Meghalaya Board
Class XII
Physics
Sample Paper 2 – Solution

GROUP-A

1. (ii) The fundamental frequencies of all pipes, independently of whether they are open-open or open-closed, varies inversely with the length of the pipe. Hence halving the length of the pipe doubles the fundamental frequency.

2. (iii) Because of the momentum of the gas molecules, they collide with the walls of the containing vessel and momentum transfer takes place, resulting in a force on the walls. Pressure is force per unit area. The basic reason for the pressure is the momentum of the gas molecules.

3. (iii) Formation of trade winds, land and sea breezes are phenomena related to convection whereas phenomenon in which metallic handle becomes colder than the wooden door is an example of conduction of heat.

4. (i) When the cohesive forces and adhesive forces are equal, then the angle of contact between a solid and a liquid is 90°.

5. (i)Kepler's law of areas can be understood as a consequence of conservation of angular momentum. L is constant as no torque acts on the planet so the rate at which it traverses an area is constant.

6. (iv) International system of unit- SI is presently internationally accepted for measuring physical quantity.

7. (iv)A frame of reference is a set of coordinate axes that helps to determine the position of a body in space at any instant of time.

8. (iii) In angular projection, the body at the highest point has velocity = u cos θ in the horizontal direction which makes zero angle with the horizontal direction.

GROUP-B

9. 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.

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

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

12. 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.

13. 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.

14. It is an isosceles right angled prism(angle 90°,45°,45°) whose critical angle is less than 45°.When a ray of light strikes the glass air interface at an angle 45°, it is totally reflected. Total reflecting glass prism is based on total internal reflection.

15. An AC circuit containing only Capacitor or inductor will have zero power dissipation even though the current is flowing through it. Such current is called wattless current.

16. Due to change in magnetic flux the induced EMF will always be produced but current will be induced only if the circuit is closed.

GROUP-C

17. 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.

18. 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.

19. 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.

20. In Rutherford's experiment, a thin gold foil was bombarded with alpha particles. According to Thomson's "plum-pudding" model of the atom, alpha particles should have passed through the foil with little or no deflection.

21. 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.

22. 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

23. Refractive index of lens for violet rays is more than that for red rays, so power of a lens will decrease if violet light is replaced by red light.

24. 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) remain 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.

GROUP-D

25.

We know,

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

for same capacitance,

$$X_c \propto \frac{1}{v}$$

For capacitor A $X_c = X_{ac}$

frequency of A = 2v

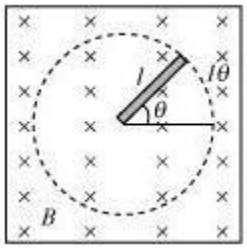
For capacitor B $X_c = X_{bc}$

frequency of B = v

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

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

26. 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

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

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

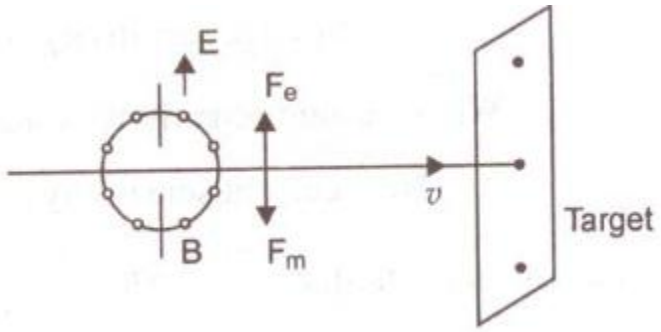
$$I = \frac{e}{R} = \frac{\frac{1}{2}Bl^2\omega}{R} = \frac{Bl^2\omega}{2R}$$

27. When a specimen of magnetic material is magnetised, a curve is drawn for magnetic field intensity (H) against intensity of magnetisation (I). The curve so formed is called Hysteresis Loop. This complete process is called Cycle of Magnetisation. It is called hysteresis because of lagging of I behind H during the cycle of magnetisation. The area of the loop gives the energy loss per unit volume of the specimen per cycle of magnetisation. The hysteresis loop of different materials is used to compare retentivity, coercivity and energy loss. Therefore, a suitable material is selected for making electromagnets, transformers, permanent magnets, generator etc.

Or

Given:
Length = 2l
Magnetic moment = M
Pole strength = m
If the magnetic needle is halved from the middle, then
Length = l
Magnetic moment becomes half i.e. = M/2
Pole strength remains same i.e. m.

28.



(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.,

$$eE = evB$$

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

$$\text{Given, } E = 50\text{kV/m} = 50\times10^{3}\text{ V/m}, B = 100\text{mT} = 100\times10^{-3}\text{T}$$

$$v = \frac{50\times10^{3}}{100\times10^{-3}} = 5\times10^{5}\text{ms}^{-1}$$

(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.

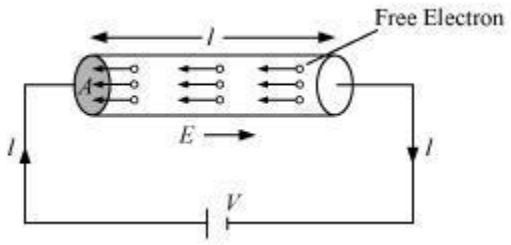
ii) If charged particle is moving perpendicular to $\vec{B}$, it experiences maximum force F= qvBsin90º= qvB.

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.

29. 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

$\therefore j \propto v_d$

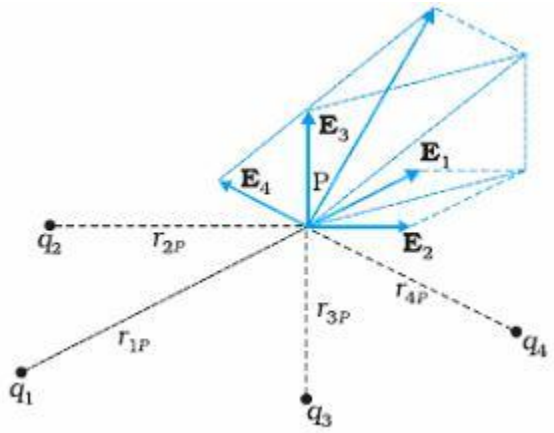
i.e., current density is directly proportional to the drift velocity

30. 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.

31. 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.

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



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,

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

32. 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.

33. 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.

GROUP-E

34.

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

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

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)

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

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

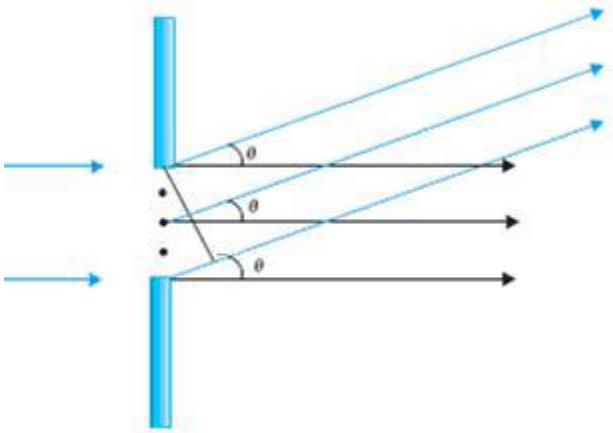
(c) It is not possible to measure simultaneously the position and momentum of a microscopic particle with absolute accuracy. There is a minimum for the product of the uncertainties of these two measurements. There is likewise a minimum for the product of the uncertainties of the energy and time.

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

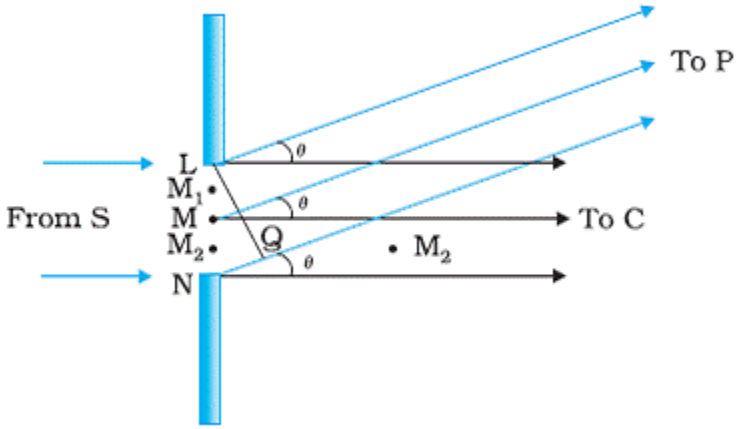
$$\Delta E \Delta t \geq \frac{h}{4\pi}$$

35. 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 $\theta = n\lambda/a$,

$n = \pm 1, \pm 2, \pm 3, ...$

Consider first the angle θ where the path difference aθ is λ. Then,

$$\theta = \lambda/a \text{.....(i)}$$

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!).

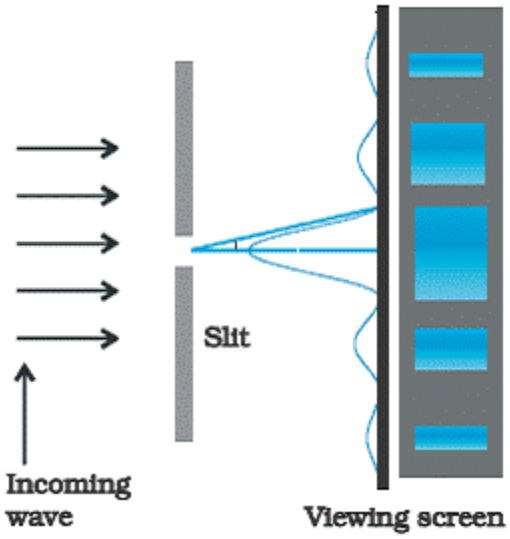
Angular size of the central maximum increases when the slit width a decreases.

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.

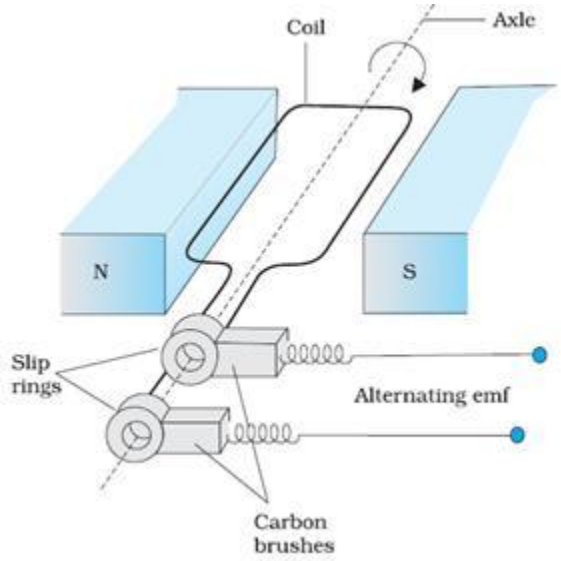


Intensity distribution and photograph of fringes due to diffraction at single slit.

Similarly we can show that there are maxima at (n + 1/2) θ/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.

36.



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.

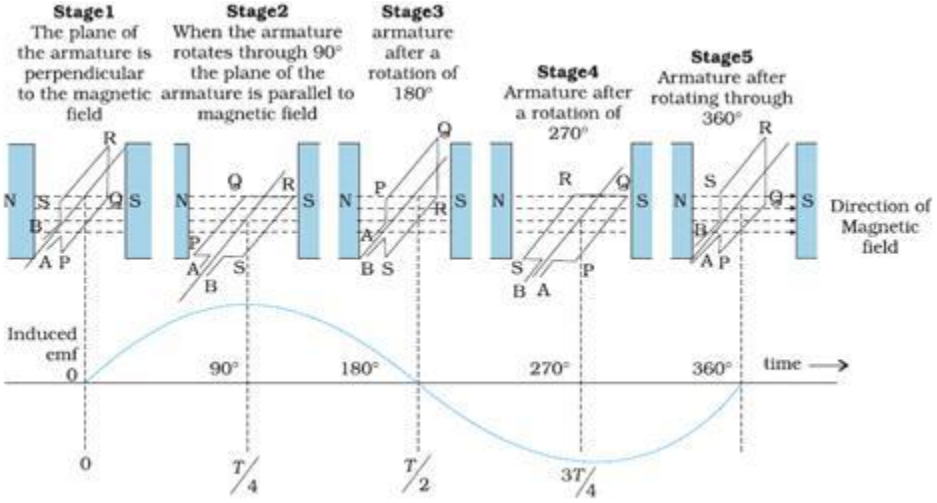
iii. The ends of the coil are connected to an external circuit by means of slip rings and brushes.

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