CBSE Class 12 Physics
Sample Paper 08 (2020-21)

Maximum Marks: 70
Time Allowed: 3 hours

General Instructions:

i. All questions are compulsory. There are 33 questions in all.
ii. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
iii. Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.
iv. There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.

Section A

1. Vehicles carrying inflammable materials usually have metallic ropes touching the ground during motion. Why?
2. State Bohr's quantisation condition for defining stationary orbits.

OR

The ground state energy of hydrogen atom is -13.6 eV. What are the kinetic and potential energies of the electron in this state?

3. Define a wavefront.
4. State two conditions to obtain sustained interference.

OR

State Huygens' principle. Depict the wavefront emanating from a point of source?

5. The image of an object formed by a lens on the screen is not in sharp focus. Suggest a method to get a clear focussing of the image on the screen without disturbing the position of the object, the lens or the screen.
6. Define the intensity of radiation on the basis of photon picture of light. Write its SI unit.
7. If 100 joule of work must be done to move electric charge equal to 4 C from a place, where potential is -10 volt to another place, where potential is V volt, find the value of V.

OR

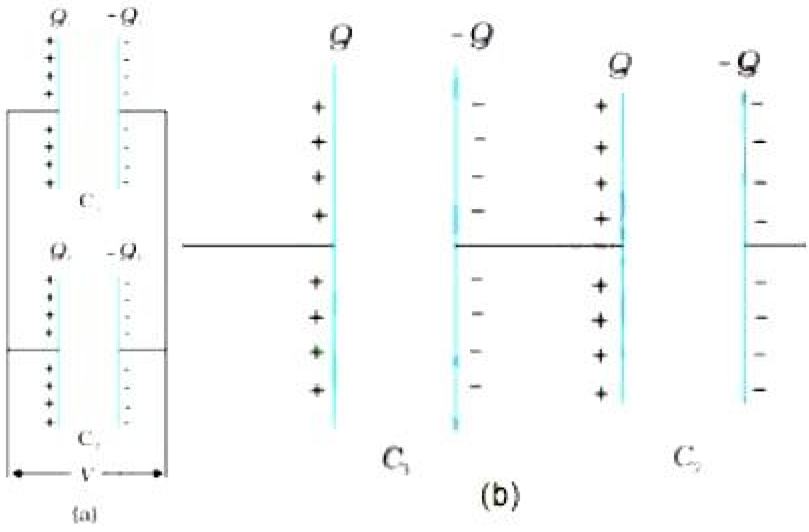
What is the electric potential due to an electric dipole at an equatorial point?
8. Name two factors on which electrical conductivity of a pure semiconductor at a given temperature depends.
9. If a compass is taken to magnetic north pole of earth, what will be the direction of the needle?
10. Write the names of majority and minority charge carriers in a n-type semi-conductor?
11. **Assertion (A):** If the current in a solenoid is reversed in direction while keeping the same magnitude, the magnetic field energy stored in the solenoid decreases.
Reason (R): Magnetic field energy density is proportional to square of magnetic field.
    a. Both A and R are true and R is the correct explanation of A
    b. Both A and R are true but R is NOT the correct explanation of A
    c. A is true but R is false
    d. A is false and R is also false
12. **Assertion (A):** Cobalt-60 is useful in cancer therapy.
Reason (R): Cobalt-60 is a source of γ-radiations capable of killing cancerous cells.
    a. Both A and R are true and R is the correct explanation of A
    b. Both A and R are true but R is NOT the correct explanation of A
    c. A is true but R is false
    d. A is false and R is also false
13. **Assertion:** A circular loop carrying current lies in X, Y - plane with its centre at origin having a magnetic flux in negative z-axis.
Reason: Magnetic flux direction is independent of the direction of current in the conductor.
    a. Both A and R are true and R is the correct explanation of A
    b. Both A and R are true but R is NOT the correct explanation of A

c. A is true but R is false
d. A is false and R is also false

14. **Assertion:** At any instant, if the current through an inductor is zero, then the induced emf may not be zero.
Reason: An inductor tends to keep the flux constant.
a. Both A and R are true and R is the correct explanation of A
b. Both A and R are true but R is NOT the correct explanation of A
c. A is true but R is false
d. A is false and R is also false

Section B

15. **Read the source given below and answer any four out of the following questions:**
If two or more capacitors are connected in series, the overall effect is that of a single (equivalent) capacitor having the sum total of the plate spacing of the individual capacitors. If two or more capacitors are connected in parallel, the overall effect is that of a single equivalent capacitor having the sum total of the plate areas of the individual capacitors. (figure (a) shows parallel combination and (b) shows series combination)



(b)

i. Capacity can be increased by connecting capacitors in:
a. parallel
b. series
c. both a and b
d. none of these

ii. Three capacitors having a capacitance equal to 2F, 4F and 6F are connected in parallel. Calculate the effective parallel capacitance:
a. 10 F

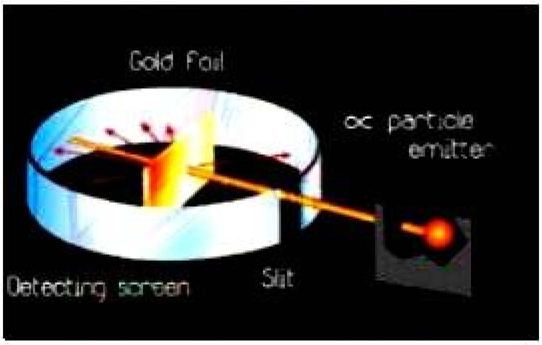
b. 11 F
c. 12 F
d. 13 F

iii. When capacitors are connected in the series ________ remains the same.
a. voltage
b. capacitance
c. charge
d. resistance

iv. The plates of a parallel plate capacitor are 10 cm apart and have an area equal to $2m^2$. If the charge on each plate is $8.85 \times 10^{-10} C$, the electric field at a point:
a. between the plates will be zero
b. outside the plates will be zero
c. between the plates will change from point to point
d. between the plates will be $25 NC^{-1}$

v. Four 10 F capacitors are connected in series, calculate the equivalent capacitance.
a. 1.5 F
b. 2.5 F
c. 3.5 F
d. 4.5 F

16. **Read the paragraph given below and answer any four out of the following questions:**
Rutherford performed one of the revealing experiments in atomic physics that is now known as the gold foil experiment. Some radioactive heavy elements emit alpha particles (helium nuclei), and a beam of these particles was directed at thin gold foil.



i. Why is the classical (Rutherford) model for an atom-of electron orbiting around the nucleus—not able to explain the atomic structure?
a. As the revolving electron loses energy continuously
b. As electron jumps to the second orbit

c. As the revolving electron gains energy continuously
d. None of these

ii. An alpha particle contains:
a. 4 positive charge and 2 mass unit
b. 2 positive charge and 4 mass unit
c. 2 positive charge and 2 mass unit
d. 4 positive charge and 4 mass unit

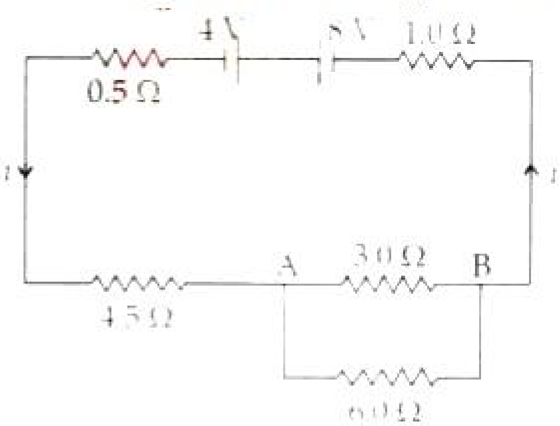
iii. Rutherford's experiment on the scattering of α-particles showed for the first time that the atom has:-
i. electron
ii. proton
iii. neutron
iv. nucleus

iv. According to Rutherford's atomic model, the electrons inside the atom are
a. stationary
b. not stationary
c. centralized
d. none of the above

v. Rutherford's α-particle experiment showed that the atoms have
a. proton
b. neutron
c. nucleus
d. electron

Section C

17. In the circuit shown in the figure, find the current through each resistor.

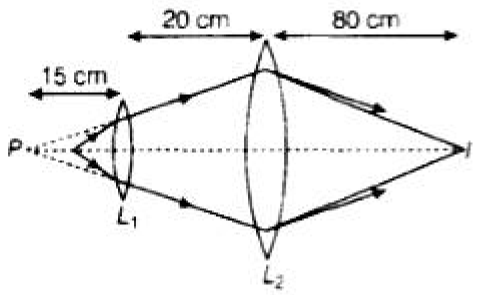


18. A diverging lens of focal length F is cut into two identical parts, each forming a Plano

concave lens. What is the focal length of each part?

OR

In the following diagram, an object 'O' is placed 15 cm in front of a convex lens L_1 of focal length 20 cm and the final image is formed at I at a distance of 80 cm from the second lens L_2. Find the focal length of the lens L_2.



19. Derive an expression for the torque experienced by an electric dipole placed in a uniform electric field.

OR

An electric dipole free to move is placed in a uniform electric field. Explain with a diagram, its motion, when it is placed

i. parallel to the field
ii. perpendicular to the field.

20. Can one have inductance without a resistance? How about a resistance without an inductance?
21. An armature coil consists of 20 turns of wire, each of area A = 0.09 m^2 and total resistance 15Ω. It rotates in a magnetic field of 0.5 T at a constant frequency of $\frac{150}{\pi}$. Calculate the value of
    i. Maximum
    ii. average induced e.m.f. produced in the coil.
22. You are given two nuclides $_3X^7$ and $_3Y^4$.
    i. Are they the isotopes of the same element? Why?
    ii. Which one of the two is likely to be more stable? Give reasons.

23. i. What is the relation between critical angle and refractive index of a material?
    ii. Does critical angle depend on the colour of light? Explain.

24. Suppose we want to verify the analogy between electrostatic and magnetostatic by an explicit experiment. Consider the motion of
    i. electric dipole $\vec{p}$ in an electrostatic field $\vec{E}$ and
    ii. magnetic dipole $\vec{m}$ in a magnetic field $\vec{B}$.

    Write down a set of conditions on $\vec{E}, \vec{B}, \vec{p}, \vec{m}$ so that the two motions are verified to be identical.

OR

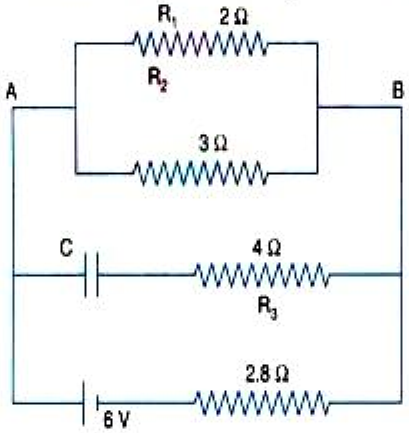
A magnetic dipole is under the influence of two magnetic fields. The angle between the field directions is 60° and one of the fields has a magnitude of 1.2×10^{-2} tesla. If the dipole comes to stable equilibrium at an angle of 15° with this field, what is the magnitude of the other field?

25. A convex lens is used to obtain a magnified image of an object on a screen 10 cm from the lens. If the magnification is 19, find the focal length of the lens.

Section D

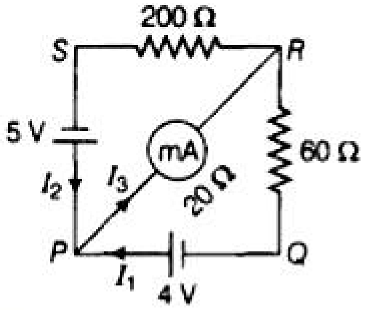
26. A beam of light consisting of two wavelengths, 650 nm and 520 nm, are used to obtain interference fringes in a Young's double slit experiment.
    a. Find the distance of the third bright fringe on the screen from the central maximum for wavelength 650 nm.
    b. What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide?

27. Calculate the steady current through the 2Ω resistor in the circuit shown in the figure.



OR

The network PQRS, shown in the circuit diagram, has the batteries of 4 V and 5 V and negligible internal resistance. A milliammeter of 20Ω resistance is connected between P and R. Calculate the reading in the milliammeter.



28. Find the expression for electric field intensity in an axial position due to electric dipole.

OR

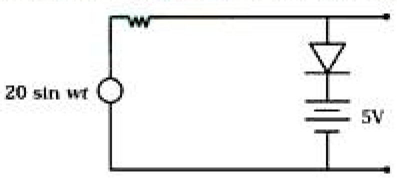
i. Two insulated charged copper spheres A and B have their centres separated by a distance of 50 cm. What is the mutual force of electrostatic repulsion if the charge on each is $6.5 \times 10^{-7}C$? The radii of A and B are negligible compared to the distance of separation.
ii. What is the force of repulsion if each sphere is charged double the above amount, and the distance between them is halved?

29. Light of wavelength $2000\overset{\circ}{A}$ falls on an aluminium surface (work function of aluminium 4.2 eV). Calculate:
   a. the kinetic energy of the fastest and slowest emitted photoelectrons
   b. stopping potential
   c. cut-off wavelength for aluminium.

30. A long solenoid of length L having N turns carries a current I. Deduce the expression for the magnetic field in the interior of the solenoid.

Section E

31. Assuming the ideal diode, draw the output waveform for the circuit given in the given Figure. Explain the waveform.



OR

Name the important processes that occurs during the formation of a p-n junction. Explain briefly, with the help of a suitable diagram, how a p-n junction is formed. Define the term 'barrier potential'?

32. A series LCR circuit is connected to an a.c. source of 220V, 50Hz. If the readings of voltmeters across resistor, capacitor and inductor are 65 V, 415 V and 204 V and R = 100Ω. Calculate (i) current in the circuit (ii) value of L, (iii) value of C and (iv) capacitance required to produce resonance with the given inductor L.

OR

a. Derive an expression for the impedance of a series L-C-R circuit connected to an AC supply of variable frequency.
b. Explain briefly how the phenomenon of resonance in the circuit can be used in the tuning mechanism of a radio or a TV set?

33. i. What is the effect on the interference fringes to a Young's double slit experiment when
    a. the separation between the two slits is decreased?
    b. the width of the source slit is increased?
    c. the monochromatic source is replaced by a source of white light? Justify your answer in each case.
  ii. The intensity at the central maxima in Young's double slit experimental set up is I_0. Show that the intensity at a point is $\frac{I_0}{4}$, where the path difference is $\frac{\lambda}{3}$.

OR

i. Describe briefly how a diffraction pattern is obtained on a screen due to a single narrow slit illuminated by a monochromatic source of light. Hence, obtain the conditions for the angular width of secondary maxima and secondary minima.
ii. Two wavelengths of sodium light of 590 nm and 596 nm are used in turn to study the diffraction taking place at a single slit of aperture $2 \times 10^{-6} m$. The distance between the slit and the screen is 1.5m. Calculate the separation between the positions of first maxima of the diffraction pattern obtained in the two cases.

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Solution

Section A

1. Due to air friction, the body of the vehicle also gets charged in addition to the charge developed on tyres. In case, the charge accumulation becomes large, it may prove hazardous to the vehicle carrying inflammable materials. So that it does not happen, metallic ropes from the vehicle are made to touch the ground. Due to this, the charge on the vehicle leaks to the earth.
2. According to Bohr, an electron can revolve only in certain discrete, non-radiating orbits for which the total angular momentum of the revolving electron is an integral multiple of $\frac{h}{2\pi}$ i.e,
   $mvr = nh/2\pi$,
   where n = 1, 2, 3 ,4.........., h is Planck's constant.

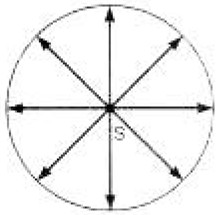
   OR

   The ground state energy of hydrogen atom is -13.6 eV.
   Given, total ground state energy = -13.6 eV
   We know that,
   Kinetic energy = - Total Energy = - (-13.6 eV) = 13.6 eV
   and
   Potential energy = 2 (TE) = 2 × (-13.6) = - 27.2 eV
3. When light is emitted from a source, then the particles present around the source in all directions begins to vibrate. The locus of all such particles which are vibrating in the same phase is termed as wavefront.
4. i. The two light waves should be of same wavelength.
   ii. The two light waves should either be in phase or should have a constant phase difference.

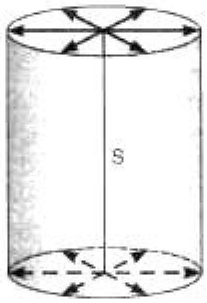
   OR

   Huygens' principle is a geometrical construction, which is used to determine the new position of a wavefront at a later time from its given position at any instant. In other words, the principle gives a method to know as to how light spreads out in the medium. Wavefront emanating from point source is

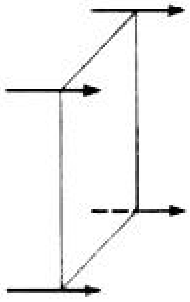
i. **Spherical wavefront**



ii. **Cylindrical wavefront**



iii. **Plane wavefront**



5. The focal length of a lens depends upon the refractive index of the material of the lens, which in turn depends upon the wavelength of light. Therefore, clear image of the object can be obtained by using light of suitable wavelength.
6. The amount of light energy/photon energy, incident per metre square per second is called the intensity of radiation.

   SI Unit: W/m^2
7. Here, q_0 = 4C; V_A = -10 volt; V_B = V volt; W_{AB} = 100 joule

   Now, $V_B - V_A = \frac{W_{AB}}{q_0}$

   $V - (-10) = \frac{100}{4} = 25$

   or V = 15 volt

OR

The distance of the equatorial point from both the charges of an electric dipole is same.

Electrostatic potential, V = $\frac{Q}{4\pi\epsilon_0 r}$.

Now for the dipole V = $V_1 + V_2 = \frac{+Q}{4\pi\epsilon_0 r} + \frac{-Q}{4\pi\epsilon_0 r}$ = Zero, as potential on equatorial point due to charges of electric dipole, is equal in magnitude but opposite in nature and hence, their resultant is zero.

8. Electrical conductivity of a pure semiconductor depends upon:

   (i) The width of the forbidden energy gap

   (ii) Intrinsic charge carrier concentration
9. Earth's magnetic field at the poles is exactly vertical with S pole of compass down side. A compass needle moves freely in a horizontal plane. Therefore, the compass needle will not necessarily rest along N-S direction, at the pole of earth. It may rest in any arbitrary direction in horizontal plane.
10. **Majority carriers.** Electrons

    Minority carriers. Holes
11. (d) A is false and R is also false

    Explanation: A is false and R is also false
12. (a) Both A and R are true and R is the correct explanation of A

    Explanation: Cobalt 60 is the radioactive isotope of cobalt. γ−radiation emitted by it is used in radiation therapy is cancer as it destroys cancerous cells. So, assertion and reason are true and reason explains assertion.
13. (c) A is true but R is false

    Explanation: The direction of the magnetic field due to the current-carrying conductor can be found by applying the right-hand thumb rule or right-hand first rule. When an electric current is passed through a circular conductor, the magnetic field lines near the centre of the conductor are almost straight lines. Magnetic flux direction is determined only by the direction of the current.
14. (b) Both A and R are true but R is NOT the correct explanation of A

    Explanation: Both A and R are true but R is NOT the correct explanation of A

Section B

15. i. (a) parallel

    ii. (c) 12 F

    iii. (b) charge

    iv. (b) outside the plates will be zero

v. (b) 2.5F

16. i. (a) As the revolving electron loses energy continuously

ii. (b) 2 positive charge and 4 mass unit

iii. (d) nucleus

iv. (b) non-centralized

v. (c) nucleus

Section C

17. Total emf in the circuit = 8 V - 4 V = 4V

The total resistance of the circuit = 1 + 0.5 + 4.5 + (3×6)/(3+6) = 8 Ω

Hence current flowing in the circuit $i = \frac{V}{R} = \frac{4}{8}$ A = 0.5 A

Current flowing through the resistors :

Current through 0.5 Ω, 1.0 Ω and 4.5 Ω is 0.5

Potential difference across the parallel combination of 3 and 6 ohm resistor is V = R × I $= \frac{3\times6}{3+6} \times 0.5 = 1$v

Current through 3.0 Ω is $\frac{1}{3} A$

Current through 6.0 Ω is $\frac{1}{6} A$

18. For single diverging lens,

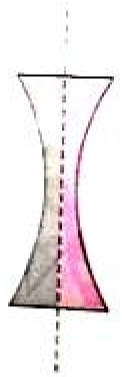
$\frac{1}{F} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Let $R_1 = -R$, $R_2 = R$

$\therefore \frac{1}{F} = (\mu - 1)\left(\frac{1}{-R} - \frac{1}{R}\right) = \frac{-2(\mu-1)}{R}$

For each half (which is plano concave) as shown in figure:

$R_1 = -R$ and $R_2 = \infty$



$\therefore \frac{1}{F_1} = \frac{1}{F_2} = (\mu - 1)\left(\frac{1}{-R} - \frac{1}{\infty}\right) = \frac{-(\mu-1)}{R} = \frac{1}{2F}$

$\therefore F_1 = F_2 = 2F$

OR

From the given figure, we have the following information:

The virtual image formed by lens L_1 is at P.

As per the parameters given in the question, we have

u = -15 cm, f_{L1} = 20 cm

So, the image distance will be

$\frac{1}{v} - \frac{1}{(-15)} = \frac{1}{20}$ (By using lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$)

Thus, v = - 60 cm

Now, this image is acting as an object for the lens L_2.

Now again by using Lens formula, we have

$\frac{1}{v_{L_2}} - \frac{1}{u_{L_2}} = \frac{1}{f_{L_2}}$

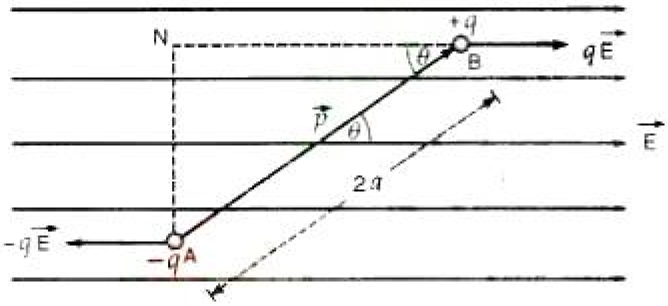
Here, u_{L_2} = v + (-20) = -60 - 20 = - 80 cm, v_{L_2} = 80 cm

Thus, $\frac{1}{80} - \frac{1}{(-80)} = \frac{1}{f_{L_2}}$

f_{L2} = 40 cm

So, the focal length of the lens L_2 = 40 cm.

19. Consider an electric dipole consisting of charges -q and +q and of length 2a placed in an uniform electric field $\vec{E}$ making an angle θ with the direction of the field as shown in figure.



The force on charge +q,

$\overrightarrow{F_A} = q\vec{E}$ along the direction of $\vec{E}$

The force on charge -q,

$\overrightarrow{F_B} = q\vec{E}$ opposite to the direction of $\vec{E}$

As these two forces are equal, unlike and parallel, so they form a couple.

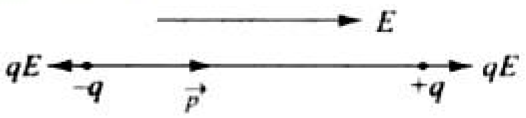
The magnitude of the torque is given by

τ = qE (AN)

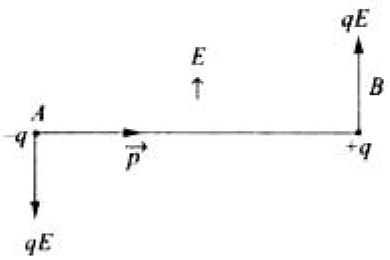
$\Rightarrow \tau = qE \times 2a\sin\theta$
$\Rightarrow \tau = (q \times 2a)E\sin\theta$
$\Rightarrow \tau = pE\sin\theta \Rightarrow \tau = \vec{p} \times \vec{E}$

OR

i. When placed parallel to the field, both net force and torque are zero. Hence there is no motion.



ii. When placed perpendicular to the field, net force is zero but a torque acts on the dipole.



τ = pE sin 90°

τ_{max} = pE

The dipole rotates about an axis perpendicular to the electric field through the midpoint of the dipole.

20. No, we can not have an inductance without resistance. It is because the wire use for making an inductance must possess some resistance.
However, we can have a resistance without an inductance. It can be done by doubling up the wire while making a resistance.

21. Here, A = 0.09 m^2; n = 20; B = 0.5T;
$\nu = \frac{150}{\pi}$ Hz
$\therefore \omega = 2\pi\nu = 2\pi \times \frac{150}{\pi} = 300$ rad s^{-1}
i. The maximum induced e.m.f. produced in the coil,
$\varepsilon_o = nBA\omega = 20 \times 0.5 \times 0.09 \times 300 = 270$ V
ii. The average induced e.m.f produced in the coil over one complete cycle is zero.

22. i. Yes, $_3X^7$ and $_3Y^4$ are isotopes of the same elements. It is because, an element is characterised by its atomic number. Since both X and Y have atomic number 3, they

represent the same element i.e. Li.

ii. $_3X^7$ (or $_3Li^7$) is more stable than $_3Y^4$ (or $_3Li^4$). It is because, the greater number of neutrons in $_3Li^7$ results in greater attractive force between the nucleons so as to win over the Coulomb's repulsive force between the protons.

23. i. Relation between refractive index of a material and critical angle is given by:
$\mu = \frac{1}{sin\ i_c}$
where, i_c = critical angle and μ = refractive index of denser medium w.r.t. rarer medium

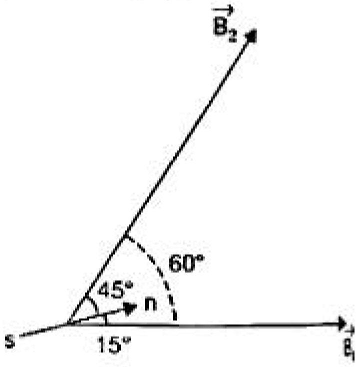
ii. Yes, colour depends on the wavelength of light and refractive index depends on wavelength of light. So for lights of different colours, the refractive index changes. This implies that critical angle also changes. Smaller the wavelength, higher the refractive index and lower the critical angle and vice -versa.
For example, $\lambda_{\text{red}} > \lambda_{\text{violet}}$, hence, $\mu_{\text{red}} > \mu_{\text{violet}}$

24. Let θ is the angle between $\vec{m}$ and $\vec{B}$.
$\therefore$ Torque on magnetic dipole in a magnetic field B is
$\tau = \vec{m}\vec{B}\sin\theta$ .....(i)
Similarly θ is the angle between electric dipole moment $\vec{p}$ and electric field $\vec{E}$, then torque on electric dipole in $\vec{E}$ is
$\tau' = \vec{p}\vec{E}\sin\theta$ .....(ii)
For if motion in (i) and (ii) of electric and magnetic dipole are identical, then $\tau' = \tau$
$\vec{p}\vec{E}\sin\theta = \vec{m}\vec{B}\sin\theta$
Or $\vec{p}\vec{E} = \vec{m}\vec{B}$ .....(iii)
We know that $\vec{E} = \vec{c}\vec{B}$ (relation between E and B) .....(iv)
where c is velocity of light.
Put the value of $\vec{E}$ from (iv) in (iii),
$\vec{p}cB = \vec{m}\vec{B}$
$\vec{p} = \frac{\vec{m}}{c}$
It is the required relation.

OR

Here $\theta = 60^o, B_1 = 1.2 \times 10^{-2}\ tesla$

$\theta_1 = 15^o, \theta_2 = 60^0 - 15^o$ = 45°



In equilibrium, torques due to two fields must balance

$\tau_1 = \tau_2$

$MB_1 \sin\theta_1 = MB_2 \sin\theta_2$

$B_2 = \frac{B_1 \sin\theta_1}{\sin\theta_2} = \frac{1.2\times10^{-2}\times\sin 15^o}{sin 45^o}$

$B_2 = \frac{1.2\times10^{-2}\times0.2588}{0.7071}$

$= 4.4 \times 10^{-3}\, tesla$

25. As the magnification of the lens is positive, so the real and inverted image will be formed by the lens. This formed image will be towards the other side of the lens and inverted in nature.

Given, v = +10 cm and u = -ve (for real image), m = -19, f = ?

$\therefore \quad m = \frac{I}{o} = \frac{v}{u} \Rightarrow -19 = \frac{v}{u} \Rightarrow v = -19u$

$\Rightarrow \quad u = -\frac{v}{19}$

Using lens formula,

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{f} = \frac{1}{v} - \frac{1}{-\left(\frac{v}{19}\right)}$

$\frac{1}{f} = \frac{1}{v} + \frac{19}{v} \Rightarrow \frac{1}{f} = \frac{20}{v}$

$\because$ v = 10 cm

$\therefore \quad f = \frac{1}{2}\text{cm} \Rightarrow f = 0.5\text{cm}$

So focal length of the convex lens is 0.5 cm.

Section D

26. Here, $\lambda_1 = 650\ nm = 650 \times 10^{-9} m$

$\lambda_2 = 520\ nm = 520 \times 10^{-9} m$

Suppose, d = distance between two slits

D = Distance of screen from the slits

a. For third bright fringe, n = 3

$x=n\,\lambda_1\cdot\frac{D}{d}$
$=3\times 650\times\frac{D}{d}=1950\frac{D}{d}$

b. Let nth bright fringe due to wavelength 650 nm coincide with (n -1)th due to wavelength 520 nm.

Therefore, $n\,\lambda_2=(n-1)\,\lambda_1$

or, $n\times 520=(n-1)\times 650\Rightarrow n=5$

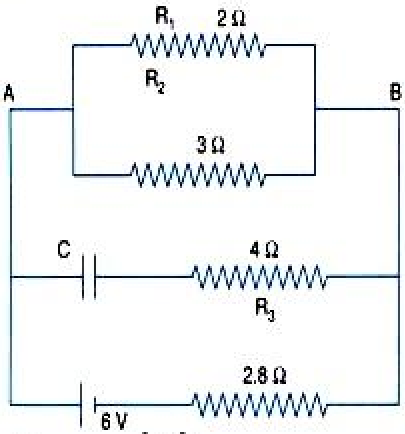
Hence, the least distance from the central maximum can be obtained by the relation:

$x=n\lambda_2\frac{D}{d}=5\times 520\frac{D}{d}=2600\frac{D}{d}\,nm$

Note: The value of d and D are not given in the question.

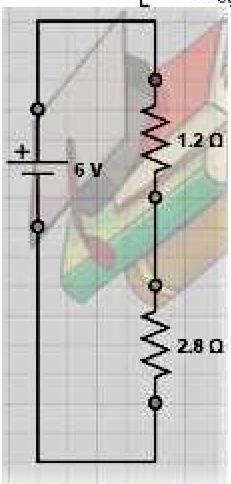
27. In DC circuit, initially capacitor is in steady state i.e. it offers infinite resistance. Therefore, no current flows through capacitor and 4Ω resistance, so resistance will produce no effect.

∴ In circuit AB, the effective resistance between $2\Omega\ and\ 3\Omega$ which are connected in parallel combination is given by



$R_{AB}=\frac{2\times 3}{2+3}$

$=1.2\Omega\left[\because\frac{1}{R_{eq}}=\frac{1}{R_1}+\frac{1}{R_2}\Rightarrow R=\frac{R_1R_2}{R_1+R_2}\right]$



Total resistance of the circuit = 1.2+ 2.8 = 4Ω [∵ these two are connected in series combination]

Given ,

Voltage = 6 V, total resistance(R) $= 4\Omega$

Net current drawn from the cell,

$I = \frac{V}{R(\text{ total resistance })} = \frac{6}{4} = \frac{3}{2} = 1.5\text{A}$

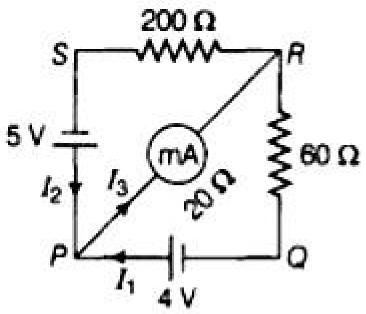
$\therefore$ Potential difference between A and B

$V_{AB} = IR_{AB} = 1.5 \times 1.2 \Rightarrow V_{AB} = 1.80\text{V}$

Current through 2Ω resistance,$I' = \frac{V_{AB}}{2}\Omega = \frac{1.8}{2} = 0.9\text{A}$

OR

The given diagram is shown below



Applying Kirchhoff's second law i.e. KVL to the loop PRSP,

$-I_3 \times 20 - I_2 \times 200 + 5 = 0$

$\Rightarrow 4I_3 + 40I_2 = 1$ ...(i)

For loop PRQP,

$-20I_3 - 60I_1 + 4 = 0$

$\Rightarrow 5I_3 + 15I_1 = 1$ ....(ii)

Applying Kirchhoff's first law i.e. KCL we get,

$I_3 = I_1 + I_2$ ....(iii)

From Eqs. (i) and (iii), we have

$4I_1 + 44I_2 = 1$....(iv)

Also from eqs. (ii) and (iii) , we have

$20I_1 + 5I_2 = 1$....(v)

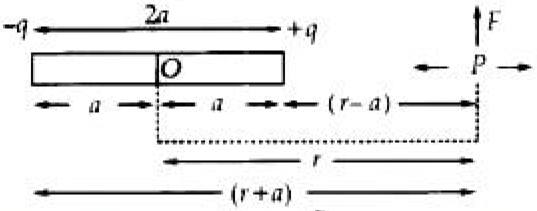
On solving eqs (iii), (iv) and (v) we get

$I_3 = \frac{11}{172}A = \frac{11000}{172}\text{mA}$

$I_2 = \frac{4000}{215}\text{mA}, I_1 = \frac{39000}{860}\text{mA}$

$\therefore$ The reading in the millimeter will be $\frac{11000}{172}$ mA

28. Consider an electric dipole whose length is 2a and centre at O. From the mid-point O, consider a point P at a distance r, where the electric field intensity is to be determined.



We have E = $\frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$, general formula

Case I, $E_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{9}{(r-a)^2}$

Case II, $E_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{(r+a)^2}$

Then E at point p is given by = $E_1 - E_2$

$$E = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]$$

$$E = \frac{q}{4\pi\varepsilon_0}\left[\frac{(r+a)^2-(r-a)^2}{(r-a)^2\cdot(r+a)^2}\right]$$

$$E = \frac{q}{4\pi\varepsilon_0} \cdot \frac{4ar}{(r^2-a^2)^2}$$

for, $r^2 >>> a^2$, (if dipole is short)

$$E = \frac{q}{4\pi\varepsilon_0}\left|\frac{4ar}{r^4}\right|$$

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2\times q\times 2a\times r}{r^4}$$

qx2a = p,the dipole moment$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2\vec{p}}{r^3} N/C [\because p = 2qa]2$

OR

i. $q_1 = q_2 = 6.5 \times 10^{-7} C$

   r = 50 cm = 0.50 m

   $k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2C^{-2}$

   F = ?

   According to Coulomb's law,

   $F = k\frac{q_1q_2}{r^2}$

   $= \frac{9\times10^9\times6.5\times10^{-7}\times6.5\times10^{-7}}{(0.50)^2}$

   $F = 1.5 \times 10^{-2} N$

ii. Now, if each sphere is charged double, and the distance between them is halved then the force of repulsion is:

$$F = k \cdot \frac{2q_1 2q_2}{\left(\frac{r}{2}\right)^2}$$

$$F = 16k \cdot \frac{q_1 q_2}{r^2}$$

$$= 16 \times 1.5 \times 10^{-2} = 24 \times 10^{-2}$$

F = 0.24 N

29. a. We know that,

Energy of photon $= \frac{hc}{\lambda}$

$$\Rightarrow E = \frac{6.62\times10^{-34}\times3\times10^{8}}{2000\times10^{-10}} J$$

or $E = \frac{6.62\times10^{-34}\times3\times10^{8}}{2\times10^{-7}\times1.6\times10^{-19}} eV$ = 6.20 eV

Energy of the fastest emitted photoelectron

$= h(\nu - \nu_0)$ (where hν_0 is the work function)

= (6.2 - 4.2)eV = 2.0 eV

Since, the emitted electrons from a metal surface have an energy distribution, the minimum energy in this distribution being zero, the energy of slowest photoelectrons is also zero.

b. Since $eV_0 = \frac{1}{2}mv_{\max}^2$ where $\frac{1}{2}mv_{\max}^2$ is the maximum energy of the emitted photo-electrons and V_0 is the stopping potential, the stopping potential is 2V.

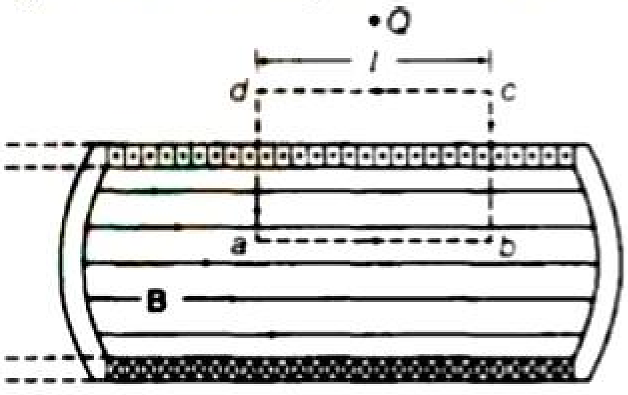
c. The threshold frequency is related to the work function by the relation

$$\phi_o = h\nu_0 = \frac{hc}{\lambda_0}$$

$$\therefore \frac{1}{\lambda_0} = \frac{\phi_0}{hc} = \frac{4.2\times1.6\times10^{-19} J}{6.62\times10^{-34} Js\times3\times10^{8} ms^{-1}}$$

$$\therefore \lambda_0 = 3\times10^{-7} m = 3000\overset{o}{A}$$

30. Figure shows the longitudinal sectional view of current carrying long solenoid.



Let B be the magnetic field at any point inside the solenoid along ab. The current comes out of the plane of paper at points marked.

The rectangular Amperian loop abcd is considered to determine the magnetic field.

Applying Ampere's Circuital Law over loop abcd,

$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 \times$ (Total enclosed current)

$\int_a^b B \cdot dl + \int_b^c B \cdot dl + \int_c^d B \cdot dl + \int_d^a B \cdot dl = \mu_0 \left(\frac{N}{L} lI\right)$

where, $\frac{N}{L}$ = n, number of turns per unit length and ab = cd = l = length of rectangular Amperian loop, and total number of turns = $\frac{N}{L} l$

As the field outside the solenoid is zero, $\int_c^d B . dl = 0$,

$\int_a^b Bdl \cos 0^\circ + \int_b^c Bdl \cos 90^\circ + 0 + \int_d^a Bdl \cos 90^\circ = \mu_0 \left(\frac{N}{L}\right) lI$

$B \int_a^b dl = \mu_0 \left(\frac{N}{L}\right) lI \Rightarrow Bl = \mu_0 \left(\frac{N}{L}\right) lI$

$\Rightarrow \quad B = \mu_0 (N/L) I$

or $B = \mu_0 nI$

This is a required expression for magnetic field inside the current carrying long solenoid.

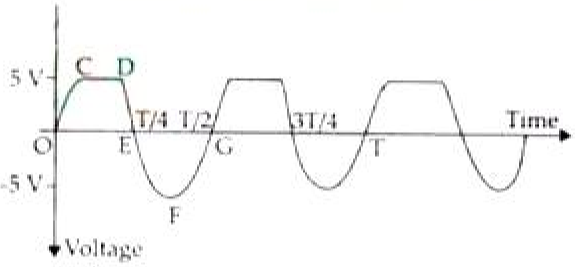
Section E

31. When signal 20 sin ωt gives input voltage less than 5 volt (because after 5V diode will get positive voltage at its P-junction) then diode will be in reverse bias so resistance of diode remain infinity so input signal will not pass through diode and battery path so output across A and B will increase from 0-5 V (graph OC).

Now when the input voltage 20 sin ωt increase beyond 5V then path of diode 5 V battery will offer very low resistance, so the current passes through diode and battery and output (across A and B) remain 5V (graph CD).

Now when the voltage decreases the diode will be in reverse bias and output will again fall from 5V to 0V as input changes (graph DE). When input voltage becomes negative (there is opposite of 5V battery in p-n junction input voltage becomes more than 5V now) the diode is in reversed bias it will not conduct current through CD, and in output across AB will get same as input AC i.e. for negative cycle diode offer infinite resistance as compared to R in series graph E, F, G.

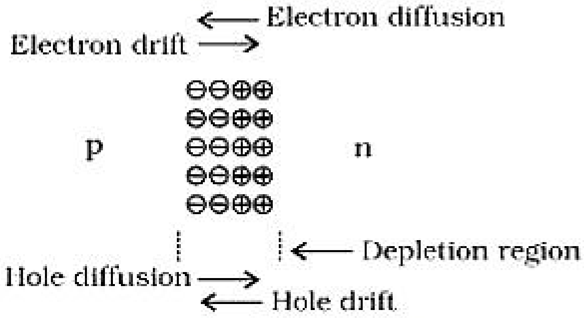
Same repetition of input and output continues-graph showing the output waveform.



OR

Two important processes occur during the formation of a p-n junction are *diffusion* and *drift*.

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 positive space-charge region on n-side of the junction and negative space charge region on p-side of the junction, an electric field directed from positive charge towards negative charge develops. Due to this field, an electron on p-side of the junction moves to n-side and a hole on nside of the junction moves to p-side. The motion of charge carriers due to the electric field is called drift. Thus a drift current, which is opposite in direction to the diffusion current (Fig.) starts.

Initially, diffusion current is large and drift current is small. As the diffusion process continues, the space-charge regions on either side of the junction extend, thus increasing the electric field strength and hence drift current. This process continues until the diffusion current equals the drift current. Thus a p-n junction is formed.

When p-type and n-type semiconductors are joined together, because of diffusion of charge carriers through the junction, a barrier is formed which opposes the further diffusion of charges through the junction. This barrier is called **potential barrier**. Thus, potential barrier in a PN junction refers to the potential required to overcome the barrier at the PN junction.

32. Given, E_V = 200V, f = 50 Hz

$R = 100\Omega$, V_R = 65V, V_C = 415V, V_L = 204V

i. If I_V is the current in the circuit, then

$$V_R = I_V \times R$$

$65 = I_V \times 100$

$I_V = 0.65A$

ii. $V_L = I_V X_L$

or $X_L = \frac{V_L}{I_V} = \frac{204}{0.65} = 313.85\Omega$

Now, $X_L = \omega L = 2\pi f L = 313.85$

$L = \frac{313.85}{2\pi f} = \frac{313.85}{2\times3.14\times50}$

or L = 1.0 H

iii. $V_C = I_V X_C$

$X_C = \frac{V_C}{I_V} = \frac{415}{0.65} = 638.5\Omega$

Now, $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

$C = \frac{1}{2\pi f X_C} = \frac{1}{2\times3.14\times50\times638.5}$

or $C = 4.99 \times 10^{-6} F$

iv. Consider C' be the capacitance that would produce resonance with L = 1.0 H, then

$f = \frac{1}{2\pi\sqrt{LC'}}$

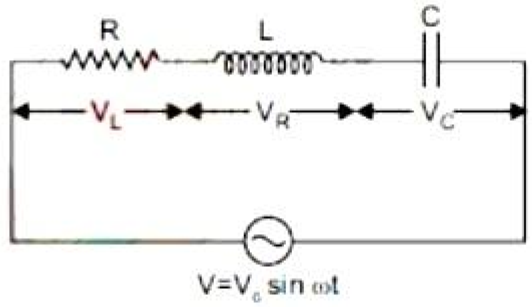
$C' = \frac{1}{4\pi^2 f^2 L}$

$C' = \frac{1}{4\times(3.14)^2\times(50^2\times1)}$

$= 10.1 \times 10^{-6} F = 10.1\mu F$

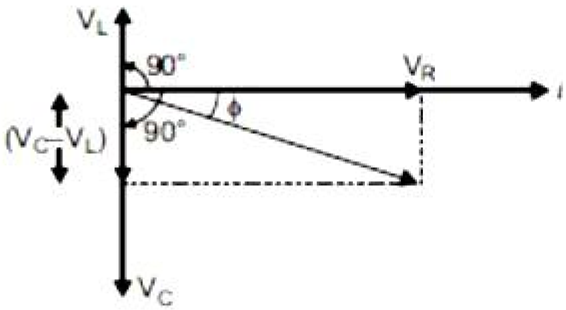
OR

a. Suppose a resistance R, inductance L and capacitance C are connected to series and an alternating voltage V = $V = V_0 sinwt$ is applied across it.



Since L, C and R are connected in series, current flowing through them is the same. The voltage across R is V_R, inductance across L is V_L and across capacitance is V_C.

The voltage V_R and current i are in the same phase, the voltage V_L will lead the current by angle 90^o while the voltage V_C will lag behind the current by 90^o.



Thus, V_R and $(V_C - V_L)$ are mutually perpendicular and the phase difference between them is 90^o. As seen in the fig, we can say that, as the applied voltage across the circuit is V, the resultant of V_R and $V_C - V_L)$ will also be V.

So,

$$V^2 = V_R^2 + (V_c - V_L)^2$$

$$\Rightarrow V = \sqrt{V_R^2 + (V_c - V_L)^2}$$

But, $V_R = Ri$, $V_c = X_c i$ and $V_L = X_L i$

where, $X_c = \frac{1}{\omega C}$ and $X_L = \omega L$

So, $V = \sqrt{(Ri)^2 + (X_c i - X_L i)^2}$,

Therefore, impendance of the circuit is given by,

$$Z = \frac{V}{i} = \sqrt{(R)^2 + (X_c - X_L)^2}$$

$$Z = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$$

This is the impedance of the LCR series circuit.

b. A radio or a TV set has an LC circuit capacitor of variable capacitance C. The circuit remains connected with an aerial coil through the phenomenon of mutual inductance. Suppose a radio or TV station has transmitted a program at frequency f, then waves produce an alternating voltage of frequency in area, due to which an emf of the same frequency is induced in LC circuit. When capacitor C is in circuit is varied then for a particular value of capacitance, C, $f = \frac{1}{2\pi\sqrt{LC}}$, the resonance occurs and maximum current flows in the circuit; so the radio or TV gets tuned.

33. i. a. From the fringe width expression, we have

$\beta = \frac{\lambda D}{d}$, therefore with the decrease in separation between two slits, 'd' the fringe width increases.

b. For interference fringes to be seen, $\frac{s}{S} < \frac{\lambda}{d}$, condition should be satisfied otherwise, the interference patterns produced by different parts of the source slit will overlap.
   As, the source slit width increases, the fringe pattern gets less and less sharp. When the source slit is so wide, the above condition does not satisfy and the interference pattern disappears. However, as long as the fringes are visible, the fringe width remains constant.

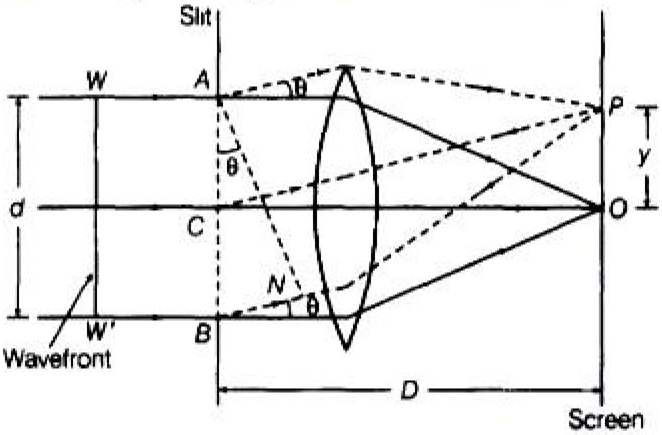
c. When monochromatic light is replaced by white light, then coloured fringe pattern is obtained on the screen.
   The interference pattern due to different colour component of white light overlap. The central bright fringes for different colours are at the same position. Therefore, central fringes are white. And on the either side of the central fringe white coloured bands will appear.

ii. Intensity at a point is given by
$I = 4I' \cos^2 \phi/2$
where I' = intensity produced by each one of the individual sources.
At central maxima, $\phi = 0$,
The intensity at the central maxima,
$I_0 = 4I'$
$I' = \frac{I_0}{4}$ ..... (i)
As, path difference $= \frac{\lambda}{3}$
Phase difference, $\phi' = \frac{2\pi}{\lambda} \times$ path difference
$= \frac{2\pi}{\lambda} \times \frac{\lambda}{3} = \frac{2\pi}{3}$
Now, intensity at this point
$I'' = 4I' \cos^2 \frac{1}{2}\left(\frac{2\pi}{3}\right)$
$= 4I' \cos^2 \frac{\pi}{3}$
$= 4I' \times \frac{1}{4}$
$= I'$
$= \frac{I_0}{4}$ [from Eq. (i)]
Hence proved.

OR

i. A single narrow slit is illuminated by a monochromatic source of light. The diffraction pattern is obtained on the screen placed in front of the slits. There is a central bright region called as central maximum. All the waves reaching this region are in phase hence the intensity is maximum. On both side of central maximum, there are alternate dark and bright regions, the intensity becoming weaker away from the center. The intensity at any point P on the screen depends on the path difference between the waves arising from different parts of the wave-front at the slit.

Diffraction of light at a single slit A parallel beam of light with a plane wavefront WW' is made to fall on a single slit AB. As width of the slit AB = dis of the order of wavelength of light, therefore, diffraction occurs on passing through the slit.



The wavelets from the single wavefront reach the centre O on the screen in same phase and hence, interfere constructively to give central maximum (bright fringe).

The diffraction pattern obtained on the screen consists of a central bright band having alternate dark and weak bright band of decreasing intensity on both sides.

Consider a point P on the screen at which wavelets travelling in a direction making an angle θ with CO are brought to focus by the lens. The wavelets from points A and B will have a path difference equal to BN.

From the right angled ΔANB, we have BN = AB sinθ or BN = d sinθ.

To establish the condition for secondary minima, the slit is divided into 2,4,6... equal parts such that corresponding wavelets from parts such that corresponding wavelets from successive regions interfere with path difference $\lambda/2$

or for nth secondary minlmum.the slit can be divided into 2n equal parts. Hence, for nth secondary minimum, path difference= $= d\sin\theta_n = n\lambda.$

or $\sin\theta_n = \frac{n\lambda}{d}(n = 1, 2, 3, \ldots)$

To establish the condition for secondary maxima, the slit is divided into 3,5,7... equal parts such that corresponding wavelets from alternate regions interfere with path difference of A./2 or for nth secondary maximum, the slit can be divided into (2n+

1)equal parts.

Hence, for nth secondary maximum

$d \sin\theta_n = (2n+1)\frac{\lambda}{2}$ (n = 1, 2, 3,...)

ii. For $\lambda_1 = 590\text{mm}$

Location of 1 maxima $y_1 = (2n+1)\frac{D\lambda_1}{2d}$

If $n = 1 \Rightarrow y_1 = \frac{3D\lambda_1}{2d}$

For $\lambda_2 = 596\text{nm}$

Location of III maxima

$y_2 = (2n+1)\frac{D\lambda_2}{2d}$, if n = 1

$\Rightarrow y_2 = \frac{3D\lambda_2}{2d}$

$\therefore$ Path difference $= y_2 - y_1 = \frac{3D}{2d}(\lambda_2 - \lambda_1)$

$= \frac{3\times1.5}{2\times2\times10^{-6}}(596 - 590) \times 10^{-9}$

$= 6.75 \times 10^{-3}\text{m}$