PRACTICE PAPER – 4

SOLUTIONS

SECTION – A

1. What are harmonics ?

Ans. The frequencies in which the standing waves can be formed are called harmonics.

(Or)

The integral multiple of fundamental frequencies are called harmonics.

2. What are the laws of reflection through curved mirrors ?

Ans. i) "The angle of reflection equals to the angle of incidence".

ii) "The incident ray, reflected ray and the normal to the reflecting surface at the point of incidence lie in the same plane".

3. What happens to the force between two charges, if the distance between is (a) halved (b) Doubled ?

Ans. From Coulombs law, F $\alpha \frac{1}{d^2}$ So

a) When distance is reduced to half, force increases by four times.

$$\left[\because F_2 = \frac{F_1 d_1^2}{\left(\frac{d_1}{2}\right)^2} = 4F_1\right]$$

b) When distance is doubled, then force is reduced by four times.

$$\left[\because F_2 = \frac{F_1 d_1^2}{2\,(d_1)^2} = 4F_1\right]$$

4. Write the colour code of a carbon resistor of resistance 23 kilo ohms.

Ans. Color code of a carbon resistor of 23 Kilo Ohms (= $23 \times 10^3\Omega$) are Red, Orange, Orange

[$\because$ Sequence number 2 for Red, 3 for orange, multiplication factor 10^3 for orange]

5. A current carrying circular loop is placed in a uniform external magnetic field. If the loop is free to turn, what is its orientation when it is achieves stable equilibrium ?

Ans. The plane of the loop is perpendicular to the direction of magnetic field because the torque on the loop in this orientation is zero.

6. Define magnetic inclination (or) angle of dip.

Ans. **Inclination or Dip (I) :** The angle which the total intensity of earth's magnetic field makes with the horizontal at any place is called inclination (I).

7. What do you understand by self inductance ?

Ans. Self inductance of a coil is defined as the induced e.m.f produced in the coil through which the rate of change of current is unity.

$$\varepsilon = -L\frac{dI}{dt}; \quad \varepsilon = -L \quad \text{If } \frac{dI}{dt} = 1 \text{ A/s.}$$

8. Give any two uses of infrared rays.

Ans. i) Infrared radiation plays an important role in maintaining the Earth warm.

ii) Infrared lamps are used in physical therapy.

iii) Infrared detectors are used in Earth Satellites.

iv) These are used in taking photographs during the conditions of fog, smoke etc.

9. In which bias can a zener diode be used as voltage regulator.

Ans. In reverse bias Zener diode can be used as voltage regulator.

10. What is world wide web (www) ?

Ans. Tern Berners -Lee invented the World Wide Web.

It is an encyclopedia of knowledge accessible to every one round the clock through out the year.

SECTION – B

11. What are beats ? When do they occur ? Explain their use, if any.

Ans. Two sound waves of nearly same frequency are travelling in the same direction and interfere to produce a regular waxing (maximum) and waning (minimum) in the intensity of the resultant sound waves at regular intervals of time is called beats.

It two vibrating bodies have slightly difference in frequencies, beats can occur.

No. of beats can be heard $\Delta\upsilon = \upsilon_1 \sim \upsilon_2$

Importance : 1. It can be used to tune musical Instruments

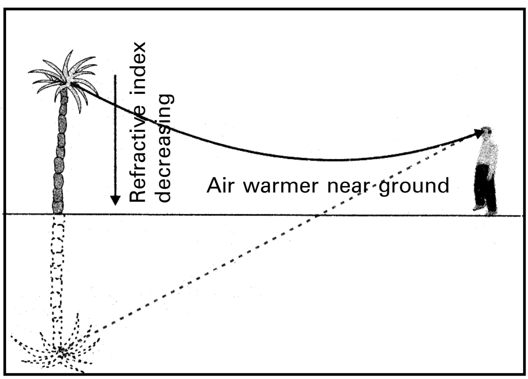
2. Beats are used to detect dangerous gases.

Explanation for tuning musical instruments with beats :

Musicians use the beat phenomenon in tuning their musical instruments. If an instrument is sounded against a standard frequency and tuned until the beats disappear then the instrument is in tune with the standard frequency.

12. Explain the formation of a mirage.

Ans. In a desert, the sand becomes very hot during the day time and it rapidly heats the layer of air which is in its contact. So density of air decreases. As a result the successive upward layers are denser than lower layers.



When a beam of light travelling from the top of a tree enters a rarer layer, it is refracted away from the normal. As a result at the surface of layers of air, each time the angle of incidence increases and ultimately a stage is reached, when the angle of incidence becomes greater than the critical angle between the two layers, the incident ray suffers total internal reflection.

So it appears as inverted image of the tree is formed and the same looks like a pool of water to the observer.

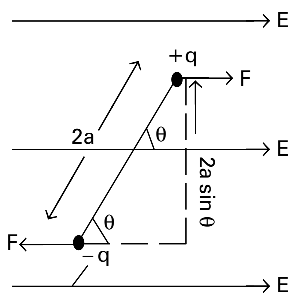
13. Derive the equation for the couple acting on an electric dipole in a uniform electric field.

Ans. 1)A pair of opposite charges separated by a small distance is called dipole.

2) Consider the charge of dipole are –q and +q coulomb and the distance between them is 2a.

3) Then the electric dipole moment P is given by $P = q \times 2a = 2aq$. It is a vector. It's direction is from –q to +q along the axis of dipole.

4) It is placed in a uniform electric field E, making an angle θ with field direction as shown in fig.



5) Due to electric field force on +q is $F = +qE$ and force on –q is $F = -qE$.

6) These two equal and opposite charges constitute torque or moment of couple.

i.e., torque, $\tau = \perp^r$ distance × magnitude of one of force

$\therefore \tau = (2a \sin\theta)qE = 2aqE \sin\theta = PE \sin\theta$

In vector form, $\vec{\tau} = \vec{P} \times \vec{E}$

14. Obtain an expression for the magnetic dipole moment of current loop.

Ans. We know that magnetic induction on the axial line of a circular coil is $B = \dfrac{\mu_0 N i R^2}{2(R^2 + x^2)^{3/2}}$

where N = Number of turns in the coil

R = Radius of the coil

x = Distance from centre of the coil

i = Current in a coil

If x >> R, Then $B = \frac{\mu_0 N i R^2}{2x^3}$

Multiplying and dividing with 2π

$$B = \frac{\mu_0 N i R^2}{2x^3} \times \frac{2\pi}{2\pi}$$

$$B = \frac{\mu_0}{4\pi} \cdot \frac{2 N i (\pi R^2)}{x^3} \qquad (\because A = \pi R^2)$$

$$B = \frac{\mu_0}{4\pi} \cdot \frac{2 N i A}{x^3} \longrightarrow (1)$$

We know that magnetic induction field on the axial line of a bar magnet

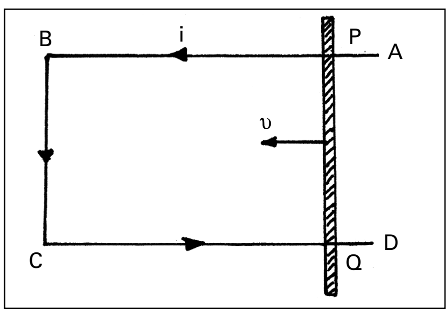
$$B = \frac{\mu_0}{4\pi} \cdot \frac{2M}{x^3} \longrightarrow (2)$$

Comparing the equations (1) and (2)

Magnetic moment (M) = N i A

15. Obtain an expression for the e.m.f induced across a conductor which is moved in a uniform magnetic field which is perpendicular to the plane of motion.

Ans. Consider a conductor PQ of length l moving freely in a uniform magnetic field $\vec{B}$ with uniform velocity υ on a rectangular conductor ABCD.



Let any arbitrary charge q in the conductor also move in the field with same velocity.

Magnitude of lorentz force on

this charge (F) = Bqυ —— (1)

Workdone in moving the charge from P to Q is given by

W = Force × displacement

W = Bqυ × l —— (2)

(∵ Direction of force on the charge as per Fleming's left hand rule)

Electromotive force (ε) = $\frac{w}{q}$

$\varepsilon = \frac{Bq\upsilon l}{q} \Rightarrow \varepsilon = Bl\upsilon$ —— (3)

16. What does an electromagnetic waves consists of ? On what factors does its velocity in vaccum depend ?

Ans. Maxwell concluded that the variation in electric and magnetic field vectors perpendicular to each other leads to the production of electromagnetic waves in space. They can travel in space even without any material medium. These waves are called electromagnetic waves.

According to Maxwell, electromagnetic waves are those waves in which there are sinusoidal variation of electric and magnetic field vectors at right angles to each other as well as at right angles to the direction of wave propagation. Thus electomagnetic waves have transverse nature.

Electric field $E_x = E_0$ Sin (kz – ωt)

Magnetic field $B_y = B_0$ sin (kz -ωt)

Where K is propagation constant $\left(K = \frac{2\pi}{\lambda}\right)$

The velocity of electromagnetic waves $C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

Velocity of e.m waves depends on

i) Permeability in free space (μ_0).

ii) Permittivity in free space (ε_0).

Velocity of e.m waves is 3×10^8 m / s.

17. Define half life period and decay constant for a radioactive substance. Deduce the relation between them.

Ans. **Half life period (T) :** Time taken for the number of radio active nuclei to disintegrate to half of its original number of nuclei is called Half life period.

Decay constant (λ) : The ratio of the rate of radioactive decay to the number of nuclei present at that instant.

It is a proportional constant and is denoted by 'λ'.

$$\therefore \lambda = \frac{-\left(\frac{dN}{dt}\right)}{N}$$

Relation between half the period and decay constant :

1. The radioactive decay law $N = N_0\, e^{-\lambda t}$ states that the number of radioactive nuclei in a radioactive sample decreases exponentially with time. Here λ is called decay constant.

2. If N_0 is the number of nuclei at t = 0 and N is the radioactive nuclei at any instant of time 't'.

3. Substituting $N = \frac{N_0}{2}$ at t = T in $N = N_0\, e^{-\lambda t}$.

4. Where T is half life of the radioactive substance.

$$\frac{N_0}{2} = N_0\, e^{-\lambda T}$$

$$e^{\lambda T} = 2; \; \lambda T = ln\, 2$$

$$T = \frac{\ln 2}{\lambda} = \frac{2.303 \log_{10}^{2}}{\lambda} \; ; \therefore \; T = \frac{0.693}{\lambda}$$

5. The above equation represents the relation between half life (T) and decay constant (λ). 'λ' is different for different radioactive substances.

18. Distinguish between zener breakdown and avalanche breakdown.

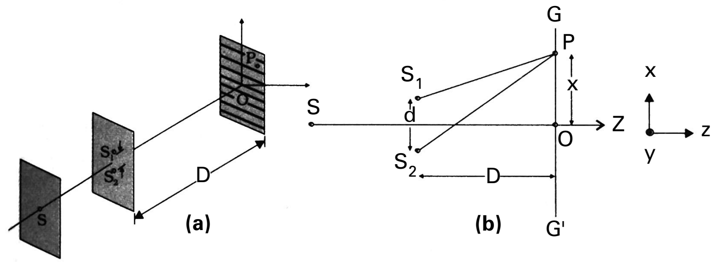
Ans.

Zener break down	Avalanche break down
1. Zener break down occurs at heavily doped diodes.	1. Avalanche break down occurs at lightly doped diodes.
2. This occurs at low reverse bias voltages.	2. This occurs at high reverse bias voltages.
3. This occurs due to field emission.	3. This occurs due to ionisation by collision.
4. Width of depletion layer is small.	4. Width of depletion layer is also small.

SECTION – C

19. Describe young's experiment for observing interference and hence derive the expression for fringe width.

Ans. **Interference :** The modification of intensity obtained by the super position of two (or) more light waves is called interference.



Young's arrangement to produce interference pattern

i) Thomas Young experimentally observed the phenomenon of interference of light using two coherent sources.

ii) A small pin hole 'S' illuminated by monochromatic source of light which produces a spherical wave.

iii) S_1 and S_2 are two narrow pin holes equidistant from S.

iv) Screen is placed at a distance D.

v) The points at which any two crests (or) any two troughs are superimposed, constructive interference takes place bright fringe will be observed on the screen.

vi) The points at which crest of one wave and trough of another wave are super imposed, destructive interference takes place dark fringe will be observed on the screen.

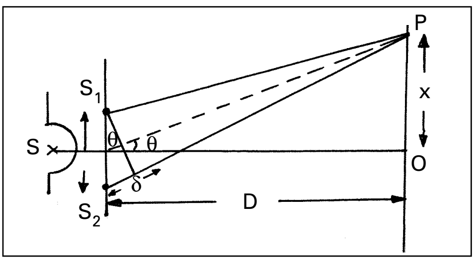
vii) Thus on the screen alternately bright and dark frings are observed.

Expression for fringe width :

i) It is the distance between two successive bright (or) dark fringes, denoted by β.

ii) The path difference (δ) = d sin θ

If θ is very small then from figure $\sin\theta \approx \tan\theta = \dfrac{x}{D}$



iii) For bright fringes path difference

$S_2P - S_1P = n\lambda$

$\therefore d\sin\theta = n\lambda$

$d \times \dfrac{x}{D} = n\lambda$

$x = \dfrac{n\lambda D}{d}$ —— (1) where n = 0, 1, 2, 3 ....

This equation represents the position of bright fringe.

When $n = 0, x_0 = 0$

$n = 1, x_1 = \dfrac{\lambda D}{d}$ and $n = 2, x_2 = \dfrac{2\lambda D}{d}$

The distance between any two consecutive bright fringes is

$$x_2 - x_1 = \frac{2\lambda D}{d} - \frac{\lambda D}{d} \Rightarrow \beta = \frac{\lambda D}{d} \quad \text{—— (2)}$$

iv) For dark fringes path difference $S_2P - S_1P = (2n + 1)\frac{\lambda}{2}$

$$\therefore d \sin \theta = (2n + 1)\frac{\lambda}{2}$$

$$d \times \frac{x}{D} = (2n + 1)\frac{\lambda}{2} \Rightarrow x = \frac{(2n+1)\lambda D}{2d} \quad \text{—— (3)}$$

where n = 0, 1, 2, 3 ....

This equation (3) represents, position of dark fringe.

When $n = 0, x_0 = \frac{\lambda D}{2d} \Rightarrow n = 1, x_1 = \frac{3\lambda D}{2d}; n = 2, x_2 = \frac{5\lambda D}{2d}$ ......

The distance between any two consecutive dark fringes is

$$x_2 - x_1 = \frac{5\lambda D}{2d} - \frac{3\lambda D}{2d} = \frac{5\lambda D - 3\lambda D}{2d}$$

$$\beta = \frac{\lambda D}{d} \quad \text{—— (4)}$$

Hence fringe width is same for bright and dark fringes.

20. Applying Gauss law derive the expression for electric intensity due to a charged conducting spherical shell at (i) a point outside the shell (ii) a point on the surface of the shell and (iii) a point inside the shell.

Ans. Expression for E due to a charged conducting spherical shell :

1) Consider a uniformly charged spherical shell. Let total charge on it is 'q' and radius is R.

Surface charge density $\sigma = \frac{\text{Total charge}}{\text{Surface area}} = \frac{q}{4\pi R^2}$ ..... (1)

2) Since the shell is uniformly charged, the intensity of electric field at any point depends on radial distance 'r' from centre 'O'. The direction of E is away from the centre along the radius.

i) E at a point outside the shell :

1) Consider a point at a distance 'r' outside the sphere. Construct a Gaussian surface with 'r' as radius (where r > R).

2) Total flux coming out of this sphere is

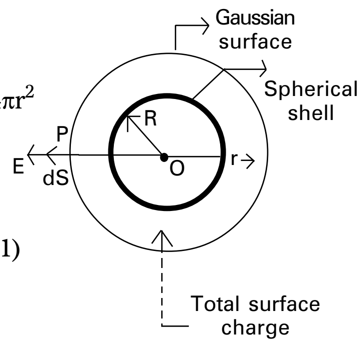
$$\phi = \oint_S \vec{E}.d\vec{s} = E\oint ds = \frac{q}{\varepsilon_0}.$$

But $\oint_S dS$ = Area of sphere = $4\pi r^2$

$\therefore E.\,4\pi r^2 = \frac{q}{\varepsilon_0}$

But $q = 4\pi R^2\sigma$ (from equation 1)

$\therefore E = \frac{1}{4\pi r^2}\frac{4\pi R^2\sigma}{\varepsilon_0}$



3) Therefore at any point outside the sphere, $E = \frac{\sigma}{\varepsilon_0}\frac{R^2}{r^2}$

ii) E at a point on the surface of shell :

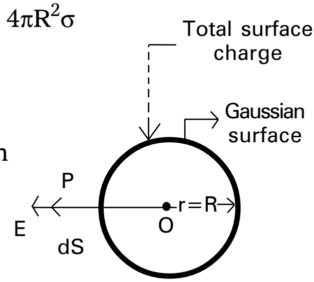
1) Construct a Gaussian surface with radius r = R.

2) Total flux through this sphere $\phi = \oint \vec{E}.d\vec{S} = E\oint_S dS = \frac{q}{\varepsilon_0}$.

But $\oint dS$ of sphere = $4\pi R^2$ and $q = 4\pi R^2\sigma$

$\Rightarrow E.\,4\pi R^2 = \frac{4\pi R^2\sigma}{\varepsilon_0} \Rightarrow E = \frac{\sigma}{\varepsilon_0}$

3) Therefore intensity at any point on surface of the sphere $E = \frac{\sigma}{\varepsilon_0}$



iii) E at a point inside the shell :

1) Consider a point P inside the shell. Construct a Gaussian surface with radius r (where r < R). There is no charge inside the shell. So from Gauss's law $\oint_S \vec{E}.d\vec{S} = \frac{q}{\varepsilon_0}$.

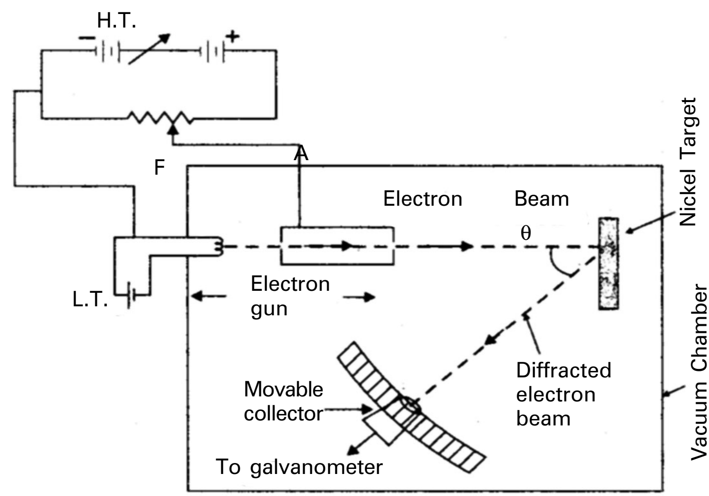
But $q = 0 \Rightarrow \oint_S \vec{E}.d\vec{S} = E.\, 4\pi r^2 = 0.$

2) Therefore, intensity of electric field at any point inside a charged shell is zero.

21. Describe the Davisson and Germer experiment. What did this experiment conclusively prove ?

Ans. Davisson and Germer experiment :

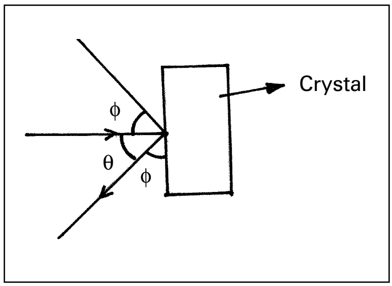
1) The experimental arrange-ment is schematically shown in fig.
2) Electrons from a filament F are rendered into a fine beam by applying a positive potential to the cylinder A.
3) A fine narrow beam of electrons is incident on the nickle crystal. The electrons are scattered in all directions by the atoms of the crystal.



Davisson-Germer electron diffraction arrangement

4) The intensity of the electron beam scattered if a given direction, is measured by the electron detector (collector). The detector can be moved on a circular scale and is connected to a sensitive galvanometer, which records the current.

5) The deflection of the galvanometer is proportional to the intensity of the electron beam entering collector.
6) The apparatus is enclosed in an evacuated chamber.
7) By moving the detector on the circular scale at different positions, the intensity of the scattered electron beam is measured for different values of angle of scattering θ.
8) The variation of the intensity (I) of the scattered electrons with the angle of scattering θ is obtained for different accelerating voltages.
9) The experiment was performed by varying the accelerating voltage from 44 V to 68 V. It is found that the intensity is maximum at 50° for a critical energy of 54 V.
10) For θ = 50°, the glancing angle, θ (angle between the scattered beam of electron with the plane of atoms of the crystal) for electron beam will be given by $\phi + \theta + \phi = 180°$



$\phi = \frac{1}{2}\ [180° - 50°] = 65°$

11) According to Bragg's law for first order diffraction maxima (n = 1), we have $2\ d \sin \phi = 1 \times \lambda$

$\Rightarrow \lambda = 2 \times 0.91 \times \sin 65° = 1.65Å = 0.165$ nm. (experimentally).

[∵ for Nickle crystal interatomic separation d = 0.91Å]

12) According to de-Broglie hypothesis, the wavelength of the wave associated with electron is given by $\lambda = \frac{12.27Å}{\sqrt{V}} = \frac{12.27}{\sqrt{54}} = 1.67Å =$ 0.167 nm, (Theoritically).
13) The experimentally measured wavelength was found to be in confirmity with proving the existence of de-Broglie waves.

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