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CONTENT

SUBJECT CODE &SUBJECT: 40013, ENGINEERING PHYSICS-I

1. NOTES OF LESSON INDEX PAGE

2. NOTES OF LESSON (VEDIO LINK AND PPT LINK ATTACHED TO INDEX PAGE)

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NOTES OF LESSON – INDEX PAGE

YEAR:	FIRST YEAR	SEMESTER:	I ST SEMESTER
SUBJECT CODE &SUBJECT	40013, ENGINEERING PHYSICS-I	SCHEME:	N SCHEME

UNIT: I - **S I UNITS AND STATICS**

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1	**Unit-Definition-Fundamental Quantities-Definition-Seven fundamental quantities; their SI units and symbol for the units-Supplementary quantities-plane angle and solid angle**	1.Engineering Physics I Author:- Publisher: published by DOTE, tamilnadu govt.& 2.Matrix Publication--Text Book	-	-	-
2	**SI units and symbol for the units Derived physical quantities. Dimensional formula for length, mass and time**	Engineering Physics I Author:- Publisher: published by DOTE, tamilnadu govt.	-	-	-
3	**Derivation of dimensional formula for area, volume, density, velocity, Momentum, acceleration, force, impulse, work or energy and power.**	1.Engineering Physics I Author:- Publisher: published by DOTE, tamilnadu govt. & 2.Matrix Publication-Text Book	-	-	-
4	**Uses of Dimensional formula. Conventions followed in SI –Units Multiples & sub-multiples and prefixes of units.**	Engineering Physics 1 Author; - Publisher: tamilnadu text book corporation	-	-	-
5	**Unit conversions (horse power to watt & calorie to joule)-applications of the method of dimensional**	Engineering Physics 1 Author; - Publisher: tamilnadu text book corporation	-	-	-
6	**STATICS:** **Scalar and vector quantities–Definitions and examples–**	-	-	https://www.slideshare.net/farazrajput1/sca	-

	Concurrent forces and coplanar forces			l ar-and-vector-quantities-73625211 Engineering Physics I- published by DOTE, tamilnadu govt.	
7	**Definition-Resolution of a vector into two perpendicular components**	Physics author: Resnick&Haliday Publisher: Wisley toppan	-	-	-
8	**Resultant and equilibrant–Definitions-Parallelogram law of forces- Statement**	Physics author: Resnick&Haliday Publisher: Wisley toppan	-	-	-
9	**Expressions for magnitude and direction of the resultant of two forces acting at a point with an acute angle between them**	1.Engineering Physics 1 Author; -Publisher: tamilnadu text book corporation& 2.Matrix Publication -Text Book	-	-	-
10	**Lami's theorem-Statement and explanation-Experimental verification of parallelogram law of forces**	-	https://youtu.be/flgqmJ_phHI	-	-
11	**Experimental verification of Lami's theorem.**	-	https://youtu.be/1jSAs8G25vU	-	-
12	Simple problems based on expressions for magnitude and direction of resultant.	Engineering Physics I published by DOTE, tamilnadu govt.	-	-	-
13	**Moment of force-Clockwise and anti-clockwise moments. Principle of moments-Couple–Torque acting due to a Couple**	1.Engineering Physics 1 Author; -Publisher: tamilnadu text book corporation 2.RSPR publication -Text Book	-	-	-

14	**Experimental determination of mass of the given body using principle of moments**	-	https://youtu.be/uJPuCRTac7s	-	-
15	**Simple problems**	Engineering Physics I published by DOTE, tamilnadu govt.	-	-	-

UNIT: II - PROPERTIES OF MATTER

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1	***ELASTICITY*** Elastic and plastic bodies–Definition-stress, strain-Definitions–Hooke's law –statement-three types of strain, Elastic and plastic limit.	-	-	https://slideplayer.com/slide/438150/ Physics-author-Resnick & Haliday publisher-Wisley toppan	-
2	Young's modulus, Bulk modulus, Rigidity modulus–Definitions-Uniform and non-uniform bending of beams.	1.Engineering Physics I published by DOTE, tamilnadu govt.& 2.RSPR publication - Text Book	-	-	-
3	Experimental determination of the Young's modulus of the material of a beam by uniform bending method.AND non uniform bending method	-	https://youtu.be/rkiMpF4r2Jk https://youtu.be/Q8Otf6k3uGk	-	-
4	Poisson's ration – Simple problems based on stress, strain and Young's modulus.	Engineering Physics Author: B.L. Theraja Publisher: S. Chand	-	-	-
5	Applications of Elasticity	Physics author: Resnick&Haliy Publisher: Wisley toppan	-	-	-
6	***VISCOSITY*** Viscosity–Definition-Coefficient of viscosity-Definition,	Engineering Physics I published by DOTE, tamilnadu govt.	-	-	-

	SIunit and dimensional formula-Stream line flow, turbulent flow - Explanation-Critical velocity–Definition-Reynolds number–Definition				
7	Experimental comparison of coefficient of viscosity of two low viscous liquids.	-	https://youtu.be/mQwlmXtRu5k	-	-
8	Terminal velocity–Definition-Experimental determination of coefficient of viscosity of a highly viscous liquid by Stokes method.	-	https://youtu.be/CRTEx29TwdI	-	-
9	Practical applications of viscosity.	1.Engineering Physics I published by DOTE, tamilnadu govt. 2.RSPR publication - Text Book	-	-	-
10	Practical applications of Stokes Law	1.Engineering Physics I published by DOTE, tamilnadu govt. 2.RSPR publication - Text Book	-	-	-
11	***SURFACE TENSION:-*** Surface tension & angle of contact-Definitions-Expression for surface tension of a liquid by capillary rise method.	Engineering Physics Author: B.L. Theraja Publisher: S. Chand	-	-	-
12	Experimental determination of surface tension of water by capillary rise method.	-	https://youtu.be/3tQDtpWEncl		
13	Practical applications of capillarity	Engineering Physics Author: B.L. Theraja Publisher: S. Chand	-	-	-
	Simple problems based on expression for surface tension.	1.Physics author: Resnick&Halay	-	-	-

14		Publisher: Wisley toppan 2.RSPR publication - Text Book 3.Matrix publication - Text Book			
15	Applications of surface tension-Solved Problems	Physics author: Resnick&Haliday Publisher: Wisley toppan	-	-	-

UNIT: III -DYNAMICS–I

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1	***STRAIGHTLINE MOTION*** Introduction-Newton's Laws of motion. Fundamental Equations of motion for objects	-	-	https://www.slideshare.net/crautry/force-and-motion-review-ppt-18860522 1.Mechanics author: Narayana Kurup publisher: S. Chand 2.RSPR publication - Text Book	-
2	Horizontal motion-falling freely-thrown vertically upwards.	Physics author: Resnick&Haliday Publisher: Wisley toppan	-	-	-
3	***PROJECTILE MOTION*** Projectile motion, angle of projection, trajectory, maximum height, time of flight, and horizontal range–Definitions	1.RSPR publication - Text Book 2.Mechanics Author: Narayana Kurup Publisher: S. Chand	-	-	-
4	Expressions for	Mechanics	-	-	-

	maximum height, time of flight and horizontal range– Condition for getting the maximum range of the projectile.	Author: Narayana Kurup Publisher: S. Chand			
5	Path of the projectile (trajectory) is a parabola	1.Engineering Physics I published by DOTE, tamilnadu govt. 2.Matix publication - Text Book	-	-	-
6	Simple problems based on expressions for maximum height, time of flight and horizontal range.	1) Engineering Physics I published by DOTE, tamilnadu govt. 2) Physics author: Resnick&Halid ay Publisher: Wisley toppan	-	-	-
7	Examples of projectile	1.Engineering Physics I published by DOTE, tamilnadu govt. 2.RSPR publication - Text Book	-	-	-
8	***CIRCULAR MOTION*** Circular motion, angular velocity, period and frequency of revolutions– Definitions– Relation between linear velocity and angular velocity	-	-	https://www.slideshare.net/SameerFattepur/circular-motion-11055535 Mechanics author: Narayana Kurup publisher: S. Chand	
9	Relation between angular velocity, period and frequency– Normal	Mechanics Author: Narayana Kurup Publisher: S. Chand	-	-	-

	acceleration, centripetal force and centrifugal force.				
10	Definitions–Expressions for normal acceleration and centripetal force. Banking of curved paths. Angle of banking–Definition	1)Mechanics Author: Narayana Kurup Publisher: S. Chand 2) Engineering Physics Author: B.L. Theraja Publisher: S. Chand	-	-	-
11	Expression for the angle of banking of a curved path { $\tan\theta = v^2/(r\,g)$ }.	-	https://youtu.be/nXm5Sw4QEsc https://youtu.be/eGZWVwcaq0U	-	-
12	Simple harmonic motion, amplitude, frequency and period-Definitions	-	https://youtu.be/tudxily5Qu0	-	-
13	Simple problems based on the expressions for centripetal force and angle of banking.	1.Engineering Physics Author: B.L. Theraja Publisher: S. Chand 2.RSPR publication - Text Book	-	-	-
14	Applications of Centripetal force and centripetal force	-	https://youtu.be/RhqErjMb7go		
15	Solved Problems	Engineering Physics Author: B.L. Theraja Publisher: S. Chand	-	-	-

UNIT :IV -DYNAMICS–II

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1	***ROTATIONAL MOTION OF RIGID BODIES*** Rigid body–Definition-	1.Mechanics Author: Narayana Kurup Publisher: S. Chand 2.RSPR publication -	-	-	-

	Moment of inertia of a particle about an axis	Text Book			
2	Moment of inertia of a rigid body about an axis - Expressions	Mechanics Author: Narayana Kurup Publisher: S. Chand	-	-	-
3	Radius of gyration–Definition	1.Mechanics Author: Narayana Kurup Publisher: S. Chand 2. J.S publication -Text Book	-	-	-
4	Expression for the kinetic energy of a rotating rigid body about an axis	Engineering Physics Author: B.L. Theraja Publisher: S. Chand	-	-	-
5	Angular momentum–Definition	Engineering Physics Author: B.L. Theraja Publisher: S. Chand 2.J.S publication -Text Book	-	-	-
6	Expression for the angular momentum of a rotating rigid body about an axis	-	-	https://www.slideshare.net/ibido https//rigin/13-angular-momentum Engineering Physics author: B.L. Theraja publisher: S. Chand	
7	Law of conservation of angular momentum–Examples.	-	https://youtu.be/_eMH07Tghs0 https://youtu.be/M6PuutIm5h4	-	-
8	***GRAVITATION*** Newton's laws of gravitation	-	https://youtu.be/0hOuNtRMSAI	-	-
9	Acceleration due to gravity on the surface of earth.	1) Engineering Physics I published by DOTE, tamilnadu govt. 2) Physics author:	-	-	-

		Resnick&Halid ay Publisher: Wisley toppan			
10	Expression for variation of acceleration due to gravity with altitude.	1.Engineering Physics I published by DOTE, tamilnadu govt. 2.RSPR publication - Text Book	-	-	-
11	***SATELLITES*** Satellites– Natural and artificial– Escape velocity and orbital velocity– Definitions Expression for escape velocity	-	-	https://www.slideshare.net/SarojSah3/satellite- 1)Mechanics author: Narayana Kurup publisher: S. Chand 2) Engineering Physics author: B.L. Theraja publisher: S. Chand	-
12	Expression for orbital velocity	1.Mechanics Author: Narayana Kurup Publisher: S. Chand 2.J.S publication -Text Book	-	-	-
13	Polar and geostationary satieties & Uses of artificial satellites.	1.Mechanics Author: Narayana Kurup Publisher: S. Chand 2. J.S publication -Text Book	-	-	-
14	Simple problems based on the expressions for escape velocity	Engineering Physics 1 Author; - Publisher: tamilnadu text book corporation	-	-	-

S.NO	TOPIC	REFER TEXT BOOK NAME	VIDEO PRESENTATION	PPT	ANY OTHER
1	***SOUND*** Wave motion– Introduction and definition–Audible range-Infrasonic-Ultrasonic-Progressive waves, longitudinal and transverse waves – Examples	-	-	https://www.slideshare.net/itutor/waves-and-sound-24410234 Text book of sound **author**: R.L. Saighal & H.R. Sarna **publisher**: S. Chand & Co	
2	Amplitude, Wave length, period and frequency of a wave – Definitions	1.Text book of sound **author**: R.L. Saighal & H.R. Sarna **publisher**: S. Chand & Co 2.RSPR publication - Text Book	-	-	-
3	Relation between wave length frequency and velocity of a wave ,Stationary or standing waves.	1.Text book of sound **author**: R.L. Saighal & H.R. Sarna **publisher**: S. Chand & Co 2.Matrix publication - Text Book	-	-	-
4	Vibrations-Free & forced vibrations and resonance– definitions and examples. Laws of transverse vibration of a stretched string.	Engineering Physics 1 Author; - Publisher: tamilnadu text book corporation	-	-	-
5	Sonometer - Experimental determination of frequency of a tuning	-	https://youtu.be/GTnPEtksTEc	-	

	fork.				
6	Acoustics of buildings–Echo-Reverberation, reverberation time, Sabine's formula for reverberation time (no derivation)	-	-	https://www.slideserve.com/abrienda/acoustics Text book of sound **author**: R.L. Saighal & H.R. Sarna **publisher**: S. Chand & Co	
7	Coefficient of absorption of sound energy–Noise pollution. Simple problems based on expression for frequency of vibration.	1.Engineering Physics I published by DOTE, tamilnadu govt. 2.J.S. publication - Text Book	-	-	-
8	Doppler effect – Definition and applications Ultrasonic and its uses	-	https://www.youtube.com/watch?v=yeBwzmMi9M0	-	-
9	SONAR –Solved problems	1.Engineering Physics I published by DOTE, tamilnadu govt. 2.RSPR publication - Text Book		-	-
10	***MAGNETISM*** Pole strength –Definitions–Magnetic moment, intensity of magnetization, 12agnetizing field intensity, magnetic induction, hysteresis, saturation, retentivity and coercivity-Definitions	Engineering Physics Author: B.L. Theraja Publisher: S. Chand		-	-
11	Method of drawing hysteresis loop of a specimen using a solenoid	-	https://youtu.be/dQuPTZgn9rg		
12	Uses of Hysteresis loop	Engineering Physics 1 Author; - Publisher:	-	-	-

		tamilnadu text book corporation			
13	Simple problems based on intensity of magnetization.	Engineering Physics 1 Author; - Publisher: tamilnadu text book corporation	-	-	-
14	Types of magnetic material and their applications- solved problems	-	https://youtu.be/yiXgYg17N0o	https://slideplayer.com/slide/5912017/#.YKkSiuM-Gmk.gmail 1.Engineering Physics I published by DOTE, tamilnadu govt. 2.RSPR publication - Text Book	-

Prepared by: P.PARIMALAM& D.BOWYA	Verified by:
Submitted by IQAC on:21.09.2020	Checked and Approval by IQAC on: 30.09.2020

Sign of IQAC coordinator

UNIT-I
SI UNITS AND STATICS

UNITS AND MEASUREMENT

Introduction:

The word physics comes from the Greek word meaning "nature". Today physics is treated as the most fundamental branch of science and finds numerous applications of life.

Measurement consists of the comparison of an unknown quantity with a known fixed quantity. The quantity used as the standard of measurement is called 'unit'.

For example, a vegetable vendor weighs the vegetables in terms of units like kilogram.

Fundamental physical quantities:

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

(eg) length, mass and time.

Derived quantities:

Quantities that can be expressed in terms of fundamental quantities are called derived quantities. (eg) area, volume, density.

Unit:

Unit of a physical quantity is defined as the accepted standard used for comparison of given physical quantity.

SI Units:

SI unit is the abbreviation for System International de units.

There are seven fundamental units (base units) and two supplementary units.

SI system of units

Physical quantity	Unit	Symbol
Fundamental quantities		
1.Length	metre	m
2.Mass	kilogram	kg
3.Time	second	s
4.Electric current	ampere	A
5.Temperature	kelvin	K
6.Luminous Intensity	candela	cd
7.Amount of substance	mole	mol
Supplementary quantities		
1. Plane angle	radian	rad
2. Solid angle	steradian	sr

Derived quantities and their units

Sl.No	Physical quantity	Formula	Unit	Symbol
1	Area of the square	side × side	metre^2 or square metre	m^2
2	Volume of the cube	side × side × side	metre^3 or cubic metre	m^3
3	Density	Mass / volume	kilogram metre^{-3}	kgm^{-3}
4	Velocity	Displacement / time	metre second^{-1}	ms^{-1}
5	Acceleration	velocity/ time	metre second^{-2}	ms^{-2}
6	Momentum	mass × velocity	Kilogram metre second^{-1}	$kgms^{-1}$
7	Force	mass × acceleration	newton	N
8	Impulse	force × time	newton second	Ns
9	Work (or) Energy	force × displacement	newton metre or joule	J
10	Power	Work / time	joule second^{-1} or watt	W

Dimensions:

The fundamental physical quantities namely length, mass and time are symbolically represented by the capital letters L, M and T respectively.

Dimensional formula is the formula in which the given physical quantity is expressed in terms of the fundamental quantities raised to suitable powers.

Dimensional formula for derived physical quantities.

1. Area of the square = side × side
   Applying dimensions
   Area of the square = $L \times L = L^2$
   Dimensional formula for Area = $[L^2]$
2. Volume of the cube = side × side × side
   Applying dimensions
   Volume of the cube = $L \times L \times L = L^3$
   Dimensional formula for Volume = $[L^3]$
3. Density is the mass per unit Volume.

   $$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

   Applying dimensions

   $$\text{Density} = \frac{M}{L^3} = ML^{-3}$$

   Dimensional formula for Density = $[ML^{-3}]$

4. Velocity is the rate of change of displacement

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

   Applying dimensions,

$$\text{Velocity} = \frac{L}{T} = LT^{-1}$$

<u>**Dimensional formula for Velocity = [LT^{-1}]**</u>

5. **Acceleration is the rate of change of velocity**

$$\text{Acceleration} = \frac{\text{velocity}}{\text{time}}$$

$$= \frac{\text{displacement}}{\text{time}} \times \frac{1}{\text{time}}$$

$$= \frac{L}{T \times T} = \frac{L}{T^2} = LT^{-2}$$

<u>**formula for Acceleration Dimensional = [LT^{-2}]**</u>

6. **Momentum is the product of mass and velocity. Momentum = mass × velocity**

$$= \text{mass} \times \frac{\text{displacement}}{\text{time}}$$

$$\text{Momentum} = M \times \frac{L}{T} = MLT^{-1}$$

<u>**Dimensional formula for Momentum = [MLT^{-1}]**</u>

7. **Force is the product of mass and acceleration. Force = mass × acceleration**

$$= \text{mass} \times \frac{\text{velocity}}{\text{time}}$$

$$= \frac{\text{mass}}{\text{time}} \times \frac{\text{displacement}}{\text{time}}$$

$$\text{Force} = \frac{M}{T} \times \frac{L}{T} = MLT^{-2}$$

<u>**Dimensional formula for force = [MLT^{-2}]**</u>

8. **Impulse is the product of force and time Impulse = force × time**

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

$$= \text{mass} \times \frac{\text{velocity}}{\text{time}} \text{ time}$$

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

$$= \text{mass} \times (\text{Displacement/time}$$

$$\text{Impulse} = \frac{M \times L}{T} = MLT^{-1}$$

<u>**Dimensional formula for Impulse= [MLT^{-1}]**</u>

9. Work (or) Energy is the product of force and displacement

Work or Energy = force × displacement

= mass × acceleration × displacement

$$= \text{mass} \times \frac{\text{velocity}}{\text{time}} \times \text{displacement}$$

$$= \text{mass} \times \frac{\text{displacement time}}{\text{time}} \times \text{displacement}$$

$$\text{Work or energy} = M \times \frac{L}{T} \times \frac{L}{T} = ML^2T^{-2}T$$

<u>Dimensional formula for Work or Energy = $[ML^2T^{-2}]$</u>

10. Power is the rate of doing work.

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

$$= \frac{\text{force} \times \text{displacement}}{\text{time}}$$

Applying dimensions,

$$\text{Power} = MLT^{-2}, \frac{L}{T} = ML^2T^{-3}$$

<u>Dimensional formula for Power = $[ML^2T^{-3}]$</u>

<u>Uses of Dimensional formula:</u>

1. To derive the equation
2. To check the correctness of the given equation.
3. To convert the unit of a physical quantity for one system to other system

<u>CONVENTIONS TO BE FOLLWED IN SI UNITS:</u>

1. When we write a unit in full, the first letter should not be in capital letter.
   (eg) metre and not as Metre
   kilogram and not as Kilogram
2. The symbols of unit in the name of scientist should be in upper case (capital) letter
   (eg) N for newton, J for joule.
3. Only the singular form of the unit is to be used. (eg) km and not as kms
   Kg and not as kgs
4. There should be no full stop at the end of the abbreviations. (eg) mm and not as mm.
   kg and not as kg.

5. **When temperature is expressed in Kelvin, the degree sign is omitted.**

(eg) 273K not as 273^0K

6. **Only accepted symbols should be used.**

(eg) ampere is represented as 'A' and not 'amp' second is represented as 's' and not 'sec'

7. **Use of the solidus or slash is to be avoided, but when used, not more than one solidus be employed.**

(eg) J/k.mol or Jk.mol^{-1} but not J/k/mol J kg^{-1} K^{-1} but not J/kg/K

8. **One letter space is always to be left between the number and the symbol of the unit. (eg) 2.3 m and not as 2.3m**

Kg m s^{-2} and not kg ms^{-2}

9. **The numerical value of any physical quantity should be expressed as p= a × 10^m. Here 'a' is a number between 1 and 10 and 'm' is the appropriate power of 10. (eg) velocity of light c = 2.997 × 10^8 m s^{-1}**

<u>Multiples and Submultiples of units:</u>

In SI, some units are not of convenient size to measure certain quantities. Hence multiples and sub- multiples of the base units are used in measurements.

Multiplication factor	Prefix	Symbol
1 000 000 000 000 = 10^{12}	Tera	T
1 000 000 000=10^9	Giga	G
1 000 000=10^6	Mega	M
1 000=10^3	Kilo	K
100=10^2	hecto*	h
10=10^1	deca*	da
0.1=10^{-1}	deci	d
0.01=10^{-2}	centi*	c
0.001=10^{-3}	milli	m
0.000 001=10^{-6}	micro	μ
0.000 000 001=10^{-9}	nano	n
0.000 000 000 001=10^{-12}	pico	p
0.000 000 000 000 001=10^{-15}	femto	f
0.000 000 000 000 000 001=10^{-18}	atto	a

STATICS

- **Statics is the part of mechanics which deals with forces acting on bodies at rest.**

- **The weight of the body, the tension of a string, the load and the reaction are the different names of forces that are used in statics.**

Scalar :

Physical quantities which have magnitude only are called scalar quantities. (e.g) Mass, Volume, Speed

Vector quantities:

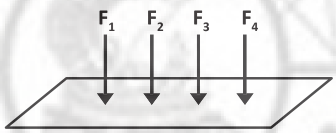
Physical quantities which have both magnitude and direction are called vector quantities. (e.g) Velocity, Momentum, Force

Concurrent forces:

Two or more than two forces acting at a point are called concurrent forces.

Coplanar forces:

Two or more than two forces lie on same plane are called coplanar forces.



Resultant:

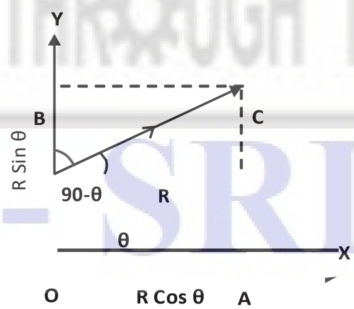
Resultant is that single force which produces the same effect as that produced by two or more forces acting on the body.

Equilibrant:

Equilibrant is the single force which acting along with the other forces keeps the body in equilibrium.

Resolution of a vector into two perpendicular components:

- **The process of splitting up a vector (force) into two perpendicular component parts is known as resolution of a vector.**
- **As the two component forces are mutually perpendicular, they are called rectangular components.**



- **Let a force R act at a point O at an angle θ with x- axis.**
- **This force can be resolved into two rectangular components along x and y axis.**
- **Two lines CA and CB are drawn perpendicular to x and y axis as shown in the figure.**
- **In the right angled triangle OAC,**

$$\cos\theta = \frac{OA}{OC}$$

$$OA = OC\cos\theta$$
$$= R\cos\theta$$

Therefore the horizontal component of the force R is R cosθ. In the right angled triangle OBC,

$$\cos(90-\theta) = \frac{OB}{OC}$$

$$\sin\theta = \frac{OB}{OC}$$

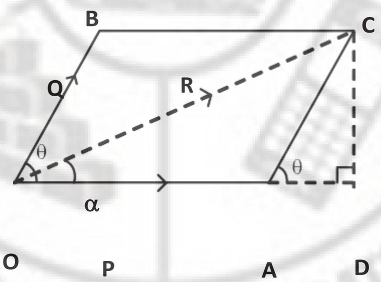
$$OB = OC\sin\theta = R\sin\theta$$

The vertical component of the force R is R sin θ.

Parallelogram law of forces:

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

Derive the expressions for magnitude and direction of the resultant of two forces acting at a point with an acute angle ϴ between them:



- **P,Q are the two forces**
- **OC=R**
- **ϴ = angle between P&Q**
- **α =angle between R&P**

Magnitude:

- **In ΔOCD**
  $OC^2=OD^2+CD^2$
  $OC^2=(OA+AD)^2+CD^2$
  $= OA^2+2.OA.AD+AD^2+CD^2$
  $OC^2= OA^2+2.OA.AD+(AD^2+CD^2)$------(1)
- **In ΔACD**
  $AC^2=AD^2+CD^2$ ---------(2)
  $\cos\theta=\frac{AD}{AC}$

$AD=AC\cos\theta$-----(3)

Sin $\theta = \frac{CD}{AC}$

CD=AC Sin θ----(4)

SUB/. Equation(2)&(3) in equation(1)

$OC^2 = OA^2 + 2.OA.\ AC\cos\theta + AC^2$------(5)

OA=P, OB=AC=Q, OC=R

$R^2 = P^2 + 2PQ\cos\theta + Q^2$

$$\boxed{R = \sqrt{P^2 + 2PQ\cos\theta + Q^2}}$$ ------------------(6)

Direction:

In ΔOCD

tan α $= \frac{CD}{OD}$

tan α $= \frac{CD}{OA+AD}$ **--------(7)**

SUB/. Equation(3)&(4) in equation(7)

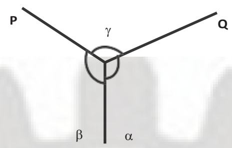
tan α $= \frac{AC\sin\theta}{OA + AC\cos\theta}$

tan α $= \frac{Q\sin\theta}{P + Q\cos\theta}$

$$\alpha = \tan^{-1}\left(\frac{Q\sin\theta}{P + Q\cos\theta}\right)$$ ----------------------------- (8)

Lami's theorem:

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

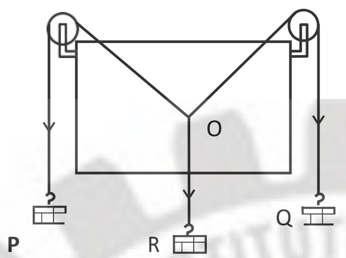


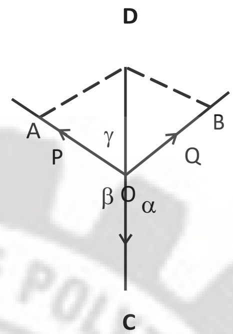
Let P, Q and R be three forces acting at a point O. Under the action of three forces, the point is at rest. Let α, β and γ be the angles opposite to the forces P, Q and R respectively.

By Lami's theorem

$$\boxed{\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma} = \text{CONTANT}}$$

Experimental verification of parallelogram law of forces:





Description:

- **A wooden drawing board is fixed vertically.**
- **Two smooth pulleys are fixed at the two top corners of the board.**
- **Three strings are tied together common points is “o”**
- **Two strings are passed over the two pulleys and third string is hanging freely.**
- **The free ends of the string are tied to the weight hangers P, Q, R.**

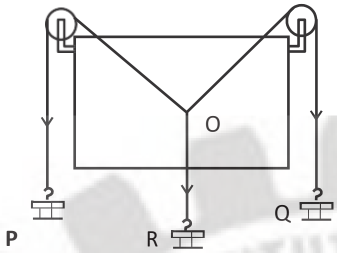
Verification:

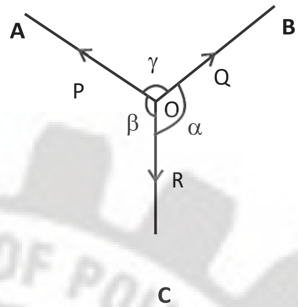
- **The weights P, Q, R are adjusted. A white paper is fixed on the board behind the string.**
- **The point “o” is marked and the direction of the strings are marked**
- **The paper is taken out. The lines OA, OB.OC, OD are drawn.**
- **The parallelogram OADB is drawn.**
- **OD is the diagonal of the parallogram.**
- **It is found that $< COD = 180^\circ$,OC=OD**

Sl. No	P	Q	R	OA	OB	OC	OD	∠COD

- **The experiment is repeated for different values of P, Q and R. It is found that OC = OD and**
- **∠COD = 180º. Thus the parallelogram law of forces is verified experimentally.**

Experimental verification of Lami's theorem:





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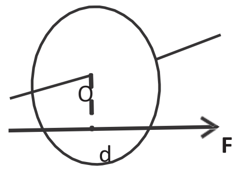
Verification:

- **The weights P, Q, R are adjusted. A white paper is fixed on the board behind the string.**
- **The point "o" is marked and the direction of the strings are marked**
- **The paper is taken out. The lines OA, OB.OC, OD are drawn.**
- **The angle α, β, γ are measured.**
- **The experiment is repeated for the different values of P,Q,R**
- **It is found that**

$$\boxed{\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}}$$

S.NO	P	Q	R	α	β	γ	$\frac{p}{\sin\alpha}$	$\frac{Q}{\sin\beta}$	$\frac{R}{\sin\gamma}$
1.									
2.									

Moment of a force



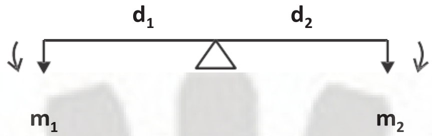
- Consider a body which is fixed at a point, about which it can rotate freely.
- Let a force F is acting on the body.
- The effect of the force is to rotate the body about the fixed point, unless the line of action of the force passes through that fixed point O.
- This rotating tendency or the turning effect of the force about that point is called moment of force i.e. the turning effect of the force acting on a body about an axis or point is called moment of force.
- **Moment of force= Force × Perpendicular Distance =F×d**
- The unit of moment of force is N m and the dimensional formula is ML^2T^{-2}.

Ex: It is common experience that in opening or closing a door, the force we apply rotates the door about its hinges. This rotating effect is known as the moment of force.

Clockwise and anti-clockwise moments:

If the moment of a force turns or rotates the body in clockwise direction, then it is called as <u>clock- wise moment.</u>

If the moment of a force turns or rotates the body in anti-clockwise direction, then it is called <u>anti-clockwise moment.</u>



Clockwise moment= $m_2 \times d_2$

Anti-clockwise **moment** = $m_1 \times d_1$

Principle of moments:

4

- <u>Sum of anti-clockwise moments = sum of clockwise moments</u>

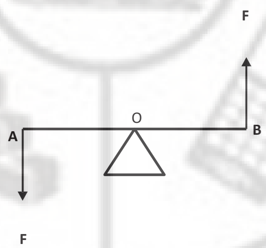
Couple:

- **Two equal and opposite forces form a <u>couple</u>**

Ex:Steering wheel and pedals of bicycles are the examples for couple, where the two forces are equal but acting in opposite direction.

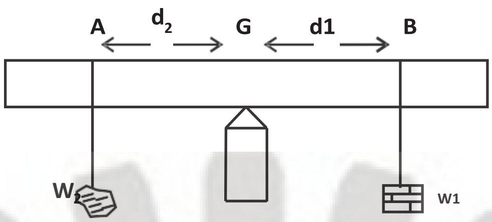
- **Torque acting due to couple (or) Moment of couple**
- **Torque is calculated by the product of either of forces forming the couple and the arm of the couple.**

i.e.) Torque = one of the force × perpendicular distance between the forces.



- **Consider two equal forces F and F acting on the arm AB.**
- **Let O be the midpoint of the arm .**
- **The forces F and F are acting in opposite direction as shown in the figure, they constitute a couple. Then**
- **Moment of couple or torque = F × AB.**
- **If the forces acting on the body have the same line of action then the moment becomes zero.**
- **The torque is maximum when the forces are at right angles to the arm i.e.) θ=90º.**

Determination of mass of the given body using principle of moments:



Description:

- A meter scale is placed on a stand
- 'G' is the centre of gravity
- A known weight W_1 is suspended from the point 'A'. AG=d_1
- The unknown weight W_2 is suspended from the point 'B'. BG=d_2
- Using principle of moments,
  $W_1d_1=W_2d_2$
  The weights of the body,
  $$W_2 = \frac{W1d1}{d_2}$$
- The readings are tabulated for different values of 'W_1' the weight 'W_2' is determined.

S.No	$w_{1(kg)}$	d_1 (m)	d_2 (m)	$w_2 = \frac{W1d1}{d_2}$ (kg)
1				

Mean =

- **The average value of the last column gives the mass of the body.**

WORKED EXAMPLES

1. **Find the magnitude and direction of the two forces 20N and 25N acting at an angle 60º to each other.**

Given:

P = 20N Q = 25N θ = 60º

Resultant R = $\sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$= \sqrt{20^2 + 25^2 + 2 \times 20 \times 25\cos 60}$

$= \sqrt{152}$

R = 39.05N

Direction $\alpha = \tan^{-1}\left[\dfrac{(Q\sin\theta)}{(P + Q\cos\theta)}\right]$

$\alpha = \tan^{-1}\left[\dfrac{25 \times \sin 60^0}{20 + 25\cos 60^0}\right]$

α = tan $^{-1}$ (0.6661) α

= 33º40'

2. **Find the magnitude and direction of the two forces 20N and 25N acting at an angle 60º to each other.**

Given:

P = 20N Q = 25N θ = 60º

Resultant R = $\sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$= \sqrt{20^2 + 25^2 + 2 \times 20 \times 25\cos 60}$

$= \sqrt{152}$

R = 39.05N

Direction $\alpha = \tan^{-1}\left[\dfrac{(Q\sin\theta)}{(P + Q\cos\theta)}\right]$

$\alpha = \tan^{-1}\left[\dfrac{25 \times \sin 60^0}{20 + 25\cos 60^0}\right]$

α = tan $^{-1}$ (0.6661)

α = 33º40'

2.Find the magnitude and direction of the resultant of two forces 3N and 4N acting at right angles to each other.

Given

P = 30N

Q = 40N θ = 90°

Resultant R = $\sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$= \sqrt{3^2 + 4^2 + 2 \times 3 \times 4 \times \cos 90}$

$= \sqrt{2500}$

R = 5N

Direction $\alpha = \tan^{-1}\left[\dfrac{(4 \times \sin 90)}{(3 + 4\cos 90)}\right]$

$= \tan^{-1}(1.333)$

$\alpha = 53^{o}7'$

3. **If the resultant of two equal force is** $\sqrt{3}$ **times a single force, find the angle between the forces.**

Given

Two forces are equal

P = Q = P

R = $\sqrt{3}$ **P**

$R^2 = P^2+Q^2+2PQ\cos\theta$

$(3P)^2 = P^2+P^2+2.P.P.\cos\theta$

$3P^2 - 2P^2 = 2P^2\cos\theta$

$P^2 = 2P^2\cos\theta$

$\cos\theta = ½$

$\therefore \theta = 60^o$

Angle between the forces is 60º

4. **If the resultant of two equal forces inclined to each other at 60º is 8** $\sqrt{3}$ **N, find the component forces.**

Given

Two forces are equal.

P = Q = P

R = $8\sqrt{3}$ **N**

$\theta = 60^o$

$R^2 = P^2+Q^2+2PQ\cos\theta$

$(8\sqrt{3})^2 = P^2+P^2+2.P.P\cos 60^o$

$192 = 2P^2+2P^2.½$

$192 = 3P^2$

$64 = P^2$

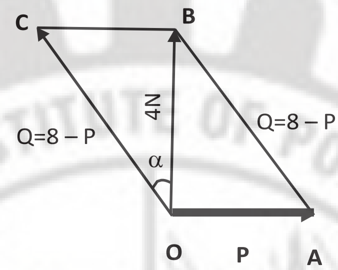
P = 8N

Component force is 8N

5. **The sum of two forces is 8N and the magnitude of the resultant is at right angles to the smaller force 4N. Find the forces and the inclination between them.**

Given

Sum of the two forces = 8
N Resultant of 2 forces = 4
N Let the smaller force be
P Larger force Q = (8–P)



In the right angled triangle OAB,

$$AB^2 = OA^2 + OB^2$$
$$(8 - P)^2 = P^2 + 4^2$$

$$64 - 16P + P^2 = P^2 + 16$$
$$16P = 48$$
$$P = 3N$$

Therefore the larger force Q = 8–3

$$Q = 5N$$

In triangle OCB,

$$\tan\alpha = \frac{BC}{OB} = \frac{P}{4} = \frac{3}{4} = 0.75$$
$$\alpha = \tan^{-1}(0.75)$$
$$\alpha = 36^\circ 52'$$

Angle between the forces P and Q

$$90 + \alpha = 90 + 36^\circ 52'$$
$$= 126^\circ 52'$$

QUESTIONS

Part A and Part B

1. What are the fundamental quantities?
2. What are the derived quantities?
3. What are the supplementary quantities and their SI units?
4. What are the units for momentum , force,impulse and work?
5. What are the units for energy and power,acceleration and density?
6. What are the dimensional formula for impulse and momentum.
7. What are the dimensional formula for work or energy.
8. What are the dimensional formula for power.and force
9. Define scalar quantity.with example

10. Define vector quantity with example.
11. What is resultant?
12. What is equilibrant?
13. Write the parallelogram law of forces.
14. Write the Lami's theorem.
15. Write any two conventions followed in SI unit.
16. Define concurrent forces.
17. Define coplanar forces.
18. Define moment of a force.
19. Write the principle of moments.
20. Define couple.
21. Define moment of a couple.
22. Define clockwise moment and anticlockwise moment.
23. Write any three uses of dimensional formula
24. Derive dimensional formula for impulse, work and power.
25. Write any three the rules and conventions followed while writing SI.
26. Explain how a vector can be resolved into two rectangular components.
27. Find the magnitude of the two forces 3 N and 5 N acting at right angle to each other

Part- C

1. Give the rules and conventions followed while writing SI units
2. Derive expressions for the magnitude and direction of the resultant of two forces acting at a point with an acute angle between them.
3. Describe an experiment to verify the parallelogram law of forces.
4. Describe an experiment to verify Lami's theorem.
5. Describe an experiment to determine the mass of the given body using principle of moments.

Exercise Problems

1. Find the magnitude and direction of the resultant of two forces of 5N and 3N at an angle of 60º.

   (Ans: R =7N, α = 21º47')

2. Two forces of magnitude 4N and 2.5N acting at a point inclined at an angle of 40º to each other. Find their resultant.

   (Ans: R= 6.149N, α =15º8')

3. Find the resultant of two forces 3N and 4N acting on a particle in direction inclined at 30º.

   (Ans: R= 6.767N, α =17º19')

4. Two forces of magnitude 4N and 3N respectively, act on a particle at right angles to each other. Find the magnitude and direction of the resultant of two forces.

   (Ans: R= 5N, α =36º52')

5.If the resultant of two equal forces is 2 times the single force, find the angle between them.

(Ans: ϑ = 90º)

6.If the resultant of two equal forces inclined to each other at 60º is 8.660 N, find the component

force.

(Ans:5N)

7.If the resultant of two forces 6N and 8N is 12N, find the angle between them.

(Ans: 62º43')

8.The sum of two forces inclined to each other at an angle is 18N and their resultant which is perpendicular to the smaller force is 12N. Find the forces and angle between them.

(Ans: P= 5N,Q=13N,ϑ =112º36')

UNIT-II
PROPERTIES OF MATTER

ELASTICITY

Introduction:

Deforming force:

- **When an external force is applied on a body, which is not free to move, the shape and size of the body change. The force applied is called deforming force.**

Restoring force:

- **When the deforming forces are removed, the body tends to regain its original shape and size due to a force developed within the body. The force developed within the body, which is equal and opposite to deforming force is called restoring force.**

Elasticity:

- **The property by virtue of which a body tends to regain its original shape and size after removal of the deforming force is known as elasticity. Ex: Rubber Band**

Plastic:

- **The property by virtue of which a body tends to not regain its not original shape and size after removal of the deforming force is known as plastic.**
  EX: Plastic Mug, Other Plastic Items

Stress:

- **Force acting per unit area is called stress**

$$\text{Stress}=\frac{\text{Force}}{\text{Area}}$$

The unit for stress is N m^{-2} or 'pascal' with symbol 'Pa'.

Strain:

- $\text{Strain}=\frac{\text{Change in dimension}}{\text{Original dimension}}$

Define Hooke's Law:

$$\frac{\text{stress}}{\text{strain}}=\text{constant (OR) Stress } \alpha \text{ Strain}$$

Three type of modulus:

1. **Young's modulus**
2. **Bulk modulus**
3. **Rigidity modulus**

young's modulus:

- $\text{Young's modulus} = \frac{\text{linear stress}}{\text{linear strain}}$

The unit for Young's modulus is newton metre^{-2} with symbol N m^{-2}.

Bulk modulus:

Bulk modulus=$\frac{\text{Bulk stress}}{\text{Bulk strain}}$

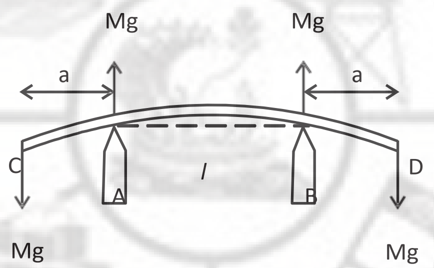
Rigidity modulus:

Rigidity modulus=$\frac{\text{Shearing stress}}{\text{Shearing strain}}$

Poisson's ratio:

Poisson's ratio=$\frac{\text{lateral strain}}{\text{linear strain}}$

Experiment to determine the Young's modulus of the material of a beam by uniform bending method:



Description:

- The given beam is kept on two knife edges.
- The two equal weight hangers are suspended at the points 'A' and 'B'.
- A pin is fixed at the centre of the scale.
- A microscope is arranged in front of the pin.

Experiment:

- The tip of the pin is focused and the reading is taken.
- Now the load in each weight is increased and the readings are noted.
- Now the load is decreased and the reading is taken.
- Then the mean elevation 'Y' is calculated.
- T he young's modulus of the material of the scale,

$$E=\frac{3Mgal^2}{2bd^2y} \quad Nm^{-2}$$

M-Mass , g-gravity

a-distance between knife edge to weight hanger

l- length between two knife edge

b-breath, d – thickness

s. S.no	Load in kg	Micrometer reading		MEAN	Elevation(Y)
		Loading	Unloading		
1	W				
2	W+M				
3	W+2M				

<u>Application of Elasticity:</u>

- Elasticity is used to design safe and stable manmade structures such as skyscrapers and over bridges to make life convenient.
- Cranes used to lift loads use ropes that are designed so that the stress due to the maximum load does not exceed the breaking stress.

<u>PROBLEM:</u>

1. The length of a wire increases from 1.25m to 1.2508m when a force of 120Nis applied. The radius of the wire is 0.5mm. Find the stress, strain and Young's modulus of the material.
   F=120N
   r=0.5mm
   L=1.25m, dl= 1.2508m
   l=1.2508-1.25=0.0008m
   (i)stress=$\frac{F}{A}$=$\frac{F}{\pi r^2}$=$\frac{120}{3.14\times(0.005)^2}$=1.529$\times\ 10^8$
   (ii)strain=$\frac{l}{L}$=$\frac{0.0008}{1.25}$=6.4$\times\ 10^{-4}$
   (iii) young modulus E=$\frac{\text{stress}}{\text{strain}}$= $\frac{1.529\times10^8}{6.4\times10^{-4}}$= 0.2389$\times\ 10^8\times 10^4$Nm^{-2}
   E=0.2389$\times\ 10^{12}$ =23.89$\times\ 10^{10}$Nm^{-2}

2.A wire of length 2m is stretched by a force of 100N. The area of cross section of the wire is 0.008m2 and the increase in length is 0.05mm.Caculate the stress, strain and young's modulus.

F=100N
A=0.008m^2
L=2m
l=0.05$\times\ 10^{-3}$ m
(i)stress=$\frac{F}{A}$=$\frac{100}{0.008}$=12500

(ii)strain=$\frac{l}{L}$=$\frac{0.05\times10^{-3}}{2}$=0.025$\times\ 10^{-3}$
(iii) Young modulus E=$\frac{\text{stress}}{\text{strain}}$= $\frac{12500}{0.025\times10^{-3}}$= 5$\times\ 10^8$Nm^{-2}

$E = 5 \times 10^{8} Nm^{-2}$

3.A load of 5 kg is attached to the free end of a wire of length 2 m and diameter 0.6 mm. If the extension of the wire is 0.2 mm, calculate the Young's modulus of the material of the wire. ($g = 9.8 ms^{-2}$)

Length of the wire L = 2 m

Extension of the wire I = 0.2 mm = 0.2×10^{-3} m

Force acting of the wire F = 5kgf = 5×9.8 N

Diameter of the wire d = 0. 6 mm = 0.6×10^{-3} m

Radius of the wire =0.3×10^{-3} m

Area of cross section of the wire a = $\pi r^2 = \pi (3 \times 10^{-4})^2 m^2$

Young's modulus = Linear stress/Linear strain

Linear stress $\frac{F}{A} = \frac{5 \times 9.8}{\pi (3 \times 10^{-4})^2} = 1.734 \times 10^{8} Nm^{-2}$

Linear strain $\frac{l}{L} = \frac{2 \times 10^{-4}}{2} = 1 \times 10^{-4}$

$$= \frac{1.734 \times 10^{8}}{1 \times 10^{-4}} = 1.734 \times 10^{12} Nm^{-2}$$

4.A copper wire of 3 m length and 1 mm diameter is subjected to a tension of 5 kg wt. Calculate the elongation produced in the wire, if Young's modulus of elasticity of copper is 120 G Pa.

Young' s modulus E = $\frac{F/A}{l/L}$

E = $\frac{FL}{Al}$

Elongation produced l = $\frac{FL}{AE}$

$$= \frac{MgL}{\pi r^2 \times E} = \frac{5 \times 9.8 \times 3}{3.14 (0.5 \times 10^{-3})^2 \times 120 \times 10^{9}} = 1.562 \times 10^{-3} m$$

5.What is the force required to a steel wire to double its length when its area of cross-section is one sq. cm and Young's modulus is 200 G Pa. As the length of the wire is doubled, the change in length is equal to its original length.

The young' s modulus E = $\frac{FL}{Al}$

F = $\frac{EAl}{L}$

$$= \frac{EAL}{L}$$

If L is the original length, then l= L

F = EA

$= 200 \times 10^{9} \times 10^{-4}$

$= 2 \times 10^{7}$

VISCOSITY:

- Let us consider a liquid flowing over a horizontal surface.
- The layer in contact with the surface is at rest.
- The top most layer have the maximum velocity.
- The intermediate layers have intermediate velocity.
- To maintain this relative motion of the layers, an external force must be acting on the liquid. Otherwise the liquid will come to rest due to internal frictional forces acting between the layers of the liquid.
- These internal frictional forces that bring the liquid to rest are known as viscous force and this property is known as viscosity.
- The property by virtue of which the relative motion between the layers of a liquid is Maintained is called viscosity. Viscosity is the resistance to flow.
  - Rain drops falling slowly- Due to the viscosity

Co-efficient of viscosity:

- The tangential force acting per unit area in between two liquid layers, maintaining unit velocity gradient.
- Example of low viscous liquid : kerosin, water, petrol
- Example of high viscous liquid : Castrol oil, honey

The viscous force F is found to be directly proportional to

i. the area of the layers 'A'

ii. the velocity gradient $\frac{dv}{dx}$

$$F \alpha \frac{Adv}{dx}$$

$$F = \frac{\eta\, Adv}{dx}$$

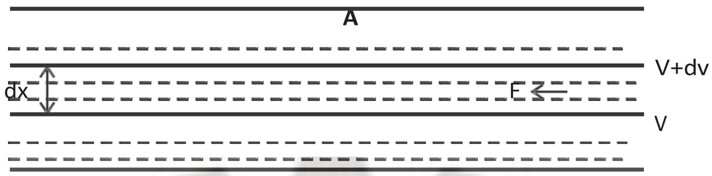
If A = 1

$$\frac{dv}{dx} = 1$$

then $F = \eta$

Where η is constant, called Coefficient of viscosity of the liquid

Coefficient of viscosity of a liquid is defined as the viscous force acting between two layers of a liquid having unit area of layers and unit velocity gradient normal to the direction of flow of the liquid.



SI unit of η:

$\eta = \dfrac{F}{A\,dv/dx}$ **Substituting the respective units of the quantities on the R.H.S,**

The unit of coefficient of viscosity η $= \dfrac{N}{m^2 . ms^{-1} / m}$

$= Nsm^{-2}$

Dimensional formula of η:

$\eta = \dfrac{F}{A\,dv/dx}$ **Substituting the respective dimentional formula of the quantities on the R.H.S,**

The dimensional formula of coefficient of viscosity $\eta = \dfrac{MLT^{-2}}{L^2 . LT^{-1} / L}$

$= ML^{-1}T^{-1}$

Critical velocity:

When the external pressure driving the flow of liquid increases slowly, the velocity of flow of liquid will also increase gradually. At a particular velocity the flow of liquid will change from laminar flow to turbulent flow. This velocity is called critical velocity.

streamline motion:

- **Pressure is low**
- **Direction of flow is parallel to the tube**
- **Velocity is same**

Turbulent Motion:

- **Pressure is high**
- **Direction of flow is not parallel to the tube**
- **Velocity is different**

Reynolds number:

- **Reynolds number is a number which determines whether the how of liquid through a pipe is streamline or turbulent.**

Reynolds number=$\rho vd/\eta$

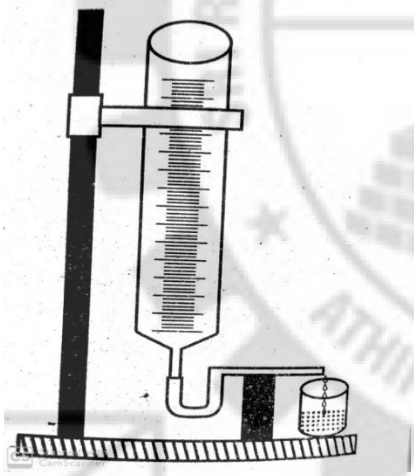
ρ- density of the liquid

v- average velocity

d-diameter of the pipe

η- coefficient of viscosity of liquid.

Describe and experiment to compare the co-efficient of viscosities of two low viscous liquids:



Description:

- **A burette is mounted on a stand.**
- **A capillary tube is connected to the burette with the help of a rubber tube.**
- **The burette is filled with the liquid 1(water).**

Experiment:

- **Now the liquid is flowing through capillary tube drop by drop.**
- **When the liquid level reaches 0cc a stop clock is stared.**
- **The time is noted when the level reaches 5, 10, 15,20cc….**
- **The burette is filled with the liquid 2(kerosene)**
- **The time taken by the liquid (I)= t_1**
- **The time taken by the liquid (II)= t_2**

S.N0	Burette reading (cc)	Time (S)		t_1 / t_2
		lquid-I(t_1)	lquid-II (t_2)	
	0-5 5-10 - - - 45-50.			

- Mea=

ρ_1, ρ_2 -density of the liquid (I)& liquid (II),

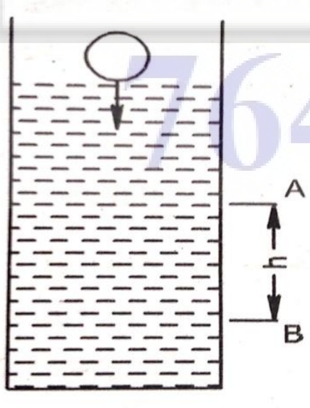
- **The ratio co-efficient of viscosities of two liquids.**

$$\frac{\eta_1}{\eta_2} = \frac{\rho_1}{\rho_2} X \frac{t_1}{t_2}$$

<u>Terminal velocity.</u>

- **A spherical ball is dropped into a highly viscous liquid.**
- **When the apparent weight of the spherical ball is equal to viscous force of liquid,**
- **the ball will move with a constant velocity called terminal velocity**

<u>Describe and experiment to determine the coefficient of viscosity of a highly viscous liquid by Stoke's method:</u>



Description:

- A high viscous is taken in a glass jar.
- The marks 'A' and 'B, are marked.
- The distance between 'A' and 'B' is 'h'.
- A steel ball is taken and its radius 'r' is measured.

Experiment:

- The ball is dropped into the liquid.
- The time taken to cross the distance AB is noted.
- The experiment is repeated by using various balls.
- The readings are tabulated.
- The viscosity of the liquid is,

$$\boxed{\eta = \frac{2(\rho-\sigma)g(r^2\ t)}{9h}\ Nsm^{-2}}$$

S.No	r	r^2	t	$r^2\ t$
1.				

Application of viscosity:

- **The highly viscous liquid is used to damp the motion of some instruments and is used as brake oil in hydraulic brakes.**
- **Blood circulation through arteries and veins depends upon the viscosity of fluids.**
- **Viscosity has important uses in such areas as inkjet printing.**
- **For low speeds, oils of lower viscosity are used.**
- **The friction between two metallic surfaces in vacuum is found to be greater than that in air.**
- **Generally, for high speeds and low pressures, highly viscous oils such as Mobil oil, grease, etc. are used**

Practical applications of Stokes Law:

- **While jumping from an airplane parachute helps us to land safely on earth.**
- **It is used to determine the value of charge on an electron (Millikan's oil drop method)**
-

Introduction:

Surface Tension:

- **The free surface of a liquid at rest behaves like a stretched elastic membrane with a tendency to contract in area. The following simple experiments will illustrate this property.**

- When the brush is taken out, the hairs cling together on account of the films of water between them contracting.
- The above examples show that a force acts on the surface of liquid to reduce the surface area to a minimum. This force is known as surface tension.
- A water drop takes the spherical shape because for a given volume, sphere has the minimum Surface area. This is due to surface tension

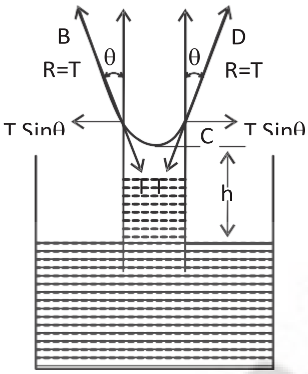
Surface Tension:

- Force acting on unit length of line drawn on the liquid surface.T= force/length
- Rain droplet is spherical in shape -Due to surface tension. The unit of surface tension is Nm^{-1} and its dimension is MT^{-2}

Angle of Contact:

- Angle between the tangent to the liquid surface and solid surface inside the liquid.
- For liquids like water and kerosene which spread on glass, the angle of contact θ = 0°. In the case of mercury and clean glass, the angle of contact θ = 137°. For ordinary water and glass, the angle of contact θ = 8°.

Derive the expression for surface tension of a liquid by capillary rise method:



Description:

- Consider a capillary tube of radius ‘r’.
- Water rises , due to surface tension
- ‘h’ – height of the capillary rise.
- $'\theta'$ - Angle of contact.
- T- Surface Tension.

Derivation:

- Horizontal component of T= $T\sin\theta$
- Vertical component of T= $T\cos\theta$
- ‘m’- mass of liquid
- $'\rho'$-Density of the liquid
- Total upward force =$2r\,\pi T\cos\theta$
- Total downward force = $\pi r^2\, h\rho g$

Total upward force = Total downward force

$$2r\,\pi\, T\cos\theta=\pi r^2\, h\rho g$$

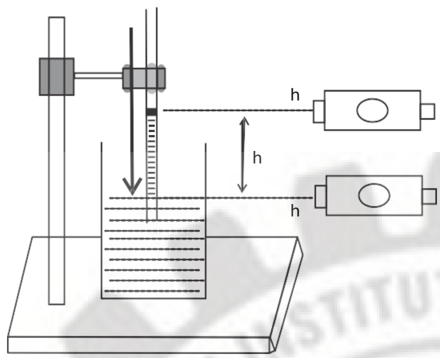
$$T=\frac{\pi r^2\, h\rho g}{2r\,\pi\,\cos\theta}$$

$$\boxed{T=\frac{r\,h\rho g}{2\,\cos\theta}}$$

for water =0 COS(0)=1

$$\boxed{T=\frac{r\,h\rho g}{2}\ \mathrm{Nm^{-1}}}$$

Describe an experiment to determine the surface tension of water by capillary rise method.



Description:

- **A Capillary tube and a pointer are clamped to a stand.**
- **A beaker of water is placed just below the capillary tube.**
- **The pointer just touches the water surface in the beaker.**
- **Due to surface tension, the water rises in the capillary tube.**

Experiment:

- **A microscope is focused on the water level in the capillary.**
- **The reading 'h_1' is taken. The beaker is removed.**
- **Now the microscope is focused on the tip of the pointer.**
- **The reading 'h_1' is taken. Now the value of 'h_2' is determined.**
- **R-radius of the capillary.**
- **ρ – density, g - gravity**
- **$h= h_1 - h_2$**

$$\boxed{T=\frac{r\,h\rho g}{2}\ Nm^{-1}}$$

S.NO	Microscope Reading		$h= h_1 - h_2$
	water level in capillary tube(h_1)	water level in capillary tube(h_2)	
1			

Applications of capillarity:

- **Oil rises in the cotton wick**
- **A sponge retains water**
- **Water rises to other parts of the plants.**

Application of Surface Tension:

- It causes small droplets of rain to stick to your windows, creates bubbles
- When you add detergent in your sink, and propel water creates bubbles
  Striding insects on the surface of ponds.
- Surface tension prevents water from passing through the pores of an umbrella.
- A duck is able to float on water as its feathers secrete oil that lowers the surface tension of water.

Worked examples

1. **A capillary tube of diameter 0.5 mm is dipped into a liquid vertically and the liquid rises to a height of 6 cm. If the density of the liquid is 1000 kgm^{-3}, calculate the value of surface tension of the liquid. (g =9.81ms^{-2})**

Diameter of the capillary tube 2r = 0.5 mm

Radius of the capillary tube r = 0.25×10^{-3} m

Rise of liquid in the tube h = 6 cm = 6×10^{-2} m

Density of the liquid $\rho = 1000 kg\ m^{-3}$

Liquid being water, angle of contact $\theta = 0°$

Surface tension of the liquid $T = \frac{h\rho g r}{2 \cos \theta}$

$$\frac{6 \times 10^{-2} \times 1000 \times 9.81 \times 0.25 \times 10^{-3}}{2 \cos \theta}$$

T = 72.5×10^{-3} Nm^{-1}

2. A capillary tube of radius 0.04cm is dipped in water vertically and water rises to a height of 4cm.If the density of water is 1000kgm^{-3}. Calculate the surface tension of water.

r=0.04cm=0.04×10^{-2} m

h=4cm =4×10^{-2} m

$\rho = 1000 kgm^{-3}$

g=9.8ms^{-2}

$$T=\frac{r\ h\rho g}{2} = \frac{0.04\times10^{-2}\ \times4\times10^{-2}\times1000\times9.8}{2}$$

$$T=\frac{1568\times10^{-4}}{2} = 784 \times 10^{-4} Nm^{-1}$$

T=0.0784Nm^{-1}

3.A capillary tube of 0.45mm diameter is dipped into a liquid of density of water is 1000kgm^{-3}. If the rise of the liquid in the tube is 6.4cm.Calculate the surface tension of the liquid.

d=0.4mm=0.225×10^{-2} m

h=6.4cm =6.4×10^{-2} m

$\rho = 1000\text{kgm}^{-3}$

$g=9.8ms^{-2}$

$$T=\frac{r\ h\rho g}{2}=\frac{0.225\times10^{-2}\ \times6.4\times10^{-2}\times1000\times9.8}{2}$$

$$T=\frac{14412\times10^{-4}}{2}=7056\times10^{-4}Nm^{-1}$$

$T=0.07056Nm^{-1}$

4.Calculate the diameter of a capillary tube in which a liquid rises 2.34×10^{-2} m. Surface tension of the liquid is 25×10^{-3} Nm^{-1}. Relative density of the liquid is 0.79. Angle of contact = 11°12'. (g = $9.81 ms^{-2}$)

Relative density of the liquid = 0.79

Density of the liquid $\rho = 0.79 \times 10^3$ kgm^{-3}

Diameter of the tube = $2r = 5.41 \times 10^{-4}$ m

$$\text{We know } T = \frac{h\rho g r}{2\cos\theta}$$

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

$$= \frac{2 \times 25 \times 10^{-3} \cos 11^0 12'}{2.34 \times 10^{-2} \times 0.79 \times 10^3 \times 9.81} = 2.705 \times 10^{-4}\ m$$

5.A liquid of density 1000 kgm^{-3} is taken in a beaker. A capillary tube of diameter 1.0 mm is dipped vertically in it. Calculate the rise of liquid in the tube. Surface tension of the liquid is $72 \times 10^{-3} Nm^{-1}$.

For water, angle of contact θ = 0°

Surface tension T = 72×10^{-3} Nm^{-1}

Diameter of the capillary tube 2r = 1 mm

Radius of the capillary tube $r = 0.5 \times 10^{-3}$ m

$h = 2.939 \times 10^{-2}$ m

$$\text{Rise of liquid in the tube } h = \frac{2T\cos\theta}{r\rho g}$$

$$h = \frac{2 \times 72 \times 10^{-3} \cos 0^0}{0.5 \times 10^{-3} \times 1000 \times 9.8} = 2.939 \times 10^{-2}\ m$$

2. **A capillary tube of internal diameter 0.5 mm is dipped into a liquid of density 1140 kgm^{-3}. The liquid rises to a height of 2.6 cm in the capillary tube. If the angle of contact of liquid with glass is 55°, calculate the surface tension of the liquid.**

Diameter of the capillary tube = 0.6 mm

Radius of the capillary tube $r = 0.3 \times 10^{-3}$ m

Density of the liquid, $\rho = 1140\ kg\ m^{-3}$

Height through which liquid rises $h = 2.6 \times 10^{-2}$ m

Angle of contact, θ = 55°

$$\text{Surface tension of the liquid } T = \frac{h\rho g r}{2\cos\theta}$$

$$T = \frac{2.6 \times 10^{-2} \times 0.3 \times 10^{-3} \times 1140 \times 9.8}{2\cos 55^0}$$

$T = 75.96 \times 10^{-3}\ Nm^{-1}$

QUESTIONS

Part -A and Part- B

1. Define stress
2. Define strain
3. Which is more elastic, rubber or steel and why?
4. What is elastic limit and plastic limit?
5. Define elastic body and plastic body.
6. What are the three modulii of elasticity?
7. Define (i) linear strain (ii) bulk strain and (iii) shearing strain.
8. Write the statement of Hooke's law.
9. Define Modulus of elasticity
10. Define (i) Young's modulus (ii) Bulk modulus and (iii) Rigidity modulus.
11. Define Poisson's ratio.
12. What is uniform bending of a beam?
13. What is non uniform bending of a beam?
14. Define coefficient of viscosity.
15. Derive the dimensional formula and the SI unit for the coefficient of viscosity.
16. What is stream line motion?
17. What is turbulent motion?
18. What is Reynolds number?
19. What is critical velocity?
20. What is terminal velocity?
21. Write the application of viscosity.
22. Derive the S.I. unit and the dimensional formula of surface tension.
23. What is the effect of surface tension on the surface area of liquids?
24. The droplet of rain is spherical. Why?
25. How do insects run on the surface of water?
26. Define surface tension of a liquid.
27. Define angle of contact.
28. Write any two applications of capillarity.
29. What are uniform bending of beams.
30. What are non-uniform bending of beams
31. Explain young’s modulus
32. Explain Bulk modulus
33. Explain Rigidity modulus
34. Explain stream line motion
35. Explain turbulent motion

Part - C

1. Explain three types of modulus
2. Describe an experiment to determine the Young's modulus of the material of a bar by bending it uniformly.
3. Distinguish between stream line and turbulent motion.
4. Describe an experiment to determine the comparission of coefficient of viscosity of two viscous liquid by capillary flow method.
5. Describe Stokes' method of determining the coefficient of viscosity of a transparent, high viscous liquid.
6. Derive an expression for the surface tension of a liquid in the case of the capillary rise.
7. Describe an experiment to determine the surface tension of water by capillary rise method.
8. List the various applications of capillarity.

Exercise Problems

1. The length of a wire increases from 1.25 m to 1.2508 m when a load of 12 kg is suspended. The radius of the wire is 0.5 mm. Find the stress, strain and young's modulus of material of the wire.

   Ans: (149.7 × 10^6 Nm^{-2}, 6.4 x 10^{-4}, 23.4 × 10^{10} Nm^{-2}

2. What load in kilogram must be applied to a steel wire of length 1m and diameter 0.05 cm to produce an extension of 1 cm. The Young's modulus of steel = 2 × 10^{11}. Pa.

   Ans: 40 kg

3. A wire 10m long of area of cross section 1.22cm^2 elongates by 1.5 cm when 4.5 kg is suspended from it. Find the (i) stress (ii) strain and (iii) young's modulus of the wire. (g = 9.8m s^{-2})

   Ans: (i) 3.528 × 105Nm^{-2} (ii) 0.0015 (iii) 2.352 × 10^8 Nm^{-2}

4. A body of mass 5kg is suspended by means of a steel wire of length 1 m and diameter 1mm. The Young's modulus of steel is 21 × 10^{10} Nm^{-2}, calculate the elongation of the wire.

   Ans: l = 2.97 × 10^{-4} m

5. A uniform metal bar, one metre long, is placed symmetrically on two knife-edges separated by a distance of 64.2 cm. When two equal weights of 0.5 kg each are suspended from points 5cm from the two ends respectively, the mid-point of the bar is elevated by 0.76 mm. Calculate the Young's modulus of the material of the bar if the width of the bar is 2.2 cm and its thickness
   0.62 cm.

   Ans: 9.81 × 10^{10} Nm^{-2}

6. Calculate the surface tension of water if it rises to a height of 4.2cm in a capillary tube dipped verti- cally in it. Radius of the capillary tube is 3.5 × 10^{-4} m.

   Ans: 72.03 × 10^{-3} Nm^{-1}

7. A capillary tube of diameter 0.5 m is dipped into a liquid vertically and the liquid rises to a height of 4.4 cm. If the density of the liquid is 1000 kg m^{-3}, calculate the value of the surface tension of the liquid.
8. A capillary tube of bore 0.84 mm in dipped into a liquid of density 840 kgm^{-3} and surface tension 0.049 Nm^{-1}. Find the rise of the liquid in the tube.

Brain teasers

1. A wire of diameter 2.5 mm is stretched by force of 980 N. If the Young's modulus of the material of the wire is 12.5×10^{10} Nm^{-2}. Find the percentage increase in the length of the wire.
2. Two wires are made of same material. The length of the first wire is half of the second wire and its diameter is double that of the second wire. If equal loads are applied on both the wires find the ratio of increase in their lengths.
3. The diameter of a brass rod is 4 mm. Calculate the stress and strain when it is stretched by 0.25% of its length. Find the force exerted ($E = 9.2 \times 10^{10}$ Nm^{-2} for brass)

UNIT-3

DYNAMICS - I

STRAIGHT LINE MOTION

Introduction:

- Dynamics is a branch of mechanics which deals with the motion of the bodies under the action of forces.
- A body is said to be at rest if it does not change its place or position with respect to its surroundings. No body in this earth is at absolute rest.
- Because, they are sharing the motion of the earth.
- A body can be at rest with respect to another body.

Newton's Laws of motion: These laws are very important in dynamics.

I Law: Everybody continues to be in its state of rest or of uniform motion in a straight line unless compelled by an external force.

II Law: The rate of change of momentum of a body is directly proportional to the force acting on it and it takes place in the direction of the force.

III Law: For every action, there is always an equal and opposite reaction.

In this unit we shall study about the Projectile motion, Circular motion, its application and Simple Harmonic Motion.

Equations of motion: Let u = initial velocity, v = final velocity, a = acceleration, t = time and s = displacement.

(I) For Objects in motion

(1) $v = u + at$

(2) $s = ut + 1/2\ at^2$

(3) $v^2 = u^2 + 2as$

(ii) For objects falling freely

Here initial velocity u = 0 and a =+g

(1) $v = gt$

(2) $S = \frac{1}{2} gt^2$

(3) $v^2 = 2gs$

(iii) For objects thrown vertically upwards

Here a = -g

(1) $v = u - gt$

(2) $s = ut - \frac{1}{2} gt^2$

(3) $v^2 = u^2 - 2gs$

Projectile:

- **A body projected into space with a given velocity in a particular direction is called projectile.**
- Example: A stone projected at an angle, a bomb released from an aeroplane, a shot fired from a gun, a shotput or javelin thrown by the athlete are the various examples for the projectile.

Velocity of projectile:

- **The velocity with which the projectile is projected is called velocity of projection**

Maximum height of projectile:

- **The maximum vertical displacement from the horizontal plane is called maximum height of the projectile**

Maximum range of projectile:

- **The distance between the point of the projection to the point where it reaches the horizontal plane is called range of the projectile**

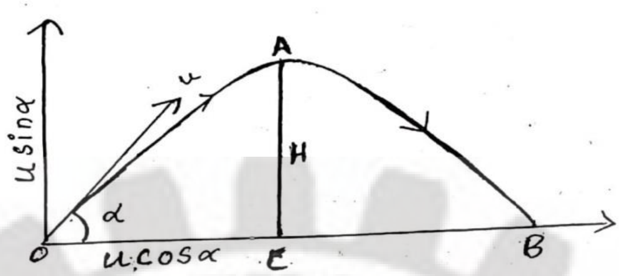
Time of the projectile:

- **The time taken from the point of projection to the point when it reaches the horizontal plane is called time of projectile**

Trajectory:

- **The path of projectile is called trajectory**

Derive the expression for maximum height of a projectile:



- **Consider a particle is projected from the point 'o'.**
- **u-initial velocity**
- **α- Angle**
- **OAB- Trajectory of the projectile.**
- **Horizontal component of = ucos α**
- **Vertical component of =usin α**

Derivation:

$v^2 = u^2 + 2as$-------------------**(1)**

$u = \mathrm{usin}\,\alpha$

$v = 0,$ **a=-g , S=H -------------(2)**

substituting equation(1) in equation(2)

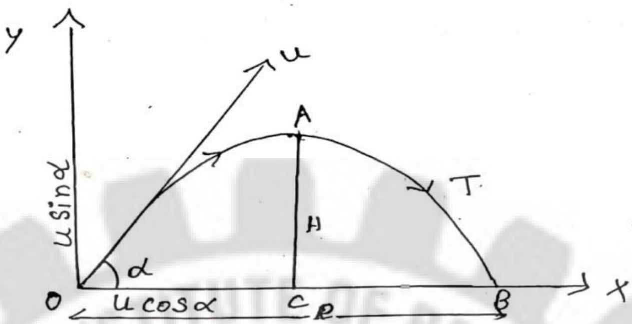
$0^2 = (\mathrm{usin}\alpha)^2 + 2(-\mathrm{g})\mathrm{H}$

0=$u^2 \sin^2 \alpha$ **-2gH**

2gH =$u^2 \sin^2 \alpha$

$$\boxed{H=\frac{u^2 \sin^2 \alpha}{2g}}$$ **----------(3)**

Derive the expression for time of flight and range a projectile:



- Consider a particle is projected from the point ‘o’.
- u-initial velocity
- α- Angle
- OAB- Trajectory of the projectile.
- OB= R(Range)
- T= Time of the projectile
- Horizontal component of = $\mathbf{ucos\ \alpha}$
- Vertical component of =$\mathbf{usin\ \alpha}$

Derivation:

$S = ut + \frac{1}{2}at^2$ --------------------(1)

$u = \mathbf{usin\ \alpha}$

$s = 0$, a=-g , t=T -------------(2)

substituting equation(1) in equation(2)

0=u Sinα .T + $\frac{1}{2}(-g)T^2$

0= u Sinα .T $-\frac{1}{2}gT^2$

$\frac{1}{2}gT^2 =$ u Sinα .T

$$\boxed{T = \frac{\mathbf{2u\ Sin\alpha}}{\mathbf{g}}}$$ ----------(3)

Range of projectile:

R= Horizontal Velocity X Time

R=$\mathbf{u\ cos\ \alpha}$ X $\frac{\mathbf{2u\ Sin\alpha}}{\mathbf{g}}$

R= $\frac{\mathbf{u \cos \alpha \ X \ 2u \ Sin\alpha}}{\mathbf{g}}$

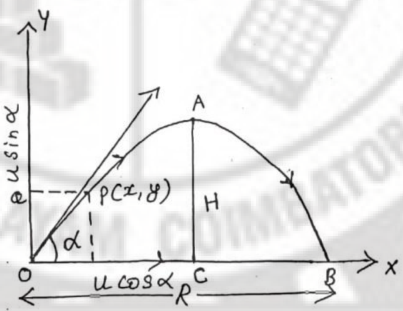
R= $\frac{\mathbf{u^2 \ 2\cos \alpha \ Sin\alpha}}{\mathbf{g}}$

R= $\frac{\mathbf{u^2 \ Sin2\alpha}}{\mathbf{g}}$ **(α=45°, 2α = 2(45°)=90°)**

R= $\frac{\mathbf{u^2 \ Sin2}(45^\circ)}{\mathbf{g}}$

$\boxed{R = \frac{\mathbf{u^2}}{\mathbf{g}}}$ **----------(3)**

Prove that the path of a projectile is a parabola:



- **Consider a particle is projected from the point 'o'.**
- **u-initial velocity**
- **α- Angle**
- **OAB- Trajectory of the projectile.**
- **AC= H, OB= R.**
- **Horizontal component of = $\mathbf{u\cos\alpha}$**
- **Vertical component of =$\mathbf{usin\ \alpha}$**
- **t=** $\frac{\mathbf{displacement}}{\mathbf{horizontal\ component}} = \frac{\mathbf{x}}{\mathbf{u\cos\alpha}}$

Derivation:

$S = ut + \frac{1}{2}at^2$ **--------------------(1)**

$u = \text{usin}\,\alpha$

$s = y$, a=-g , t =$\frac{x}{u\cos\alpha}$-------------(2)

substituting equation(1) in equation(2)

y=u Sinα . $\frac{x}{u\cos\alpha} + \frac{1}{2}(-g)(\frac{x}{u\cos\alpha})^2$

y=$x(\frac{\sin\alpha}{\cos\alpha}) \; -x^2(\frac{g}{2u^2\cos^2\alpha})$

y= (tanα)x $- x^2\left(\frac{g}{2u^2\cos^2\alpha}\right)$

$\boxed{y = bx - cx^2}$ ----------(3)

<u>Example of projectile motion:</u>

- Throwing a ball.
- A motion of a shell fired from a gun.
- A motion of a boat in a river.
- The motion of the earth around the sun.

SOLVED PROBLEMS

1. **A body is thrown with a velocity of projection 49 ms^{-1} at an angle of projection 45°. Find (i) Maximum height (ii) Time of flight (iii) Range (g= 9.8 ms^{-2}).**

Given

u = 49ms^{-1}

α = 45°

Maximum height, H = $\frac{u^2\sin^2\alpha}{2g}$

$= \frac{49 \times 49 \times \sin 45^0 \times \sin 45^0}{2 \times 9.8}$

= 61.25 m

Time of flight,T =

$\frac{2u\sin\alpha}{g}$

$$= \frac{2 \times 49 \times \sin 45}{9.8}$$

$= 7.07$ s

$$\text{Range,R} = \frac{u^2 \sin 2\alpha}{g}$$

$$= \frac{49 \times 49 \times \sin (2 \times 45)}{9.8}$$

$$= \frac{49 \times 49 \times \sin 90}{9.8}$$

$= 245$ m

2. **A bullet fired from a gun with a velocity of 80 ms-1 strikes the ground at the same level as the gun at a distance of 460 m. Find the angle of inclination with the horizontal at which the gun was fired.**

Given

$u = 80\ ms^{-1}$, $R = 460$ m, $g = 9.8\ ms^{-2}$

$$\text{Range R} = \frac{u^2 \sin 2\alpha}{g}$$

$$\text{Sin } 2\alpha = \frac{g.R}{u^2} = \frac{9.8 \times 460}{(80)^2} = 0.7044$$

$2\alpha = \text{Sin}^{-1}\ (0.7044) = 44°\ 46'$ $\quad\therefore\ \alpha = 22°\ 23'$

3. **The range of a projectile is equal to double the maximum height attained. Find the angle of projection.**

Given

Horizontal range = 2 × maximum height

ie., R = 2H

$$\frac{u^2 \sin 2\alpha}{g} = 2\,\frac{u^2 \sin^2 \alpha}{2g}$$

$\sin 2\alpha = \sin^2 \alpha$

$2 \sin \alpha \cos \alpha = \sin \alpha \sin \alpha$

$2 \cos \alpha = \sin \alpha$

$\therefore\ \tan \alpha = 2$

$\therefore\ \alpha = \tan^{-1}\ (2) = 63°26'$

4. **A projectile is thrown at an angle and another is thrown at (90-) from the same point both with the velocities 78.4ms^{-1}. The second reaches 36.4m higher than the first. Find the individual heights.**

Given

Angle of projection of first projectile = θ

Angle of projection of second projectile = $(90 - \theta)$ Velocity of projection $u = 78.4\ ms^{-1}$

and $H_2 = H_1 + 36.4m$

$H_2 - H_1 = 36.4m$

Where H_1 is the maximum height of first one and H_2 is the maximum height of second one.

$$H_1 = \frac{u^2 \sin^2\theta}{2g} \text{ and } H_2 = \frac{u^2 \sin^2(90-\theta)}{2g} = \frac{u^2\cos^2\theta}{2g}$$

Adding, $$H_2 + H_1 = \frac{u^2\cos^2\theta}{2g} + \frac{u^2\sin^2\theta}{2g}$$

$$= \frac{u^2}{2g} = \frac{78.4 \times 78.4}{2 \times 9.8} = 313.6$$

$$2H_2 = 36.4 + 313.6 = 350$$

$$H_2 = 175 \text{ m}$$

Also, $H_1 = H_2 - 36.4 = 175 - 36.4$

$H_1 = 138.6$ m

CIRCULAR MOTION

Introduction:

- In this chapter we study the motion of the bodies moving in a circular path.
- The motion of the body in a circular path is called circular motion.
- The motion of the body in the circular path with uniform velocity is called uniform circular motion. When it is in uniform velocity, the direction of motion at any point is along the tangent to the circle at that point. If the body is set free, it would move in the direction of the tangent at that point.

Angular Velocity:

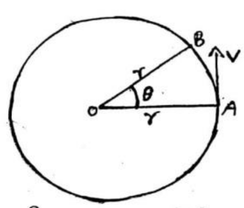
Angle turned by the radius vector in one second is called angular velocity:

Angular velocity $\omega = \frac{\theta}{t}$

The angle covered or swept or turned by the radius vector in one second is known as angular velocity.

SI Unit of angular velocity is radian / second (rad s^{-1})

Write the relationship between linear velocity and angular velocity:



Angular velocity=$\omega=\frac{\theta}{t}$ ---------(1)

Linear velocity =v=$\frac{AB}{t}$ ----------(2)

InΔOAB

$\sin\theta=\frac{AB}{r}$

θis very small , sinθ=θ

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

AB=r.θ ----------------------(3)

substituting equation(2) in equation(3)

$v=\frac{r.\theta}{t}$ =r ω ($\omega=\frac{\theta}{t}$)

v =r ω

Simple harmonic motion:

- It is a periodic motion of a particle in which the acceleration is always directed towards the centre

period:

- The time taken to complete one vibration is called period

Frequency (n): Frequency of revolution of a particle is the number of revolutions made in one second.

Normal acceleration:

- When a particle is moving along the circular path, the particle is accelerator towards the centre and it is called normal acceleration.

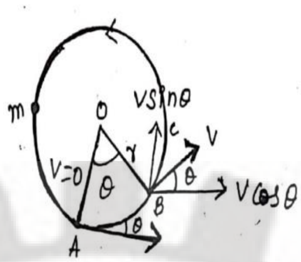
Centripetal:

- When a particle is moving along the circular path a force is acting on the particle towards the centre of the circular path is called centripetal force.$F=\frac{mv^2}{r}$

Centrifugal:

- When a particle is moving along the circular path a force is acting on the particle away from the centre of the circular path is called centripetal force $F=-\frac{mv^2}{r}$

Derive the expression for normal acceleration:



Description:

- **Consider a particle is moving along a circular path.**
- **r= radius of the circular path**
- **initially the object is A**
- **after t seconds, it reaches ‘B’**

Derivation:

Angular velocity=$\omega = \frac{\theta}{t}$ **---------(1)**

velocity along OA=0

velocity along BC= V Sinθ

Change In Velocity=V Sinθ**-0**

= V Sinθ

Time=t

Normal Acceleration=a=$\frac{\text{change in velocity}}{time} = \frac{\text{V Sin}\theta}{t}$ **----------(2)**

θ **is very small , sin**θ**=**θ

So, $a = \frac{v.\theta}{t}$

a =vω**---------(3)**

(i) When v=rω**, a =r**ω**.** ω

$$\boxed{a = rW^2}$$ **---------(4)**

(ii) when $\omega = \frac{v}{r}$ **,** $a = v\ \frac{v}{r}$

$$\boxed{a = \frac{v^2}{r}}$$ **----------(5)**

SOLVED PROBLEMS

1. **A ball weight 1 kg tied to one end of string of length 2m is whirled at a constant speed of $10ms^{-1}$. Calculate the centripetal force on the ball.**

   M=1kg

   $V=10ms^{-1}$

   r=2m

   $F=\frac{mv^2}{r}$

$F=\frac{1\times10\times10}{2}=\frac{100}{2}=50N$

2.A ball weighing 0.5 kg is tied to one end of a string and is whirled at a constant speed of 10ms-1 in a horizontal plane. If the length of the string is 1m, calculate the normal acceleration and the tension in the string.

Given

$m = 0.5$ kg, $v = 10ms^{-1}$ $l = r = 1m$ a = ? F = ?

Normal acceleration $a = \frac{v^2}{r} = \frac{(10)^2}{1} = 100\ ms^{-2}$.

Tension in the string (Cntripetal force)

$F = \frac{mv^2}{r} = 0.5 \times (10)^2 = 50N$

3.A body of mass 1 kg is tied to a string of length 1m revolves in a horizontal circle. If the angular velocity is 3 rad s^{-1}, calculate the centripetal force acting on the body.

Given : $m = 1$ kg, $l = r = 1$ m, $\omega = 3$ rad s^{-1}

Centripetal force $F = mr\omega^2 = 1 \times 1 \times (3)^2 = 9$

4.Find the centripetal force on a body of mass 500 g when it revolves in a circle of radius 1.5m. The body makes 120 R.P.M.

Given : m = 500 g = 0.5 kg, r=1.5m

No. of revolutions = 120 per minute

i.e.,$n = \frac{120}{60}$ = 2 revolutions per second

Centripetal force $F = m\, r\, \omega^2$

$= mr(2\pi n)^2$ (since $\omega = 2\pi n$)$= 4\pi^2 mrn^2$

$= 4 \times 3.14 \times 3.14 \times 0.5 \times 1.5 \times 2^2$

F = 118.4N

5. **A mass of 5kg is moving in a circle of radius 1m. If the centripetal force acting on the mass is 20N, find the linear velocity and angular velocity.**

Given : F = 20N, r = 1m, m = 5 kg

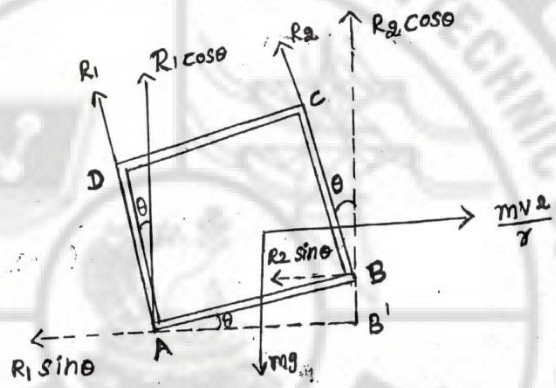
$$F = \frac{mv^2}{r}$$

$$v^2 = \frac{Fr}{m} = \frac{20 \times 1}{5} = 4$$

$$v = 2\ ms^{-1}$$

Angular velocity, $\omega = \frac{v}{r} = \frac{2}{1} = 2\ rad\ s^{-1}$

Derive the expression for the angle of banking of a curved path:



Description:

- **Consider a train is moving along a curved path.**
- **R-radius of the curved path**
- **θ -angle**
- **m- mass**
- **v-velocity of the train**

Derivation:

Total vertical component of R_1 and R_2= $(R_1+R_2)\cos\theta$-----(1)

Total horizontal component of R_1 and R_2= $(R_1+R_2)\sin\theta$-----(2)

weight of the body =mg ----(3)

centripetal force=$\frac{mv^2}{r}$ ------(4)

Total vertical component= weight of the body

$(R_1+R_2)\cos\theta$= mg-----------(5)

$(R_1+R_2)\sin\theta = \frac{mv^2}{r}$-----------(6)

$$\frac{\text{equation (6)}}{\text{equation(5)}} \Rightarrow \frac{(R1+R2)\sin\theta}{(R1+R2)\cos\theta} = \frac{\frac{mv^2}{r}}{mg}$$

tan Θ=$\frac{v^2}{rg}$

$$\boxed{\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)}$$ ----------(5)

Application of centripetal:

i) Motion in a vertical circle
(ii) Motion on a level circular road
(iii)Bending of a cyclist round a curve (Condition for skidding)

Application of centrifugal:

1. **Washing machine**
2. **Sperating cream from milk**

1.An electric train has travel on a railway track with a bend of radius 120m with speed of 45 kmph. Calculate the angle of banking.

r=120m

V=45kmph =45$\times\frac{5}{18}$= 12.5ms^{-1}

$$\theta = \tan^{-1}(\frac{v^2}{rg})$$

$$\theta = \tan^{-1}(\frac{12.5 \times 12.5}{120 \times 9.8})$$

$$= \tan^{-1}(0.1327)$$

$$\theta = 7^\circ\, 30'$$

2. **A scooter rider negotiates a curve of 100m radius on a level road with a speed of 72kmph. Calculate the angle of banking he should make to avoid falling.**

r=100m

V=72kmph =72$\times\frac{5}{18}$=20ms^{-1}

$$\theta = \tan^{-1}(\frac{v^2}{rg})$$

$$\theta = \tan^{-1}\left(\frac{20 \times 20}{100 \times 9.8}\right)$$

$$= \tan^{-1}(0.4082))$$

$$\theta = 22^\circ 2'$$

UNIT-4

DYNAMICS - II

INTRODUCTION:

Rigid body:

- **A body in which the distance between the particles are unchanged by any external force**

Moment of inertia of a particle:

- **It is the product of mass and square of the distance from the axis of rotation.**

Radius of gyration:

- **The radius of gyration is the distance between the axis of rotation and the point where the entire mass of the rigid body is supposed to be concentrated. I=MK^2**

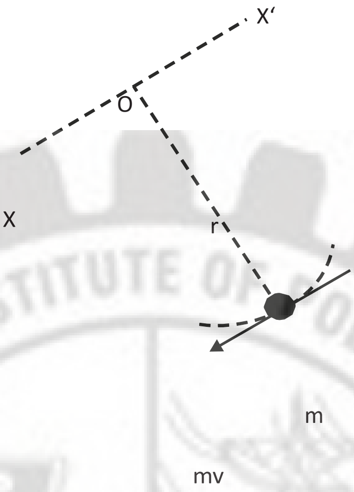
Angular momentum:

- **Momentum of linear momentum is called angular momentum**

Then, Angular momentum of the particle = linear momentum × perpendicular distance between the particle and the axis of rotation

= m v × r

$= m\,r\,\omega \times r \qquad (\because v = r\omega)$

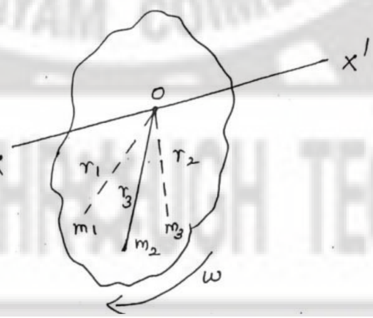


$\therefore$ Angular momentum = $mr^2\omega$

Where ω is the angular velocity of the particle.

The SI unit for angular momentum is kg $m^2\,s^{-1}$

Derive the expression for kinetic energy of a rigid body rotating about an axis:



Description:

- **Consider a rigid body is rotating about an axis XOX'**
- **m_1, m_2, m_3……… masses of the particle**
- **r_1, r_2, r_3…………distance of the particle**
- **ω ……………… angular velocity**
- **v ………………..linear velocity**

Derivation:

Kinetic energy = $\frac{1}{2}\mathrm{mv}^2 \quad = \frac{1}{2}\mathrm{mr}^2\omega^2$

K.E $_1$ =$\frac{1}{2}\mathrm{m}_1\mathrm{r}_1^2\omega^2$

K.E $_2$ =$\frac{1}{2}\mathrm{m}_2\mathrm{r}_2^2\omega^2$

K.E $_3$ =$\frac{1}{2}\mathrm{m}_3\mathrm{r}_3^2\omega^2$

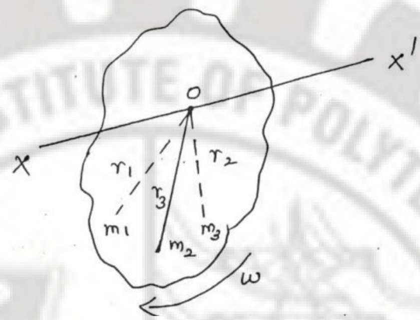
K.E =$\frac{1}{2}\mathrm{m}_1\mathrm{r}_1^2\omega^2 + \frac{1}{2}\mathrm{m}_2\mathrm{r}_2^2\omega^2 + \frac{1}{2}\mathrm{m}_3\mathrm{r}_3^2\omega^2 + \cdots$

=$\frac{1}{2}\omega^2\left(\mathrm{m}_1\mathrm{r}_1^2 + \mathrm{m}_2\mathrm{r}_2^2 + \mathrm{m}_3\mathrm{r}_3^2 + \cdots\right)$

=$\frac{1}{2}\omega^2\sum \mathrm{mr}^2$

K.E =$\frac{1}{2}\mathrm{I}\omega^2$

Derive the expression for angular momentum of a rigid body rotating about an axis:



Description:

- **Consider a rigid body is rotating about an axis XOX'**
- **m_1, m_2, m_3……… masses of the particle**
- **r_1, r_2, r_3…………distance of the particle**
- **ω ……………… angular velocity**
- **v ………………..linear velocity**

Derivation:

Angular Momentum = Linear Momentum × Distance

$$L = mv \times r$$

$$= mvr$$

$$L = mr^2\omega$$

$$L_1 = m_1 r_1^2 \omega$$

$$L_2 = m_2 r_2^2 \omega$$

$$L_3 = m_3 r_3^2 \omega$$

$$L = m_1 r_1^2 \omega + m_2 r_2^2 \omega + m_3 r_3^2 \omega + \cdots$$

$$= \omega\left(m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + \cdots\right)$$

$$= \omega \sum mr^2 = \omega I$$

$$L = \omega I$$

- <u>Law of conservation of angular momentum with example</u>:

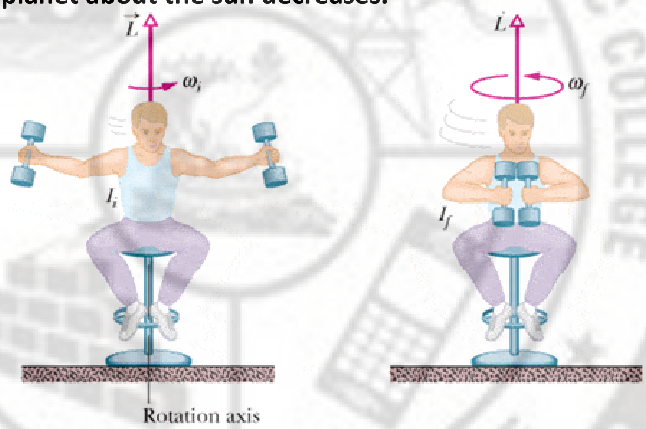
When no external torque acts on the body, the net angular momentum of rotating rigid body remains constant. This is known as law of conservation of angular momentum.

Total angular momentum of the body= constant

$L=I\omega$ = constant

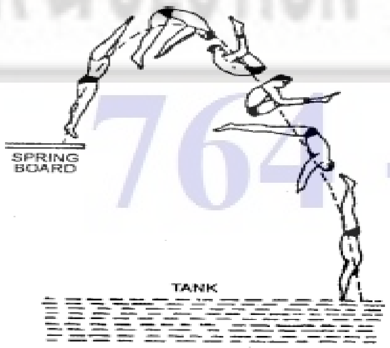
- <u>**Example for law of conservation of angular momentum:**</u>

1. **A person sitting on a turntable holding a pair of heavy dumbbells one in each hand with arms outstretched. The table is rotating with a certain angular velocity. The person suddenly pushes the weight towards his chest. The speed of rotation is found to increase considerably.**
2. **The angular velocity of a planet in its orbit round the sun increases when it is nearer to the sun as the moment of inertia of the planet about the sun decreases.**



(a) (b)

3. **A spring board diver, while jumping into a swimming pool , curls himself in such a way that his feet and head are driven close to each other.**
4. **Gymnasts curl their body during floor exercises.**
5. **A helicopter is provided with two propellers.**
6. **The speed of wind in the inner layers of tornedo is very high.**
7. **Planets move round the sun in elliptical orbits with sun situated at one of its foci.**



v

GRAVITATION

Newton's laws of Gravitation:

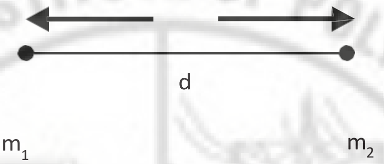
Law 1 : Any two particles of matter attract each other with a force

Law 2 : The force of attraction between any two objects is

i. **directly proportional to the product of the masses**

ii. **inversely proportional to the square of the distance between them.**

If m_1, m_2 are masses of two particles, separated by a distance 'd' then the force of attraction between the particles,



$$F \propto \frac{m_1 m_2}{d^2}$$

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

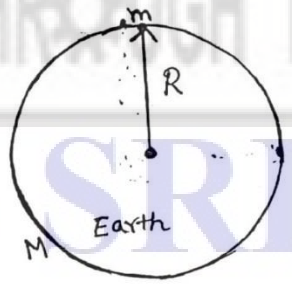
where G is known as "universal gravitational constant" and the value of G = 6.6733×10^{-11} N $m^2 kg^{-2}$

Newton's law of gravitation:

- **The force of attraction between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance them.**

$$\boldsymbol{F = \frac{Gm_1 m_2}{r^2}}$$

Derive the expression for the acceleration due to gravity on the surface of the earth:



- **m- mass of the body is placed on the surface of the earth**
- **M-mass of the earth**
- **R-radius of the earth**
- **Gravitational Force F=** $\frac{\mathbf{GMm}}{\mathbf{R^2}}$ $----(1)$

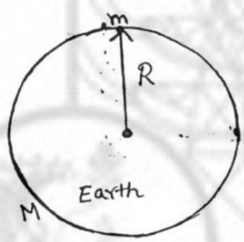
- **Weight of the body w=mg---------------(2)**

Equation (1)=(2)

$\frac{GMm}{R^2}$ **=mg**

$$\boxed{g=\frac{GM}{R^2}----(3)}$$

Derive the expression for the acceleration due to gravity on the surface of the earth:



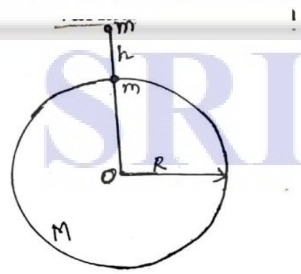
- **m- mass of the body is placed on the surface of the earth**
- **M-mass of the earth**
- **R-radius of the earth**
- **Gravitational Force F=** $\frac{GMm}{R^2}$ $----(1)$
- **Weight of the body w=mg---------------(2)**

Equation (1)=(2)

$\frac{GMm}{R^2}$ **=mg**

$$\boxed{g=\frac{GM}{R^2}----(3)}$$

Derive the expression for the variation of acceleration due to gravity 'g' with the attitude:



- **m- mass of the body is placed on the surface of the earth**
- **M-mass of the earth**
- **R-radius of the earth**

$$g=\frac{GM}{R^2}----(1)$$

$$g_h=\frac{GM}{(R+h)^2}----(2)$$

$$\frac{\text{Equation}(2)}{\text{Equation}(1)} => \frac{g_h}{g}=\frac{\frac{GM}{(R+h)^2}}{\frac{GM}{R^2}}$$

$$\frac{g_h}{g}=\frac{GM}{(R+h)^2}\times\frac{R^2}{GM} =\frac{R^2}{(R+h)^2}$$

$$\frac{g_h}{g}=\frac{R^2}{R^2(1+\frac{h}{R})^2} => \frac{g_h}{g}=\frac{1}{(1+\frac{h}{R})^2}$$

$$\frac{g_h}{g}=(1+\frac{h}{R})^{-2}$$

$$\frac{g_h}{g}=(1-\frac{2h}{R})$$

$$\boxed{g_h=g\left(1-\frac{2h}{R}\right)--(3)}$$

Satellite:

- **A body revolving round a planet is called satellite. Two type of satellite**

1. **Natural satellite**
2. **Artificial satellite**

Natural satellite:

- The objects that are moving in orbit by nature itself around a planet are called natural satellites. For example, moon is the natural satellite for the earth.

Artificial satellite:

- The earth is a satellite for the sun. Man also has placed artificially some satellites to move in orbit around the desired planets. These satellites are called artificial satellite. EX: Apple, Baskara ,Rohini,

Escape velocity:

- **Minimum velocity require to project an object from the earth's surface to escape from the gravitational pull**

Orbital velocity:

- **The velocity with which the satellite revolves around the earth**

<u>Derive the expression for escape velocity.</u>

Description:

- **m- mass of the body is placed on the surface of the earth**
- **M-mass of the earth**
- **R-radius of the earth**

DERIVATION:

Gravitational Force F= $\frac{GMm}{R^2} \quad ----(1)$

w=mg---------------(2)

Equation(1)=(2)

$\frac{GMm}{R^2}$ **=mg**

GM=g$R^2 \ ------ (3)$

The K.E is converted into work

w= F× d

dw= $\frac{GMm}{R^2} \times \ dr$

$$\int dw = \int_R^\infty \frac{GMm}{R^2} \times dr$$

$$\int dw = \int_R^\infty \frac{GMm}{r^2} \times dr$$

W=GMm $\int_R^\infty \frac{1}{r^2}\ dr$

W=GMm $\left(\frac{2-1}{r^{2-1}}\right)_\infty^R = GMm\left(\frac{1}{r^1}\right)_\infty^R$

W= $GMm\left(\frac{1}{R}-\frac{1}{\infty}\right)$**=** $GMm\left(\frac{1}{R}\right)$

W= $\frac{GMm}{R}$

W=$\frac{GMm}{R}$ **----------(4)**

kinetic energy = $\frac{1}{2}mv_e^2 \quad ---(5)$

Equation(4)=(5)

$\frac{1}{2}mv_e^2=\frac{GMm}{R}$

$$v_e^2 = \frac{GMm}{R} \times \frac{2}{m}$$

$v_e^2 = \frac{2GM}{R}$-------------------(6)

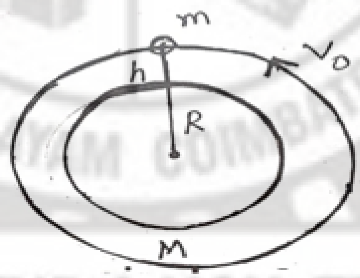
substitute equation(3)in (6)

$$v_e^2 = \frac{2gR^2}{R}$$

$$v_e^2 = 2g\,R$$

$$\boxed{V_e = \sqrt{2g\,R} \text{ ----(7)}}$$

Derive the expression for orbital velocity



Description:

- **m- mass of the body is placed on the surface of the earth**
- **M-mass of the earth**
- **R-radius of the earth**

Derivation:

Gravitational Force F= $\frac{GMm}{R^2}$ $----(1)$

w=mg---------------(2)

Equation(1)=(2)

$\frac{GMm}{R^2}$ =mg

GM=gR^2 $-----(3)$

Centripetal Force F=$\frac{mv_o^2}{r}$-----(4)

Gravitational Force F= $\frac{GMm}{r^2}$ ---------(5)

Equation(4)=(5)

$\frac{mv_o^2}{r}=\frac{GMm}{r^2}$

$$v_o^2 = \frac{GMm}{r^2} \times \frac{r}{m}$$

$$v_o^2 = \frac{GM}{r} \quad (r=R+h)$$

$$v_o^2 = \frac{GM}{R+h} \text{----------}(6)$$

substitute equation(3)in (6)

$$v_o^2 = \frac{gR^2}{(R+h)} = \frac{gR^2}{R} \qquad (R+h\sim R)$$

$$\boxed{V_0 = \sqrt{g\,R} \text{ -----------(6)}}$$

__Polar and geostationary satellites:__

__Polar satellites:__

- Polar satellite is a satellite whose orbit is perpendicular and it passes over the north and south poles as it orbits the earth.
- It can be at any height from the earth, typically at 500-800 kms. As the earth rotates under it while it orbits the earth.
- Earth presents a different face at every pass, making it possible to map the entire earth surface with polar satellite over time.

Geostationary satellite:

- A Geostationary satellite is placed at an altitude of approximately 36000km directly over the equator that revolves in the same direction the earth rotates (west to east).
- At this altitude one orbit takes 24 hours, the same length of time as the earth requires rotating once on its axis.
- The term geostationary comes from the fact that such a satellite appears nearly stationary in the sky as seen by a ground based observer.
- Three satellites each separated by 120˚ of longitude, can provide coverage of the entire planet.
- It is used for telecommunication and TV.
- It is also used to broad cast the programme conducted in othercountries of TV shows lively.

Uses of Artificial Satellites:

- The artificial satellites are launched for many purposes by different countries. The important uses of artificial satellite are

i) Collection of scientific data
ii) Weather monitoring
iii) Military Spying
iv) Remote sensing
v) Communication purpose – the satellite receives microwaves and TV signals from the earth and amplifies them and transmits them back to various stations on the earth.

WORKED PROBLEMS

1. **If the radius of the earth is 6400km and the acceleration due to gravity is 9.8ms^{-2}. Calculate the escape velocity**

Given: R = 6400 km and g = 9.8 ms^{-2}

Escape velocity $V_0 = \sqrt{2gR} = \sqrt{2\times 9.8\times 6400\times 10^3}$

V_0 = 11.2 km per second

2. **A satellite is revolving round the earth at a distance of 182 km from the surface of the earth. The radius of the earth is 6371 km and g is 9.81 ms^{-2}. Calculate the orbital velocity of the satellite.**

Given: g = 9.81 ms^{-2}, R = 6371 × 10^3 m, h = 182 × 10^3 m

(R+h) = (6371 + 182) 10^3 = 6553 × 10^3 m

$$V_0 = \sqrt{\frac{gR^2}{(R+h)}} = \sqrt{\frac{9.81\times(6371\times10^3)^2}{}}$$

V_0 = 7795 ms^{-1} (or) 7.795 kms^{-1}

QUESTIONS

Part – A and B

1. Define rigid body
2. Define moment of inertia of a particle
3. Define moment of inertia of a rigid body
4. Define radius of gyration
5. Define angular momentum
6. State the law of conservation of angular momentum
7. State Newton's I law of gravitation
8. State Newton's II Law of gravitation
9. What is a satellite?
10. Define escape velocity
11. Define orbital velocity
12. Give any two uses of artificial satellites
13. Derive an expression for the moment of inertia of a rigid body about an axis.
14. Explain Newton's Law of Gravitation
15. Explain escape velocity and orbital velocity
16. Write the uses of artificial satelites

Part – C

1. Derive an expression for the kinetic energy of a rigid body rotating about an axis.
2. Derive an expression for the angular momentum of a rigid body rotating about an axis.
3. Obtain an expression for the acceleration due to gravity on the surface of the earth.
4. Obtain an expression for the variation of acceleration due to gravity with altitude.
5. Derive an expression for the escape velocity from the surface of the earth
6. Derive an expression for the orbital velocity of a satellite.

Exercise Problems

1. Find the escape velocity at the surface of the moon, given that the radius of moon is 2×10^6 m and acceleration due to gravity on the surface of moon is 1.69 ms^{-2}.
2. A satellite is revolving in circular orbit at a height of 800 km from the surface of the earth. Calculate the orbital velocity. The radius of the earth is 6400 km and g = 9.8 ms^{-2}

Brain teaser

1. The escape velocity from the surface of the earth is 11.2 kms^{-1}. Find the escape velocity from the surface of another planet where mass and diameter are twice that of earth.
2. What is the acceleration due to gravity at a distance from the centre of the Earth, which is equal to diameter of the Eart

UNIT-V

SOUNDANDMAGNETISM

SOUND

INTRODUCTION:

SOUND:

- Sound is produced due to the vibrations of the body. These vibrations are transferred to the air Medium and propagated in all directions in the form of waves.
- The number of vibrations made in one second is known as frequency of the sound. It is expressed in hertz (Hz).
- The range of the frequency between 20 Hz and 20,000 Hz is the audible range,
- Human ears cannot respond to the sound below and above this range.
- The vibrations of frequency below 20 Hz are called infrasonic and above 20,000 Hz are called ultrasonic.

Wave motion:

When a stone is thrown on a pond of water, ripples spread out in all directions on the surface of water. The stone disturbs the water medium at one place but the disturbance is transferred in all directions continuously. This continuous movement of the disturbance is called a wave.

There are two types of wave motion. They are

1) Longitudinal wave motion and

2) Transverse wave motion

1) Longitudinal wave motion:

If the particles of the medium vibrate parallel to the direction of propagation of the wave, the wave is known as longitudinal wave.

Examples:

1. The propagation of sound in air
2. The propagation of sound in gas
3. The propagation of sound inside the liquid

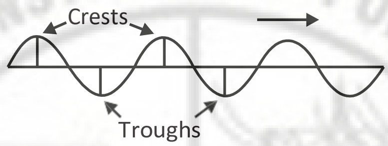
2) Transverse wave motion:

If the particles of the medium vibrate perpendicular to the direction of propagation of the wave, the wave is known as transverse wave.

Examples :

1. Ripples travelling on the water surfaces.
2. Waves travelling along a rope.
3. Other waves like light waves, heat radiations, radio waves etc.

The transverse waves travel in a medium in the form of crests and troughs. The points where the particles of the medium displaced maximum in the upward direction are called crests. The points where the particles displaced maximum in the downward direction are called. troughs



The crests and troughs produced by the transverse wave motion are as shown in the figure.

In transverse wave, alternate crests and troughs are transmitted in the medium.

As a result, the particles of the medium move up and down about their mean position perpendicular to the direction of propagation of the wave.

Progressive Waves:

- If a wave travels continuously in a medium without any disturbance, then the wave is said to be progressive wave. Longitudinal waves and Transverse waves are two types of progressive waves and they can travel continuously in any medium if there is no obstruction.

Amplitude:

- When sound wave propagates in a medium, the maximum displacement of the vibrating particles of the medium from their mean position is called amplitude.

Wavelength (λ) :

- The wavelength is the distance between two consecutive particles of the medium which are in the same state of vibration.
- It is also defined as the distance travelled by the wave during the time the vibrating particle completes one vibration.
- In longitudinal waves, the wavelength is the distance between two successive compressions or rarefactions. In transverse waves, the wavelength is the distance between two successive crests or troughs.

Period (T):

The time taken by the vibrating particle to make one vibration is called period.

Frequency (n):

The frequency is the number of vibrations made by the vibrating particle in one second.

Velocity (v):

The distance travelled by the sound wave in one second is known as velocity of sound.

Relation between Wavelength, Frequency and Velocity of a Wave :

Let n be the number of vibrations made by the vibrating particle in one second. It is also known as its frequency.

Time taken for one vibration = period (T) = 1/n.

Let λ be the wavelength of the wave produced

Velocity of the wave is the distance through which the wave advances in the medium in one second

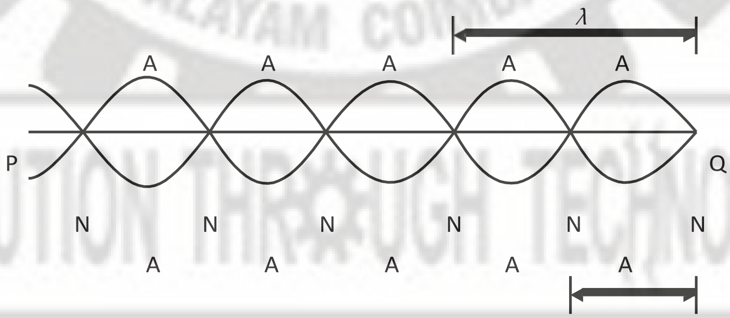
$$\therefore \text{ Velocity of wave motion, } V = \frac{\text{dis tan ce travelled}}{\text{time taken}}$$

$$V = \lambda/T = \lambda/(1/n) = \lambda n$$

$$\therefore V = n\lambda$$

Stationary Waves:

- If a progressive wave travelling in a medium meets the surface of an obstacle, it is reflected. The reflected wave is superimposed on the incident wave to form a new type of wave called stationary wave.
- Also, when two identical waves having equal wavelength and amplitude travel in opposite directions they superimpose on each other forming stationary wave.
- At certain points of the medium, the displacement due to the two waves cancel each other and those points remain at rest. Such points are called nodes (N).
- At certain other points there is maximum displacement. Such points are called antinodes (A). The distance between two successive nodes or antinodes is λ / 2.



The distance between a node and the next antinode is λ / 4

The longitudinal waves also produce the stationary waves.

VIBRATIONS:

Free Vibrations :

- The vibrations of any body with its natural frequency are called free vibrations.
- When a body is set in vibration and left free, it executes vibrations. The frequency depends upon the dimensions and elastic constants of the body. Such vibrations are called free

vibrations and the frequency of vibration is known as the natural frequency.

- If a tuning fork is set in vibration, it vibrates with its own frequency. Such vibrations are called Free vibrations or natural frequency.

Forced Vibrations :

- The vibrations of a body with a frequency induces vibrations on another vibrating agent are called forced vibrations.
- Suppose a vibrating tuning fork is placed with its stem on a table, the vibrations of the fork are impressed on the table and the table is forced to vibrate. The vibrations set up on the table are called forced vibrations.

Resonance:

- When the forced vibrations given on the body is equal to its natural frequency of vibrations, the body vibrates with maximum amplitude. This phenomenon is called resonance.
- When a vibrating tuning fork is kept on a table, the table is forced to vibrate with the frequency of the tuning fork. If the natural frequency of the table is equal to the frequency of the tuning fork, the table vibrates with its natural frequency and hence resonance occurs.

Explain the three laws of transverse vibrations of stretched string and obtain the expression for frequency of vibration of string:

(i)The frequency of vibration (n) is inversely proportional to the length(l) of the string

$$n \propto \frac{1}{l}$$

(ii)The Frequency of vibration (n) is direction proportional to the square root of

Tension (T).

$$n \propto \sqrt{T}$$

(iii) The frequency of vibration (n) is inversely proportional to the square root of linear density (m).

$$n \propto \frac{1}{\sqrt{m}}$$

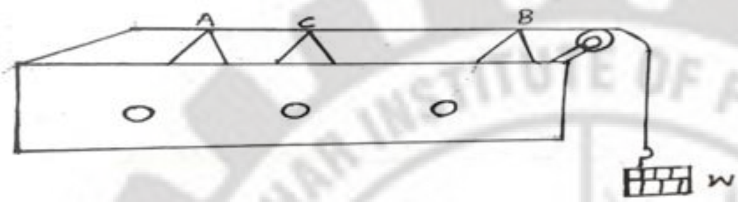
From equation(1),(2),(3)

Frequency $n \propto \frac{1}{l}\frac{\sqrt{T}}{\sqrt{m}}$

Frequency $n = k\frac{1}{l}\frac{\sqrt{T}}{\sqrt{m}}$ **(k=$\frac{1}{2}$)**

Frequency $\boxed{n = \frac{1}{2l}\sqrt{\frac{T}{m}} \quad \text{HZ}}$

Experiment to determine the frequency of the tuning fork using the Sonometer:



DESCRIPTION:

- Sonometer consists of a hollow wooden box
- One end of the string is tied with nail
- Other end is passed over the pulley
- A weight hanger is attached to the free end
- Three knife edges A and B are fixed. C is movable

EXPERIMENT:

- A suitable weight is applied to the string
- A small paper rider is placed on the stream between A and C
- A tuning fork is striked on the rubber hammer and it is kept on the box
- Now the strain vibrate the knife 'C' is adjusted until the string vibrates with frequency of fork
- Now the paper rides falls down. The length 'l' is measured

$$n = \frac{1}{2}\sqrt{\left(\frac{M}{l^2}\right)\frac{g}{m}} \qquad HZ$$

M=Load

g =gravity

m=linear density

S.NO	Load(M)	Vibrating length(l)	l^2	$\frac{M}{l^2}$
1				

PROBLEMS:

1. A sonometer wire is loaded with a mass of 2kg. The linear density of the wire is 2x10 kgm^{-1}.When an exited tuning fork is placed on the sonometer box, the resonating length i found to be 15.4cm, Find the frequency of the tuning fork.

Solution:

M=2kg

m=2x10^{-3} kgm^{-1}

l=15.4cm=15.4 x10^{-2}m=.154m

$$n = \frac{1}{2}\sqrt{\left(\frac{M}{l^2}\right) \times \frac{g}{m}}\ HZ$$

$$n = \frac{1}{2}\sqrt{\left(\frac{2}{(0.154)^2}\right) \times \frac{9.8}{2x10^{-3}}}\ HZ$$

$$n = \frac{1}{2}\sqrt{\left(\frac{44.1\times10^3}{0.04743}\right)} = \frac{1}{2}\sqrt{929.7\times10^3}$$

$$n = \frac{1}{2}\sqrt{929700} = \frac{1}{2}\times 964.2$$

n =482.10 HZ

2.The vibrating length of 0.24m of a Sonometer wire is vibrating with a tuning fork when stretched b weight of 4.5kg. The linear density of the wire is 0.65$\times 10^{-3}$ kgm^{-1}

M=4.5kg

m=.65x10^{-3} kgm^{-1}

l=0.24m

$$n = \frac{1}{2}\sqrt{\left(\frac{M}{l^2}\right) \times \frac{g}{m}}\ HZ$$

$$n = \frac{1}{2}\sqrt{\left(\frac{4.5}{(0.24)^2}\right) \times \frac{9.8}{0.65x10^{-3}}}\ HZ$$

$$n = \frac{1}{2}\sqrt{\left(\frac{44.1\times10^3}{0.03744}\right)} = \frac{1}{2}\sqrt{1177.8\times10^3}$$

$$n = \frac{1}{2}\sqrt{11778} = \frac{1}{2}\times 1085$$

n =542.6 HZ

ACOUSTICS OF BUILDINGS:

Echo : The first reflected sound is known as echo. The sound produced by a source is propagated continuously in a medium if there is no disturbance. But if it meets the hard surface of an obstacle, it is reflected. The clear echo depends upon the following factors.

1. Good reflector of sound
2. Maximum surface area of the reflector and
3. The distance of the reflector from the source of sound.

Reverberation :

- The sound produced in a hall suffers multiple reflections before it becomes inaudible.
- As a result of these reflections, the listener continues to receive sound, even if the source of sound is cut off.
- This prolonged reflection of sound in a room even after the sound source has been stopped is called reverberation.
- It is the persistence of sound due to multiple reflections from the walls, floor and ceiling of a hall. The reverberation is also called multiple echoes.
- In a room, the walls, floor and other flat surfaces reflect sound with a small loss of energy.

Reverberation time:

- If a building is to be acoustically correct, its reverberation time must be in optimum level.
- It should not be too long or too short. if it is too short, then the room becomes dead in sound aspect. If it is too long, then the reverberation will be there inside the building for long duration.
- The reverberation produces continuous sound with decreasing intensity upto a particular time after that it disappears.
- This time is known as reverberation time.
- The reverberation time is defined as the time taken by the sound to fall from its original intensity to one millionth of its original intensity.

Sabine formula :

- Sabine derived an equation for the reverberation time.
- Where V is the volume of the hall, a is the coefficient of absorption of each reflecting surface present

in the hall and A is the area of the each

$$T = \frac{0.16\,V}{\alpha\,A} \text{ second}$$

sound absorbing surface present in the hall.

Coefficient of absorption of sound energy:

The co-efficient of absorption of sound energy of any surface is defined as the ratio of the sound energy absorbed by the surface to the total sound energy incident on the surface.

Let α be the coefficient of absorption of sound energy of a surface, then

$$\alpha = \frac{\text{The sound energy absorbed by the surface}}{\text{The total sound energy incident on the surface}}$$

Noise pollution and various methods of controlling different types of industrial noise.

- **The unwanted sound is called noise pollution.**
- **Noise makes irritation to human beings.**
- **Noise reduces the efficiency of worker in industry.**
- **Noise affects the normal growth of children.**

TTwo type of noise:

(i)indoor ,(ii)outdoor

Controlling the noise pollution :

- **Industries should be shifted beyond residential areas.**
- **Road, railway lines should be formed away from residential areas.**
- **Trees and plants should be cultivated by new machines.**
- **Old machines should be replaced by new machine.**

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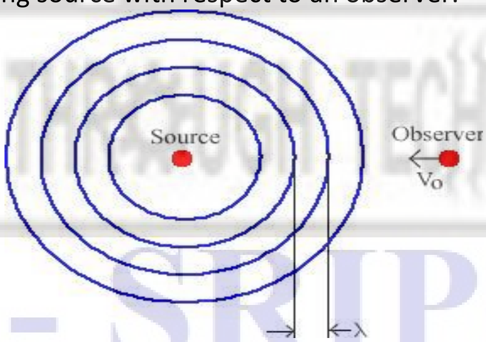
- **Trees and plants should be cultivated by new machines.**
- **Old machines should be replaced by new machine.**
- **Lubricants can be used to reduce noise due to friction.**

Doppler Effect:

- The Doppler effect describes the change in frequency of any kind of sound or light wave produced by a moving source with respect to an observer.



Examples :

1. Often we have noticed that the siren sound coming from a police vehicle or ambulance increases when it comes closer to us and decreases when it moves away from as

2. When we stand hear any passing train the train whistle initially increases and then it will decreases.

This is known as Doppler effect, named after Christian Doppler

Applications of Doppler Effect:

- Doppler effect in light has many applications in astronomy, as an example, while observing the spectra from distant objects like stars or galaxies, it is possible to determine the velocities at which distant objects like stars or galaxies move towards or away from earth.

Ultrasonic:

- Sound is produced by vibrating bodies.
- We can hear sound of frequencies ranging from 20Hz to 20000Hz.
- This range of frequencies, sensed by our ear is known as the audible range of sound.
- Sound of frequencies above 20,000Hz are known as ultrasonic.
- Sound of frequencies below 20Hz are called infrasonic.
- We cannot hear ultrasonic's and infrasonic. but certain animals can produce and detect ultrasonic's and infrasonic.

Examples:

Elephants use infrasonics to communicate with other members of the groups in the forest.

Some animals sense the infrasonic vibration during earthquake and migrate to safer places.

Uses of ultrasonic's:

1. High frequency ultrasonic waves are used to drill a metal, kill bacteria and mix paints.

2. Ultrasonics are used in medicines to cure rheumatic and neurologic paints.

3. Ultrasonics are used in the molecular acoustics for studying the structure and properties of organic and inorganic substances.

4. Ultrasonic are used in the preparation of emulsions for photographic plates and cosmetics.

5. They are used to form alloys of a number of metals in their liquid state.

6. Fish and frog can be killed by using ultrasonic's.

7. Ultrasonics can be used to accelerate the molecular reactions of high polymers.

8. These wave are also used for gas purification because they coagulate minute particles and droplets of liquid in the gas.

9. ultrasonic's are used to determine the depth of see at various places and to detect ships and rocks in the sea. The device SONOR is used for the above purpose.

SONAR:

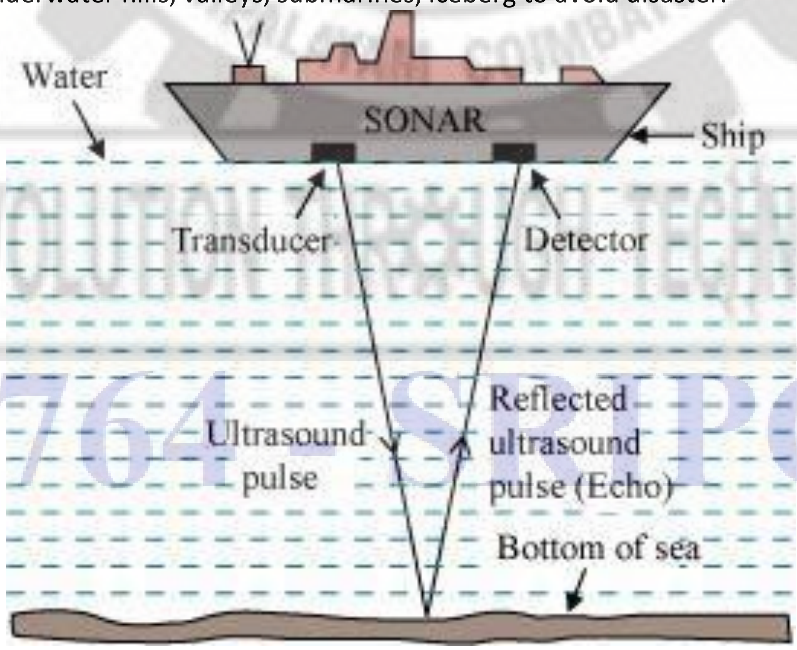
- SONAR stands for sound navigation and ranging it is a device which uses ultrasonic waves to measure the distance, direction and speed of underwater objects and helps mariners to invertigate nature, size and location of the object so that potential threat to the vessed can be identified and over come
- Sonar has a transmitter and a receiver which are installed at the bottom of the ship. The ultrasonic waves transmitted by transmitter travels under water and get reflected back from obstacles. The detector to electric signal.
- A computer forms image of the obstacle and displays it on a moniter.it also calculate the distance of theobject using

Distance = $\frac{speed \times time}{2}$

Speed = speed of sound in saltine water

= 1530 M/s

- This method is called echo- ranging
- The SONAR technique is installed in every ship to determine the depth of sea and locate underwater hills, valleys, submarines, iceberg to avoid disaster.



WORKED PROBLEMS

1. **A wire 50 cm long and of mass 6.5×10^{-3} kg is stretched so that it makes 80 vibrations per second. Find the stretching tension.**

$$m = \frac{\text{mass}}{\text{length}} = \frac{6.5 \times 10^{-3}}{0.5} = 13 \times 10^{-3}\ \text{kgm}^{-1}$$

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \text{ or } n^2 = \frac{1}{4l^2}\frac{T}{m}$$

$\therefore$ Tension $T = 4l^2m^2 n = 2 \times 0.5 \times 0.5 \times 13 \times 10^{-3} \times 80 \times 80$

$= 83.2$ N

2. **The density of a sonometer wire of radius 0.3mm is 7800 kgm^{-3}. Find its linear density.**

Linear density $m = \pi r^2 \rho$

$m = 3.14 \times (0.3 \times 10^{-3})^2 \times 7800$

$= 2204.28 \times 10^{-6}$

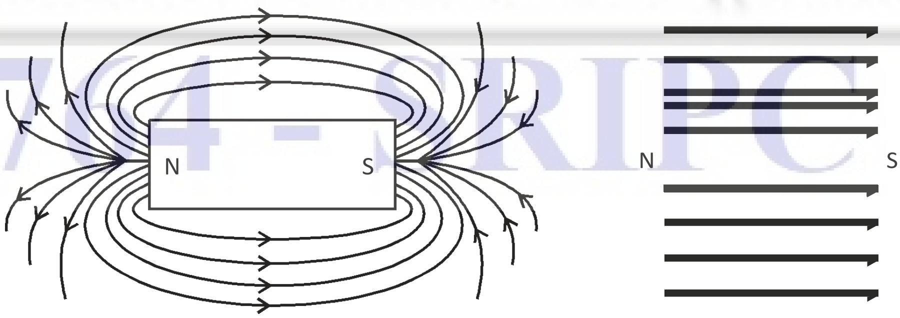
$= 2.204 \times 10^{-3}$ kg m^{-1}

MAGNETISM

- The word 'magnetism' is derived from the name of a dark brown coloured ore called magnetite found in Magnesia.
- The ore possesses the property of attracting small pieces of iron.
- The ore magnetite available in nature is called as natural magnet.
- Artificial magnets also can be prepared from iron or steel materials.
- Iron materials are mostly used to prepare electromagnets and temporary magnets whereas the steel materials are used to prepare permanent magnets.

Magnetic field:

- The space around the magnet in which the magnetic lines of force act is called the magnetic field.
- The direction of magnetic field at a point is given by the direction of the force acting on the north pole of a magnetic needle placed at the point.
- If the magnetic lines of force formed are parallel, the field is called uniform magnetic field and have equal strength at all the points.



Pole Strength (P) :

- The pole strength of a magnet is defined as the force acting on the pole when it is placed in a uniform magnetic field of unit intensity.
- Let P be the pole strength placed in a uniform magnetic field of intensity H, Force acting on the pole, F = HP. If H = 1, then F = P The unit of pole strength is ampere metre (Am.)

Magnetic Moment:

- Magnetic Moment of a magnet is the product of the pole strength and length of the magnet.
  m=px2l
- p is the pole strength of the magnet 2l is the length of the magnet.
- The unit of magnetic moment is ampere metre² (Am²)

Intensity of magnetic field (H) :

- Intensity of magnetization (M)=$\frac{\text{Magnectic moment}}{\text{Volume}}$
- The unit of Intensity of magnetic field is ampere/metre (Am^{-1})

Intensity of magnetic field (H):

- Intensity of magnetic field is define as the fore experienced by unit north pole placed at that point. Unit :Am^{-1}

Magnetic induction (B):

- Magnetic induction is defined as the total number of magnetic lines of force passing through unit area. Unit : Tesla (or)weber/metre².

Magnetic permeability(μ):

- Magnetic permeability(μ)=$\frac{\text{Magnetic induction (B).}}{\text{Intensity of magnetic field (H).}}$
- The unit of magnetic permeability is weber/ampere-metre (WbA m)or henry/metre.

Saturation:

- When the magnetizing field H is increased, the intensity of magnetizations M also increase and reaches a maximum value for a particular value of H. After that, the intensity of magnetization will not increase. This is called magnetic saturation

Retentivity (or) residualmagnetism:

- The amount of intensity of magnetization (M) retained in the specimen even after removing magnetic field (H).

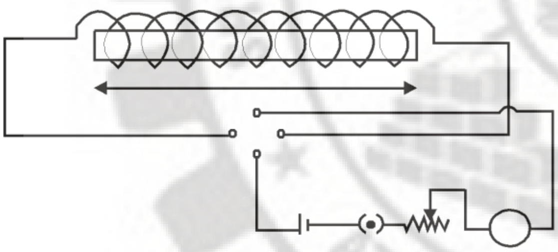
Coercivity (or) coercive force:

t of reverse magnetic field (-H) required to completely demagnetize (remove magnetism) the specimen is called coercivity.

Hysteresis:

- The lagging of intensity of magnetizations behind magnetizing field is called hysteresis

Describe an experiment to draw hysteresis curve (loop) of a specimen in the form of rod:

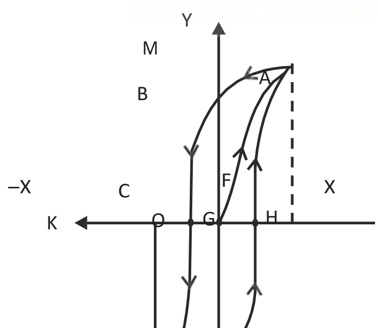


Description:

- Experimental arrangement is shown in figure.
- Along solenoid is connected in the circuit.
- It consist of a commutater, battery, key etc.
- The given specimen is placed inside the solenoid.
- A magnetometer is placed at a short distance
- Intensity of magnetic field,
- $H = \frac{NI}{L}$

  Intensity of magnetization, $M=K\tan\theta$

Experiment:



- The current is gradually increased in steps.
- Every time the value of H and M are calculated.
- A graph is drawn between H and M.

Saturation(OA):

- When H is increased the value of M is also increase from O to A
- At the point a specimen reached saturation.

Retentivity (OB):

- If H is decreased from A, the value of M is also decreases from A to B. But not zero
- Now the specimen retains some amount residual magnetism known as retentivity.

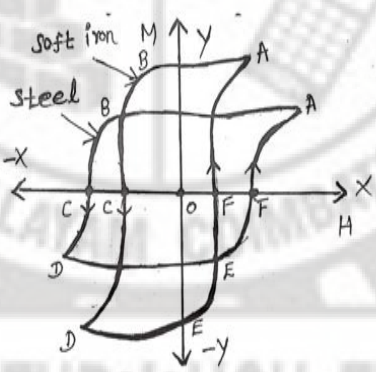
Coercivity(OC):

- When h is increased in the reverse direction from zero to C. the value of M reaches zero at C.
- The amount of H is the reverse direction to remove residual magnetism is called Coercivity.
- The loop ABCDEFA is called Hysteresis loop (or)M-H

Explain how you will select magnetic material for temporary magnets and permanent magnets with the help of hysteresis.

(or)

Explain the usefulness of hysteresis loopS



S.No	Steel	Soft iron
1	Small Retentivity	Large Retentivity
2	Large Coercivity	Small Coercivity
3	Energy is not taken	Energy loss is less
4	It is used for permanent magnets	It is used for temporary magnets

Types of magnetic materials:

They are mainly three types of magnetic materials they are

1. Diamagnetic materials

2Paramagnetic materials

1. Ferromagnetic materials

Diamagnetic materials:

- Diamagnetic materials are those which are repelled by magnets.

Ex: copper , water, bismuth etc

Paramagnetic materials:

- Paramagnetic materials are those which are not strongly attracted by magnets

  Ex: Aluminium, platinum, manganese etc

Ferromagnetic materials:

- Ferromagnetic materials are those which are strongly attracted by the magnets**.**

Ex: Iron, Nickel, Cobalt

Applications of magnetic materials:

i) Motors
ii) Generators
iii) Electromagnets
iv) Transformers
v) sensors

WORKED PROBLEM

1.The moment of a bar magnet is 0.6Am^2 and its volume is 3x10^{-5} m^2. Calculate the intensity of magnetization of the magnet.

m=0.6Am^2

v=3x10^{-5} m^2

M=$\frac{m}{v}$ =$\frac{0.6}{3x10^{-5}}$

M=0.2$\times 10^5 Am^{-1}$

2. The length, breath and thickness of bar magnet are 30cm, 2cm and 1cm respectively. Calculate the intensity of magnetization if its magnetic moment is 6$\times 10^{-6}$ Am^2.

l=30cm=$30X10^{-2}$ m

b=2cm =$2X10^{-2}$ m

h=1cm =$1X10^{-2}$ m

m=6×10^{-6} Am²

M=$\frac{m}{v} = \frac{m}{lbh} = \frac{6\times10^{-6}}{30X10^{-2}\times2\times10^{-2}\times1\times10^{-2}} = \frac{6\times10^{-6}}{60\times10^{-6}}$=0.1 Am^{-1}

QUESTIONS

Part - A and Part – B

1. Define wave motion.
2. Define transverse wave motion.
3. Define longitudinal wave motion.
4. Define progressive wave.
5. Define amplitude of a wave.
6. Define wavelength of a wave.
7. Define period of wave motion.
8. Define frequency of a wave.
9. Define velocity of sound wave.
10. Define stationary wave.
11. Define free vibrations.
12. Define forced vibrations.
13. Define Resonance.
14. State any one of the laws of transverse vibrations in stretched string

15. What is the use of a sonometer?
16. What is an echo?
17. What is reverberation?
18. What is reverberation time?
19. Write sabine's formula.
20. Define co-efficient of absorption of sound energy.
21. Define Pole Strength.
22. Define magnetic induction.
23. Define intensity of magnetic field.
24. Define permeability.
25. Define magnetic moment of a magnet.
26. Define intensity of magnetisation.
27. Define Hysteresis.
28. Define Retentivity
29. Define coercivity
30. Define magnetic saturation.
31. Explain transverse wave motion.
32. Explain longitudinal wave motion.
33. Explain stationary wave
34. Explain the laws of tranvers vibration of stretched string
35. What are the important factor of good acoustics
36. Explain noise pollution
37. Explain resonance
38. Explain Hysterisis
39. Write the uses of hysteresis loop.

Part – C

1. Explain transverse wave motion and longitudinal wave motion.
2. Distinguish between transverse and longitudinal wave motion.
3. Explain the laws of transverse vibrations in a stretched string and obtain the expression for the fre- quency of vibration.
4. Describe how the frequency of a tuning fork is determined using a sonometer.
5. Write a note on acoustics of buildings.
6. Explain noise pollution and the methods of controlling industrial noise.
7. Describe the method of drawing hysteresis loop of a specimen using a solenoid.
8. Explain and uses of hysteresis loop.

Exercise Problems

1. A sonometer wire of 0.5 m long gives vibrations of 256 Hz when stretched with a load of 5 kg. Find the linear density of the material of the wire.
2. Find the frequency of sound produced by a string 25 cm long stretched by load of 5 kg. The linear density of the wire is 4.9×10^{-3} kgm^{-1}
3. A string 75 cm long and weighing 15 g produces a note of frequency 100 cycles per second on plucking. What is the tension in the string?

Ans: 450 N

4. A wire of 50 cm long and of mass 6×10^{-3} kg is stretched so that it makes 60 vibrations per second. Find the tension in the wire.

Ans: 43.20 N

5. The vibrating length of 0.75 m of a sonometer wire is unison with a tuning fork when stretched by weight of 5 kg. The linear density of the wire is 0.5×10^{-3} kg m^{-1}. Calculate the frequency of the tuning fork.

Ans: 209 Hz

6. 6.A wire 50 cm long and of mass 0.6×10^{-3} kg is stretched by a tension of 4 kg.wt. When sounded, it is found to vibrate in 2 loops. Calculate the frequency of the note emitted by the wire.

Ans: 361.Hz

7. 7.A wire 0.5 m long vibrates 100 times a second. If the length of the wire is shortened to 0.4 m and the stretching force is increased to 4 times its original value, what will be the new frequency?

Ans : 250 Hz

Brain Teaser

1. Thunder was heard 6 second after a flash of lighting was seen. If the velocity of sound is $345 ms^{-1}$, calculate the distance at which flash occurred.
2. Two magnetic poles, one of which is twice stronger than the other repel one another with a force of 2×10^{-5} N when kept separated at a distance of 20 cm in air. Calculate the strength of each pole.

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