Class XII Session 2026-27
Subject - Physics
Sample Question Paper - 2

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

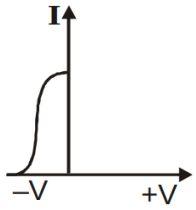
General Instructions:

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.

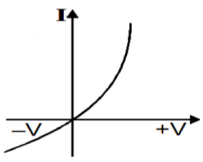
Section A

1. Different voltages are applied across a PN junction and the currents are measured for each value. Which of the following graphs is obtained between voltage and current? **[1]**

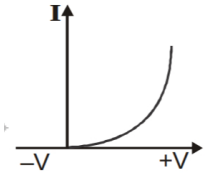
a)



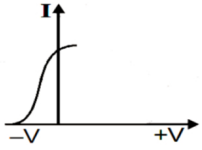
b)



c)



d)



2. The dimension of electrical resistance is: **[1]**

a) $[ML^3T^{-3}A^{-2}]$ b) $[ML^2T^{-3}A^1]$

c) $[ML^2T^{-3}A^{-1}]$ d) $[ML^2T^{-3}A^{-2}]$

3. A diver in a swimming pool wants to signal his distress to a person lying on the edge of the pool by flashing his waterproof flash light. **[1]**

a) He must direct the beam vertically upward

b) He has to direct the beam at an angle to the vertical which is slightly less than the critical angle of incidence for total internal reflection

c) He has to direct the beam horizontally

d) He has to direct the beam at an angle to the vertical which is slightly more than the critical angle of incidence for total internal reflection.

4. Two bar magnets having same geometry with magnetic moments M and 2M are firstly placed in such a way that their similar poles are on the same side and its period of oscillation is T_1. Now the polarity of one of the magnets is reversed and its time period becomes T_2. Then, **[1]**

a) $T_1 < T_2$ b) $T_1 = T_2$

c) $T_1 > T_2$ d) $T_2 = \infty$

5. Some charge is being given to a conductor. Then, it's potential: **[1]**

a) remains the same throughout the conductor b) is maximum at centre

c) is maximum somewhere between surface and centre d) is maximum at surface

6. Two parallel wires carrying equal currents in opposite directions are placed at $x = \pm$ a parallel to y-axis with $z = 0$. Magnetic field at origin O is B_1 and at $P(2a, 0, 0)$ is B_2. Then the ratio B_1/B_2 is: **[1]**

a) $\frac{1}{2}$ b) 3

c) 2 d) $\frac{1}{3}$

7. A loop, made of straight edges has six corners at A(0, 0, 0), B(L, 0, 0) C(L, L, 0), D(0, L, 0) E(0, L, L) and F(0, 0, L). A magnetic field $\mathbf{B} = B_o(\hat{\mathbf{i}} + \hat{\mathbf{k}})\text{T}$ is present in the region. The flux passing through the loop ABCDEFA (in that order) is **[1]**

a) $4\ B_0L^2$Wb b) $\sqrt{2}B_oL^2$Wb

c) B_0L^2Wb d) $2\ B_0L^2$Wb

8. Which one of the following has relative magnetic permeability between 0 and 1? **[1]**

a) Alnico b) Water

c) Sodium d) Aluminium

9. Electromagnetic radiation of frequency n, wavelength λ, travelling with velocity v in air enters a glass slab of refractive index μ. The frequency, wavelength and velocity of **[1]**

light in the glass slab will be respectively,

a) n, 2λ and $\frac{v}{\mu}$

b) $\frac{2n}{\mu}$, $\frac{\lambda}{\mu}$ and v

c) $\frac{n}{\mu}$, $\frac{\lambda}{\mu}$ and $\frac{v}{\mu}$

d) n, $\frac{\lambda}{\mu}$ and $\frac{v}{\mu}$

10. Eight dipoles of charges of magnitude **e** are placed inside a cube. The total electric flux coming out of the cube will be- **[1]**

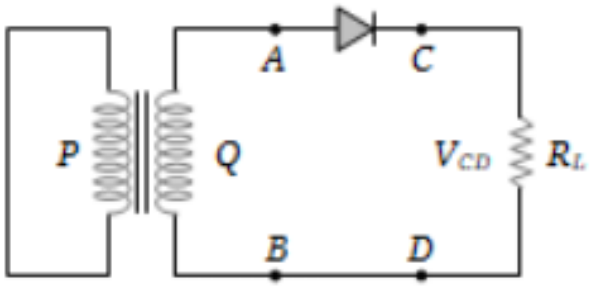
a) $\frac{16e}{\epsilon_o}$

b) $\frac{8e}{\epsilon_o}$

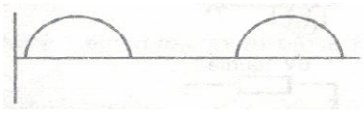
c) $\frac{e}{\epsilon_o}$

d) Zero

11. In the half wave rectifier circuit shown which one of the following wave forms is true for V_{CD}, the output across C and D? **[1]**



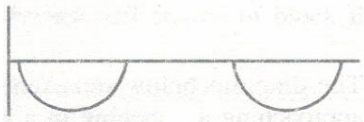
a)



b)



c)



d)



12. A biconvex lens of glass having refractive index 1.47 is immersed in a liquid. It becomes invisible and behaves as a plane glass plate. The refractive index of the liquid is **[1]**

a) 1.47

b) 1.62

c) 1.51

d) 1.33

13. **Assertion (A):** On increasing the frequency of light, the photocurrent remains unchanged. **[1]**

Reason (R): Photocurrent is independent of frequency but depends only on intensity of incident light.

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 (A):** The potential of earth is assumed zero. **[1]**

Reason (R): Earth is insulator and so earth can not hold any charge.

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.

15. **Assertion (A):** Light from two coherent sources is reaching the screen. If the path difference at a point on the screen for yellow light is $\frac{3\lambda}{2}$, then the fringe at that point will be coloured. **[1]**

Reason (R): Two coherent source always have constant phase relationship.

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.

16. **Assertion:** By only knowing the power factor for a given L-C-R circuit, it is not possible to tell whether the applied alternating voltage leads or lags the current. **[1]**

Reason: For certain value of cos θ (power factor) two values of θ are possible as cos (-θ) = cos θ.

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. Given: Wavelength of light in mercury is $5.5 \times 10^{-5} cm$. **[2]**

i. Calculate its frequency and period.

ii. What is the wavelength of the light in the glass, if the refractive index of glass is 1.5?

18. In a full-wave junction diode rectifier, the input a.c. has an rms value of 10 V. The transformer used is a step-up transformer having a transformation ratio 1 : 2. Calculate the d.c. and a.c. voltages in the rectified output. **[2]**

19. Which state of the triply ionised beryllium (Be^{3+}) has the same orbital radius as that of the ground state of hydrogen **[2]**

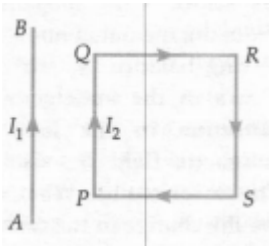
20. A bar magnet placed in a uniform magnetic field of strength 0.3T with its axis at 30° to the field, experiences a torque of 0.06 Nm. What is the magnetic moment of the bar magnet? **[2]**

OR

An iron ring of mean circumferential length 30 cm and cross-section 1 cm^2 is wound uniformly with 300 turns of wire. When a current of 0.032 A flows in the windings; the flux in the ring is 2 $\times$ 10^{-6} Wb. Find the flux density in the ring, magnetising field intensity and relative permeability of iron.

21. In Fig. the straight wire AB is fixed while the loop PQRS is free to move under the influence of the electric currents flowing in them. In which direction does the loop **[2]**

begin to move? Give reason for your answer.



OR

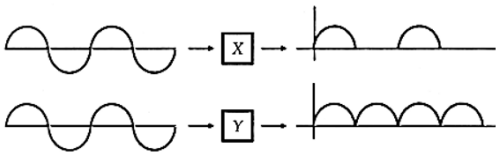
Why is it that while using a moving coil galvanometer as a voltmeter a high resistance in series is required whereas in an ammeter a shunt is used?

Section C

22. i. You are required to select a carbon resistor of resistance $47k\Omega \pm 10\%$ from a large collection. What should be the sequence of colour bands used to code it? **[3]**
    ii. Write the characteristics of manganin which make it suitable for making standard resistance.

23. Ultra-violet light of wavelength 200 nm from a source is incident on a metal surface. If the stopping potential is -2.5 V, **[3]**
    a. Calculate the work function of the metal, and
    b. How would the surface respond to a high intensity red light of wavelength 6328 A produced by a laser?

24. An a.c. the signal is fed into two circuits X and Y and the corresponding output in the two cases have the waveforms shown in the figure. Name the circuits X and Y. Also draw their detailed circuit diagrams. **[3]**

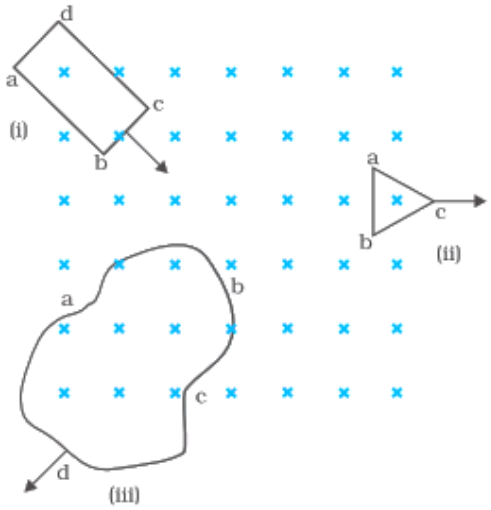


25. How are protons, which are positively charged, held together inside a nucleus? Explain the variation of the potential energy of a pair of nucleons as a function of their separation. State the significance of negative potential energy in this region? **[3]**

26. The ground state energy of an atom is - 13.6 eV. The photon emitted during the transition of an electron from n - 3 to n = 1 state, is incident on a photosensitive material of unknown work function. The photoelectrons are emitted from the materials with a maximum kinetic energy of 9 eV. Calculate the threshold wavelength of the material used. **[3]**

27. In Figure, shows planar loops of different shapes moving out of or into a region of a magnetic field which is directed normal to the plane of the loop away from the reader. **[3]**

Determine the direction of induced current in each loop using Lenz's law.



OR

Derive the expression for the magnetic energy stored in a solenoid in terms of magnetic field B, area A and length l of the solenoid carrying a steady current I. How does this magnetic energy per unit volume compare with the electrostatic energy density stored in a parallel plate capacitor?

28. What is the effect on the interference fringes in Young's double-slit experiment due to each of the following operations? Justify your answers. **[3]**

i. The screen is moved away from the plane of the slits.

ii. The separation between slits is increased.

iii. The source slit is moved closer to the plane of double slit.

Section D

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

Maxwell showed that the speed of an electromagnetic wave depends on the permeability and permittivity of the medium through which it travels. The speed of an electromagnetic wave in free space is given by $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$. The fact led Maxwell to predict that light is an electromagnetic wave. The emergence of the speed of light from purely electromagnetic considerations is the crowning achievement of Maxwell's electromagnetic theory. The speed of an electromagnetic wave in any medium of permeability μ and permittivity ε will be $\frac{c}{\sqrt{K\mu_r}}$ where K is the dielectric constant of the medium and μ_r is the relative permeability.

(a) The dimensions of $\frac{1}{2}\varepsilon_0 E^2$ (ε_0 : permittivity of free space; E = electric field) is

a) ML^2T^{-2} b) MLT^{-1}

c) ML^2T^{-1} d) $ML^{-1}T^{-2}$

(b) Let $[\varepsilon_0]$ denote the dimensional formula of the permittivity of the vacuum. If M = mass, L = length, T = time and A = electric current, then

a) $[\varepsilon_0] = MLT^{-2}A^{-2}$ b) $[\varepsilon_0] = ML^2T^{-1}$

c) $[\varepsilon_0] = M^{-1}L^{-3}T^4A^2$ d) $[\varepsilon_0] = M^{-1}L^{-3}T^2A$

(c) An electromagnetic wave of frequency 3 MHz passes from vacuum into a dielectric medium with permittivity $\varepsilon = 4$. Then

a) wavelength is doubled and the frequency becomes half

b) wavelength and frequency both remain unchanged

c) wavelength is doubled and the frequency remains unchanged

d) wavelength is halved and the frequency remains unchanged.

(d) Which of the following are not electromagnetic waves?
cosmic rays, γ-rays, β-rays, X-rays

a) γ-rays

b) β-rays

c) X-rays

d) cosmic 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. In coulomb's law, $F = k\frac{q_1 q_2}{r^2}$, then on which of the following factors does the proportionality constant k depends?

ii. What is the dimensional formula for the permittivity constant ε_0 of free space?

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

iv. 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.

Section E

31. i. Draw a ray diagram showing refraction of light through a prism of angle A and obtain the relation between μ, A and the angle of minimum deviation δ_m. **[5]**

ii. An equiconvex lens of radius of curvature R and made of glass of refractive index μ is cut into two identical plano-convex lenses. Find the focal length of the plano-convex lenses.

OR

i. Write three characteristic features to distinguish between the interference fringes in Young's double-slit experiment and the diffraction pattern obtained due to a narrow single slit.

ii. A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m away. It is observed that

the first minima are at a distance of 2.5 mm away from the centre. Find the width of the slit.

32. a. Derive an expression for the potential energy of an electric dipole in a uniform electric field. Explain conditions for stable and unstable equilibrium. **[5]**

b. Is the electrostatic potential necessarily zero at a point where the electric field is zero? Give an example to support your answer.

OR

Calculate potential on the axis of a disc of radius R due to a charge Q uniformly distributed on its surface.

33. i. Draw a labelled diagram of a step-up transformer. Obtain the ratio of secondary to primary voltage in terms of the number of turns and currents in the two coils. **[5]**

ii. A power transmission line feeds input power at 2200 V to a step-down transformer with its primary windings having 3000 turns. Find the number of turns in the secondary to get the power output at 220 V.

OR

A small town with a demand of 800 kW of electric power at 220 V is situated 15 km away from an electric plant generating power at 440 V. The resistance of the two wirelines carrying power is 0.5 Ω per km. The town gets power from the line through a 4000 - 220 V step-down transformer at a sub-station in the town.

a. Estimate the line power loss in the form of heat.

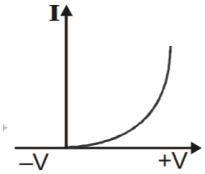
b. How much power must the plant supply, assuming there is negligible power loss due to leakage?

c. Characterize the step-up transformer at the plant.

Solution

Section A

1. **(c)**



Explanation:
The correct graph for a PN junction under varying voltages shows a nonlinear relationship between voltage and current. As the voltage increases in the forward bias region, the current increases exponentially. This behavior is characteristic of diodes, where small increases in voltage lead to large increases in current after a certain threshold (the forward voltage). The graph typically starts at zero current, rises steeply, and levels off in reverse bias, indicating that the current remains very low until breakdown occurs. Correct option accurately represents this exponential increase in current with voltage.

2. **(d)** $[ML^2T^{-3}A^{-2}]$

Explanation:

$\text{Power} = i^2R \Rightarrow \frac{\text{Work done}}{\text{Time}} - \frac{\text{Force} \times \text{Dis tance}}{\text{Time}}$

$\Rightarrow [R] = \left[\frac{MLT^{-2}L}{T}\right]\left[\left(\frac{1}{A^2}\right)\right]$

$\Rightarrow [R] = ML^2T^{-3}A^{-2}$

3. **(b)** He has to direct the beam at an angle to the vertical which is slightly less than the critical angle of incidence for total internal reflection

Explanation:
He has to direct the beam at an angle to the vertical which is slightly less than the critical angle of incidence for total internal reflection.

4. **(a)** $T_1 < T_2$

Explanation:
In sum position,

$T_1 = 2\pi\sqrt{\frac{I_1+I_2}{(M_1+M_2)B_H}}$

$= 2\pi\sqrt{\frac{I+I}{(M+2M)B_H}}$

$= 2\pi\sqrt{\frac{2I}{3MB_H}}$

In difference position,

$T_2 = 2\pi\sqrt{\frac{I_1+I_2}{(M_2-M_1)B_H}}$

$= 2\pi\sqrt{\frac{I+I}{(2M-M)B_H}}$

$= 2\pi\sqrt{\frac{2I}{MB_H}}$

$\therefore \frac{T_1}{T_2} = \frac{1}{\sqrt{3}} < 1$ or $T_1 < T_2$

5. **(a)** remains the same throughout the conductor

Explanation:

The potential at all points inside a conductor is same as that on its surface.

6.

(b) 3

Explanation:

The magnetic field due to a long straight wire carrying current is given by the formula $B = \frac{\mu_0 I}{2\pi r}$, where r is the distance from the wire to the point where the magnetic field is being calculated. At the origin O, the distance from each wire (located at $x = \pm a$) is a. Since the currents are in opposite directions, the magnetic fields produced by each wire at the origin will add up, resulting in a total magnetic field B_1. At point $P(2a, 0, 0)$, the distance from each wire is $2a$. The magnetic fields from each wire at this point will also oppose each other, but since they are further away, the magnitude of each field will be $\frac{\mu_0 I}{2\pi(2a)}$. Calculating the ratio $\frac{B_1}{B_2}$: - B_1 is proportional to $\frac{1}{a}$. - B_2 is proportional to $\frac{1}{2a}$. Thus, $\frac{B_1}{B_2} = \frac{\frac{1}{a}}{\frac{1}{2a}} = 2$.

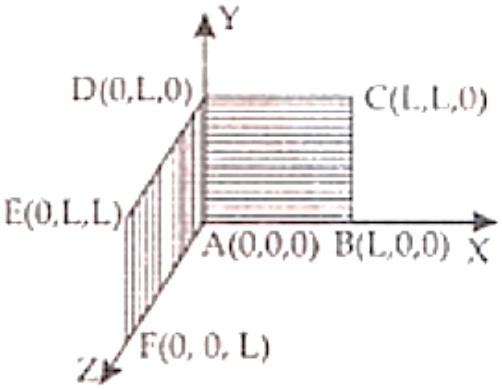
However, since the fields from the two wires at point P are in opposite directions, the effective field at P is actually $B_1 - B_2$. The calculation shows that the effective field at P is one-third of that at the origin, leading to the ratio $\frac{B_1}{B_2} = 3$. This confirms that the solution provided is correct.

7.

(d) 2 B_0L^2Wb

Explanation:

The loop can be considered in two planes:



i. Plane of ABCDA is in X-Y plane So its vector $\vec{A}$ is in Z-direction so

$A_1 = |A|\hat{k} = L^2\hat{k}$

ii. Plane of DEFAD is in Y-Z plane

So $A_2 = |A|i = L^2 i$

$\therefore A = A_1 + A_2 = L^2(\hat{i} + \hat{k})$

B = B_0 (i + k)

the magnetic flux linked with uniform surface of area A in uniform magnetic field is given by, $\phi = B \cdot A = B_0(i + k) \cdot L^2(i + k)$ $= B_0L^2[i.i + i.k + k.i + k.k]$

= B_0L^2[1 + 0 + 0 + 1] $\because \cos 90^\circ = 0$

= 2 B_0L^2Wb

8.

(b) Water

Explanation:

As Water is a diamagnetic substance.

9.

(d) n, $\frac{\lambda}{\mu}$ and $\frac{v}{\mu}$

Explanation:

Frequency n remains same

$\mu = \frac{\lambda}{\lambda_{med}}$ or $\lambda_{med} = \frac{\lambda}{\mu}$

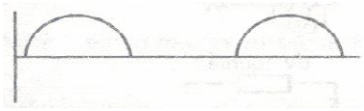
$\mu = \frac{v}{v_{med}}$, $v_{med} = \frac{v}{\mu}$

10.

(d) Zero

Explanation:

On all the dipoles, net charge = 0. Hence net charge enclosed within the surface = 0. So the total electric flux coming out of the surface, $\phi = \frac{q_{net}}{\varepsilon_0} = 0$

11. **(a)** 

Explanation:

When an alternating voltage is applied across a half wave rectifier, a pulsating voltage appears across the load only during the half cycles of the ac input i.e., only when the diode is forward biased.

12. **(a)** 1.47

Explanation:

the refractive index of liquid must be equal to refractive index of glass=1.47

13. **(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.

14.

(c) A is true but R is false.

Explanation:

A is true but R is false.

15.

(d) A is false but R is true.

Explanation:

When the source is emitting yellow light, then there will be a dark fringe at a point where path difference is $\frac{3\lambda}{2}$ [from condition for dark fringe $x = (2n+1)\frac{\lambda}{2}$]. If the light is white then the fringe will be coloured, the yellow and neighbouring colours being absent.

16. **(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.

Section B

17. Given: Wavelength, $\lambda = 5.5\times10^{-5}$ cm = 5.5×10^{-7} m

    1. Frequency, $\nu = \frac{c}{\lambda} = \frac{3\times10^{8} m/s}{5.5\times10^{-7} m} = 5.45\times10^{14}$ Hz $= 5.45 \times 10^{8} MHz$
       Time period, $T = \frac{1}{\nu} = \frac{1}{5.45\times10^{8}} = 1.83 \times 10^{-9} \mu s$
    2. Wavelength of the light in the glass, $\lambda_g = \frac{\lambda}{\mu} = \frac{5.5\times10^{-7}}{1.5} = 3.67\times10^{-7}$ m

18. rms value of input a.c., V_{rms} = 10 V

    Peak value of input a.c.,
    $V_0 = \sqrt{2}V_{rms} = \sqrt{2} \times 10$ = 14.14 V
    As the step-up transformer has a transformation ratio 1 : 2, the maximum value of the output voltage of the transformer applied to the diodes is
    $V_0' = 2 \times V_0 = 2\times$ 14.14 = 28.28 V
    d.c. voltage in the rectified output = $\frac{2V_0'}{\pi}$
    = 0.637 $\times$ 28.28 = 18.01 V
    a.c. voltage in the rectified output
    = 0.305 V_0' = 0.305 $\times$ 28.28 = 8.62 V

19. Radius of nth orbit is given by $r_n = \frac{n^2h^2}{4\pi^2mkZe^2}$ i.e; $r_n \propto \frac{n^2}{Z}$

    Let $r_n(Be^{3+}) = r_1(H)$
    $x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$
    or $\frac{n^2}{4} = \frac{1^2}{1}$ or n =2

20. Here, B = 0.3 T, $\theta = 30^o$, τ = 0.06 N-m, M = ?

    As τ = Mb sin θ, M = $\frac{\tau}{B\sin\theta} = \frac{0{\cdot}06}{0{\cdot}3\sin30^\circ}$ = 0.4 Am^2

    OR

    Here l = 30cm = 0.30 m, A = 1 cm^2 = 10^{-4} m, N = 300, I = 0.032 A, $\phi = 2 \times 10^{-6}$ Wb,
    n = $\frac{N}{l} = \frac{300}{0.30}$ = 1000 m^{-1}
    Magnetic flux density,
    B = $\frac{\phi}{A} = \frac{2\times10^{-6}}{10^{-4}}$ = 2 $\times$ 10^{-2} Wb m^{-2}
    Magnetising field intensity,
    H = nI = 1000 $\times$ 0.032 = 32 A turns m^{-1}
    Permeability,
    $\mu = \frac{B}{H} = \frac{2\times10^{-2}}{32}$ = 6.25 $\times$ 10^{-4} T mA^{-1}
    Relative permeability, $\mu_r = \frac{\mu}{\mu_0} = \frac{6.25\times10^{-4}}{4\pi\times10^{-7}}$ = 500

21. The currents in QR and PS have no effect on AB. There is a force of attraction between AB and PQ and a force of repulsion between AB and SR. But PQ is closer to AB than SR, so force of attraction is stronger than the force of repulsion. So the loop begins to move towards AB.

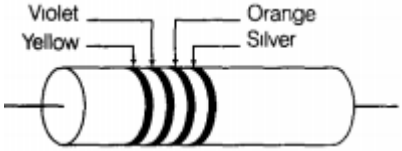
    OR

    In order that the insertion of an ammeter in series in a circuit does not affect the current in the circuit, an ammeter must have the least possible resistance. So a galvanometer is converted into ammeter by connecting a small resistance in parallel with it. A voltmeter is connected in parallel with the component across which the p.d. is measured. It must have very high resistance so that a very small current passes through it and the p.d. across that component is not affected. So a galvanometer is converted into a voltmeter by connecting a high resistance in series with it.

Section C

22. i. Given, resistance $= 47k\Omega \pm 10\%$
    $= 47 \times 10^3\Omega \pm 10\%$

∴ 1st colour band should be yellow as code for it is 4, 2nd colour band should be violet as code for it is 7, 3rd colour band should be orange as code for it is 3, 4th colour band should be silver because approximation is ± 10%.



ii. Two properties of manganin are:

a. low temperature coefficient of resistance.

b. high value of resistivity of material of manganin make it suitable for making a standard resistor.

23. a. λ = 200 nm, stopping potential = -2.5 V

K.E. = $2.5 \times 1.6 \times 10^{-19}$ J = 4×10^{-19} J

$E = hv = h\frac{c}{\lambda}$

$= \frac{6.63\times10^{-34}\times3\times10^{8}}{200\times10^{-9}}$

$= 9.945 \times 10^{-19}$ J

Work function = E - eV

$= (9.945 \times 10^{-19} - 4 \times 10^{-19})$J

$= 5.595 \times 10^{-19}$ J

b. Wavelength of red light = 6328 $\overset{\circ}{A}$

$E = hv = h\frac{c}{\lambda}$

$= \frac{6.63\times10^{-34}\times3\times10^{8}}{6328\times10^{-10}}$

$= 0.00314 \times 10^{-16}$ J

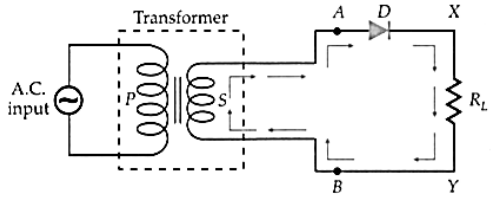
$= 3.14 \times 10^{-19}$ J

Energy of red light < work function of metal surface

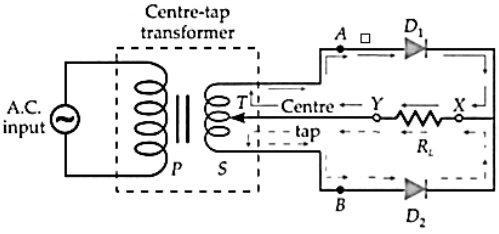
∴ No emission of photoelectrons takes place.

24. we know that A half-wave rectifier **converts an AC signal to DC by passing either the negative or positive half-cycle of the waveform and blocking the other**. A *full wave rectifier* is defined as a rectifier that converts the complete cycle of alternating current into pulsating DC

Here, X, is a half-wave rectifier and Y is a full-wave rectifier.



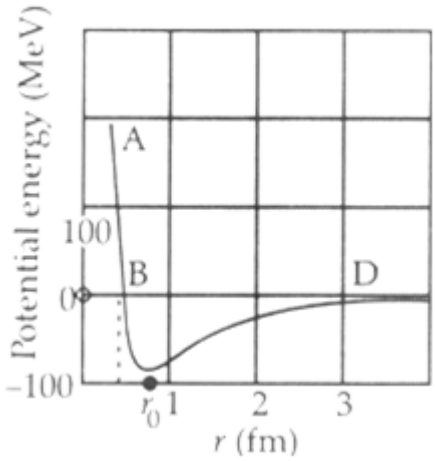
Half-wave rectifier circuit.



Full wave rectifier circuit.

25. There are two types of forces: Coulomb force and nuclear force which are acting between protons in the nucleus. The gravitational force between two protons is very weak. Between these two forces, nuclear force is stronger as compared to Coulomb force but it is a very short-range force.

Coulomb force is repulsive in nature for two protons dominant over nuclear force when the distance between two protons increases more than a few femtometer. As the nuclear size is in the order of the femtometer, hence in the nucleus, nuclear force between protons dominates over the Columbian force. It is attractive in nature and binds together. Moreover, neutrons in nucleus also act as glue to held protons together as there is no Coulomb force between protons and neutrons but there is an attractive nuclear force between them.



It is clear from the graph, as the nucleons come closer under attractive nuclear force, the potential energy decreases and PE becomes more and more negative. When the distance between two nucleons falls below 10^{-15} m, the nuclear force becomes repulsive and potential energy increases rapidly. Hence negative PE shows that force between nucleons is attractive.
The characteristic properties of nuclear force:

i. The nuclear force is short-range force.
ii. The nuclear force is independent of electric charge.

26. For a transition from n = 3 to n = 1 state, the energy of the emitted photon,
hv = E_2 - E_1

$= 13.6\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$ eV $= 12.1$eV

From Einstein's photoelectric equation,
hv = K_{max} + W_0

$\therefore$ W_0 = hv - K_{max} = 12.1 - 9 = 3.1 eV

Threshold wavelength, $\lambda_0 = \frac{hc}{W_0}$

$= \frac{6.62\times10^{-34}\times3\times10^8}{3.1\times1.6\times10^{-19}} = 4\times10^{-7}$ m

27. i. The magnetic flux through the rectangular loop abcd increases, due to the motion of the loop into the region of a magnetic field According to Lenz's law, this increase in flux is opposed by the induced current. The induced current must flow along the path bcdab so that it opposes the increasing flux.
ii. Due to the outward motion, magnetic flux through the triangular loop abc decreases due to which the induced current flows along bacd, so as to oppose the change in flux.
iii. As the magnetic flux decreases due to motion of the irregularly shaped loop abcd out of the region of the magnetic field, the induced current flows along cdabc, so as to oppose change in flux. Note that there is no induced current as long as the loops are completely inside or outside the region of the magnetic field.

OR

Rate of work done,
$\frac{dW}{dt} = |\varepsilon| i$
$dW = \left(LI\frac{dI}{dt}\right) dt$
dW = LI dl
Total amount of work done,

$\int dW = \int LIdI$

W = $\frac{1}{2}LI^2$

For the solenoid:

Inductance, L = $\mu_0 n^2 AE$; B = $\mu_0 nI$

$\therefore$ W = U_B = $\frac{1}{2}LI^2$

= $\frac{1}{2}\left(\mu_0 n^2 Al\right)\left(\frac{B}{\mu_0 n}\right)^2$

= $\frac{B^2 Al}{2\mu_0}$

Magnetic energy per unit volume

Electrostatic Energy Stored Per Unit Volume stored in parallel plate capacitor = $\frac{1}{2}\varepsilon_0 E^2$

28. i. D is Distance between screen to slits, d is distance between the slits, λ is wavelength
Fringe width $\beta = \frac{\lambda D}{d}$
Since $\beta \propto D$, the fringe width will increase, as screen is moved away.
ii. $\beta \propto \frac{1}{d}$, therefore fringe width will decrease as the separation between slits is increased.
iii. Let s be the width of the source slit and S its distance from plane of two slit. For interference fringes to be distinctly seen, the condition
$\frac{s}{S} < \frac{\lambda}{d}$
should be satisfied, otherwise, the interference patterns produced will overlap.

Section D

29. **Read the text carefully and answer the questions:**
Maxwell showed that the speed of an electromagnetic wave depends on the permeability and permittivity of the medium through which it travels. The speed of an electromagnetic wave in free space is given by c = $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$. The fact led Maxwell to predict that light is an electromagnetic wave. The emergence of the speed of light from purely electromagnetic considerations is the crowning achievement of Maxwell's electromagnetic theory. The speed of an electromagnetic wave in any medium of permeability μ and permittivity ε will be $\frac{c}{\sqrt{K\mu_r}}$ where K is the dielectric constant of the medium and μ_r is the relative permeability.

(a) **(d)** $ML^{-1}T^{-2}$
Explanation:
$\frac{1}{2}\varepsilon_0 E^2$ = energy density = $\frac{\text{Energy}}{\text{Volume}}$
$\therefore \left[\frac{1}{2}\varepsilon_0 E^2\right] = \frac{ML^2 T^{-2}}{L^3}$ = $[ML^{-1}T^{-2}]$

(b) **(c)** $\left[\varepsilon_0\right] = M^{-1}L^{-3}T^4A^2$
Explanation:
As $\varepsilon_0 = \frac{q_1 q_2}{4\pi FR^2}$ (from Coulomb's law)
$\varepsilon_0 = \frac{C^2}{Nm^2}\frac{[AT]^2}{MLT^{-2}L^2} = M^{-1}L^{-3}T^4A^2$

(c) **(d)** wavelength is halved and the frequency remains unchanged.
Explanation:
The frequency of the electromagnetic wave remains same when it passes from one medium to another.
Refractive index of the medium, n = $\sqrt{\frac{\varepsilon}{\varepsilon_0}} = \sqrt{\frac{4}{1}} = 2$

Wavelength of the electromagnetic wave in the medium,

$\lambda_{med} = \frac{\lambda}{n} = \frac{\lambda}{2}$

(d) **(b)** β-rays

Explanation:

β-rays consists of electrons which are not electromagnetic in nature.

30. i. The proportionality constant k depends on the nature of the medium between the two charges.

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

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

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

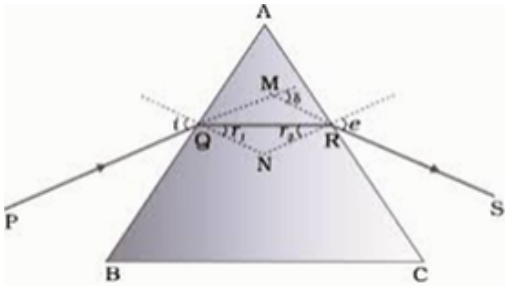
$\therefore (10 \times 10^{-3}) \times 10 = \frac{(9\times10^9)\times q^2}{(0.6)^2}$

or $q^2 = \frac{10^{-1}\times0.36}{9\times10^9} = 4 \times 10^{-12}$

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

Section E

31. i.



From the figure

$\angle A + \angle QNR = 180^o$

From ΔQNR

$r_1 + r_2 + \angle QNR = 180^o$

comparing the above equations

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

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

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

At the minimum derivation D_m

$\delta = D_m$, i = e and $r_1 = r_2$

From equation (i)

$2r = A$

$r = \frac{A}{2}$

From equation (ii)

$D_m = 2i - A$

$i = \frac{A+D_m}{2}$

The refractive index of the prism is

$n_{21} = \frac{\sin i}{\sin r} = \frac{\sin\left[\frac{(A+D_m)}{2}\right]}{\sin[A/2]}$

ii. $\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$\frac{1}{f_1} = (n-1)\left[\frac{2}{R}\right]$

$\frac{1}{f_2} = (n-1)\left[\frac{1}{R}\right]$

$f_2 = 2\, f_1$

Hence, the focal length of the plano-convex lenses is $f_2 = 2\, f_1$.

OR

i.

S.No	Interference	Diffraction
1.	The width of central maxima is the same as that of the other fringes.	The width of central maxima is more than of the other fringes.
2.	All bright fringes are of equal intensity.	The intensity of secondary maxima keeps on decreasing.
3.	A large number of fringes.	Only a small number of fringes.

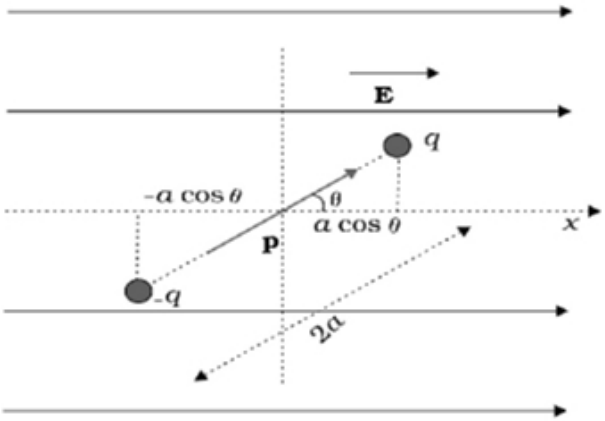
ii. $y_n = \frac{n\lambda D}{d}$, $\lambda = 500 \times 10^{-9}$ m, D=1m.and y_n = 2.5 x 10^{-3} m thus the width of the slit is given by:-

$\Rightarrow \quad d = \frac{n\lambda D}{y_n}$

$\therefore d = \frac{1\times500\times10^{-9}\times1}{2.5\times10^{-3}}\text{m}$

d = 2 $\times$ 10^{-4} m = 0.2 mm

32. a.



Since torque acting on dipole

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

$\vec{\tau} = pE\sin\theta \cdot \hat{n}$

work done $d\omega = \tau . d\theta$

$= pE\sin\theta d\theta$

$w = \int_{\theta_1}^{\theta_2} dw \quad pE\int_{\theta_1}^{\theta_2} \sin\theta d\theta$

$w = pE[-\cos\theta]_{\theta_1}^{\theta_2}$

$= pE\left[\cos\theta_1 - \cos\theta_2\right]$

if $\theta_1 = 0, \theta_2 = \theta$

w = pE (1 - cosθ)

Conditions-

For stable equilibrium - When electric dipole is parallel to electric field.

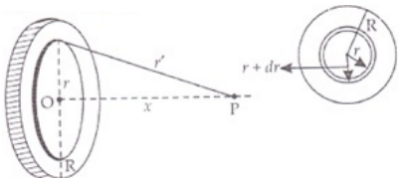
For unstable equilibrium - Anti Parallel to electric field.

b. No.

Inside equipotential surface

OR

Consider a point P on the axis perpendicular to the plane of disc and at distance x from the center O of the disc as shown in the figure.



Now consider a ring of radius r of thickness dr on a disc of radius R, as shown in the figure, Let us consider disc is divided into a large number of rings, Again let the charge on the ring is dq then potential dV due to ring at P, will be

$dV = \frac{kdq}{r'}\left[\because r' = \sqrt{r^2 + x^2}\right]$

dq is the charge on the ring = σ area of ring

$= \sigma \cdot \left[\pi(r + dr)^2 - \pi r^2\right]$

$dq = \sigma \cdot \pi\left[r^2 + dr^2 + 2rdr - r^2\right]$

Because dr is small, therefore, dr_2 is negligible.

$\therefore dq = \sigma\pi(2rdr) = 2\pi r\sigma \cdot dr$

$\therefore dV = \frac{k.2\pi r\sigma dr}{\sqrt{(r^2+x^2)}}$

So the potential due to charged disc

$\int_0^V dV = \int_0^R \frac{k.2\pi\sigma dr}{\sqrt{r^2+x^2}}$

$V = k.2\pi\sigma \cdot \int_0^R \frac{rdr}{(r^2+x^2)^{12}} = k.\pi\sigma\int_0^R r \cdot \left(r^2 + x^2\right)^{-1/2} 2dr = \frac{k\pi\sigma[\sqrt{r^2+x^2}]_0^R}{1/2}$

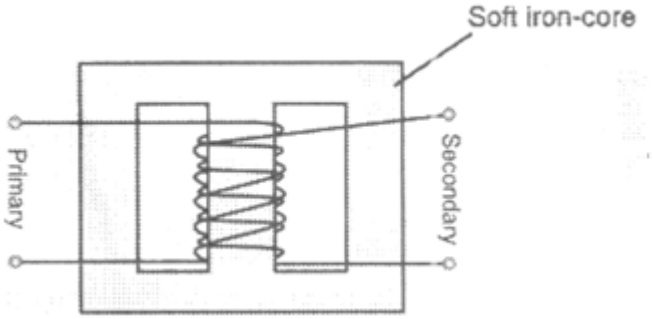
$= 2\pi k\sigma\left[\left(R^2 + x^2\right)^{1/2} - x\right] = \frac{2\pi\sigma}{4\pi\varepsilon_0}\left[\left(R^2 + x^2\right)^{1/2} - x\right]$

[$\because$ $\pi R^2\sigma$ = Q(charge on disc) $\sigma = \frac{Q}{\pi R^2}$

$= \frac{\pi 2R^2\sigma}{4\pi\varepsilon_0 R^2}\left[\sqrt{R^2 + x^2} - x\right]$ thus the potential due to a disc is given by,

$V = \frac{2Q}{4\pi\varepsilon_0 R^2}\left[\sqrt{R^2 + x^2} - x\right]$

33. i.



Whenever current in one coil changes an emf gets induced in the neighbouring coil (Principle of mutual induction)

Voltage across secondary

$V_s = e_s = -N_s \frac{d\phi}{dt}$

Voltage across primary

$V_p = e_p = -N_p \frac{d\phi}{dt}$

$\frac{V_s}{V_p} = \frac{N_s}{N_p}$ (here, $N_s > N_p$)

In an ideal transformer

Power Input = Power output

$I_p V_p = I_s V_s$

$\therefore \frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$

ii. Calculation of the number of turns in the secondary:
No. of turns in primary coil N_p = 3000, V_s = 220V, V_p = 2200V

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

$\frac{N_s}{3000} = \frac{220}{2200}$

$\therefore N_s = 300$

OR

Total electric power required,
Supply voltage, V = 220 V
The voltage at which electric plant is generating power, V' = 440 V
Distance between the town and power generating station, d = 15 km
The resistance of the two-wire lines carrying power = 0.5 Ω/km
Total resistance of the wires, R = (15 + 15) 0.5 = 15 Ω
A step-down transformer of rating 4000 - 220 V is used in the sub-station.
Input voltage is , V_1 = 4000 V
Output voltage is, V_2 = 220 V
Rms current in the wire lines is given as:

$I = \frac{P}{V_1}$

$= \frac{800 \times 10^3}{4000}$ = 200 A

a. Line power loss in the form of heat is given by = I^2R
   = $(200)^2 \times 15$
   = 600×10^3 W
   = 600 KW
b. Assuming that the power loss is negligible due to the leakage of the current:
   hence Total power supplied by the plant = 800 KW + 600 KW
   = 1400 KW
c. Voltage drop in the power line is given by = IR = 200 × 15 = 3000 V
   Hence, total voltage transmitted by the plant = 3000 + 4000
   = 7000 V
   Hence, the rating of the step-up transformer situated at the power plant is 440 V - 7000 V.