CBSE Class 12 Physics
Sample Paper - 04 (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. A conducting sphere of radius 10 cm has an unknown charge. If the electric field 20 cm from the centre of the sphere is $1.5 \times 10^3 \mathrm{N/C}$ and points radially inward, what is the net charge on the sphere?

   a. -6.67 nC

   b. 7.67 nC

   c. 7.27 nC

   d. -6.27 nC

2. Four point charges $q_A = 2\mu A$, $q_B = 2\mu C$, $q_C = -5\mu C$, $q_D = -5\mu C$ are located at the corners of a square ABCD of side 10 cm. Force on a charge of $1\mu\mathrm{C}$ placed at the centre of the square is

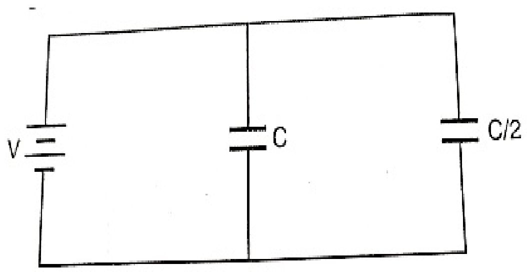
a. 0 N

b. 3.6 N

c. 1.8 N

d. 4.5 N

3. Two capacitors, one of capacitance C and the other of C/2 are connected to a V volt battery as shown in the figure.



The work done in charging both the capacitors fully is

a. $\frac{1}{2}$ CV^2

b. $\frac{3}{4}$ CV^2

c. $\frac{1}{4}$ CV^2

d. 2 CV^2

4. Work done in moving a unit positive charge through a distance of x metre on an equipotential surface is:

a. $\frac{1}{x}$ joule

b. zero

c. x^2 joule

d. x joule

5. A cube-shaped permanent magnet is made of a ferromagnetic material with a magnetization M of about 500A/m. The side of cube is 20 cm. Magnetic dipole moment of the magnet is.

a. $4Am^2$

b. $5Am^2$

c. $3Am^2$

d. $6Am^2$

6. Medical x rays are taken with electromagnetic waves having a wavelength of around 0.10 nm. What are the frequency and period of such waves?

   a. $3.4 \times 10^{15}\mathrm{Hz}, 3.3 \times 10^{-17}\mathrm{s}$

   b. $3 \times 10^{15}\mathrm{kHz}, 3.3 \times 10^{-17}\mathrm{s}$

   c. $3.2 \times 10^{15}\mathrm{Hz}, 3.3 \times 10^{-17}\mathrm{s}$

   d. $3.2 \times 10^{15}\mathrm{Hz}, 3.3 \times 10^{-17}\mathrm{s}$

7. The angular resolution of a 10 cm diameter telescope at a wave length of $5000\overset{o}{\mathrm{A}}$ is of the order of:

   a. 10^6rad

   b. 10^{-2}rad

   c. 10^{-6} rad

   d. 10^{-4}rad

8. A viewing screen is separated from a double-slit source by 1.2 m. The distance between the two slits is 0.030 mm. The second-order bright fringe m =2 is 4.5 cm from the center line. Wavelength of the light is

   a. 620 nm

   b. 560 nm

c. 590 nm

d. 660 nm

9. A convex lens is placed between an object and a screen which are a fixed distance apart. For one position of the lens the magnification of the image obtained on the screen is m_1. When the lens is moved by a distance d, the magnification of the image obtained on the same screen is m_2. The focal length of the lens is ($m_1 > m_2$)

   a. $\frac{dm_2}{m_1}$

   b. $\frac{d}{m_1 - m_2}$

   c. $\frac{d}{m_1 + m_2}$

   d. $\frac{dm_1}{m_2}$

10. In various experiments on photo electricity the stopping potential for a given frequency of the incident radiation

    a. is independent of radiation intensity

    b. is proportional to radiation intensity

    c. is independent of the radiation intensity

    d. is inversely proportional to radiation intensity

11. Fill in the blanks:

    The lines joining the places of equal dip or inclination are called ________ lines.

OR

Fill in the blanks:

Torque is ________ when the magnet lies perpendicular to the direction of the magnetic field.

12. Fill in the blanks:

In case of Hall effect for a strip having charge Q and area of cross-section A, the Lorentz force is ________ proportional to Q.

13. Fill in the blanks:

    The magnetic field near a current carrying conductor is given by ________ law.

14. Fill in the blanks:

    ________ forces are the strongest forces in nature.

15. Fill in the blanks:

    Visible spectrum is a band of ________ colours.

16. A nucleus undergoes β^- decay. How does its

    i. mass number and
    ii. atomic number changes?

17. Name two radioactive elements which are not found in observable quantities?

18. State the relation between the frequency ν of radiation emitted by LED and the band gap energy E of the semiconductor used to fabricate it.

19. Why is photoelectric emission not possible at all frequencies?

20. State the relation between the frequency ν of radiation emitted by LED and the band gap energy E of the semiconductor used to fabricate it.

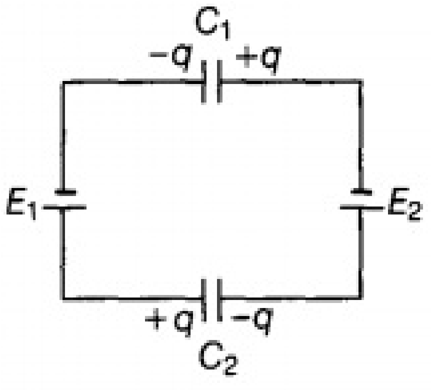
OR

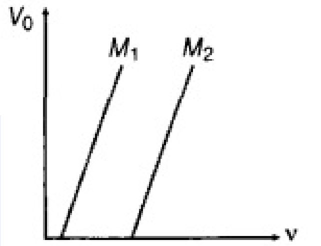
Name the type of biasing of a p-n junction diode so that the junction offers very high resistance.

Section B

21. Find out the expression for the potential energy of a system of three charges q_1, q_2 and q_3 located at r_1, r_2 and r_3 with respect to the common origin O.

22. Determine the potential difference across the plates of the capacitor C_1 of the network shown in the figure. (assume, $E_2 > E_1$)



23. 

i. Why is the slope same for both lines?
ii. For which material will the emitted electrons have greater kinetic energy for the incident radiation of the same frequency? Justify your answer.

24. Yellow light ($\lambda = 6000\overset{o}{A}$) illuminates a single slit of width $1 \times 10^{-4} m$. Calculate the distance between two dark lines on either side to the central maximum, when the diffraction pattern is viewed on a screen kept 1.5 m away from the slit.

25. If a compass is taken to magnetic north pole of earth, what will be the direction of the needle?

26. Using Rutherford model of the atom, derive the expression for the total energy of the electron in hydrogen atom. What is the significance of total negative energy possessed by the electron?

OR

The ground state energy of hydrogen atom is -13.6 eV. If an electron makes a transition from an energy level -1.51 eV to - 3.4 eV, then calculate the wavelength of the spectral line emitted and name the series of hydrogen spectrum to which it belongs.

27. How does a light emitting diode (LED) work? Give two advantages of LED's over the conventional incandescent lamps.

OR

The gain of a common-emitter amplifier is given by $A_V = -g_m R_L$. If R_L is increasing indefinitely, will the gain of the amplifier also increase indefinitely? Explain.

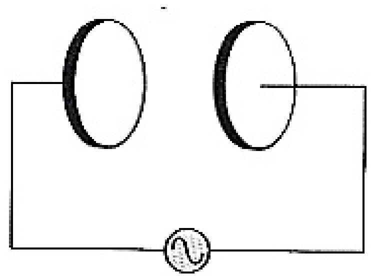
Section C

28. An oil drop of 12 excess electrons is held stationary under a constant electric field of $2.55 \times 10^4 NC^{-1}$ in Millikan's oil drop experiment. The density of the oil is 1.26g cm^{-3}. Estimate the radius of the drop. ($g = 9.81 ms^{-2}, e = 1.60 \times 10^{-19} C$)

29. Three identical parallel plate capacitor (air) C_1, C_2, C_3 have capacitance C each. The space between their plates is now filled with dielectrics as shown. If all three capacitors still have equal capacitance, obtain the relation between dielectric constants, k, k_1, k_2, k_3 and k_4.

30. i. A rod of length l is moved horizontally with a uniform velocity v in a direction perpendicular to its length through a region in which a uniform magnetic field is acting vertically downward. Derive the expression for the emf induced across the ends of the rod.
    ii. How does one understand this motional emf by invoking the Lorentz force acting on the free charge carriers of the conductor? Explain.

31. A parallel plate capacitor made of circular plates each of radius R = 6.0 cm has a capacitance C = 100 pF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad s^{-1}.



a. What is the rms value of the conduction current?
b. Determine the amplitude of B at a point 3.0 cm from the axis between the plates.

32. Two sources of intensity I and 4 I are used in an interference experiment. Find the intensity at a point where the waves from the two sources superimpose with a phase difference of

i. zero
ii. $\frac{\pi}{2}$
iii. π.

OR

i. Light passes through two polaroids P_1 and P_2 with pass axis of P_2 making an angle θ with the pass axis of P_1. For what value of θ is the intensity of emergent light zero?
ii. A third polaroid is placed between P_1 and P_2 with its pass axis making an angle β with the pass axis of P_1. Find the value of β for which the intensity of light from P_2 is $I_0/8$, where I_0 is the intensity of light on the polaroid P_1. $(Given,\ \theta = 90^\circ)$

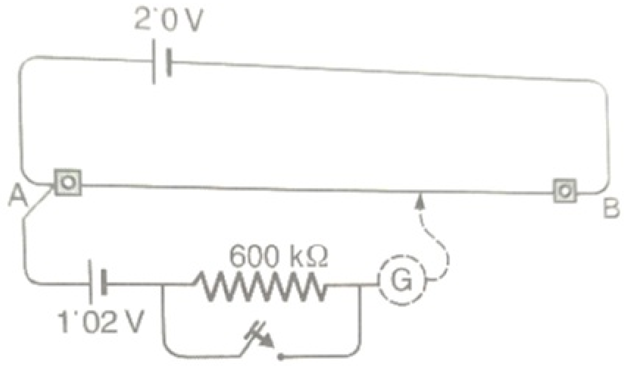
33. The ground state energy of hydrogen atom is -13.6 eV . What are the kinetic and potential energies of the electron in this state?

34. i. Describe briefly the functions of the three segments of n-p-n transistor.
ii. Draw the circuit arrangement for studying the output characteristics of n-p-n transistor in CE configuration. Explain how the output characteristics is obtained.

Section D

35. Figure shows a potentiometer with a cell of 2·0 V and internal resistance 0·4 Ω maintaining a potential drop across the resistor wire AB. A standard cell which

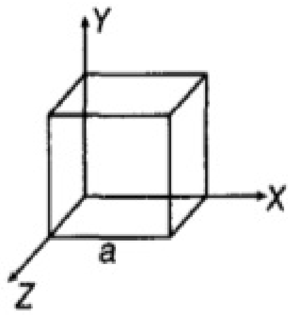
maintains a constant e.m.f. $E_1 = 1 \cdot 02$ V (for very moderate currents up to a few ampere) gives a balance point at $67 \cdot 3$ cm length of the wire. To ensure very low currents drawn from the standard cell, a very high resistance of 600 kΩ is put in series with it, which is shorted close to the balance point. The standard cell is then replaced by a cell of unknown e.m.f. E_2 and the balance point found similarly turns out to be at $82 \cdot 3$ cm length of the wire.



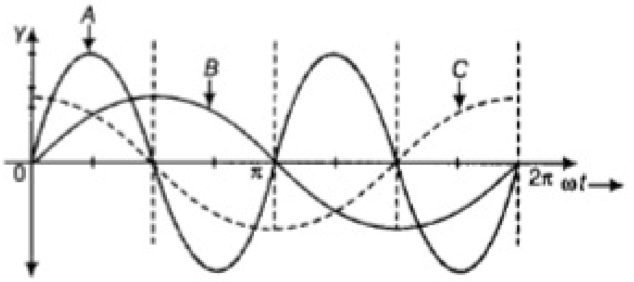
a. What is the value of E_2?
b. What purpose does the high resistance of 600 kΩ have? Is the balance point affected by this high resistance?
c. Is the balance point affected by the internal resistance of the driver cell?
d. Would the method work in the above situation, if the driver cell of the potentiometer had an e.m.f. of $1 \cdot 0$ V instead of $2 \cdot 0$ V?
e. Would the circuit work well for determining extremely small e.m.f., say of the order of a few mV (such as the typical e.m.f. of a thermocouple)?

OR

i. An electric dipole of dipole moment p consists of point charges +q and -q separated by a distance 2d apart. Deduce the expression for the electric field E due to the dipole at a distance r from the centre of the dipole on its axial line in terms of the dipole moment p. Hence, show that in the limit $r >> d, \mathbf{E} \longrightarrow 2p/\left(4\pi\varepsilon_0 r^3\right)$.
ii. Given the electric field in the region $E = 2x\hat{\mathbf{i}}$, find the net electric flux through the cube and the charge enclosed by it.



36. A device X is connected to an AC source, $V = V_0 \sin \omega t$. The variation of voltage, current and power in one cycle is shown in the following graph.



i. Identify the device X
ii. Which of the curves A, B and C represent the voltage, current and the power consumed in the circuit? Justify the answer.
iii. How does its impedance vary with the frequency of the AC source? Show graphically.
iv. Obtain an expression for the current in the circuit and its phase relation with AC voltage.

OR

A potentiometer wire of length 100 cm has a resistance of 10Ω. It is connected in series with a resistance and an accumulator of emf 2V and of negligible internal resistance. A source of emf 10 mV is balanced against a length of 40 cm of the potentiometer wire. What is the value of the external resistance?

37. a. Explain, using a suitable diagram, how unpolarized light gets linearly polarized by scattering.
b. Describe briefly the variation of the intensity of transmitted light when a polaroid sheet kept between two crossed polaroids is rotated. Draw the graph depicting the variation of intensity with the angle of rotation. How many maxima and minima

would be observed when θ varies from 0 to π?

OR

With the help of ray diagram, show the formation of image of a point object by refraction of light at a spherical surface separating two media of refractive indices n_1 and n_2 ($n_2 > n_1$)respectively. Using this diagram, derive the relation. $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ Write the sign conventions used. What happens to the focal length of convex lens when it is immersed in water?

Answer
Section A

1. (a) -6.67 nC

   Explanation:

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

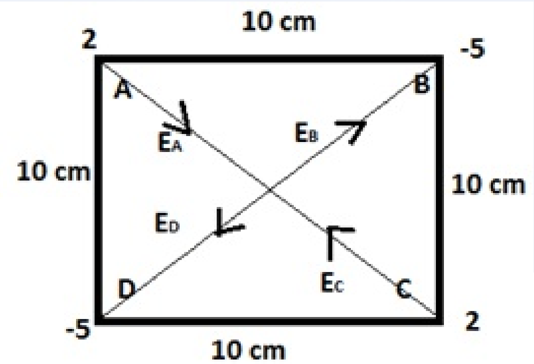
   $1.5 \times 10^3 = \frac{9\times10^9 q}{\left(20\times10^{-2}\right)^2}$

   $q = 6.67 \times 10^{-9} C = 6.67 nC$

   Since the electric field is inwards so charge is negative.

2. (a) 0 N

   Explanation:



   All the point charges (placed at vertices of sqaure) are equidistant from centre of the sqaure. Electric field at centre due to charge placed A is equal and opposite to electric field at centre due to charge placed at C.
   Similiarly, Electric field at centre due charge placed B is equal and opposite to electric field at centre due to charge placed at D. So the net electric field at centre = 0, so force on charge 1μC, (q x Enet) =0

3. (b) $\frac{3}{4}$ CV^2

   Explanation: $\frac{3}{4}$ CV^2

4. (b) zero

   Explanation: As on a equipotential surface the potential is constant. Thus potential diffrence between two points in zero thus W=(V_b - V_a)/q will be equal to zero as V_b - V_a = 0

5. (a) $4Am^2$

   Explanation: Magnetic Moment = Magnetization × Volume

   Side of cube = 20 cm = 0.2 m

   = 500 × 0.2 × 0.2 × 0.2 = $4Am^2$

6. (b) $3 \times 10^{15}\text{kHz}, 3.3 \times 10^{-17}\text{s}$

   Explanation:

   $$\nu = \frac{c}{\lambda} = \frac{3\times10^8}{0.1\times10^{-9}} = 3\times10^{18}Hz = 3\times10^{15}kHz$$

   $$T = \frac{1}{\nu} = \frac{1}{3\times10^{18}Hz} = 3.33\times10^{-17}s$$

7. (c) 10^{-6} rad

   Explanation:

   The limit of resolution of a telescope is given by $d\theta = 1.22\lambda$
   limit of resolution $\theta = \frac{1.22\lambda}{d}$
   putting the values in above equation we get,
   $\theta = \frac{1.22\times5000\times10^{-10}}{10\times10^{-2}}$
   order 10^{-6} rad.

8. (b) 560 nm

   Explanation:

   using the relation $\frac{xd}{D} = 2\lambda$
   $= \frac{4.5\times0.030\times10^{-3}}{2.4}$ = 560nm

9. (b) $\frac{d}{m_1 - m_2}$

Explanation:

If D is the distance between the object and the screen, d is separation between two positions of lens forming images on the screen, then

$m_1 = \frac{D+d}{D-d}$ and $m_2 = \frac{D-d}{D+d}$

$m_1 - m_2 = \frac{4dD}{D^2-d^2}$

but, $\frac{D^2-d^2}{4D} = f$

so $m_1 - m_2 = \frac{d}{f}$

or $f = \frac{d}{m_1-m_2}$

10. (c) is independent of the radiation intensity
    Explanation: The stopping potential is defined as the potential necessary to stop any electron even the electron with the most kinetic energy from reaching the other plate. By changing radiation intensity only no.of emitted electron changes their Kinetic energy will not change.

11. Isoclinical

OR

Maximum

12. Directly

13. Biot-Savart's law

14. Nuclear

15. Seven

16. During β- decay, neutron gets converted into proton, electron and anti neutrino as following -
    n $\rightarrow$ p + e + v

    i. no change in mass number.

ii. atomic number increases by 1.

17. Tritium and Plutonium.

18. In LED, energy of the photon should be equal to or less than the band gap energy i.e.
$h\nu \leqslant E_g$
where, E_g = band gap energy,
ν = frequency of emitted photon.

19. Photoelectric emission is not possible at all frequencies because below the threshold frequency for photosensitive surface of different atoms emission is not possible.

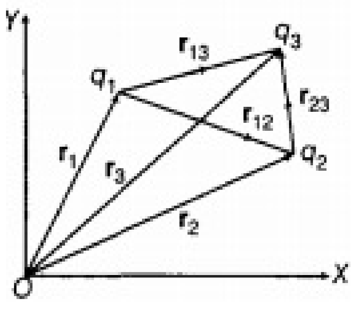
20. In LED, energy of the photon should be equal to or less than the band gap energy i.e.
$h\nu \leqslant E_g$
where, E_g = band gap energy,
ν = frequency of emitted photon.

OR

Reverse biasing.

Section B

21. Let three point charges q_1, q_2 and q_3 have their position vectors r_1, r_2 and r_3 from the origin O, respectively.



Potential energy due to the charges q_1 and q_2,
$U_{12} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{|\mathbf{r}_{12}|} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{|\mathbf{r}_2 - \mathbf{r}_1|}$
Slmilary potential energy due to the charges q_2 and q_3, $U_{23} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_2 q_3}{|\mathbf{r}_3 - \mathbf{r}_2|}$ and the potential energy due to the charges q_1 and q_3,
$U_{31} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_3}{|\mathbf{r}_3 - \mathbf{r}_1|}$

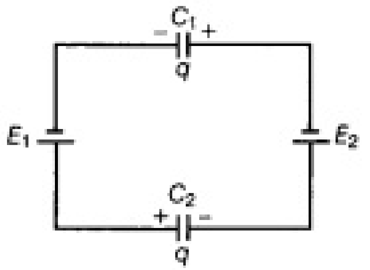
$\therefore$ Net potential energy of the system of the three charges,

U = U_{12} + U_{23} + U_{31}

$$\Rightarrow U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{|\mathbf{r}_2-\mathbf{r}_1|} + \frac{q_2q_3}{|\mathbf{r}_3-\mathbf{r}_2|} + \frac{q_1q_3}{|\mathbf{r}_3-\mathbf{r}_1|}\right]$$

22. Potential difference(taking the clockwise closed loop of the circuit and applying KVL in the closed loop),

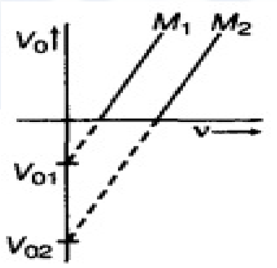
$\frac{-q}{C_1} + E_1 - \frac{q}{C_2} - E_2 = 0$ or $\frac{q}{C_1} + \frac{q}{C_2} = E_1 - E_2$



Now, $V_1 = \frac{-q}{C_1}$ and $V_2 = \frac{+q}{C_2}$

23. i. The slope of stopping potential (V_0) versus frequency (v) is equal to (h/e) which is universal constant, so slope is same for both lines.

ii. K.E. = hv - hv_0 As threshold frequency $v_0$is lesser for M_1, so K.E. will be greater for M_1 for same frequency v.



24. Given wavelength of the light used, $\lambda = 6000\overset{o}{A} = 6 \times 10^{-7}$ m ; distance of separation between the slits, $d = 1 \times 10^{-4}m$ and source to screen distance, D = 1.5 m. The separation between two dark lines on either side of the central maxima = fringe width of central maxima $= \frac{2D\lambda}{d}$

$= \frac{2\times1.5\times6\times10^{-7}}{1\times10^{-4}} = 18 \times 10^{-3}\text{m} = 18\text{mm}$

25. 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.

26. The Rutherford nuclear model of the atom describes the atom as an electrically neutral sphere consisting of a very small, massive and positively charged nucleus at the centre surrounded by the revolving electrons in their respective dynamically stable orbits. The electrostatic force of attraction F, between the revolving electrons and the nucleus provides the requisite centripetal force (F_c) to keep them in their orbits. Thus, for a dynamically stable orbit in a hydrogen atom

$F_c = F_e$

$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r^2}$ [Z = 1]

Thus, the relation between the orbit radius and the electron velocity is

$r = \frac{e^2}{4\pi\varepsilon_0 mv^2}$

The kinetic energy (K) and electrostatic potential energy (U) of the electron in hydrogen atom are

$K = \frac{1}{2}mv^2 = \frac{e^2}{8\pi\varepsilon_0 r}$

and $U = -\frac{e^2}{4\pi\varepsilon_0 r}$

(The negative sign in U signifies that the electrostatic force is attractive in nature.)

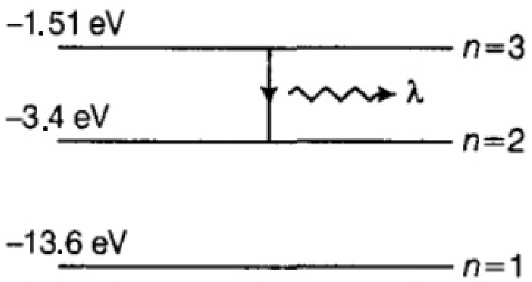
Thus, the total mechanical energy E of the electron in a hydrogen atom is

$E = K + U = \frac{e^2}{8\pi\varepsilon_0 r} - \frac{e^2}{4\pi\varepsilon_0 r} = -\frac{e^2}{8\pi\varepsilon_0 r}$

The total energy of the electron is negative. This implies the fact that the electron is bound to the nucleus. If E were positive, an electron will not follow a dosed orbit around the nucleus and it would leave the atom.

OR

Energy levels of H-atom are ,



we know that , The wavelength of spectral line emitted

$\lambda = hc/\Delta E$

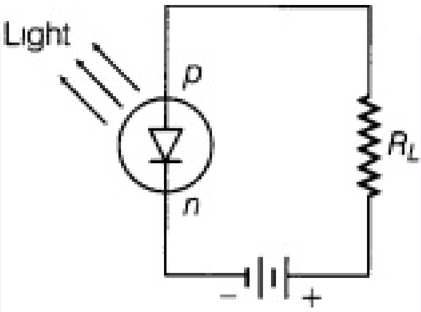
Taking, hc = 1240 eV-nm

We have, ΔE = 1.51 - (-3.4) = 1.89 eV

$\therefore \quad \lambda = \frac{12.4}{1.89} = \frac{1240}{189} \approx 656\text{nm}$

This belongs to Balmer series.

27. Working of LED:-When we apply sufficient voltage to LED, electron move across the junction into p-region and get attracted to the holes these holes are sent from p region ton region (where they are minority carriers). Thus, electrons and holes recombine. During each recombination, the electric potential energy is converted into the electromagnetic energy and a photon of light with a characteristic frequency is emitted, this is how, LED works.



Advantages of LED

i. **LED** are small
ii. solid **light bulbs** which are extremely energy efficient and long-lasting.
iii. Low operational voltage and less power consumed, long life.

OR

No, if the load resistance is increased indefinitely, the output current will become zero. Hence, the voltage gain will be zero. (Here g_m is called trans-conductance and is equal to current gain per unit input resistance).

Section C

28. Given, $E = 2.25 \times 10^4 NC^{-1}$

n = 12

$\rho = 1.26gm\ cm^{-3}$ or $1.26 \times 10^3 kg\ m^{-3}$

Since, the droplet is stationary weight of the droplet = force due to the electric field

$\therefore \frac{4}{3}\pi r^3 \rho g$ = Ene mg = Eq

or $r^3 = \frac{3Ene}{4\pi\rho g}$

or $r^3 = \frac{3\times 2.55\times 10^4\times 12\times 1.6\times 10^{-19}}{4\times 3.14\times 1.26\times 10^3\times 9.81}$

$= 0.9\times 10^{-18}$

or $r = (0.9\times 10^{-18})^{1/3}$

$r = 9.81\times 10^{-7}m$

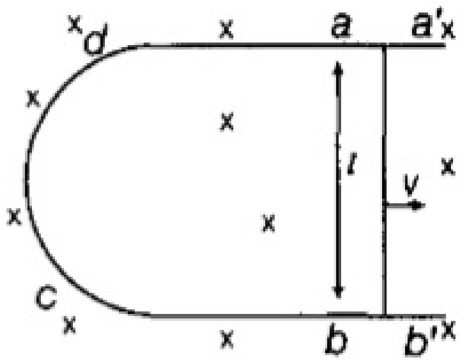
29. After introducing the dielectrics the capacitance of capacitors C_1, C_2 and C_3 respectively is given as

$C = \frac{k\varepsilon_0 A}{d}, C = \frac{2\varepsilon_0 A}{d}\left[\frac{k_1 k_2}{k_1+k_2}\right] C = \frac{\varepsilon_0 A}{2d}[k_3 + k_4]$

$\Rightarrow \frac{k\varepsilon_0 A}{k} = \frac{2\varepsilon_0 A}{d}\left(\frac{k_1 k_2}{k_1+k_2}\right) = \frac{\varepsilon_0 A}{2d}(k_3 + k_4)$

$\Rightarrow k = \frac{2k_1 k_2}{k_1+k_2} = \frac{k_3+k_3}{2}$

30. i. Consider a straight conductor moving with uniform velocity v perpendicular to the magnetic field as shown in the figure.



Let conductor shifts from position a b to a' b' in time dt, then change in magnetic flux

$d\phi = B\times$ change in area

$= B\times(\text{ area } of\ a'b'ab) = B\times(l\times vdt)$

$\therefore \quad \frac{d\phi}{dt} = Bvl$

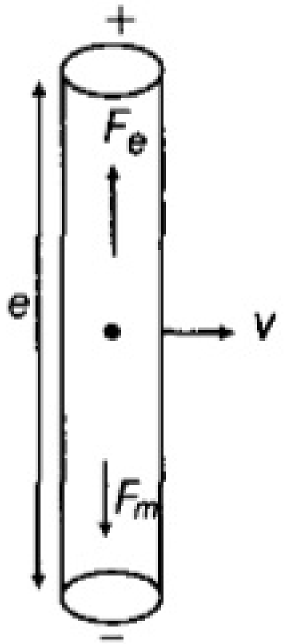
$\therefore \quad$ Induced emf $|e| = \frac{d\phi}{dt} = Bvl$, this is the expression for induced emf.

Thus, the emf induced across the ends of conductor due to its motion is called motional emf.

ii. During motion, free electrons(e^-) are shifted at one end due to magnetic force.

So, due to polarisation of rod, electric field is produced which applies electric force on free electrons (e^-) in opposite direction. Thus, induced emf will be motional.

At the state of equilibrium of Lorentz force,



$\mathrm{F}_e + \mathrm{F}_m = 0$ [sum of electrostatic force and magnetic force = 0]

$\Rightarrow \quad q\mathbf{E} + q(\mathbf{v} \times \mathbf{B}) = 0$

$\Rightarrow \vec{E} = -\vec{v} \times \vec{B} = \vec{B} \times \vec{v}$

$\therefore |\mathrm{E}| = |Bv \sin 90^\circ|$

$\Rightarrow \frac{dV}{dr} = Bv$ [$\because \vec{E} = -\frac{dV}{dr}\hat{n}$] Hence potential difference i.e. the emf produced,

∴Potential~difference = B v l

31. a. Here, a = 6.0 cm

C = 100 pF = $100 \times 10^{-12} F$

$\omega = 300\ rads^{-1}$

E_{rms} = 230V

$I_{rms} = \frac{E_{rms}}{X_C} = \frac{E_{rms}}{\frac{1}{\omega C}} = E_{rms} \times \omega C$

$\therefore I_{rms} = 230 \times 300 \times 100 \times 10^{-12}$

$= 6.9 \times 10^{-6} A = 6.9 \mu A$

b. Since, I = I_D whether I is steady d.c. or a.c. This is shown below:

$I_D = \varepsilon_0 \frac{d(\phi_E)}{dt} = \varepsilon_0 \frac{d}{dt}(EA) (\because \phi_E = EA)$

Or $I_D = \varepsilon_0 A \frac{dE}{dt}$
$= \varepsilon_0 A \frac{d}{dt}\left(\frac{Q}{\varepsilon_0 A}\right)\left(\because E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}\right)$
$I_D = \varepsilon_0 A \times \frac{1}{\varepsilon_0 A}\frac{dQ}{dt} = \frac{dQ}{dt} = I$
We know that
$B = \frac{\mu_0}{2\pi}\frac{r}{R^2} I_D$
This formula goes through even if I_D (and therefore B) oscillates in time. The formula shows that they oscillate in phase. Since I_D = I , we have
$B = \frac{\mu_0 r I}{2\pi R^2}$
If I = I_0 , the maximum value of current, then amplitude of B = maximum value of B
$= \frac{\mu_0 r I_0}{2\pi R^2} = \frac{\mu_0 r \sqrt{2}\ I_{rms}}{2\pi R^2}\ (\because I_0 = \sqrt{2}\ I_{rms})$
$= \frac{4\pi \times 10^{-7} \times 0.03 \times \sqrt{2} \times 6.9 \times 10^{-6}}{2 \times 3.14 \times (0.06)^2} T$
$= 1.63 \times 10^{-11} T$

32. In case of interference
$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

i. As $\phi = 0, \cos\phi = 1$
$\therefore I = 4I + I + 2\sqrt{4I \times I} \times 1 = 9I$
ii. As $\phi = \frac{\pi}{2}, \cos\phi = 0$
$\therefore I = 4I + I + 2\sqrt{41 \times I} \times 0 = 5I$
iii. As $\phi = \pi, \cos\phi = -1$
$\therefore I = 4I + I + 2\sqrt{4I + I} \times (-1) = I$

OR

i. By Malus' law, intensity of emergent light from the polaroid $P_2, I = I_0 \cos^2\theta$, where θ is the angle between P_1 and P_2
when $\theta = 90^\circ \quad \Rightarrow I = I_0 \times 0\,(\because \cos\theta = 0)$
Intensity of emergent light,
I = 0
ii. The intensity of emergent light from P_3

$I = \frac{I_0}{2} \cos^2 \beta$

The intensity of emergent light from P_2

$\frac{I_0}{8} = I \cos^2(\theta - \beta)$ [where $(\theta - \beta)$ is the axis of polaroid P_2 with respect to the polaroid P_3]

$\therefore \frac{I_0}{8} = \frac{I_0}{2} \cos^2 \beta \cos^2(\theta - \beta) \Rightarrow cos^2\beta\ sin^2\beta = \frac{1}{4}$ [given, $\theta = 90°$]$\Rightarrow$
$(2sin\beta\ cos\beta)^2 = 1$

$\Rightarrow \sin 2\beta = 1$

$\Rightarrow \quad 2\beta = 90°$

$\Rightarrow \quad \beta = 45°$

33. Here, Ground Energy, E = -13.6 eV

Kinetic energy, $E_k = \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{2r} [E_k = 2E_p]$

and Potential energy, $E_p = -\frac{1}{4\pi\varepsilon_0} \frac{e^2}{r} \left[\because E_p = \frac{-k\ q_1 q_2}{r}\right]$

Total energy, E = E_k + E_p

$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{2r} - \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r}$

$E = -\frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r}\right)$

$-13.6 = -\frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r}\right)$

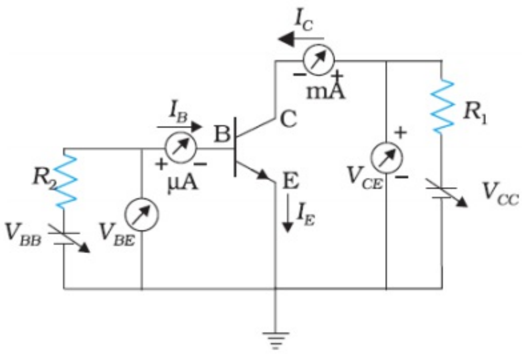
$\therefore \frac{1}{4\pi\varepsilon_0} \frac{e^2}{r} = 27.2$

$\therefore E_k = \frac{1}{4\pi\varepsilon_0} \frac{e^2}{2r} = \frac{27.2}{2} eV = 13.6EV$

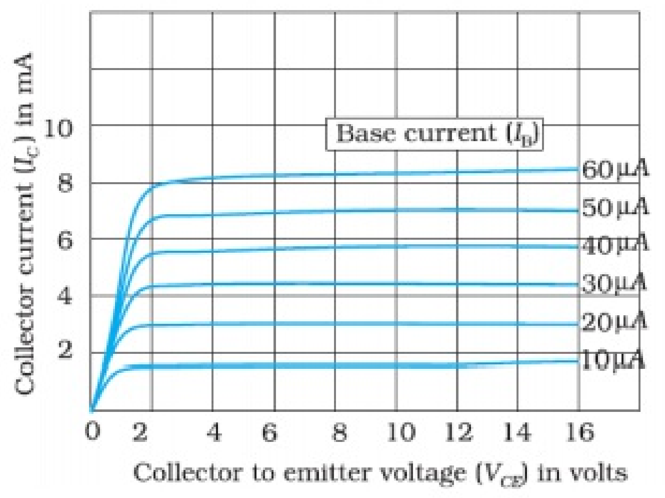
$E_p = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{r} = -27.2\ eV$

34. i. Function of the three segments of n-p-n transistor are
    i. Emitter: Supplies the large number of majority carriers for current flow through the transistor.
    ii. Base: Allows most of the majority charge carriers to go over to the collector.
    iii. Collector: collects a major portion of the majority charge carriers supplied by the emitter.

ii.



The output characteristics are obtained by observing the variation of Ic when V_{CE} is varied keeping I_B constant.



Section D

35. a. Here, l_1 = 67·3 cm; l_2 = 82·3 cm; E_1 = 1·02 V

Now, $\frac{E_2}{E_1} = \frac{l_2}{l_1}$

or E_2 = $\frac{l_2}{l_1} \times E_1 = \frac{82{\cdot}3}{67{\cdot}3} \times 1 \cdot 02 = 1 \cdot 243V$

b. The purpose of using high resistance is to allow only a very small current to flow through the galvanometer when the balance point has not been obtained.

No, the balance of point is not affected by the presence of high resistance.

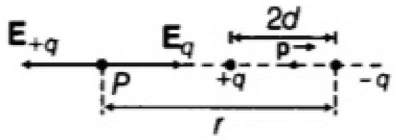
c. No, the balance point is not affected by the internal resistance of the driver cell.

d. No, the arrangement will not work. If the e.m.f. of the driver cell is less than that of the cell whose e.m.f. is to be found, the balance point will not be obtained.

e. The circuit is not suitable for measuring extremely small e.m.f. It is because in such a case, the balance point will be just close to the end A.

OR

i. Let P be a point at distance r from the centre of the dipole on the side of charge -q so its distance from +q will be r+d and from +q its distance will be r-d.



Then, the Electric field at point P due to charge -q of the dipole is given by,

$E_{-q} = -\frac{q}{4\pi\varepsilon_0 (r+d)^2}\hat{p}$

where, $\hat{p}$ is the unit vector along the dipole axis (from -q to q) as shown in the figure.

Also, the electric field at point P due to charge +q of the dipole is given by,

$\mathbf{E}_{+q} = \frac{q}{4\pi\varepsilon_0 (r-d)^2}\hat{p}$

The total field at point P will be the vector sum of all the electric fields

$\mathbf{E} = \mathbf{E}_{+q} + \mathbf{E}_{-q} = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-d)^2} - \frac{1}{(r+d)^2}\right]\hat{p}$

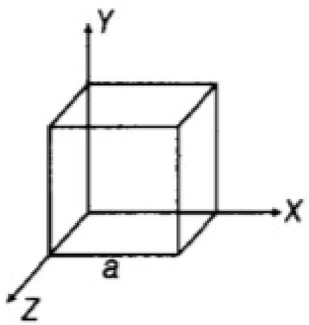
$\Rightarrow \quad \mathbf{E} = \frac{q}{4\pi\varepsilon_0} \cdot \frac{4dr}{\left(r^2-d^2\right)^2}\hat{p}$

For r >> d, $\mathbf{E} = \frac{4qd}{4\pi\varepsilon_0 r^3}\hat{\mathbf{p}}$

Now, electric dipole moment vector, $\mathbf{p}$ = q$\times$2d $\hat{p}$

Thus, $\mathbf{E} = \frac{2\mathbf{p}}{4\pi\varepsilon_0 r^3}$

So, electric field due to a dipole decreases as cube of the distance from the centre of the dipole.

ii. 

As per the problem, electric field has only x component, for faces normal to X - direction. The angle between E and ΔS is $\pm\pi/2$. Therefore, the flux is separately zero for each of the cube except the shaded ones. The magnitude of the electric field at the left face will be

$E_L = 0$ (as, x = 0 at the left face).

The magnitude of the electric field at the right face is E_R = 2a (as, x = a at the right face).

The corresponding fluxes are:

$\phi_L = \mathbf{E}_L \cdot \Delta\mathbf{S} = 0$

$\phi_R = \mathbf{E}_R \cdot \Delta\mathbf{S} = E_R \Delta S \cos\theta = E_R \Delta S \quad (\because \theta = 0^\circ)$

$\Rightarrow \quad \phi_R = E_R a^2$

Net flux (ϕ) through the cube

$= \phi_L + \phi_R = 0 + E_R a^2 = E_R a^2 \Rightarrow q = 2a(a)^2 = 2a^3$

Now,

$\phi = q/\varepsilon_0 \quad \therefore \quad q = \phi\varepsilon_0 = 2a^3\varepsilon_0$

36. i. Device X is a capacitor.

As the current is leading voltage by $\frac{\pi}{2}$ radians. And it happens only then when an ac source is connected with a pure capacitive circuit.

ii. Curve A represents power,

Curve B represents voltage and

Curve C represents current.

As, V (t)= V_0 sinωt

Current, I(t) = I_0 cos ωt ,with $I_0 = \frac{V_0}{X_C}$ (X_C being capacitive reactance)

As, in the case of capacitor,

$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$ [current is leading the voltage]

Average power, $P = V(t)I(t) = \frac{V_0 I_0}{2}\cos\phi$

where, ϕ = phase difference

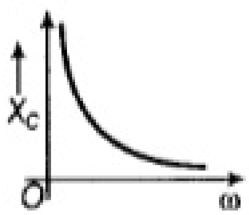
iii. As, X_C= capacitive reactance = $\frac{1}{C\omega}$

where ω is angular frequency and C being capacitance of the capacitor.

So, reactance or impedance decreases with increase in frequency.

Graph of X_C versus ω is shown below,

Phasor diagram



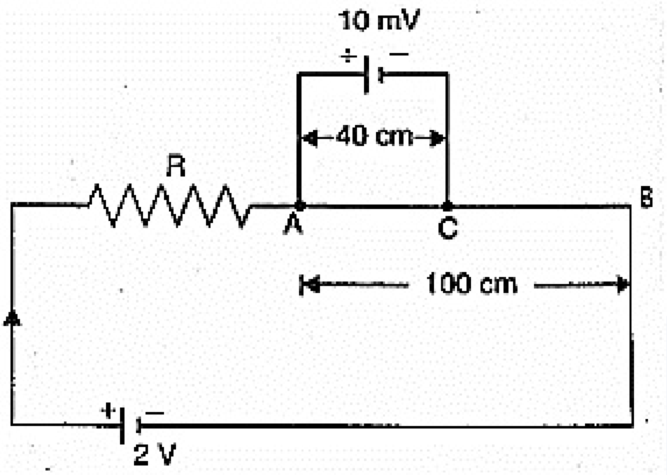
iv. For a capacitor fed with an AC supply

$V = \frac{q}{C}$ or $q = CV = CV_0 \sin \omega t$

$\therefore \quad I = \frac{dq}{dt} = V_0 \omega C \cos \omega t = \frac{V_0}{X_C} \sin\left(\omega t + \frac{\pi}{2}\right)$, since $\omega C = \frac{1}{X_C}$

OR

Let AB be the potentiometer wire and R, the external resistance, as shown in the figure. Potential drop across the wire AB = current × resistance



$= \left(\frac{2}{R+10}\right) \times 10 = \frac{20}{R+10}$

Therefore, the potential drop per cm of the wire is

$\frac{20}{100(R+10)} V cm^{-1}$

The fall of potential across 40 cm of the wire is

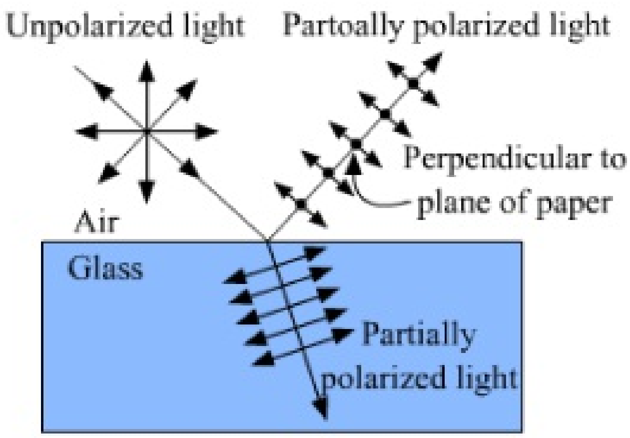
$= \frac{40 \times 20}{100(R+10)} = \frac{8}{R+10} V$

Which must be equal to the emf of the source when the balance is achieved.

Thus, $\frac{8}{R+10} = 10 \times 10^{-3} = \frac{1}{100}$

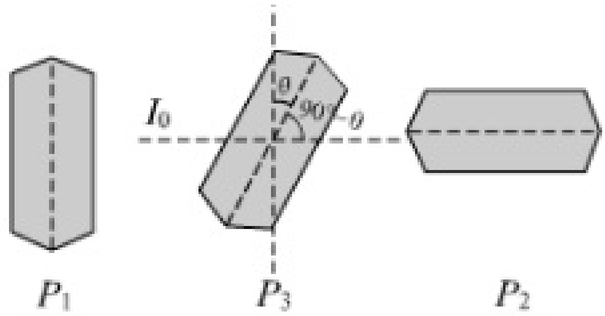
R + 100 = 800 or R = 790Ω

37. a.



When unpolarized light falls on a refracting medium some part of the light is refracted and some part is reflected. These reflected and refracted light is partially polarized and separated by an angle of $\frac{\pi}{2}$. The reflected polarized light is called polarisation by scattering.

b.



Let the rotating polaroid sheet makes an angle θ with the first polaroid. So, the angle with the other polaroid will be (90^0 - θ)

Let the intensity from the first polaroid be I_0, then by malus law the intensity by the polaroid P_2 is given by

$$I' = I_0 \cos^2 \theta$$

And by the third polaroid P_3 is given by

$$I'' = \left(I_0 \cos^2 \theta\right) \cos^2(90^\circ - \theta)$$

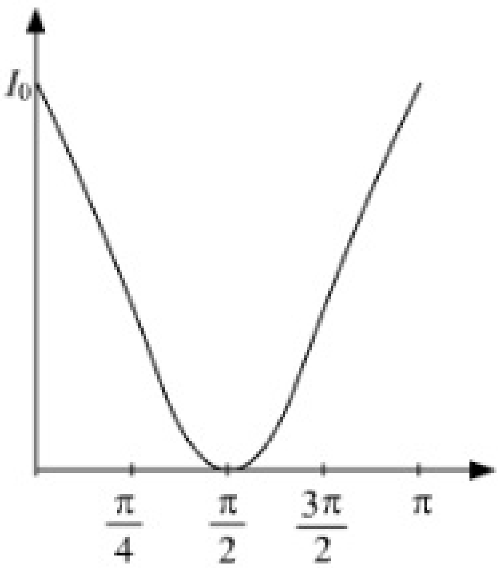
$$I'' = \frac{I_0}{4} \sin^2 \theta$$

Transmitted intensity will be maximum when $\sin^2 2\theta = 1$

$$\sin^2 2\theta = \sin^2 \frac{\pi}{2}$$

$$2\theta = \frac{\pi}{2}$$

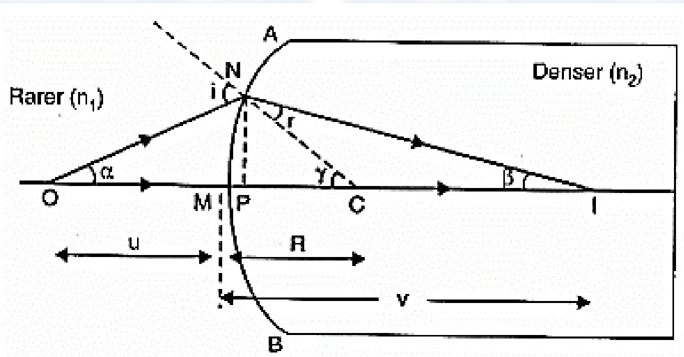
$$\theta = \frac{\pi}{4}$$



From the graph, we can see that there will be two maxima and one minimum would be observed when θ varies from 0 to π

OR

AMB is a convex surface separating two media of refractive indices n_1 and $n_2(n_2 > n_1)$. Consider a point object O placed on the principal axis. A ray ON is incident at N and refracts along NI. The ray along ON goes straight and meets the previous ray at I. Thus I is the real image of O.



From Snell's law, $n_2 = \frac{\sin i}{\sin r}$

$n_1 \sin i = n_2 \sin r$

$\frac{n_2}{n_1} = \frac{\sin i}{\sin r}$

or $n_1 i = n_2 r$ [$\because \sin\theta \cong \theta$ as θ is very small]

From $\Delta NOC, i = \alpha + \gamma$

From $\Delta NIC, \gamma = r - \beta$

or $r = \gamma - \beta$

$\therefore n_1(\alpha+\gamma)=n_2(\gamma-\beta)$

or $n_1\alpha+n_2\beta=(n_2-n_1)\gamma$

But $\alpha \cong \tan\alpha=\frac{NP}{OP}=\frac{NP}{OM}$ [P is close to M]

$\beta \cong \tan\beta=\frac{NP}{PI}=\frac{NP}{MI}$

$\gamma \cong \tan\gamma=\frac{NP}{PC}=\frac{NP}{MC}$

$\therefore n_1\cdot\frac{NP}{OM}+n_2\cdot\frac{NP}{MI}=(n_2-n_1)\frac{NP}{MC}$

or $\frac{n_1}{OM}+\frac{n_2}{MI}=\frac{n_2-n_1}{MC}$

Using Cartesian sign convention,

OM = -u, MI = +v, MC = +R

$\therefore \frac{n_1}{-u}+\frac{n_2}{v}=\frac{n_2-n_1}{R}$

or $\frac{n_2}{v}-\frac{n_1}{u}=\frac{n_2-n_1}{R}$