Semester-I

18BEAE102/18BEME102 Electromagnetism **7H-5C**

(Theory & Lab.)

Instruction Hours/week: L:3 T:1 P:3 **Marks:** Internal:**40** External:**60** Total:**100**

End Semester Exam:3 Hours

(i) Theory

Course Objective:

- To divulge knowledge on the basics of static electric and magnetic field and the associated laws.
- To make the students familiar on the fundamentals of magnetic field and the associated laws.
- To inculcate the basics of properties of matter and its applications.
- To disseminate the fundamentals of quantum physics and their applications in modern equipments.
- To impart knowledge on the basics of vacuum and its applications in pumps and gauges.

Course Outcomes

Upon completion of this course, the students will be able to

1. Analyze field potentials due to static charges and apply for electrostatic applications.
2. Understand the concepts of magnetic field and apply for electromagnetic applications.
3. Gain knowledge on the basics of properties of matter and its applications
4. Analyse the concepts of advanced physics in quantum theory and its applications in electron microscopes
5. Integrate the properties on vacuum and its applications in various pumps and gauges.
6. Apply the knowledge inputs of the course for engineering applications.

Unit 1- Electrostatics

Basic laws, Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential and uniqueness of their solution and connection with steady state diffusion and thermal conduction; Continuity equation and relaxation time.Polarization: Field of a polarized object, Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement.

Unit 2- Magnetostatics

Bio-Savart law - Applications, Ampere's circuital law – Applications, Divergence and curl of static magnetic field; Magnetic flux density, vector potential and calculating it for a given magnetic field using Stokes' theorem, Maxwell's equations.

Magnetization- diamagnets, paramagnets, ferromagnets- Field of a magnetized object- bound currents; auxiliary magnetic field $\vec{H}$; Boundary conditions on $\vec{B}$ and $\vec{H}$- magnetic susceptibility and permeability - Ferromagnetism.

Unit 3 - Properties of Matter

Elasticity: Hooke's law, stress- strain diagram, types of moduli of elasticity – basic definitions, relation connecting the moduli (Derivation)-factors affecting elastic modulus and tensile strength–Poisson's ratio- Torsional pendulum- bending of beams - bending moment – uniform and non-uniform bending - I-shaped girders.

Unit 4 - Quantum Mechanics

Introduction to quantum theory, Merits of Quantum theory – Black body radiation, Laws - dual nature of matter and radiation – de Broglie wavelength, uncertainty principle –Schrödinger's wave equation – time dependent and time independent equations – physical significance of wave function - particle in one dimensional box- degenerate and non-degenerate states, scanning electron microscope.

Unit 5 -Vacuum science

Introduction - Importance of vacuum in industries - Pumping speed and throughput - Types of pumps-Rotary vane type Vacuum pump(oil sealed), Diffusion Pump and Turbo Molecular Pump - Measurement of High Vacuum-McLeod Gauge-Pirani Gauge-Penning Gauge.

SUGGESTED READINGS

1. David Griffiths**,**(2017).Introductionto Electrodynamics**,**Cambridge publisher**.**
2. Ganesan.S and Baskar.T**,** (2015) Engineering Physics I**,** GEMS Publisher, Coimbatore-1.
3. Ganesan S. IyanduraiN ,(2007).,Applied Physics, KKSPublishersGaur.
4. R.K. and Gupta, S.C(2012).Engineering Physics, DhanpatRai Publications.
5. Halliday and Resnick, (2007).Physics, Wiley (5thedition).
6. W. Saslow, (2002) Electricity, magnetism and light,Academic Press.

(ii) Laboratory

Course Objective:

- To learn the basic concepts in physics relevant to different branches of Engineering and Technology.
- To study the concept of semiconductor and conductivity.
- To learn the properties of materials.

Course Outcome:

1 Familiarize the properties of material and basic concepts in physics.

LIST OF EXPERIMENTS – PHYSICS

1. Torsional pendulum - Determination of rigidity modulus of wire and moment of inertia of disc
2. Non-uniform bending - Determination of young's modulus
3. Uniform bending – Determination of young's modulus
4. Lee's disc Determination of thermal conductivity of a bad conductor
5. Potentiometer-Determination of thermo e.m.f of a thermocouple
6. Laser- Determination of the wave length of the laser using grating
7. Air wedge - Determination of thickness of a thin sheet/wire
8. Optical fibre -Determination of Numerical Aperture and acceptance angle
9. Ultrasonic interferometer – determination of the velocity of sound and compressibility of liquids
10. Determination of Band gap of a semiconductor.
11. Spectrometer- Determination of wavelength using grating.
12. Viscosity of liquids-Determination of co-efficient of viscosity of a liquid by Poiseuille's flow

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established under Section 3 of UGC Act 1956)

COIMBATORE – 641021

FACULTY OF ENGINEERING

DEPARTMENT OF SCIENCE AND HUMANITIES

LECTURE PLAN

Subject : ELECTROMAGNETISM

Code : 18BEAE102/18BEME102

Unit No.	List of Topics	No. of Hours
UNIT I	**Electrostatics in vacuum**	
	Basic laws, Calculation of electric field for a charge distribution	1
	Calculation of electrostatic potential for a charge distribution	1
	Divergence and curl of electrostatic field	1
	Laplace's and Poisson's equations for electrostatic potential	1
	uniqueness of their solution and connection with steady state diffusion and thermal conduction;	1
	Continuity equation and relaxation time	1
	Tutorial	1
	Polarization, Field of a polarized object, Bound charges due to electric polarization	1
	Electric displacement, boundary conditions on displacement	1
	Tutorial	1
	TOTAL	**10**
UNIT – II	**Magnetostatics**	
	Bio-Savart law, Divergence and curl of static magnetic field	1
	vector potential, Calculating vector potential for a given magnetic field using Stokes' theorem	2
	Magnetostatics in a linear magnetic medium, MagnetizationDiamagnets, paramagnets, ferromagnets	1
	Tutorial	1
	Field of a magnetized object- bound currents	1
	auxiliary magnetic field $\vec{H}$	1

	Boundary conditions on $\vec{B}$ and $\vec{H}$	1
	magnetic susceptibility and permeability	1
	Tutorial	1
	TOTAL	**10**
UNIT – III	**Properties of Matter**	
	Elasticity, Hooke's law, stress –strain diagram	1
	Three types of modulus of elasticity	
	relation connecting the moduli	1
	factors affecting elastic modulus and tensile strength	1
	Poisson's ratio, Torsional pendulum	1
	Tutorial	1
	bending of beams, bending moment	1
	uniform and non-uniform bending	1
	I-shaped girders	1
	Tutorial	1
	TOTAL	**10**
UNIT – IV	**Quantum Mechanics**	
	Introduction to quantum theory	1
	Black body radiation	1
	dual nature of matter and radiation	1
	de Broglie wavelength, uncertainty principle	1
	Tutorial	1
	Schrödinger's wave equation – time dependent equation	1
	time independent equations, physical significance of wave function	1
	particle in one dimensional box	1
	scanning electron microscope	1
	Tutorial	1
	TOTAL	**10**
UNIT – V	**Vacuum science**	
	Introduction, Importance of vacuum in industries	1
	Pumping speed and throughput	1
	Types of pumps- Rotary vane type Vacuum pump	1
	Diffusion Pump	1
	Turbo Molecular Pump	1
	Tutorial	
	Measurement of High Vacuum - McLeod Gauge	1
	Pirani Gauge	1
	Penning Gauge	1
	Tutorial	1
	TOTAL	**10**
	TOTAL NO OF HOURS	**50**

S.NO	AUTHOR(S) NAME	TITLE OF THE BOOK	PUBLISHER	YEAR OF PUBLICATION
1.	David Griffiths	Introductionto Electrodynamics	Cambridge publisher	2017
2.	Ganesan.S and Baskar.T	Engineering Physics I	GEMS Publisher, Coimbatore-641 001	2015
3.	Ganesan S. Iyandurai N	Applied Physics	KKS Publishers	2007
4.	Gaur, R.K. and Gupta, S.C	Engineering Physics	DhanpatRai Publications	2012
5.	Halliday and Resnick	Physics	Wiley (5th edition)	2007
6.	W. Saslow	Electricity, magnetism and light	Academic Press	2002

WEBSITES:

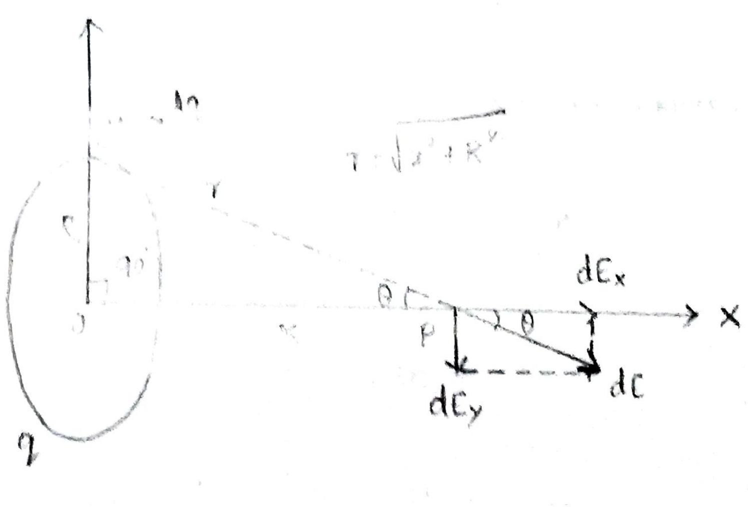
1. https://www.youtube.com/watch?v=EzcWpOFJ6P4
2. https://www.youtube.com/watch?v=x1-SibwIPM4
3. https://www.youtube.com/watch?v=TcmGYe39XG0
4. www. nptel.ac.in

STAFF IN-CHARGE **HOD**

Electrostatics

Electric Field of a Ring of charge

Consider a conducting ring of radius R has a total charge q uniformly distributed over its circumference. We are finding the electricfield at a point P that lies on the axis of the ring at a distance x from its centre.



We divide the ring into segments of length dl. Each segment has a charge dq and acts as a point charge source of electric field.

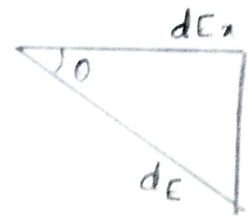
Let $d\vec{E}$ be the electric field, from one such Segment ; the net electric field at P is then the sum of all contributions $d\vec{E}$ from all the segments that make up the ring. If we consider two ring segments at the top and bottom of the ring.

we see that the contributions $d\vec{E}$ to the field at P from these segments have the same x-component but opposite y-components. Hence, the total y-component of field due to this pair of segments is zero. So the field at P is described completely by its x component E_x

Calculation of E_x

$$dq \propto \quad d\vec{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq}{r^2}$$

$$dE_x = dE \cos\theta$$



$$\cos\theta = \frac{dE_x}{dE}$$

$$dE_x = \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq}{r^2} \cos\theta$$

$$= \frac{1}{4\pi\varepsilon_0} \left(\frac{dq}{x^2+R^2}\right) \left(\frac{x}{\sqrt{x^2+R^2}}\right)$$

$$= \frac{1}{4\pi\varepsilon_0} \left(\frac{x\,(dq)}{(x^2+R^2)^{3/2}}\right)$$

at

t

$$E_x = \int dE_x$$

$$= \frac{x}{4\pi\varepsilon_0 (x^2+R^2)^{3/2}} \int dq$$

$$\boxed{E_x = \frac{1}{4\pi\varepsilon_0} \frac{q\,x}{(x^2+R^2)^{3/2}}}$$

From the above expression

(i) when $E_x = 0$ at $x = 0$

ie field is zero at the centre of the ring. Charges on opposite sides of the ring would push in opposite directions on a test charge at the centre, add the forces would add to zero

ii) when $x >> R$, $E_x = \frac{1}{4\pi\varepsilon_0} \frac{q x}{x^3}$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q}{x^2}$$

when the point P is much farther from the ring, its field is the same as that of a point charge.

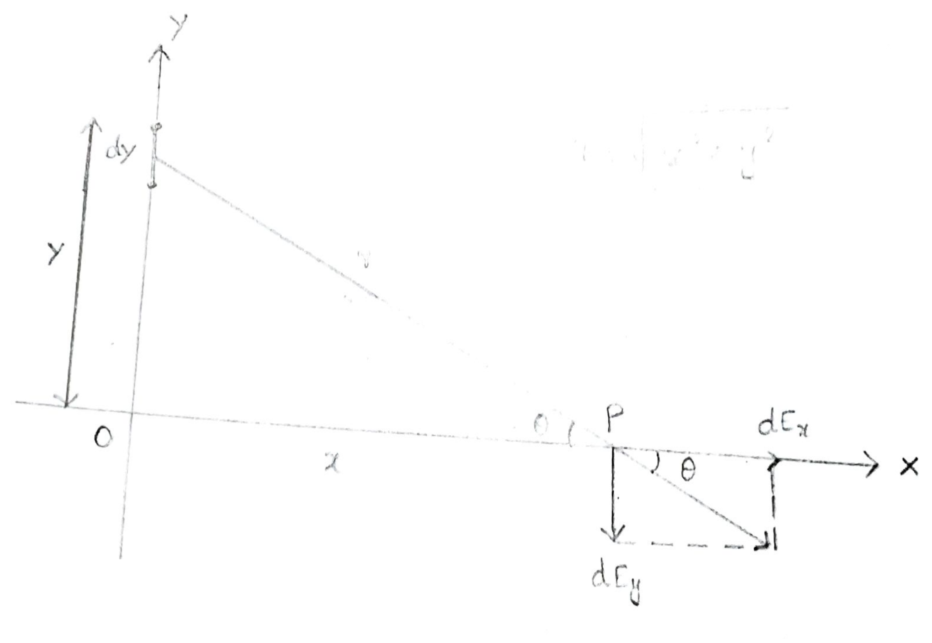
iii) E_x will be maximum where $\frac{dE_x}{dx} = 0$ [since cos ●:]

Electric field of a Line charge

Positive charge q is distributed uniformly along a line with length $2a$, lying along the Y-axis between $Y = -a$ and $Y = +a$.

$$\lambda = \frac{\text{charge}}{\text{unit length}}$$

$$\lambda = \frac{q}{2a}$$



$$dq = \lambda\, dy$$

$$= \frac{q}{2a}\, dy$$

$$dE = \frac{1}{4\pi\varepsilon_0} \cdot \frac{dq}{r^2}$$

$$= \frac{q}{4\pi\varepsilon_0} \cdot \frac{dy}{2a(x^2+y^2)}$$

$$dE_x = dE \cos\theta$$

$$= \frac{q}{4\pi\varepsilon_0} \cdot \frac{dy}{2a(x^2+y^2)} \cdot \frac{x}{r}$$

$$= \frac{q}{4\pi\varepsilon_0} \cdot \frac{dy}{2a(x^2+y^2)} \cdot \frac{x}{(x^2+y^2)^{1/2}}$$

$$dE_x = \frac{q}{4\pi\varepsilon_0} \cdot \frac{x\,dy}{2a(x^2+y^2)^{3/2}}$$

$$\int_{-a}^{a} dE_x = E_x = \frac{qx}{4\pi\varepsilon_0(2a)} \int_{-a}^{a} \frac{dy}{(x^2+y^2)^{3/2}}$$

$$= \frac{q}{4\pi\varepsilon_0} \cdot \frac{1}{x\sqrt{x^2+a^2}}$$

$$E_x = \frac{q}{4\pi\varepsilon_0 x\sqrt{x^2+a^2}}$$

Gauss's Law

Gauss's law states that the total electric flux ψ through any closed surface is equal to the total charge enclosed by that surface.

$$\psi = \oint_S d\psi = \oint_S D.ds$$

Poisson's and Laplace's Equations.

Poisson's and Laplace's equations are easily derived from Gauss's law

$$\nabla . D = \nabla \cdot \varepsilon E = \rho_v$$

$$E = -\nabla V$$

Hence

$$\int_V |\nabla_d|^2 dv = 0$$

$$\nabla V_d = 0 \qquad (V_d = V_2 - V_1 = \text{constant})$$

everywhere in V

Polarization

When external Electric field is applied positive charge displaced from the equilibrium position, in the direction of electric field E by the force,

$$F = QE$$

-ve charge is displaced in the opposite direction by the force

$$F = -QE$$ (-ve charge is displaced in the opposite direction)

A dipole results from displacement of charges an dielectric is said to be polarized $P = Q \cdot d$

where $d \rightarrow$ distance vector from $-Q$ to Q

If there are N dipoles in a volume ΔV of the dielectric

The total dipole moment

$$P = Q_1 d_1 + Q_2 d_2 + \dots\dots Q_N d_N$$

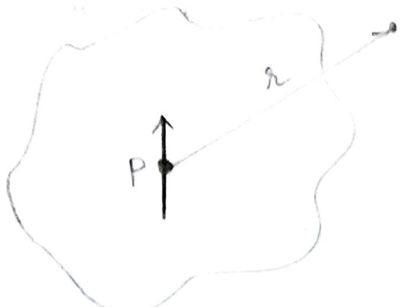
$$\therefore \text{Polarization } P = \frac{\text{dipolemoment}}{\text{unit volume}} = \frac{\sum_{K=1}^{n} Q_K d_K}{\Delta V}$$

Electric field of a polarized object

Let us consider a dielectric material and it consists of large number of dipoles with dipolemoment per unit volume.

We have dipole moment

$$P = P\, d\tau'$$



The dipole moment Per unit volume P is given by

$$V(r) = \frac{1}{4\pi\varepsilon_0} \cdot \frac{\hat{r}\cdot P}{r^2} \quad \text{—— } ①$$

where r is the vector from the dipole to the point

Here, we have

$$\frac{\hat{r}}{r^2} = \nabla'\left(\frac{1}{r}\right) \quad \text{—— } ②$$

Substituting equ ② in equ ① and integrating equ ①,

$$V = \frac{1}{4\pi\varepsilon_0} \int_{V} P \cdot \nabla'\left(\frac{1}{r}\right) d\tau' \quad \text{—— } ③$$

Integrating by parts, then equ ③ becomes

$$V = \frac{1}{4\pi\varepsilon_0}\left[\int_{\mathcal{V}} \nabla'\left(\frac{P}{\mathscr{r}}\right) d\tau' - \int_{\mathcal{V}} \frac{1}{\mathscr{r}} (\nabla' . P)\, d\tau'\right] \quad \text{—— ④}$$

By using the divergence theorem,

$$V = \frac{1}{4\pi\varepsilon_0} \oint \frac{1}{\mathscr{r}} P . da' - \frac{1}{4\pi\varepsilon_0}\int_{\mathcal{V}} \frac{1}{\mathscr{r}} (\nabla' . P)\, d\tau' \quad \text{—— ⑤}$$

The first term looks like the potential of a surface charge

$$\sigma_b = P . \hat{n} \quad \text{and} \quad \rho_b = -\nabla' . P$$

Then equation ⑤ becomes

$$V(r) = \frac{1}{4\pi\varepsilon_0} \oint_S \frac{\sigma_b}{\mathscr{r}}\, da' + \frac{1}{4\pi\varepsilon_0}\int_{\mathcal{V}} \frac{\rho_b}{\mathscr{r}}\, d\tau' \quad \text{—— ⑥}$$

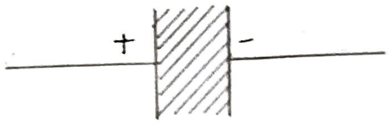
From Gauss law

$$E = -\nabla V = -\frac{1}{3\varepsilon_0} P, \quad \text{for } r < R \quad \text{—— ⑦}$$

This remarkable result will be very useful inside the sphere. Outside the sphere the potential is identical to that of a perfect dipole at the origin

$$V = \frac{1}{4\pi\varepsilon_0} \frac{P . \hat{r}}{r^2} \quad \text{for } r \geq R \quad \text{—— ⑧}$$

Boundary condition



The conditions existing at the boundary of two media, when the Electric field passes from one medium to other are called boundary condition

Boundary between conductor and Dielectric

Maxwell's Equation

We know that

$$\oint E\, dl = 0$$

$$\oint D . ds = Q$$

E is required both tangential component and Normal component

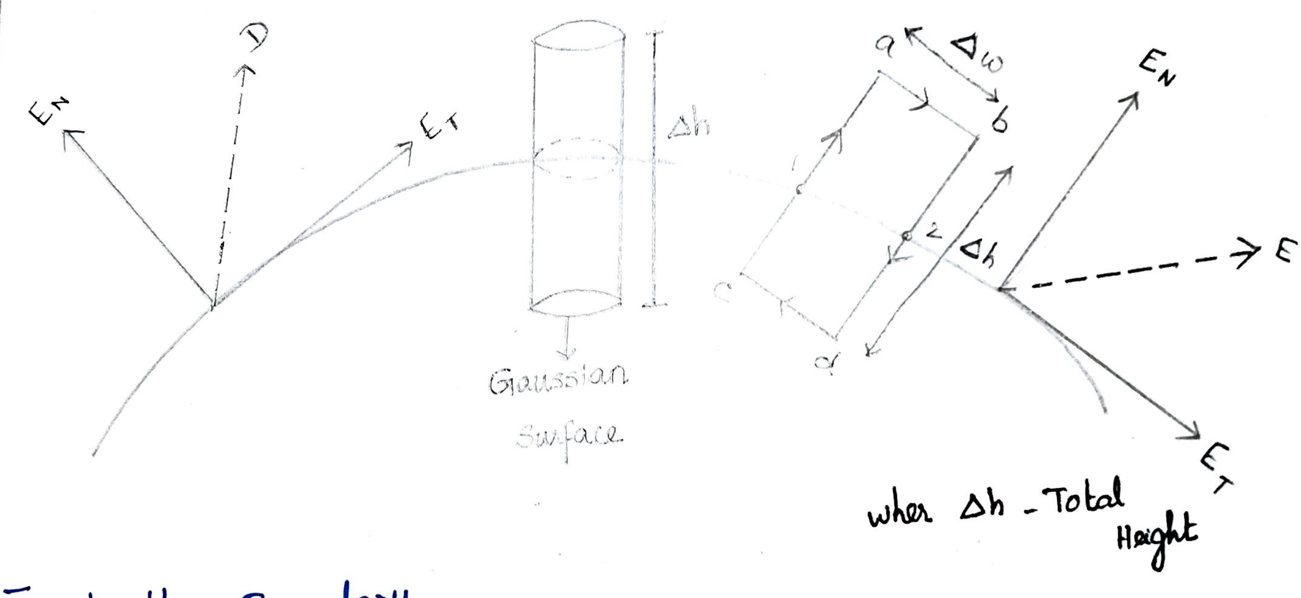
$$\bar{E} = \bar{E}_{tangent} + \bar{E}_{Normal}$$

Assumption

1. Field intensity inside the conductor is zero, flux density inside a conductor is also zero

2. No charge can exist in the conductor, charge appears in surface in the form of surface charge density.

3. charge density within the conductor is zero. Therefore E, D and ρ_v (volume charge density) are zero.



wher Δh - Total Height

$\bar{E}$ at the Boundary

$$\oint E \cdot dl = 0 \quad \text{—— (1)}$$

consider the closed path

$$\oint E.dl = \int_a^b E.dl + \int_b^c E.dl + \int_c^d E.dl + \int_d^a E.dl \quad \text{—— (2)}$$

Here

$a \rightarrow b \parallel c \rightarrow d$
$b \rightarrow c \parallel d \rightarrow a$ | half in conductor

for $c \rightarrow d$, $E = 0$

$$\therefore \int_a^b E.dl + \int_b^c E.dl + \int_d^a E.dl = 0$$

$$\int_a^b E.dl = E\int_a^b dl = \bar{E}\,(\Delta w) \quad \text{—— (3)}$$

Δw is very small

$\bar{E}$ it can be assumed as constant

$$\cancel{\int_a^b E.dl} = \cancel{E\int_a^b dl} = \cancel{E(\Delta w)} \quad \text{—— (4)}$$

Δw is along tangential direction

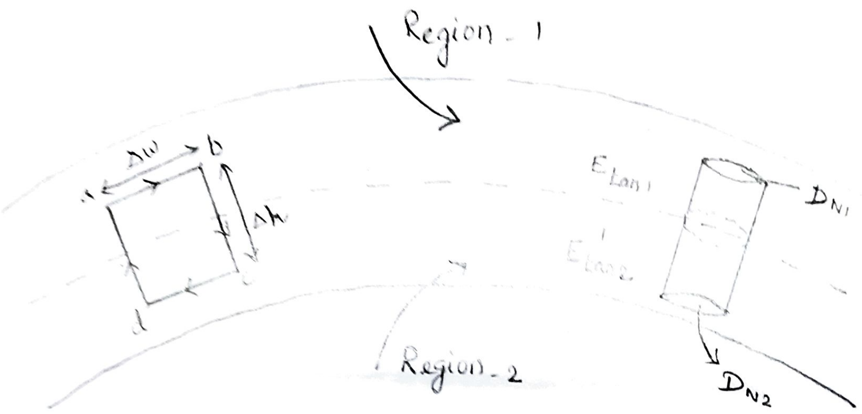
$$\therefore \int_a^b dl = E\,\Delta w \quad \text{when } E_{tan} = |E_{tan}| \quad \text{—— (5)}$$

$b \rightarrow c$ is normal to the component $\bar{E} = \bar{E}_N$

$$D_N = \varepsilon_0 E_N = \rho_s \qquad (D_N = \rho_s)$$

$$E_N = \frac{\rho_s}{\varepsilon_0}$$

Boundary conditions between two dielectric



From Gaussian Law

We know that

$$\oint E \cdot dl = 0 \quad \text{——} \; (1)$$

$$\therefore \int_a^b E \cdot dl + \int_b^c E \cdot dl + \int_c^d E\, dl + \int_d^a E \cdot dl = 0 \quad \text{——} \; (2)$$

Here E is required tangential and Normal to the component.

Over the small height Δh E_n is assumed as constant

$$\int_b^c E \, dl = \bar{E} \int_b^c dl = \bar{E} \int_b^c dl \quad \text{——— (6)}$$

$$\therefore \int_b^c dl = \frac{\Delta h}{2} \quad \text{——— (7)}$$

The surface integration must be equal to over the surface

(i) Top (ii) bottom and (iii) Lateral

$$\int_{top} D \, ds + \int_{bottom} D . ds + \int_{Lateral} D . ds = Q$$

Lateral surface area $= 2\pi r \Delta h$

$r \rightarrow$ Radius of the cylinder

$$\int_{top} D \, ds = D_N \int_{top} ds = D_N \Delta s$$

$$D_N \Delta s = Q$$

At boundary charge value $= \rho_s$

$$Q = \rho_s \Delta s$$

$\therefore \quad E_1 = E_{1t} + E_{1N} \longrightarrow ③$

$E_2 = E_{2t} + E_{2N} \longrightarrow ④$

$|E_{1t}| = E_{tan\,1}\ , \quad |E_{2t}| = E_{tan\,2}$

$|E_{1N}| = E_{1N} \qquad |E_{2N}| = E_{2N}$

$\Delta h \rightarrow 0$

$a \rightarrow b$ is in dielectric

$E_{tan\,1}$ as $a \rightarrow b$ direction

$$\therefore \int_a^b E \cdot dl = E_{tan\,1} \int_a^b dl = E_{tan\,1}\ \Delta w \longrightarrow ⑤$$

$c \rightarrow d$ is in dielectric 2, $\bar{E}$ is $E_{tan\,2}$

direction is also tangential

$c \rightarrow d$ is opposite to $a \rightarrow b$

$$\int_c^d E \cdot dl = -E_{tan\,2} \cdot \Delta w \text{ ——— } ⑥$$

$$E_{tan_1} \Delta w - E_{tan_2} \Delta w = 0$$

$$E_{tan_1} = E_{tan_2}$$

$$D = \varepsilon E$$

$$D_{tan_1} = \varepsilon_1 E_{tan_1}$$

$$D_{tan_2} = \varepsilon_2 E_{tan_2}$$

$$\frac{D_{tan_1}}{\varepsilon_1} = \frac{D_{tan_2}}{\varepsilon_2} \; ; \quad \frac{\varepsilon_1}{\varepsilon_2} = \frac{\varepsilon_{r_1}}{\varepsilon_{r_2}}$$

For Gaussian Surface

$$\Delta h \to 0 \qquad \oint D \, ds = Q$$

$$\left(\int_{Top} + \int_{bottom} + \int_{Lateral} \right) \cdot \bar{D} \, ds = Q$$

$$\int_{Lateral} D \cdot ds = 0 \qquad \Delta h \to 0$$

$$\int_{top} D \cdot ds + \int_{bottom} D \cdot ds = Q$$

$$\int_{top} D.ds = D_{N_1} \int_{top} ds = \cancel{D_{N_1}} D_{N_1} \Delta S$$

$$\int_{bottom} D.ds = -D_{N_2} \int_{bottom} ds = -D_{N_2} . \Delta S$$

$$D_{N_1} \Delta S - D_{N_2} \Delta S = Q$$

$$Q = \rho_s \Delta s$$

$$\rho_s \Delta s = D_{N_1} \Delta s - D_{N_2} \Delta s$$

where $\rho_s = 0$

$$D_{N_1} - D_{N_2} = 0 \qquad (\because D = \varepsilon E)$$

$$D_{N_1} = \varepsilon_1 E_{1 N_1}$$

$$D_{N_2} = \varepsilon_2 E_{2N_2}$$

$$\frac{D_{N_1}}{D_{N_2}} = \frac{\varepsilon_1 E_{1N_1}}{\varepsilon_2 E_{2N_2}} = 1$$

$$D_{N_1} = D_{N_2}$$

$$\boxed{\frac{E_{N_1}}{E_{N_2}} = \frac{\varepsilon_2}{\varepsilon_1}}$$

questions	opt1	opt2	opt3	opt4	answer
If the distance between two charges is doubled the electrostatic force between the charges will be	four times more	four times less	will increase two times	will decrease two times	four times less
The field due to an electric dipole at an axial point E1of the dipole and at a point on the perpendicular bisector of dipole E2 are related as	$E_1 = E_2$	$E_1 = 2E_2$	$2E_1 = E_2$	$E_1 = 4E_2$	$E_1 = 2E_2$
The magnitude of electric displacement depends on	The applied field alone	the dielectric polarization	the applied field and dielectric polarization	dielectric breakdown	the applied field and dielectric polarization
The Coulomb force is proportional to	1/r	r	r^2	$1/ r^2$	$1/ r^2$
Which of the following is true regarding electrical field intensity.	It is defined in terms of unit +ve charge.	It is a scalar	It is force per unit charge.	a and c.	a and c.
E due to uniform infinite line charge is proportional to	the square radial distance.	the line charge density	the inverse of the square of the distance	the square of the line charge density	the line charge density
The concept of potential gradient	gives the rate of increase of potential with respect to distance.	gives the rate of decrease of potential with respect to distance.	is a scalar.	is the same as E	gives the rate of increase of potential with respect to distance.
Gradient of potential is notated as follows	Del V	Del V	Div V	Curl V	Del V
Potential due to a dipole varies as	1/sinθ	1/cosθ	Qd	r	Qd
Which of the following is true?	E = D	E = - Del V	E = B X D	a and b.	E = - Del V
The field in which closed loop integration of E.dL is equal to zero is called	conservative	rotational	irrotational	solenoidal	conservative
Divergence theorem equates	surface integral and a volume integral	surface integrals of two different vectors over the same surface.	volume integrals of two different vectors over the same volume.	a line integral and a volume integral.	surface integral and a volume integral
The Electrical field intensity due to an infinite sheet charge	is independent of any distance parameters	varies as the inverse of the perpendicular distance.	varies inversely as the surface charge density	none of the above.	is independent of any distance parameters
The electrical field intensity between planes that are defined by ρs and - ρs is	ρs	ρs /2	ρs /2ξ0	ρs / 4	ρs /2ξ0
The flux due to a point charge through a sphere of 5 cm radius is 10 n C. The flux passing through a sphere of 10 cm radius is	10 nC	0.1 nC	20 nC	0	10 nC
The flux density due to a line charge	varies as inverse of sphere radius.	varies as inverse of cylindrical radius.	is independant of distance.	is in the direction of gradient.	varies as inverse of cylindrical radius.
E in SI units is defined in terms of	1C +ve charge.	1C -ve charge	1 microcoulomb +ve charge	1 microcoulomb -ve charge	1C +ve charge.
E is	a force per 10 C	a force per 1C	Force per -C charge	a velocity	a force per 1C
A force of 4ΠЄ0 N is experienced between two equal charges in free space separated by 1m, having a magnitude of	1C	approximately 100 pC.	approximately 10 micro coulombs.	5 C	1C
The unit of electrical flux is	Coulomb	Coulombs / square metre	volts/metre	volts metre.	Coulomb
The unit of surface charge density is	Coulomb per meter.	micro coulomb per square metre.	Coulomb per square metre.	Coulomb per cubic metre.	Coulomb per square metre.
Divergence	is a vector.	is a force.	involves concept of sourcing and sinking	is an acceleration	involves concept of sourcing and sinking
Gradient	is a vector	is a force.,	is a rate of increase of a scalar with respect to distance	is a rate of change of a scalar with respect to distance.	is a rate of increase of a scalar with respect to distance
Divergence theorem	is applicable for all flux vectors.	is applicable for all kinds of vectors	equates surface integral to another surface integral.	equates line integral to another line integral.	equates surface integral to another surface integral.
E on the axis of a circular ring of certain C/m density	will have only component parallel to the ring	will have only axial component	will have a resultant of parallel and axial components	will be equal to zero.	will have only axial component
Div D =0 says	the volume charge density is equal to zero.	the surface charge density is equal to zero.	the line charge density is equal to zero.	The field is non solenoidal	the volume charge density is equal to zero.
Gauss's law	is applicable for all kinds of vectors	is applicable for only flux densities	is applicable for only electrical flux density.	does not need symmetry.	is applicable for only flux densities
The potential at a point which is 50 cm away from a point charge of 4ΠЄ0 Coulombs is	2 V	1 V	4 V	0.5V	2 V
. If E is equal to 1 microvolt per metre, the PD is over 10 m is	20 micro volts	10 micro volts	5 micro volts	5 micro volts	10 micro volts
In free space, what of the following is true?	D and E are in the same direction	D is perpendicular to E.	D is exactly opposite to E.	E and D are not relate	D and E are in the same direction
When the distance is increased by two times the potential due to a dipole	increases by 6 times	remains constant.	decreases by 4 times	decreases by 6 times.	decreases by 4 times
A dipole field can be best described in terms of	Spherical coordinate system	Cartesian system	Cylindrical system	Parabolic system.	Spherical coordinate system
Which of the following regarding the relation between E and V is true?	E is directed along the tangential of equipotential surface.	E is directed along the normal to the equipotential surface.	E is directed along the normal to the equipotential surface and the normal is in the increasing potential direction	E is directed along the normal to the equipotential surface and the normal is in the decreasing potential direction.	E is directed along the normal to the equipotential surface and the normal is in the decreasing potential direction.
Gauss's law	deals with only closed surfaces.	deals with only open surfaces.	deals with arcs and not with surfaces.	deals with open surface and the volume within.	deals with only closed surfaces.
The electrical flux density outside the outer conductor is of a metallic shell	equal to zero.	inversely proportional to distance	inversely proportional to square of distance.	constant , but not zero.	equal to zero.
The field intensity outside the outer conductor of a metallic shell	equal to zero.	inversely proportional to distance	inversely proportional to square of distance.	constant , but not zero.	equal to zero.
Volts per metre is the unit of	Electrical Flux density	Electrical field intensity	Electrical Flux	Magnetic Flux	Electrical field intensity
Which Of the following is not a vector?	work	Force	Field intensity	Flux density.	work
aΘ is in the direction of	increasing spherical radius	decreasing spherical radius	increasing Θ	decreasing Θ	increasing Θ
aΦ is in the direction of	increasing spherical radius	decreasing spherical radius	increasing Φ	decreasing Φ	increasing Φ

$$\psi(x) = A \sin \frac{n\pi x}{L}$$

$$\int_0^L |\psi(x)|^2 \, dx = 1$$

$$\int_0^L A^2 \sin^2 \frac{n\pi x}{L} \, dx = 1$$

$$\sin^2\theta = \frac{1-\cos 2\theta}{2}$$

$$A^2 \int_0^L \left(\frac{1-\cos 2\frac{n\pi x}{L}}{2} \right) dx = 1$$

$$\frac{A^2}{2} \left[\int_0^L dx - \int_0^L \cos \frac{2n\pi x}{L} \right] dx = 1$$

$$\frac{A^2}{2} \left[[x]_0^L - \left[\frac{\sin \frac{2n\pi x}{L}}{\frac{2n\pi}{L}} \right]_0^L \right] = 1$$

$$\sin n\pi = 0$$

$$\frac{A^2}{2}(L) = 1$$

$$A^2 = \frac{2}{L}$$

$$\boxed{A = \sqrt{\frac{2}{L}}}$$

Magnetic materials :

Magnetic field

The space around the magnet in which magnetic lines of force acting is called Magnetic field.

Magnetic induction or magnetic flux density, (B)

The magnetic lines of force per unit area normal to ~~their~~ direction are termed ~~It is denoted by B it~~ as magnetic induction or magnetic flux density. It has denoted by B. It has a unit of W/m^2. Tesla.

Magnetic field intensity : (H)

The externally applied magnetic field some times called magnetic field intensity.

Magnetic permeability (μ) :

The magnetic induction (B) is directly proporsional to magnetic field intensity.

$$B \propto H$$

$$B = \mu_0 H$$

where μ_0 is permeability of free space

Magnetic moment (M) :

The magnetic dipole strength is produced of pole strength (m) and distance (l) between the poles.

$$M = ml \text{ amp/m}^2$$

Intensity of Magnetisation (I) :

Intensity of Magnetisation of a sample of material is the magnetic moment per unit volume.

$$I = M/V \quad W/m^2$$

Susceptibility : χ

Magnetic susceptibility of a material is the ratio of the intensity of magnetisation (I) produce in the sample to applied magnetic field intensity.

χ - Kai

$$\chi = I/H$$

Bohr Magneton :

The spining of electron would produce a magnetic moment and its magnitude is defined as a Bohr magneton.

planck constant

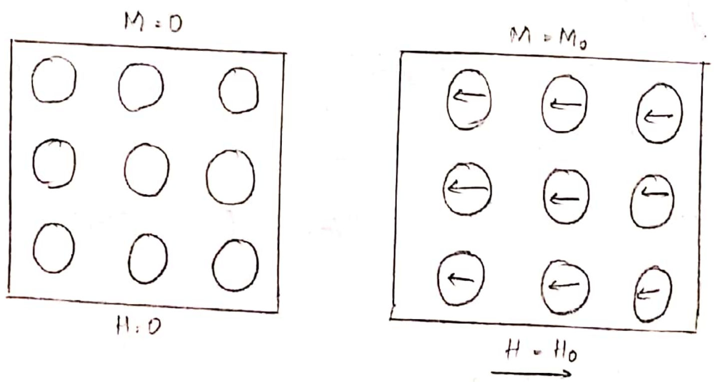
Classifications of interaction and Types of magnetism

Magnetic field and forces are originated from the movement of electrons. When electrons move in conducting wire a magnetic field is produced around the wire.

Diamagnetism :

When certain substance placed in the external magnetic field they occur and induced magnetic moment which would oppose external magnetic field. That is the direction of induced dipole moment is opposite to external magnetic field and substance has negative magnetic susceptibility. This type of substance are called Diamagnetic substances.

Magnetisation becomes zero when applied magnetic field is removed.



Properties :

* They repel the magnetic lines of force.
* Susceptibility is negative and it is independent of temperature and applied magnetic field strength.
* Permeability is less than 1.
* There is no permanent dipole moment.

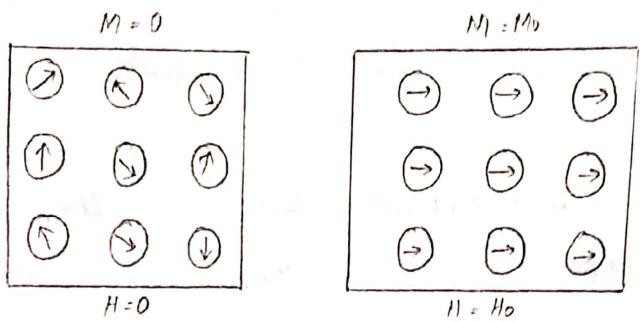
so they are called weak magnets.

* When temperature is less than critical temperature diamagnetic become normal material.

Eg : copper, gold, mercury, silver.

Paramagnetic materials :

When certain substances are placed in an external magnetic field the magnetic moments of an atom is tend to align themselves in the direction of the magnetic field and acquire very low degree of magnetisation. This types of substances are called paramagnetic substances.



The net magnetisation in the absence of external magnetic field. since spins are randomly oriented or alligned. Due to the applied magnetic field the individual magnetic moments tend to align themselves in the direction of the magnetic field applied.

Properties :

* The magnetic lines of force pass through the material.

* susceptibility is positive and it is given by $\chi = \frac{C}{T-\theta}$ (curie weiss law)

where C - curie constant

T - absolute temperature

θ - curie temperature

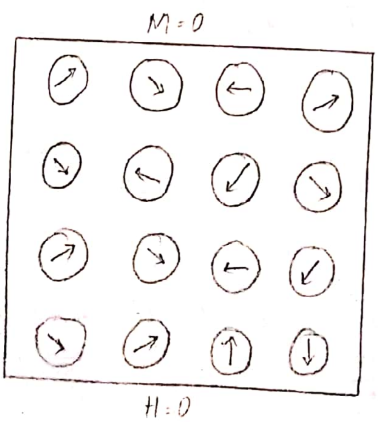
* Permeability is greater than 1.
* They forces permanent dipole moment.
* When the temperature is less than curie temperature, paramagnetic material becomes normal temperature material. (diamagnetic)

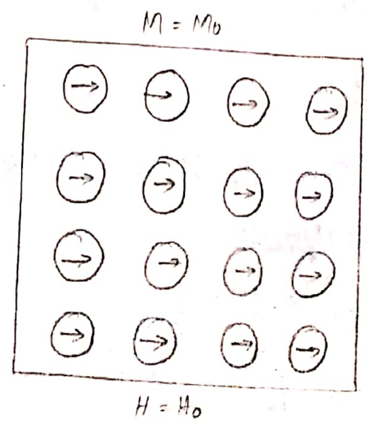
Eg: Aluminium, Titanium, sodium eg..

Ferromagnetism :

When certain substances are placed in an external magnetic field the magnetic moments of an atom tend to align themselves in a direction of the magnetic field and acquire very high degree of magnetisation. These types of substances are called Ferromagnetic substances.

In ferromagnetic substance the atomic magnetic moments are alligned even the absence of external field so these materials exhibit spontaneous magnetisation. This shows that the ferromagnetic material has strong internal field that makes the atomic magnetic moments align with eachother.





Properties :

Since some magnetisation is already existing in these materials all the magnetic lines of forces passes through it.

They have permanent dipole moment so they act as strong magnet.

They exhibit magnetisation event in the absence of magnetic field. This property is called spontaneous magnetisa

Its susceptibility is positive and it is given by $\chi = \frac{C}{T-\theta}$

where, C - curie constant

T - absolute temperature

θ - curie temperature

Permeability is very much greater than 1.

Eg: Nickel (Ni), cobalt (Co), Iron (Fe) ... etc.

When the temperature is less than curie temperature, ferromagnetic material becomes para magnetic material.

Diamagnetism	Paramagnetism	Ferromagnetism
* In diamagnetic material there are equal no. of electron spins which are randamly oriented and hence the net magnetic moment is zero.	* In paramagnetic material there are unequal no. of electron spins and hence there exist a permanent magnetic moment.	* In ferromagnetic material there are large no. of electron spins and hence there exist enormous amount of permanent magnetic moment.
* When the external magnetic field is applied the electrons will align ⊥ to the field direction and hence it reduces the magnetic induction present in the material. Thus they are termed as weak magnets.	* When the external magnetic is applied the electrons will align $\parallel^{el}$ to the field direction and hence the material is magnetized. Thus they are termed as strong magnets.	* When the external magnetic field is applied the electrons which are already alliged $\parallel^{el}$ to the field direction & re-orient itself. Hence it will be very easily magnetized. Thus they are termed as very strong magnets.
* When the material is placed in the magnetic field the magnetic flux lines are repel away from the material.	* When the material is placed the magnetic flux lines are pass through the material.	* When the material is placed the magnetic flux lines are pass through the material.

* The susceptibility is negative. * The susceptibility is independent of temperature * Permeability is less than 1. * When the temperature is less than critical temperature diamagnetic material becomes normal material.	* The susceptibility is positive and small. * The susceptibility varies inversely with absolute temperature. * Permeability is greater than 1. * When the temperature is less than curie temperature paramagnetic material becomes diamagnetic material.	* The susceptibility is positive and large. * The susceptibility is dependents upon the temperature * Permeability is very much greater than 1. * When the temperature is less than curie temperature Ferromagnetic material becomes Paramagnetic material.

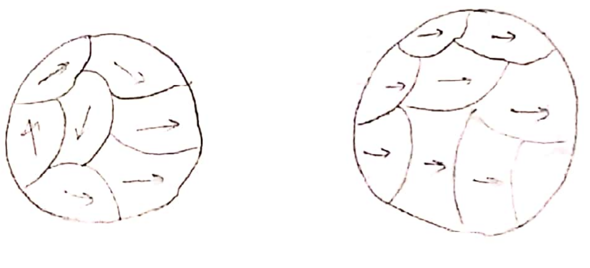
Domain theory :

A Magnetic domain describes a within a magnetic material which has uniform magnetization. This means that the individual magnetic moments of the atoms are alligned with one other in the same direction.

In the absence of magnetic field the magnetic moment in the domain of the ferromagnetic material are randomly oriented

When the magnetic field is applied to the ferromagnetic material the magnetic moment in the domains are alligned parallel with the field direction.

Magnetic domain structure is responsible for the magnetic behaviour of ferromagnetic materials like iron. The regions separating magnetic domains are called domain walls



Formation of domains:

There are two possible ways to align the domains by applying an external magnetic field. They are :

* By the motion of domain walls
* By rotation of domains.

By the

When the small magnetic field is applied the domains will move in magnetization direction parallel to the field, grow at the extense of anti-parallel domains by virtue of a motion of domain walls.

The motion of domain walls can be considered as stealing of neighbouring dipoles from other domains are alligning them in the direction of external field so that refered domain increases in size.

Energy involved in the process of domain growth:

* Exchange energy:

It is also called magnetic field energy are magneto stat energy. It is the energy associated with quantum mechanical coupling that aligns individual atomic dipoles within a single domain.

It arises interaction of electron spins. It depends upon the inter atomic distance.

* Crystal anisotropic energy:

Crystals are anisotropic in nature. The ease of magnetization varies with crystalo graphic direction.

(100) direction - (easy direction) xyz - direction

(110) - Hard direction

(111) - Very hard direction

The energy needed to magnetize to hard

questions	opt1	opt2	opt3	opt4	answer
Field at a point on the axis of circular loop at a distance R far away from the loop is	directly proportional to R^2	inversely proportional to R^2	directly proportional to R^3	inversely proportional to R^3	inversely proportional to R^2
Magnetic vector potential due to magnetic dipole is proportional to	r	r^{-1}	r^{-2}	r^{-3}	r^{-2}
Magnetostatics deals with	magnetic field from dc currents.	magnetic field magnetic field from pulsating dc current	any time-varying current	static charges	magnetic field from dc currents.
The magnetic field intensity in SI system is	certain amperes per metre	certain volts per metre	certain amperes Square metre.	certain volts Square metre.	certain amperes per metre
Magnetic field intensity is proportional to	inverse of distance	inverse of square of distance	square of distance.	Cube of distance.	inverse of square of distance
H due to an infinitely thin current element is proportional to	inverse of length of current element	inverse of square of current element.	Length of current element	The square of length of current element.	Length of current element
H due to an infinitely thin current element is in the direction of	aθ of spherical coordinate system.	aΦ of cylindrical coordinate system	aρ of cylindrical coordinate system	ar of spherical coordinate system	aΦ of cylindrical coordinate system
H due to an infinitely long conductor is	inversely proportional to the radial distance	proportional to square of radial distance	proportional to cube of radial distance	proportional to inverse of square of distance.	inversely proportional to the radial distance
H due to a finitely long conductor is	inversely proportional to the current	proportional to current	proportional to cube of current	proportional to inverse of square of distance.	proportional to current
Magnetic flux density outside a coaxial cable is	equal to zero.	Inversely proportional to distance	Inversely proportional to distance from outer surface.	Inversely proportional to square of distance from outer surface.	equal to zero.
Magnetic field intensity inside inner conductor of a coaxial cable	is inversely proportional to cube of radius	is proportional to cue of radius.	s proportional to radius	d is inversely proportional to square of radius	is inversely proportional to square of radius
H in the space between inner and outer conductor of a coaxial cable is	is inversely proportional to cube of radius	is proportional to cue of radius.	is proportional to inverse radius	is inversely proportional to square of radius	is proportional to inverse radius
Curl of magnetic field intensity is equal to	The surface current density	The linear current density	The current itself	Divergence of magnetic fiel	The surface current density
An irrotational H means	The field is conservative	There is no divergence	There is no gradient	there is no curl	there is no curl
Magnetic field intensity outside a coaxial cable	equal to zero.	inversely proportional to distance	inversely proportional to distance from outer surface.	inversely proportional to square of distance from outer surface.	equal to zero.
Magnetic flux density inside inner conductor of a coaxial cable	is inversely proportional to cube of radius	is proportional to cue of radius.	is proportional to radius	is inversely proportional to square of radius	is inversely proportional to square of radius
B in the space between inner and outer conductor of a coaxial cable is	is inversely proportional to cube of radius	is proportional to cue of radius.	is proportional to inverse radius	is inversely proportional to square of radius	is proportional to inverse radius
Stokes theorem relates	line integral to surface integral of a closed surface	line integral to surface integral of an open surface	surface integral and volume integral of a closed surface.	Two volume integrals	line integral to surface integral of an open surface
Curl H = J is	point form of Gauss's law.	Continuity equation.	Point form of Ampere's circuital law.	Point form of Faraday's law.	Point form of Ampere's circuital law.
B in SI system is measured in	Ampere per square metre.	Ampere per metre.	Weber per square metre.	Weber per metre.	Weber per square metre.
The hysteresis is	lagging of the magnetising force H with respect to the force	lagging of flux density B with respect to the magnetising force H	the ratio of B and H	the ratio of temperature and magnetic field and temperature	the ratio of B and H
The susceptibility value of ferromagnetic material is	positive	negative	zero	infinity	positive
The origin of magnetism is	ions	dipoles	atoms	monopoles	dipoles
Diamagnetic materials are	Attracting magnetic lines	supplying magnetic lines	repelling magnetic lines	neutral	repelling magnetic lines
Ampere's circuital law is applicable for	only outside a conductor.	only inside an inner conductor.	Any region.	time-varying currents.	Any region.
Magnetic moment is proportional to	The current	The square of current	The square of number of turns.	The square of area.	The current
When the current is doubled the magnetic moment of a rectangular coil	gets quadrupled	reduces y four times.	gets doubled.	is unchange	gets doubled.
For a rectangular coil of 5 turns ,0 .1 sq metre and 0.1 amp the magnetic moment is	0 .1 Ampere sq metre	0.01 Ampere per sq metre	0.05 Ampere square metre	0.05 Ampere per square metre	0.05 Ampere square metre
Magnetic moment in SI system is measured in	Ampere square metre	Ampere metre.	Ampere per square metre.	Weber per square metre.	Ampere square metre
Solenoid is	an effective way of producing magnetic field	an effective way of producing electrical field.	an effective way of producing both E and H fields.	is used for increasing capacitance.	an effective way of producing magnetic field
Magnetic Flux density is measured in	Webers.	Tesla.	H/m	Hm	Tesla.
Magnetic flux is measured in	Coulombs	Weers.	Tesla	Fadads.	Weers.
If B is flux density, L is length and v is velocity Current moment is	I/L	IL	BIL	BvL.	IL
Magnetic Flux density is	Force per unit current moment	Force multiplied y current moment	current moment per unit force	a force.	Force per unit current moment
Force between two current carrying conductors is proportional to	the square of individual currents	distance etween them	the individual currents.	inverse of the length of the conductor	the individual currents.
Gauss's law for magnetic fields is	Div B = Q	Div D = Q	Div B = 0	Div H =Q	Div B = 0
Magnetic fields are always	irrotational	nonsolenoidal	solenoidal	conservative.	solenoidal
Tesla is the unit of	Magnetic Flux density	Electrical flux density	Electrical field intensity	Magnetic Field intensity	Magnetic Flux density
Henry is the unit of	capacitance	mutual inductance	magnetic field intensity	electrical field intensity	mutual inductance
Magnetic flux intensity is proportional to	inverse of square of distance	inverse of distance	square of distance.	cube of distance	inverse of square of distance
Div B=0 is called	Maxwell's first law.	Gauss's law for magnetic fields.	Ampere's circuital law.	Gauss's law for electrical fiel	Gauss's law for magnetic fields.
∫B.dS =0 is	Gauss's law for electrical fields.	Gauss's law for magnetic fields.	Ampere's circuital law.	Faraday's law.	Gauss's law for magnetic fields.
∫H.dL=I is	Maxwell's first law.	Faraday's first law.	Gauss's law for magnetic fields.	Ampere's circuital law.	Ampere's circuital law.
Ampere/ metre is the unit of	Magnetic flux.	Magnetic field intensity	Electrical field intensity.	Magnetic moment.	Magnetic field intensity
Weber is the unit of	Magnetic flux.	Electrical Flux density	Magnetic flux density	Electrical Flux.	Magnetic flux.
Self Inductance is proportional to	the square of turns	The turns of the coil	The length of the magnetic circuit.	Inverse of cross section .	the square of turns

Properties of Matter

Elasticity

Elasticity is the property of the body which tends to regain its original shape (or) size after the removal of deforming forces applied externally to it.

Hooke's law

stress is directly proportional to the strain produced, within the elastic limit

$$\text{stress} \propto \text{strain}$$

$$\text{stress} = E \times \text{strain}$$

$$E = \frac{\text{stress}}{\text{strain}} \; Nm^{-2}$$ where E - Elastic modulus

stress

stress is defined as the restoring force per unit area which brings back to its original state from the deformed state.

Types of stress

(i) Normal stress

(ii) Tangential stress

strain

strain is defined as the change in dimension produced by the external force on the body. In other way, it can also be defined as the ratio of the change in dimension to the original dimension

$$\text{strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

Types of strain

(i) Longitudinal strain
(ii) shearing strain
(iii) Volumetric strain

Classification of Elastic modulus

Depending on the three types of strain, there are three types of elastic modulus

(i) Young's modulus (Y)

(ii) Bulk modulus (K)

iii) Rigidity modulus (n)

(i) Young's modulus (Y)

It is defined as the ratio between the longitudinal stress to the longitudinal strain, within the elastic limits.

$$\text{Young's modulus (Y)} = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} \quad Nm^{-2} \text{ (or) Pascals.}$$

(ii) Bulk modulus (K)

It is defined as the ratio between the volume stress (or) bulk stress to the volume strain (or) bulk strain within the elastic limits.

$$\text{Bulk modulus (K)} = \frac{\text{Bulk stress}}{\text{Bulk strain}} \quad Nm^{-2} \text{ (or) pascals.}$$

(iii) Rigidity modulus (n)

It is defined as the ratio between the tangential stress to the shearing strain, within the elastic limits

$$\text{Rigidity modulus (n)} = \frac{\text{Tangential stress}}{\text{Shearing strain}} \quad Nm^{-2} \text{ (or) pascals}$$

Poisson's Ratio (σ)

It is defined as the ratio between the lateral strain per unit stress (β) to the longitudinal strain per unit stress (α) within the elastic limits.

$$\text{Poisson's ratio } (\sigma) = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

Relationship between three modulli of Elasticity

There are many relations connecting the lateral strain longitudinal strain (α), Poisson's ratio (σ) and the three elastic modulii. Some of the relations are

(i) Relation between α and Youngs modulus

$$\alpha = \frac{1}{Y}$$

ii) Relation between α and β with the Bulk modulus

$$\alpha - 2\beta = \frac{1}{3K}$$

iii) Relation between α and β with the rigidity modulus

$$\alpha + \beta = \frac{1}{2n}$$

iv) Relation between Y, n and K is

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

v) Relation between n, K and σ is

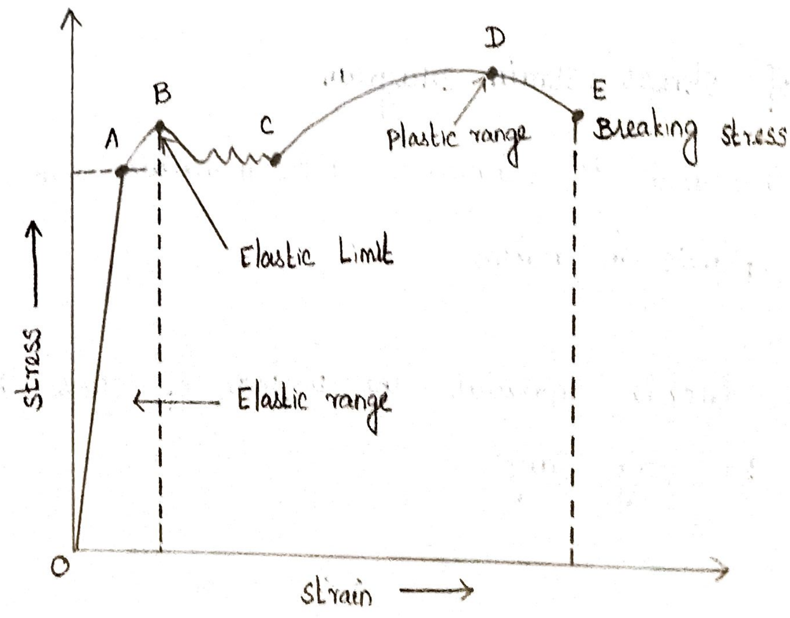
$$\sigma = \frac{3K - 2n}{6K + 2n}$$

vi) Relation between Y, n and σ is

$$\sigma = \frac{Y}{2n} - 1$$

Stress - strain diagram

Let us consider a body which is subjected to an uniformly increasing stress. Due to the application of the stress, the change in dimension of the body takes place. If we plot a graph between stress and strain, we get a curve is called as stress - strain Diagram.



1. It is found that the body obeys Hooke's law upto the region OA called as elastic range.

2. As soon as the maximum elastic limit (i.e) Yield point 'B' is crossed, the strain increases rapidly than the stress.

3. At this stage, the body remains partly elastic and partly plastic which is represented by the curve BC.

4. Now, even if a small external force is applied, the body will take a new path CD and remains as plastic called as plastic range, where D is called as ultimate strength.

5. After this, the body will not come to its original state and the body acquires a permanent residulal strain and it breaks down at a point called as breaking stress, indicated by dotted line EF.

uses of stress - strain Diagram

1. It is used to catagorize the materials into ductile (or) Brittle (or) plastic in nature.

2. For ductile material the portion of curve between C to E will be very large.

3. For a brittle material, the yield point coincides with the breaking point.

4. For a plastic material the stress - strain diagram runs parallel to the strain axis beyond the yield point.

Factors Affecting Elastic modulus and tensile strength

(i) Effect of stress

(ii) Effect of annealing

(iii) change in Temperature

(iv) Presence of Impurities

(v) Due to the nature of crystals

Torsion Pendulum

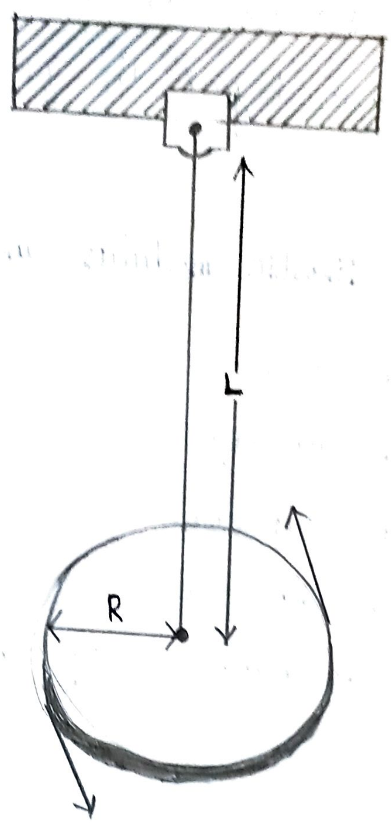
Principle

When a disc (torsion pendulum) is rotated in a horizontal plane, the disc executes simple harmonic osillation due to the restoring couple produced in the wire.

Description

A torsion pendulum consists of a wire with one end fixed to a split chuck and the other end fixed to the centre of the circular disc of radius R.

Let `L' be the distance between the chuck and the disc and `r' be the radius of the suspended wire.



Warking

The circular disc is rotated in horizontal plane so that the wire is twisted through an angle θ. The various elements of the wire will undergo shearing strain and a restoring couple is produced. Now if the disc is released, the disc will produce torsion osillations.

The couple acting on the disc produces an angular acceleration in it, which is propotional to the angular displacement and is always directed towards its mean position.

Therefore from the law of conservation of energy of the system is conserved.

$\therefore$ Total energy of the torsion pendulum = Potential Energy (P.E) + Kinetic Energy (K.E) —— ①

The potential energy confined to the wire is equal to the work done in twisting the disc, thereby creating a restoring couple (C)

$\therefore$ Restoring couple (P.E) through an angle (θ) = $\int_0^\theta$ Moment of couple $\times d\theta$

$$P.E = \int_0^\theta C\theta \cdot d\theta$$

$$P.E = \frac{C\theta^2}{2} \quad \text{——} \ ②$$

Let 'ω' the angular velocity with which the disc oscillates, due to the resorting couple, then

$\therefore$ The kinetic energy confined to the rotating disc $= \frac{1}{2} I\omega^2$

$$K.E = \frac{1}{2} I\omega^2 \quad \text{——} \ ③$$

where I - moment of inertia

$\therefore$ Total Energy $T = \frac{C\theta^2}{2} + \frac{I\omega^2}{2} = \text{constant}$ —— (4)

Differentiating equation (4) with respect to time 't'

$$\frac{\cancel{2} C\theta \frac{d\theta}{dt}}{\cancel{2}} + \frac{\cancel{2} I\omega \frac{d\omega}{dt}}{\cancel{2}} = 0 \quad \text{—— (5)}$$

Since the angular velocity $\omega = \frac{d\theta}{dt}$ and the angular acceleration $\frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$

We can write equ (5)

$$C\theta \frac{d\theta}{dt} + I \frac{d\theta}{dt} \cdot \frac{d^2\theta}{dt^2} = 0$$

$$\frac{d\theta}{dt}\left[C\theta + I \frac{d^2\theta}{dt^2}\right] = 0$$

Here

$$\frac{d\theta}{dt} \neq 0 \quad , \quad C\theta + I\frac{d^2\theta}{dt^2} = 0$$

$\therefore$ Angular acceleration

$$\frac{d^2\theta}{dt^2} = -\frac{C\theta}{I} \quad \text{—— (6)}$$

-ve sign indicates that the couple tends to decrease the twist on the wire.

Period of osillation

We know, the time period of osillation

$$T = 2\pi \sqrt{\frac{\text{Displacement}}{\text{Acceleration}}}$$

substituting from equ ⑥,

$$T = 2\pi \sqrt{\frac{\cancel{\theta}}{C\cancel{\theta}/I}}$$

$$\therefore T = 2\pi \sqrt{\frac{I}{C}} \quad \text{—— ⑦}$$

Rigidity modulus of the wire

If 'r' is the radius of the wire and 'L' is the length of the wire suspended, then we know

The torque per unit twist

$$C = \frac{n\pi r^4}{2L} \quad \text{—— ⑧}$$

substituting equ ⑧ in equ ⑦ we get,

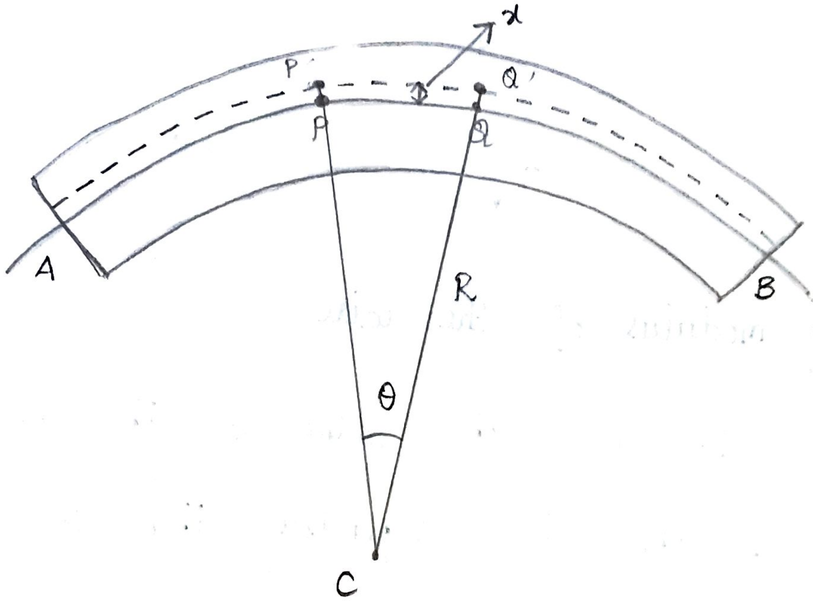
$$T = 2\pi \sqrt{\frac{I\,2L}{n\pi r^4}}$$

$$T^2 = 4\pi^{\cancel{2}} \times \frac{I\,2L}{n\cancel{\pi} r^4}$$

$$n = \frac{8\pi\ IL}{T^2 r^4} \quad Nm^{-2}$$

Expression For the Bending moment

Let us consider a beam under the action of deforming forces. The beam bends into a circular arc. Let AB be the neutral axis of the beam. Here the filaments above AB are elongated and the filaments below AB are compressed. The filament AB remains unchanged.



Let PQ be the arc chosen from the neutral axis. If R is the radius of curvature of the neutral axis and θ is the angle subtended by it at its centre of curvature 'C'.

We can write original length $PQ = R\theta$ ——— ①

Let us consider a filament P'Q' at a distance 'x' from the neutral axis.

∴ We can write the extended length $= P'Q' = (R+x)\theta$ —— ②

Increase in its length $= P'Q' - PQ$

$$= (R+x)\theta - R\theta$$

$$= R\theta + x\theta - R\theta$$

Increase in its length $= x\theta$ —— ③

We know Linear strain $= \dfrac{\text{Increase in length}}{\text{Original length}}$

$$= \frac{x\theta}{R\theta}$$

∴ Linear strain $= \dfrac{x}{R}$ —— ④

We know,

The young's modulus of the material

$$Y = \frac{\text{stress}}{\text{Linear strain}}$$

stress $= Y \times$ Linear strain —— ⑤

substituting equ ④ in ⑤, we have

$$\text{stress} = \frac{Yx}{R}$$

If δA is the area of cross section of the filament $P'Q'$.

Then

The tensile force on the area (δA) = stress × Area

$$\therefore \text{Tensile Force} = \frac{Yx}{R} \cdot \delta A$$

We know that

$$\text{Moment of Force} = \text{Force} \times \text{Perpendicular distance}$$

$\therefore$ Moment of the tensile force about the neutral axis AB (or) PQ

$$PQ = \frac{Yx}{R} \cdot \delta A \cdot x$$

$$PQ = \frac{Y}{R} \delta A\, x^2$$

$\therefore$ The moment of all the forces about the neutral axis $= \frac{Y}{R} \Sigma x^2 \delta A$

Here $\Sigma x^2 \delta A = I_g = AK^2$ is called as the geometrical moment of inertia.

where A is the total area of the beam

K is the radius of the gyration

$$\text{Internal bending moment} = \frac{Y I_g}{R} \quad \text{——} \quad (6)$$

Special Cases

(i) Rectangular Cross Section

If 'b' is the breadth and 'd' is the thickness of the beam, then

Area $A = bd$ ~~and~~ $k^2 = \frac{d^2}{12}$

$\therefore I_g = Ak^2 = \frac{bd^3}{12}$

Substituting I_g value in equ (6)

$\therefore$ Bending moment for a rectangular cross section $= \frac{Ybd^3}{12R}$ —— (7)

(ii) circular cross section

Area $A = \pi r^2$ $\quad k^2 = \frac{r^2}{4}$

$\therefore I_g = Ak^2 = \frac{\pi r^2 \times r^2}{4}$

$I_g = \frac{\pi r^4}{4}$

substituting I_g value in equ (6)

$\therefore$ Bending moment of a circular cross section $= \frac{\pi Y R^4}{4}$

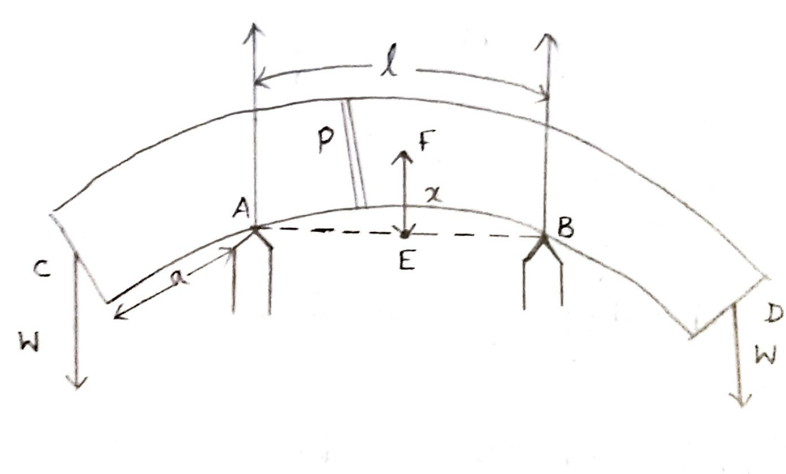
$= \frac{\pi Y r^4}{4R}$ —— (8)

Uniform Bending - Elevation at the centre of the beam loaded at both ends.

Theory

Let us consider a beam of negligible mass, supported symmetrically on the two ~~kin~~ knife edges A and B. Let the length between A and B be 'l'. Let equal weights W, be added to either end of the beam C and D.

Let the distance CA = BD = a



Due to the load applied, the beam bends from position E to F into an arc of a circle and produces as elevation 'x' from position E to F. Let 'W' be the reaction produced at the points A and B which acts vertically upwards

$\therefore$ External bending moment about P can be written as

$$= Wa \quad \text{——} \quad (1)$$

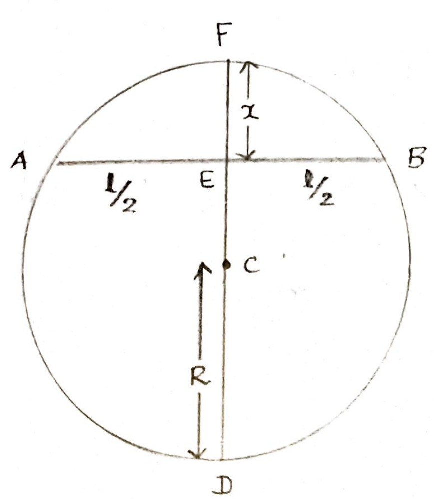
We know the internal bending moment $= \dfrac{Y I_g}{R}$ —— (2)

Under equilibrium condition

External bending moment = Internal bending moment

$$Wa = \frac{Y I_g}{R} \quad \text{——} \quad (3)$$

Here it is found that the elevation 'x' forms an arc of the circle of radius 'R'



According to circle rule

$$AE \times EB = FE \times ED$$

$$\frac{l}{2} \times \frac{l}{2} = x \times (FD - EF)$$

$$\frac{l^2}{4} = x \times (2R - x)$$

$$\frac{l^2}{4} = 2xR - x^2$$

If the elevation 'x' is very small, then the term x^2 can be neglected.

$$\therefore \frac{l^2}{4} = 2xR$$

$\therefore$ Radius of curvature $R = \dfrac{l^2}{8x}$ ——— (4)

Substituting the value of 'R' value in equ (3)

$$W.a = \frac{Y I_g}{\frac{l^2}{8x}}$$

$$W \cdot a = \frac{8 Y I_g x}{l^2} \quad \text{—} \quad 6$$

Rearranging the equation

The elevation of point F above A is given by

$$x = \frac{Wal^2}{8 Y I_g} \quad \text{—} \quad 7$$

$(W = mg)$

For a rectangular bar,

moment of inertia $I_g = \frac{bd^3}{12}$ — 8

substituting equ 8 in equ 7

$$x = \frac{mgal^2}{2\cancel{8} Y \frac{bd^3}{\cancel{12}_3}}$$

$$x = \frac{3}{2} \frac{mgal^2}{\cancel{2} bd^3 Y}$$

$\therefore$ The young's modulus $\boxed{Y = \frac{3mgal^2}{2bd^3 x}}$ Nm^{-2}

questions	opt1	opt2	opt3	opt4	opt5
Stress is	External force	Internal resistive force	Axial force	Radial force	Internal resistive force
Following are the basic types of stress except	Tensile stress	Compressive stress	Shear stress	Volumetric stress	Volumetric stress
Which of the following is not a basic type of strain?	Compressive strain	Shear strain	Area strain	Volume strain	Area strain
Hooke’s law is applicable within	Elastic limit	Plastic limit	Fracture point	Ultimate strength	Elastic limit
The deformation per unit length is called	Strain	Stress	Elasticity	None of these	Strain
The ability of the material to deform without breaking is called	Elasticity	Plasticity	Creep	None of these	Plasticity
Which of the following material is more elastic?	Rubber	Glass	Steel	Wood	Steel
The percentage elongation and the percentage reduction in area depends upon	Tensile strength of the material	Ductility of the material	Toughness of the material	None of these	Ductility of the material
The property of a material by which it can be beaten or rolled into thin sheets, is called	Elasticity	Plasticity	Ductility	Malleability	Malleability
The property of a material by which it can be drawn to a smaller section by applying a	Elasticity	Plasticity	Ductility	Malleability	Ductility
If a material has identical properties in all directions, it is called	Elastic	Plastic	Isotropic	Homogeneous	Isotropic
The stress at which extension of a material takes place more quickly as compared to	No elastic zone	Plastic point	Yield point	Breaking point	Yield point
A brittle material has	No elastic zone	No plastic zone	Large plastic zone	None of these	No plastic zone
Every material obeys the Hooke’s law within	Elastic limit	Plastic limit	Limit of proportionality	None of these	Elastic limit
The ratio of lateral strain to linear strain is called	Modulus of Elasticity	Modulus of Rigidity	Bulk Modulus	Poisson’s Ratio	Poisson’s Ratio
A perfectly elastic body	Can move freely	Has perfectly smooth surface	Is not deformed by any external surface	Recovers its original size and shape	Recovers its original size and shape
The value of Poison’s ratio depends upon	Nature of load, tensile or compressive	Magnitude of load	Material of the test specimen	Dimensions of the test specimen	Material of the test specimen
Which of the following is a dimensionless quantity?	Shear stress	Poison’s ratio	Strain	Poison’s ratio and Strain	Poison’s ratio and Strain
Percentage elongation during tensile test is indication of	Ductility	Malleability	Creep	Rigidity	Ductility
Brittleness is opposite to	Toughness	Plasticity	Malleability	None of these	Plasticity
The statement : stress is proportional to strain, i.e. the Hooke’s law holds good upto	Elastic Limit	Proportional Limit	Plastic Limit	Yield point	Proportional Limit
The limit beyond which the material does not behave elastically is known as	Proportional limit	Elastic limit	Plastic limit	Yield Point	Elastic limit
When mild steel is subjected to a tensile load, its fracture will conform to	Star shape	Granular shape	Cup and cone shape	Fibrous shape	Cup and cone shape
When a wire is stretched to double in length, the longitudinal strain produced in it is	0.5	1	1.5	2	1
When a bar is subjected to a change of temperature and its longitudinal deformation is	Tensile	Compressive	Shear	Temperature	Temperature
When a bar is subjected to increase in temperature and its deformation is prevented, the	Tensile	Compressive	Shear	None of the above	Compressive
In a composite body, consisting of two different materials………..will be same in both materials.	Stress	Strain	Both stress and strain	None of these	Strain
The external effect of a force in a rigid body is the same for all points along its line of action.	principle of transmissibility of a force	axioms of mechanics	characteristics of force	scalar and vector quantities	principle of transmissibility of a
The resultant of two forces is the diagonal formed on two vectors of those forces.	parallelogram law	resolution	cosine law	triangle law	parallelogram law
The forces are in equilibrium only when equal in magnitude ,opposite in direction and	principle of transmissibility of a force	axioms of mechanics	characteristics of force	scalar and vector quantities	axioms of mechanics
Is a convenient corollary of the parallelogram law.	parallelogram law	resolution	cosine law	triangle law	triangle law
The determination of the resultant of 3 or more concurrent forces that are not collinear.	resultant of concurrent,coplanar	collinear forces system	parallel,coplanar	non concurrent,coplanar	resultant of concurrent,coplanar
Stress is	External force	Internal resistive force	Axial force	Radial force	Internal resistive force
Following are the basic types of stress except	Tensile stress	Compressive stress	Shear stress	Volumetric stress	Volumetric stress
Which of the following is not a basic type of strain?	Compressive strain	Shear strain	Area strain	Volume strain	Area strain
Tensile Strain is	Increase in length per original length	Decrease in length per	Change in volume per original volume	All of the above	Increase in length per original length
Compressive Strain is	Increase in length per original length	Decrease in length per	Change in volume per original volume	All of the above	Decrease in length per original
Hooke’s law is applicable within	Elastic limit	Plastic limit	Fracture point	Ultimate strength	Elastic limit
Young’s Modulus of elasticity is	Tensile stress per Tensile strain	Shear stress per Shear strain	Tensile stress per Shear strain	Shear stress per Tensile strain	Tensile stress per Tensile strain

Quantum Mechanics

Planck's Quantum theory of Black Body Radiation

Assumptions

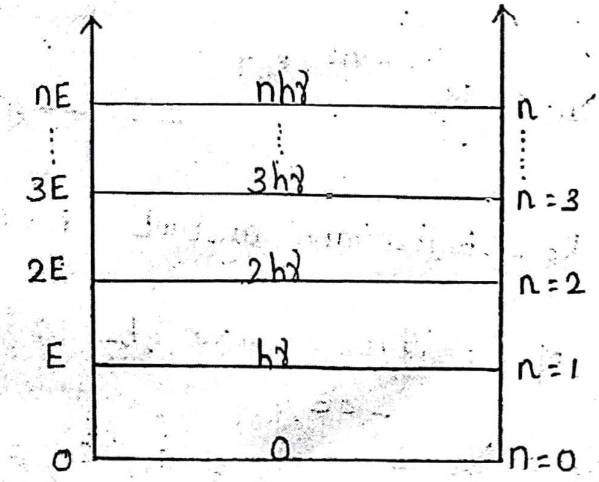
(i) A black body radiator contains electrons or so called simple harmonic oscillators.

ii) The frequency of radiation emitted by an oscillator is the same as that of the frequency of its vibration.

iii) The oscillators radiate energy in a discrete manner and not in a continuous manner.

iv) The oscillators exchange energy in the form of either absorption or emission within the surroundings in terms of quanta of $h\nu$.

ie. $E = nh\nu$ $[n = 0, 1, 2, 3 \ldots]$



Planck's Radiation Law

To derive the Planck's radiation law, let us consider 'N' number of oscillators with total Energy as E_T

Then, the average energy of an oscillator is given by

$$\bar{E} = \frac{E_T}{N} \quad \text{---} \ (1)$$

(i) The total number of osillators

$$N = N_0 + N_1 + N_2 + N_3 + \dots\dots\dots N_n \quad \text{---} \ (2)$$

ii) Total Energy of oscillators

$$E_T = 0N_0 + EN_1 + 2EN_2 + 3EN_3 + \dots\dots nEN_n \quad \text{---} \ (3)$$

According to Maxwell's distribution equation

$$N_n = N_0 e^{-nE/K_BT} \quad \text{---} \ (4)$$

where K_B - Boltzmaann constant. $n = 0, 1, 2, 3, \dots$

∴ Number of osillators can be calculated

$$n=0; \quad N_0 = N_0 e^{-0E/K_BT} = N_0 e^0 = N_0 \quad [e^0 = 1]$$

$n=1 \quad ; \quad N_1 = N_0 e^{-1E/K_BT}$

$n=2 \quad ; \quad N_2 = N_0 e^{-2E/K_BT}$

$n=3 \quad ; \quad N_3 = N_0 e^{-3E/K_BT}$

$n=n \quad ; \quad N_n = N_0 e^{-nE/K_BT}$

∴ The total number of osillators can be getting by substituting the values of $N_0, N_1, N_2 \ldots\ldots N_n$ in equ ②

$$N = N_0 + N_0 e^{-E/K_BT} + N_0 e^{-2E/K_BT} + N_0 e^{-3E/K_BT} + \ldots\ldots N_0 e^{-nE/K_BT}$$

$$= N_0 \left[1 + e^{-E/K_BT} + e^{-2E/K_BT} + e^{-3E/K_BT} + \ldots\ldots e^{-nE/K_BT}\right] \quad \text{—— ⑤}$$

Let us take $e^{-E/K_BT} = x$

$$N = N_0 \left[1 + x + x^2 + x^3 + \ldots\ldots\ldots x^n\right] \qquad \left[1+x+x^2+\ldots x^n = \frac{1}{1-x}\right]$$

using Binomial expansion

$$N = \frac{N_0}{(1-x)} \quad \text{—— ⑥}$$

Similarly, by substituting the values of $N_0, N_1, N_3 \ldots\ldots N_n$ in equ ③

$$E_T = \underset{\downarrow \atop 0}{0N_0} + EN_0 e^{-E/K_BT} + 2EN_0 e^{-2E/K_BT} + 3EN_0 e^{-3E/K_BT} + \ldots\ldots nEN_0 e^{-nE/K_BT}$$

$$= \cancel{N_0}\left[E\cancel{e^{-E/K_BT}}\right]\left[\cancel{1}+\cancel{2e}^{-E}\right.$$

Let us take $e^{-E/K_BT} = x$

$$= \left[0 + EN_0 x + 2EN_0 x^2 + 3EN_0 x^3 + \ldots\ldots nEN_0 x^n\right]$$

$$E_T = EN_0 x\left[1 + 2x + 3x^2 + \ldots\ldots nx^{n-1}\right] \qquad (7)$$

$$\left[1+2x+3x^2+\ldots\ldots nx^{n-1} = \frac{1}{(1-x)^2}\right]$$

Substitut

$$E_T = \frac{EN_0 x}{(1-x)^2} \qquad (8)$$

substituting equations (6) and (8) in equ (1)

$$\bar{E} = \frac{E_T}{N}$$

$$= \frac{\dfrac{EN_0 x}{(1-x)^2}}{\dfrac{N_0}{(1-x)}} \Rightarrow \frac{E\cancel{N_0}x}{(1-x)^{\cancel{2}}} \times \frac{(\cancel{1-x})}{\cancel{N_0}}$$

$$= \frac{Ex}{(1-x)}$$

$$\therefore \quad \bar{E} = \frac{E e^{-E/K_BT}}{(1 - e^{-E/K_BT})}$$

$$= \frac{E}{\frac{1 - e^{-E/K_BT}}{e^{-E/K_BT}}}$$

$$= \frac{E}{\frac{1}{e^{-E/K_BT}} - \frac{e^{-E/K_BT}}{e^{-E/K_BT}}}$$

$$= \frac{E}{e^{E/K_BT} - 1} \qquad [\because E = h\nu)$$

$$\bar{E} = \frac{h\nu}{(e^{h\nu/K_BT}) - 1} \quad \text{——— (9)}$$

$\therefore$ Energy density $(E_\nu d\nu)$ = No. of osillators per unit volume $\times$ Average energy of an osillator

$$E_\nu d\nu = N\bar{E} \quad \text{——— (10)} \qquad \left[\because N = \frac{8\pi\nu^2 d\nu}{c^3}\right]$$

Substituting equation (9) in equation (10)

$$E_\nu d\nu = \frac{8\pi\nu^2 d\nu}{c^3} \times \frac{h\nu}{e^{h\nu/K_BT} - 1} \Rightarrow \boxed{E_\nu = \frac{8\pi h\nu^3}{c^3[e^{h\nu/K_BT} - 1]}}$$

Planck's radiation law interms of frequency

Schrodinger wave equation

The equation that describes the wave nature of a particle in mathematical form is known as schrodinger wave equation.

There are two forms of schrodinger wave equation.

1. Time independent equation
2. Time dependent equation

Schrodinger time independent wave equation

Let us consider a particle of mass 'm' moving with a velocity 'v'. Let ψ be the wave function of the particle along x, y, z axes.

The classical differential equation of wave moving with velocity v can be written as,

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} = \frac{1}{v^2} \frac{\partial^2 \psi}{\partial t^2} \quad \text{——— (1)}$$

The solution of the above equ is given by

$$\psi = \psi_0 e^{-i\omega t} \quad \text{——— (2)}$$

Differentiating equation ② with respect to 't' twice,

$$\frac{\partial \psi}{\partial t} = -i\omega \psi_0 e^{-i\omega t}$$

$$\frac{\partial^2 \psi}{\partial t^2} = (-i\omega)\psi_0 e^{-i\omega t}(-i\omega)$$

$$= i^2 \omega^2 \psi_0 e^{-i\omega t} \qquad [\because i^2 = -1]$$

$$\frac{\partial^2 \psi}{\partial t^2} = -\omega^2 \psi \quad \text{——} \ ③$$

substituting equation ③ in equ ①, we get

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} = \frac{-\omega^2}{V^2}\psi \qquad \left[\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right]$$

$$\nabla^2 \psi = \frac{-\omega^2}{V^2}\psi \quad \text{——} \ ④$$

We know that

$$\omega = 2\pi \nu \qquad \left[\because \nu = \frac{V}{\lambda}\right]$$

$$\omega = \frac{2\pi V}{\lambda}$$

$$\frac{\omega}{V} = \frac{2\pi}{\lambda}$$

$$\frac{\omega^2}{V^2} = \frac{4\pi^2}{\lambda^2} \quad \text{——} \ ⑤$$

Substituting equation (5) in equation (4)

$$\nabla^2 \psi = -\frac{4\pi^2}{\lambda^2} \psi$$

$$\nabla^2 \psi + \frac{4\pi^2}{\lambda^2} \psi = 0 \quad \text{———} \quad (6)$$

From De-Broglie wave length $\lambda = \frac{h}{mv}$

Then equ (6) becomes

$$\nabla^2 \psi + \frac{4\pi^2}{\frac{h^2}{m^2 v^2}} \psi = 0$$

$$\nabla^2 \psi + \frac{4\pi^2}{h^2} m^2 v^2 \psi = 0 \quad \text{———} \quad (7)$$

If E is the total Energy of the particle, V the potential energy and $\frac{1}{2}mv^2$ the kinetic energy,

$$E = V + \frac{1}{2}mv^2$$ [~~for free particle V=0~~]

$$(E - V) = \frac{1}{2}mv^2$$

$$2(E - V) = mv^2$$

multiplying by 'm' on bothsides

$$2m(E - V) = m^2 v^2 \quad \text{———} \quad (8)$$

substituting equation (8) in (7)

$$\nabla^2\psi + \frac{4\pi^2}{h^2}[2m(E-V)]\psi = 0$$

$$\nabla^2\psi + \frac{2m(E-V)}{\frac{h^2}{4\pi^2}}\psi = 0$$

We know $\hbar^2 = \frac{h^2}{4\pi^2}$

$$\therefore \boxed{\nabla^2\psi + \frac{2m}{\hbar^2}(E-V)\psi = 0} \quad \text{——— (9)}$$

This equation is known as schrodinger's time independent wave equation.

special case :

For free particle $V = 0$.

$$\therefore \nabla^2\psi + \frac{2m}{\hbar^2}E\psi = 0 \quad \text{——— (10)}$$

schrodinger's time dependent wave equation

We know that

$$\psi = \psi_0 e^{-i\omega t} \quad \text{——— (1)}$$

Differentiating equ (1) with respect to 't'

Scanned by CamScanner

$$\frac{\partial \psi}{\partial t} = -i\omega \psi_0 e^{-i\omega t}$$

$$= -i(2\pi\nu)\psi \qquad [\because \omega = 2\pi\nu]$$

$$\frac{\partial \psi}{\partial t} = -i\, 2\pi \frac{E}{h} \psi \qquad [\because E = h\nu]$$

multiplying by 'i' on bothsides

$$i\frac{\partial \psi}{\partial t} = -i^2\, 2\pi \frac{E}{h} \psi \qquad [i^2 = -1]$$

$$i\frac{\partial \psi}{\partial t} = -(-1)\, 2\pi \frac{E}{h} \psi$$

$$i\frac{\partial \psi}{\partial t} = 2\pi \frac{E}{h} \psi$$

$$E\psi = \frac{ih}{2\pi} \frac{\partial \psi}{\partial t} \qquad \left[\frac{h}{2\pi} = \hbar\right]$$

$$E\psi = i\hbar \frac{\partial \psi}{\partial t} \quad \text{——— (2)}$$

Substituting equation (2) in schrodinger time independent equation

$$\nabla^2 \psi + \frac{2m}{\hbar^2}\left[i\hbar \frac{\partial \psi}{\partial t} - V\psi\right] = 0$$

$$\nabla^2 \psi = -\frac{2m}{\hbar^2}\left[i\hbar \frac{\partial \psi}{\partial t} - V\psi\right]$$

Multiplying by $-\frac{\hbar^2}{2m}$ on both sides.

$$-\frac{\hbar^2}{2m}\nabla^2\psi = \left[+i\hbar\frac{\partial\psi}{\partial t} - V\psi\right]$$

$$\boxed{-\frac{\hbar^2}{2m}\nabla^2\psi + V\psi = i\hbar\frac{\partial\psi}{\partial t}} \quad \text{——— } (3)$$

This equation is known as schrodinger time dependent wave equation.

From equ (3)

$$\left(-\frac{\hbar^2}{2m}\nabla^2 + V\right)\psi = i\hbar\frac{\partial\psi}{\partial t}$$

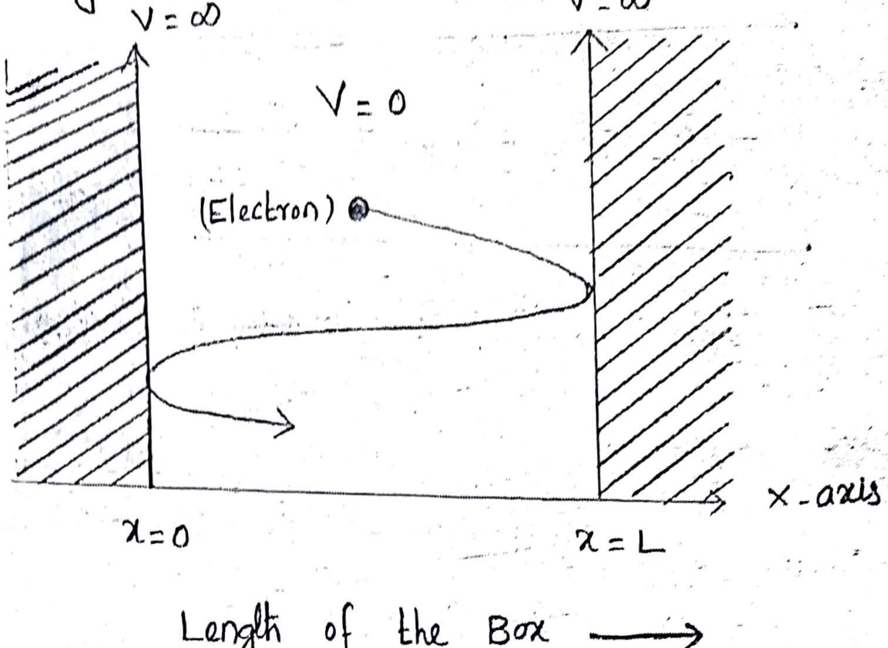
$$H\psi = E\psi$$

where $H \rightarrow$ Hamiltonian operator

$E \rightarrow$ Energy operator

Particle in one dimensional potential Box

Consider a particle (electron) of mass 'm' moving with velocity v along x-axis is confined within a box of width L



The particle bounces back and forth within the box. The particle cannot comes out of the box as the potential barrier at the walls of the box are infinity. But inside the box the potential energy of the particle is zero.

Boundary condition for the potential barrier,

$V = 0$ when $0 < x < L$

$V = \infty$ when $0 \geq x \geq L$

$\psi = 0$ when $0 \geq x \geq L$

The schrodinger one dimensional time independent wave equation for a free particle is given by

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}[E-V]\psi = 0 \quad \text{——} \ (1)$$

For a free particle $V=0$

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}E\psi = 0 \quad \text{——} \ (2)$$

Let us consider $\frac{2mE}{\hbar^2} = k^2$ —— (3)

∴ ~~The solution for equation~~

$$\frac{d^2\psi}{dx^2} + k^2\psi = 0 \quad \text{——} \ (4)$$

∴ The solution of equation (4) is given by

$$\psi(x) = A \sin kx + B \cos kx \quad \text{——} \ (5)$$

where A and B are called arbitrary constants

Boundary condition (i)

At $x=0$, $V=\infty$ and $\psi(x)=0$

Equation (5) becomes

$$0 = A \sin 0 + B \cos 0$$

$\therefore \; B = 0$

Boundary condition (ii)

At $x = L$, $V = \infty$ and $\psi(x) = 0$

Equation (5) becomes

$$0 = A \sin KL + B \cos KL \qquad (\because B = 0)$$

$$0 = A \sin KL + 0$$

$$A \sin KL = 0$$

Since $A \neq 0$; $\sin KL = 0$

$$KL = \sin^{-1}(0)$$

$$KL = n\pi$$

$$K = \frac{n\pi}{L} \quad \text{—— (6)}$$

Substituting the value of B and K in equation (5)

$$\psi(x) = A \sin \frac{n\pi x}{L} \quad \text{—— (7)}$$

To find Energy of the particle

From equ (3)

$$K^2 = \frac{2mE}{\hbar^2}$$

$$= \frac{2mE}{\frac{\hbar^2}{4\pi^2}}$$

$$K^2 = \frac{8\pi^2 mE}{h^2} \quad \text{---} \quad (8)$$

Squaring equation (6)

$$K^2 = \frac{n^2\pi^2}{L^2} \quad \text{---} \quad (9)$$

Equating equations (8) and (9)

$$\frac{8\cancel{\pi^2} mE}{h^2} = \frac{n^2 \cancel{\pi^2}}{L^2}$$

$\therefore$ Energy of the particle $\boxed{E = \frac{n^2 h^2}{8mL^2}}$ — (10)

Normalisation of wave function

$i^2 = -1$

$$\int_0^L |\psi|^2 dx = 1$$

$\sin^2\theta = \frac{1 - \cos 2\theta}{2}$

$$\int_0^L A^2 \sin^2 \frac{n\pi x}{L} dx = 1$$

$$A^2 \int_0^L \left(\frac{1 - \cos \frac{2n\pi x}{L}}{2} \right) dx = \cancel{0}\,1$$

$$\frac{A^2}{2} \int_0^L \left(1 - \cos \frac{2n\pi x}{L}\right) dx = \cancel{0}\,1$$

$$\frac{A^2}{2} \left[\int_0^L dx - \int_0^L \cos \frac{2n\pi x}{L}\, dx \right] = \cancel{0}\,1$$

$$\int \cos 2\theta \, d\theta = \frac{\sin 2\theta}{2}$$

$$\frac{A^2}{2} \left[x - \frac{\sin 2n\pi x / L}{2n\pi / L} \right]_0^L = 1$$

$$\left[\sin n\pi = 0 \right]$$

$$\frac{A^2}{2} (L - 0) = 1$$

$$\frac{A^2 L}{2} = 1$$

$$A^2 = \frac{2}{L}$$

$$\boxed{A = \sqrt{\frac{2}{L}}}$$

substituting the value of A in equation (7)

$$\boxed{\psi(x) = \sqrt{\frac{2}{L}} \sin \frac{n\pi x}{L}}$$

questions	opt1	opt2	opt3	opt4	answer
Waves associated with electrons are referred to as	plasma waves	UV waves	gamma rays	matter waves	matter waves
Frequency below which no electrons are emitted from metal surface is	minimum frequency	angular frequency	maximum frequency	threshold frequency	threshold frequency
Loss of energy of an electron results in	absorption of photon	emission of photon	destruction of photon	formation of photon	emission of photon
According to Newton, light travels as	particles	waves	both A and B	dust	particles
In electron diffraction, rings behave as	particles	waves	both A and B	rays	waves
Energy absorbed by electron is used in	escaping the metal	increasing kinetic ener	both A and B	increasing frequency	both A and B
Diffraction of slow moving electrons is used to estimate	arrangement of atoms in	nature of atoms	number of atoms in meta	position of atoms in metalloids	arrangement of atoms in metals
Energy of photon is directly related to the	wavelength	wave number	frequency	amplitude	frequency
When a charged particle is accelerated through a potential difference V, it's kinetic energy	decreases	remains same	increases	varies depending on resistance of wire	increases
Energy of an electron in an atom is	quantized	continuous	radial	randomized	quantized
In dark, LDR has	low resistance	high current	high resistance	both A and B	high resistance
Electrons show diffraction effects because their de Broglie wavelength is similar to	spacing between atomic	no. of atomic layers	nature of atomic layers	positioning of atomic layers	spacing between atomic layers
Plank's constant has units	J	s	J /s	J s	J s
Gas atoms that exert negligible electrical forces on each other are	molecules	compounds	isotopes	isolated atoms	isolated atoms
Quantum of electromagnetic energy is called	particles	photons	waves	energy	surface
In photoelectric effect, electrons should be removed from the	inner shells	surface	from core	the nucleus	surface
Light interacts with matter as	wave	particle	both A and B	rays	particle
When white light is passed through cool gases, spectra observed is called	line spectra	continuous spectra	emission line spectra	absorption line spectra	absorption line spectra
Wavelength of ultraviolet region of electromagnetic spectrum is	121 nm	120 nm	119 nm	130 nm	121 nm
In an insulator, valence band is	fully occupied	fully empty	half filled	half charged	fully occupied
Most energetic photons are	alpha	beta	gamma	x-rays	gamma
Which of the following colors is associated with the lowest temperature of a black body radiator?	Violet	Blue	Green	Red	Red
Classical physics could not explain the behavior of a black body radiator at very short wavelengths. What was this problem called?	Absorption failure	Ultraviolet Explosion	Wavelength decrease	Photoelectric Effect	Ultraviolet Explosion
What did Max Planck propose to solve the black body radiator problem?	Radiation is made up of	Light changes its spee	Light comes in packets c	Light has a continuous energy profile.	Light comes in packets of energy.
The energy of a photon depends on its:	Amplitude	Speed	Temperature	Frequency	Frequency
How does the energy of a photon change if the wavelength is doubled?	Doubles	Quadruples	Stays the same	Is cut to one-half	Is cut to one-half
How does the momentum of a photon change if the wavelength is halved?	Doubles	Quadruples	Stays the same	Is cut to one-half	Doubles
The photoelectric effect was explained by Albert Einstein by assuming that:	light is a wave.	light is a particle.	an electron behaves as a	an electron behaves as a particle.	light is a particle.
The kinetic energy of photoelectrons depends on the:	speed of light.	angle of illumination.	intensity of the light.	photon frequency.	photon frequency.
When an electron falls from an orbit where n = 2 to n = 1:	A photon is emitted.	A photon is absorbed.	No change in atomic ene	The atomic energy increases.	A photon is emitted.
When an electron jumps from an orbit where n = 1 to n = 4, its energy in terms of the energy of the ground level (E_1) is:	E1/9	2 E 0	2 E1	16 E1	16 E1
The Compton Effect supports which of the following theories?	Special Theory of Relati	Light is a wave.	Thomson model of the a	Light is a particle.	Light is a particle.
Which one of the following objects, moving at the same speed, has the greatest de Broglie wavelength?	Neutron	Electron	Tennis ball	Bowling ball	Electron
Which theory explains the interaction of photons with matter (electrons)?	Quantum Chromodynan	The Standard Model	String Theory	Quantum Electrodynamics	Quantum Electrodynamics
Which theory explains the attraction between protons and neutrons?	Quantum Chromodynan	The Grand Unified Th	The Standard Model.	String Theory	Quantum Chromodynamics
How much of the universe is comprised of matter and energy that is explained by current Physics theory?	95 percentage	75percentage	50percentage	5 percentage	5 percentage
A perfect black body is one which ________________ all the radiations.	absorbs	emits	absorbs and emits	reflects	absorbs and emits
The classical theory was not able to explain the_______	diffraction	interference	emission of black body r	diffraction and interference	emission of black body radiation
The wave nature associated with a material particle is called as __________	standing wave	progressive wave	transverse wave	matter wave	matter wave
The relation between energy and the momentum of the photon is_______	P is equal to EC	Eis equal toP/C	C is equal toEP	E is equal to PC	E is equal toPC
According to de-broglie wave equation, when velocity of the particle increases wavelength will be___________.	doubles	increases	decreases	zero	decreases
A particle in one dimensional box at the walls of the box, the wave function will be___________.	zero	increases	decreases	Infinity	zero
A perfect black body is a perfect absorber and radiator of___________ radiation.	monochromatic	all wavelengths of th	coherent	polychromatic	all wavelengths of the given
The source used in the SEM is ___________.	electrical source	chemical source	neutron gun	electron gun	electron gun
For a free particle, the potential energy is___________.	0	1	2	3	0
According to ___________ theory, the hydrogen spectrum is a discrete spectrum.	classical	electromagnetic	quantum	wave	quantum
The equation of motion of matter wave was derived by	Heisenberg	Bohr	de Broglie	Schrodinger	Schrodinger

McLeod Vacuum Gauge

Basic Principle of McLeod Vacuum Gauge:

A known volume gas is compressed to a smaller volume whose final value provides an indication of the applied pressure. The gas used must obey Boyle's law given by;

$P1V1=P2V2$

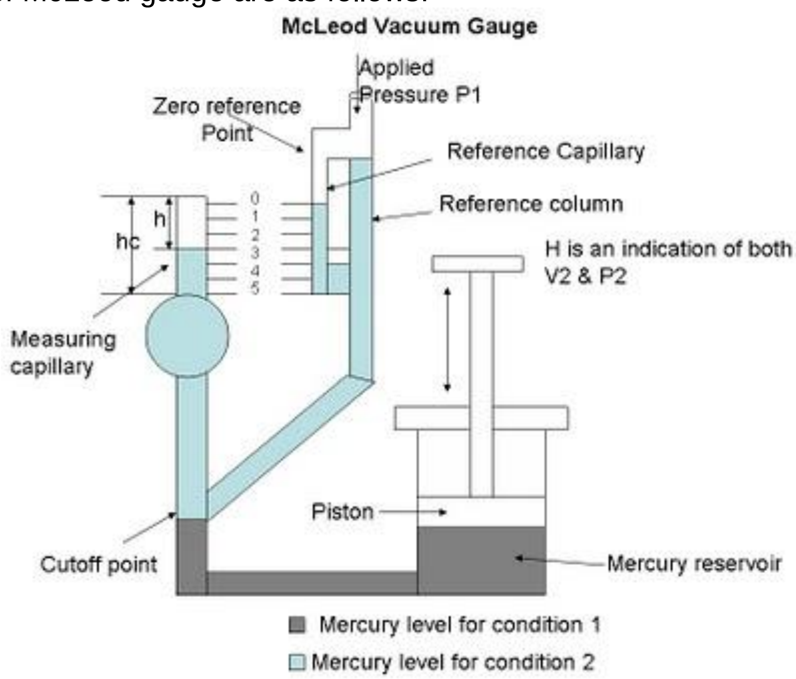
Where, P1 = Pressure of gas at initial condition (applied pressure).
P2 = Pressure of gas at final condition.
V1 = Volume of gas at initial Condition.
V2 = Volume of gas at final Condition.

Initial Condition == Before Compression.
Final Condition == After Compression.

A known volume gas (with low pressure) is compressed to a smaller volume (with high pressure), and using the resulting volume and pressure, the initial pressure can be calculated. This is the principle behind the McLeod gauge operation.

Description of McLeod Vacuum Gauge:

The main parts of McLeod gauge are as follows:



A reference column with reference capillary tube. The reference capillary tube has a point called zero reference point. This reference column is connected to a bulb and measuring capillary and the place of connection of the bulb with reference column is called as cut off point. (It is called the cut off point, since if the mercury level is raised above this point, it will cut off the entry of the applied pressure to the bulb and measuring capillary. Below the reference column and the bulb, there is a mercury reservoir operated by a piston.

Operation of McLeod Vacuum gauge:

The McLeod gauge is operated as follows:

The pressure to be measured (P1) is applied to the top of the reference column of the McLeod Gauge as shown in diagram. The mercury level in the gauge is raised by operating the piston to fill the volume as shown by the dark shade in the diagram. When this is the case (condition – 1), the applied pressure fills the bulb and the capillary.
Now again the piston is operated so that the mercury level in the gauge increases.

When the mercury level reaches the cutoff point, a known volume of gas (V1) is trapped in the bulb and measuring capillary tube. The mercury level is further raised by operating the piston so the trapped gas in the bulb and measuring capillary tube are compressed. This is done until the mercury level reaches the “Zero reference Point” marked on the reference capillary (condition – 2). In this condition, the volume of the gas in the measuring capillary tube is read directly by a scale besides it. That is, the difference in height ‘H’ of the measuring capillary and the reference capillary becomes a measure of the volume (V2) and pressure (P2) of the trapped gas.

Now as V1,V2 and P2 are known, the applied pressure P1 can be calculated using Boyle’s Law given by;

$P_1V_1 = P_2V_2$

Let the volume of the bulb from the cutoff point upto the beginning of the measuring capillary tube = V

Let area of cross – section of the measuring capillary tube = a
Let height of measuring capillary tube = hc.

Therefore,

Initial Volume of gas entrapped in the bulb plus measuring capillary tube = V1 = V+ahc.

When the mercury has been forced upwards to reach the zero reference point in the reference capillary, the final volume of the gas = V2 +ah.

Where, h = height of the compressed gas in the measuring capillary tube
P1 = Applied pressure of the gas unknown.

P2 = Pressure of gas at final condition, that is, after compression
= P1+h

We have, P1V1 = P2V2 (Boyle's Law)
Therefore, P1V1= (P1+h)ah

$P1V1 = P1ah + ah^2$

$P1V1-P1ah = ah^2$

$P1 = ah^2/(V1-ah)$

Since ah is very small when compared to V1, it can be neglected.

Therefore, $P1 = ah^2/V1$

Thus the applied pressure is calculated using the McLeod Gauge.

Applications

The McLeod Gauge is used to measure vacuum pressure.

Advantages of the McLeod Gauge:

- It is independent of the gas composition.
- It serves as a reference standard to calibrate other low pressure gauges.
- A linear relationship exists between the applied pressure and h
- There is no need to apply corrections to the McLeod Gauge readings.

Limitations of McLeod Gauge:

- The gas whose pressure is to be measured should obey the Boyle's law
- Moisture traps must be provided to avoid any considerable vapor into the gauge.
- It measure only on a sampling basis.
- It cannot give a continuous output.

Source:

http://instrumentationandcontrollers.blogspot.in/2010/12/mcleod-vacuum-gauge.html

The most important area of applications for vacuum engineering is in the semiconductor industry, which accounts for around a 40 percent share. Chip manufacturers work in a high-vacuum range of between 10–3 and 10–7 mbar. It is only in this pure atmosphere that 100 percent circuits can be manufactured during doping. Amongst relatively new users, mention can be made of the solar section, currently enjoying an international boom, with its hunger for wafers as the carrier material in the production of modules. The sector for surface coatings and finishes has, to date, enjoyed a share of just under nine percent of the total vacuum technology market.

1. Pfeiffer Vacuum states that it is primarily rotary vane pumps, Roots pumps and dry pumps which are used for rough and medium vacuum applications. Turbomolecular pumps are employed to produce a high and ultra-high vacuum. Turbopumps—the key product group at Pfeiffer Vacuum and “invented” by that company—are available in a range of options: From the smallest and most compact pump in the world, with a suction capacity of 11 l/s, for the analytics industry, through to the large 3000 l pump used primarily in the coating and semiconductor industry.

2. Screws with direct internal water-cooling

The Korean company Dongbang manufactures dry screw vacuum pumps in the EVAP series. The company emphasizes that its patented, unique design with directly internally water-cooled screws offers particular advantages in chemical, petrochemical and pharmaceutical applications (evaporation, condensation, freeze-drying, distillation, deodorization, degassing, absorption, impregnation). Hermetic has exclusive responsibility in many European countries for marketing, repair and servicing of these vacuum pumps. The pump works as follows: The EVAP is a single-stage, dry-running screw vacuum pump with a contact-free mode of operation. Two screws, arranged in parallel, rotate in opposite directions, with cut timing gears positioning the screws relative to one another. A defined clearance is maintained between the rotors and between the rotor and the housing. The pumping chamber is an oil- and water-free design. The drive power is transferred to the driveshaft via a coupling. All parts coming into contact with the gas are corrosion-protected using a special coating. The design, with cooling water in the screw interior, exhibits the following advantages: no heat expansion on the screws; no warm-up phase to achieve the final vacuum, and low surface temperature.

3.Vacuum pumps in biofuel production

One interesting area of application for vacuum pumps is in biofuel production. This is true of both first- and second-generation biofuels, as Dr. MarinellaVarallo, Edwards General Manager Industrial Sales explains: “Edwards vacuum equipment can supply the full starting material for first- and second-generation for methanol recovery and purification of ethanol.” That includes traditional fluid ring pump technology and dry-running pumps from the CDX range for producing biofuels. There are considerable advantages to using the CDX range, fully in line with the ideas behind the biofuel industry: lower energy consumption, no consumption of water, and in addition to this they also require less space. Edwards offers systems which do not compete for water and energy in biofuel production.

In brief: Other interesting developments

4. Chemical vacuum pumps for heavy applications

The NT series of chemical vacuum pumps is setting new standards in performance, quietness of operation, ease of servicing and design, according to Vacuubrand. At the same time, they achieve the robustness and reliability of the predecessor models—even in demanding applications in the chemicals and pharmaceuticals industries. The range is rounded off with vacuum systems and chemical pump stands with electronic vacuum control using the CVC 3000 vacuum controller.

5. Lubrication of the working chamber a thing of the past

The screw rotors on the S-VSI Twister from Gardner Denver, with their contact-free operation, are making lubrication of the working chamber a thing of the past. In other words, no costs incurred for disposing of contaminated oil. The optimized screw rotors have a variable pitch and are synchronized using a system of gears. Other features of this new innovation emphasized by the manufacturer are the short evacuation times, the low compression heat, the high maximum tolerable water vapor inlet pressure and the good suction capacity. When it comes to profitability, the high efficiency level and variable speed are significant. The final vacuum achieved by the pump is 0.1 mbar.

6. Dry-running diaphragm pumps

Dry-running vacuum pumps for rough and medium vacuum range play an important role in research, laboratory work and industry. In all these areas, Ilmvac diaphragm pumps are used. The company claims that, with the range of types it has available, it can always offer a solution which is optimized in terms of suction capacity and final pressure, whilst also being economical. Diaphragm pumps are available in different materials finishes for chemical and physical processes, with regulated or non-regulated under-pressure, and with suction capacity from 0.3 to 16 m3/h and final pressures from 75 to <1 mbar. Atex-compliant versions are also available.

7. Liquid ring vacuum pumps

Busch has launched two complete series of liquid ring vacuum pumps onto the market. Dolphin pumps are available in a single-stage version in a modular design (Dolphin LC) and in single-stage or two-stage versions with base plate (Dolphin LA and LB). These new liquid ring vacuum pumps cover suction capacities from 25 to 5100 m^3/h. Dolphin vacuum pumps achieve a final pressure of up to 33 mbar. Given their robust design, these pumps are equipped for demanding continuous operation in applications for the chemicals, crude petroleum and pharmaceuticals industries.

8. Sterling Sihi similarly offers liquid ring vacuum pumps: The pumps are available in a single-stage and two-stage finish, with suction capacity of up to 12,000. In addition to the familiar advantages of liquid ring vacuum pumps, e.g. isothermal compression, an oil-free vacuum, low-noise operation and high flexibility in terms of applications, the company emphasizes the following features of the LPH-X series:

- modular design (simple fitting and dismantling, and low cost of storing spare parts);
- compact (space-saving) design;
- few components (high availability and short delivery times);
- simple replacement operation on shaft seals (short maintenance times).

9. High-performance cryopumps

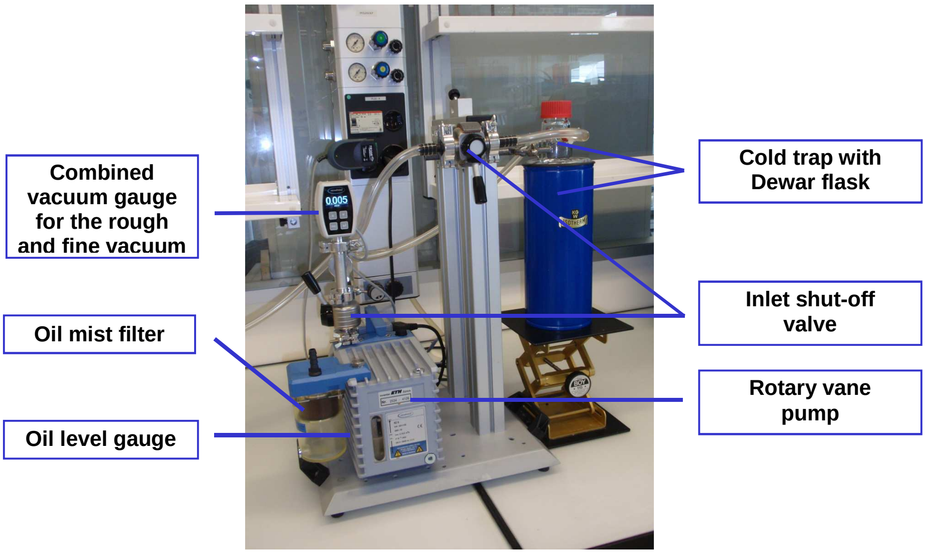
In April, OerlikonLeybold Vacuum began supplying cryopumps produced at its Dresden plant with a suction capacity of 60,000 l/s, to a customer in India. This is a global first. The company’s information suggests that this capacity puts all other known high vacuum pumps in the shade. Cryopumps (Coolvac) are used for applications in vacuum coating engineering, in vacuum furnaces, in physical laboratories and, at present, also in space simulation. The cryopumpexploits the physical effect that gases can freeze or be bound onto extremely cold surfaces. To that end, the cryopump creates temperatures down to below ten Kelvin (–253 °C).

Notes for trouble-free operation of rotary vane (oil-sealed) pumps

In principle:

Never use an oil-sealed rotary vane vacuum pump when an oil-free diaphragm (membrane) pump provides sufficient vacuum for your application. Rotary vane pumps are strictly reserved for demanding applications requiring fine vacuum (</= 1 mbar, e.g., lyophilisation and other stringent drying applications).

Recommended setup of a rotary vane pump (Picture: experimental setup / ETH Zurich).



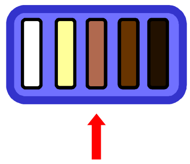
Start up:

- Check the oil level.
- Always allow the pump to warm up (app. 15 – 20 minutes) by operating with the inlet shut-off valve closed and the gas ballast valve open. Only when the operating temperature is reached should the inlet valve to the process be opened.
- Always use a cold trap when applying vacuum to processes containing potentially corrosive vapours. Maintain the cold trap responsibly: check and maintain level of freezing agent (liquid nitrogen), dispose of any remaining freezing agent when finished, and clean the Dewar flask (see information supplied by the manufacturer).
- Operate the pump with the gas ballast valve open to minimize condensation of solvent vapours in the pump. Note that the pump consumes more oil when operated with gas ballasting.

Shut down:

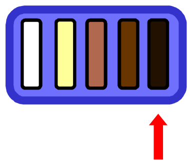
- Before shutting down, operate the pump for at least 30–60 minutes with the inlet shut-off valve closed and the gas ballast valve open to purge solvents from the pump oil.
- Inspect the level and condition of the oil and the ultimate vacuum level; perform oil changes when appropriate (see "Maintenance").

Maintenance



Change the pump oil when:

- The oil is dark or cloudy.
- An acceptable ultimate vacuum level < = 10^{-2} mbar (two-stage rotary vane pump "RZ") is no longer attainable even after operating for 60 minutes with the inlet shut-off valve closed and the gas ballast valve open.



Measures to take when the pump oil is heavily contaminated (Oil dark):

- Flush the pump.
- Disassemble the oil reservoir; clean the interior of the reservoir and the exterior of the pump housing.
  ATTENTION: Disassembly of the pump should be undertaken only by experienced users.

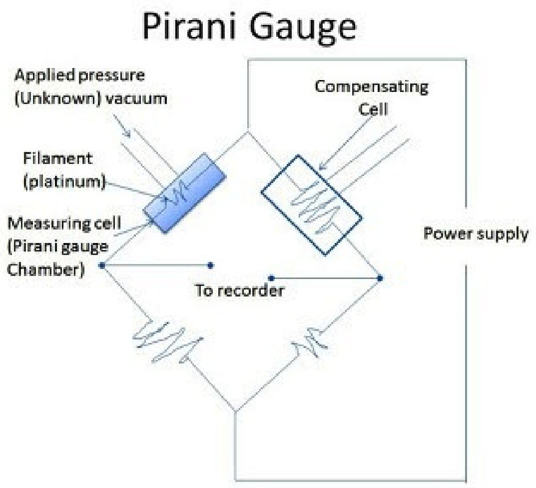
Please follow the directions for operation and maintenance in the pump’s instruction manual. Instruction manuals can be found at www.vacuubrand.com under "Support" and can be downloaded as PDF files.

Waste oil must be disposed of as hazardous waste according to waste key (Observe all relevant regulations).

In principle:

Don’t be sparing with pump oil. The oil costs substantially less than the repair or overhaul of a pump. Whenever a pump is taken temporarily out of service, carry out an oil change so that the pump is stored with clean oil in the reservoir.

PIRANI VACUUM GAUGE



The Pirani Gauge is a type of Thermal Conductivity Gauge.

The Pirani gauge consists of a metal filament (usually platinum) suspended in a tube which is connected to the system whose vacuum is to be measured. Connection is usually made either by a ground glass joint or a flanged metal connector, sealed with an o-ring. The filament is connected to an electrical circuit from which, after calibration, a pressure reading may be taken.

A conducting wire (platinum filament) gets heated when electric current flows through it. This wire suspended in a gas will lose heat to the gas as its molecules collide with the wire and remove heat. As the gas pressure is reduced (by the vacuum pumps) the number of molecules present will fall proportionately, the conductivity of the surrounding media will fall and the wire will lose heat more slowly. Measuring the heat loss is an indirect indication of pressure.

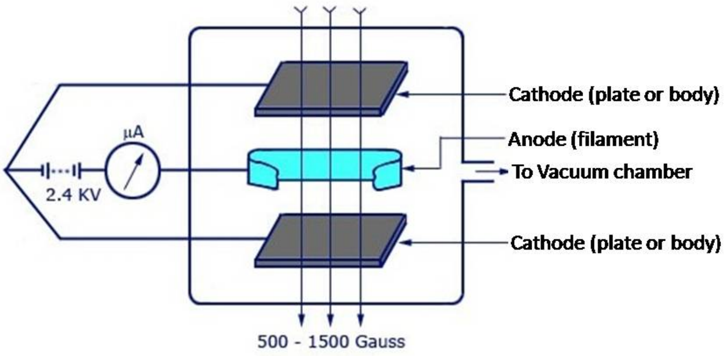
The electrical resistance of the wire varies with its temperature, so the measurement of resistance also indicates the temperature of wire. Now the change in resistance of the filament is determined using the bridge. This change in resistance of the pirani gauge filament becomes a measure of the applied pressure when calibrated.

In many systems, the wire is maintained at a constant resistance R by controlling the current I through the wire. The resistance can be set using a bridge circuit. The power delivered to the wire is I^2R, and the same power is transferred to the gas. The current required to achieve this balance is therefore a measure of the vacuum.

The gauge may be used for pressures between 0.5 Torr to 10^{-3} Torr. The thermal conductivity and heat capacity of the gas may affect the readout from the meter, and therefore the apparatus may need calibrating before accurate readings are obtainable. For lower pressure measurement other instruments such as a Penning gauge are used.

Animation of Pirani Gauge can be seen at : https://www.youtube.com/watch?v=T-0Nt7xzb2Y

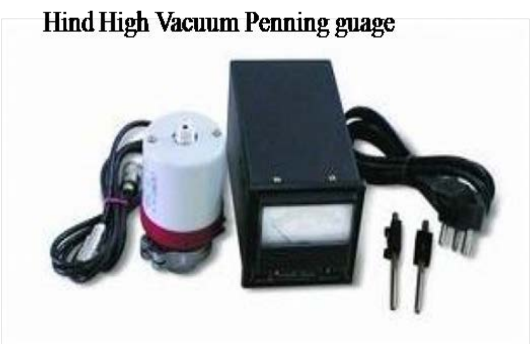
PENNING VACUUM GUAGE

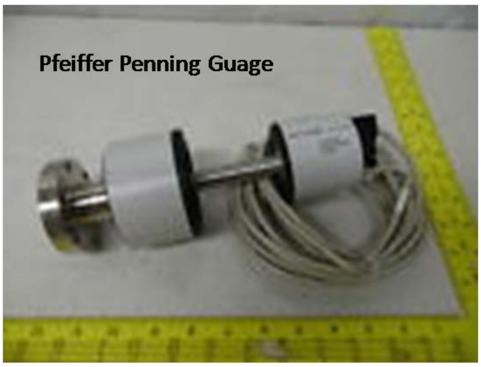


The Penning gauge is a cold cathode type ionisation gauge consisting of two electrodes anode and cathode. The outer cylinder of the gauge is the cathode and is at room temperature. The anode consists of a tungsten wire mounted in the center of the tube A potential difference of about 2 to 3 KV is applied between anode and cathode through current limiting resistors. A magnetic field is introduced at right angles to the plane of the electrodes by a permanent magnet having nearly 800 gauss magnetic field which will increase the ionisation current.

The electrons emitted from the cathode (gauge head body) of the gauge head are deflected by means of magnetic field applied at right angles to the plane of the electrodes and are made to take helical path before reaching the anode loop. Thus following very long path, the electrons ionize the gas by collision, even at low pressures. The secondary electrons produced by ionisation themselves perform similar oscillations and the rate of ionisation increases rapidly. Eventually, the electrons are captured by the anode and equilibrium is reached when the number of electrons produced per second by ionisation is the sum of positive ion current to the cathode and the electron current to the anode. This small current is calibrated to give a measure of the pressure of the gas and hence the chamber to which it is attached.

The Cold Cathode Penning gauge can detect vacuum from 10-2 to 10-7 Torr or mbar.





Animation of Penning gauge can be seen at: https://www.youtube.com/watch?v=TG9vtKK-LLw

questions	opt1	opt2	opt3	opt4	answer
Units associated with pumping speed	molecules/cm^3	liters/sec	inches of mercury	torr-liters/sec	liters/sec
The units associated with throughput (Q) is	molecules/cm^3	torr - liters/sec	liters/sec	inches of mercury	torr - liters/sec
A heated working fluid that passes through a chimney escaping through nozzles at extremely high velocities that bombard gas molecules down and toward a cool wall best describes which kind of pump?	diffusion pump	molecular drag pump	cryogenic pump	cryosorption pump	diffusion pump
Vacuum system pressure is lowest at the	inlet of the vacuum pump	outlet of the vacuum pump	chamber	foreline trap	inlet of the vacuum pump
Which of the following is not a desirable characteristic of vacuum pump oil?	ability to lubricate pump	high vapor pressure	ability to flush away contaminants	to seal clearances between parts	high vapor pressure
The standard calibration gas used in conjunction with ion gauges & mass flow controllers	argon	helium	nitrogen	air	nitrogen
During downstream pressure control, what device controls the position of the throttle valve?	Pressure controller	Mass Flow Controller outpu	Ion gauge	Pirani gauge	Pressure controller
From a health and safety point of view, which one of the following gauges is the most dangerous?	liquid mercury gauge	Bayard-Alpert ion gauge	pirani gauge	capacitance manometer	liquid mercury gauge
Which of the following is NOT a possible unit for Mass Flow?	liters/sec	Kg/min	molecules/min	SCCM	SCCM
Which of the following gases is the most reactive?	argon	oxygen	helium	nitrogen	oxygen
The ability of changing from a solid to a gas without passing through the liquid state is a definition of	gettering	capture or entrapment	sublimation	ionization	sublimation
An example of a momentum transfer pump would be	roots blower	cryopump	turbopump	sputter ion pump	turbopump
An example of a positive displacement pump would be	rotary vane pump	diffusion pump	depression pump	cryogenic pump	rotary vane pump
Which of the following is a thermal conductivity gauge?	Cold cathode gauge	Hot cathode gauge	Capacitance manometer	Pirani gauge	Pirani gauge
Which pressure gauge from the following list might be damaged if turned on at atmospheric pressure?	thermocouple gauge	pirani gauge	cold cathode gauge	hot cathode gauge	hot cathode gauge
Of the following gauges, only one is a direct reading gauge. Which one of the following is a direct reading gauge?	capacitance manometer	thermocouple	pirani	Bayard-Alpert gauge	capacitance manometer
A controlled gaseous environment at a pressure less than atmospheric is a good definition of	pascal	sputtering	adsorption	vacuum	vacuum
Pumping capacity for a pump is equal to the mass flow through the pump in	intake port	outlet port	fore pump	vessel	intake port
pumping speed is measured at the intake port as	volumetric flow	compression	circulation	lateral flow	volumetric flow
In rotary oil pump, oil used for	lubricating	cooling	density variation	increaing the speed	cooling
In diffusion pump, width of the outer tube is	smaller	equal to nozzle width	wider	equal to fore pump tube width	wider
Gaede's molecular pump is woking based on	Thomson theory	Boyles theory	Crooks theory	Knudsen's theory	Knudsen's theory
Mean free path in high vacuum	increases	decreases	moderates	with out change	increases
Mcleaod gauge is used to measure very low pressure of the order of	10^{-3} of mercury	10^{-5} of mercury	10^{-1} of mercury	10^{-2} of mercury	10^{-5} of mercury
pirani gauge uses	weetstone bridge	milestone bridge	wein brige	tuned collector bridge	weetstone bridge
Pump transfers the mechanical energy of a motor or of an engine into-------- of a fluid.	Pressure energy	Kinetic energy	Either pressure energy or kinetic energy	Pressure energy, kinetic energy or both	Pressure energy, kinetic energy or both
Rotary displacement pumps are suitable for handling -------	Oils	Gritty liquids	Both oils as well as gritty liquids	Granules	Oils
The process of filling the liquid into the suction pipe and pump casing up to the level of delivery valve is called as -----	Filling	Pumping	Priming	Leveling	Priming
__________ pump is also called as velocity pump.	Reciprocating	Rotary displacement	Centrifugal	Screw	Centrifugal