Class XII Session 2026-27
Subject - Physics
Sample Question Paper - 9

Time Allowed: 3 hours **Maximum Marks: 70**

General Instructions:

1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. All the sections are compulsory.
4. **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.
5. There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
6. Use of calculators is not allowed.

Section A

1. If n_e and v_d be the number of electrons and drift velocity in a semiconductor. When the temperature is increased **[1]**

   a) Both n_e and v_d increase
   b) n_e decreases and v_d increase
   c) Both n_e and v_d decrease
   d) n_e increases and v_d decreases

2. Power is represented by- **[1]**

   a) newton
   b) newton sec
   c) joule
   d) watt

3. A bird flies down vertically towards a water surface. To a fish inside the water, vertically below the bird, the bird will appear to **[1]**

   a) be closer than its actual distance
   b) move slower than its actual speed
   c) move faster than its actual speed
   d) be at its actual distance

4. Consider the two idealised systems: (i) a parallel plate capacitor with large plates and small separation and (ii) a long solenoid of length L > > R, radius of cross-section. In (i), E is ideally treated as a constant between plates and zero outside. In (ii), magnetic field is constant inside the solenoid and zero outside. These idealised assumptions, however, contradict fundamental laws as below: **[1]**

a) case (ii) contradicts en $\oint H.d1 = I_{en}$

b) case (ii) contradicts Gauss's law for magnetic fields.

c) case (i) agrees with $\oint E.d1 = 0$

d) case (i) contradicts Gauss's law for electrostatic fields.

5. When a capacitor is connected to a battery, **[1]**

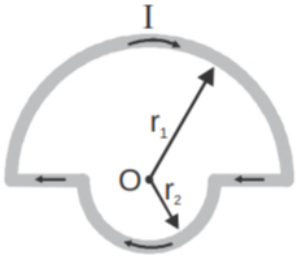
a) no current flows in the circuit at all

b) a current flows in the circuit for sometime and then decreases to zero

c) the current keeps on increasing

d) the current keeps on decreasing

6. In the figure shown there are two semicircles of radii r_1 and r_2 in which a current I is flowing. The magnetic induction at the center O will be: **[1]**



a) $\frac{\mu_0 I}{r}(r_1 + r_2)$

b) $\frac{\mu_0 I}{4}(r_1 - r_2)$

c) $\frac{\mu_0 I}{4}\left(\frac{r_1+r_2}{r_1 r_2}\right)$

d) $\frac{\mu_0 I}{4}\left(\frac{r_1-r_2}{r_1 r_2}\right)$

7. Two concentric circular coils, one of small radius r_1 and the other of large radius r_2, such that $r_1 << r_2$, are placed co-axially with centres coinciding. Mutual inductance of the arrangement is **[1]**

a) $\frac{\mu_0 \pi r_1^3}{2r_2^2}$

b) $\frac{\mu_0 \pi r_1^2}{2r_2}$

c) $\frac{\mu_0 \pi r_1}{3r_2}$

d) $\frac{\mu_0 \pi r_1^2}{2r_2^3}$

8. Which of the following has its permeability less than that of free space? **[1]**

a) Copper chloride

b) Nickel

c) Aluminium

d) Copper

9. The idea of secondary wavelets for the propagation of a wave was first given by: **[1]**

a) Newton

b) Fresnel

c) Huygens

d) Maxwell

10. The electric flux depends on: **[1]**

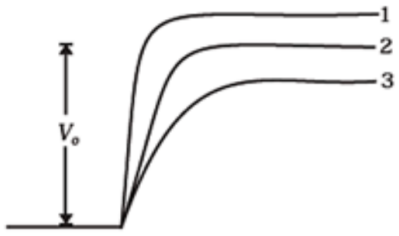
a) Angle between the surface and the electric field

b) Each one of these

c) The intensity of the electric field

d) Area of the surface

11. In the given Fig., V_0 is the potential barrier across a p-n junction, when no battery is connected across the junction **[1]**



a) 3 and 1 both correspond to reverse bias of junction.

b) 3 corresponds to forward bias of junction and 1 corresponds to reverse bias of junction

c) 1 corresponds to forward bias and 3 corresponds to reverse bias of junction.

d) 1 and 3 both correspond to forward bias of junction

12. The magnifying power of telescope is high if **[1]**

a) the objective has a short focal length and the eye-piece has a long focal length

b) the objective has a long focal length and the eye-piece has a short focal length

c) both objective and eye-piece have long focal length

d) both objective and eye-piece have short focal lengths

13. **Assertion (A):** The de Broglie wavelength of a molecule varies inversely as the square root of temperature. **[1]**

Reason (R): The root mean square velocity of the molecule depends on the temperature.

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 but R is true.

14. **Assertion:** Two protons placed at different distances, between the plates of a parallel plate capacitor experience the same force. **[1]**

Reason: The electric field between the plates of the capacitor is constant.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

15. **Assertion (A):** When Young's double-slit experiment is performed with a source of white light, only black and white fringes are observed. **[1]**

Reason (R): White light does not disperse in different colours in case of interference.

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

16. **Assertion:** Faraday's laws are consequences of conservation of energy. **[1]**
Reason: In a purely resistive AC circuit, the current lags behind the emf in phase.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

Section B

17. A light beam travelling in the x-direction is described by the electric field: E_y = 270 sin $\omega\left(t-\frac{x}{c}\right)$. An electron is constrained to move along the y-direction with a speed of 2.0 $\times$ 10^7 ms^{-1}. Find the maximum electric force and maximum magnetic force on the electron. **[2]**

18. In a centre trap full wave rectifier, the load resistance R_L = 1 kΩ. Each diode has a forward bias dynamic resistance of 10Ω. The voltage across half the secondary winding is 220 sin 314t. Find **[2]**

i. the peak value of current
ii. the dc value of current and
iii. the rms value of current

19. In a head-on collision between an α - particle and a gold nucleus, the minimum distance of approach is 3.95 $\times$ 10^{-14} m. Calculate the energy of the α-particle. **[2]**

20. A magnetising field of 1500 A/m produces a magnetic flux of 2.4 $\times$ 10^{-5} weber in a bar of iron of crosssection 0.5 cm^2. Calculate permeability and susceptibility of the iron-bar used. **[2]**

OR

A current of 5 A is flowing through a 10 turn circular coil of radius 7 cm. The coil lies in the x-y plane. What is the magnitude and direction of the magnetic dipole moment associated with it?
If this coil were to be placed in a uniform external magnetic field directed along the x-axis, in which plane would the coil lie, when in equilibrium? (Take $\pi = \frac{22}{7}$)

21. Why do we prefer phosphor - bronze alloy for the suspension wire of a moving coil galvanometer? **[2]**

OR

Show that no work is done and no change in the magnitude of the velocity of the particle is produced by this force.

Section C

22. What is the difference between 'emf' and 'terminal voltage' of a cell? **[3]**
Two cells of emfs E_1 and E_2 and internal resistances r_1 and r_2 are connected in

parallel. Derive an expression for the emf and internal resistance of the equivalent cell.

23. a. State briefly, with what purpose was Davisson and Germer experiment performed and what inference was drawn from this. **[3]**

b. Obtain an expression for the ratio of the accelerating potentials required to accelerate a proton and an α-particle to have the same de-Broglie wavelength associated with them.

24. Draw the circuit diagram of a full-wave rectifier using p-n junction diode. Explain its working and show the output input waveforms. **[3]**

25. i. The density of the nuclear matter is tremendously larger than the physical density of the material. Explain. **[3]**

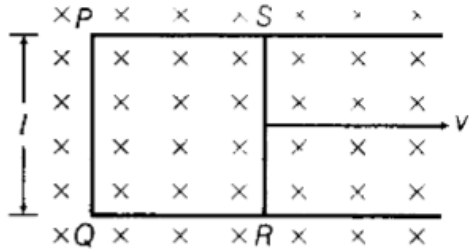
ii. The nuclear forces are not coulomb forces between nucleons. Explain.

iii. Draw a plot of the potential energy between a pair of nucleons as a function of distance between them inside a nucleus.

26. a. How is the stability of hydrogen atom in Bohr model explained by de-Broglie's hypothesis? **[3]**

b. A hydrogen atom initially in the ground state absorbs a photon which excites it to n = 4 level. When it gets de-excited, find the maximum number of lines which are emitted by the atom. Identify the series to which these lines belong. Which of them has the shortest wavelength?

27. Figure shows a rectangular conducting loop PQRS in which arm RS of length I is movable. The loop is kept in a uniform magnetic field B directed downward perpendicular to the plane of the loop. The arm RS is moved with a uniform speed v. **[3]**



Deduce an expression for

i. the emf induced across the arm RS

ii. the external force required to move the arm and

iii. the power dissipated as heat.

OR

A coil of number of turns N, area A, is rotated at a constant angular speed ω , in a uniform magnetic field B, and connected to a resistor R.

Deduce expressions for: (i) maximum emf induced in the coil. (ii) power dissipation in the coil.

28. White light reflected at perpendicular incidence from a soap film has, in the visible spectrum, an interference maximum at 6000 $\overset{\circ}{A}$ and a minimum at 4500 $\overset{\circ}{A}$ with no minimum in between. If $\mu = \frac{4}{3}$ for the film, what is the film thickness? **[3]**

Section D

29. **Read the text carefully and answer the questions:** **[4]**

All the known radiations from a big family of electromagnetic waves which stretch over a large range of wavelengths. Electromagnetic wave include radio waves, microwaves, visible light waves, infrared rays, UV rays, X-rays and gamma rays. The orderly distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum.

(a) Which wavelength of the Sun is used finally as electric energy?
radio waves, infrared waves, visible light, microwaves

a) infrared waves b) radio waves

c) microwaves d) visible light

(b) Which of the following electromagnetic radiations have the longest wavelength?
X-rays, γ-rays, microwaves, radiowaves

a) γ-rays b) X-rays

c) microwaves d) radiowaves

(c) Which one of the following is not electromagnetic in nature?
X-rays, gamma rays, cathode rays, infrared rays

a) infrared rays b) gamma rays

c) cathode rays d) X-rays

(d) Which of the following has minimum wavelength?
X-rays, ultraviolet rays, γ-rays, cosmic rays

a) ultraviolet rays b) X-rays

c) cosmic rays d) γ-rays

30. Coulomb's law states that the electrostatic force of attraction or repulsion acting between two stationary point charges is given by **[4]**

$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$



where F denotes the force between two charges q_1 and q_2 separated by a distance r in free space, ε_0 is a constant known as the permittivity of free space. Free space is a vacuum and may be taken to be air practically. If free space is replaced by a medium, then ε_0 is replaced by $(\varepsilon_0 k)$ or $(\varepsilon_0 \varepsilon_r)$ where k is known as dielectric constant or relative permittivity.

i. What is the dimensional formula for the permittivity constant ε_0 of free space? (1)

ii. What is the force of repulsion between two charges of 1 C each, kept 1m apart in vaccum? (1)

iii. Two identical charges repel each other with a force equal to 10 mgwt when they are 0.6 m apart in air. ($g = 10\ m\ s^{-2}$). Then find the value of each charge. (2)

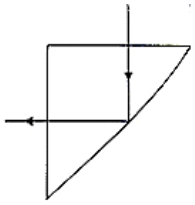
Section E

31. i. Draw a ray diagram for the formation of image of an object by an astronomical telescope, in normal adjustment. Obtain the expression for its magnifying power. **[5]**

ii. The magnifying power of an astronomical telescope in normal adjustment is 2.9 and the objective and the eyepiece are separated by a distance of 150 cm. Find the focal lengths of the two lenses.

OR

A ray of light incident normally on one of the faces of a right angled isosceles prism is found to be totally reflected as shown.



i. What is the minimum value of the refractive index of the material of the prism?

ii. When the prism is immersed in water, trace the path of the emergent ray for the same incident ray indicating the values of all the angles. (μ of water = $\frac{4}{3}$).

32. i. Obtain an expression for the potential energy of an electric dipole placed in a uniform electric field. **[5]**

ii. Three capacitors of capacitance C_1, C_2 and C_3 are connected in series to a source of V volt. Show that the total energy stored in the combination of capacitors is equal to sum of the energy stored in individual capacitors.

iii. A capacitor of capacitance C is connected across a battery. After charging, the battery is disconnected and the separation between the plates is doubled. How will (i) the capacitance of the capacitor, and (ii) the electric field between the plates be affected? Justify your answer.

OR

i. Two isolated metal spheres A and B have radii R and 2R respectively, and the same charge q. Find which of the two spheres have greater:

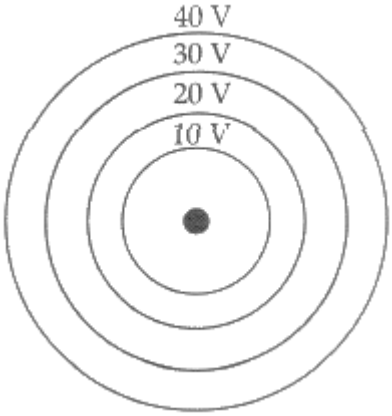
a. capacitance and

b. energy density just outside the surface of the spheres

ii. a. Show that the equipotential surfaces are closed together in the regions of a strong field and far apart in the regions of a weak field. Draw equipotential surfaces for an electric dipole,

b. Concentric equipotential surfaces due to a charged body placed at the centre are shown. Identify the polarity of the charge and draw the electric field lines

due to it.



33. An emf $\varepsilon = 100 \sin 314\ t$ is applied across a pure capacitor of 637 μF. Find **[5]**

i. the instantaneous current I

ii. instantaneous power P

iii. the frequency of power and

iv. the maximum energy stored in the capacitor.

OR

i. Draw a labelled diagram of a step-down transformer. State the principle of its working.

ii. Express the turn ratio in terms of voltages.

iii. Find the ratio of primary and secondary currents in terms of turn ratio in an ideal transformer.

iv. How much current is drawn by the primary of a transformer connected to 220 V supply when it delivers power to a 110 V - 550 W refrigerator?

Solution

Section A

1.

(d) n_e increases and v_d decreases

Explanation:

The solution states that when the temperature of a semiconductor increases, the number of electrons, n_e, increases while the drift velocity, v_d, decreases. This is correct because increasing temperature provides more energy to the electrons, allowing more of them to be excited from the valence band to the conduction band, thus increasing n_e. However, as temperature rises, the increased lattice vibrations can lead to more scattering events for the electrons, which can reduce their average drift velocity v_d. Therefore, the behavior of n_e and v_d in response to temperature changes aligns with the principles of semiconductor physics.

2.

(d) watt

Explanation:

Power is the rate of doing work per unit time. It is the amount of energy consumed per unit time. In the SI system unit of power is Joules per second which is also called Watt in honour of James Watt, the eighteenth-century developer of steam engine.

3.

(c) 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)

= $\frac{3}{4}$ (since refractive index of water with respect to air is $\frac{4}{3}$)

If v is the actual speed and v' be the apparent speed of bird, then

v = $\frac{dh}{dt}$ and v' = $\frac{dh'}{dt}$

Thus, $\frac{v}{v'} = \frac{3}{4}$

or v' = $\frac{4v}{3}$

4.

(b) case (ii) contradicts Gauss's law for magnetic fields.

Explanation:

case (ii) contradicts Gauss's law for magnetic fields.

5.

(b) a current flows in the circuit for sometime and then decreases to zero

Explanation:

When an uncharged capacitor is connected to a battery, charges flow from the poles of the battery to the plates of the capacitor and this process continues till the potential across the capacitor attains the potential difference of the battery. The current flows in the circuit till the time the capacitor is charged and then it ceases.

6.

(c) $\frac{\mu_0 I}{4}\left(\frac{r_1+r_2}{r_1 r_2}\right)$

Explanation:
The solution is correct because it applies the principle of superposition for magnetic fields generated by current-carrying conductors. Each semicircle contributes to the magnetic field at the center O, and the total magnetic induction is the sum of the contributions from both semicircles. For a semicircular wire carrying current, the magnetic field at the center is given by the formula $B = \frac{\mu_0 I}{4r}$, where r is the radius of the semicircle. In this case, we have two semicircles with radii r_1 and r_2. The magnetic fields due to each semicircle at point O will be: - For the semicircle of radius r_1: $B_1 = \frac{\mu_0 I}{4r_1}$ - For the semicircle of radius r_2: $B_2 = \frac{\mu_0 I}{4r_2}$ Since both semicircles contribute to the magnetic field in the same direction, we can add these contributions: $B_{total} = B_1 + B_2 = \frac{\mu_0 I}{4r_1} + \frac{\mu_0 I}{4r_2} = \frac{\mu_0 I}{4}\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$ This can be rewritten as: $B_{total} = \frac{\mu_0 I}{4}\left(\frac{r_1 + r_2}{r_1 r_2}\right)$ Thus, the expression matches option ($\frac{\mu_0 I}{4}\left(\frac{r_1 + r_2}{r_1 r_2}\right)$), confirming that the solution is correct.

7.

(b) $\frac{\mu_0 \pi r_1^2}{2r_2}$
Explanation:
Let a time varying current I_2 flow through the outer circular coil.
$\therefore$ Magnetic field at the centre of this coil is
$B_2 = \frac{\mu_0 I_2}{2r_2}$
Since the inner coil placed co-axially has very small radius, B_2 may be considered constant over its cross-sectional area.
$\therefore$ Magnetic flux associated with inner coil is
$\phi_1 = B_2 \times \pi r_1^2 = \left(\frac{\mu_0 I_2}{2r_2}\right)\pi r_1^2 = \pi r_1^2 \frac{\mu_0 I_2}{2r_2}$
or $\phi_1 = \left(\frac{\mu_0 \pi r_1^2}{2r_2}\right) I_2 = M_{12} I_2$
$\therefore M_{12} = \frac{\mu_0 \pi r_1^2}{2r_2}$
Now, $M_{12} = M_{21} = \frac{\mu_0 \pi r_1^2}{2r_2}$

8.

(d) Copper
Explanation:
as Copper is diamagnetic substance.

9.

(c) Huygens
Explanation:
Huygens principle states that every point on a wavefront is a source of secondary wavelets. These wavelets spread out in the forward **direction**, at the same speed as the source wave. The new wavefront is a line tangent to all of the wavelets.

10.

(b) Each one of these
Explanation:
If the electric field is E and the area is A, the electric flux associated with the area is ϕ = EA cos θ.

Where θ represents the angle formed between the surface and the electric field.
The electric flux is clearly dependent on the electric field strength, area, and angle between the surface and the electric field.

11.

(b) 3 corresponds to forward bias of junction and 1 corresponds to reverse bias of junction
Explanation:
When p-n junction is forward biased, it opposes the potential barrier across junction. When p-n junction is reverse biased, it supports the potential barrier junction, resulting increase in potential barrier across the junction.

12.

(b) the objective has a long focal length and the eye-piece has a short focal length
Explanation:
Magnifying power of telescope is directly proportional to $\frac{f_o}{f_e}$.
Hence, f_o should be large and f_e should be small.

13. **(a)** Both A and R are true and R is the correct explanation of A.
Explanation:
$v_{rms} \propto \sqrt{T}$
$\lambda = \frac{h}{mv} \Rightarrow \lambda \propto \frac{1}{v}$

14. **(a)** Assertion and reason both are correct statements and reason is correct explanation for assertion.
Explanation:
Assertion and reason both are correct statements and reason is correct explanation for assertion.

15.

(d) A is false and R is also false
Explanation:
A is false and R is also false

16.

(c) Assertion is correct statement but reason is wrong statement.
Explanation:
Faraday's laws of electromagnetic induction are consequences of conservation of energy. It involves only transformation of energy into electrical energy. In purely resistive circuit, current and voltage are in the same phase.

Section B

17. Maximum electric field,
$E_0 = 270\ Vm^{-1}$
Maximum magnetic field,
$B_0 = \frac{E_0}{c} = \frac{270}{3\times10^8} = 9 \times 10^{-7}$ T,
directed along z-direction
Maximum electric force on the electron,
$F_e = qE_0 = 1.6 \times 10^{-19} \times 270 = 4.32 \times 10^{-17}$ N
Maximum electric force on the electron

$F_m = qvB_0 = 1.6 \times 10^{-19} \times 2.0 \times 10^7 \times 9 \times 10^{-7}$

$= 2.88 \times 10^{-18}$ N.

18. The voltage across half the secondary winding is V = 200 sin 314t

i. Peak value of voltage, V_0 = 220 V

$\therefore$ Peak value of current is

$I_0 = \frac{V_0}{r_d + R_L} = \frac{220}{10+1000}$ = 0.2178 A = 217.8 mA

ii. d.c. value of current,

$I_{dc} = \frac{2I_0}{\pi} = 2 \times 0.637 \times 217.8$ = 138.66 mA

iii. rms value of current is

$I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707 \times 217.8$ = 154 mA

19. $K = \frac{2kZe^2}{5_0} = \frac{2\times9\times10^9\times79\times\left(1.6\times10^{-19}\right)^2}{3.95\times10^{-14}\times1.6\times10^{-13}}$ MeV = 6 MeV

20. Here H = 1500 Am^{-1}, $\phi = 2.4 \times 10^{-5}$ Wb, A = 0.5×10^{-4} m^2

Magnetic induction,

$B = \frac{\phi}{A} = \frac{2.4\times10^{-5}}{0.5\times10^{-4}}$ = 0.48 Wbm^{-2}

Permeability,

$\mu = \frac{B}{H} = \frac{0.48}{1500}$ = 3.2×10^{-4} TmA^{-1}

As $\mu = \mu_0 (1 + \chi_m)$

$\therefore$ Susceptibility,

$\chi_m = \frac{\mu}{\mu_0} - 1 = \frac{3.2\times10^{-4}}{4\times3.14\times10^{-7}} - 1$

= 254.77 - 1 = 253.77

OR

Magnetic dipole moment,

$m = NIA = N \times \pi r^2$

$= 10 \times 5 \times \frac{22}{7} \times \left(\frac{7}{100}\right)^2$ = 0.77 Am^2

The direction of the magnetic dipole moment is perpendicular to the plane of the coil. Hence it is along z-axis.

Torque on the current loop of magnetic moment m is

$\tau = mB \sin \alpha$

where α is angle between $\vec{m}$ and $\vec{B}$. For stable equilibrium torque is zero, so $\alpha = 0^o$. For this $\vec{B}$ should

be perpendicular to the plane of the coil. Hence the coil will lie in y-z plane in the condition of stable equilibrium.

21. The phosphor bronze alloy is used for the suspension wire of a moving coil galvanometer because of its following properties:

i. Small restoring torque per unit twist. This makes the galvanometer highly sensitive.

ii. High tensile strength so that even their fibre does not break under the weight of the suspended coil.

iii. Rust resisting.

OR

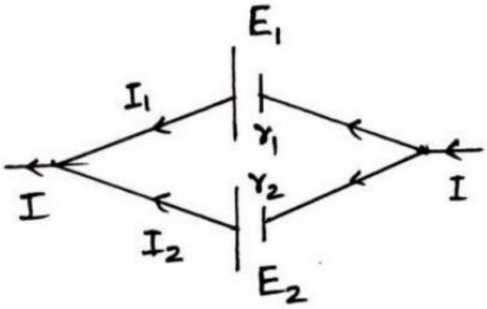
The magnetic force $\vec{F}$ acts, at all instants, perpendicular to the instantaneoious direction of $\vec{v}$ which is also the instantaneous direction of displacement ($d\vec{s}$). So $\vec{F}$ acts perpendicular to $d\vec{s}$ at all instants.

$\therefore \quad W = \vec{F} d\vec{s} = 0$

As no work is done by the magnetic force, there can be no change in the K.E. and hence no change in the magnitude of the velocity of the charged particle by this force.

Section C

22. i. Potential difference between the terminals of a cell in open circuit is emf and in closed circuit it is terminal voltage.
    ii. An emf does not depend on the external resistance, while terminal voltage depends on external resistance.
    iii. emf is the cause and terminal voltage is the effect.



$V = E_1 - I_1 r_1$

$V = E_2 - I_2 r_2$

$I = I_1 + I_2$

$I = \left(\frac{E_1 - V}{r_1}\right) + \left(\frac{E_2 - V}{r_2}\right)$

On comparing above equation with $I = \frac{E_{eq} - V}{r_{eq}}$

$E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$

$r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$

23. a. Purpose of Davisson Germer Experiment was to verify the wave nature of electron. It confirms the de Broglie relations for matter waves / Diffraction effect of electron beams from crystal

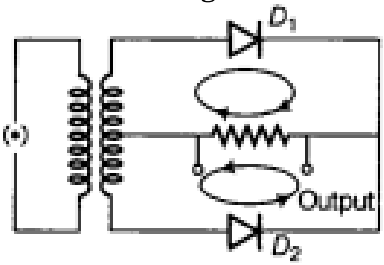
    b. de Broglie wavelength

    $\lambda = \frac{\mathrm{h}}{\sqrt{2\mathrm{mqV}}}$

    $\therefore \frac{\mathrm{h}}{\sqrt{2\ \mathrm{m}_p \mathrm{eV_p}}} = \frac{\mathrm{h}}{\sqrt{2\ \mathrm{m}_\alpha \mathrm{eV}_\alpha}}$

    $\therefore \frac{\mathrm{V_p}}{\mathrm{V}\alpha} = \frac{8}{1}$

24. 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 diagram of full-wave rectifier is shown below:

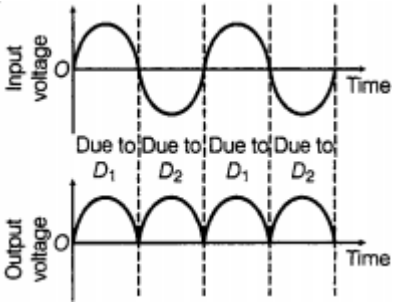


Circuit diagram of full wave rectifier

During the first half of input cycle, the upper end of the coil is at positive potential and lower end at negative potential. This provides forward bias to diode D_1 and reverse bias to diode D_2. So diode D_1 conducts only and diode D_2 does not conduct. Current flows in output load in the direction shown in figure.

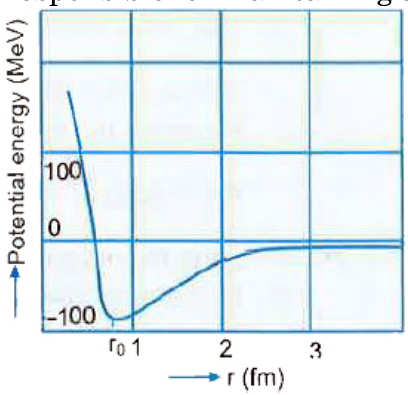
During the second half of input cycle, D_2 is forward biased and conducts. In this way, current flows in the load in the single direction in both the half of the input wave as shown in figure.

The input and output wave forms are given below:



25. i. The density of nuclear matter is approximately 2.3×10^{17}kgm^{-3} which is tremendously larger than the density of ordinary material, say water, which is 10^{3}kgm^{-3}. This is due to the fact that most of an atom is empty and its whole mass is concentrated at its nucleus. Ordinary material, consisting of atoms, has a large amount of empty space and consequently its density is small.

ii. Coulombian force between two protons is repulsive. However, within a nucleus a number of protons and neutrons exist together within a very small space. So it is clear that nuclear force is not coulomb force but is an extremely short range force which is attractive in nature and is responsible for maintaining all the nucleons together.

iii. 

26. a. The quantised electron orbits and energy state are due to wave nature of the electron and only resonant standing waves can persist. Ace. De Broglie Apotheosis.

$2\pi r = n\lambda$

$= \frac{nh}{mv}$

$mvr = \left(\frac{nh}{2\pi}\right)$

b. Lyman series

transition from n = 4 to n = 1 will have shortest wavelength.

27. i. Let RS moves with speed v rightward and also RS is at distances x_1 and x_2 from PQ at instants t_1 and t_2, respectively.

Change in flux, $d\phi = \phi_2 - \phi_1 = Bl\left(x_2 - x_1\right)$ $\left[\because \text{magnetic flux, } \phi = \vec{B}.\vec{A} = BAcos0^0 = Blx\right]$

$\Rightarrow$ dϕ = Bldx$\Rightarrow$ $\frac{d\phi}{dt} = Bl\frac{dx}{dt} = Blv$ $\left[\because v = \frac{dx}{dt}\right]$

If resistance of loop is R, then $I = \frac{vBl}{R}$

ii. Magnetic force = $BIl \sin 90^\circ$

$= \left(\frac{vBl}{R}\right) Bl = \frac{vB^2l^2}{R}$

Now, External force must be equal to magnetic force

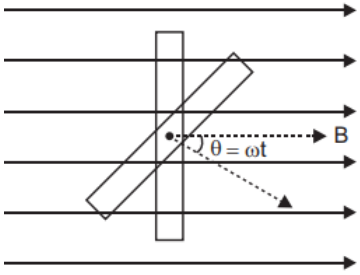
$\therefore$ External force $= \frac{vB^2l^2}{R}$

iii. As, $P = I^2R = \left(\frac{vBl}{R}\right)^2 \times R = \frac{v^2B^2l^2}{R^2} \times R$

$\therefore P = \frac{v^2B^2l^2}{R}$

OR

i. Suppose initially the plane of coil is perpendicular to the magnetic field B. When coil rotates with angular speed ω, then after time t, the angle between magnetic field vector B and normal to plane of coil is



$\theta = \omega t$

$\therefore$ At this instant magnetic flux linked with the coil $\phi = BA\cos\omega t$. If coil contains, N-turns, then emf induced in the coil.

If coil contains, N-turns, then emf induced in the coil

$\varepsilon = -N\frac{d\phi}{dt} = -N\frac{d}{dt}(BA\cos\omega t)$

$= +NBA\omega\sin\omega t$

$\therefore$ For maximum value of emf ε,

sin ωt = 1

$\therefore$ Maximum emf induced, $\varepsilon_{max} = NBA\omega$

ii. If R is resistance of coil, the current induced, $I = \frac{\varepsilon}{R}$

$\therefore$ Instantaneous power dissipated,

$P = \varepsilon I = \varepsilon\left(\frac{\varepsilon}{R}\right) = \frac{\varepsilon^2}{R}$

$= \frac{N^2B^2A^2\omega^2\sin^2\omega t}{R}$

but, $\left(\sin^2\omega t\right)_{av} = \frac{1}{2}$ (Average power dissipated in a complete cycle is obtained by taking average value of $\sin^2\omega$t over a complete cycle which is $\frac{1}{2}$)

$\therefore$ Average power dissipated $P_{av} = \frac{N^2B^2A^2\omega^2}{2R}$

28. Here λ_1 = 6000 $\mathring{A}$ = 6×10^{-7}m, λ_2 = 4500 $\mathring{A}$ = 4.5×10^{-7}m, $\mu = \frac{4}{3}$

For normal incidence, the condition for (n + 1)th maximum is

2 μt = (n + $\frac{1}{2}$) λ_1 or n + $\frac{1}{2} = \frac{2\mu t}{\lambda_1}$ ...(i)

The condition for (n + 1)th minimum is

2 μt = (n + 1) λ_2 or n + 1 = $\frac{2\mu t}{\lambda_2}$ ...(ii)

Subtracting (i) from (ii), we get

$\frac{1}{2} = 2\mu t\left[\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right] = 2\mu t\left[\frac{\lambda_1 - \lambda_2}{\lambda_1\lambda_2}\right]$

$\therefore$ t = $\frac{\lambda_1\lambda_2}{4\mu(\lambda_1 - \lambda_2)} = \frac{6\times10^{-7}\times4.5\times10^{-7}}{4\times\frac{4}{3}\times(6-4.5)10^{-7}}$

$= \frac{27}{8} \times 10^{-5}$m = 3.375×10^{-5}m

Section D

29. **Read the text carefully and answer the questions:**

All the known radiations from a big family of electromagnetic waves which stretch over a large range of wavelengths. Electromagnetic wave include radio waves, microwaves, visible light waves, infrared rays, UV rays, X-rays and gamma rays. The orderly distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum.

(a) **(a)** infrared waves
Explanation:
Infrared rays can be converted into electric energy as in solar cell.

(b) **(d)** radiowaves
Explanation:
Radiowaves have longest wavelength.

(c) **(c)** cathode rays
Explanation:
Cathode rays are invisible fast moving streams of electrons emitted by the cathode of a discharge tube which is maintained at a pressure of about 0.01 mm of mercury.

(d) **(d)** γ-rays
Explanation:
γ-rays have minimum wavelength.

30. i. The dimensional formula for the permittivity constant is $[ML^{-3}T^4A^2]$.

ii. The force of repulsion will be 9×10^9 N.

iii. $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{d^2}$

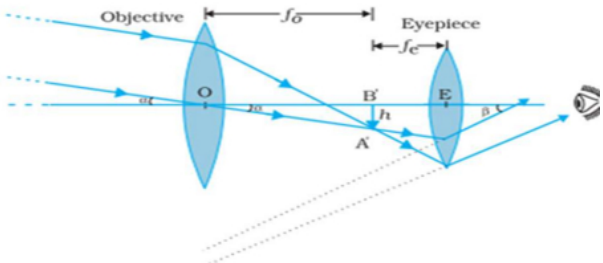
$\therefore (10 \times 10^{-3}) \times 10 = \frac{(9\times10^9)\times q^2}{(0.6)^2}$

or $q^2 = \frac{10^{-1}\times 0.36}{9\times10^9} = 4 \times 10^{-12}$

or $q = 2 \times 10^{-6}$ C $= 2\ \mu$C

Section E

31. i.



Magnifying power (m)

$m \approx \frac{\beta}{\alpha}$

$\beta = \frac{h}{f_c}$

$\alpha = \frac{h}{f_0}$

$m = \frac{f_0}{f_e}$

Hence,the expression for its magnifying power is given by $m = \frac{f_0}{f_e}$

ii. m = 2.9, d = 150cm (Given)

$m = \frac{f_o}{f_c} = \frac{29}{10}$

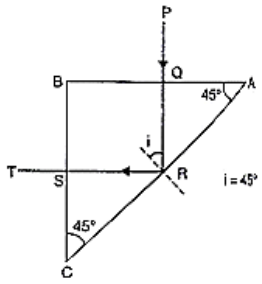
$f_0 + f_c = 150$

$f_c = 38.5$ cm

$f_0 = 150 - 38.5 = 111.5$ cm

OR

i. ABC is the section of the prism, B is a right angle. A and C are equal angles i.e. A = C = 45°. The ray PQ is normally incident on the face AB. Hence it is normally refracted and the ray QR strikes the face AC at an angle of incidence 45°. It is given that the ray does not undergo refraction but is totally reflected at the face AC. This gives a maximum value for the critical angle as 45°.



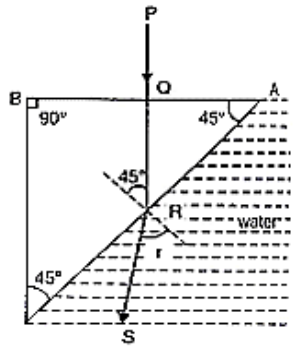
$\sin C = \sin 45° = \frac{1}{\sqrt{2}}$ in the limit

Since $\mu = \frac{1}{\sin C} = \frac{1}{\sqrt{2}}$

or, $\mu = \frac{1}{\sin 45}$ *or* $\mu_{\min} = \sqrt{2}$

The minimum value of refractive index $= \sqrt{2}$.

ii. When the prism is immersed in water the critical angle for the glass water interface is given by



$\sin C_1 = \frac{4/3}{\sqrt{2}} = \frac{4}{3\sqrt{2}}$

$C_1 = 70.53°$

The angle of incidence at R continues to be 45° and since 45° < 70.53°, refraction taking place and the refracted ray is RS. The angle of refraction r is given by $\mu_g \sin i = \mu_w \sin r$

$g\mu_\omega = \frac{\sin i}{\sin r}$

$\frac{\mu_\omega}{\mu_g} = \frac{\sin i}{\sin r}$

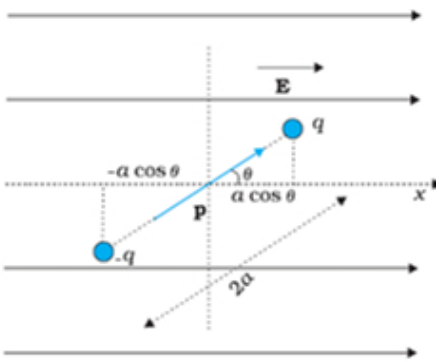
$\sqrt{2} \sin 45° = \frac{4}{3} \sin r$

$\sin r = \frac{3\sqrt{2}}{4} \sin 45° = \frac{3\sqrt{2}}{4} \times \frac{1}{\sqrt{2}} = \frac{3}{4}$

$r = \sin^{-1} \frac{3}{4} = 48°36'$

$\therefore$The angle of refraction in water = $48°36'$

32. i.



Consider a dipole with charges q1 = +q and q2 = -q is placed in a uniform electric field E, as shown in Fig The dipole experiences no net force; but experiences a torque $\boldsymbol{\tau}$ given by $\boldsymbol{\tau}$ = p × E

which will tend to rotate it (unless p is parallel or antiparallel to E). Suppose an external

torque τ_{ext} is applied in such a manner that it just neutralizes this torque and rotates it in the plane of paper from angle θ_o to angle θ_1 at an infinitesimal angular speed and without angular acceleration. The amount of work done by the external torque will be given by

$W = \int_{\theta_0}^{\theta_1} \tau_{ext}(\theta) d\theta = \int_{\theta_0}^{\theta_1} pE \sin\theta d\theta$

$W = U = pE(\cos\theta_0 - \cos\theta_1)$

ii. $U = \frac{1}{2}\frac{Q^2}{C_{eff}}$

$\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

$U = \frac{1}{2}\frac{Q^2}{C_1} + \frac{1}{2}\frac{Q^2}{C_2} + \frac{1}{2}\frac{Q^2}{C_3}$

$U = U_1 + U_2 + U_3$

iii. When battery is disconnected then charge (q) remains constant.

Capacitance is halved

$C' = \frac{\varepsilon_o A}{2d} = \frac{C}{2}$

Electric field (E) is unaffected.

$E = \frac{\sigma}{\varepsilon} = \frac{q}{\varepsilon_o A}$

Alternatively for effect on electric field.

$E = \frac{V}{d}$

$V' = \frac{Q}{C'} = \frac{Q}{\frac{C}{2}} = 2V$

$E' = \frac{V'}{d'} = \frac{2V}{2d} = \frac{V}{d} = E$

OR

i. $C_A = 4\pi\varepsilon_0 R$, $C_B = 4\pi\varepsilon_0 (2R)$ (in general form $C = 4\pi \in 0r$

a. $\therefore C_B > C_A$

b. $U = \frac{1}{2}\varepsilon_0 E^2$

$E = \frac{\sigma}{\varepsilon_P} = \frac{Q}{A\varepsilon_0}$

$\therefore U \propto \frac{1}{A^2}$

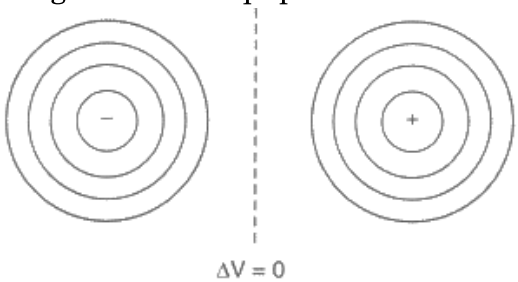
$\therefore U_A > U_B$

ii. a. $E = -\frac{dV}{dr}$

For the same change in dV, $E \propto \frac{1}{dr}$

where, 'dr' represents the distance between equipotential surfaces.

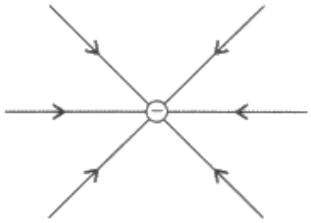
Diagram of the equipotential surface due to a dipole



b. The polarity of charge: negative

The direction of the electric field is radially inward,(for a negative charge electric field

lines are radially inward)



33. i. Given ε = 100 sin 314 t volt

As the current in a capacitor leads the voltage by 90°, so the instantaneous current is given by

I = $I_0 \sin(314t + 90^\circ) = I_0 \cos 314t$

where $I_0 = \frac{\varepsilon_0}{X_C} = \frac{\varepsilon_0}{1/\omega C} = \varepsilon_0 \omega C$

But ε_0 = 100 V, $\omega = 314$ rads^{-1}, C = 637×10^{-6} F

$\therefore I_0 = 100 \times 314 \times 637 \times 10^{-6} = 20$ A

Where $I_0 = \frac{\varepsilon_0}{X_C} = \frac{\varepsilon_0}{1/\omega C} = \varepsilon_0 \omega C$

But ε_0 = 100 V, $\omega = 314$ rad s^{-1}, $C = 637 \times 10^{-6}$ F

$\therefore I_0 = 100 \times 314 \times 637 \times 10^{-6} = 20$ A

Hence I = 20 cos 314 t ampere

ii. Instantaneous power,

P = $\varepsilon I = 100 \sin 314t \times 20 \cos 314t$

= 1000 sin 628 t watt

iii. Angular frequency of power, $\omega_p = 628$ rads^{-1}

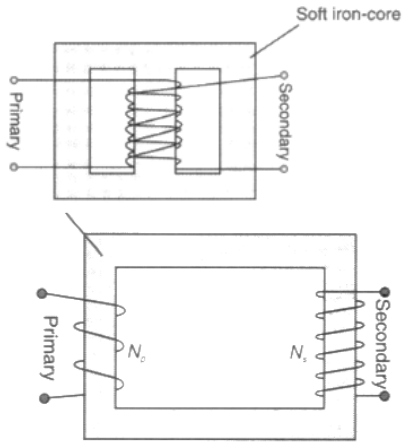
$\therefore$ Frequency of power, $f_p = \frac{\omega_p}{2\pi} = \frac{628}{2\pi} = 100$ Hz

iv. The maximum energy stored in the capacitor is

$U_0 = \frac{1}{2} C E_0^2 = \frac{1}{2} \times 637 \times 10^{-6} \times (100)^2$ = 3.185 J

OR

i.



Principle: Step-down transformer is made up of two or more coil wound on the iron core of the transformer. It works on the principle of magnetic induction between the coils. When the current flowing through the primary coil changes, an emf is induced in the secondary coil due to the change in magnetic flux linked with it.

ii. $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

iii. For an ideal transformer,

$i_p V_p = i_s V_s$

$\therefore \frac{i_p}{i_s} = \frac{V_s}{V_p} = \frac{N_s}{N_p}$

iv. We have

$i_p V_p = i_s V_s = 550$ W

$V_p = 220$ V

$i_p = \frac{550}{220} = \frac{5}{2} = 2.5$ A