CBSE Class 12 Physics

Sample Paper 04 (2020-21)

Maximum Marks: 70

Time Allowed: 3 hours

General Instructions:

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

Section A

1. A positive charge +q is located at a point. What is the work done, if a unit positive charge is carried once around this charge along a circle of radius r about this point?
2. Write two uses of microwaves.

   OR

   Microwaves are used in Radar. Why?
3. State Huygens principle.
4. A solenoid of length 0.5 m has a radius of 1 cm and is made up of 500 turns. It carries a current of 5 A. What is the magnitude of the magnetic field inside the solenoid?

   OR

   A particle carrying a charge of 5 μC is moving with a velocity $\vec{v} = (4\hat{i} + 3\hat{k})\text{ms}^{-1}$ in a magnetic field $\overrightarrow{\mathbf{B}} = (3\hat{k} + 4\hat{i})\text{Wbm}^{-2}$. Calculate the force acting on the particle.

5. Why do we prefer a magnifying glass of smaller focal length?
6. Calculate the frequency associated with a photon of energy 3.3×10^{-20}J. Given, h = 6.6×10^{-34}J s.
7. A chain reaction dies out. State the reasons, why this could happen.

OR

State Einstein's mass-energy relation.

8. Under what condition does a junction diode works as an open switch?
9. Define the term magnetic flux.
10. Name one impurity each, which when added to pure Si, produces
    i. n-type and
    ii. p-type semiconductor.
11. **Assertion (A):** A current flows in a conductor only when there is an electric field within the conductor.

    Reason (R): The drift velocity of electrons in the presence of electric field decreases.
    a. Both A and R are true and R is the correct explanation of A
    b. Both A and R are true but R is NOT the correct explanation of A
    c. A is true but R is false
    d. A is false and R is also false
12. **Assertion (A):** If the distance between parallel plates a capacitor is halved and dielectric constant is made three times then the capacitance becomes six times.

    Reason (R): Capacitance of the capacitor does not depend upon the nature of the material of the plates of the capacitor.
    a. Both A and R are true and R is the correct explanation of A
    b. Both A and R are true but R is NOT the correct explanation of A
    c. A is true but R is false
    d. A is false and R is also false
13. **Assertion:** No interference pattern is detected when two coherent sources are infinitely close to each other.

    Reason: The fringe width is inversely proportional to the distance between the two slits.
    a. Both A and R are true and R is the correct explanation of A

b. Both A and R are true but R is NOT the correct explanation of A
c. A is true but R is false
d. A is false and R is also false

14. **Assertion:** In Rutherford's experiment majority of α-particles went straight through the metal foil without being stopped or even appreciably deflected.
Reason: Almost all the spac3e occupied by an atom is empty.
a. Both A and R are true and R is the correct explanation of A
b. Both A and R are true but R is NOT the correct explanation of A
c. A is true but R is false
d. A is false and R is also false

Section B

15. **Read the source given below and answer any four out of the following questions:**
Electric dipole consist of a pair of equal and opposite point charges separated by a small distance and its strength is measured by the dipole moment. The field around the dipole in which the electric effect of the dipole can be experienced is called the dipole field.

i. The electric dipole moment is:
   a. a scalar quantity
   b. neither scalar nor vector quantity
   c. a vector quantity
   d. none of the above
ii. Electric field due to the electric dipole is
   a. spherically symmetric.
   b. cylindrically symmetric.
   c. asymmetric.
   d. none of the above
iii. The SI unit of dipole moment is:
   a. C-m
   b. C-m^2
   c. C/m
   d. c/m^2
iv. Charges ± 20 nC are separated by 5mm. calculate the magnitude of dipole moment:-

a. 10^{-10} C-m

b. 10^{-8} C-m

c. 10^{10} C-m

d. 10^{-7} C-m

v. When an electric dipole is placed in a uniform electric field, it experiences

a. Force as well as torque

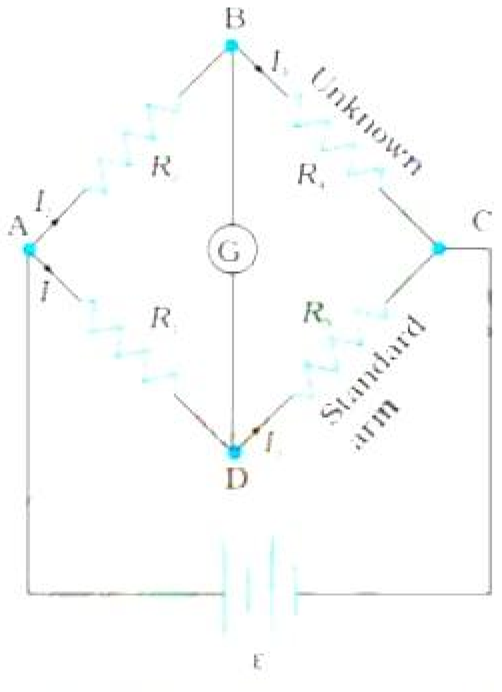
b. Torque but no net force

c. Force but no torque

d. Neither any force nor any torque

16. **Read the source given below and answer any four out of the following questions:**

The Wheatstone bridge works on the principle of null deflection, i.e. the ratio of their resistances are equal and no current flows through the circuit. Under normal conditions, the bridge is in the unbalanced condition where current flows through the galvanometer. The bridge is said to be in a balanced condition when no current flows through the galvanometer. This condition can be achieved by adjusting the known resistance and variable resistance.



i. The Wheatstone bridge is an arrangement of four resistances – R_1, R_2, R_3, R_4. The null-point condition is given by:

a. $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

b. $R_1 + R_2 = R_3 + R_4$

c. $R_2 = \frac{R_3}{R_4+R_1}$

d. $\frac{R_2}{R_1} = \frac{R_3}{R_4}$

ii. The Wheatstone bridge is used for the precise measurement of _______.

a. high resistance

b. low resistance

c. low current

d. high current

iii. Why are the connections between resistors in a Wheatstone or meter bridge made of thick copper strips?

a. Minimize the resistance

b. Maximize the resistance

c. Minimize current

d. None of these

iv. What happens if the galvanometer and cell are interchanged at the balance point of the bridge?

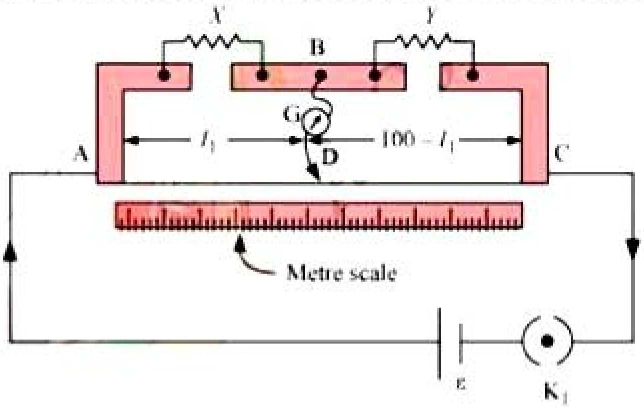
a. Current flow

b. Show deflection

c. No deflection

d. Low resistance

v. In a metre bridge [Fig. below], the balance point is found to be at 39.5 cm from the end *A*, when the resistor *Y* is of 12.5 Ω. Determine the resistance of *X*.



a. 8.2 Ω

b. 8.4 Ω

c. 7.2 Ω

d. 8.6 Ω

Section C

17. Calculate the nearest distance of approach of an α -particle of energy 2.5 eV being scattered by a gold nucleus (Z = 79).

18. i. Name the factors on which the deviation produced in the path of a ray of light by a prism depends.

ii. What are the features, when a prism is placed in minimum deviation position.

OR

An object is placed at a distance of 10 cm from a co-axial combination of two lenses A and B in contact. The combination forms a real image three times the size of the object. If lens B is concave with a focal length of 30 cm, what is the nature and focal length of lens A?

19. Two equal small spheres each weighing 1 g are hung by equal silk threads attached to the same point. The spheres are charged when in contact and come to rest with their centres 2 cm apart and 20 cm vertically below the point of support. Find the charge on each sphere, if g = 980 cm s^{-2}. How will the force of repulsion be affected, if the plate of glass of K = 8 is placed between the spheres?

OR

A charge having magnitude Q is divided into two parts q and (Q - q). If the two parts exert a maximum force of repulsion on each other, then find the ratio $\frac{Q}{q}$.

20. The value of ground state energy of hydrogen atom is -13.6 eV.

i. Find the energy required to move an electron from the ground state to the first excited state of the atom.

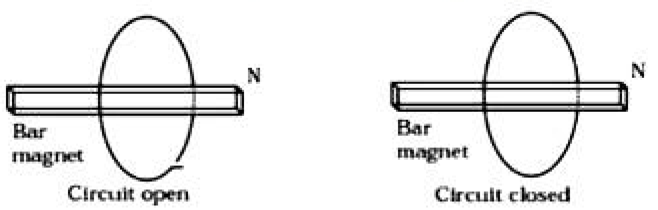
ii. Determine

a. the kinetic energy and

b. orbital radius in the first excited state of the atom.

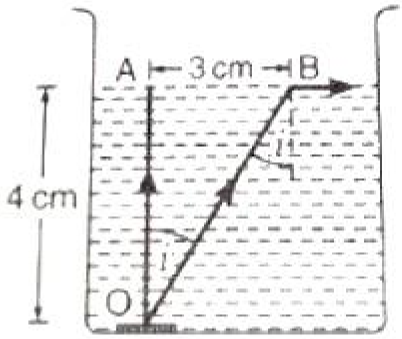
(Given, the value of Bohr's radius = 0.53 A)

21. Consider a magnet surrounded by a wire with an on/off switch S (Figure). If the switch is thrown from the off position (open circuit) to the on position (closed circuit), will a current flow in the circuit? Explain.



22. What is mass defect? How is it related to stability of the nucleus?

23. A small coin is resting on the bottom of a beaker filled with a liquid. A ray of light from the coin travels upto the surface of the liquid and moves along it surface as shown in the figure.



How fast is the light travelling in the liquid?

24. A magnet is suspended so that it may oscillate in the horizontal plane. It performs 20 oscillations per minute at a place where the angle of dip is 30° and 15 oscillations per minute, where the angle of dip is 60°. Compare the earth's total magnetic field at these two places.

OR

Suppose we want to verify the analogy between electrostatic and magnetostatic by an explicit experiment. Consider the motion of

i. electric dipole $\vec{p}$ in an electrostatic field $\vec{E}$ and
ii. magnetic dipole $\vec{m}$ in a magnetic field $\vec{B}$.

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

25. Which two of the following lenses L_1, L_2 and L_3 will you select as objective and eyepiece for constructing best possible (i) telescope (ii) microscope? Give reason to support your answer.

Lens	**Power(P)**	**Aperture(A)**
L_1	6D	1 cm
L_2	3D	8cm
L_3	10D	1 cm

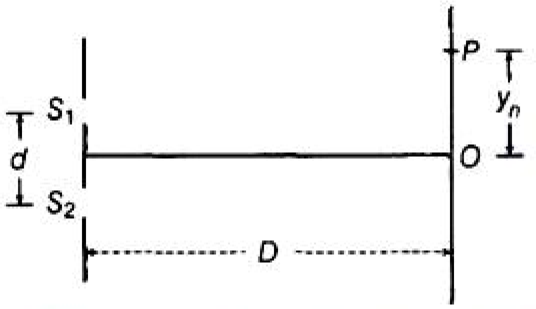
Section D

26. A rectangular loop of sides 8 cm and 2 cm with a small cut is moving out of a region of uniform magnetic field of magnitude 0.3 tesla directed normal to the loop. What is the voltage developed across the cut if velocity of loop is $1\ cms^{-1}$ in a direction normal to the (i) longer side (ii) shorter side of the loop? For how long does the induced voltage last in each case?

27. Monochromatic light of wavelength 589 nm is incident from air on a water surface. What are the wavelength, frequency and speed of
(a) reflected, and (b) refracted light? Refractive index of water is 1.33.

OR

The intensity at the central maxima (O) in a Young's double slit experiment is I_0. If the distance OP equals one-third of fringe width of the pattern, then show that the intensity at point P would be $I_0/4$.



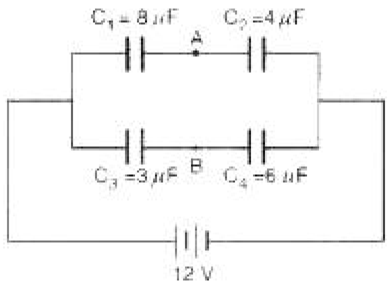
28. Following are the statements about the relationship between the electric field and electric potential:
    i. If the electric field at a certain point is zero, then the electric potential at the same point is also zero.
    ii. If the electric potential at a certain point is zero, then the electric field at the same point is also zero.
    iii. If the electric potential is constant in a region, then the electric field is zero in that region.

Giving example, predict whether these statements are correct or false.

OR

Four capacitors C_1, C_2, C_3 and C_4 are connected to a battery of 12 V as shown in Figure.

Find the potential difference between points A and B.



29. The following graph shown the variation of stopping potential V_0 with the frequency ν of the incident radiation for two photosensitive metals P and Q.
    i. Explain which metal has smaller threshold wavelengths.
    ii. Explain, giving reason, which metal emits photoelectrons having smaller kinetic energy.
    iii. If the distance between the light source and metal P is doubled, how will the stopping potential change?
30. What is the relationship between the current and the magnetic moment of a current carrying circular loop? Use the expression to derive the relation between the magnetic moment of an electron moving in a circle and its related angular momentum?

Section E

31. State the principle of working of p-n diode as a rectifier. Explain, with help of a circuit diagram, the use of p-n diode as a full wave rectifier.

OR

    i. Draw the circuit diagram of a p-n junction diode in
        a. forward bias.
        b. reverse bias.

    How are these circuits used to study the V-I characteristics of a silicon diode? Draw the typical V-I characteristics.
    ii. What is a Light Emitting Diode (LED)? Mention two important advantages of LEDs over conventional lamps.
32. A device X is connected across an ac source of voltage V = $V_0 \sin \omega t$. The current through X is given as $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$
    a. Identify the device X and write the expression for its reactance.
    b. Draw graphs showing variation of voltage and current with time over one cycle of ac, for X.

c. How does the reactance of the device X vary with frequency of the ac? Show this variation graphically.
d. Draw the phasor diagram for the device X.

OR

i. Derive an expression for the average power consumed in a series L-C-R circuit connected to AC source for which the phase difference between the voltage and the current in the circuit is ϕ .
ii. Define the quality factor in an AC circuit. Why should the quality factor have high value in receiving circuits? Name the factors on which it depends.

33. i. What is the effect on the interference fringes to a Young's double slit experiment when
   a. the separation between the two slits is decreased?
   b. the width of the source slit is increased?
   c. the monochromatic source is replaced by a source of white light? Justify your answer in each case.

ii. The intensity at the central maxima in Young's double slit experimental set up is I_0. Show that the intensity at a point is $\frac{I_0}{4}$, where the path difference is $\frac{\lambda}{3}$.

OR

i. A plane wavefront approaches a plane surface separating two media. If medium 1 is optically denser and medium 2 is optically rarer, using Huygens' principle, explain and show how a refracted wavefront is constructed? Verify Snell's law.
ii. When a light wave travels from a rarer to a denser medium, the speed decreases. Does it imply a reduction in its energy? Explain.

CBSE Class 12 Physics

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Solution

Section A

1. The potential at each point on the circular path around the charge is same i.e. potential difference between the initial and final position is zero.
   Therefore, work done,
   W = V × q = 0 × 1 = 0
2. i. In RADAR communication.
   ii. An analysis of molecular and atomic structure or in a microwave oven for cooking food.

OR

Due to their smaller wavelength, microwaves can be transmitted as beam signals in a particular direction, much better than radio waves. Microwaves do not bend around the corners of any obstacle coming in their path & it improves the accuracy of radar immensely.

3. Huygens' principle is a geometrical construction, which is used to determine the new position of a wavefront at a later time from its given position at any instant. In other words, the principle gives a method to know as to how light spreads out in the medium.
4. The number of turns per unit length is,
   $n=\frac{500}{0.5}=1000$ turns/m
   The length l = 0.5 m and radius r = 0.01 m. Thus, l/r = 50 i.e., l >> r
   Hence, we can use the long solenoid formula, namely,
   $B=\mu_0 nI$
   = $4\pi \times 10^{-7} \times 10^3 \times 5$
   = 6.28×10^{-3} T

OR

Here, $e=5\mu\text{C}=5\times 10^{-6}\text{C}; \vec{v}=(4\hat{i}+3\hat{k})\text{ms}^{-1}$

and $\vec{B} = (3\hat{k} + 4\hat{i})\text{Wbm}^{-2}$

Now, $\vec{B} = e(\vec{v} \times \vec{B})$

$= 5 \times 10^{-6}[(4\hat{i} + 3\hat{k}) \times (3\hat{k} + 4\hat{i})] = 0$

5. For a magnifying glass, M = $\left(1 + \frac{D}{f}\right)$

   It will be large if the focal length of the magnifying lens is small.

6. v = $\frac{E}{h} = \frac{3.3 \times 10^{-20}}{6.6 \times 10^{-34}}$ = 5×10^{13}Hz

7. A nuclear chain reaction dies out, when the neutrons produced are so fast that they escape the uranium block without interacting or when the neutrons are lost due to the extremely small size of the uranium block.

   OR

   In a process, when a mass m is completely converted into energy, the energy obtained is given by

   E = mc^2

8. When the junction diode is reverse biased.

9. Magnetic flux through a surface is defined as the number of magnetic field lines passing normally through a surface.

10. i. Pentavalent impurity atoms i.e. atoms having 5 valence electrons such as antimony (Sb) or arsenic (As).
    ii. Trivalent impurity atoms i.e. atoms having 3 valence electrons such as indium (In) or gallium (Ga).

11. (c) A is true but R is false

    Explanation: Current flows when there in P.D.

    The presence of P.D implies the presence of an Electric field.

    Drift velocity $\propto$ Electric field.

12. (b) Both A and R are true but R is NOT the correct explanation of A

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

13. (b) Both A and R are true but R is NOT the correct explanation of A

    Explanation: When d is negligibly small, fringe width p which is proportional to β may become too large. Even a single fringe may occupy the whole screen. Hence, the pattern cannot be detected.

14. (a) Both A and R are true and R is the correct explanation of A

Explanation: Both A and R are true and R is the correct explanation of A

Section B

15. i. (c) a vector quantity
    ii. (b) cylindrical symmetric
    iii. (a) C-m
    iv. (a) 10^{-10} C-m
    v. (b) torque but no net force
16. i. (a) $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
    ii. (b) low resistance
    iii. (a) Minimize the resistance
    iv. (c) No deflection
    v. (a) 8.2 Ω

Section C

17. The nearest distance of approach of an α -particle,

$x = \frac{2Ze^2}{4\pi\varepsilon_0} \times \frac{1}{\left(\frac{mv^2}{2}\right)}$

Now energy of α-particle $= \frac{1}{2}mv^2$ = 2.5 MeV

$= 2.5 \times 10^6 \times 1.6 \times 10^{-19} J$

$= 2.5 \times 1.6 \times 10^{-13} J$

Substituting values we get,

$x = \frac{2\times79\times1.6\times1.6\times10^{-38}\times9\times10^9}{2.5\times1.6\times10^{-13}}$

$= 9.101 \times 10^{-14} m$

18. i. It depends on angle of prism, material of prism and the angle of incidence.
    ii. a. The prism lies symmetrically w.r.t. incident ray and the emergent ray i.e. the angle of incidence is equal to the angle of emergence. As a result, the angle of refraction at the first face is equal to that at the second face.
    b. The refracted ray passes parallel to the base of prism.

OR

f_B = -30 cm

u = -10 cm

m = -3

v/u = -3, or v = -3u

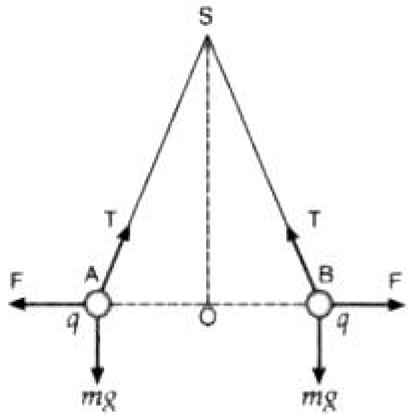
Now,

$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{30}+\frac{1}{10}=\frac{4}{30}$

Also, $\frac{1}{f}=\frac{1}{f_A}-\frac{1}{f_B}$

$\frac{4}{30}=\frac{1}{f_A}+\frac{1}{-30}$

On solving, f_A = +6 cm. Hence lens is convex (since focal length is positive).

19. 

Here, AB = 2 cm and SO = 20 cm

According to the triangle law of forces,

$\frac{q\times q}{(\mathrm{AB})^2}=mg\times\frac{\mathrm{OA}}{\mathrm{SO}}$

Setting m = 1 g, g = 980 cm s^{-2} and OA = $\frac{AB}{2}$ = 1 cm, we get

q = 14 statC

On introducing dielectric:

$\mathbf{F}=\frac{1}{\mathrm{K}}\cdot\frac{q\times q}{(\mathrm{AB})^2}$

Setting K = 8, we get

F = 6.125 dyne

OR

Suppose that the parts q and (Q - q) are placed at a distance r apart. Then,

$\mathbf{F}=\frac{1}{4\pi\varepsilon_0}\cdot\frac{q(\mathrm{Q}-q)}{r^2}$

Now, for force F to be maximum, $\frac{d\mathrm{F}}{dq}=0$

i.e. $\frac{d}{dq}\left[\frac{1}{4\pi\varepsilon_0}\cdot\frac{q(\mathrm{Q}-q)}{r^2}\right]=0$

$\frac{d}{dq}[q(Q-q)]=0$

$1(\mathrm{Q}-q)+q(0-1)=0$

$Q-2q=0$

$\frac{Q}{q}$ = 2

20. i. We know, Energy of electron in nth orbit of hydrogen atom is

$E_n = \frac{-13.6}{n^2}\text{eV}$

For n = 1 ⇒ $E_1 = \frac{-13.6}{1^2}\text{eV}$ = -13.6 eV

For n = 2 ⇒ $E_2 = \frac{-13.6}{2^2}\text{eV}$ = -13.6/4 = -3.4 eV

Energy required = $E_2 - E_1$ = -3.4- (-13.6) = 10.2 eV

ii. a. Kinetic energy = - (Total energy of the electron in first excited state) = -(- 3.4) = 3.4 eV

b. Orbital radius in the excited state,

$r = r_0 n^2 = (0.53 \times 10^{-10}) \times (2)^2 = 0.53 \times 10^{-10} \times 4 = 2.12 \overset{o}{A}$

21. No part of the wire is moving and so motional e.m.f. is zero. The magnet is stationary and hence the magnetic field does not change with time. This means no electromotive force is produced and hence no current will flow in the circuit.

22. The difference between the sum of the masses of the nucleons constituting a nucleus and the rest mass of the nucleus is known as mass defect.

The stability of a nucleus depends upon the higher value of its B.E./A. Therefore, more the mass defect, more is the binding energy of the nucleus (or B.E./ A) and hence more stable the nucleus will be.

23. The ray of light from the coin will move along the surface of the liquid, if i = C

Now, the refractive index of the liquid,

$\mu = \frac{1}{sin\ C} = \frac{1}{AB/OB} = \frac{OB}{AB}$

$= \frac{\sqrt{AB^2+OA^2}}{AB} = \frac{\sqrt{3^2+4^2}}{3} = \frac{5}{3}$

Therefore, speed of light in the liquid,

$v = \frac{c}{\mu} = \frac{3\times10^8}{5/3} = 1 \cdot 8 \times 10^8 ms^{-1}$

24. Let the total magnetic field due to earth at two places be B_1 and B_2. If the horizontal components be $(B_H)_1$ and $(B_H)_2$ respectively, then,

$(B_H)_1 = B_1 \cos 30^o$ and $(B_H)_2 = B_2 \cos 60^o$

Here T_1 = 3 sec and T_2 = 4 sec

$T_1 = 3 = 2\pi\sqrt{\frac{I}{MB_1 \cos 30^\circ}}$

$T_2 = 4 = 2\pi\sqrt{\frac{I}{MB_2 \cos 60^\circ}}$

$\frac{3}{4} = \left(\frac{B_2 \cos 60^\circ}{B_1 \cos 30^\circ}\right)^{1/2}$

$\Rightarrow \frac{B_1}{B_2} = \frac{16}{9} \times \frac{\cos 60^\circ}{\cos 30^\circ}$

$\Rightarrow \frac{B_1}{B_2} = \frac{16}{9} \times \frac{1}{2} \times \frac{2}{\sqrt{3}} = \frac{16}{9\sqrt{3}}$

or B_1:$B_2 = 16 : 9\sqrt{3}$

OR

Let θ is the angle between $\vec{m}$ and $\vec{B}$.

$\therefore$ Torque on magnetic dipole in a magnetic field B is

$\tau = \vec{m}\vec{B}\sin\theta$ .....(i)

Similarly θ is the angle between electric dipole moment $\vec{p}$ and electric field $\vec{E}$, then torque on electric dipole in $\vec{E}$ is

$\tau' = \vec{p}\vec{E}\sin\theta$ .....(ii)

For if motion in (i) and (ii) of electric and magnetic dipole are identical, then $\tau' = \tau$

$\vec{p}\vec{E}\sin\theta = \vec{m}\vec{B}\sin\theta$

Or $\vec{p}\vec{E} = \vec{m}\vec{B}$ .....(iii)

We know that $\vec{E} = \vec{c}\vec{B}$ (relation between E and B) .....(iv)

where c is velocity of light.

Put the value of $\vec{E}$ from (iv) in (iii),

$\vec{p}cB = \vec{m}\vec{B}$

$\vec{p} = \frac{\vec{m}}{c}$

It is the required relation.

25. An astronomical telescope should have an objective of larger aperture and longer focal length while an eyepiece have small aperture and small focal length. Therefore, we will use L_2 as an objective and L_3 as an eyepiece. For constructing microscope, L_3 should be used as objective and L_1 as eyepiece because both the lenses of microscope should have short focal lengths and the focal length of objective should be smaller than the eyepiece.

Section D

26. Given,

Length of loop, l = 8 cm $= 8 \times 10^{-2}\ m$

Breadth of loop, b = 2 cm $= 2 \times 10^{-2}\, m$

Strength of magnetic field, B = 0.3 T

Velocity of loop, v = 1 cm / sec $= 10^{-2}\, m/sec$

Let the field be perpendicular to the plane of the paper directed inwards.

i. The magnitude of induced emf,

$\varepsilon = Blv$

$= 0.3 \times 8 \times 10^{-2} \times 10^{-2}$

$= 2.4 \times 10^{-4}\, V$

Time for which induced emf will last is equal to the time taken by the coil to move outside the field is

$I = \frac{distance\ travelled}{velocity} = \frac{2\times10^{-2}}{10^{-2}}$ = 2 sec

ii. The conductor is moving outside the field normal to the shorter side.

$b = 2 \times 10^{-2}\, m$

The magnitude of induced emf is

$\varepsilon = Bbv$

$= 0.3 \times 2 \times 10^{-2} \times 10^{-2}$

$= 0.6 \times 10^{-4}\, V$

Time, $t = \frac{distance\ travelled}{velocity} = \frac{8\times10^{-2}}{10^{-2}} = 8\ sec$

27. Given, $\lambda = 589nm$

$c = 3 \times 10^8 m/s, \mu = 1.33$

a. For reflected light,

Wavelength $\lambda = 589nm = 589 \times 10^{-9}m$

$\nu = \frac{c}{\lambda} = \frac{3\times10^8}{589\times10^{-9}}$

$= 5.09 \times 10^{14} Hz$

Hence, the speed, frequency, and wavelength of the reflected light are 3×10^8 m/s, 5.09 $\times 10^{14}$ Hz, and 589 nm respectively.

b. Frequency of light does not depend on the property of the medium in which it is travelling. Hence, the frequency of the refracted ray in water will be equal to the frequency of the incident or reflected light in air.

$v = \frac{c}{\mu}$

$v = \frac{3\times10^8}{1.33} = 2.26 \times 10^8 \mathrm{m/s}$

Wavelength of light in water is given by the relation,

$\lambda = \frac{c}{\nu}$
$= \frac{2.26 \times 10^8}{5.09 \times 10^{14}}$
$= 444.007 \times 10^{-9}\text{m} = 444.01\ nm$

Hence the speed, frequency and wavelength of refracted light are 2.26×10^8 m/s, 5.09×10^{14} Hz and 444.01 nm respectively .

OR

Given, $OP = y_n$
The distance OP equals one-third of fringe width of the pattern
i.e. $y_n = \frac{\beta}{3}$
$= \frac{1}{3}\left(\frac{D\lambda}{d}\right)\left(\because \beta = \frac{D\lambda}{d}\right)$
$= \frac{D\lambda}{3d}$
$\Rightarrow \frac{dy_n}{D} = \frac{\lambda}{3}$
Path difference, $S_2P - S_1P = \frac{dy_n}{D} = \frac{\lambda}{3}$
we know that ,
Phase difference $= \frac{2\pi}{\lambda} \times$ Path difference
$= \frac{2\pi}{\lambda} \times \frac{\lambda}{3}$
$\therefore$ Phase difference $= \frac{2\pi}{3}$.
Intensity at point P is given by
$I = I_0 \cos^2 \phi$
$\Rightarrow I = I_0\left(\cos \frac{2\pi}{3}\right)^2$
$= I_0\left(-\cos \frac{\pi}{3}\right)^2 = I_0\left(-\frac{1}{2}\right)^2 = \frac{I_0}{4}$
Hence, the intensity at point P would be $\frac{I_0}{4}$.

28. i. **The statement 1 is false.** It is because, in case of two equal and opposite charges, at the point midway between the charges, the electric field is zero but the potential is non-zero.
 ii. **The statement 2 is false.** It is because, in case of an electric dipole, at any point on the equitorial line of the dipole, the electric potential is zero but the field is nonzero.
 iii. **The statement 3 is true.** It is because, in case of a charged conducting sphere, the electric potential is constant inside the sphere but the field is zero.

OR

Here, $C_1 = 8\ \mu F$; $C_2 = 4\ \mu F$; $C_3 = 3\ \mu F$ and $C_4 = 6\ \mu F$

Let V_A and V_B be the potentials of points A and B respectively.

Then, potential difference across $C_1 = 12 - V_A$

Potential difference across $C_2 = V_A - 0 = V_A$

Potential difference across $C_3 = 12 - V_B$

and potential difference across $C_4 = V_B - 0 = V_B$

Since the capacitors C_1 and C_2 are connected in series,

$q_1 = q_2$

i.e. $C_1(12 - V_A) = C_2V_A$

or $8(12 - V_A) = 4V_A$

or $V_A = 8V$

Also, as the capacitors C_3 and C_4 are in series,

$q_3 = q_4$

i.e. $C_3(12 - V_B) = C_4V_B$ or $3(12 - V_B) = 6V_B$

or $V_B = 4V$

Therefore, potential difference between the points A and B,

$V_A - V_B = 8 - 4 = 4V$

29. i. Suppose the frequency of incident radiations of metal Q and P be ν_0 and ν_0' respectively.

$\therefore \nu_0 > \nu_0'$

$\because \nu_0 = \frac{c}{\lambda_0}$

$\therefore \frac{c}{\lambda_0} > \frac{c}{\lambda_0'}$

$\Rightarrow \lambda_0 < \lambda_0'$

Therefore, metal 'Q' has smaller wavelength.

ii. As we know,

$E = h\nu_0$

$\Rightarrow E \propto \nu_0$

Hence, metal 'P' has smaller kinetic energy.

iii. Stopping potential remains unaffected because the value of stopping potential for a given metal surface does not depend on the intensity of the incident radiation. It depends on the frequency of incident radiation.

30. Let us assume that an electron of mass m_e and charge e revolves in a circular orbit of radius r around the positive nucleus in anti-clockwise direction.

The angular momentum of the electron due to its orbital motion is given by

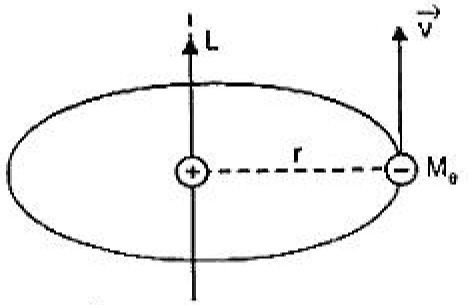
$L = m_e vr$ ...(i)

Let the period of orbital motion of the electron is T. Then, the electron crosses any point on its orbit after every T seconds.

Therefore, orbital motion of electron is equivalent to a current.

$I = e \cdot \left(\frac{1}{T}\right)$

The period of revolution of the electron is given by



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

$\therefore I = e\left(\frac{1}{2\pi r/v}\right) = \frac{ev}{2\pi r}$

The area of the electron orbit, $A = \pi r^2$

The magnetic dipole moment of the atom is M = IA

$M = \frac{ev}{2\pi r} \times \pi r^2 = \frac{evr}{2}$ ....(ii)

$\therefore$Using the equation (i) we have

$M = \left(\frac{e}{2m_e}\right) L$ [From i]

In vector notation,

$\vec{M} = -\left(\frac{e}{2m_e}\right) \vec{L}$

which tells that the magnetic dipole moment vector is directed in a direction opposite to that of angular momentum vector.

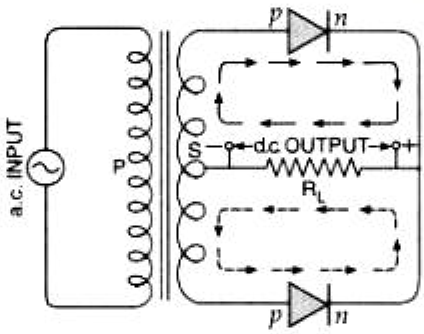
Section E

31. **Junction Diode as a Rectifier:** An electronic device which converts a.c. power into d.c. power is called a rectifier. The junction diode offers a low resistance path when forward

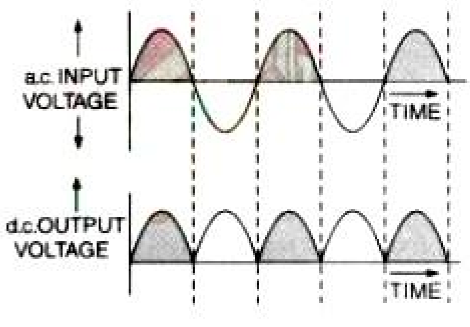
biased; and a high resistance path when reverse biased. This feature of the junction diode enables it to be used as a rectifier.

Full-wave Rectifier:

A rectifier which rectifies both halves of each a.c. input cycle is called a full-wave rectifier. To make use of both the halves of input cycle, two junction diodes are used. The circuit arrangement is shown in the figure.

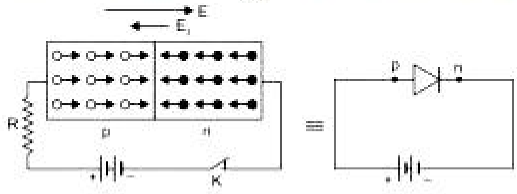


Suppose that during first half of the input cycle, upper end of coil S is at positive potential and the lower end is at negative potential. The junction diode D_1 will get forward biased, while the diode D_2 reverse biased. The conventional current due to the diode D_1 will flow along the path of full arrows. When the second half of the input cycle comes, the situation will be exactly reverse. Now, the junction diode D_2 will conduct and the conventional current will flow along the path of the dotted arrows. Since current during both the half cycles flows from right to left through the load resistance R_L, the output during both the half cycles will be of the same nature. The right end of the load resistance R_L will be at positive potential w.r.t. its left end. The magnitude of output across R_L at any time will vary in accordance with the a.c. input as shown in Fig. Thus, in a full wave rectifier, the output is continuous but pulsating in nature. However, it can be made smooth by using a filter circuit.



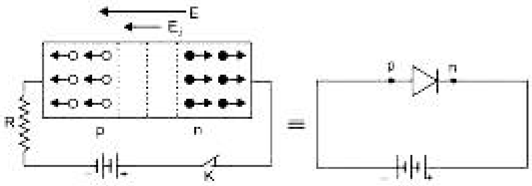
OR

1. The circuit diagram for forward bias of P-n junction diode is as follows



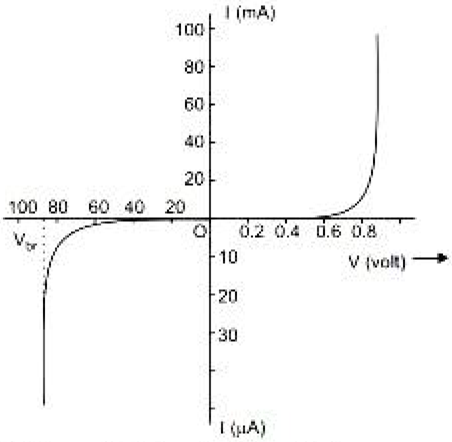
Forward current

2. Circuit diagram for reverse bias of P-n junction diode is given as



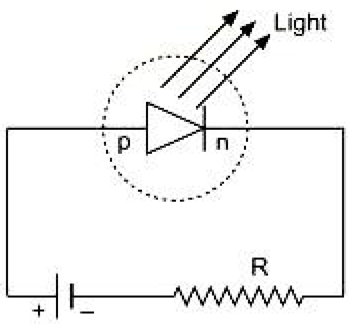
Reverse current   Reverse biasing

The battery is connected to the diode so that the applied voltage to the diode can be changed. For different values of voltages, the value of the current is noted. A graph between V and I is obtained as in figure. Note that in forward bias measurement, we use a milliammeter since the expected current is large while a micrometer is used in reverse bias to measure current.



***V-I* characteristics of a silicon diode**

2. A light emitting diode is simply a forward biased p-n junction which emits spontaneous light radiation. When forward bias is applied, the electron and holes at the junction recombine and energy released is emitted in the form of light. The circuit diagram is shown below.



Two advantages of LED over conventional incandescent lamps are:

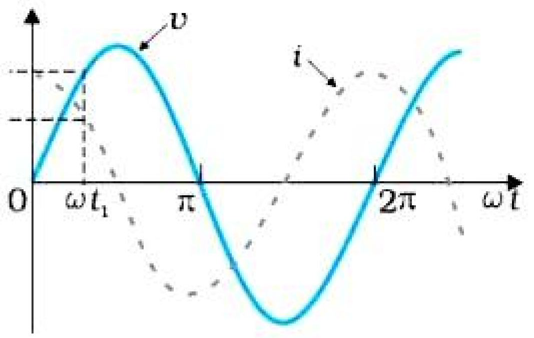
(i) In LED energy is produced in the form of light only, whereas in incandescent lamp energy is produced in the form of heat and light. Thus, there is no energy loss in LED.

(ii) To operate LED, very small voltage (≈ 1V) is required, whereas for the incandescent lamp higher voltages are required.

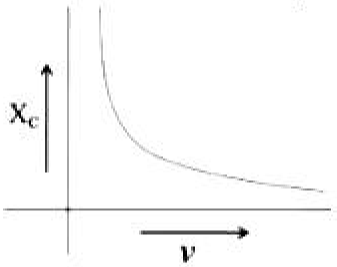
32. a. X: capacitor

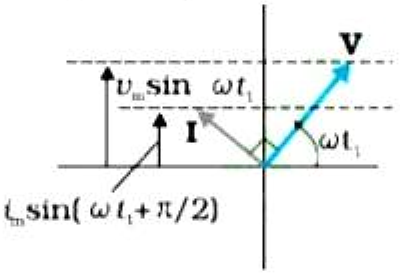
Reactance $X_c = \frac{1}{\omega C} = \frac{1}{2\pi v C}$

b.



c. Reactance of the capacitor varies in inverse proportion to the frequency i.e., $X_C \alpha \frac{1}{v}$





OR

i. In series LCR circuit, Voltage, V = V_0 sinωt

Current in circuit, I = I_0 sin$(\omega t - \phi)$

Instantaneous Power, P = VI

= $V_0 I_0 \sin \omega t \sin(\omega t + \phi)$

= $\frac{1}{2} V_0 I_0 2 \sin \omega t \sin(\omega t + \phi)$ = $\frac{1}{2} V_0 I_0 [\cos\phi - \cos(2\omega t + \phi)]$

Average value of cos(2ωt + ϕ) over a complete cycle is zero i.e.,

$\cos(2\omega t + \phi) = 0.$

$\therefore$ Average power over a complete cycle,

$P_{av} = \frac{1}{2} V_0 I_0 \cos\phi = \frac{V_0}{\sqrt{2}} \frac{I_0}{\sqrt{2}} \cos\phi$

$P_{av} = V_{rms} I_{rms} \cos\phi$

ii. **Quality Factor (Q):** In series LCR circuit, the ratio of the voltage drop across inductor (or capacitor) to the voltage drop across resistor under resonance condition is called the quality factor.

$Q = \frac{\omega_r LI}{RI} = \omega_r \frac{L}{R} = \frac{1}{\sqrt{LC}} \cdot \frac{L}{R}$

$\Rightarrow Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

Also, $Q = \frac{\omega_r}{\omega_2 - \omega_1}$

where ω_1 - ω_2 is the bandwidth of the resonant curve. Smaller is the bandwidth, larger is the quality factor and selectivity (or sharpness of resonance) of the circuit. That is why in receiving circuits, the quality factor must be very high. The quality factor depends on the values of resistance, inductance, and capacitance of the circuit.

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

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

b. For interference fringes to be seen, $\frac{s}{S} < \frac{\lambda}{d}$, condition should be satisfied otherwise, the interference patterns produced by different parts of the source slit will overlap.

As, the source slit width increases, the fringe pattern gets less and less sharp. When the source slit is so wide, the above condition does not satisfy and the interference pattern disappears. However, as long as the fringes are visible, the fringe width remains constant.

c. When monochromatic light is replaced by white light, then coloured fringe pattern is obtained on the screen.

The interference pattern due to different colour component of white light overlap. The central bright fringes for different colours are at the same position. Therefore, central fringes are white. And on the either side of the central fringe white coloured bands will appear.

ii. Intensity at a point is given by

$I = 4I' \cos^2 \phi/2$

where I' = intensity produced by each one of the individual sources.

At central maxima, $\phi = 0$,

The intensity at the central maxima,

$I_0 = 4I'$

$I' = \frac{I_0}{4}$ ..... (i)

As, path difference $= \frac{\lambda}{3}$

Phase difference, $\phi' = \frac{2\pi}{\lambda} \times$ path difference

$= \frac{2\pi}{\lambda} \times \frac{\lambda}{3} = \frac{2\pi}{3}$

Now, intensity at this point

$I'' = 4I' \cos^2 \frac{1}{2}\left(\frac{2\pi}{3}\right)$

$= 4I' \cos^2 \frac{\pi}{3}$

$= 4I' \times \frac{1}{4}$

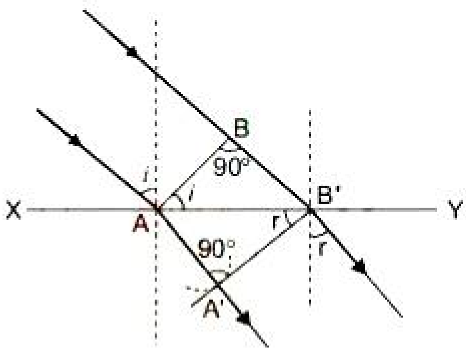
$= I'$

$= \frac{I_0}{4}$ [from Eq. (i)]

Hence proved.

OR

i. Suppose a plane wavefront AB in first medium is incident obliquely on the boundary surface XY and its end A touches the surface at A' at time t = 0 while the other end B reaches the surface at point B' after time-interval t.



As the wavefront AB advances, it strikes the points between A and B' of boundary surface. According to Huygen's principle, secondary spherical wavelets originate from these points. First of all secondary wavelet starts from A, which traverses a distance $AA' = v_2 t$ in second medium in time t. In the same time-interval t, the point of wavefront traverses a distance $BB' = v_1 t$ in first medium and reaches B', from, where the secondary wavelet now starts. Assuming A as centre, draw an arc of radius

$AA' = v_2 t$ and draw tangent B' A' on this arc from B'. As the incident wavefront AB advances, the secondary wavelets start from points between A and B', one after the other and will touch A' B' simultaneously. According to Huygen's principle A' B' is the new position of wavefront AB in the second medium.

As the lines drawn normal to wavefront denote the rays, therefore we may say that the incident ray, refracted ray and the normal at the point of incidence all lie in the same plane.

Let the incident wavefront AB and refracted wavefront A' B' make angles i and r respectively with refracting surface XY.

Now, in $\Delta ABB'$,

$\sin i = \frac{BB'}{AB} = \frac{v_1 t}{AB'}$

In $\Delta AA'B'$,

$\sin r = \frac{AA'}{AB'} = \frac{v_2 t}{AB'}$

Dividing equation (i) by (ii) , we get :

$\frac{\sin i}{\sin r} = \frac{v_1 t / AB'}{v_2 t / AB'}$

$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \text{ constant } = {}^1\mu_2$

where, ${}^1\mu_2$ = refractive index of second medium w.r.t. first medium. Hence, Snell's law of refraction is verified.

ii. No, the energy carried by the wave does not depend on its speed instead, it depends on the frequency of the wave.