 newton
Momentum = newton-second

ISOLATED SYSTEM:

A thermodynamic system which is completely enclosed by walls through which can pass neither matter nor energy, though they can move around inside it.

LAW OF CONSERVATION OF MOMENTUM:

Law of conservation of mass states that,
When there is no external force acting on a system then the total momentum of the system remains constant.

EXPLANATION:
Consider the isolated system. Let the system consist of two objects A and B of masses m1 and m2 with velocities U1 and U2 respectively before collision. After collision there velocities become v1 and v2 respectively.

Total momentum before collision is
$M_1u_1 + m_2u_2$
Total momentum after collision is
$M_1v_1 + m_2v_2$
When two bodies collide with each other at time interval.

$m_2v_2 - m_2U_2/t$
average force acting on body
$m_1v_1 - m_1U_1/t$
as both the forces are opposite the relation become

$m_2v_2 - m_2u_2/t = -m_1v_1 - m_1u_1/t$
or $(m_2v_2 - m_2u_2) = -(m_1v_1 - m_1U_1)$
$m_2V_2 - m_2U_2 = m_1v_1 + m_1u_1$

$$\mathbf{m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2}$$
this is the relation for law of conservation of mass.

FRICTION:

The opposing force produce during the motion is called as friction.
When a liquid or gas flow this type of friction is called as viscosity.

COEFFICIENT OF FRICTION:

The ratio of limiting friction to the normal reaction acting between two surfaces in contact is called the coefficient of friction and usually denoted by μ.
$\mu = F/R$

Chapter 4

MOTION IN TWO DIMENTSION

TWO DIMENSION MOTION:

The motion along two co-ordinate axis that's x axis and y axis is called as two dimensional motions.

PROJECTILE MOTION:

When an object having any initial velocity and moving under the force of gravity that makes any angle along the horizontal component is called as projectile motion.

Assumptions for projectile motion:

- The acceleration due to gravity is constant over the range of motion and is directed downward.
- The affect of air resistance is negligible
- The rotation of earth does not affect the motion.

MOTIONS ALONG X AXIS AND Y AXIS:

MOTION ALONG X-AXIS	MOTION ALONG Y-AXIS
Acceleration a = 0	Ay = -g
Velocity v = 0	Vy= vay – gt
Displacement x = vax t	Y = vay – ½ gt2

MAXIMUM HEIGHT OF THE PROJECTILE:

The maximum height of a projectile when the vertical component of the velocity become

$v_{y=v_0 \sin\theta - gt = 0}$

Suppose t=T will be the time when the vertical component of a velocity reduced to zero

Substituting $\begin{matrix} v_y = 0 \\ t = T \end{matrix}$ in above equation

T= $\frac{v_0 y}{g}$

When T is the half of the total time

h= $v_0 yT - \frac{1}{2} gT^2$

Substituting for T

$$h = v_0 y(\frac{v_0 y}{g}) - \frac{1}{2} g(\frac{v_0 y}{g})^2$$

$$h = \frac{(v_0 y)^2}{g} - \frac{1}{2}\frac{(v_0 y)^2}{g}$$

$$h = \frac{1}{2g}(v_0 y)^2$$

Substituting for $v_0 y$

$$h = \frac{1}{2g} v_0{}^2 \sin^2 \theta$$

RANGE OF THE PROJECTILE:

The horizontal distance from origin (x=0,y=0) to the point where the projectile returns (X=R,Y=0) is called the range of the projectile and is represented by R. X=R; where t = 2T

$$x = v_{0x} t$$

$$R = 2v_{0x} T$$

Substituting for T $= \frac{v_0 y}{g}$, we get

$$R = \frac{2}{g} v_{0x} * v_{0y}$$

Substituting for v_{0x} and v_{0y} from equation

$$R = \frac{2}{g} v_{0x} * v_{0y}$$

$$R = \frac{2v_{0x}{}^2}{g} \sin\theta \cos\theta$$

$$2\sin\theta\cos\theta = \sin 2\theta 0$$

$$R = \frac{\theta^2}{g} \sin 2\theta$$

THE MAXIMUM RANGE:

$$R_{\max} = \frac{v_0{}^2}{g}; at\theta = 45^\circ$$

PROJECTILE TRAJECTORY:

The path followed by projectile is called as trajectory.

$$Y = \upsilon_{0y} t - \frac{1}{2} g t^2$$

$$Y = \upsilon_0 \sin\theta t - \frac{1}{2} g t^2$$

$$x = \upsilon_{0x} t$$

$$t = \frac{x}{\upsilon_{0x}} = \frac{x}{\upsilon_{0x} \cos\theta}$$

$$t = \frac{x}{\upsilon_0 \cos\theta}$$

Substituting for t
We get

$$Y = \upsilon_0 \sin\theta (x / \upsilon_0 \cos\theta) - \frac{1}{2} g (\frac{x}{\upsilon_0 \cos\theta})^2$$

$$Y = x \tan\theta - (\frac{1}{2} g) - \frac{1}{\upsilon_0{}^2 \cos^2\theta} x^2$$

For a given value of projection angle θ and initial velocity of a projectile the g, sin θ and cos θ is constant.

$$a = \tan\theta$$

$$b = \frac{g}{\upsilon_0{}^2 \cos^2\theta}$$

$$Y = ax - \frac{1}{2} b x^2$$

UNIFORM CIRCULAR MOTION:

When an object moves in a circular path is a constant velocity then this type of motion is called as circular motion.

ANGULAR DISPLACEMENT:

The angle body produce during the circular motion is called as angular displacement.
It is measures as radian.

$$\theta = \frac{S}{r}$$

$$s = r\theta$$

1radian = 57.3°

ANGULAR VELOCITY:

The change in motion in displacement in a unit time or 1 seond is called as angular velocity.
The direction of angular velocity vector ϖ lies in the axis of rotation.

$$\varpi = \frac{\theta}{t}$$

ANGULAR ACCELERATION:

When the angular velocity changes with respect to time, an angular acceleration produced.
OR
The rate of change of angular velocity with respect to time defines angular acceleration.

$$\alpha_{av} = \frac{\omega_2 - \omega_1}{t_2 - t_1} = \frac{\Delta\omega}{\Delta t}$$

RELATION BETWEEN ANGULAR AND LINEAR QUANTITIES:

Relation between linear and angular displacement is
$s = r\theta$
The relation between angular and linear velocity is
$v = r\omega$
The relation between linear and angular acceleration is
$\alpha = ra$

TENGENTIAL VELOCITY:

In a circular motion when the body has linear acceleration as well as arc velocity that is tangent to the circular path is called as tangential velocity.

TIME PERIOD:

The time required for one complete revolution of motion is called as time period..
The period is denoted as T.
The greater the angular velocity will be the shorter time required for one complete revolution.
Therefore,

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{2\pi f} = \frac{1}{f}$$

CENTRIPETAL ACCELERATION:

- When the object is moving in a circular path and directed toward the circle. It produces acceleration due to the continuous change in the direction of velocity is called as centripetal acceleration.
- The centripetal is a Greek word.

CENTRIPETAL FORCE:

The force that acts toward center during the circular motion of a body is called as centripetal force.

EXPLANATION:

Consider a ball of mass m tied to a string of length r is whirled with a constant speed in circular orbit with the velocity $\vec{\upsilon}$.
According to the first law of motion
The inertia of ball tends to maintain motion in straight line path.
The force acting on a circular motion is F_c.

According to the 2nd law of motion.

$$F_c = ma_c$$

Substituting $a_c = \frac{\upsilon^2}{r}$

$$F_c = \frac{m\upsilon^2}{r}$$

$$F_c = \frac{mr^2\omega^2}{r} = mr\omega^2$$

This is the relation of centripetal force.

EXAMPLES:

(i) A stone attached to the end of a string is whirled in a circle, the tension T in the string provide the centripetal force that constrains the stone to a circular path.

(ii) In a racing car moving around a curved track the friction at the wheels provides the centripetal force. If the friction "breaks" or not sufficient on the turning car, the car skids off the track.

(iii) An electron revolves in circular path around a nucleus has electric force which provides the centripetal force.

Chapter 5

TORQUE ANGULAR MOMENTUM AND EQUILIBRIUM

TORQUE:

The turning affect of the force on a body is called as torque.
Its symbol is τ .

MOMENT ARM:

The perpendicular distance of the line of action is called as moment of arm.

FORMULA:

Magnitude of torque = (magnitude of force)*(moment arm)

COUPLE:

Two forces are considered as a couple if and only if they have
1. Same magnitudes
2. Opposite directions
3. Different lines of action

These forces cannot produces transitory motion, but produce rotator motion.

Explanation:

Consider a body A that can rotate about axis of rotation. A force F is acting on it.
F has two components F1 and F2 and θ is the angle between F and r.
F1 produces rotation in the body.
The direction of torque can be found by using Right Hand Rule and is always perpendicular to the plane containing r & F.
A torque which produces a counter clockwise rotation is considered to be positive.
While a torque which produces clockwise rotation is considered to be negative.

FORMULA:

$$\vec{\tau} = \vec{r} x \vec{F}$$
$$\vec{\tau} = rF \sin\theta$$

CENTER OF MASS:

The **center of mass** is the point where all of the **mass** of the object is concentrated. When an object is supported at its **center of mass** there is no net torque acting on the body and it will remain in static equilibrium.
The concept of the center of mass is that of an average of the masses factored by their distances from a reference point. In one plane, that is like the balancing of a seesaw about a pivot point with respect to the torques produced.

EXPLANATION:

Consider a rectangular block of wood lying on smooth horizontal surface. Let the block be acted upon by a number of forces. In order to describe the motion of the

block as a whole we assume that these forces were acting at the center of mass which is geometrical center of the block. And where the concentrated.
We then find the resultant of these forces and apply Newton's second law of motion to determine the acceleration and hence the velocity of center of mass at any instant of time by using initial condition of motion.
The motion of the block is same as the motion of the center of the mass.

DERIVATION:

Let x, y and z be the coordinates of the center of mass.
Suppose that the field is completely gravitational field.

$$x_c = \frac{\sum m_i x_i}{\sum m_i}$$

$$y_c = \frac{\sum m_i y_i}{\sum m_i}$$

$$z_c = \frac{\sum m_i z_i}{\sum m_i}$$

Where x, y and z are the co-ordinates of the particle of the mass.

EQUILIBRIUM:

When the body is at rest or moving with the uniform velocity it is said to be at equilibrium state.

It has following conditions:
1. Static equilibrium
2. Dynamic equilibrium

CONDITIONS OF EQUILIBRIUM:

There are following conditions of **EQUILIBRIUM.**

STATIC EQUILIBRIUM:

When a body is at rest it is said to be in static equilibrium or first condition of equilibrium.

For example:

- A book lying on the table.
- A building
- A bridge.

DYNAMIC EQUILIBRIUM:

When a body is moving with the uniform velocity then it is said be in dynamic equilibrium second condition of equilibrium.

For example:

- A clock on a wall.
- Jumping of a paratrooper.

FIRST CONDITION OF EQULIBRIUM:

The conditions states that,
If the resultant of the forces acting upon it is zero then it is considered to be in first condition of equilibrium.

F1 +F2+F3+.........Fn=0

SECOND CONDITION OF EQULIBRIUM:

The body is said to be in rotational equilibrium, if the vector sum of the torque acting on it is zero.

$\tau_1 + \tau_2 + \tau_3 + ...\tau_n$

ANGULAR MOMENTUM:

The vector product of position vector r and momentum P relative to the fixed origion at that instant called Angular Momentum. OR “in rotational motion, the analogue of linear momentum is called Angular Momentum.”
Mathematically;
L = r x P = r p sinθ n^---------------- (1)

Explanation:

We know that linear momentum is very helpful in translational Motion. But angular momentum is good in circular motion. Angular momentum plays an important role in the rotational Motion.

Let us consider a particle of mass m moves along a circle with velocity V and linear momentum P at a vector distance r from the origin on of O of a reference frame then.
“The angular momentum L of a particle with respect to the origin on O is defined as”
L = r x P---------------------- (2)
Angular momentum us a vector quantity having magnitude
As well as direction;
L = r x P = rpsinθ n^---------------- (3)
Where rpsinθ represent the magnitude and n^ represents the direction. Where θ is the angle between r and P.

UNITS AND DIMENSIONS:

In the SI unit the unit of length is meter (m), the unit of mass is kilogram (kg) and the unit of time is second. Hence the unit of angular momentum is
Kg.m2s-1 which is equal to JS (Joule. Second)

L = rp = rmv = m. Kg. m/s = Kg. m/s .m x s/s
L = Kg. m/s2 .ms = N. m. s =J. s.
Dimension [L] = [L2M T-1]

LAW OF CONSERVATION OF ANGULAR MOMENTUM:

The law of conservation of angular momentum states that
When net torque acting on a system is zero, the total vector angular momentum of the system remain constant
According to the second law of motion net force acting on a body is equal to its rate of change of linear momentum.
Mathematically;

$$\vec{F} = \frac{d}{dt}(\vec{p})$$

$$\vec{r} * \vec{F} = \vec{r} * \frac{d\vec{p}}{dt}$$

$$\tau = \vec{r} * \frac{d\vec{p}}{dt}$$

$$\vec{l} = \vec{r} * \vec{p}$$

$$\frac{d\vec{l}}{dt} = \frac{d}{dt}(\vec{r} * \vec{p})$$

$$= \frac{\overrightarrow{dr}}{dt} * \vec{p} + \vec{r} * \frac{d\vec{p}}{dt}$$

where,

$$\vec{V} = \frac{\overrightarrow{dr}}{dt}$$

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

$$\frac{\overrightarrow{dl}}{dt} = m\vec{v} * \vec{v} + \vec{\tau}$$

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

Since the vector product of a vector with itself is zero

$$\vec{v} * \vec{v} = 0$$

$$\vec{\tau} = \frac{\overrightarrow{dl}}{dt}$$

This is the required relation.

Chapter 6

GRAVITATION

GRAVITATION:

The force of attraction which attract the body downward is called as gravitational force or force of gravity.

NEWTON'S LAW OF GRAVITATION:
Newton proposed law of gravitation in 1666,
This law states that,
Two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.
Mathematically,

$$F \alpha m_1 m_2$$

$$F \alpha \frac{1}{r^2}$$

Combining both equations.

$$F \alpha \frac{m_1 m_2}{r^2} \therefore \alpha / = const$$

$$F = (const)\frac{m_1 m_2}{r^2} \therefore const = G$$

$$F = G\frac{m_1 m_2}{r^2}$$

This is the relation for law of gravitation.

MASS OF EARTH:

From Newton's law of gravitation,

$$F = G\frac{m\ M}{r^2}$$

Here, M and m are the two masses the r is the distance between their centers. And G is the gravitational constant.
From Newton's second law of motion, we know that F=ma
By putting the value of F in equation above equation

$$ma = G\frac{m\ M}{r^2}$$

Cancelling m both sides,

$$a = G\frac{M}{r^2}$$

Solving for M

$$M = \frac{gr^2}{G} \therefore a = g$$

We know that this is the mass of earth so we can write as

$$M_e = \frac{g{r_e}^2}{G_e}$$

Me is the mass of earth
Ge is the gravitational force of earth

g is the gravity which is 9.8 m/sec2
Re is the radius of earth.

$$M_e = \frac{9.8*(6.38*10^6)}{6.67*10^{-11}}$$
$$M_e = 5.98*10^{24} kg$$

DENSITY OF THE EARTH:

$$\rho = \frac{M_e}{V}$$

To find out V=?

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

Putting the values in above equation

$$V = \frac{4}{3}3.14(6.38*10^6)^3$$

Putting these values in formula

$$\rho = \frac{5.98*10^{24}}{\frac{4}{3}3.14(6.38*10^6)^3} = 5.5*10^3 kg/m^3$$

MASS OF SUN:

$$F = G\frac{Mm}{R^2}$$

From centripetal acceleration

$$a = \frac{4\pi^2 R}{T^2}$$

From 2nd law of motion

$$f = ma$$

putting value of a in formula of acceleration

$$f = m(\frac{4\pi^2 R}{T^2})$$

comparing both equations of F

$$G\frac{Mm}{R^2} = m(\frac{4\pi^2 R}{T^2})$$

hence,

$$M = \frac{4\pi^2 R^3}{GT^2}$$

For astronomical data

$R=1.49*10^{-11}$

$G=6.63*10^{-11}$

$T=365*24*60*60\text{second}$

substituting the values of R, G and T in above relation we get

$M=1.99*10^{30}$

VARIATION OF 'g' WITH ALTITUDE AND DEPTH:

VARIATION OF 'g' WITH ALTITUDE:

Consider a variation in g when the body moves upward or downward from the earth surface. Let g be the value of acceleration due to gravity at the surface of the earth and g' at the height h above the surface of earth. If a earth is considered as a sphere of homogenous composition. Then g will be vary at any point inversely as the square of the distance from that point to its center.

$$g=\frac{M_eG}{R_e^{\,2}}$$

we know that the value of g is at the distance (R_e+h)

$$g^{'}=\frac{M_eG}{(R_e+h)^2}$$

therefore

$$\frac{g}{g^{'}}=\frac{\frac{M_eG}{R_e^{\,2}}}{\frac{M_eG}{(R_e+h)^2}}$$

$$\frac{g}{g^{'}}=\frac{(R_e+h)^2}{R_e^{\,2}}$$

$$=1+\frac{2h}{\text{Re}}+\frac{h^2}{\text{Re}}+....$$

the value of h is very small so we can write as

$$g'=g(1-\frac{2h}{R_e})$$

This is the relation for g with altitude

VARIATION OF 'g' WITH DEPTH:

Let g' be the acceleration due to gravity at depth d below the surface of the earth that is at a distance (Re-d) from the center of the earth.
The mass of the earth is given by,

$$M_e=\frac{4\pi}{3}R_e^{\,3}\rho$$

Where ρ is the density of the earth that is supposed to be uniform.

Now the mass of the earth for thhe depth become,

$$M_e = \frac{4\pi}{3}(R_e - d)^3 \rho$$

$$g' = \frac{M_e G}{R_e^2}$$

putting the value of M_e in above equation we get,

$$g' = \frac{\frac{4\pi}{3} R_e^3 \rho G}{R_e^2}$$

$$g' = \frac{4\pi}{3} R_e^3 \rho G$$

At depth d the value of acceleration due to gravity is equal to the

$$g' = \frac{M_e' G}{(R_e - d)^2}$$

$$g' = \frac{\frac{4\pi}{3}(R_e - d)^3 \rho G}{(R_e - d)^2}$$

$$g' = \frac{4\pi}{3}(R_e - d)^3 \rho G$$

Dividing g and g' we get

$$\frac{g'}{g} = \frac{R_e - d}{R_e}$$

$$g' = g\left(1 - \frac{d}{R_e}\right)$$

This is the relation for the depth of gravity.
We know that the value of g decreases with depth from the surface of earth.
When d = Re the value of g become zero.

WEIGHT:

- The weight is a force with which the earth attracts the bodies toward its center.
- It is a vector quantity.
- It is variable quantity. It may vary due to the place with reference to the value of g
- Weight result in decreasing value in case of height or depth increases.

FORMULA:

W=mg

S.I UNIT:

Newton

WEIGHTLESSNESS IN SATTELITE:

The satellites that are moving around the earth cause weightlessness because their centripetal acceleration is equal to the acceleration due to gravity.

WEIGHT OF A BODY IN AN ELEVATOR:

- When an elevator or lift is at rest or moving with uniform velocity then the weight of a body remain same because the force required to lift the bodies is equal to the mass of bodies.

- If elevator is moving upward the weight of body will increase because the elevator is moving with the acceleration a and the force that is used to lift the bodies become F= ma+mg
- When the bodies moving downward then the weight of bodies will decrease because the relation become F= ma-mg

ARTIFICIAL GRAVITY:

- To surmount the reason of weightlessness artificial gravity is introduced.
- This gravity can be created in spacecrafts.
- Artificial gravity can be created by spinning around its own axis at a certain frequency.

Chapter 7

WORK, POWER AND ENERGY

Work is often though in terms of physical or mental effort in physics, however; the term work involves two things (i) Force (ii) Displacement.

WORK:

The work done by a constant force in displacing an object is defined as the product of the displacement and the component of the force in the direction of displacement.
OR
When any movement takes place it is said that work is done.

Mathematically;

Work = ($F\cos\theta$) S
Or W = F. S ----------------------- (A)

EXPLANATION:

Let us consider a body acted on by a constant forces F and the motion take place or displacement S covered, then the work done by the force on the body as the product of the component of the force along the line of motion and the magnitude of the displacement. If the constant force F makes an angle ☐ with the direction of displacement S of the body, the work W done by F is given;
W = ($F\cos\theta$) S---------------- (i)
Or W = F. S ----------------------- (ii)
From equation (ii) we can say that work is the scalar product of force and displacement work has no direction and it is a scalar quantity.

The work done can be positive negative or zero. The following cases are considered for various situations.

CASE I WORK IS POSITIVE:

The work done by a force is positive, if the force has non-zero component in the same direction as the displacement i.e. the angle ☐ is 0o.

CASE II WORK IS NEGATIVE:

The work done by a force is negative if the force has non-zero component in opposite direction i.e. angle is 180o.

CASE III WORK IS ZERO:

When the force is act at the right angle to the displacement that means the angle is 90o. The work is zero.

UNITS OF WORK:

Work is a scalar quantity. And its unit is the unit of force multipled by unit of distance.
In SI unit the unit of work is newton- meter 1(N-m).

Another name for N-m is the joule (j).
1 joule = (1 newton) (meter)

1 JOULE:

One joule is defined as the amount of work done when a force of one Newton acting on a body displacement it through a distance of one meter along the direction of force.

WORK DONE AGAINST GRAVITATIONAL FIELD:

the space around the earth in which its gravitational force acts on a body is called the gravitational field. When an object is moved in the gravitational field, the work is done by the gravitational force. If displacement is in the direction of gravitational force, the work is positive. If the displacement. Is against the gravitational force, the work is negative.

EXPLANATION:

Let us consider an object of mass m. which is initially at height h from the surface of the earth. The object is moving upward and finally it reaches at height hf. During this upward motion and only force acting is gravitational which is weight is mg
W=F.S

$W=Fs\cos\theta$

$W=Fh\cos\theta$

W=Fhcos180o

W=mgh(-1)

W=-mgh

This is work done against gravitational force.

POWER:

The power is defined as the rate at which work is done, is called power.

When an amount of work done by an agent is W in time interval t then the average power of the agent is:
P = W/t -----------(i)

$P = W/\Delta t$ ------------ (iii)

Power is also related to the force performing the work and imparting velocity to the body on which
work is being done.
Since
W = F.S and S/t = V
Then P = W/t = F.S/t = F.V
$P = F.V = FV\cos\theta$-------------------(iv)

If F and V are parallel to one another then
P = FV -------------------(v)

This is the formula for power.

UNITS AND DIMENSION OF POWER:

The SI unit of power is the joule per second which is called watt (James watt).

WATT:
The rate of doing one joule of work in a unit time or 1 second is called as 1 watt i.e. 1 watt = 1J/1sec.

The other commonly used units of power are: horse power; kilowatt and Megawatts.

HORSE - POWER:

The horse power is generally used to describe the power electric motors or automobiles engines. One horse – power is defined to be 550 ft – lbs of work done in one second. i.e.
1 horse – power = 550 ft – lbs/1 sec ≅ 456 watts

KILOWATT HOUR:

Work can also be expressed in unit of power x time i.e. W = Pt.
If a power of one kilowatt is maintained for one hour, the work done is one kilowatt hour (1KWH).

1KWH = 1000* watt * 3600 S
1KWH = 3.6*106 joules

This is the unit of energy (work) which the P electric company uses to measure the energy delivered to your house. Which is also called Board of Trade unit (BOTU).
1KW = 1 kilo watt = 10* watts
1MW =1 Mega watts = 106 watts

ENERGY:

The ability of a body to do work is called its Energy.

UNITS OF ENERGY:

The SI unit of energy is joule as same as that of work. The other units are erg, foot-pound and kilowatt-hour. i.e.
1 J = 107 ergs = 0.7376 ft lbs
1 KWH = 3.6*106 ft lbs
Another unit 1 electron – volt = 1 ev = 1.6*10-19 joules

There are two types of energy possessed by a body
(i) Kinetic energy
(ii) Potential energy.

KINETIC ENERGY:

The energy possessed by a body due to the virtue of its motion is called as Kinetic energy.

Derivation: To prove

K.E = 1/2 mv2 ---------------------------------- (i)

EXPLANATION:

Let us consider a body of mass m which is at rest initially. A constant force F is applied and the body displaced, moving with velocity "V" in the direction of applied force, so the work-done on the body.

W = F.S = FScosθ .: θ= 0o
W = FS ------------------------------- (ii)
W = mas -------------------------------(iii)

We know that ;
From third equation of motion

2as = vf2 – vi2
As the body start from rest vi = 0
The final velocity become v
2as =v2
As = v2/2 putting in (iii)
W = mas = m (v2/2)
W = 1/2 mv2

This work done on the body, bring the body in motion, appears as its Kinetic energy; W = K.E
So,
K.E = 1/2 mv2

Hence, proved.

POTENTIAL ENERGY:

When a body is being moved against a field of force, energy is stored in it. This energy is called potential energy.

EXPLANATION:

Consider a ball of mass m which is taken very slowly to the height h. The force acting on a body is the gravitational pull of the earth (i.e.)m*g which acts downward to lift the body above the surface area of the earth. In this condition, we have to do the work against gravity.
Very slow motion is possible only when the applied force on the body by an external energy is equal is magnitude to that of the force of gravity.

W= FS
Where distance is height so we will write as
W= Fh F=w=mg
W= mgh

ABSOLUTE P.E:

The P.E of a body at a height h from the center of the earth with respect to the gravitational field that is 0 is called absolute P.E.

DERIVATION:

The amount of work done against the earth's force field is taking the body from that pint P(r) to and arbitrary chosen reference point (level) of zero potential energy called potential in the Gravitational Field.

Mathematically;

$W \propto$------r = - GMm/r --------------------------- (i)

EXPLANATION:

When the earth surface is chosen as zero potential energy then the PE of mass m raised ot height h is
mgh. This equation is true only if h is very small compared with the distance of mass from the center of the earth and "g" is considered constant. If h is large g is not constant the potential energy must be calculated as below;
To obtain a general expression for potential energy at any point P(r) from the center of earth of radius R.
From R to r1 the force varies from GMm/R2 to GMm/r1
If R and r1 are closed, the average force is Fav = GMm/Rr1
Then the work done
Against gravity from R to r_1 is;
$W_1 = GMm/Rr_1 (r_1 – R)$.: $W = F_{av} S$
$W_1 = GMm(1/R – 1/r_1)$ --------------------- (i)
Similarly the work done from r1 to r2 is;
$W_2 = GMm (1/r_1 – 1/r_2)$ ------------------ (ii)
$W_3 = GMm (1/r_1 – 1/r_2)$ ------------------ (iii)
$W_{rN----- r} = GMm (1/r_n – 1/r)$ -------------- (iv)
Now the total work done in carrying the body R to r.
$W_1 = W_1 + W_2 + W_3 +$ -------------- + $W\ r_{N----- r}$.
$W = GMm (1/R – 1/r + 1/r_1 – 1/r_2 + 1/r_2 - +$ ------------ $+ 1/r_n -1/r$.
$W = GMm (1/R – 1/r)$ --------------------- (v)
When the point P(r) ---------------$\propto$, then r ---------------- $\propto$ and 1/r ------------- 0, the equation (v) becomes
$W_{R-----\propto} = GMm/R$ ------------------- (vi)
This is the work done in carrying a body from earth surface to infinity against gravitational field.
The work done against the earth's field is
$W_{R-----\propto} = GMm/R$ ------------------- (vii)
Similarly the work done in displacing a body from inifity to the point at a distance r from the earth center is
$W_{R-----\propto} = - GMm/R$ ------------------- (viii)
So $W_{R-----\propto} = (P.E)\ g = - GMm/r$
This is the required relation

LAW OF CONSERVATION OF ENERGY:

Law of conservation of energy states that, The energy can neither be created nor be destroyed but it can transform from one form into another form.

DERIVATION:

P.E = mgh, K.E =0
P.E +K.E = mgh
K.E=1/2mv^2
Using the equation of motion
Vf2-vi2=2gh
V^2=2gh
Hence,
K.E=1/2 mv^2=1/2m*2gh=mgh
Now taking the relation
P.E + K.E= mgh
P.E = mg(h-x) and K.E = ½ m V2
K.E = mgx
.: P.E + K.E = mg (h-x) + mgx
=mgh

VARIOUS SOURCES OF ENERGY:

Energy is an essential economic and commercial service. Energy is being used at incredible rates in the globe today. Energy is used to operate industries, automobiles, washing machines, television sets. It has been estimated that the present annual consumption of energy in the world about 6*1013 KWH. The common sources of energy are:

- **WIND ENERGY:**

The source of this energy is wind. They are used in wind floor mills. Wind blows from high pressure are to low pressure area over the surface of earth in windy regions. In Karachi near Sohrab goth,you can see a wind mill used for drawing underground water.

- **HYDROELETRICAL POWER:**

Mangla dam, Tarbela dam and other dams in our country are used to produce electrical energy. The prime function is to retain river water so that it can be shuttled off to a water turbine that drives an electrical generator. The principle involve a ways of supplying water a generator other then by a steam turbine.

- **FOSSIL FUELS:**

The fossil fuels are the remaining of plants and animals which were died several years ago. The fossil fuels are mainly coal, wood petroleum and natural gas. They store energy as chemical potential energy. In recent era the main source of energy is gasoline

- **NUCLEAR ENERGY:**

Nuclear reactors are another main source of energy which release energy in the process of fission and fusion which produce electricity. The Karachi Nuclear power plant and cheshma nuclear power plant generates electricity.

- **GEOTHERMAL ENERGY**:

Geothermal energy is the earth natural heat. Heat in fact conducted out from the interior of the surface of earth. We can get this energy from the shallow ground to hot water and hot rocks that found a underneath the Earth, and also down even innate to the tremendously high temperatures of soften rocks called magma. They help to generate electricity. The other way involves the tapping of very hot water used to run turbines.
A geyser is a good example for the geothermal energy. A geyser is hot spring discharges steam and hot water at irregular intervals releasing an explosive column of steam and hot water into the air.
Water from near by streams seeps into the hole where due to volcanic hear below heated up to boiling point. The boiling point of water 100oc at high pressure. This superheated water nears the surface of earth discharges an explosive column of steam and hot water.

- **SOLAR ENERGY:**

Solar energy is by far our most available energy source. Our lives absolutely depends upon it for food production and we call on it for a multitude of a things ranging from sun tanning to clothes drying. Solar energy make a good impact on our economy.

- Providing space heating, space cooling and hot water building
- Providing clean fuels.
- And generating electricity by solar cells. These solar cells are also known as photovoltaic cells. These cells are used to drive radio calculators. Solar panels have a major use in satellites.

- **TIDAL ENERGY:**

The tides have their origin in the gravitational force exerted on the earth by moon and the sun. water powered mills operating the tidal motion were used in new England in 18^{th} century.

Chapter 8

WAVE MOTION AND SOUND

WAVE:

The disturbance caused by the energy transference in a medium is called as wave.

WAVE MOTION:

A disturbance that transmits through a medium which move energy through the process of oscillations in the medium is called as wave motion.

The waves are divided in three categories.

Mechanical Waves:

The waves that are produced by mechanical energy and require a channel for their propagation are called as Mechanical waves.
Examples: waves produced by Guitar, the waves produced by earthquake.

Electromagnetic waves:

The waves that are produced because of the vibration in electric charge and they do not require any channel for their transmission are called as electromagnetic waves
Examples: Light waves, TV waves, and Radio waves.

Matter Waves:

The waves which are produced in a material particles like electrons, protons and neutrons is called as matter waves.

GENERATION OF WAVES:

When a stone is dropped into a lake a disturbance is created where the medium is transfer from its original position and spreads out in all the parts through the medium.
Now take another example that considers a string is tied to a rigid support. And then we try a up and down motion then it will create disturbance in a medium and cause the wave.

NECESSARY CONDITION FOR PROPAGATION OF WAVES:

In mechanical waves atom of the medium carry out vibratory motion. When a wave is reached to the particle it disturbs the particle and creates the wave. If a particle enter in a medium is completely independent then there will be no wave generation.

TRANSVERSE AND LONGITUDINAL WAVES:

There are many kinds of waves like water waves, light waves and sound wave. They are classified according to their physical properties.
These waves are classified in two types

1. Transverse waves
2. Longitudinal waves.

TRANSVERSE WAVES:

The Waves, in which the particles of the medium vibrate along line perpendicular to the direction of propagation of the wave itself, are called Transverse waves.

EXAMPLES:

(i) When a stone is dropped into still water pond, circular pattern of waves spread out from the point of impact.
(ii) Light radio and television waves, although they are not mechanical waves are also Transverse waves.
For propagation of Mechanical waves in a medium, it is important that the atoms of the
Channel must be close with each other to exert relatively large forces on one another in a Transverse wave does not travel through a gas due to their less elasticity.

LONGITUDINAL WAVES:

The waves, in which the particles of the medium vibrate about their mean positions along the direction of propagation of waves, are known as longitudinal waves or compression waves.

EXAMPLES:

(i) Sound waves are longitudinal waves.
(ii) Compressional waves travel along the spring and moved to and fro.

Longitudinal waves do not require a medium or channel of high elasticity. They can travel through solids, liquids and gases.

SIMPLE HARMONIC WAVE:

The type of waves, in which the particles or atoms vibrates in regular wave or in simple harmonic motion is called as simple harmonic wave.

EXPLANATION:

A wave is a type of disturbance in a medium spreading from the original point to the other. The simple harmonic wave is the simplest wave among all the kinds of waves.

CHARACTERISTICS OF WAVES:

Both the transverse wave and longitudinal wave have simple harmonic motion. They have following parameters.

- Wave speed
- Frequency
- Time period
- Phase
- Wave length
- Amplitude
- Intensity

WAVE SPEED:

The distance covered by a wave in a unit time or 1 second is called as wave speed.
The speed depends upon the nature of the waves and the properties of the medium.
For example in a transverse wave we can find out the wave speed by following formula.

$$V = \sqrt{T / m1}$$

Where m1 is the mass per unit length.

This relation represents that when the tension will increase the speed of the wave will also increase. This means that they both are directly proportional to each other.

The speed for longitudinal waves can be calculated as

$$V = \sqrt{E / S}$$

Where E is the stress and S is the mass or volume.

Frequency of wave:

The number of waves passing through a medium in a unit time is called as frequency of waves.
Frequency can be measured in hertz (hz)

TIME PERIOD OF THE WAVES:

The time required for a single wave to pass through a medium is called as the time period of the wave.
We know that the time period and frequency are inversely proportional to each other i.e.
$T = 1/f$ or $f = 1/T$

Phase of wave Motion:

The state motion in a wave is called Phase of wave.

WAVE LENGTH:

The distance between two successive particles that are exactly in the some state of motion (same phase), is called as wavelength of wave.
It is denoted by Greek letter λ (lambda).

$\lambda = VT$
$V = \lambda/T = f\lambda$
$V = f\lambda$

This is the equation for wave length.

AMPLITUDE OF WAVES:

The displacement of a particle from its initial position is called as the amplitude of wave or particles.
The amplitude of wave is identical with the amplitude of the particles of the medium in which the wave travels. Amplitude of a wave is an important parameter because it is related to the transmission of energy by waves.

Intensity harmonic waves:

The energy transmitted per unit time area perpendicular to the direction of the wave is called intensity of wave
OR
The average power transmitted per unit area is called intensity.
Mathematically;

$$I = E/A.t = P/A.$$

EXPLANATION:

We know that the wave transfer energy not matter.
When waves travel through a medium the particles are set in simple harmonic motion. These particles have some K.E and P.E at the mean position the particles having only K.E max but no P.E. thus the total energy is in the form of maximum K.E i.e.

The intensity is proportional to the frequency and square of the amplitude of the wave.
And intensity is directly proportional to the density of the medium.

SOUND:

The longitudinal waves which produce the some sensation in the ear is called as sound.
Sound waves can transmit through solids, liquids, and gases.
We can get sound by playing Guitar strings, by using our vocal cords, a drum beats or tuning forks.
The sensation propagates through the air and reaches at our ear where a receptor and an amplifier convert that sensation into a electrical signal. Then these signals travel to the brain.
Humans can detect frequency waves from 20Hz to 20,000 hertz which is called as audible sound.
The sound range below the 20 hertz is called as infrasonic sounds and cannot be hear by human ear. Ants use this frequency.
The waves louder than the 20,000 hertz is called as ultrasonic sounds. The fusion reactions on sun are more than 20,000 hertz

SPEED OF SOUND IN A MEDIUM:

We know that light do not require any medium to travel but sound requires medium to travel through it. Without medium sound cannot travel from one point to another.
The speed of sound depends upon the elasticity and density of the medium through which it will pass.
The greater the elasticity of the medium then best the sound can travel.
The less the dense material the more best sound can travel
Mathematically,

$V = \sqrt{E / S}$

NEWTON'S FORMULA FOR SPEED OF SOUND WAVES:

We know that
$V = \sqrt{E / S}$

Newton considered that sound waves have compressions and rarefaction.
In compression temperature rises where as in rarefaction the temperature falls.
The compression will be denoted as B and ρ is the density.

$\vartheta = \sqrt{B / \rho}$

This expression is known as Newton's formula for the speed of waves.

Now B is,

$B = -\Delta\rho / (\frac{\Delta v}{v})$

$(\frac{\Delta v}{v})$ Is negative because the Δv decreases as $\Delta\rho$ increases.

$\vartheta = \sqrt{elasticproperty / \text{inertialproperty}}$

LAPLACE'S CORRECTION:

From Newton's law,

$\vartheta = \sqrt{B / \rho}$

Applying Boyle's law here
$Pv\gamma = cons\,\text{tant}$
Where $\gamma = cp / cv$. The ratio of specific heat at constant temperature.
Let the pressure change
$PV\gamma = (P + \Delta P)(V - \Delta V)\gamma$
Taking the values,

$PV\gamma = (P + \Delta P)\,\text{V}\,\gamma(1 - \frac{\Delta V}{V})^{\gamma}$

We know that, $(1 - \frac{\Delta V}{V})^{\gamma} = 1 - \gamma\frac{\Delta V}{V}$

$P = p - \gamma p\frac{\Delta V}{V} + \Delta P - \frac{\gamma}{V}\Delta P.\Delta V$

Canceling p on both sides, and neglecting ΔP and ΔV because these are too small.

$-\gamma p\frac{\Delta V}{V} + \Delta P = 0$

L.H.S shows the bulk modules so,
B= γp
Substituting in equation

$V = \sqrt{\gamma P / P}$

This is the equation for Laplace's correction.

MUSICAL SOUND:

The sound which produces pleasant sensation on the ears is called as musical sound.
For example: guitar, piano.

NOISE:

The sound produces unpleasant sensation on ears is called as noise.
For example:
Slamming of door, yelling

CHARACTERISTICS OF MUSICAL SOUND:

Intensity or loudness
Pitch or frequency
Quality

- **Intensity or loudness:**

Intensity or loudness is the magnitude of auditory sensation produced by the sound. It depends upon the intensity of sound & as well as it depends upon the auditory sensation of the ear.

- **Pitch or frequency:**

It is defined as the sensation that sound produces in the ear of a listener & is clearly related to the frequency of sound. Frequency & pitch are both measured in hertz (HZ).

- **QUALITY:**

Quality or timber is a characteristic of a musical sound. It is quality which enables us to distinguish between notes of the same pitch & intensity when played on different instruments or sung by different voices.

SUPERPOSITION OF SOUND WAVES:

According to this principle,
When the two waves of same medium travel the net displacement of these two waves at any point is equal to the algebraic sum of the displacement of all the waves.

EXPLANATION:

Suppose there are two waves traveling simultaneously along the same medium Let W1 and W2 be the displacements of waves. The resultant displacement will become.
W= W1 + W2 ….
For large number of waves, we have

W = W1 + W2 + W3 + ...

INTERFERENCE OF WAVES:

Definition:

The disturbance due to the super position of the two waves is known interference.
OR
When two or more waves combine at a particular point, they create some disturbance they are said to interfere and the Phenomena is called interference.

CONSTRUCTIVE INTERFERENCE:

When two waves combine to form a resultant wave is called as constructive interference.

EXPLANATION:

When two waves combine with the equal length and same amplitude then the resultant wave is double of these two waves. So we can say that this type of interference is called as constructive interference.

DESTRUCTIVE INTERFERENCE:

When two or more than two waves of different wavelength combine together then the resultant wave is smaller than the original wave. This process is called as destructive interference.

EXPLANATION:

When two waves combine of unequal wave length and different amplitude then the resultant wave will be small as compared to these two waves. So we can say that this type of interference is called as destructive interference.

PATH DIFFERENCE:

The difference of path covered by two consecutive waves is called as path difference.

For destructive interference the formula will be

$$d = n\lambda/2$$

BEATS:

The cyclic fluctuations in loudness of sound of different frequencies are called as beats.

ECHO:

The bouncing back of the sound waves from a distance is called as echo.

STANDING WAVES:

When two equal waves are propagating in a same medium but in opposite direction then they superpose each other and form a resultant wave that vibrate with a different pattern, this process is called as standing or stationary waves.

EXPLANATION:

NODES:

When the waves have same wave length and same amplitude then the displacement of wave is all the time is zero is called as nodes.

ANTI-NODES:

When the waves have different wave length and different amplitude then the displacement takes place at largest amplitude then this process is called as anti nodes.

FREQUENCY:

The number of vibrations in a unit time or 1 second is called as frequency.

DOPPLER EFFECT:

The change in the pitch of sound caused by movement of the listener and of the source of sound is called as Doppler Effect.

EXPLANATION:

It has following cases.
In case 1 a listener is moving toward the stationary source of sound so the frequency of the sound will be higher. In case II the listener is in moving away from stationary source of sound so the sound will be lower as the more listener will move away.

Now we consider the following cases to derive the relations for respective cases.

(A-1) SOUNDING SOURCE MOVES TOWARD A STATIONARY LISTENER:

In this case consider a sounding source is emitting sound waves of with the wavelength λ. Suppose that the speed of waves is v
When both the listener and source are at rest then the limited number of sound waves will pass then the relation will be
V (S = vt , t = 1s)
We know that
$f = V/\lambda$ ……………………… (i)
And no pf waves passed in one second is representing as λ, so we can write as
$\lambda = V/f$ …………………….. (ii)
Now suppose that the source is moving with the velocity Vs s means the velocity of source towards the stationary listener then the frequency will be
(V – Vs), the apparent wavelength λ' is given by;
$\lambda' = V - Vs/f$ ………………….. (iii)
The apparent frequency f' of the sound wave is then given by;
$f' = V/\lambda' = V/V\text{-}Vs/f = V/V\text{-}Vs = f$
$f' = (V/V\text{-}Vs)\, f$ ……………………….. (iv)

This equation show that f′ > f, which means that the loudness of sound will increase when the listener or source are moving toward each other.

A -2) SOUNDING SOURCE MOVES AWAY FROM A STATIONARY LISTENER:

In this case consider that the source moves away from stationary listener then the waves will be (V + Vs) so the apparent wavelength λ′ is;

λ′ = V + Vs/f ……………………(A)
=> f′ = V/λ′
f′ = V/V+Vs/f
f ′ = (V /V+ Vs) f ……………………………. (B)
As f′ < f, the pitch of the receding sound appears lower to the listener at rest i.e. (λ′>λ)
(B – 1) LISTENER MOVES TOWARD A STATIONARY SOURCE:

When a listener moves toward the source with a velocity V2 then the frequency will become V + V_2 (The velocity increases in opposite direction and decreases in the same direction.
As the wavelength is remains constant, the apparent frequency is given by;
f′ = velocity /wavelength = V+ Vs/λ
f′ = V + Vs/V/f .: λ = V/f
f′ = (V + Vs/V) f ………………………….. (1)
As f′ > f, the Pitch of the sound is increased when the listener and the sound source approach each other.
(B – 1) LISTENER MOVES AWAY FROM STATIONARY SOURCE:

In this case the listener will move away from the source of sound. The speed of sound will decrease we can write as,
(V – V2) As the wavelength remains the same then by argument similar to the above the observed frequency
f′ = V - Vs/λ
f′ = (V - V_2/V) f……………………....... (2)
As f′ < f the pitch of the reading sound appears lower to the moving listener. We can generalize the above equations and combing these equations we hare
f′ = (V +- V_2/V +- Vs) f …………………………. (3)
This equation shows that there is clear change in frequency of sound due to the relative motion of listener (V_L) and source (Vs).

APPLICATION OF DOPPLER'S EFFECT:

Some important applications of Doppler Effect are given below;
- Doppler's effect is used to track the satellite.
- They are used to measure the speed of automobiles.
- Radar is used for military purpose at civilian airports and military air busses.
- VOR is a guiding system that is used in airports to guide the incoming air crafts toward the location.
- It is important for the study of astronomy.
- It is used for X-rays and ultra sounds.

- We can detect the motion of objects underwater.

IMPORTANT REASON:

Reason: It has been claimed that a certain singer cold shatter a glass goblet by singing a particular note is it possible?

Answer. The glass has a particular frequency of vibrations of atoms. If the frequency of note sung by singer match with the frequency of the atoms of that glass, then phenomenon of resonance takes place. Due to resonance the amplitude of vibration become large and it may break.

Chapter 9

NATURE OF LIGHT

PHYSICAL OPTICS:

It is the branch of physics in which we study about the physical behaviors of light so we called it as physical optics.

LIGHT:

The radiations that contain electro magnetic properties to create a sense of vision is called as light.
The wave length of light has range from 750nm to 350nm.
Here are some theories to understand the nature of light.

- **NEWTON'S CORPUSCULAR THEORY OF LIGHT:**

According to the Newton's corpuscular theory,

The light consists of tiny particles called corpuscles. These particles are emitted by the body and travels in a straight line.
Newton's theory explains the rectilinear propagation reflection and refraction.

- **HUYGENS'S WAVE THEORY OF LIGHT:**

According to the Huygen's theory,
The light is a form of wave. According to this theory the wave nature of light represent the rectilinear propagation; reflection and refraction.
He also states that there is a medium through which light can pass which is called as ether.

FAILURES:

This theory was failed due to the following reasons.

1. Light do not require any medium to travel. There is not a medium called as ether.
2. If light is a wave then it should bend and we are able to see the corners but we can not see corners.

- **YOUNG'S EXPERIMENT**:

In 19th century Thomas young performed and experiment which is called young double-slits experiments which represents the interference and diffraction phenomena of light. Due to that experiment many scientists believe that light is wave in nature.

Maxwell also state his theory that light is an electro magnetic wave and it do not require any medium to travel.

- **Planks' theory of light**.

In 20th century the plank gave his theory about light according to that theory Light consists of packets of energy that are called as photons.

- **DUAL NATURE OF LIGHT:**

Light has dual nature. Some time light act as a wave and some time it act as a particle.

DIFFRACTION OF LIGHT:

The Bending of light around the sharp edge is called as diffraction of light.
It depends upon the size of obstacle.
Diffraction effects are classified in two types.

FRESNEL DIFFRACTION:

If the source and the screen on which the diffraction pattern will form are at finite distance their corresponding waves are not to each other and their wave fronts are not plane then this type of diffraction is called as Fresnel diffraction.

FRAUNHOFER DIFFRACTION:

If the source and the screen on which the diffraction pattern will form is far from each other and their corresponding waves are parallel to each other and their wave fronts are plane then this type of diffraction is called as Fraunhofer's diffraction.

DIFFRACTION GRATING:

A piece of glass plate consists of number of marks on it is called as diffraction grating.
A find grating with 6000 lines per cm has a slit spacing d equal to 1.66*10-4cm.

MEASUREMENT OF WAVELENGTH:

Grating equation relation is

$d\sin\theta = m\lambda \Rightarrow \lambda = d\sin\theta/m$

HUYGEN'S PRINCIPLE:

Statement: Every point on a wave front considered as a source that produces secondary wavelets. These wavelets propagate in the forward direction with a speed equal to the speed of direction with a speed equal to the speed of wave motion.

EXPLANATION:

In this principle Huygen shows us how the wave fronts generate in the space from one point to another point.
Consider a wave front WX that is produced by a source of Light L
Each point on the wave front WX produces secondary wavelets.
The tangents to these wavelets produce a new wave front YZ after a time Δt for radius $r = L\,\Delta t$. This process can be repeated and infinite number of wave fronts can be generated.

COHERENT SOURCES:

When two sources generate the same wavelengths and constant phases the they called as coherent sources. And those waves are called as coherent waves.

EXPLANATION:

Coherency is an essential for interference. If the two waves are not coherent, interference will take place but can not be observed.

PRODUCTION OF COHERENT WAVES:
We can generate coherent waves through following points.
(i) When two slits are enlightened by a same source of light then they will generate two coherent waves.
(ii) Coherent waves can generated by connecting two loud speakers on the same audio oscillation.
(iii) When two antennas are connected to the same electromagnetic oscillator, coherent waves are generated.

INCOHERENT SOURCES:

When the difference of phase is not constant between two consecutive waves then these types of sources are called as incoherent sources.

EXAMPLE:

The lights produced by two different bulbs are not coherent.

INTERFERENCE OF LIGHT:

When two coherent sources generate equal waves and then these waves overlap each other at a point, then this combined wave intensity becomes greater or less than the intensity of either of two waves is called interference.

EXPLANATION:

In this case we can say that if two waves arrive at the same point from two different sources then the resultant wave will be either too big or small.
Mathematically,
$y = y1+y2$, will result in increases the intensity if they are in phase and decrease the intensity if they are out of phase. The following are the conditions for interference.

CONDITION FOR INTERFERENCE:

The given conditions are necessary for the interference.

(1) The both Sources should be coherent that means that two consecutive waves must maintain constant phase difference among each other.
(2) The waves must be monochromatic.
(3) The principle of linear super position must be obeyed i.e. $y = y1 + y2$.

CONSTRUCTIVE INTERFERENCE:

If the two waves combine at a point at the same time, and increases the intensity, a bright fringe is observed, is called as consecutive interference.

Suppose that the wave difference is given us in the following manner 0, λ, 2λ, 3λ, 4λ………. All theses waves are always arriving at a point in phase results a bright fringe on the screen.
Therefore in terms of path difference the condition for constructive interference is

d=mλ where m = 0, 1, 2, 3, 4 …

DESTRUCTIVE INTERFERENCE:

If two waves are arrived at a same point but they are out of phase they cancel the affect of each other and result in a dark fringe on the screen that type of interference is called as destructive interference.
If the path differences between the waves is λ/2, 3λ/2, 5λ/2, 7λ/2,….
The waves arriving at that point are out of phase so therefore The path difference can be calculated by following formula;

D = (m + 1/2) λ .: m = 0, 1, 2, 3, 4 …

YOUNG'S DOUBLE – SLIT EXPERIMENT:

The young's double slit experiment is used to check the wave nature of the light as well as the wave length of the light that is used in the phenomenon.
We can check the wave nature light because interference or overlapping is possible in the waves not in the case of particles.
Let us consider the two narrow slits A and B, which are enlighten by a single monochromatic source of light in order to produce two coherent waves. Light from each slit spread out or diffraction takes place and interfere in space and we get a pattern of bright and dark fringes on the screen. The bright fringes on the screen refer to the constructive interference and dark fringes due to destructive interference.

FRINGE SPACING:

The midpoint distance between two consecutive bright or dark fringes is called fringe space or fringe width."
Let yn is the position of the nth bright;
$y_n = n\lambda D/d$
To find the the lower consecutive bright position y_{n-1}
$y_{n-1} = (n-1/2)\lambda D/d$
So fringe with $\Delta y = y_n - y_{n-1}$
$\Delta y = \lambda D/d$ -----------------(4)
From this equation, Fringe width depends on wave length screen distance D and separate between the slits and independent of the order of fringe (n).

Determination of wave length:

The wave length of light can be measured during this experiment i.e.

$\Delta y = \lambda D/d$
$\Rightarrow \lambda = \Delta y d/D$

INTERFERENCE IN THIN FILM:

The overlapping of light waves reflected from the upper and lower surface of the thin film is called interference in thin films.

NEWTON'S RINGS:

The circular bright and dark rings or fringes due to the interference or disturbance from the thin film are called as Newton rings.

EXPLANATION:

To explain the Newton's rings let us consider a Plano-convex of large focal length that is placed on glass plate or (film) is formed of variable thickness. A monochromatic light is passed through the lens. The light ray is partially reflected from the top surface of the air and the transmitted ray is reflected from the bottom surface of the air film.
The light ray reflected from of 180o = λ2 . these two rays overlap and form bright and dark fringes that were observed first by Newton. So, they are called as Newton's rings. Due to this phase change, the condition change the condition for constructive and destructive interference will interchange.
Mathematically we can write as;
For a path difference of 0, λ, 2 λ, 3 λ, we get dark rings due to phase change.
Path difference + Phase change = Interference
$0 + \lambda/2 = \lambda/2 =$ Dark
Path difference + Phase change = $(m+1/2)\lambda$
There fore; at the center of the Newton rings the path difference is zero we observe dark spot.
Similarly for constructive interference;
$\lambda/2 + \lambda/2 = \lambda =$ Bright and so on
I.e. Path difference + Phase change = $m\lambda$

MICHELSON INTERFEROMETER:

The type of optical instrument that is used to measure the length of objects and wave length of light with high precision by interference is called Michelson interferometer.

EXPLANATION:

Let us consider a monochromatic light which is passing on semi-silver glass plate "C". This plate is divided into two parts one is movable mirrior and the other is a compensator.
Now, one ray is reflected towards the movable mirror M1 and another transmitted toward the mirror M2 after passing from a compensator D.
The compensator compensate the light ray 1 i.e. decease the wave length two times because ray2 passes two times from the splitter.
The light rays travel two different paths from C to M1 and back to C and from C to M2 and back to C, reach the eye. These rays overlap each other and produce interference, and fringes are observed.
If the distance traveled by light ray 1 is l1 and light ray2 is l2, then the path difference;

$l_1 - l_2 = 0, \lambda, 2\lambda, 3\lambda, \ldots\ldots$
Will produce constructive interference and
$l_1 - l_2 = \lambda/2, 3\lambda/2, 5\lambda/2 \ldots\ldots$

As the path covered by ray 1 is 2l1 and ray 2 is 2l2;
So
$2l_1 - 2l_2 = 0, \lambda, 2\lambda, 3\lambda, \ldots$
$l_1 - l_2 = 0, \lambda/2, \lambda, 3\lambda/2, 2\lambda \ldots$
$d = 0, \lambda/2, \lambda, 3\lambda/2, 2\lambda \ldots$
$d = n\lambda/2$.: $n = 0,1,2,3, \ldots$
This equation shows that by counting the number of fringes "n" measuring "d" (distance of the moveable mirror) the wavelength of light.

DIFFRACTION OF LIGHT:

The bending of light around the sharp edge of an a narrow opening is called diffraction of light.

EXPLANATION:

When light passes through a narrow slit, the light beams not only spread out; that overlap each other (wave fronts overlap) and give rise to a series of alternate light and dark bands.
Let us consider a circular aperture of diameter d which is made in the opaque cord board. The light waves coming from monochromatic source of wave length λ is incident on the aperture d λ λ, we will observe, circular bright and dark fringes around the sharp edge. If there is no diffraction, a white spot is observed.
If the wavelength λ of light is large as compared to the edge size or Spacing of the slit or aperture, the diffraction is more prominent.

DIFFRACTION DUE TO A NARROW SLIT:

The pattern which is observed due to the overlapping of large number of wavelets of a wave coming from a single slit is called diffraction by single slit.

EXPLANATION:

Let us consider a slit AB of width d enlighten by monochromatic light only of wavelength λ.
Now place a screen named as S. notice the diffraction pattern on the screen S There is a symmetry in eavery wave front for any point on the screen.
The wavelets sent out by such point "O" on the screen in phase. These wavelets superimpose constructively and produce a bright spot at "O".
Now suppose another position P on the screen. the light rays that reach position "P" differ "$\lambda/2$".
The path difference between the wavelets sent out by 1 and 4, 2 and 5 or 3 and 6 is $\lambda/2$.
So, the wavelets arriving at that position P out of phase, produces dark bands. Thus the condition for 1st band will be writing as;
$d/2 \sin\theta = \lambda/2$
so $d/2 \sin\theta = m\lambda/2$
Where m = 1, 2, 3, 4,…….. This is the derivation for diffraction of light due to the narrow slits.

DIFFRACTION GRATING:

A glass sheet or thin sheets on which there are large numbers of opaque thin lines are ruled is called as Diffraction Grating.

EXPLANATION:

A thin layer of aluminum or gold is placed on a glass sheet. To make diffraction grating we put layer equally spaced parallel lines are ruled using different techniques.
Typically grating may contain N = 1000 lines/cm, 3000 lines/cm………. 6000 lines/cm.
To find the distance between any two adjacent lines we write it as "d". and relation becomes d = 1/N where Nd = 1 represent the total width of the grating.
This grating is used to diffract the light and diffraction pattern is observed.
When a monochromatic light is illuminated on this grating each slit send out Huygen wavelets in the forward direction. These wavelets produces a pattern when we focused them by lens on the screen and result in bright and dark fringes.

DIFFRACTION OF X-RAYS:

The bending and spreading of the X rays on crystals is called as diffraction of X rays.

BRAGG'S LAW:

This law state that
Diffraction pattern is also produced die to the over lapping of X-rays beams reflected from successive planes of a crystals."

The relation for this law is,
$2\,d\sin\theta = n\lambda$

Where d is the spacing between the planes.

APPLICATION OF BRAGG'S LAW:

(1) It used to study the arrangement of atoms in crystals.
(2) We can measure the wave length through this relation.
(3) X-Ray diffraction helps us to map the DNA molecules as well as the other complex structures.

POLARIZATION OF LIGHT WAVES:

A process in which we differentiate between transverse waves and longitudinal waves is called as polarization of light waves.
A light is a transverse wave that consists of a magnetic field, electric field and direction of propagation.

EXPLANATION:

Interference and diffraction of light showed that light is a wave but we can not understand that which kind of wave the light is.
The phenomenon of polarization tells us that light is a transverse wave.

APPLICATION OF POLARIZATION OF LIGHT:

1. We use Polaroid sunglasses to avoid the reflected light of the sun come from roads, lakes windows and table tops.
2. Intensity of sunlight can be reduced by using the Polaroid windows.
3. We can control head light glare in night driving by using polarizing viewer (screen, shoot etc).
4. Polarizing lenses are used in photographic cameras.
5. we can diagnose the concentration of optical active substance such as sugar in blood urine.

Important reason:
Reason: Why Polaroid's sun glasses are better than ordinary sun glass?

Ans. Polaroid sunglasses are used to reduce the intensity of sunlight by stopping particular components in one direction where as ordinary sun glasses reduce the intensity in general.

Chapter 10

GEOMERICAL OPTICS

OPTICAL INSTRUMENTS:

The optical instruments are used to see the distant or tiny objects and see their finer details are called optical instruments."
These instruments are based on the reflection and refraction of light.

LENSES:

A lens is a piece of transparent material that can focus a transmitted beam of light. Basically lenses fall into two categories, converging or convex lenses and diverging or concave lenses.

TYPES OF LENSES:

- Double convex lens
- Plano convex lens
- Concavo convex lens
- Double concave lens
- Convexo concave lens
- Plano concave

DIFFERENCE BETWEEN CONVEX LENSE AND CONCAVE LENSE:

Concave lens	Convex lens
A concave lens is thinner in the middle and thicker at the edges.	A convex lens is thicker in the middle and thinner at the edges.
It is a diverging Lens	It is a converging Lens
The image is virtual, upright and smaller than the object. (regardless of the object's position)	The image is real , inverted, smaller than object.
Concave means "hollowed or rounded".	Convex means "curved or rounded like the outside of a sphere or circle".
It is used for the correction of problem in short sight.	It is used for the correction of problem in long sight.
It can use in glasses (to correct for short sight), spy holes in doors, some telescopes, back window of coaches, etc.	It can use in eye, camera, overhead projector, focus sunlight, projector microscope, simple telescope, glasses (to correct for long sight), magnifying glass, etc.
It has negative focal length.	It has positive focal length .

IMAGE FORMATION:

In case of convex lense light rays from a very distant point on its axis arrive parallel to the axis and meet to form an image on principle focus. Rays from other points form images whose locations can be found graphically. If the focal length of lens is known we consider only three rays out of them. Whose intersaction determine the formation of image.
Three rays are drawn to form the image

1. The first ray leaving the tip of the object parallel to the axis.
2. The ray 2 passes through the principle focus and emerges to the lens.
3. The ray 3 passes through the optical center of the lens remains unchanged in the direction.

MIRROR FORMULA:

For the spherical mirror this equation is used.

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

Where f is the focal length, p is the distance of object and q is the distance of image.

POWER OF LENSES:

If two lenses with focal length is f1 and f2 then their equivalent focal length will be f. and like that if there are two power p1 and p2 then they both are added to dinf the resultant power.
P= P1+p2.

LENS ABERRATION:

It has following two types. Spherical aberration and chromatic aberration.

SPERICAL ABERRATION:

This problem cause due to the focal point of light rays is far from the optical axis as a spherical lens is different from of those rays passing through the centre.

CHROMATIC ABERRATION:

The fact that different wave length of light refracted by lens focus at different points increases chromatic aberration.

MAGNIFICATION:

The magnification produced by mirrors is calculated as M =q/p = h1/ ha

If M > 1 image will be magnified, then that of object.
If M < 1 image will be diminished, smaller then that of object.
If M = 1 image will be of same size, of object.

SIMPLE MICROSCOPE OR MAGNIFYING GLASS:

It consists of only one convex lens. It is also known as magnifying glass.
The magnification of magnifying glass is M = d/f + 1
where 'd' is the least distance of distinct vision = 25cm.

VISUAL ANGLE:

The angle that is made by the apparent or visible size of the object that can be seen by naked eye is called visual angle."
The greater is the visual angle, the greater is the apparent size of the object.
Mathematically,

$$M = \frac{\beta}{\alpha}$$

USES OF SIMPLE MICROSCOPE:

(1) A magnifying glass can be used as an eye piece in many optical instruments.
(2) It is used to examine the slides in biology.
(3) These are used to find the defects and then repair those defects.
(4) Finger prints can be detected by using this.

COMPOUND MICROSCOPE:

Compound microscope is an optical instrument of very high magnification. It consists of an objective having short focal length and an eyepiece having large focal length.
The image formed by the microscope is real, inverted and enlarged as compared to the object.
The final image of this type of compound microscope is virtual and very much enlarged that that of object.
We can calculate magnification of compound microscope by using following formula
M = L/fo (d/fe + 1)
In this Fo = focal length of objective
fe = focal length of eyepiece.
CONSTRUCTION:

A compound microscope consists of biconvex lenses at the end of two tubes which can move into one another.
The lens toward the object is called as objective and the lens near the eye piece is called as eye piece.

WORKING:

When the object is placed in between F and 2F Rays of light form the object enters into the lens and image is formed beyond 2F which is real inverted and large in size.
When an object is placed inside the focal length of a convex lens the image formed will be virtual, erect and magnified.

For the magnification of the compound microscope we will write as

$M = M_1 * M_2$ -------------- (A) .: $M_1 = A_1B_1/AB$
$A_1B_1/AB = q_o/P_o$
$q_o/P_o = q_o/f_o$
$M = q_o/f_o\,(1+d/f_e)$ -------------- (B) .: $M_2 = (1+d/f_e)$
To get maximum magnification A1B1 is placed closed to eye-piece i.e.
$q_o \cong L$, so;
$M = L/f_o(1+d/f_e)$

ASTRONOMICAL TELESCOPE:

- Astronomical telescope is used to see distant or far objects.

- It is used to see the stars and planets.
- It has two convex lenses one is used as an objective having large focal length and has an eyepiece having smaller focal length.
- A virtual, inverted and diminished image is formed through this telescope.
- The magnifying power of astronomical telescope is M = fo/fe

Where fo = focal length of objective,
Fe = focal length of eyepiece

- The length of telescope is L = fo +fe

CONSTRUCTION:
It consists of two convex lens that are fixed at the both ends of metal tube. The lens near the object will be called as objective having large focal length fo and the other lens near the eye will be considered as an eye piece having short focal length fe.

WORKING PRINCIPLE:

Consider the rays coming from an object which is placed at a distance. These rays formed an image after refraction that is inverted, real and smaller that will be called as A1B1. The image will be virtual for eye piece. After that we will adjust the eyepiece so that the image will be lie with the short focal length. The final image of this object is fall at the infinite distance and that will be virtual, inverted and magnified.

MAGNIFYING POWER:

$$M = \frac{\beta}{\alpha}$$

As the object lies at very large distance so we can wirte as

$\alpha = A1B1 / B1C$

Now the angle fromed by the image is same as the formed by an eyepiece so we can wirte as

$\beta = A1B1 / B1C1$

Putting equations in equation 1

$M = A_1B_1B_1C_1 / A_1B_1B_1C = B_1C / B_1C_1 = f_o/f_e$.

$M= f_o/f_e$.

This is the magnification equation for astronomical telescope.

GALILIEAN TELESCOPE:

- It is used to see the objects on earth.
- This telescope has a convex lens as an objective and a concave lens is used in this telescope as an eyepiece.
- To calculate the magnification of Galilean telescope we can use the formula

M = fo/fe

- We can calculate the length of telescope is L = fo - fe

TERRESTRIAL TELESCOPE:

- This telescope gives us the erect image as a final image.
- We can get the upright image by placing the third lens between the objective and the eye piece.
- Convex lens is used between the objective and eye piece for erect image.

SPECTROMETER:

This instrument is used to study the spectrum of luminous bodies. It helps us to find the wave length of the light passes through the bodies.
It has collimator, telescope and turn table.

USES:

- It is used to measure the wavelength.
- When light from an incandescent solid, liquid or gas is examined by spectrometer, then the spectrum is formed called as emission spectrum.
- The images of slit are separated from one another and appear as a series of bright light is called as line spectrum.
- A third type of emission is called as band spectrum which shows band instead of lines.

THE EYE:

The natural instrument used to see the the world is called as eye.

CORNEA:

The front part of eye covered by the white membrane is called as cornea.

RETINA:

Light entering the eye is focus by cornea on the back surface of the eye is called as retina.

DEFECTS OF EYE:

MYOPIA:

When the eye produces an image of distant object behind the retina is called as myopia.

REMOVAL:

We can correct this error by using converging lens or concave lens .

HYPEROPIA:

When an image of distant object is focus in front of retina this is called as hyperopia or short sightedness.

REMOVAL:

This defect can be removed by using diverging lens or convex lens.

FOR IMAGE FORMATION:

- Object distance p is positive for real objects
- Negative for virtual object
- Image distance q is positive for real objects
- Negative for virtual object
- Focal length f is positive for convex lens
- Negative for concave lens.

IMPORTANT SCIENTIFIC REASONS

Scientific Reason1: Rolling friction is less than the sliding friction.

Reason: Force of friction depends upon the contact surface. When a body rolls over a surface the contact surface is much less than that in sliding. Therefore, rolling friction is less than the sliding friction.

Scientific Reason2: A body becomes weight less in space.

Reason: weight is the force with which earth attracts a body towards its centre. As the body taken away from the earth its weight decreases because the gravitational pull of the earth also decreases. In space there is no gravitational force, therefore a body becomes weight less in space.

Scientific Reason 3: why do we not hear explosive sounds produced in the sun?

Reason: there is a vast vacuum between the sun & the earth. Sound waves are mechanical waves & can not travel through a vacuum. Hence, explosive sounds produced in the sun can not be heard on the earth.

Scientific Reason 4: When a gun is fired its sound is heard a little after seeing its flash.

Reason: when a gun is fired, its sound is heard a little after seeing its flash. The reason is that light travels much faster than sound. Due to its low velocity sound lags behind & so it is heard a little after seeing the flash.

Scientific Reason 5: Small gaps are left between two adjacent pieces of rails.

Reason: materials expand on heating. Rails also expand as the temperature rises in summer days. To accommodate this expansion the gap between two pieces of rails is left. In the absence of this provision, railway tracks will buckle & get destroyed.

Scientific Reason 6: Value of g at a hill is less than its value at the sea-shore.

Reason: The value of g depends on the distance of a body from the centre of the earth. The distance from the centre of earth is more at a hill than at the sea-shore. The value of g varies inversely as the square of the distance. therefore, the value of g at hill is less.

Scientific Reason 7: Body floats on the surface of the liquid.

Reason: Body floats on the surface of the liquid when the weight of the body is balanced by the up thrust force.

Scientific Reason 8: Sharp knife cuts things easily but blunt knife cuts with difficult. Give scientific reason.

Reason: In case of sharp knife the area of contact is smaller so the pressure is greater. In case of blunt knife the area of contact is greater so the pressure is smaller, so we can cut things easily with sharp knife & it is difficult to cut with blunt knife.

Image in short sightedness is formed in front of retina. This defect can be removed by wearing spectacles (all contact lenses) with concave lens of the suitable focal length. These lenses can focus the image clearly on the retina.

Scientific Reason 9: Why is a concave lens of suitable focal length used to remove short sightedness of the eye?
Reason: in short sightedness a person can see near objects clearly but distant objects are not seen clearly. The reason for this defect is either the focal length of the eye lens is too short or the eye ball is too elongated.

Scientific Reason 9: The value of g at the poles is greater than at the equator.

Reason: The distance of poles from the centre of the earth is less than the distance of equator from the centre of the earth. Hence, the value of g at the poles is greater than at the equator.

Scientific Reason 10: Why is lightening seen earlier than the sound of thunder?

Reason: Speed of light is much higher than speed of sound. Light travels faster than sound. Hence, lightening on a rainy day is seen earlier than the sound of thunder.

While the density of a ship is less than that of water. Hence, a nail sinks but a ship floats on water.

Scientific Reason 11: Why does a nail sink but a ship having a huge mass floats on water?

Reason: Nail is a solid body because it does not contain air whereas a ship is a large hollow body because it contains air. Density of nail is more than density of water. Anything whose density is more than that of water will sink into it.

Scientific Reason 12: A body thrown upward always falls to the ground.

Reason: According to Newton's law of gravitation every body in the universe attracts every other body. Earth also attracts every thing towards its centre. When a body is thrown upward than because of gravitational force of earth it always falls to the ground.

Scientific Reason 13: Why Polaroid's sun glasses are better than ordinary sun glass?

Ans. Polaroid sunglasses are used to reduce the intensity of sunlight by stopping particular components in one direction where as ordinary sun glasses reduce the intensity in general.

IMPORTANT TOPICS FOR PHYSICS:

These topics are required to be covered while preparation.

1. Vector
2. Scalar
3. Centripetal force
4. Centripetal acceleration
5. Michelson's Interferometer
6. Law of conservation of Linear Momentum
7. Diffraction grating
8. Work done in Gravitational Field
9. Young's Double Slit Experiment -Petrol
10. Speed of sound in Air
11. Beats
12. Stationary Waves
13. Telescope