Nagaland Board
Class XII
Physics
Sample Paper 2 – Solution

1. (iv)
For a resistive circuit, e.m.f. and current are always in phase.

2. (iv)
All the regions in the electromagnetic spectrum have the same speed. The speed depends on the material in which the wave is traveling.

3. (iii)
The extent of polarization depends on the relative strength of two mutually opposite factors: the dipole potential energy in the external field tending to align the dipoles with the field and thermal energy tending to disrupt the alignment.

4. (ii)
Copper, silver and gold are all diamagnetic substances, Whereas nickel is a ferromagnetic substance.

5. (iii)
It is because the work function of wood is more than the energy of the incident photons of light. Hence, photoelectrons are not emitted from the wooden table.

6. Long distance radio broadcast use short wave bands as ionosphere layer of the atmosphere reflects the waves in these bands hence making the long distance broadcast feasible.

7. No, because there are no free charge carriers in the depletion region .In the absence of any forward biasing it offers infinite resistance

8. Nuclear fusion is not possible in laboratory as it is performed in high temperature. This cannot be attained in the laboratory.

9. No, they are a new kind of waves proposed to locate the position of a moving particle. For this reason, they are sometimes called pilot waves

10. Coherent sources are defined as the sources in which initial phase difference remains constant. In the case of two independent sources, the initial phase difference cannot remain constant because light is emitted due to millions of atoms and their number goes on changing in a quite random manner.

11. The power of the modulated signal is not high enough and hence the modulator is followed by a power amplifier. The amplifier provides necessary power and then feeds the modulated signal to the antenna of the transmitter. While propagating through the channel. The transmitted signal gets attenuated. So to increase the power the receiving antenna is followed by an amplifier. The amplified signal is fed to the detector which separates the modulating signal and reproduces it back into message form

12. In the formation of the nucleus, the neutron and protons have to collect in a very small space whose size is of the order of 10^{-14}m. The energy required for this purpose is spent by the nucleons at the cost of their masses. As a result of this, the mass of the nucleus formed becomes less than the sum of the masses of the individual nucleons.

13. The NOT gate is also known as an inverter. It has only one input and one output. The output of an inverter is always opposite to the input i.e. if input is 1 (high), the output is 0 (low) and vice versa.

Or

A zener diode is a properly doped p-n junction diode, which has a sharp breakdown voltage. It works in the breakdown region of the characteristics, so it is also called breakdown diode.

14. In the formation of the nucleus, the neutron and protons have to collect in a very small space whose size is of the order of 10^{-14}m. The energy required for this purpose is spent by the nucleons at the cost of their masses. As a result of this, the mass of the nucleus formed becomes less than the sum of the masses of the individual nucleons.

15. Infra red waves are emitted by hot bodies. They are produced due to the de-excitation of atoms. They are called Heat waves as they produce heat on falling on matter. This is because water molecules present in most materials readily absorb infra red waves. After absorption, their thermal motion increases, that is, they heat up and heat their surroundings.

Or

The speed of the electromagnetic waves (whether its infra red rays or gamma rays) remains same no matter in which ever medium they travel. Hence the ratio of the speeds of infra red rays and gamma rays in vacuum is 1:1.

16. The work function of copper is 4.5 eV while that for sodium is 2 eV. Therefore, radiation of more energy is required to remove a free electron from copper as compared to sodium. Since threshold radiation is inversely proportional to the work function $(W_0 = hc/\lambda_0)$, its value will be more for sodium.

Or

The fringe width in interference pattern is inversely proportional to the separation between the coherent sources (β=λD/d).When the distance d between the coherent source is large; the fringe width becomes very small. In such a case, the fringes may overlap and the interference pattern may not be observed

17.

We know,

$$X_c = \frac{1}{2\pi v C}$$

for same capacitance,

$$X_c \, \alpha \, \frac{1}{v}$$

For capacitor A $X_c = X_{ac}$

frequency of $A = 2v$

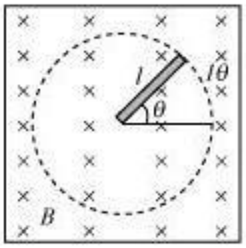
For capacitor B $X_c = X_{bc}$

frequency of $B = v$

$$\frac{X_{ac}}{X_{bc}} = \frac{1/2v}{1/v} = \frac{v}{2v}$$

$$\frac{X_{ac}}{X_{bc}} = \frac{1}{2}$$

18. The given situation can be shown as:



Let θ be the angle traced by the free end of the rod in time t. The area swept-out by the rod in time t is given as:

$$A = \pi l^2 \times \left(\frac{\theta}{2\pi}\right) = \frac{l^2\theta}{2}$$

Since the angle between the area vector and the magnetic field vector is zero, the magnetic flux linked to this area is given as:

$$\phi = B\left(\frac{1}{2}l^2\theta\right)\cos 0^\circ \qquad [\because \text{Flux, } \phi = BA\cos\theta]$$
$$= \frac{1}{2}Bl^2\theta \qquad [\because \cos 0^\circ = 1]$$

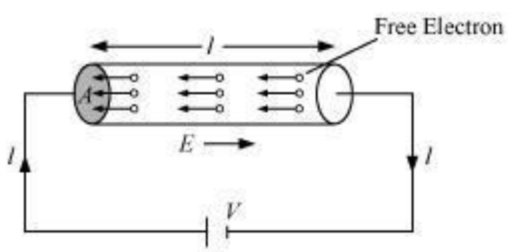
According to Faraday's laws of electromagnetic induction, induced emf (e) is given as

$$e = \frac{d\phi}{dt} = \frac{d}{dt}\left(\frac{1}{2}Bl^2\theta\right) = \frac{1}{2}Bl^2\omega \qquad [\because \omega = \frac{d\theta}{dt}]$$

Hence, the current induced in the rod is given as:

$$I = \frac{e}{R} = \frac{\frac{1}{2}Bl^2\omega}{R} = \frac{Bl^2\omega}{2R}$$

19. Consider a conductor of length l and area of cross-section A, having n electrons per unit volume, as shown in the following figure.



Volume of the conductor = Al

Total number of electrons in the conductor = Volume × Electron density = Aln

Since e is the charge of an electron, the total charge contained in the conductor: Q = Alen

Let a potential difference V be applied across the conductor. The resulting electric field in the conductor is given by: E=V/I

Hence, free electrons begin to drift in a direction opposite to that of the electric field E. The time taken by the free electrons to cross-over the conductor is given as:

$$t = \frac{l}{v_d}$$

v_d is the drift velocity of free electrons.

Current flowing through the conductor is given by:

$$I = \frac{Q}{t} = \frac{Alen}{\frac{l}{v_d}} = neAv_d$$

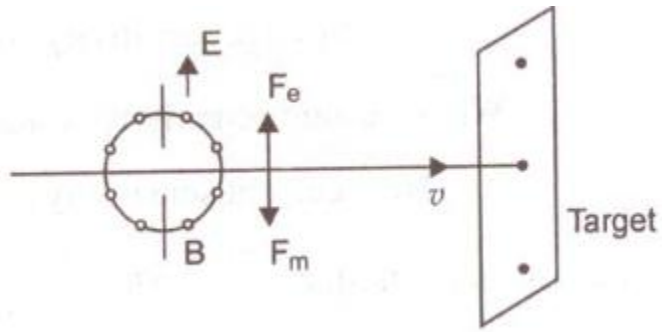
Current density, $j = \frac{I}{A} = nev_d$

Where, n and e are constants

$\therefore j \propto v_d$

i.e., current density is directly proportional to the drift velocity

20.



(i) For a beam of charged particles to pass undeflected through crossed electric and magnetic fields, the condition is that electric and magnetic forces on the beam must be equal and opposite i.e.,

$$eE = evB$$

$$v = \frac{E}{B}$$

Given, $E = 50\text{kV/m} = 50 \times 10^3\ \text{V/m}, B = 100\text{mT} = 100 \times 10^{-3}\text{T}$

$$v = \frac{50 \times 10^3}{100 \times 10^{-3}} = 5 \times 10^5 \text{ms}^{-1}$$

(ii) The beam strikes the target with a constant velocity, so force exerted on the target is zero. However, if proton beam comes to rest, it exerts a force on the target, equal to rate of change of linear momentum of the beam i.e.,

$$F=\frac{\Delta p}{\Delta t}=\frac{mv}{\Delta t}=\frac{mv}{q/i}=\frac{mvi}{q}=\frac{mvi}{ne}$$

where n is the number of protons striking the target per second

Or

Nature of the paths executed by the charged particle moving in a uniform magnetic field will be:

i) If the charged particle is moving parallel to the direction of $\vec{B}$, it does not experience any force, because angle θ between $\vec{v}$ and $\vec{B}$ is 0º or 180º and

F= qvBsin0= 0.

So, the particle will continue to move along the straight line.

ii) If charged particle is moving perpendicular to $\vec{B}$, it experiences maximum force F= qvBsin90º= qvB.

So, this force will provide the required centripetal force and the charged particle will describe a circular path of radius r i.e

$$mv^2/r = qvB.$$

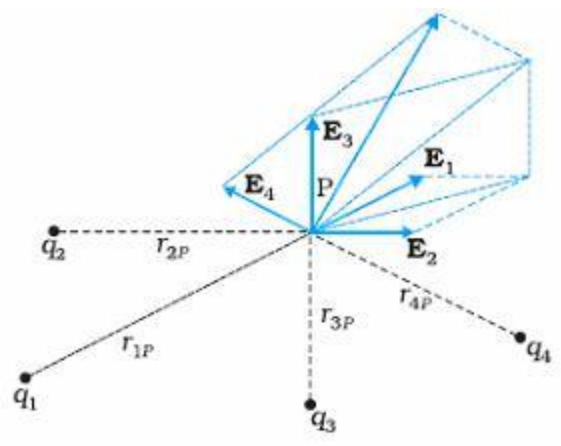
If the charged particle is moving in the magnetic field such that its velocity $\vec{v}$ makes angle θ with the direction of $\vec{B}$, the particle will move under the combined effect of velocity components i.e vcosθ and vsinθ. So, the particle will cover linear, as well as circular path i.e the path will be helical.

21. Molecules of polar dielectric have permanent dipole moment. In the absence of electric field, these dipoles align randomly due thermal agitation. So, the total dipole moment is zero. On applying electric field, these randomly aligned dipoles try to align in the direction of electric field. As a result there is net dipole moment in the direction of electric field.

22. We can apply superposition principle to find the resultant electrostatic force at a point due to multiple charges.

Let's consider a group of charges q_1, q_2, q_3, …, etc with position vectors $\vec{r}_1$, $\vec{r}_2$, $\vec{r}_3$, …, etc with respect to a given point P.

$$E_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_{1P}^2}\hat{r},\quad E_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_{2P}^2}\hat{r}\ldots\ldots\ldots$$



Then according to the superposition principle net electric field at P due to the system of charges is the vector sum of the electric field due to each charge at P.

Hence,

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \ldots + \vec{E}_n$$

Or

A digital signal is a discontinuous function of time (unlike an analog signal) in which current or voltage takes only two discrete values.
Advantages of digital communication are as follows:
(i) This mode of communication is more reliable.
(ii) Its transmission needs simple technique.
In Fax, we get a hard copy of the message at the recipient's terminal. In E-mail, we get a soft copy of the message at the recipient's terminal

23. Threshold frequency: The minimum frequency of incident radiation, which can eject electrons from a metal, is called threshold frequency. Below threshold frequency, there is no photoelectric emission.

Stopping potential: The minimum negative potential given to the anode of a photocell for which the photoelectric current becomes zero is called stopping potential.

(i) The increase of frequency of incident radiation has no effect on the photoelectric current.

(ii) The photoelectric current increases proportionally with the increase in intensity of incident radiation.

Or

Radioactive decay constant (λ) is the reciprocal of time during which the number of atoms in the radioactive substance reduced to 36.8% of the original number of atoms in it.

(i) Y-rays are similar to X-rays

(ii) Penetration power of α-ray is less than that of β and Y -rays so Y-rays are easily absorbed by matter.

24. The big difference really wouldn't be the charge. The scattering of a negative particle really doesn't look that much different from the scattering of a positive particle. The big difference would be the mass. Alpha particles are much, much bigger and hence tend to carry much, much more energy than electrons. So while the alpha particle shrugs off the electrons in the gold foil, the electron is more likely to get scattered by them. The experiment wouldn't be nearly as clean.

25. Radioactive decay constant (λ) is the reciprocal of time during which the number of atoms in the radioactive substance reduced to 36.8% of the original number of atoms in it.

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26. Modulation: It is the process in which some characteristic such as amplitude, frequency or phase angle of a high frequency carrier wave is changed in accordance with the instantaneous value of the low frequency modulating signal.

A sinusoidal carrier wave can be modulated in three ways:

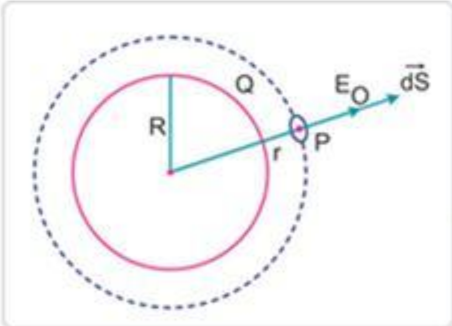
(i) Amplitude modulation

(ii) Frequency modulation

(iii) Phase modulation

Phase modulation: When the modulating wave is superimposed on a high frequency carrier wave in a manner that the magnitude of the phase angle of the modulated signal varies in accordance with the amplitude of the modulating wave,the process is called phase modulation.

27.



Consider a spherical Gaussian surface of radius r (›R), concentric with given shell. If $\vec{E}$ is electric field outside the shell, then by symmetry, electric field strength has same magnitude $\vec{E}_o$ on the Gaussian surface and is directed radially outward. Also the directions of normal at each point are radially outward, so angle between $\vec{E}_o$ and $d\vec{s}$ is zero at each point. Hence, electric flux through Gaussian surface =

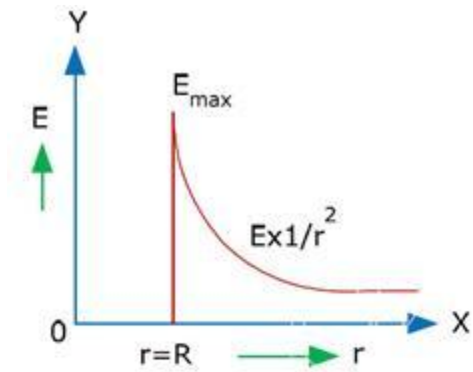
$$= \oint_s \vec{E}_o . d\vec{s}$$
$$= \oint E_o dS \cos 0^o = E_o . 4\pi r^2$$

Now, Gaussian surface is outside the given charged shell, so charge enclosed by the Gaussian surface is Q.

Hence, by Gauss's theorem

$$\oint_s \vec{E}_o . d\vec{s} = \frac{1}{\varepsilon_o} \times charge - enclosed$$
$$\Rightarrow E_o . 4\pi r^2 = \frac{1}{\varepsilon_o} \times Q$$
$$\Rightarrow E_o = \frac{1}{4\pi\varepsilon_o} \frac{Q}{r^2}$$

Thus, electric field outside a charged thin spherical shell is same as if the whole charge Q is concentrated at the centre. Graphically,



For r ‹ R, there is no strength of electric field inside a charged spherical shell.

For r › R, electric field outside a charged thin spherical shell is same as if the whole charge Q is concentrated at the centre.

28.

$$\vartheta = \frac{me^4}{(4\pi)^3 \varepsilon_o^2}\left[\frac{1}{(x-1)^2} - \frac{1}{x^2}\right]$$

$$= \frac{me^4(2x-1)}{(4\pi)^3 \varepsilon_o^2 \left(\frac{h}{2\pi}\right) x^2(x-1)^2}$$

for large x,

$$\upsilon = \frac{me^4}{32\pi^3 \varepsilon_o^2 \left(\frac{h}{2\pi}\right)^3 x^3}$$

orbital frequency $\upsilon = \frac{V}{2\pi r}$

where $V = \frac{nh}{2\pi mr}$

and $r = \frac{4\pi\varepsilon_o \left(\frac{h}{2\pi}\right)^2 x^2}{me^2}$

This leads to -

$$\upsilon = \frac{me^4}{32\pi^3 \varepsilon_o^2 \left(\frac{h}{2\pi}\right)^3 x^3}$$

which is same as ϑ for large x

Or

(a)

(i) It does not obey the Maxwell's theory of electrodynamics, according to it "A small charged particle moving around an oppositely charged centre continuously loses its energy". If an electron does so, it should continuously lose its energy and should set up spiral motion ultimately failing into the nucleus.

(ii) It could not explain the discrete spectra exhibited by atoms. Bohr rectified Rutherford atom model by suggesting that electrons are allowed to revolve only in certain privileged orbits, which are stationary orbits i.e., energy of revolving electrons in such orbits shall remain stationary, involving no loss.

(b)

According to Bohr's postulate, angular momentum of electron orbiting around the nucleus is quantized.

$$mvr = \frac{nh}{2\pi} \quad \text{---------}(1)$$

According to de Broglie, a stationary orbit is that which contains an integral no. of de Broglie waves associated with the revolving electron.

For an electron revolving in nth circular orbit of radius r,

total distance covered = circumference = $2\pi r$

For permissible orbit, $2\pi r = n\lambda$

$$r = \frac{n\lambda}{2\pi} \quad \text{----------}(2)$$

Put (2) in (1)

$$mv \times \frac{n\lambda}{2\pi} = \frac{nh}{2\pi}$$

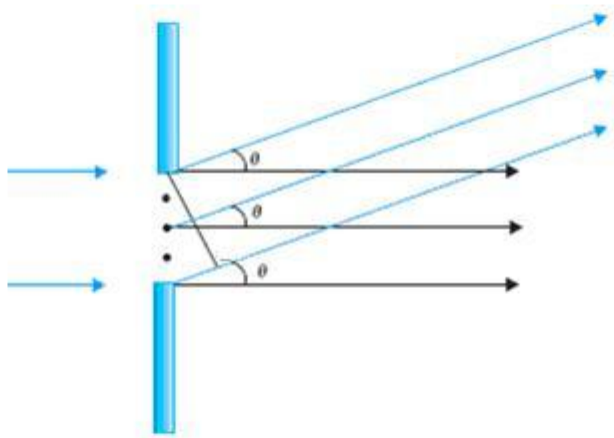
$$\Rightarrow \lambda = \frac{h}{mv} = \frac{h}{p}$$

(c) It is not possible to measure simultaneously the position and momentum of a microscopic particle with absolute accuracy. There is a minimum for the product of the uncertainties of these two measurements. There is likewise a minimum for the product of the uncertainties of the energy and time.

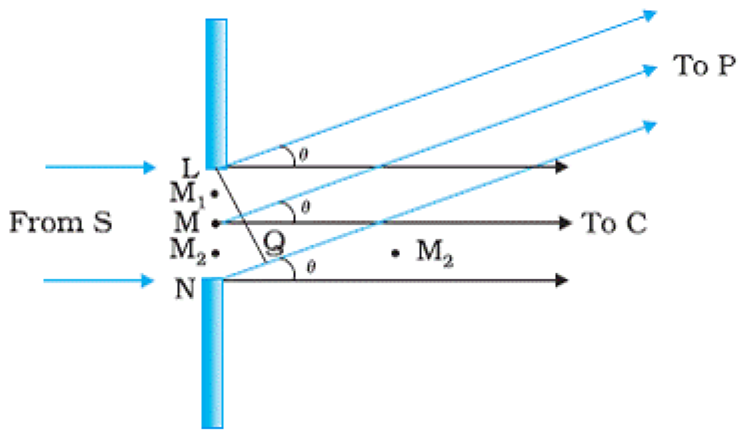
$$\Delta x \Delta p \geq \frac{h}{4\pi}$$

$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

29. According to Huygens principle, each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. These wavelets emanating from the wavefront are usually referred to as secondary wavelets and if we draw a common tangent to all these spheres, we obtain the new position of the wavefront at a later time.



The geometry of path differences for diffraction by a single slit.



When a monochromatic light passes through a single slit, there are alternate dark and bright regions, the intensity becoming weaker away from the centre on the screen.

We can apply Huygen's principle to explain this.

The diffracted light goes on to meet a screen.

The basic idea is to divide the slit into much smaller parts, and add their contributions at P with the proper phase differences.

The midpoint of the slit is M. The path difference NP - LP between the two edges of the slit can be calculated, where P is some point on the screen.

If θ is the angle with the normal MC, then if two points M_1 and M_2 in the slit plane are separated by y, the path difference

$$M_2P - M_1P = y\,\theta$$

At the central point C on the screen, the angle θ is zero. All path differences are zero and hence all the parts of the slit contribute in phase.

This gives maximum intensity at C.

Experimental observation indicates that the intensity has a central maximum at $\theta = 0$ and other secondary maxima at $\theta = (n+1/2)\lambda/a$, and has minima (zero intensity) at $\theta = n\lambda/a$,

$n = \pm1, \pm2, \pm3, ...$

Consider first the angle θ where the path difference $a\theta$ is λ. Then,

$$\theta = \lambda/a ....(i)$$

Now, divide the slit into two equal halves LM and MN each of size a/2. For every point M_1 in LM, there is a point M_2 in MN such that $M_1M_2 = a/2$. The path difference between M_1 and M_2 at P = $M_2P - M_1P = \theta a/2 = \lambda/2$ for the angle chosen. This means that the contributions from M_1 and M_2 are 180º out of phase and cancel in the direction $\theta = \lambda/a$. Contributions from the two halves of the slit LM and MN, therefore, cancel each other.

Equation (i) gives the angle at which the intensity falls to zero. Similarly we can show that the intensity is zero for $\theta = n\lambda/a$, with n being any integer (except zero!).

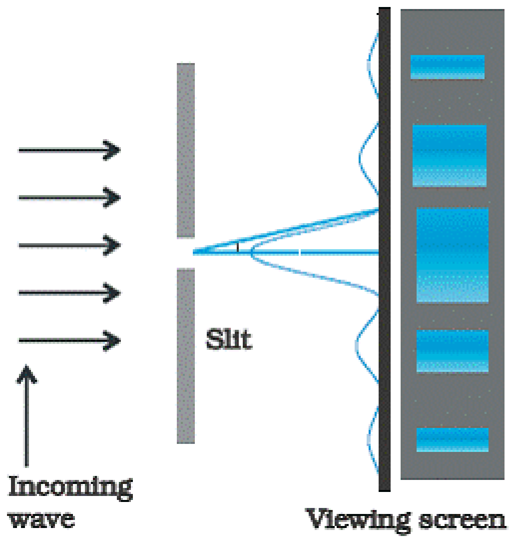
Angular size of the central maximum increases when the slit width a decreases.

Consider an angle $\theta = 3\lambda/2a$ which is midway between two of the dark fringes.

Divide the slit into three equal parts. If we take the first two thirds of the slit, the path difference between the two ends would be

$$\frac{2}{3}a \times \theta = \frac{2a}{3} \times \frac{3\lambda}{2a} = \lambda$$

The first two-thirds of the slit can therefore be divided into two halves which have a $\lambda/2$ path difference. The contributions of these two halves cancel in the same manner as described earlier. Only the remaining one-third of the slit contributes to the intensity at a point between the two minima. This will be much weaker than the central maximum.

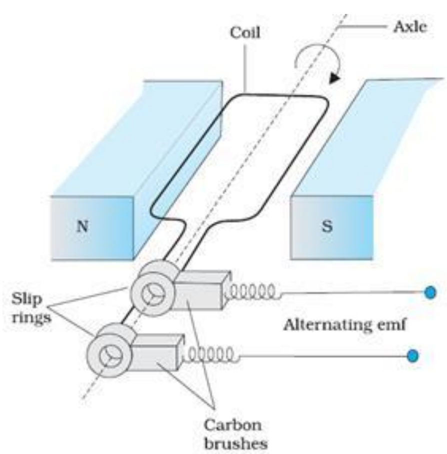


Intensity distribution and photograph of fringes due to diffraction at single slit.

Similarly we can show that there are maxima at $(n + 1/2)\,\theta/a$ with n = 2, 3, etc.

These become weaker with increasing n, since only one-fifth, one-seventh, etc., of the slit contributes in these cases.

Or



Basic parts of the AC generator:

i. Rectangular coil mounted on a rotor shaft. The coil also called armature is mechanically rotated in the uniform magnetic field by some external means.

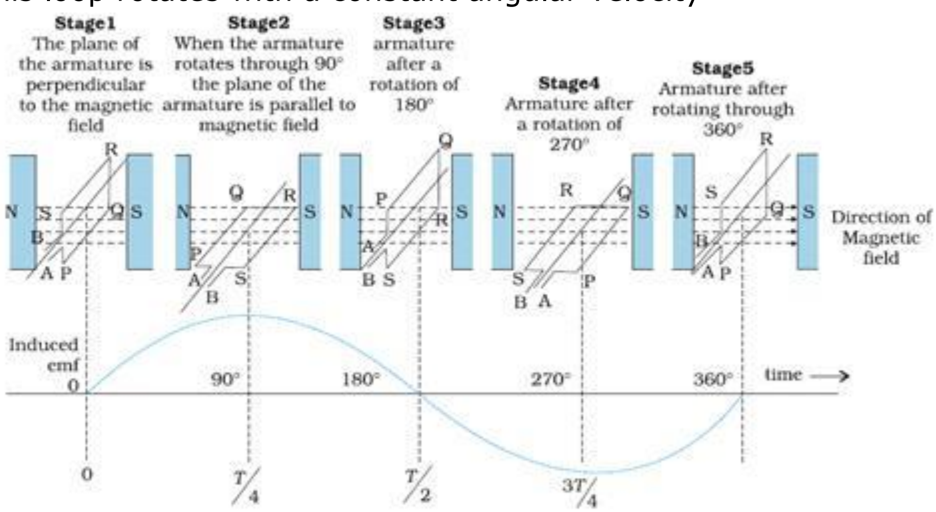
Ii.The axis of rotation of the coil is perpendicular to the direction of the magnetic field. The rotation of the coil causes the magnetic flux through it to change, so an emf is induced in the coil.

iii. The ends of the coil are connected to an external circuit by means of slip rings and brushes.

iv. N and S are two permanent magnets which provide a constant magnetic field region in which the coil rotates.

Principle of working:
A wire loop of area A is free to rotate about an axis which is perpendicular to a uniform magnetic field B. If the normal to the loop makes an angle θ with $\vec{B}$, then, flux through the loop $\Phi = BA\cos\theta$.

If this loop rotates with a constant angular velocity $\omega = \frac{d\theta}{dt}$



The flux through it changes at the rate,

$$\frac{d\Phi}{dt} = -BA\sin\theta\frac{d\theta}{dt} = -BA\omega\sin(\omega t + C_o)$$

where C_o is a constant
emf is induced between ends A and B given by:

$$V = \frac{-d\Phi}{dt} = BA\omega\sin(\omega t + C_o)$$

$V = V_m\sin(\omega t + C_o)$, here $V_m = BA\omega$ Peak value of emf generated.
Since the emf induced in the coil is varying as a function of sine, it is alternating in value and direction

30. The magnitude of the Coulomb force between multiple charges on one of the charge is

$$F_1 = F_{12} + F_{13} + \ldots + F_{1n}$$
$$\therefore F = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{r_{12}^2} + \frac{q_1q_3}{r_{13}^2} + \ldots + \frac{q_1q_n}{r_{1n}^2}\right]$$

Since four charges exert force on the charge placed at x = 0 cm, we get the resultant force as

$$F_0 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_0q_2}{r_{02}^2} + \frac{q_0q_4}{r_{04}^2} + \frac{q_0q_8}{r_{08}^2} + \frac{q_0q_{16}}{r_{016}^2}\right]$$
$$\therefore F_0 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q^2}{(2\times10^{-2})^2} + \frac{q^2}{(4\times10^{-2})^2} + \frac{q^2}{(8\times10^{-2})^2} + \frac{q^2}{(16\times10^{-2})^2}\right]$$
$$\therefore F_0 = 9\times10^9 \times (10\times10^{-6})^2\left[\frac{1}{(2\times10^{-2})^2} + \frac{1}{(4\times10^{-2})^2} + \frac{1}{(8\times10^{-2})^2} + \frac{1}{(16\times10^{-2})^2}\right]$$
$$\therefore F_0 = 9\times10^9 \times (10\times10^{-6})^2[2500 + 625 + 156.25 + 39.06]$$
$$\therefore F_0 = 3\times10^3 \text{ N}$$

Or

$$\vartheta = \frac{me^4}{(4\pi)^3\mathcal{E}_o^2}\left[\frac{1}{(x-1)^2} - \frac{1}{x^2}\right]$$
$$= \frac{me^4(2x-1)}{(4\pi)^3\mathcal{E}_o^2\left(\frac{h}{2\pi}\right)x^2(x-1)^2}$$

for large x,

$$\upsilon = \frac{me^4}{32\pi^3\mathcal{E}_o^2\left(\frac{h}{2\pi}\right)^3x^3}$$

orbital frequency $\upsilon = \frac{V}{2\pi r}$

where $V = \frac{nh}{2\pi mr}$

and $r = \frac{4\pi\varepsilon_o\left(\frac{h}{2\pi}\right)^2x^2}{me^2}$

This leads to -

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which is same as ϑ for large x