CBSE Class 12 Physics
Sample Paper - 06 (2019-20)

Maximum Marks: 70
Time Allowed: 3 hours

General Instructions:

i. All questions are compulsory. There are 37 questions in all.
ii. This question paper has four sections: Section A, Section B, Section C and Section D.
iii. Section A contains twenty questions of one mark each, Section B contains seven questions of two marks each, Section C contains seven questions of three marks each, and Section D contains three questions of five marks each.
iv. There is no overall choice. However, internal choices have been provided in two questions of one mark each, two questions of two marks, one question of three marks and three questions of five marks weightage. You have to attempt only one of the choices in such questions.

Section A

1. Six charges, each equal to + q, are placed at the corners of a regular hexagon of side a. The electric field at the point of intersection of diagonals is

   a. $\frac{1}{4\pi\epsilon_o}\cdot\frac{\sqrt{3}q}{2a^2}$

   b. Zero

   c. $\frac{1}{4\pi\epsilon_o}\cdot\frac{6q}{a^2}$

   d. $\frac{1}{4\pi\epsilon_o}\cdot\frac{q}{a^2}$

2. Two equal negative charges -q are fixed at points (0, a) and (0, -a). A positive charge Q is released from rest at the point (2a, 0) on the x-axis. The charge Q will:

   a. Move to origin and remain at rest

b. Execute oscillation but not SHM

c. Execute SHM about the origin

d. Move to infinity

3. To make a condenser of $16\mu\mathrm{F}$, 1000 volts, how many condensers are needed which have written on them “$8\mu\mathrm{F}$,, 250 volts”?

a. 8.0

b. 32.0

c. 40.0

d. 2.0

4. A variable capacitor and an electroscope are connected in parallel to a battery. The reading of the electroscope would be decreased by
a. Decreasing the battery potential
b. Increasing the area of overlapping of the plates
c. Decreasing the distance between the plates
d. Placing a dielectric between the plates

5. An iron bar magnet of length 10cm and cross section 1 cm^2 has a magnetization of 10^2 A/m. Magnet's pole strength is

a. 0.0025 Am

b. 0.0015 Am

c. 0.01 Am

d. 0.002 Am

6. If, λ_v, λ_x and λ_m represent the wavelengths of visible light, x-rays and microwaves respectively in the free space then________________

a. $\lambda_m > \lambda_v > \lambda_x$

b. $\lambda_v > \lambda_x > \lambda_m$

c. $\lambda_m > \lambda_x > \lambda_v$

d. $\lambda_v > \lambda_m > \lambda_x$

7. In Young's double-slit experiment using monochromatic light of wavelength l, the intensity of light at a point on the screen where path difference is λ, is K units. What is the intensity of light at a point where path difference is $\frac{\lambda}{3}$?

a. $\frac{K}{8}$

b. $\frac{K}{2}$

c. K

d. $\frac{K}{4}$

8. The critical angle for total internal reflection at a liquid–air interface is 42.5° If a ray of light traveling in the liquid has an angle of incidence at the interface of 35° what angle does the refracted ray in the air make with the normal?

a. 59.1°

b. 58.1°

c. 61.1°

d. 60.1°

9. A convex lens is dipped in a liquid whose refractive index is equal to the refractive index of the lens. Then its focal length will:

a. Become infinite

b. Become zero

c. Reduce

d. Remain same as in air

10. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential is

    a. 2 V
    b. 10 V
    c. 4 V
    d. 6 V

11. Fill in the blanks:

    The space around a magnet within which its influence can be experienced is called its ________.

    OR

    Fill in the blanks:

    Horizontal and vertical components of earth's magnetic field are equal, then angle of dip is ________.

12. Fill in the blanks:

    If two electron beams travel in the same direction, they will ________ each other.

13. Fill in the blanks:

    Tesla is the unit of ________.

14. Fill in the blanks:

    The activity of a radioactive source is measured by the rate of ________ of the source.

15. Fill in the blanks:

    The unit of solid angle is ________.

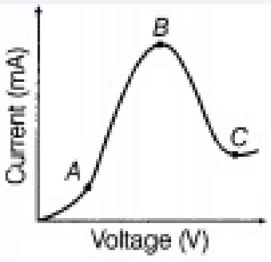
16. Write the equation of decay of the radioactive nuclei.

17. Name the absorbing material used to control the reaction rate of neutrons in a nuclear reactor.

18. A radar has a power of 1 kW and is operating at a frequency of 10 GHz. It is located on a steep mountain top of 600 m. What is the maximum distance upto which it can detect an object located on the surrounding earth's surface?(use radius of earth R = 6400 km)

19. Write the relationship of de-Broglie wavelength λ associated with a particle of mass m in terms of its kinetic energy E.

20. The graph shown in the figure represents a plot of current versus voltage for a given semiconductor. Identify the region, if any over which the semiconductor has a negative resistance.



OR

What is the most common use of photodiode?

Section B

21. What is the work done by the field of a nucleus in a complete circular orbit of the electron? What if the orbit is elliptical?

22. Two uniformly large parallel thin plates having charge densities $+\sigma$ and $-\sigma$ are kept in the X Z- plane at a distance d apart. Sketch an equipotential surface due to electric field between the plates. If a particle of mass m and charge q remains stationary between the plates. What is the magnitude and direction of this field?

23. Why are alkali metals most suited for photoelectric emission?

24. Unpolarised light is passed through a polaroid P_1. When this polarised beam passes

through another polaroid P_2 and if the pass axis of P_2 makes an angle θ with the pass axis of P_1, then write the expression for the polarised beam passing through P_2. Draw a plot showing the variation of intensity, when θ varies from 0 to 2π.

25. Write the relation between relative permeability (μ_r) and susceptibility (χ_m).

26. A 12.5 eV electron beam is used to excite a gaseous hydrogen atom at room temperature. Determine the wavelengths and the corresponding series of the lines emitted.

OR

Find out the wavelength of the electron orbiting in the ground state of hydrogen atom.

27. Using the concept of electron and hole current, write an expression for the conductivity of a semiconductor.

OR

State the factor, which controls:

i. Wavelength of light and
ii. intensity of light emitted by an LED.

Section C

28. Suppose that the particle in an electron projected with velocity $v_x = 2.0 \times 10^6 ms^{-1}$. If E between the plates separated by 0.5 cm is $9.1 \times 10^2 N/C$, where will the electron strike the upper plate? $(|e| = 1.6 \times 10^{-19}\ C, m_e = 9.1 \times 10^{-31} kg)$.

29. A magnetic field of 100 G (1G = 10^{-4}T) is required which is uniform in a region of linear dimension about 10 cm and area of cross section about $10^{-3}m^2$. The maximum current carrying capacity of a given coil of wire is 15 A and the number of turns per unit length that can be wound round a core is at most 1000 turns m^{-1}. Suggest some appropriate design particulars of a solenoid for the required purpose. Assume the core is not ferromagnetic.

30. Write Faraday's law of electromagnetic induction. Express it mathematically. A conducting rod of length 'l', with one end pivoted, is rotated with a uniform angular speed 'of in a vertical plane, normal to a uniform magnetic field 'B'. Deduce an expression for the emf induced in this rod.

31. Answer the following questions.

    i. Name the waves which are produced during radioactive decay of a nucleus. Write their frequency range.
    ii. Welders wear special glass goggles while working. Why? Explain.
    iii. Why are infrared waves often called as heat waves? Give their one application

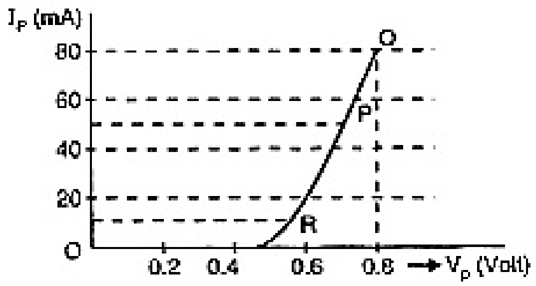
32. The maximum intensity in Young's double-slit experiment is I_0. Distance between the slits is d = 5λ, where λ is the wavelength of monochromatic light used in the experiment. What will be the intensity of light in front of one of the slits on a screen at a distance D = 10d?

OR

Show using a proper diagram show how unpolarised light can be linearly polarised by reflection from a transparent glass surface.

33. State any two postulates of Bohr's theory of hydrogen atom. What is the maximum possible number of spectral lines observed when the hydrogen atom is in its second excited state? Justify your answer.
Calculate the ratio of the maximum and minimum wavelengths of the radiations emitted in this process.

34. The characteristics curve of a diode is shown in the above figure. Determine the d.c. and a.c. resistance around point.



Section D

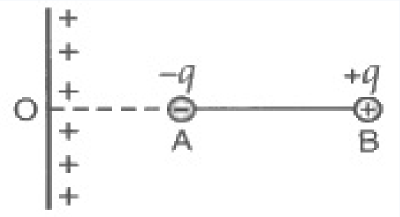
35. a. State the working principle of a potentiometer with the help of a circuit diagram. Describe a method to find the internal resistance of a primary cell.

b. In a potentiometer arrangement, a cell of emf 1.20 volt gives a balance point at 30 cm length of the wire. This cell is now replaced by another cell of unknown emf. If the ratio of the length of the two cells is 1.5. Calculate the difference in the balancing length of the potentiometer wire in the two cases.

OR

a. Using Gauss' theorem, obtain an expression for the electric field intensity at a point at a distance r from an infinitely long uniformly charged straight wire.

b. An electric dipole AB consists of charges ± 5 nC and separated by a distance of 2 $\times$ 10^{-3} m [Fig].



The dipole is placed near a long line charge having linear charge density 4.5×10^{-4} Cm^{-1}, such that the negative charge is at a distance OA = 2·5 cm from the line charge. Find the force acting on the dipole.

36. 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?

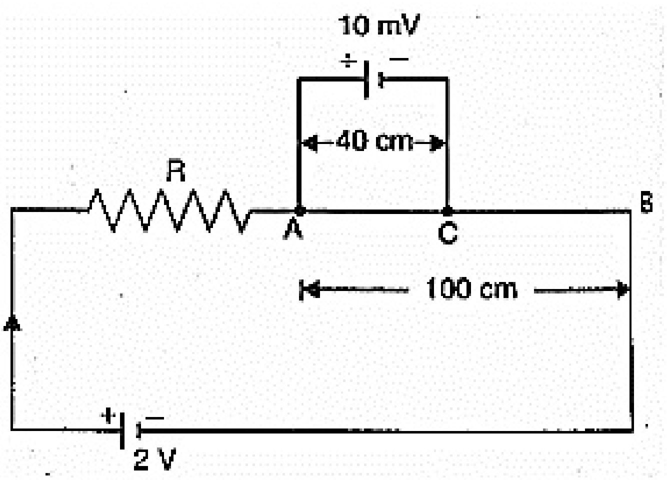
OR

A network of resistors is connected to a 16 V battery with internal resistance of 1Ω as shown in figure

a. Compute the equivalent resistance of the network.

b. Obtain the current in each resistor

c. Also obtain the voltage drops V_{AB}, V_{BC} and V_{CD}.



37. How is the working of a telescope different from that of a microscope?
    The focal lengths of the objective and eyepiece of a microscope are 1.25 cm and 5 cm respectively. Find the position of the object relative to the objective in order to obtain an angular magnification of 30 in normal adjustment.

OR

i. Draw a labelled ray diagram to obtain the real image formed by an astronomical telescope in normal adjustment position. Define its magnifying power.
ii. You are given three lenses of power 0.5 D, 4D and 10 D to design a telescope.
    a. Which lenses should be used as objective and eyepiece? Justify your answer.
    b. Why is the aperture of the objective preferred to be large?

Answer

Section A

1. (b) Zero

   Explanation: The field of opposite charges cancels each other so net electric field at centre = 0
2. (b) Execute oscillation but not SHM

   Explanation: Direction of net electric field due both the charges at any point on +X axis will be along -X axis, hence the positive charge will experience force in negative X axis direction.

   When it reaches origin, net electric field will become zero, but due to its kinetic energy positive charge will continue moving in the -X direction, but now the direction of electric field and hence force on poitive charge wll be in the +X axis direction, which will tend to bring it back towards origin. So the charge will oscillate about origin. Since force and hence acceleration is not proportional to displacement, its not SHM.
3. (b) 32.0

   Explanation:

   Each capacitor of capacitance $8\mu F$ can withstand a maximum potential of 250 V. When equal capacitors are connected in series, the potential difference across them is equal.

   If there are m capacitors in series such that the potential across each is 250 V, then, $\frac{1000}{m} = 250; m = 4.$

   The equivalent capacitance of 4 capacitors connected in series is $C_S = \frac{C}{m} = \frac{8}{4} = 2\mu F.$

   To achieve a capacitance of 16, n such rows of capacitors need to be connected in parallel.

   $C_{eq} = nC_S = 16\mu F; n = \frac{16}{C_S} = \frac{16}{2} = 8.$

   To make a condenser of 16 μF, 8 rows of capacitors with each row containing 4

capacitors are to be connected.
The total number of capacitors= n×m=4×8=32.

4. (a) Decreasing the battery potential Explanation: An electroscope is a device which measures the potential difference. If it is connected in parallel to the capacitor, the potential across it will be equal to the potential across the capacitor, which is equal to the potential across the battery. On decreasing the battery potential, the potential difference across the electroscope reduces and hence the reading reduces. While the capacitor is connected to the battery, Placing a dielectric between the plates, or decreasing the distance between the plates or increasing the area of the plates will not change the potential difference across it; since it will always remain equal to the potential difference maintained by the battery. In the cases B, C and D, The capacitance of the capacitor , however increases ; but this increase happens due to increase in the charge stored in the capacitor while the potential remains constant.
5. (c) 0.01 Am

   Explanation: $M = \frac{magnetic\ moment}{volume} = \frac{q_m \times l}{A \times l} = \frac{q_m}{A}$

   Hence pole strength, q_m = M × A = 100 A/m × 10^{-4} m^2 = 10^{-2} Am

6. (a) $\lambda_m > \lambda_v > \lambda_x$

   Explanation: Since of the given regions, wavelength of microwave is highest and that of x-ray is minimum.

7. (d) $\frac{K}{4}$

   Explanation:

   use $I = I_0 \cos^2\theta$
   When phase difference is 2π path difference is λ
   $I' = I_0 \cos^2 \frac{2\pi}{3}$
   = $\frac{K}{4}$

8. (b) 58.1°

   Explanation: for total internal reflection,
   $\mu_1 sin\theta_i = \mu_2 sin\theta_t$

$\theta_t = 90^\circ$ *at which total* internal reflection, exist at this point $\theta_i = \theta_c$
where *critical angle* $\theta_c = 42.5^\circ$
using snell's law:
$\mu_1 sin42.5^\circ = \mu_2 sin90^\circ$
these gives ratios of refractive index
again applying snell's law
$\mu_1 sin35^\circ = \mu_2 sin\theta_r$
$\mu_1 = 1.48,\ \mu_2 = 1$
so, $\theta_r = 58.1^\circ$

9. (a) Become infinite

   Explanation:

   $\frac{1}{f} = (\frac{\mu_2}{\mu_1} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$
   since, $\mu_2 = \mu_1$,
   $\frac{1}{f} = 0,\ hence\ f = \infty$

10. (c) 4 V

    Explanation:

    $eV_0 = k_{max}$

    $eV_0 = 4eV$

    $V_0 = 4V$

11. Magnetic field

OR

45°

12. Attract
13. Magnetic induction
14. Disintegration
15. Steradian

16. $N = N_0 e^{-\lambda t}$

17. Heavy water

18. Here, R = 6400 km = 6.4 $\times$ 10^6 m, h = 600 m From the relation

d = $\sqrt{2hR}$

= $\sqrt{2 \times 6.4 \times 10^6 \times 600}$

= 87.6 km

Distance d is independent of the power and frequency of the signal.

19. Relation between Kinetic energy and linear momentum is, $K = \frac{p^2}{2m}$

where p = momentum, k = kinetic energy, m = mass

So,

$\Rightarrow \quad p = \sqrt{2mK}$

de-Broglie wavelength, where, p =$\sqrt{2mK}$

$\Rightarrow \quad \lambda = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mE}} \quad [K = E]$

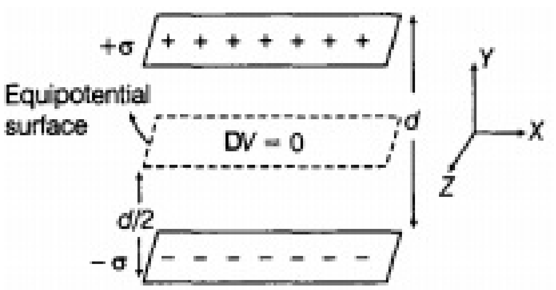
20. The slope of the V-I graph gives the resistance. Negative slope of curve means negative resistance. In the given graph, part BC of the curve shows the negative resistance as in this region slope is negative and current decreases by increasing the voltage.

OR

The photodiode can be used as light detector.

Section B

21. Whatsoever be the shape of the orbit work done is always zero because electron will be in the same energy state after it completes an orbit.

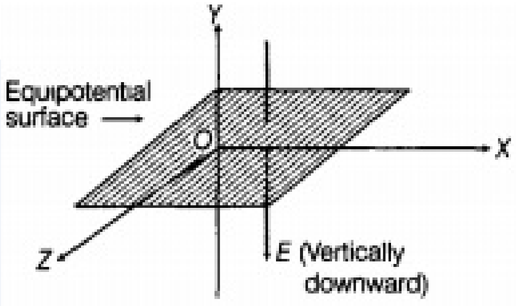
22. 

The equipotential surface is at a distance d/2 from either plate in XZ-plane. -q charge experiences a force in a direction opposite to the direction of electric field i.e. along the direction of the plate having charge density $+\sigma$.

$\therefore$ The force on the '-q' charge balances when, the electrostatic force becomes equal to the weight of the charge itself i.e.

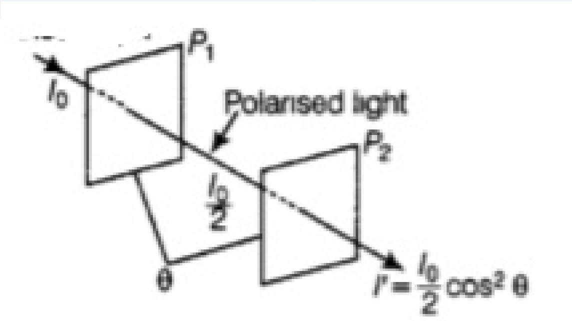
$qE = mg \Rightarrow E = \frac{mg}{q}$

The direction of electric field along vertically downward direction. The XZ-plane is so chosen that the direction of electric field due to two plates is along vertically downward direction, otherwise weight (mg) of the charged particle could not be balanced. The equipotential surface lies in between the two given plates and on the XZ - plane, as shown below.



23. This is because alkali metals has low work function. It is easy to remove electrons from alkali than from other metals.

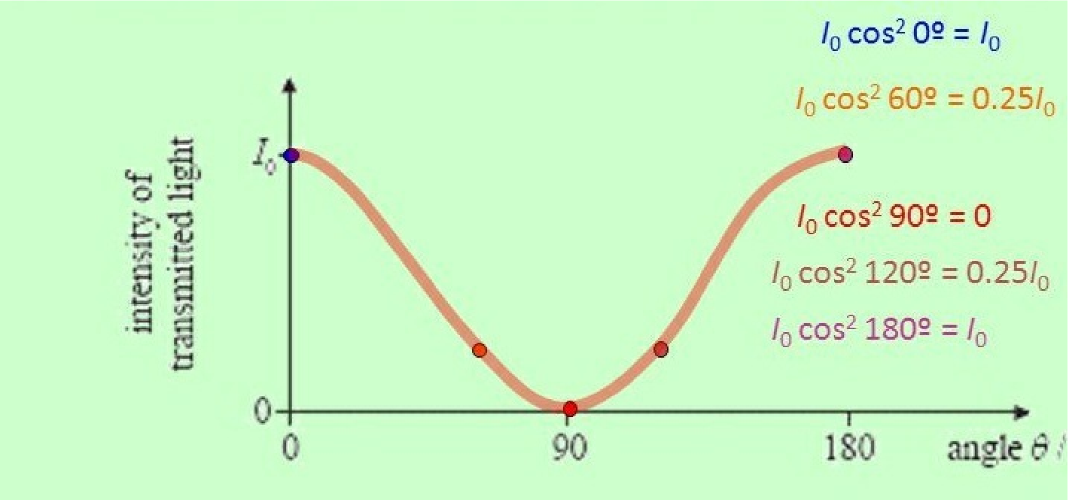
24. The figure when unpolarised light beam is passed through polaroid is shown below.



By the law of Malus,

intensity received after passing through the Polaroid, $P_2 = I' = \frac{I_0}{2} \cos^2 \theta$.

Variation of intensity with rotation angle θ from 0 to π i.e. from 0° to 180°of the Polaroid is shown below.



25. $\mu_r = 1 + \chi_m$

26. The wavelength of series emitted during transition is given by the formula:

hc / E = λ

E = 12.5 eV
hc = 1240 eV

Therefore wavelength of emitted series is:

λ = 1240 / 12.5 = 99.2 nm
This belongs to the Lyman series of Bohr's Hydrogen Spectrum.
therefore, The wavelength of emitted series is 99.2 nm and this belongs to the Lyman series of Bohr's Hydrogen Spectrum.

OR

Radius of ground state of hydrogen atom $= 0.53 A^{\circ} = 0.53 \times 10^{-10} m.$
According to de Broglie relation 2πr = nλ
For ground state n=1
$2 \times 3.14 \times 0.53 \times 10^{-10} = 1 \times \lambda$
therefore, $\lambda = 3.32 \times 10^{-10} m$
$\Rightarrow \lambda = 3.32 A^{\circ}$

27. In a Semi-Conductor of length (ℓ) and area of Cross-Section. Let ne and nh be the no. of electrons and holes with drift velocities Ve and Vh respectively. So, the total current

in the semi-conductor will be the sum of current due to electrons as well as holes, i.e. I = I_e + I_h .....(i)$I = I_e + I_h \qquad ....(i)$

As we know that I = $n_e AV_d$$I = n_e AV_d$

I_e = $n_e eAV_e$ And I_h = $n_h eAV_h$ $I_e = n_e eAV_e \ And \ I_h = n_h eAV_h$

I = $n_e eAV_e$ + $n_h eAV_h$ $I = n_e eAV_e + n_h eAV_h$

I = eA[$n_e V_e$ + $n_h v_h$] $I = eA[n_e V_e + n_h v_h]$

$\frac{I}{A} = e[n_e V_e + n_h V_h]$ ......(ii)

As we know that E = $\frac{V}{l}$ (in magnitude)

Also, $R = \rho \frac{l}{A} \rho = \frac{RA}{l}$ or

Where ρ is resistivity and R is resistance

or $\frac{E}{\rho} = \frac{\frac{V}{l}}{\rho}$

or $\frac{E}{\rho} = \frac{V}{l} \times \frac{l}{RA}$

or $\frac{E}{\rho} = \frac{I}{A}$ ...(iii)

Put (3) in (2) we get,

$\frac{E}{\rho} = e[n_e V_e + n_h V_h]$

$\Rightarrow \frac{1}{\rho} = \frac{e}{E}[n_e V_e + n_h V_h]$

$\Rightarrow \sigma = e[n_e \frac{V_e}{E} + n_h \frac{v_h}{E}]$

Here, mobility (m) = $\frac{Drift\ velocity}{Electric\ field}$

$\sigma = e[n_e m_e + n_h m_h]$

This is the derivation and expression for the conductivity of a semiconductor.

OR

i. Energy, hence the wavelength of photons emitted depends upon the band gap.
ii. The forward current increases as the intensity of light increases and reaches a maximum. Further, increase in the forward current results in decrease of light intensity. LEDs are biased such that the light emitting efficiency is maximum.

Section C

28. Acceleration, $a = \frac{qE}{m}$

$= \frac{1.6 \times 10^{-19} \times 9.1 \times 10^{2}}{9.1 \times 10^{-31}} = 1.6 \times 10^{14} m/s^2$

Using formula $y = ut + \frac{1}{2} at^2$

We get, $0.005 = 0 + \frac{1}{2} \times 1.6 \times 10^{14} \times t^2$

Simplifying for value of t, we get

$t = 8 \times 10^{-9} s$

The electron covers vertical distance is shown as

y = v_xt

$= 2.0 \times 10^6 \times 8 \times 10^{-9}$

$= 1.6 \times 10^{-2} m$

= 1.6 cm

29. Given, B = 100 G = 10^{-2}T

I = 15 A, n = $1000 m^{-1}$

Magnetic field inside a solenoid is

$B = \mu_0 n I$

$nI = \frac{B}{\mu_0} = \frac{10^{-2}}{4\pi \times 10^{-7}} = \frac{10^5}{4\pi} = 7955$

We may have I = 10 A and n = 800

The solenoid may have length 50 cm and cross section $5 \times 10^{-3} m^2$ (five times given values) so as to avoid edge effects etc.

30. According to Faraday's law of electromagnetic induction, the magnitude of induced emf is equal to the rate of change of magnetic flux linked with the closed circuit (or coil). Mathematically,

$E = -N \frac{d\phi_B}{dt}$

where N is the number of turns in the circuit and ϕ_B is the magnetic flux linked with each turn.

Suppose the conducting rod completes one revolution in time T. Then

Change in flux $= B \times Area\ swept = B \times \pi l^2$

Induced emf $= \frac{\text{Change in flux}}{\text{Time}}$

$\varepsilon = \frac{B \times \pi l^2}{T}$

But $T = \frac{2\pi}{\omega}$

$\therefore \varepsilon = \frac{B \times \pi l^2}{\frac{2\pi}{\omega}} = \frac{1}{2} B 1^2 \omega$

31. i. γ-rays are produced during radioactive decay of a nucleus. Its frequency range is from 3×10^{18} Hz to 5×10^{22} Hz.
    ii. Welders wear special glass goggles while working to protect their eyes from

radiation hazards of ultraviolet rays(UV rays). The range of UV rays is 10^{15} Hz to 10^{17} Hz. Because the radiation hazards are harmful to human eyes.

iii. Infrared waves are called heat waves because they cause the atoms and molecules to vibrate when they encounter a substance. This increases the velocity and hence internal energy of atoms and molecules. Thereby, increasing the temperature of the substance(As, heat produced in matter is directly proportional to the internal energy of atoms and molecules). They are used in physical therapy and weather forecasting.

32. Path difference,

$\Delta x = \frac{yd}{D}$

Here, y = $\frac{d}{2} = \frac{5\lambda}{2}$ (as d = 5λ)

and D = 10d = 50λ

So, $\Delta x = \left(\frac{5\lambda}{2}\right)\left(\frac{5\lambda}{50\lambda}\right) = \frac{\lambda}{4}$

Corresponding phase difference will be

$\phi = \left(\frac{2\pi}{\lambda}\right)(\Delta x)] = \left(\frac{2\pi}{\lambda}\right)\left(\frac{\lambda}{4}\right) = \frac{\pi}{2}$

or, $\frac{\phi}{2} = \frac{\pi}{4}$

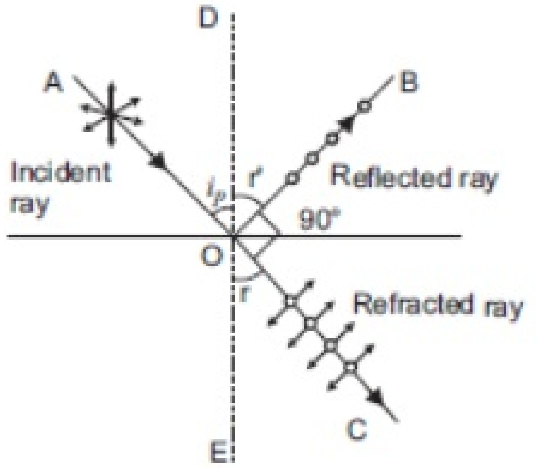
$\therefore$ I = $I_0 \cos^2\left(\frac{\phi}{2}\right)$

I = $I_0 \cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2}$

OR

When an unpolarized light falls on a polaroid, only those electric vectors that are oscillating along a direction prependicular to the aligned molecules will pass through. Thus, incident light gets linearly polarized.

Electric vectors which are along the direction of the aligned molecules gets absorbed.



Whenever unpolarized light is incident on the boundary between two transparent media, the reflected light gets partially or completely polarized. When reflected light is perpendicular to the refracted light, the reflected light, is completely polarized light.

33. Bohr's Postulates

    i. Every atom consists of small and massive central core, known as nucleus around which electron revolve and necessary centripetal force prevailed by electrostatic force of attraction between positively charged nucleus and negatively charged electrons.

    ii. The electrons are revolved around the nucleus in only those circular orbits which satisfy the quantum condition that the angular momentum of electrons is equal to integral multiple of $\frac{h}{2\pi}$ where, h is Planck's constant.

    $mvr = \frac{nh}{2\pi}$

    where, n = 1, 2, 3,...

    In second excited state i.e., n =3, two spectral lines namely Lyman series and Balmer series can be obtained corresponding to transition of electron from n = 3 to n = 1 and n = 3 to n = 2, respectively.

    For Lyman series, n = 3 to n = 1, for minimum wavelength

    $\frac{1}{\lambda_{\text{man}}} = R\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = \frac{8R}{9}$ ....(i)

    For Balmer series(maximum wavelength),

    $\frac{1}{\lambda_{\max}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

    $= \left(\frac{9-4}{36}\right) R = \frac{5R}{36}$ ....(ii)

    On dividing Eq. (i) by Eq. (ii), we get

    $\frac{\lambda_{\max}}{\lambda_{\text{man}}} = \frac{8R/9}{5R/36} = \frac{8R}{9} \times \frac{36}{5R} = \frac{32}{5}$

$\Rightarrow \lambda_{\max} : \lambda_{\text{man}} = 32 : 5$

34. d.c. resistance

$r_{dc} = \frac{0.5}{5\times10^{-3}} = 100\Omega$

a.c. resistance

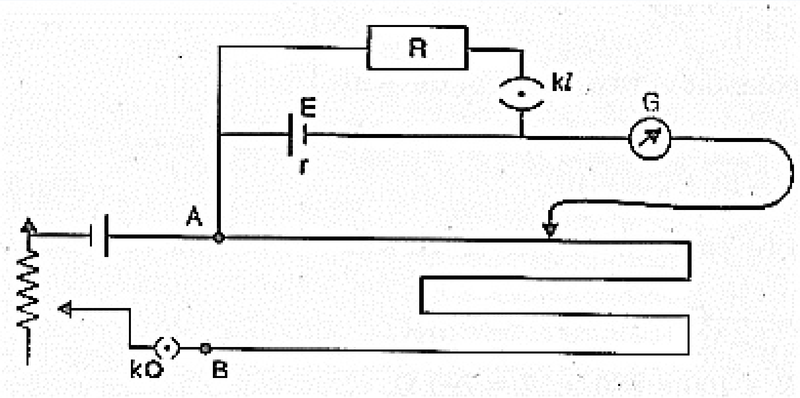
$r_{ac} = \frac{0.8-0.5}{(80-20)\times10^{-3}}$

$= \frac{0.3}{60\times10^{-3}} = 5\mu$

Section D

35. a. The connections are made as shown in the figure. E is the cell whose internal resistance r is to be determined. A resistance R is connected across the cell through a key k. The key k' is closed and k is kept open. The balance point is found out. Let the balancing length be 1_1. Then,

$E \propto l_1$ ...(i)



A suitable resistance R is introduced in the resistance box R and with the key k' closed, the balancing length l_2 is found out. When the circuit is closed, the potential difference across the cell falls to $\frac{ER}{R+r}$. Then,

$\frac{ER}{R+r} \propto 1_2$ ....(ii)

Dividing equation (i) by (ii) we get

$\frac{E(R+r)}{ER} = \frac{1_1}{1_2} \Rightarrow \frac{E+r}{R} = \frac{1_1}{1_2}$

or $\frac{R+r}{R} - 1 = \frac{l_1}{l_2} - 1 = \frac{l_1-l_2}{l_2}$

or $r = \frac{l_1-l_2}{l_2} \times R$

b. Given, $E_1 = 1.20V, l_1 = 30cm$

$\frac{E_1}{E_2} = \frac{l_1}{l_2} = 1.5$

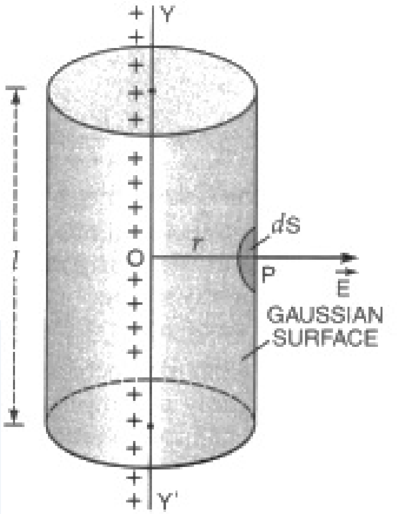
or $l_2 = \frac{l_1}{1.5} = \frac{30}{1.5}$ = 20 cm

Difference in the balancing length,

$1_1 - 1_2 = 30 - 20 = 10$ cm

OR

a. Consider a thin infinitely long straight line charge having a uniform linear charge density λ placed along YY'. Draw a cylindrical surface of radius r and length l about the line charge as its axis.



If E is the magnitude of electric field at point P, then electric flux through the gaussian surface is given by

$\phi = \mathrm{E} \times$ area of the curved surface of a cylinder of cylinder radius r and length l

or

$\phi = \mathrm{E} \times 2\pi\ r\ l$

According to Gauss' theorem, we have $\phi = \frac{q}{\varepsilon_0}$

Now, charge enclosed by the gaussian surface, q = λ l

$\therefore \quad \phi = \frac{\lambda l}{\varepsilon_0}$

Thus,

$\mathrm{E} \times 2\ \pi\ r\ l = \frac{\lambda l}{\varepsilon_0}$

or $\mathrm{E} = \frac{1}{2\pi\varepsilon_0} \frac{\lambda}{r}$

b. Electric field at a distance r from the line charge,

$\mathrm{E} = \frac{1}{2\pi\varepsilon_0} \cdot \frac{\lambda}{r}$

To calculate force on charge -q at point A:

Here, OA = 2·5 cm = 2·5 $\times 10^{-2}$ m

Electric field at point A,

$\mathrm{E}_1 = \frac{1}{2\pi \times 8.854 \times 10^{-12}} \times \frac{4.5 \times 10^{-4}}{2.5 \times 10^{-2}}$

$= 3 \cdot 24 \times 10^8\ NC^{-1}$

Force on charge - q at point A, $F_1 = qE_1 = 5 \times 10^{-9} \times 3 \cdot 24 \times 10^8 = 1 \cdot 62$ N (towards the line charge)

To calculate force on charge +q at point B:

Here, OB $= 2 \cdot 5 \times 10^{-2} + 2 \times 10^{-3} = 2 \cdot 7 \times 10^{-2}$ m

Electric field at point B,

$E_2 = \frac{1}{2\pi \times 8.854 \times 10^{-12}} \times \frac{4.5 \times 10^{-4}}{2.7 \times 10^{-2}}$

$= 3 \times 10^8\ NC^{-1}$

Force on charge + q at point B,

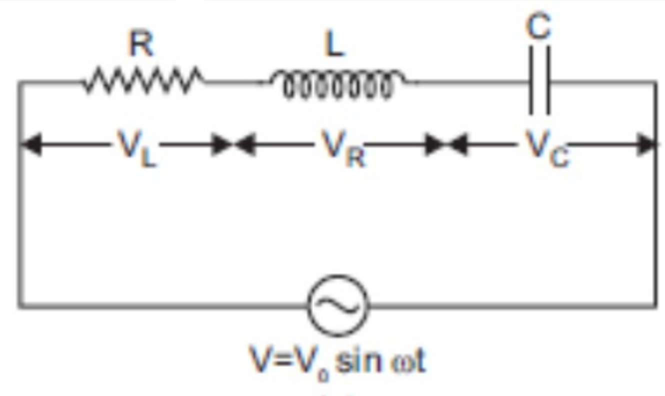
$F_2 = qE_2 = 5 \times 10^{-9} \times 3 \times 10^{-8} = 1 \cdot 5$ N (away from the line charge)

Hence, net force on electric dipole,

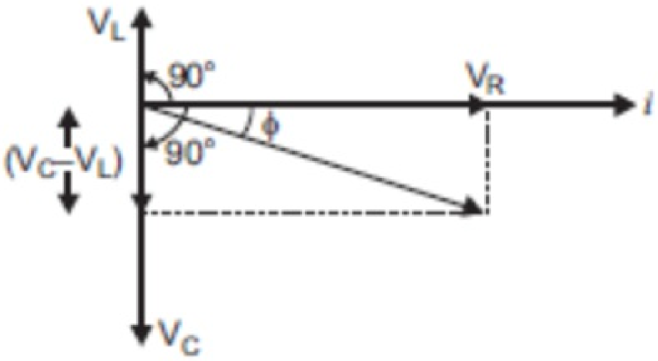
$F = F_1 - F_2 = 1.62 - 1.5 = 0 \cdot 12$ N (towards the line charge)

36. a. Expression for impedance in LCR series circuit:

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 90^0 while the voltage V_C will lag behind the current by 90^0.



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_ci and V_L = X_Li

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

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.

OR

a. Equivalent resistance of two 4Ω resistors in parallel is $\frac{4\times4}{4+4}\Omega$ i.e. 2Ω. Equivalent resistance of 12Ω and 6Ω resistors in parallel is $\frac{12\times6}{12+6}\Omega$ i.e. $\frac{72}{18}\Omega$ or 4Ω. Now $2\Omega, 1\Omega$ and 4Ω(equivalent of 12Ω and 6Ω) are in series. So, total resistance is $(2+1+4)\Omega$, i.e. 7Ω.

b. $I = \frac{E}{R+r} = \frac{16}{7+1}A$ = 2 A

Consider the resistors between A and B. It is a case of two equal resistors connected in parallel. So, current in each resistor is 1A. current through 1Ω is clearly 2A. Let us now consider resistors between C and D. It is a parallel combination of two resistances. Current would be divided in the inverse ratio of resistances. If I_1 is the current through 12Ω and I_2 is the current through 6Ω, then $\frac{I_1}{I_2} = \frac{6}{12} = \frac{1}{2}$. So, current through 12Ωresistor is $\frac{2}{3}A$.

Similarly, current through 6Ω resistor is $\frac{4}{3}A$.

c. The voltage V_{AB} between A and B is the product of total current between A and B and the equivalent resistance between A and B.

$\therefore V_{AB} = 2\times 2V = 4V$

Similarly $V_{BC} = 2\times 1V$ = 2 V $V_{CD} = 2\times 4V$ = 8 V

37. Working Differences:
   i. The objective of a telescope forms the image of a very far off object at, or within, the focus of its eyepiece. The microscope does the same for a small object kept just beyond the focus of its objective.
   ii. The final image formed a telescope is magnified relative to its size as seen by the unaided eye, while the final image formed by a microscope is magnified relative to its absolute size.
   iii. The objective of a telescope has large focal length and large aperture, while the corresponding for a microscope have very small values.

Given: f_0 = 1.25 cm, f_e = 5 cm

M = -30 (Magnifying power is negative)

We know,

$M = \frac{v_0}{u_0}\left(1+\frac{D}{f_e}\right)$

Where, v_0 = Distance of image from objective, u_0 = Distance of object from objective, D = Distance of least distinct vision

Thus,

-30 = $\frac{v_0}{u_0}\left(1+\frac{25}{5}\right)$

$v_0 = -5\ u_0$

Using lens formula,

$$\frac{1}{f_0} = -\frac{1}{u_0} + \frac{1}{v_0}$$

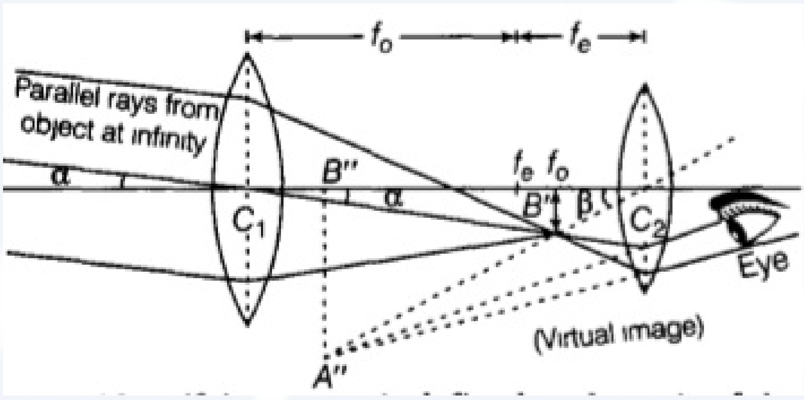
$$\frac{1}{1.25} = -\frac{1}{u_0} - \frac{1}{5u_0}$$

$u_0 = -1.5$ cm

Thus the distance of object from objective is 1.5 cm.

OR

i. In astronomical telescope for normal adjustment, final image is formed at infinity and it is virtual.
   The labelled ray diagram to obtain one of the real image formed by the astronomical telescope is shown below:



   Magnifying power is defined as the ratio of the angle subtended at the eye by the focal image as seen through the telescope to the angle subtended at the eye by the object seen directly, when both the image and the object lies at infinity.

ii.
   a. We know the objective lens of a telescope should have larger focal length and eyepiece lens should have smaller focal length. And focal length is inverse of power, So lens of power (P = 1/f).
      10D can be used as eyepiece and lens of power 0.5 D can be used as objective lens.
   b. The objective lens of a telescope should have larger aperture, in order to form bright image of distant objects, so that it can gather sufficient light rays from the distant objects.