CBSE Class 12 Physics
Sample Paper - 08 (2019-20)

Maximum Marks: 70
Time Allowed: 3 hours

General Instructions:

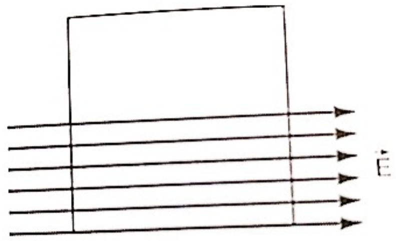
i. All questions are compulsory. There are 37 questions in all.
ii. This question paper has four sections: Section A, Section B, Section C and Section D.
iii. Section A contains twenty questions of one mark each, Section B contains seven questions of two marks each, Section C contains seven questions 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 charge q is placed at the center of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to

   a. $\frac{Q}{5}$
   b. $\frac{Q}{2}$
   c. $\frac{Q}{4}$
   d. $\frac{-Q}{4}$

2. A square surface of side L metres is in the plane of the paper. A uniform electric $\vec{E}$ (volt m^{-1}), also in the plane of the paper, is limited only to the lower half of the square surface as shown in the firgure. The electric flux (in SI units) associated with the surface is



a. EL^2

b. $\frac{EL^2}{2\epsilon_0}$

c. zero

d. $\frac{EL^2}{2}$

3. Which of the following is correct for energy of a dipole in a uniform electric field?

   a. It only alligns itself along the electric field

   b. Potential energy remains constant

   c. Dipole alligns along electric field and its energy decreases

   d. Energy is gained

4. Two parallel plate capacitors of capacitances C and 2C are connected in parallel and charged to a potential difference V by a battery. The battery is then disconnected and the space between the plates of capacitor C is completely filled with a material of dielectric constant K = 3. The potential difference across the capacitors now becomes

   a. $\frac{2V}{5}$

   b. $\frac{3V}{6}$

   c. $\frac{V}{4}$

   d. $\frac{3V}{5}$

5. Diamagnetic substances are

   a. those which have tendency to move from weaker to the stronger part of the external magnetic field

b. those which have tendency to move from stronger to the weaker part of the external magnetic field

c. those that develop a net magnetic moment in direction of applied field

d. those that are uneffected by external magnetic fields

6. A sinusoidal electromagnetic wave is propagating in vacuum in the +*z*-direction. If at a particular instant and at a certain point in space the electric field is in the +*x*-direction and has magnitude 4.00 V/m, what are the magnitude and direction of the magnetic field of the wave at this same point in space and instant in time?

a. 12.4 nT, +y-direction

b. 12.7 nT, +y-direction

c. 13.3 nT, +y-direction

d. 13.0 nT, -y-direction

7. The propagation of light is best described by-

a. Particle model

b. Wave model

c. Rectilinear propagation of light

d. Dual / schizophrenic model

8. Referring to the Young's double slit experiment, if D is the distance from two slit plane to screen and d the distance between two coherent sources then fringe width is given by

a. $\frac{3\lambda D}{d}$

b. $\frac{2\lambda D}{d}$

c. $\frac{\lambda D}{d}$

d. $\frac{\lambda D}{2d}$

9. A bird flies down vertically towards a water surface. To a fish inside the water, vertically below the bird, the bird will appear to

   a. move faster than its actual speed

   b. be at its actual distance

   c. move slower than its actual speed

   d. be closer than its actual distance

10. A photoelectric cell converts

    a. light energy into electric energy

    b. electric into light energy

    c. light energy into heat energy

    d. light energy into sound energy

11. Fill in the blanks:

    Above Curie's temperature, ferromagnetic substances becomes ________.

OR

Fill in the blanks:

The lines joining the places of equal declination are called ________ lines.

12. Fill in the blanks:

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

13. Fill in the blanks:

    If two wires carry currents in ________ directions, the wires repel each other.

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 focal length of a plane glass plate is ________.

16. Why is it found experimentally difficult to detect neutrinos in nuclear β-decay?

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

18. How does the thickness of the depletion layer in a p-n junction vary with the increase in reverse bias?

19. Show the variation of photoelectric current with collector plate potential for different frequencies but same intensity of incident radiation.

20. 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)

    OR

    How does the energy gap in an intrinsic semiconductor change, when doped with a trivalent impurity?

Section B

21. Define the term 'dielectric constant' of a medium in terms of capacitance of a capacitor.

22. 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?

23. A proton and an α-particle are accelerated the same potential difference. How are the λ_p and λ_α related to each other?

24. Find an expression for intensity of transmitted light, when a polaroid sheet is rotated

between two crossed polaroids. In which position of the polaroid sheet will the transmitted intensity be maximum?

25. What is the angle of dip at a place where horizontal and vertical components of earth's field are equal?

26. An α-particle moving with initial kinetic energy K towards a nucleus of atomic number Z approaches a distance d at which it reverses its direction. Obtain the expression for the distance of closest approach d in terms of the kinetic energy of α-particle K.

OR

Using the relevant Bohr's postulates derive the expression for the radius of the electron in the nth orbit of the electron in hydrogen atom.

27. How is forward biasing different from reverse biasing in a p- n junction diode?

OR

How is forward biasing different from reverse biasing in a p- n junction diode?

Section C

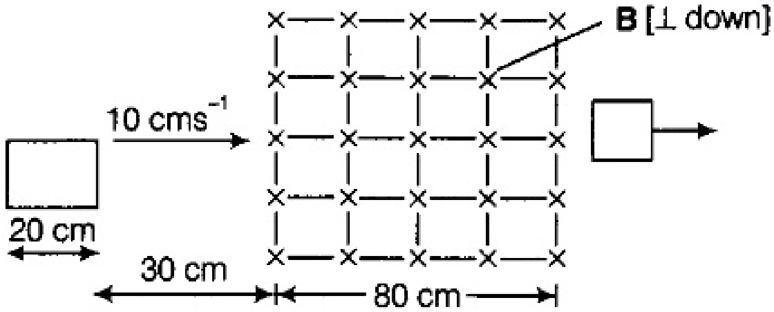
28. A dipole with a dipole moment of magnitude p is in stable equilibrium in an electrostatic field of magnitude E. Find the work done in rotating this dipole from its stable position to unstable position?

29. An electron of mass m_e revolves around a nucleus of charge +Ze. Show that it behaves like a tiny magnetic dipole. Hence, prove that the magnetic moment associated with it is expressed as $\mu = -\frac{e}{2m_e}L$, where L is the orbital angular momentum of the electron. Give the significance of negative sign.

30. A square loop of side 20 cm is initially kept 30 cm away from a region of uniform magnetic field of 0.1 T as shown in the figure. It is then moved towards the right with a velocity of 10 cm s^{-1} till it goes out of the field. Plot a graph showing the variation of

    i. magnetic flux (ϕ) through the loop with time (t).

ii. induced emf (ε) in the loop with time t.
iii. induced current in the loop, if it has resistance of 0.1Ω



31. Find the wavelength of electromagnetic waves of frequency 5×10^{19} Hz in free space. Give its two applications.

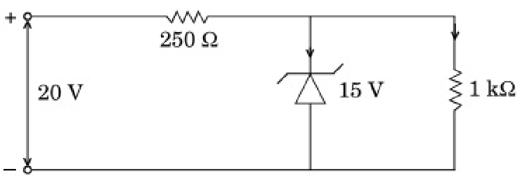
32. The ratio of the intensities at minima in the interference pattern is 9 : 25. What will be the ratio of the widths of the two slits in the Young's double slit experiment?

OR

i. In what way is diffraction from each slit related to the interference pattern in a double slit experiment.
ii. Two wavelengths of sodium light 590 nm and 596 nm are used, in turn to study the diffraction taking place at single slit of aperture $2 \times 10^{-4} m$. The distance between the slit and the screen is 1.5 m. Calculate the separation between the positions of the first maxima of the diffraction pattern obtained in the two cases.

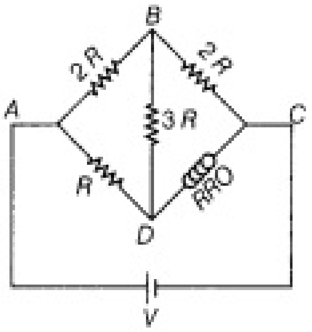
33. Calculate the radius of the first orbit of hydrogen atom. Show that the velocity of electron in the first orbit is $\frac{1}{137}$ times the velocity of light.

34. Give reason to explain why n and p regions of a Zener diode are heavily doped. Find the current through the Zener diode in the circuit given below: (Zener breakdown voltage is 15 V)



Section D

35. i. Use Kirchhoffs rules to obtain the balance condition in a Wheatstone bridge.



ii. Calculate the value of R in the balance condition of the Wheatstone bridge, if the carbon resistor connected across the arm CD has the colour sequence red, red and orange, as shown in the figure.

iii. If now the resistance of the arms BC and CD are interchanged, to obtain the balance condition, another carbon resistor is connected in place or R. What would now be sequence of colour bands of the carbon resistor?

OR

An electric dipole of dipole moment $\vec{\mathbf{p}}$ is placed in a uniform electric field $\vec{\mathbf{E}}$. Write the expression for the torque $\vec{\tau}$ experienced by the dipole. Identify the two pairs of perpendicular vectors in the expression. Show diagrammatically the orientation of the dipole in the field for which the torque is

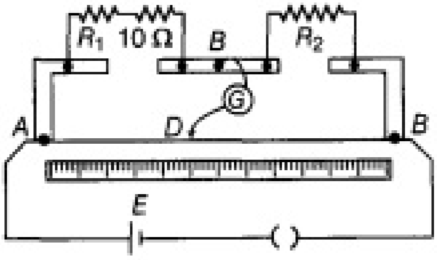
i. maximum,
ii. half the maximum value and
iii. zero

36. i. Write the function of a transformer. State its principle of working with the help of a diagram. Mention various energy losses in this device.
ii. The primary coil of an ideal step-up transformer has 100 turns and transformation ratio is also 100. The input voltage and power are respectively 220 V and 1100 W. Calculate
  a. number of turns in secondary
  b. current in primary
  c. voltage across secondary
  d. current in secondary
  e. power in secondary

OR

a. State Kirchhoff's rules for an electric network. Using Kirchhoff's rules, obtain the balance condition in terms of the resistances of four arms of Wheatstone bridge.
b. In the meter bridge experimental set up, shown in the figure, the null point D is obtained at a distance of 40 cm from end A of the meter bridge wire. If a resistance of 10Ω is connected in series with R_1, null point is obtained at AD = 60 cm.

Calculate the values of R_1 and R_2.



37. a. Draw the ray diagram showing the refraction of light through a glass prism and hence obtain the relation between the refractive index μ of the prism, angle of prism and angle of minimum deviation.
b. Determine the value of the angle of incidence for a ray of light travelling from a medium of refractive index $\mu_1 = \sqrt{2}$ into the medium of refractive index μ_2 = 1, so that it just grazes along the surface of separation.

OR

Complete the path of an incident ray of light, showing the formation of a real image. Hence derive the relation connecting object distance u image distance v radius of curvature R, and the refractive indices n_1 and n_2 of the two media.

Briefly explain, how the focal length of a convex lens changes, with an increase in wavelength of the incident light.

Answer
Section A

1. (d) $\frac{-Q}{4}$

   Explanation: Let the separation between the two particles of charges Q be 2a. Coulomb's forces on the charge q due to the other two charges are equal and opposite.

   Hence, charge q is always in equilibrium irrespective of its sign and magnitude. Coulomb's force on a charge Q due to another charge Q is repulsive in nature and has magnitude $F_Q = Q^2/\left(16\pi\varepsilon_0 a^2\right) = -Qq/\left(4\pi\varepsilon_0 a^2\right)$. Which gives $q = \frac{-Q}{4}$

2. (c) zero
   Explanation: zero
3. (c) Dipole alligns along electric field and its energy decreases
   Explanation: The potential energy of an electric dipole at any point in uniform electric field is $U = -pE\cos\theta$, when the dipole alligns itself along electric field it gains low energy state during this process due to which its energy decreases.
4. (d) $\frac{3V}{5}$

   Explanation: The charges on the capacitors after being charged to a potential V are Q_1 = CV; Q_2 = 2CV.

   After being filled with a material of dielectric K = 3 the capacitor which initially had a capacitance C has now the capacitance KC = 3C. The common potential
   $V_1 = \frac{\text{Total charge}}{\text{Total capacitance}} = \frac{Q_1+Q_2}{3C+2C}$
   $= \frac{CV+2CV}{5C} = \frac{3}{5}V$

5. (b) those which have tendency to move from stronger to the weaker part of the external magnetic field
   Explanation: Diamagnetic substances get feebly magnetized in the direction opposite to that of applied magnetic field, hence they tend to move from region of stronger magnetic field to weaker magnetic field.

6. (c) 13.3 nT, +y-direction

   Explanation:

   $$B_o = \frac{E_o}{c} = \frac{4}{3 \times 10^8} = 1.33 \times 10^{-8} T = 13.3 nT$$

   Direction of propogation of wave is in the direction of $\overrightarrow{E} \times \overrightarrow{B}$, hence direction of $\overrightarrow{B}$ is along +y axis.

7. (d) Dual / schizophrenic model

   Explanation: According to Maxwell's Electromagnetic theory of light, Light is an electromagnetic wave and it has a dual nature i.e it has both wave nature and particulate nature.

8. (c) $\frac{\lambda D}{d}$

   Explanation: $\beta = \frac{\lambda D}{d}$

   where lambda is the wavelength of light
   Dis the distance of coherent sources from screen
   d is the distance between the slits

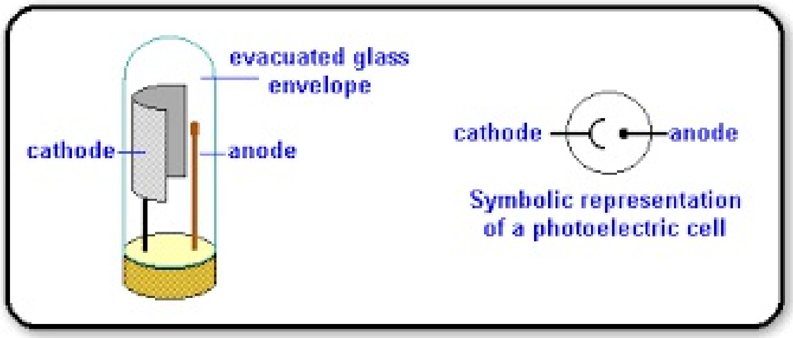
9. (a) move faster than its actual speed

   Explanation: Let h be the actual height and h' be the apparent height of bird at any instant.

   Then, $\frac{h}{h'} = \mu_{aw}$ (refractive index of air with respect to water) = 3/4 (since refractive index of water with respect to air is 4/3)
   If v is the actual speed and v' be the apparent speed of bird, then
   v = dh/dt and v' = dh'/dt
   v/v' = (dh/dt) / (dh'/dt) = 3/4
   or v' = 4v/3

10. (a) light energy into electric energy

Explanation:



A photo cell is a device which converts light energy into electric energy.

11. Paramagnetic

OR

Isogonic

12. Attract

13. Opposite

14. Disintegration

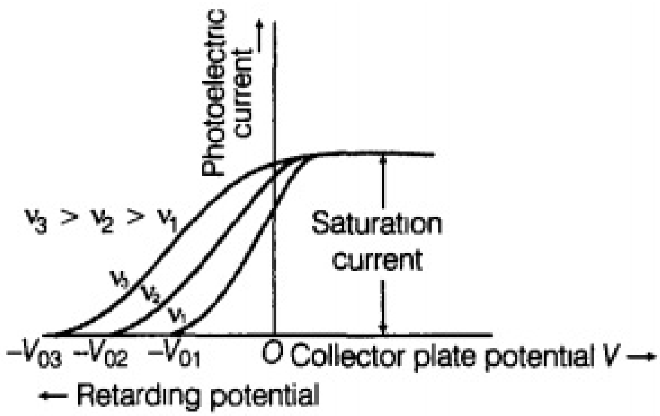
15. Infinity

16. A neutrino is a subatomic particle that is very similar to an electron but has no electrical charge and a very small mass. Because they have very little interaction with matter. However, they are incredibly difficult to detect.

17. Tritium and Plutonium.

18. With the increase in the reverse bias, the thickness of depletion layer increases.

19. The variation of photoelectric current with collector plate potential for different plate frequencies is shown below:



20. 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.

OR

The value of the energy gap becomes more when an intrinsic semiconductor is doped with a trivalent impurity.

Section B

21. The ratio of the capacitance of the capacitor with the dielectric as the medium to its capacitance with vacuum between its plates is termed as 'dielectric constant'.

22. 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.

23. We know that, λ = $\frac{h}{p}$ = $\frac{h}{\sqrt{2mqV}}$

    Therefore, we have

    $\frac{\lambda_p}{\lambda_\alpha}$ = $\frac{\sqrt{m_\alpha q_\alpha}}{\sqrt{m_p q_p}}$

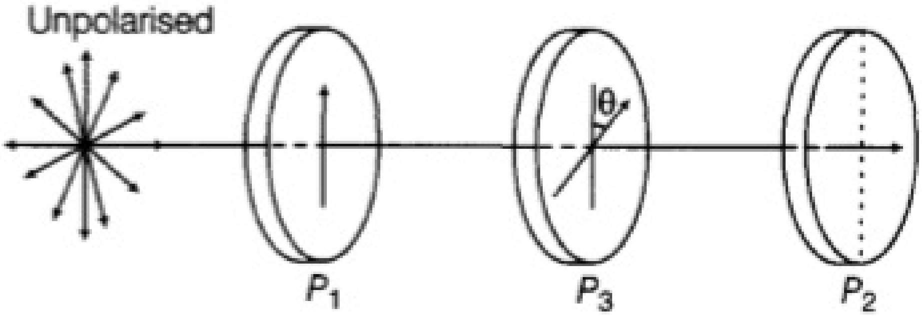
    = $\frac{\sqrt{4m_p \times 2q_p}}{\sqrt{m_p q_p}}$

    = $\sqrt{8}$

24. According to the law of Malus when completely plane polarized light is incident on

the analyzer, the intensity I of the light transmitted by the analyzer is directly proportional to the square of the cosine of angle between the transmission axes of the analyzer and the polarizer. Therefore, $I \propto \cos^2\theta$.

Let us consider two crossed polarisers, P_1 and P_2 with a polaroid sheet P_3 placed between them.



Let I_0 be the intensity of polarised light after passing through the first polariser P_1. If θ is the angle between the axes of P_1 and P_3, then the intensity of the polarised light after passing through P_3 will be $I = I_0 \cos^2\theta$. As, P_1 and P_2 are crossed, the angle between the axes of P_1 and P_2 becomes 90°.

$\therefore$ Angle between the axes of P_2 and P_3 is $(90^\circ - \theta)$.

The intensity of light emerging from P_2 will be given by

$I' = I\cos^2(90 - \theta)$, where $I = I_0 \cos^2\theta$ is the intensity of the polarised light just before entering the polariser P_2..

$$I = \left[I_0 \cos^2\theta\right]\sin^2\theta$$

$$\Rightarrow \quad I = \frac{I_0}{4}\left(4\cos^2\theta\sin^2\theta\right)$$

$$\Rightarrow \quad I = \frac{I_0}{4}(2\sin\theta\cos\theta)^2$$

$$\Rightarrow \quad I = \frac{I_0}{4}\sin^2(2\theta)$$

The intensity of polarised light transmitted from P_2 will be maximum, when

$\sin 2\theta$ = maximum = 1

$\Rightarrow \sin 2\theta = \sin 90^\circ \Rightarrow 2\theta = 90^\circ \Rightarrow \theta = 45^\circ$

Also, the maximum transmitted intensity will be given by $I = \frac{I_0}{4}$.

25. Here $B_V = B_H$

$\tan\delta = \frac{B_V}{B_H}$

$\tan\delta = \frac{B_H}{B_V} = 1$
$\tan\delta = \tan 45^\circ$
$\delta = 45^\circ$

26. When alpha particle approaches Nucleus, Kinetic energy of alpha particle will be converted into potential energy of the system.

Kinetic energy of α-particle is given as,
$K = \frac{1}{4\pi\varepsilon_0}\frac{2e.Ze}{d^2}$
where d is the distance of closest approach.
$d^2 = \frac{2Ze^2}{4\pi\varepsilon_0 K} \Rightarrow d = \sqrt{\frac{2Ze^2}{4\pi\varepsilon_0 K}}$
This is the required expression for the distance of closest approach d in terms of kinetic energy K.

OR

A hydrogen like atom consists of a tiny positively charged nucleus and an electron revolving in a stable circular orbit around the nucleus
As, the centripetal force is provided by the electrostatic force of attraction, we have
$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{(Ze)\times e}{r^2}$ or $mv^2 = \frac{Ze^2}{4\pi\varepsilon_0 r}$ ....(i)
From the first postulate of Bohr's atomic model, the angular momentum of the electron is
$mvr = n\frac{h}{2\pi}$ ....(ii)
where, n (= I, 2, 3, ...) is **principal quantum number**.
From Eqs. (i) and (ii), we get
$r = n^2\frac{h^2\varepsilon_0}{\pi m Ze^2}$ ....(iii)
This is the equation for the radii of the permitted orbits.
According to this equation, $r_n \propto n^2$
Since, n = 1, 2. 3, ... it follows that the radii of the permitted orbits increase in the ratio 1: 4: 9: 16:....

27. **Forward bias :**

- current is due to majority carriers.
- Voltage depletion region becomes thin.

- current is measured in milli amperes.
- low voltage required.
- PN Diode offers low resistance.
- establishes the easy path for the flow of current.

Reverse bias :

- current is due to minority carriers.
- Voltage depletion region becomes wider.
- current is measured in micro amperes.
- ideal PN diode offers infinite resistance.
- PN diode offers high resistance.
- High Voltage required

OR

Forward bias :

- current is due to majority carriers.
- Voltage depletion region becomes thin.
- current is measured in milli amperes.
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- current is due to minority carriers.
- Voltage depletion region becomes wider.
- current is measured in micro amperes.
- ideal PN diode offers infinite resistance.
- PN diode offers high resistance.
- High Voltage required

Section C

28. To solve the question we have to find the change in potential energy of the dipole in two cases.

For stable equilibrium, the angle between p and E

$\theta_1 = 0^\circ$.

So potential energy in stable equilibrium, U_1 = - pE

For unstable equilibrium, $\theta_2 = 180^\circ$.

So potential energy in unstable equilibrium, U_2 = pE

We know that from work energy theorem,

$W = -\Delta U$

Work done in rotating the dipole from angle θ_1 to θ_2

$W = pE(\cos\theta_1 - \cos\theta_2) = pE(\cos 0^\circ - \cos 180^\circ)$

$[cos0^\circ = 1]$, $[cos180^\circ = -1]$

W = 2 pE

29. When electron revolves around a positively charged nucleus, the circular loop constitutes a current, which have a definite dipole moment. So, it behaves as a tiny magnetic dipole.

The current, $I = \frac{e}{T}$

where, e is charge of electron, T is the time period of revolution

$T = \frac{2\pi r}{v}$

where r is electron orbital radius and v is the orbital speed.

Thus, $I = \frac{ev}{2\pi r}$

Magnetic moment is given by,

$\mu = I\ A = I\ \pi r^2 = \frac{evr}{2}$

and its direction is into the plane of paper.

Now, $\mu = \frac{e}{2m_e}(m_e vr) = \frac{e}{2m_e} L$

where L is orbital angular momentum.

In vector form, $\mu = \frac{-eL}{2M_e}$

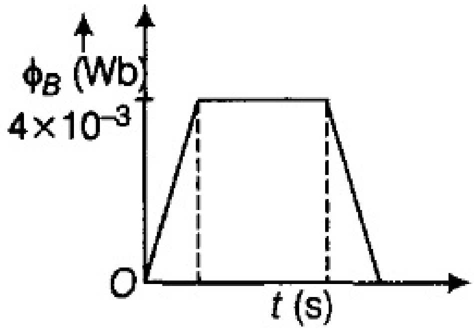
Here, negative sign indicates that angular momentum of electron is opposite in direction to magnetic moment.

30. Given, I = 20cm = 0.2m,

$B = 0.1T, v = 10\text{cms}^{-1} = 0.1\text{ms}^{-1}$

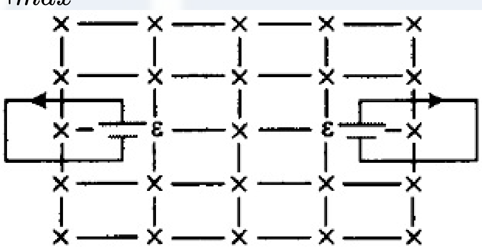
i. Magnetic flux through loop, $\phi_B = \vec{B} \cdot \vec{A} = BA\cos 0^0 = Blx$ (with A = lx)

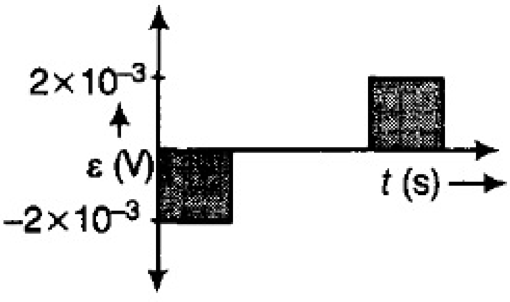
$\phi_{\max} = 0.1 \times 0.2 \times 0.2 = 0.004\text{Wb} = 4 \times 10^{-3}\text{Wb}$ (for maximum flux x = l = 0.2m)



ii. Induced emf, $\varepsilon = \frac{-d\phi}{dl} = -Blv$

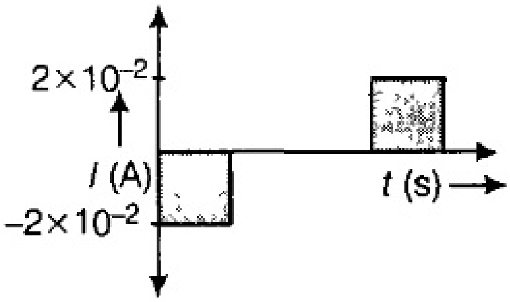
$|\varepsilon|_{max} = 0.1 \times 0.2 \times 0.1 = 0.002V = 2 \times 10^{-3}\text{V}$





iii. Induced current,

$I = \frac{|\varepsilon|}{R} = \frac{2\times10^{-3}}{0.1} = 2 \times 10^{-2}\text{A}$



31. Here it is given that, $\nu = 5 \times 10^{19}$ Hz.
    Now, we know that the wavelength is given by:
    $\lambda = \frac{c}{v} = \frac{3\times10^8}{5\times10^{19}} = 6 \times 10^{-12}$ m
    This wavelength corresponds to either gamma rays or X-rays. These are used:

    i. for causing certain nuclear reactions, and
    ii. for treatment of cancer

32. Intensity is proportional to width of slit. So, amplitude a_1 and a_2 I proportional to the square root of the width of the slit.
    $\therefore \frac{a_1}{a_2} = \sqrt{\frac{\omega_1}{\omega_2}}$
    Here ω_1 and ω_2 represent the widths of the two slits.
    Now, $\frac{I_{\min}}{I_{\max}} = \frac{(a_1-a_2)^2}{(a_1+a_2)^2} = \frac{\left(1-\frac{a_2}{a_1}\right)^2}{\left(1+\frac{a_2}{a_1}\right)^2}$
    $\Rightarrow \frac{9}{25} = \frac{\left(1-\frac{a_2}{a_1}\right)^2}{\left(1+\frac{a_2}{a_1}\right)^2}$ or $\frac{3}{5} = \frac{1-\frac{a_2}{a_1}}{1+\frac{a_2}{a_1}}$
    or $8\frac{a_2}{a_1} = 2$
    or $\frac{a_1}{a_2} = 4$
    Thus, $\sqrt{\frac{\omega_1}{\omega_2}} = \frac{4}{1}$
    or , $\frac{\omega_1}{\omega_2} = \frac{16}{1} \Rightarrow \omega_1 : \omega_2$ = 16 : 1

OR

i. Relation between diffraction from each slit to the interference pattern in a double slit experiment:
   If slit width in interference pattern is reduced to the size of wavelength of light used; the diffraction will also take place along with interference.

The diffraction pattern is itself due to the interference of wavelength belonging to same.

ii. Given that, wavelength of the light beam,

$\lambda_1 = 590\text{nm}$

$= 5.9 \times 10^{-7}\text{m}$

Wavelength of another light beam,

$\lambda_2 = 596\text{nm}$

$= 5.96 \times 10^{-7}\text{m}$

Distance of the slit from the screen,

D = 1.5 m

Aperture of the slit = d $= 2 \times 10^{-4}\text{m}$

For the first secondary maxima,

$\sin\theta = \frac{3\lambda_1}{2d} = \frac{x_1}{D}$ or $x_1 = \frac{3\lambda_1 D}{2d}$

Similarly, for the second wavelength, $x_2 = \frac{3\lambda_2 D}{2d}$

$\therefore$ Spacing between the positions of first secondary maxima of two sodium lines

$x_2 - x_1 = \frac{3D}{2d}(\lambda_2 - \lambda_1)$

Substituting the value of all elements

$= \frac{3\times1.5}{2\times2\times10^{-4}}(5.96 - 5.9) \times 10^{-7}$

$= 6.75 \times 10^{-5}\text{m}$

33. Radius, $r = \frac{n^2h^2}{4\pi^2 mKZe^2}$

We have n = 1 for 1st orbit

$h = 6.6 \times 10^{-34}Js$

$m = 9 \times 10^{-31}kg$

$K = 9 \times 10^9\ Nm^2C^{-2}$

Z = 1 for hydrogen, $e = 1.6 \times 10^{-19}$ coulomb

On substituting we get, $r = 0.53 \times 10^{-10}m$

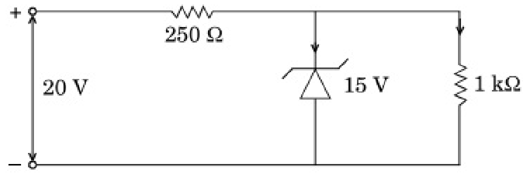
Also, $\nu = \frac{2\pi Ke^2}{nh} = \frac{c}{n}\left(\frac{2\pi Ke^2}{ch}\right)$

$\nu = \frac{c}{1} \times 2 \times \frac{22}{7} \times \frac{9\times10^9\times(1.6\times10^{-19})^2}{3\times10^8\times6.6\times10^{-34}}$

$\nu = \frac{1}{137}c$

34. Zener diodes are designed to work in breakdown region.Due to heavy doping, the depletion layer becomes very thin and electric field, across the junction,

becomes extremely high even for a small reverse bias voltage. A heavily doped diode has a low Zener breakdown voltage, while a lightly doped diode has a high Zener breakdown voltage.



As, zener diode and load resistance, 1kΩ are parallel, so

Voltage across 1 kΩ = Voltage across zener diode = 15V

Thus, Potential drop across 250 ohm resistance = 20 - 15 = 5V

So, current in the circuit is,

$I_S = \frac{V}{R} = \frac{5}{250} = 20$ mA

Current through resistor of 1 kΩ is,

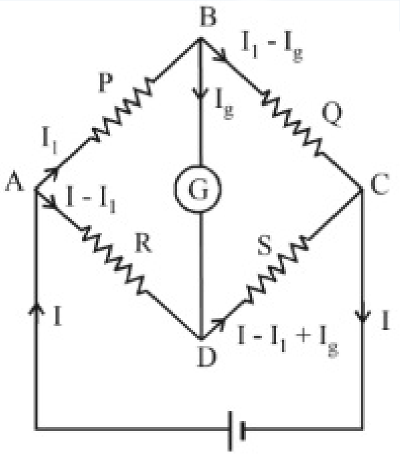
$I_L = \frac{15}{1000} = 15$ mA

As zener diode and 1kΩ resistor are in parallel, so applying current junction rule, the current through the zener diode is,

$I_Z = 20 - 15 = 5$ mA

Section D

35. i. The balanced condition in Wheatstone bridge:



$\frac{P}{Q} = \frac{R}{S}$ or $\frac{P}{R} = \frac{Q}{S}$

ii. Let a carbon resistor S is given to the bridge arm CD. Then,

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

$\therefore \frac{R}{S} = 1 \Rightarrow R = S = 22 \times 10^3\ \Omega$

iii. After interchanging the resistances, the balanced bridge would be

$\frac{2R}{X} = \frac{22\times10^3}{2\times22\times10^3} = \frac{1}{2}$

Here X is the resistance of arm AD

$\Rightarrow$ X = 4R = 4 $\times$ 22 $\times$ 103 = 88 kΩ

Hence colour code is Grey orange.

OR

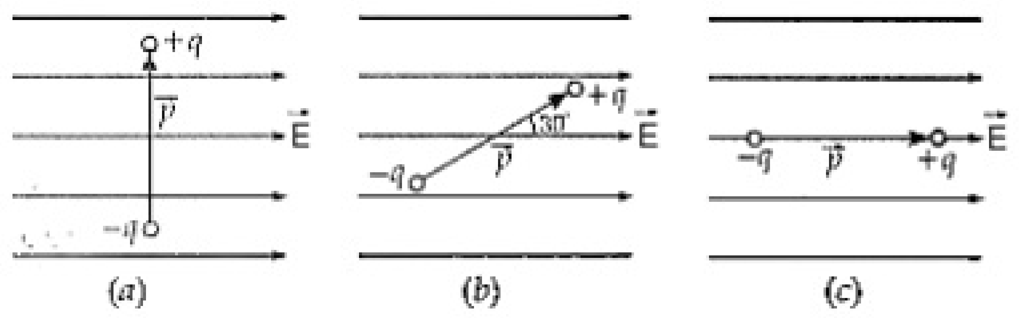
When an electric dipole is placed in a uniform electric field, the torque acting on the dipole is given by

$\vec{\tau} = \vec{p} \times \vec{E}$

In the above expression, one pair of perpendicular vectors is $\overrightarrow{\tau}$ and $\overrightarrow{\mathbf{p}}$ the other is $\overrightarrow{\tau}$ and $\overrightarrow{\mathbf{E}}$.

The magnitude of the torque on the dipole is given by τ = p E sin θ

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



ii. For the torque to be half the maximum value,

p E sin θ = p E/2

or sin θ = 1/2

or θ = 30°

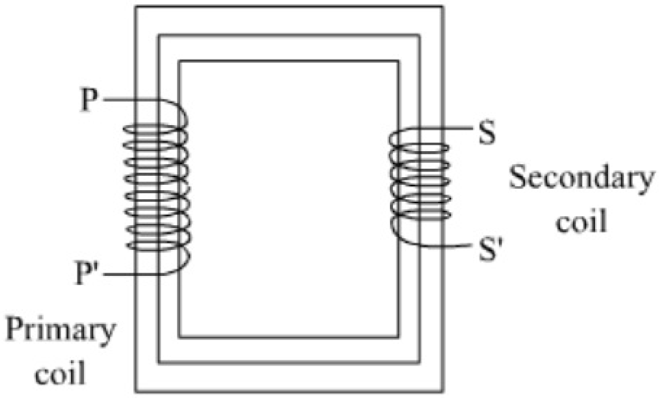
Therefore, torque on the dipole will be half the maximum value, when it is placed making an angle of 30° to the direction of the electric field as shown in Fig. (b).

iii. It follows that the torque will be zero when the dipole is placed along the direction of the electric field as shown in Fig. (c).

36. i. A transformer is a device that changes a low alternating voltage into a high alternating voltage or vice versa.

The transformer works on the principle of mutual induction.

A changing alternate current in the primary coil produces a changing magnetic field, which induces a changing alternating current in the secondary coil.



Energy losses in transformer :

a. Flux leakage due to poor structure of the core and air gaps in the core.

b. Loss of energy due to heat produced by the resistance of the windings.

c. Eddy currents due to alternating magnetic flux in the iron core, which leads to loss of energy due to heat.

d. Hysterisis, frequent and periodic magnetisation and demagnetisation of the core, leading to loss of energy due to heat.

ii. a. Number of turns in the secondary coil is given by,

$\frac{N_s}{N_p} = n$

$\Rightarrow \frac{N_S}{100} = 100$

$\Rightarrow N_S = 10{,}000$

b. Current in primary is given by,

$I_P V_P = P$

$\Rightarrow I_P = \frac{1100}{220} = 5A$

c. Voltage across secondary is given by,

$\frac{V_s}{V_p} = \frac{N_s}{N_p} = n$

$\Rightarrow V_S = 100 \times 220 = 22{,}000$ V

d. Current in secondary is given by

$V_S I_S = P$

$\Rightarrow I_S = \frac{P}{V_s} = \frac{1100}{22000} = 0.05$ A

e. In an ideal transformer,

Power in secondary = Power in primary = 1,100 W

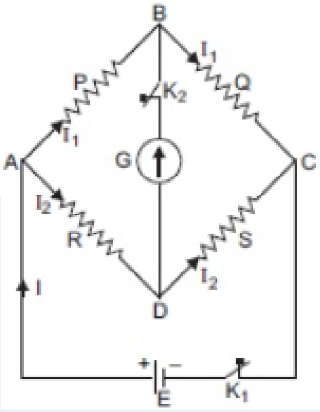
OR

a. Kirchhoff's I rule states that, at any junction, the sum of the currents entering the junction is equal to the sum of the currents leaving the junction.

Kirchhoff's II rule states that, the algebraic sum of the charges in potential around any closed loop involving resistors and cells in the loop is zero.

Conditions balance of a Wheatstone bridge:

P, Q, R and S are four resistance forming a closed bridge, called Wheatstone bridge.



A battery is connected across A and C, while a galvanometer is connected B and D. Current is absent in the galvanometer's balance point.

Derivation of Formula: Let the current given by battery in the balanced position be I. This current on reaching point A is divided into two parts I_1 and I_2. At the balanced point, current is zero.

Applying Kirchhoff's I law at point A,

$I - I_1 - I_2 = 0$ or

$I = I_1 + I_2$ ...... (i)

Applying Kirchhoff's II law to closed mesh ABDA,

$-I_1P + I_2R = 0$ or

$I_1P = I_2R$ ..... (ii)

Applying Kirchhoff's II law to mesh BCDB,

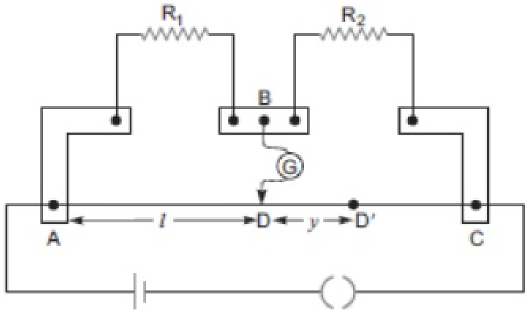
$-I_1Q + I_2S = 0$ or

$I_1Q = I_2S$ ...... (iii)

Dividing equation (ii) by (iii), we get

$$\frac{I_1 P}{I_1 Q} = \frac{I_2 R}{I_2 S}$$

$\Rightarrow \frac{P}{Q} = \frac{R}{S}$; which is the required condition of balance for Wheatstone bridge.

b. 

For null point at D, balance length l_1 = 40cm

So, $\frac{R_1}{R_2} = \frac{AD}{DC} = \frac{40}{(100-40)} = \frac{2}{3}$ ..... (i)

If resistance 10Ω is connected in series or R_1, balance point shifts towards $'\lambda'$ i.e.,

AD = 60cm

$\frac{R_1+10}{R_2} = \frac{AD'}{D'C} = \frac{60}{100-60} = \frac{3}{2}$ ..... (ii)

$\frac{R_1}{R_2} + \frac{10}{R_2} = \frac{3}{2}$

From equations (i) and (ii), we have

$\frac{2}{3} + \frac{10}{R_2} = \frac{3}{2}$

$\Rightarrow \frac{10}{R_2} = \frac{3}{2} - \frac{2}{3} = \frac{9-4}{6} = \frac{5}{6}$

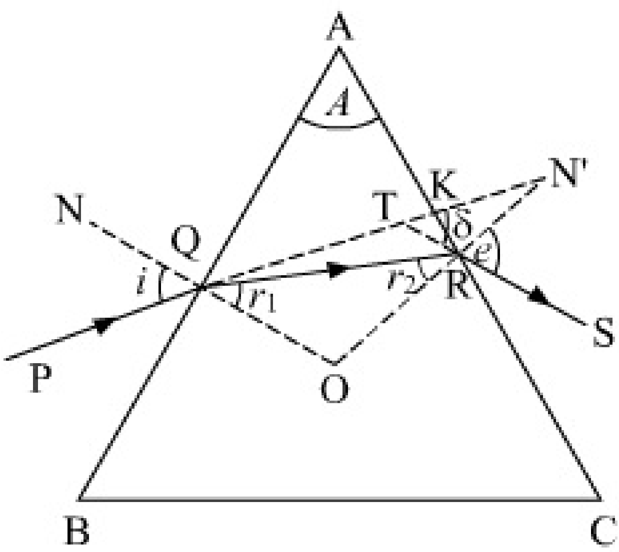
$\Rightarrow R_2 = \frac{10\times6}{5} = 12 \text{ ohm}$

From equation (i), we have

$\frac{R_1}{12} = \frac{2}{3}$

$\Rightarrow R_1 = \frac{12\times2}{3} = 8 \text{ ohm}$

37. a. The figure below shows the passage of light through a triangular prism ABC.



The angles of incidence and refraction at first face AB are $\angle i$ and $\angle r_1$

The angles of incidence at the second face AC is $\angle r_2$ and the angle of emergence $\angle e$

δ is the angle between the emergent ray RS and incident ray PQ and is called the angle of deviation.

Here, $\angle PQN = i$, $\angle SRN' = e$, $\angle RQO = r_1$, $\angle QRO = r_2$, $\angle KTS = \delta$

$\because$ $\angle TQO = i$ and $\angle RQO = r_1$, we have

$\angle TQR = i - r_1$

$\angle TRO = e$ and $\angle QRO = r_2$

$\angle TRQ = e - r_2$

In triangle TQR, the side QT has been produced outwards. Therefore, the exterior angle δ should be equal to the sum of the interior opposite angles.

i.e., $\delta = \angle TQR + \angle TRQ = (i - r_1) + (e - r_2)$

$\delta = (i + e) - (r_1 + r_2)$ ...(i)

In triangle QRO,

$r_1 + r_2 + \angle ROQ = 180^o$ ...(ii)

From quadrilateral AROQ, we have the sum of angles ($\angle AQO + \angle ARO = 180^o$) This means that the sum of the remaining two angles should be 180^o.

i.e., $\angle A + \angle QOR = 180^o$ [$\angle A$ is called the angle of prism]

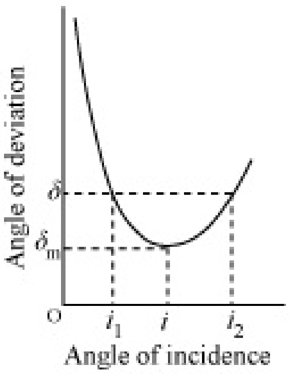
From equations (i) and (ii),

$r_1 + r_2 = A$ ...(iii)

Substituting (iii) in (i), we obtain,

$\delta = (i + e) - A$

$A + \delta = i + e$



If the angle of incidence is increased gradually, then the angle of deviation first decreases, attains a minimum value (δ_m), and then again starts increasing.
When angle of deviation is minimum, the prism is said to be placed in the minimum deviation position.
There is only one angle of incidence for which the angle of deviation is minimum.
When
$\delta = \delta_{\mathrm{m}}$ [prism in minimum deviation position],
e = i and $r_2 = r_1 = r$ ...(iv)
$\because r_1 + r_2 = A$
From equation (iv), r + r = A
r = $\frac{A}{2}$
Also, we have
A + δ = i + e
Setting,
$\delta = \delta_{\mathrm{m}}$ and e = i
A + δ_{m} = i + i
$i = \frac{(A+\delta_{\mathrm{m}})}{2}$
$\because \mu = \frac{\sin i}{\sin r}$
$\therefore \mu = \frac{\sin\left(\frac{A+\delta_{\mathrm{m}}}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

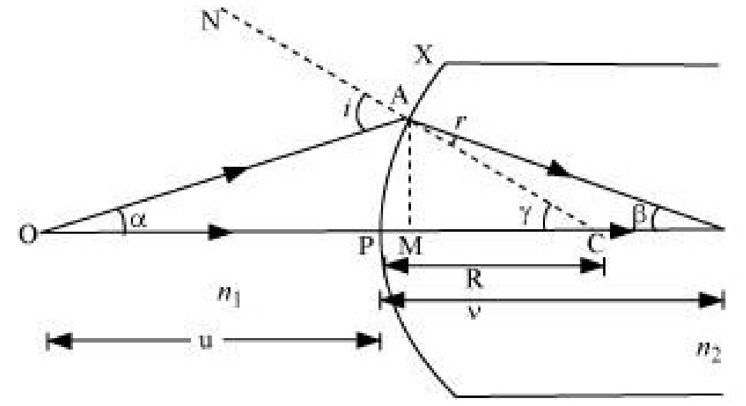
b. The incident ray travelling from denser medium to rarer medium grazes along the surface of the separation of the medium only when the light ray incident at the surface at an angle called critical angle (C) such that the angle of reflection is 90^{o}.
Therefore, following Snell's law, we can write
$\frac{\mu_1}{\mu_2} = \frac{\sin 90}{\sin C}$
$\frac{\mu_1}{\mu_2} = \frac{1}{\sin C}$
$\frac{\sqrt{2}}{1} = \frac{1}{\sin C}$
Sin C = $\frac{1}{\sqrt{2}}$
C = $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$
$\therefore$ Critical angle = Angle of incidence = 45^{o}

OR

Sign conventions:

i. All distances are measured from the pole of the spherical surface.
ii. Distances measured in the direction of incident light are taken positive.
iii. Distances measured in the opposite direction of incident light are negative.

Derivation:



Let a spherical refracting surface XY separate a rarer medium of refractive index n_1 from a denser medium of refractive index n_2. Let P be the pole, C be the centre and R = PC be the radius of curvature of this surface.
Consider a point object O lying on the principal axis of the surface.
From A, draw AM $\perp$ OI
Let $\angle \mathrm{AOM} = \alpha, \angle \mathrm{AlM} = \beta, \angle \mathrm{ACM} = \gamma$
As external angle of a triangle is equal to sum of internal opposite angles, therefore, in ΔIAC,
r + β = γ
r = γ - β ....(i)
Similarly, in ΔOBC , i = α + γ ...(ii)
According to Snell's law, $\frac{n_2}{n_1} = \frac{\sin i}{\sin r} = \frac{i}{r}$ ...(ii) ($\because$ angles are small)
$\therefore$ $n_1 i = n_2 r$
Using (i) and (ii), we obtain
$n_1(\alpha + \gamma) = n_2(\gamma - \beta)$
As angles α, β and γ are small, using $\theta = \frac{l}{r}$, we obtain
$\therefore n_1 \left(\frac{AM}{MO} + \frac{AM}{MC}\right) = n_2 \left(\frac{AM}{MC} - \frac{AM}{MI}\right)$ ...(iii)
As aperture of the spherical surface is small, M is close to P. Therefore, MO $\approx$ PO, MI $\approx$ PI, MC $\approx$ PC

From (iii),

$$n_1\left(\frac{1}{PO}+\frac{1}{PC}\right)=n_2\left(\frac{1}{PC}-\frac{1}{PI}\right)$$

$$\therefore \frac{n_1}{PO}+\frac{n_2}{PI}=\frac{n_2-n_1}{PC}$$

Using new Cartesian sign conventions, we put

PO = -u, PI = +v, PC = R

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

This is the required relation.

Now, $f \propto \frac{1}{\mu-1}$

As a wavelength of incident light increases, μ it decreases. Hence, the focal length f increases.