Solved Paper 2013
Physics
Class-XII

Time : 3 Hours *Max. Marks : 70*

General Instructions :

(i) *All questions are compulsory.*

(ii) *There are **29** questions in total. Questions **1** to **8** are very short answer type questions and carry one mark each.*

(iii) *Questions **9** to **16** carry **two** marks each, questions **17** to **25** carry three marks each and questions **27** to **29** carry five marks each.*

(iv) *There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each. You have to attempt only one of the choices in such questions.*

(v) *Question **26** is a value based question carrying four marks.*

(vi) *Use of calculators is **not** permitted. However, you may use log tables if necessary.*

(vii) *You may use the following values of physical constants wherever necessary :*

$$c = 3 \times 10^{8} \text{ m/s}$$
$$h = 6.63 \times 10^{-34} \text{ Js}$$
$$e = 1.6 \times 10^{-19} \text{ C}$$
$$\mu_o = 4\pi \times 10^{-7} \text{ T m A}^{-1}$$
$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^{9} \text{ N m}^2 \text{ C}^{-2}$$
$$m_e = 9.1 \times 10^{-31} \text{ kg}$$
$$\text{Mass of Neutron} = 1.675 \times 10^{-27} \text{ kg}$$
$$\text{Mass of Proton} = 1.673 \times 10^{-27} \text{ kg}$$

1. Write the expression for the work done on an electric dipole of dipole moment $\vec{p}$ in turning it from its position of stable equilibrium to a position of unstable equilibrium in a uniform electric field $\vec{E}$.

Ans. In stable equilibrium the angle between $\vec{P}$ and $\vec{E}$ is 0°

In unstable equilibrium the angle between $\vec{P}$ and $\vec{E}$ is 180°

So, the work done $= PE(\cos\theta_1 - \cos\theta_2)$
$= PE(\cos 0° - \cos 180°)$
$= PE(1+1)$
$= 2PE$

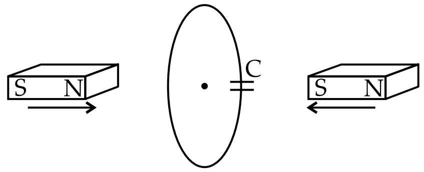
2. Is the steady electric current the only source of magnetic field? Justify your answer.

Ans. No. Displacement current, alternating current, electromagnet, permanent magnet can also produce magnetic field.

3. When is H_α line of the Balmer series in the emission spectrum of hydrogen atom obtained?

Ans. H_α line in emission spectrum of Hydrogen atom is obtained when electron falls from its third (n = 3) to second lowest (n = 2) energy level.

4. Predict the polarity of the capacitor in the situation described in the figure.



Ans. Looking from left side the current will be anticlockwise. Looking from left side the current will be clockwise. So, upper plate will be positive and lower plate will be negative.

5. Why is the core of a transformer laminated?

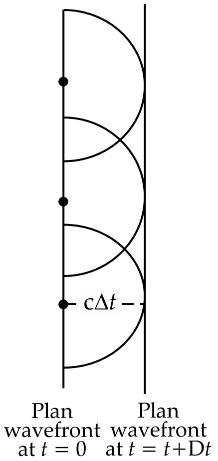
Ans. Core of a transformer is laminated to reduce the eddy current.

6. Show on a plot the nature of variation of photoelectric current with the intensity of radiation incident on a photosensitive surface.

Ans. Photoelectric current is proportional to intensity of light. So, the graph will be a straight line passing through the origin.

Ans. OR

(a) m



(b) Proof of Snell's law of refraction:

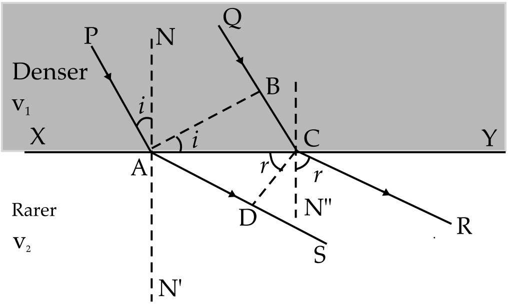
XY is the separation of two media.

AB is the incident wavefront

CD is the refracted wavefront.

v_1 is the velocity of light in denser medium.

v_2 is the velocity of light in rarer medium.



$$\angle PAN = \angle i = \text{angle of incidence}$$
$$= \angle BAC$$
$$\angle RCN'' = \angle r = \text{angle of refraction}$$
$$= \angle ACD$$

In ΔABC,

$$\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC}$$

In ΔACD,

$$\sin i = \frac{AD}{AC} = \frac{v_2 t}{AC}$$

$$\therefore \quad \frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

= Refractive index of rarer medium with respect to denser medium.

This Snell's law of refraction.

(c) Reflection and refraction occur due to the interaction of light with the atoms / molecules of the media which vibrate with the same frequency of the incident light. For this the reflected and refracted light have the same frequency as that of incident light.

29. State Biot-Savart law, expressing it in the vector form. Use it to obtain the expression for the magnetic field at an axial point, distance 'd' from the centre of a circular coil of radius 'a' carrying current 'I'. Also find the ratio of the magnitudes of the magnetic field of this coil at the centre and at an axial point for which $d = a\sqrt{3}$.

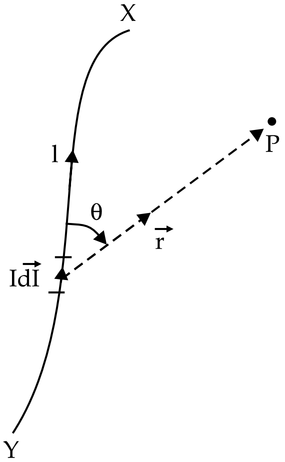
OR

(a) Draw the magnetic field lines due to a current carrying loop.

(b) State using a suitable diagram, the working principle of a moving coil galvanometer. What is the function of a radial magnetic field and the soft iron core used in it?

(c) For converting a galvanometer into an ammeter, a shunt resistance of small value is used in parallel, whereas in the case of a voltmeter a resistance of large value is used in series. Explain why.

Ans. Biot-Savart law:



XY is a current carrying wire.

$\vec{dl}$ is a small element on it.

At point P, whose position vector is $\vec{r}$, the magnetic field is to be determined.

According to Biot Savart law, the magnitude of magnetic field $\vec{dB}$ at P is

(i) Proportional to current I

(ii) Proportional to length dl

(iii) Inversely proportional to the square of the distance of the point

The direction of magnetic field is perpendicular to the plane containing $\vec{dl}$ and $\vec{r}$.

In vector form,

$$\vec{dB} \propto \frac{I\,\vec{dl} \times \vec{r}}{r^3}$$

Or, $$\vec{dB} = \frac{\mu_0}{4\pi}\frac{I\,\vec{dl} \times \vec{r}}{r^3}$$

Magnetic field due to a current carrying circular coil:

A single turn circular coil of radius a carrying current I is considered. P is a point on the axis at a distance d where the magnetic field is to be determined.

Two small lengths dl are considered at two diametrical opposite ends on the coil.

Distance of point P from dl is r.

If dB is the magnetic field, then

$$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin 90°}{r^2}$$

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

The 2 components of dB are dB cos ϕ and dB sin ϕ.

The two dB cos ϕ components corresponding to two dl elements (at the upper and the lower end) cancel each other.

The two dB sin ϕ components are in same direction and hence resultant magnetic field at P becomes 2dB sin ϕ.

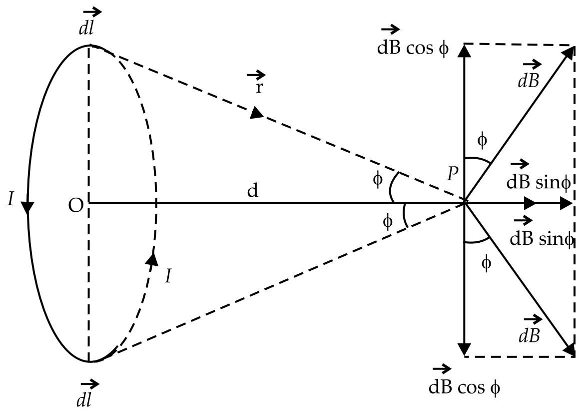
So, the resultant magnetic field at point P due to the entire coil is

$$B = \frac{\mu_0}{4\pi}\sum\frac{2Idl\sin\phi}{r^2}$$

Or, $$B = \frac{\mu_0}{4\pi}\frac{2I\sin\phi}{r^2}\sum dl$$

Or, $$B = \frac{\mu_0}{4\pi}\frac{2I\sin\phi}{r^2}\times \pi a$$

[since at a time two dl portions have been considered at two diametrical opposite ends.]



Or, $$B = \frac{\mu_0}{4\pi}\frac{2I\times\frac{a}{r}}{r^2}\times \pi a$$

[since, $\sin\phi = \frac{a}{r}$]

Or, $$B = \frac{\mu_0}{4\pi}\frac{2\pi a^2 I}{r^3}$$

Or, $$B = \frac{\mu_0}{2}\frac{a^2 I}{(a^2+d^2)^{3/2}}$$

Ratio of magnetic fields:

When $d = a\sqrt{3}$

$$B_P = \frac{\mu_0}{2}\frac{a^2 I}{[a^2+(a\sqrt{3})^2]^{3/2}}$$

$$= \frac{\mu_0}{2}\times\frac{I}{8a}$$

At centre ($d = 0$)

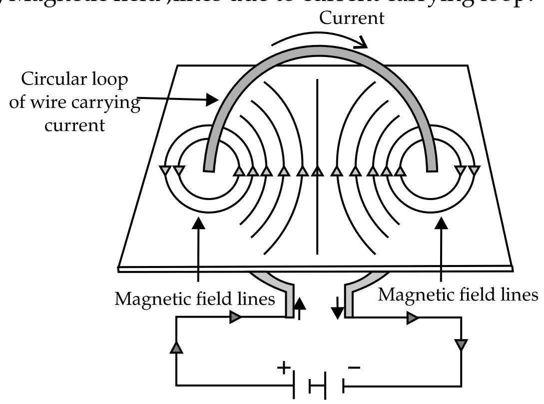
$$B_{\text{centre}} = \frac{\mu_0}{2}\times\frac{a^2 I}{(a^2)^{3/2}}$$

$$= \frac{\mu_0}{2}\times\frac{I}{a}$$

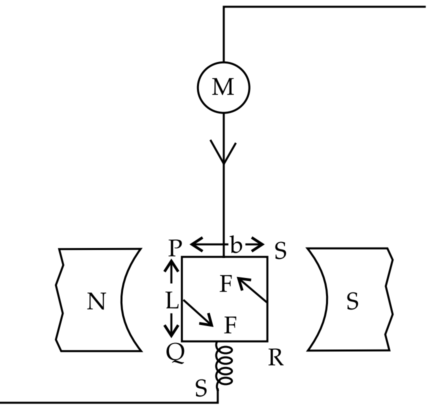
So, the ratio $= \frac{B_{\text{centre}}}{B_P} = 8:1$

OR

(a) Magnetic field ;lines due to current carrying loop:



(b) Working principle of Moving coil galvanometer:



PQRS is a rectangular coil, of copper wire of length L and breadth b, having n number of turns, current i flowing through it, is hung in a permanent magnetic field B with the help of a phosphor bronze strip.

Force acting on PQ and SR is $F = nBiL$. These two forces are oppositely directed.

So, the moment of deflecting couple is

$$\tau = f \times b = nBilb$$

As the coil rotates, a restoring torque $c\theta$ is produced in the phosphor bronze strip, where c is the torsional constant and θ is the angle of twist.

At equilibrium, $c\theta = nBiLb$

Or, $c\theta = nBiA$ $\quad$ (A = area of the coil)

Or, $$i = \frac{c\theta}{nBA}$$

Or, $$i = k\theta$$

$$\left(k = \frac{c}{nBA} = \text{Galvanometer constant}\right)$$

$$\therefore \quad i \propto \theta$$

Function of radial magnetic field: Due to radial magnetic field, magnetic field lines become perpendicular to magnetic moment and hence the torque becomes maximum.

Function of soft iron core: Using soft iron core sensitivity increases since the magnetic field lines prefer to pass through soft iron.

(c) A shunt resistance of small value is connected in parallel with a galvanometer to convert it to an ammeter. Ammeter is used in series in a circuit. Its resistance should be as low as possible so that it does not make any change in the circuit current. So, a low resistance is connected in parallel with the galvanometer to achieve this.

A high value resistance is connected in series with a galvanometer to convert it to an voltmeter. Voltmeter is used in parallel to a component in a circuit. Its resistance should be as high as possible so that it does not make any change in the circuit current. So, a high value resistance is connected in series with the galvanometer to achieve this.

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