Solution

Class 12 - Physics

2020-21 paper 8

Section A

1. $E_k = \frac{1}{2}mv^2 = \frac{e\lambda}{4\pi\varepsilon_0}$ = 9 $\times$ 10^9 $\times$ 1.6 $\times$ 10^{-9} $\times$ 2.0 $\times$ 10^{-8}
   = 2.88 $\times$ 10^{-17} J
2. The shape of the trajectory of scattered α-particles depends on (i) impact parameter and (ii) nature of the potential field encountered by the α-particle.

   OR

   This suggests that scattering is predominantly due to a single collision, because the chance of a single collision increases linearly with the number of the target atoms, and hence linearly with the thickness of the foil.
3. Distance between central bright fringe and fourth dark fringe = $\frac{7}{2}\beta$, where $\boldsymbol{\beta}$ is fringe width.
4. As fringe width $\beta = \frac{D\lambda}{d}$, so as the screen is moved away from the slits (D increases), fringe width increases.

   OR

   The resolving power of the telescope is given by the expression = $\frac{D}{1.22\lambda}$
   When the aperture of the objective lens is doubled, the resolving power of telescope also gets doubled.
5. When an object is placed at the focus of concave lens, image is formed at infinity.
6. The minimum amount of radiant energy needed to pull an electron (without imparting it any kinetic energy) from a metallic surface is called work function of the metal. The relation between work function W_0 and threshold frequency ν_0 is $W_0 = h\nu_0$
7. A capacitor provides electrical energy stored in it. A cell provides electrical energy by converting chemical energy into electrical energy

   OR

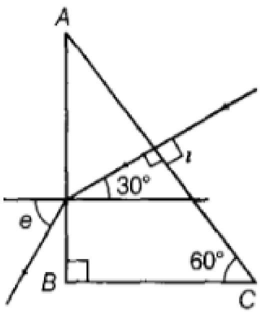
   JC^{-1} is the SI unit of electrostatic potential or electrostatic potential difference.
   It is a scalar quantity.
8. Using, E = Eg = $\frac{hc}{\lambda}$
   = $\frac{6.6\times10^{-34}\times3\times10^{8}}{589\times10^{-9}}J$
   = $\frac{6.6\times10^{-34}\times3\times10^{8}}{589\times10^{-9}\times1.6\times10^{-19}}eV$ = 2.1 eV
9. Torque, τ = mB sin θ
10. GaAs has a better solar conversion efficiency because of its suitable bandgap (E $\simeq$ 1.53eV) and high absorption coefficient. So it is a preferred material for solar cells.
11. **(b)** Assertion and reason both are correct statements but reason is not correct explanation for assertion.
    Explanation: Assertion and reason both are correct statements but reason is not correct explanation for assertion.
12. **(b)** Assertion and reason both are correct statements but reason is not correct explanation for assertion.
    Explanation: Both assertion and reason are true but reason is not the correct explanation of the assertion.
13. **(c)** Assertion is correct statement but reason is wrong statement.
    Explanation: Assertion is true but reason is false.
    $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$
    $\Rightarrow r \propto \frac{\sqrt{m}}{q}$
    $r_p = \frac{\sqrt{m_p}}{e}$
    $r_\alpha = \frac{\sqrt{4m_p}}{2e} = r_p$
14. **(a)** Both A and R are true and R is the correct explanation of A
    Explanation: Both A and R are true and R is the correct explanation of A

Section B

15. i. (a) 0.156 joule
    ii. (b) 4
    iii. (d) $4\mu C$
    iv. (b) Voltage
    v. (d) there can be no charge inside the region
16. i. (d) The position and velocity of the electrons in the orbit cannot be determined simultaneously
    ii. (c) A Nucleus
    iii. (c) both a and b
    iv. (d) A discrete spectrum
    v. (a) quantized

Section C

17. As $\frac{r}{r}=\frac{r}{r}$, So the given circuit is a balanced Wheatstone bridge and the resistance r in the vertical arm is ineffective. The circuit is then equivalent to two resistances of 2r and 2r connected in parallel.
    $\therefore$ Equivalent resistance, R = $\frac{2r\times 2r}{2r+2r}=r=10\Omega$
    Current supplied by the battery of emf 6 V,
    I = $\frac{\varepsilon}{R}=\frac{6}{10}$ = 0.6 A
18. While tracing the path of the ray, we should remember that the prism bends the incident rays towards its base. The ray diagram is shown in the figure.



Given: Refractive index of glass, $\mu_g=\sqrt{3}$ ....(i)
Since, i = 0, therefore at the interface AC, we have
$\frac{\sin i}{\sin r}=\frac{\mu_g}{\mu_a}$ (by using Snell's law)
But, $\sin i=\sin 0^{\circ}=0$
Thus, sin r = $\frac{\mu_a \sin i}{\mu_g}=0$
Hence, r = 0
This ray pass unrefracted at AC interface and reaches AB interface. Here, we can see angle of incidence becomes 30°
Thus, by applying Snell's law we get,
$\frac{\sin 30^{\circ}}{\sin e}=\frac{\mu_a}{\mu_g}=\frac{1}{\sqrt{3}}$ [by using equation (i)]
$\sin e=\sqrt{3}\times\sin 30^{\circ}=\frac{\sqrt{3}}{2}$
Thus, e = 60^0.

OR

The relationship between refractive index μ, prism angle A and angle of minimum deviation δ_m is given by
$\mu=\frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin(\frac{A}{2})}$
Given, $\delta_m=A$
Substituting the value of δ_m, we have
$\therefore \mu=\frac{\sin A}{\sin(A/2)}$
On solving, we have
$\mu=\frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}}=2\cos\frac{A}{2}$
For the given value of refractive index, $\mu=\sqrt{3}$, we have

$\cos\frac{A}{2}=\frac{\sqrt{3}}{2}$ or $\frac{A}{2}=30$

A = 60°

This is the required value of prism angle.

19. Electric flux: The total electric flux linked with a surface is equal to the total number of electric lines of force passing through the surface when the surface is held normal to the direction of the electric field. The SI unit of electric flux is Nm^2C^{-1}.

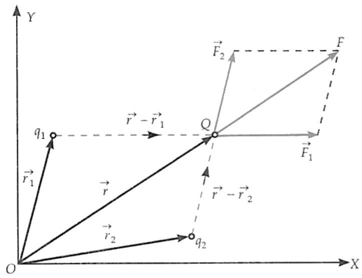
    According to Gauss theorem, if charge q is enclosed by closed surface, therefore total electric flux linked with the closed surface is given by,

    $\phi=\oint_S \mathbf{E}\cdot d\mathbf{S}=\frac{q}{\varepsilon_0}$

    Flux only depend on charge and permittivity, so flux will not change by reducing the radius.

    OR

    The forces exerted by q_1 and q_2 on Q are shown in Fig.

    According to Coulomb's law, the force exerted by q_1 on Q is

    $\overrightarrow{F_1}=\frac{1}{4\pi\varepsilon_0}\frac{Qq_1}{\left|\vec{r}-\overrightarrow{r_1}\right|^2}\frac{\vec{r}-\overrightarrow{r_1}}{\left|\vec{r}-\overrightarrow{r_1}\right|}$

    $=\frac{1}{4\pi\varepsilon_0}Qq_1\frac{\vec{r}-\vec{r}_1}{\left|\vec{r}-\vec{r}_1\right|^3}$

    Force exerted by q_2 on Q is

    $\vec{F}_2=\frac{1}{4\pi\varepsilon_0}Qq_2\frac{\vec{r}-\overrightarrow{r_2}}{\left|\vec{r}-\overrightarrow{r_2}\right|^3}$

    According to the principle of superposition, the total force exerted by q_1 and q_2 on Q is

    $\vec{F}=\overrightarrow{F_1}+\vec{F}_2$

    $=\frac{1}{4\pi\varepsilon_0}\left[Qq_1\frac{\vec{r}-\overrightarrow{r_1}}{\left|\vec{r}-\overrightarrow{r_1}\right|^3}+Qq_2\frac{\vec{r}-\overrightarrow{r_2}}{\left|\vec{r}-\overrightarrow{r_2}\right|^3}\right]$

    The charge Q will be in equilibrium if the force exerted by is equal and opposite to the combined force exerted by q_1 and q_2.

    $\therefore$ Force exerted by q_3 on Q = -$\vec{F}$

    $=-\frac{Q}{4\pi\varepsilon_0}\left[q_1\frac{\vec{r}-\vec{r}_1}{\left|\vec{r}-\vec{r}_1\right|^3}+q_2\frac{\vec{r}-\vec{r}_2}{\left|\vec{r}-\vec{r}_2\right|^3}\right]$

    $=\frac{Q}{4\pi\varepsilon_0}\left[q_1\frac{\vec{r}-\vec{r}}{\left|\vec{r}-\vec{r}_1\right|^3}+q_2\frac{\vec{r}_2-\vec{r}}{\left|\vec{r}-\vec{r}_2\right|^3}\right]$

    The above vector gives the direction of the force on Q due to q_3.

20. A = 20 cm $\times$ 30 cm = 6 $\times$ 10^{-2} m^2,

    B = 0.3 T

    Let θ be the angle made by the field B with the normal to the plane of the coil.

    i. Here θ = 90^0 - 90^0 = 0^0

       $\therefore\phi=BA\cos\theta=0.3\times6\times10^{-2}\times\cos0^\circ$

       = 1.8 $\times$ 10^{-2} Wb

    ii. Here θ = 90^0 - 30^0 = 60^0

       $\therefore\phi=0.3\times6\times10^{-2}\times\cos60^\circ$

       $=0.9\times10^{-2}$ Wb

iii. Here $\theta = 90^\circ$

$\therefore \phi = 0.3 \times 6 \times 10^{-2} \times \cos 90^\circ$

= zero

21. Given I = 10A

t = 0.5A

ϕ = 500 wb/turn

N = 200

total flux = 500 $\times$ 200

= 10^5wb

mutual inductance = ?

induced emf e = ?

Q = MI

$\mathbf{m} = \frac{\mathbf{Q}}{\mathbf{I}} = \frac{10^5}{\mathbf{10}}$

m = 10^4 H

$\mathbf{e} = \frac{\mathbf{mdI}}{\mathbf{dt}} = \frac{\mathbf{10^5 \times 10}}{\mathbf{0.5}}$

e = 2 $\times$ 10^6 V

22. It is found that the mass of a stable nucleus is always less than the sum of the masses of its constituent protons and neutrons in their free state.

The difference between the rest mass of a nucleus and the sum of the rest masses of its constituent nucleons is called its mass defect.

Consider the nucleus $^A_Z\mathrm{X}$. It has Z pro (A - Z) neutrons. Therefore, its mass defect will be

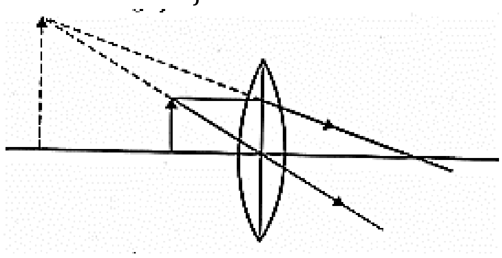
$\Delta m = Zm_p + (A - Z)m_n - m$

where mp, m_n and m are the rest masses of a proton, neutron and the nucleus $^A_Z\mathrm{X}$ respectively.

23. i. In case of magnifying lens, the lens is convergent and the image is erect, virtual and enlarged and at infinity and the object on the same side of the lens as shown in figure.

So, here f = +10 cm, v = -30 cm

Let 'x' be the object distance.



Using lens formula,

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

$\frac{1}{-30} - \frac{1}{(-x)} = \frac{1}{10}$

$\Rightarrow$ x = 7.5 cm

ii. $m = \frac{I}{O} = \frac{v}{u} = \frac{-30}{-8.5} = +4$

Thus, the image is erect and virtual and four times of the object.

24. Let the potential difference between the ends of the wings 'e' = B_V

Given Velocity, v = 900 km/hour = 250 m/s

Wing span length (l) = 20 m

Vertical component of Earth's magnetic field is given as

$B_V = B_H \tan \delta = 5 \times 10^{-4} \tan 30^o$

Potential difference, E = $B_V lv$

= $5 \times 10^{-4} \tan 30^o \times 20 \times 250$

= $\frac{5 \times 20 \times 250 \times 10^{-4}}{\sqrt{3}}$

= 1.44 volt

So, 1.44 V potential difference is developed across the ends of the wings of aeroplane.

OR

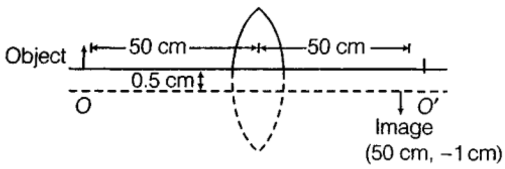
Magnetic poles: These are the regions of apparently concentrated magnetic strength in a magnet where the magnetic attraction is maximum. The poles of a magnet lie somewhat inside the magnet and not at its geometrical ends.

Magnetic axis: The line passing through the poles of a magnet is called the magnetic axis of the magnet.

Magnetic equator: The line passing through the centre of the magnet and at right angles to the magnetic axis is called the magnetic equator of the magnet.

Magnetic length: The distance between the two poles of a magnet is called the magnetic length of the magnet. It is slightly less than the geometrical length of the magnet.

25. Let OO' be the principal axis of the convex lens whose f = 25cm. Since it is cut into two pieces 0.5 cm above principle axis, the top part is placed at (0,0) and the object is at (50,0).
If there was no cut, then the object would have been at a height of 0.5 cm from the principal axis OO'.
By using Lens formula, we have
$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$
$\frac{1}{v}=\frac{1}{u}+\frac{1}{f}$
$=\frac{1}{-50}+\frac{1}{25}=\frac{1}{50}$
Thus, v = 50 cm
Magnification, $m=\frac{v}{u}=-\frac{50}{50}=-1$
Thus, the image would have been formed at 50 cm from the pole and 0.5 cm below the principal axis.
Hence, with respect to the X-axis passing through the edge of the cut lens, the coordinates of the image are (50 cm, -1 cm).



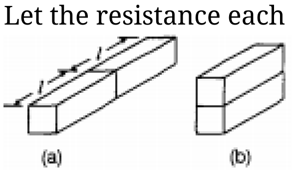
Section D

26. i. Any two points of difference

Interference	**Diffraction**
Fringes are equally spaced.	Fringes are not equally spaced.
Intensity is same for all maxima.	Intensity falls as we go to successive maxima away from the centre.
Superposition of two waves originating from two narrow slits.	Superposition of a continuous family of waves originating from each point on a single slit.

ii. Let D be the distance of the screen from the plane of the slits.
We have d= 1mm =10^{-3} m.
Fringe width, $\beta=\frac{\lambda D}{d}$
In the first case $\beta=\frac{\lambda D}{d}$ or $\beta d=\lambda D$ ...(i)
In the second case $\left(\beta-30\times10^{-6}\right)=\frac{\lambda(D-0.05)}{d}$
or $\left(\beta-30\times10^{-6}\right)d=\lambda(D-0.05)$ ...(ii)
Subtracting (ii) from (i) we get
$30\times10^{-6}\times d=\lambda\times0.05$
$\therefore\lambda=\frac{30\times10^{-6}\times10^{-3}}{5\times10^{-2}}\mathrm{m}$
$\therefore\lambda=6\times10^{-7}\mathrm{m}$ = 600 nm

27. Let the resistance each of the conductor is' R '.



Case I: According to Fig. (a), the resistances are connected in series combination, so equivalent resistance of slab is calculated by using the formula,

$R_{eq} = R_1 + R_2 + ... R_n$

Let the equivalent resistance in the Case I is R_1.

$R_1 = R + R = 2R$

Case II: According to Fig. (b), the resistances are connected in parallel combination, so equivalent resistance of slab is calculated by using the formula,

$\frac{1}{Req} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} .. + \frac{1}{R_n}$

Let the equivalent resistance in the Case II is R_2

$\frac{1}{R_2} = \frac{1}{R} + \frac{1}{R}$

$\Rightarrow \frac{1}{R_2} = \frac{2}{R}$

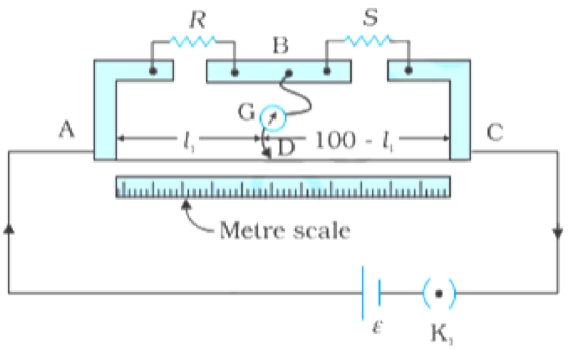
$\Rightarrow R_2 = \frac{R}{2}$

Ratio of the equivalent resistance in two combinations is calculated below.

$\therefore \quad \frac{R_1}{R_2} = \frac{2R}{(R/2)} = 4$

$\therefore R_1 = 4R_2$

OR



A meter bridge shown in the figure above is a practical form of Wheatstone bridge. Here R is the unknown resistance.

Connections between resistors are made of thick copper strips so that the resistance of the resistors remain unchanged.

Let initially with resistance R in left gap and S in right gap, the null point is obtained at a length l_1, then

$\frac{R}{S} = \frac{l_1}{100 - l_1}$ ....(i)

If R and S are interchanged then the null point will be obtained at l' such that

$\frac{S}{R} = \frac{l'}{100 - l'}$ ....(ii)

On comparing (i) and (ii), the shift in the position of the balance point is

$l' - l_1 = (100 - l_1) - l_1 = (100 - 2l_1)$ cm.

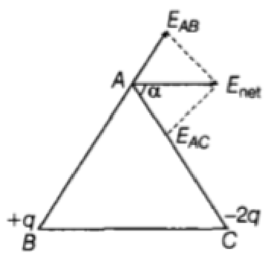
28. The resultant electric field at point A will be the resultant of electric fields produced by charge +q and -2q placed at B and C respectively.

$|\mathbf{E}_{\mathrm{AB}}| = \frac{1}{4\pi\varepsilon_0} \times \frac{q}{a^2} = E$

as charge on B is q and its distance from A is 'a'

$|\mathbf{E}_{\mathrm{AC}}| = \frac{1}{4\pi\varepsilon_0} \times \frac{2q}{a^2} = 2E$

as charge on C is -2q and its distance from A is 'a'



$E_{\text{net}} = \sqrt{E_{AB}^2 + E_{AC}^2 + 2E_{AB}E_{AC}\cos\theta}$

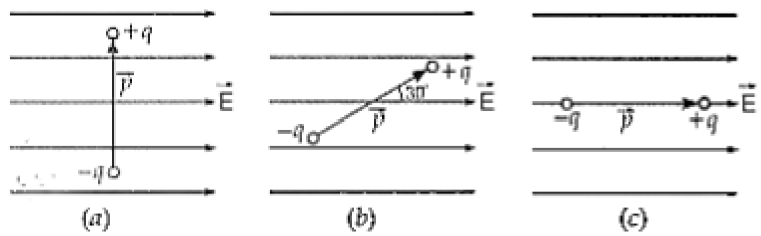
where θ is the angle between two electric field vectors.
Now, θ = $\angle ABC + \angle ACB$ (Exterior angle property)
= 60^o + 60^o (as the triangle is equilateral triangle)
= 120^o
Thus, E_{net} = $\sqrt{(2E)^2 + E^2 + 2 \times 2E \times E \times \left(-\frac{1}{2}\right)}$
$= \sqrt{4E^2 + E^2 - 2E^2} = E\sqrt{3}$ .... (i)
We know that, $E = \frac{q}{4\pi\varepsilon_0 a^2}$
So, $E_{net} = \frac{q\sqrt{3}}{4\pi\varepsilon_0 a^2}$

i. Direction of resultant electric field at vertex with side AC:
$\tan\alpha = \frac{E_{AB}\sin 120^\circ}{E_{AC}+E_{AB}\cos 120^\circ}$
$= \frac{E\times\sqrt{3}/2}{2E+E\times(-1/2)} = \frac{1}{\sqrt{3}}$
$\Rightarrow \quad \alpha = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$
$\Rightarrow \alpha = 30^\circ$
ii. Direction of resultant electric field at vertex with side AB:
$\tan\alpha = \frac{E_{AC}\sin 120^\circ}{E_{AB}+E_{AC}\cos 120^\circ}$
$= \frac{2E\times\sqrt{3}/2}{E+2E\times(-1/2)} = \infty$
$\Rightarrow \alpha = 90^\circ$

OR

When an electric dipole is placed in a uniform electric field, the torque acting on the dipole is given by
$\vec{\tau} = \vec{p} \times \vec{E}$
In the above expression, one pair of perpendicular vectors is $\vec{\tau}$ and $\vec{p}$ the other is $\vec{\tau}$ and $\vec{E}$.
The magnitude of the torque on the dipole is given by τ = p E sin θ

i. It follows that the torque will be maximum (= p E), when the dipole is placed perpendicular to the direction of the electric field as shown in Fig. (a).



ii. For the torque to be half the maximum value,
p E sin θ = p E/2
or sin θ = 1/2
or θ = 30°
Therefore, torque on the dipole will be half the maximum value, when it is placed making an angle of 30° to the direction of the electric field as shown in Fig. (b).
iii. It follows that the torque will be zero when the dipole is placed along the direction of the electric field as shown in Fig. (c).

29. i. Einstein's photoelectric equation is given by
KE_{max}= hν - ϕ_o.......(i)
But, KE_{max} = eV_0
Here, h = 6.63 $\times$ 10^{-34}J-s, V_0 = 1.3 V
$\lambda = 2271\overset{o}{A} = 2271 \times 10^{-10}$m
$\nu = \frac{c}{\lambda} = \frac{3\times10^8}{2271\times10^{-10}} = 1.32 \times 10^{15}$Hz
eV_0 = 1.6 $\times$ 10^{-19} $\times$1.3 = 2 $\times$ 10^{-19}J

Work function, ϕ_0 = hν - eV_0

= $(6.63 \times 10^{-34}) \times (1.32 \times 10^{15}) - 2 \times 10^{-19}$

$= \frac{6.76\times10^{-19}}{1.6\times10^{-19}}$eV = 4.22 eV

ii. $\lambda = 6328 \times 10^{-10}$m

KE_{max} = hν - ϕ......(i)

Here, h$\nu = \frac{hc}{\lambda} = 3.14 \times 10^{-19}\text{J} = 1.96\text{eV}$

But, $\phi = 4.22$ eV i.e. h$\nu < \phi$

Therefore, KE_{max} < 0 [From Eq(i)]

which is not possible. Hence, the photocell will not respond to the red light produced by the laser.

30. Mean radius of toroid,

r = $\frac{20+22}{2}$ = 21 cm = 0.21 m

Number of turns per unit length

= $\frac{4200}{2\pi r}$ = $\frac{4200}{2\pi\times0.21}$ = $\frac{1000}{\pi}\text{m}^{-1}$

i. Field inside the core of the toroid,

B = $\mu_0 nI$ = $4\pi \times 10^{-7}$

= $\frac{1000}{\pi} \times 10$

= 0.04 T

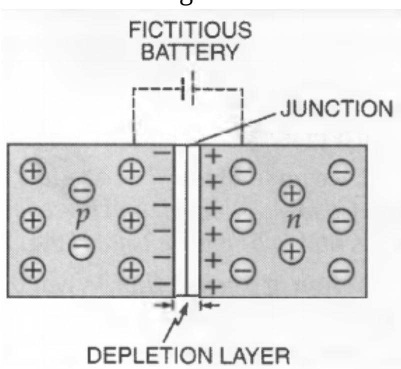
ii. Magnetic field outside the toroid is zero.

iii. Magnetic field in the empty space surrounded by the toroid is zero.

Section E

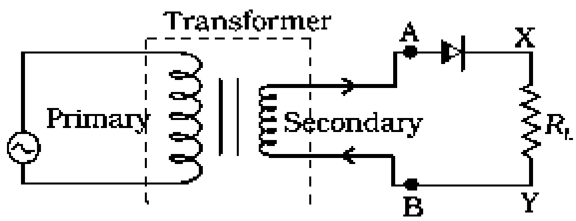
31. i. A p-n juntion is a basic semiconductor device.

In the p-section, holes are the majority carriers; while in n-section, the majority carriers are electrons. Due to the high concentration of different types of charge carriers in the two sections, holes from p-region diffuse into n-region and electrons from n-region diffuse into p-region. In both cases, when an electron meets a hole, the two cancel the effect of each other and as a result, a thin layer at the junction becomes devoid of charge carriers. This is called **depletion layer** as shown in Fig.



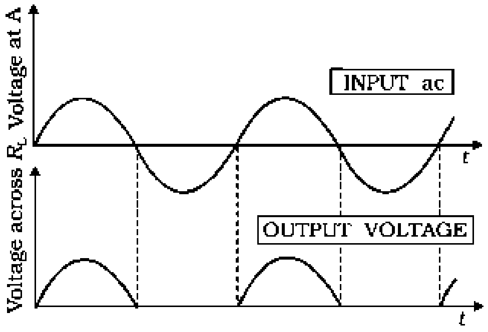
Due to the diffusion of holes and electrons, the two sections of the junction diode no longer remain neutral. The p-section of the junction diode becomes slightly negative, while the n-section is rendered positive. It appears as if some fictitious battery is connected across the junction with its negative pole connected to p-region and positive pole connected to n-region. The potential difference developed across the junction due to migration of majority charge carriers is called **potential barrier**. It opposes the further diffusion of charge carriers.

ii. The half-wave rectifier circuit is shown in the figure.



The secondary of a transformer supplies the desired ac voltage across terminals A and B. When the voltage at A is positive, the diode is forward biased and it conducts. When A is negative, the diode is reverse-biased and it does not conduct.

Therefore, in the positive half-cycle of a.c. there is a current through the load resistor R_L and we get an output voltage, as shown in Fig., whereas there is no current in the negative halfcycle. In the next positive half-cycle, again we get the output voltage. Thus, the output voltage, though still varying, is restricted to only one direction and is said to be rectified. Since the rectified output of this circuit is only for half of the input ac wave it is called as half-wave rectifier. The input-output waveforms are shown in the Fig. below.



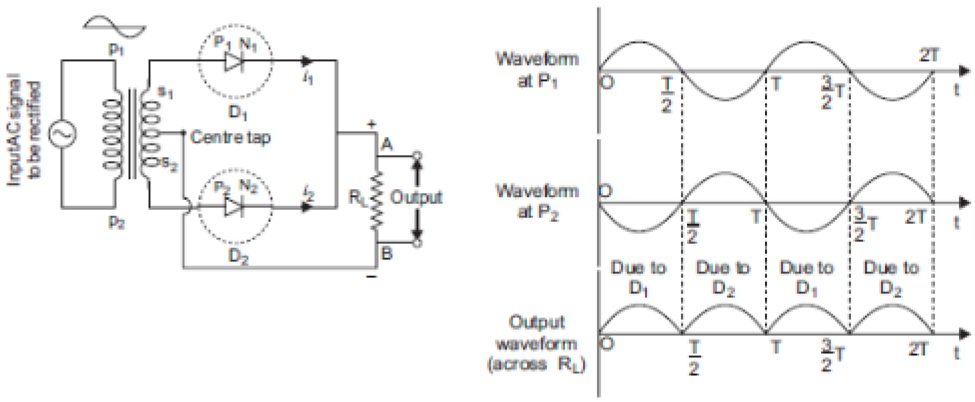
OR

Full wave Rectifier Working:- The AC input voltage across secondary s_1 and s_2 changes polarity after each half cycle. Suppose during the first half cycle of input AC signal, the terminal s_1 is positive relative to centre tap O and s_2 is negative relative to O. then diode D_1 is forward bias and diode D_2 is reverse biased. Therefore diode D_1 conduct while diode D_2 does not.

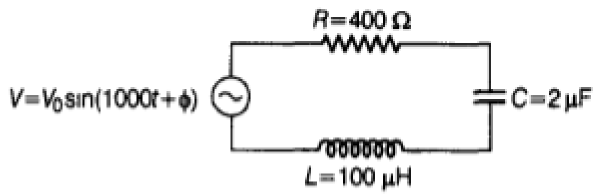
In the next half cycle,

the terminal s_1 is negative relative to centre tap O and s_2 is positive relative to O. then diode D_2 is forward bias and diode D_1 is reverse biased. Therefore diode D_2 conduct while diode D_1 does not.

The direction of current in resistance RL is the same from A to B for both half cycles. Hence for input AC signal, the output current is a continuous series of unidirectional pulses.



full-wave rectifier and output and input waveforms are shown in the figure.

32. i. 

$V=V_0\sin(1000t+\phi)\Rightarrow\omega=1000\text{Hz}$

$R=400\Omega, C=2\mu F, L=100\text{mH}$

Capacitive reactance, $X_c=\frac{1}{\omega C}$

$\Rightarrow\quad X_C=\frac{1}{1000\times2\times10^{-6}}$

$\Rightarrow\quad X_c=\frac{10^3}{2}\Rightarrow X_c=500\Omega$

Inductive reactance, $X_L=\omega L$

$\Rightarrow \quad X_L = 1000 \times 100 \times 10^{-3} \Rightarrow X_L = 100\Omega$

So, $X_c > X_L$

$\Rightarrow \tan\phi$ is negative.

Hence, the voltage lags behind the current by a phase angle ϕ .

Phase difference, tanϕ = $= \frac{X_L - X_C}{R}$

$\tan\phi = \frac{100-500}{400} \Rightarrow \tan\phi = \frac{-400}{400}, \tan\phi = -1$

$\Rightarrow \quad \tan\phi = -\tan\left(\frac{\pi}{4}\right) \Rightarrow \phi = -\frac{\pi}{4}$

This is the required value of the phase difference between the current and the voltage in the given series L-C-R circuit.

ii. Suppose, new capacitance of the circuit is C'. Thus, to have power factor unity

$\cos\phi' = 1 = \frac{R}{\sqrt{R^2 + (X_L - X_C')^2}}$

$\Rightarrow \quad R^2 = R^2 + \left(X_L - X_C'\right)^2$

$\Rightarrow \quad X_L = X_C' = \frac{1}{\omega C'}$ or $\quad \omega L = \frac{1}{\omega C'}$

$\Rightarrow \omega^2 = \frac{1}{LC'}$ or $(1000)^2 = \frac{1}{LC'}$ $(\because \omega = 1000)$

$\Rightarrow \quad C' = \frac{1}{L \times 10^6} = \frac{1}{100 \times 10^{-3} \times 10^6}$

$= \frac{10}{10^6} = \frac{1}{10^5} = 10^{-5}$

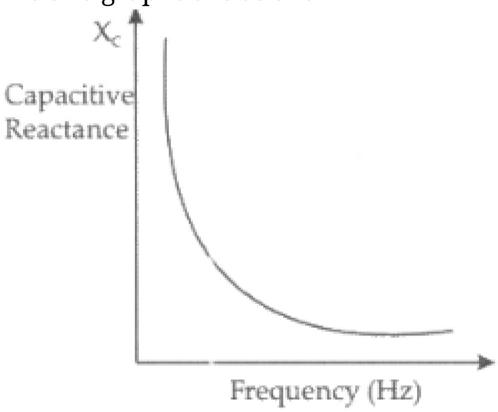
$\Rightarrow \quad C' = 10^{-5}\text{F} = 10 \times 10^{-6}\text{F} = 10\mu\text{F}$

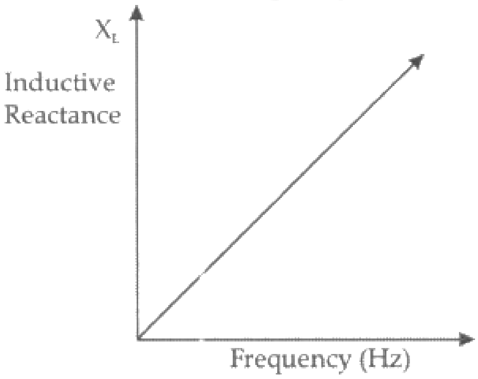
As, C' > C, hence, we have to add an additional capacitor of capacitance = $10\mu F - 2\mu F = 8\mu F$ in parallel with previous capacitor.

OR

a. Drawing the two graphs the graph shows the variation of capacitive resistance with frequency and inductive resistance with frequency.

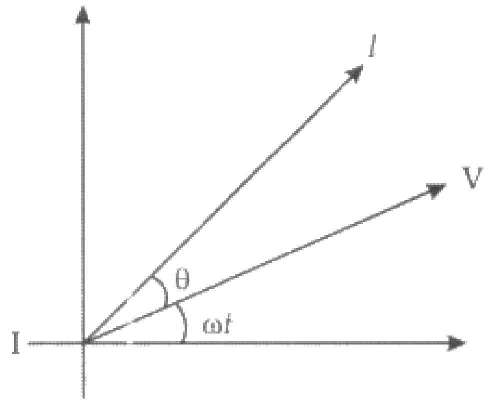
The two graphs are as shown





b. Drawing the phaser diagram

(the current leads the voltage by an angle θ where $0 < \theta < \frac{\pi}{2}$). The required phaser diagram is as shown.



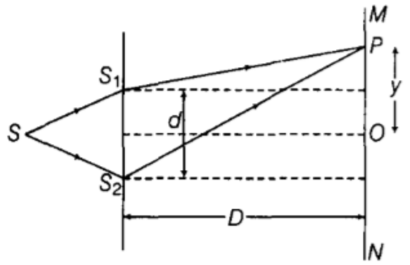
[Here, $\theta = \tan^{-1}\left[\frac{1}{\omega CR}\right]$

c.

i. In device X:
Current lags behind the voltage by $\frac{\pi}{2}$
$\therefore$ X is an inductor.
In device Y:
Current in phase with the applied voltage.
$\therefore$ Y is resistor.

ii. We are given that
0.25 = $\frac{220}{X_L}$
or X_L = $\frac{220}{0.25}\Omega$ = 880 Ω
Also 0.25 = $\frac{220}{X_R}$
$\therefore X_R = \frac{220}{0.25}\Omega$ = 880 Ω
For the series combination of X and Y,
Equivalent impedance = $\sqrt{X_L^2 + X_R^2} = (880\sqrt{2})\Omega$
$\therefore$ Current flowing $\frac{220}{880\sqrt{2}}$ A = 0.177 A

33. Suppose S_1 and S_2 are two fine slits, a small distance d apart. They are illuminated by a strong source S of monochromatic light of wavelength λ. MN is a screen at a distance D from the slits.



Consider a point P at a distance y from 0, the centre of the screen.
The path difference between two waves arriving at point Pis equal to S_2P - S_1P.

Now, $(S_2P)^2$ -$(S_1P)^2$

$$= \left[D^2 + \left(y + \frac{d}{2}\right)^2\right] - \left[D^2 + \left(y - \frac{d}{2}\right)^2\right] = 2yd$$

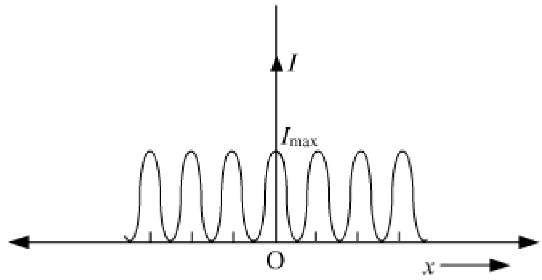
Thus, $S_2P - S_1P = \frac{2yd}{S_2P + S_1P}$
But $S_2P + S_1P \approx 2D$
$\therefore \quad S_2P - S_1P \approx \frac{dy}{D}$

a. For constructive interference (Bright fringes)
Path difference $= \frac{dy}{D} = n\lambda$, where,
n = 0, 1, 2, 3,......
$\therefore \quad y = \frac{nD\lambda}{d}$ [$\because$ n = 0, 1, 2, 3, ...]

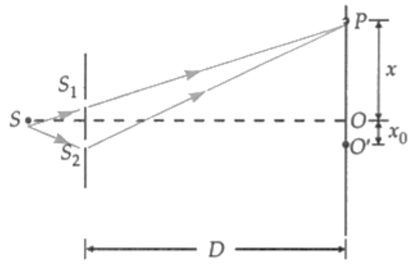
b. For destructive interference (Dark fringes)

Path difference $= \frac{dy}{D} = (2n-1)\frac{\lambda}{2}$

The distribution of intensity in Young's double slit experiment is as shown below



OR



Initial path difference between S_1 and S_2,

$\Delta_0 = SS_2 - SS_1 = \frac{\lambda}{4}$

Path difference between disturbances from S_1 and S_2 at point P,

$\Delta = \frac{xd}{D}$

Total path difference between the two disturbances at P,

$\Delta_T = \Delta_0 + \Delta = \frac{\lambda}{4} + \frac{xd}{D}$

$\therefore$ For constructive interference,

$\Delta_T = \left(\frac{\lambda}{4} + \frac{xd}{D}\right) = n\lambda$; n = 0, 1, 2, ...

or $\frac{x_n d}{D} = \left(n - \frac{1}{4}\right)\lambda$ ... (1)

For destructive interference,

$\Delta_T = \left(\frac{\lambda}{4} + \frac{xd}{D}\right) = (2n-1)\frac{\lambda}{2}$ ...(2)

or $\frac{x'_n d}{D} = \left(2n - 1 - \frac{1}{2}\right)\frac{\lambda}{2}$

or $\frac{x'_n d}{D} = \left(2n - \frac{3}{2}\right)\frac{\lambda}{2}$

Fringe width, $\beta = x_{n+1} - x_n = \frac{\lambda D}{d}$

The position x_0 of central fringe is obtained by putting n = 0 in equation (1). Therefore,

$\therefore x_0 = -\frac{\lambda D}{4d}$

The negative sign shows that the central fringe is obtained at a point O' below the (central) point O.