BUDHA DAL PUBLIC SCHOOL, PATIALA
First Term Examination (18 September 2023)
Class XII (Science)
Subject - Physics
(Set - B)

Time: 3hrs **M.M. 70**

General Instructions:

(1) There are 35 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 18 questions, 15 MCQ and 3 Assertion Reasoning based of 1 mark each, **Section B** contains 7 questions of two marks each, **Section C** contains 5 questions of three marks each, **Section D** contains three long answer questions of five marks each **and Section E** contains two case study based questions of four marks each.
(5) Use of calculators is not allowed.

i) $c = 3 \times 10^8$ m/s
ii) $me = 9.1 \times 10^{-31}$ kg
iii) $e = 1.6 \times 10^{-19}$ C
iv) $\mu 0 = 4\pi \times 10^{-7}$ TmA−1
v) $h = 6.63 \times 10^{-34}$ Js
vi) $\varepsilon 0 = 8.854 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$
Vii) Avogadro's number = 6.023×10^{23} per gram mole

Section - A

Q1. An electric dipole consisting of charges + q and − q separated by a distance L is in stable equilibrium in a uniform electric field $\vec{E}$. The electrostatic potential energy of the dipole is

a) qLE b) zero c) $-qLE$ d) -2qEL

Q2. A straight conducting rod of length l and mass m is suspended in a horizontal plane by a pair of flexible strings in a magnetic field of magnitude B. To remove the tension in the supporting strings, the magnitude of the current in the wire is

a) $\frac{mgB}{l}$ b) $\frac{mgl}{B}$ c) $\frac{mg}{LB}$ d) $\frac{lB}{mg}$

Q3. When an alternating voltage $E = E_0 \sin \omega t$ is applied to a circuit, a current $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$ flows through it. The average power dissipated in the circuit is

a) $E_{rms} \cdot I_{rms}$ b) $E_0 I_0$ c) $\frac{E_0 I_0}{\sqrt{2}}$ d) zero

Q4. A bar magnet has magnetic dipole moment $\vec{M}$. Its initial position is parallel to the direction of uniform magnetic field $\vec{B}$. In this position the magnitudes of torque and force acting on it respectively are

a) 0 and MB b) MB and MB c) 0 and 0 d) $|\vec{M} \times \vec{B}|$ and 0

Q5. If both the number of turns and core length of an inductor is doubled keeping other factors constant, then its self-inductance will be

a) unaffected b) doubled c) halved d) quadrupled

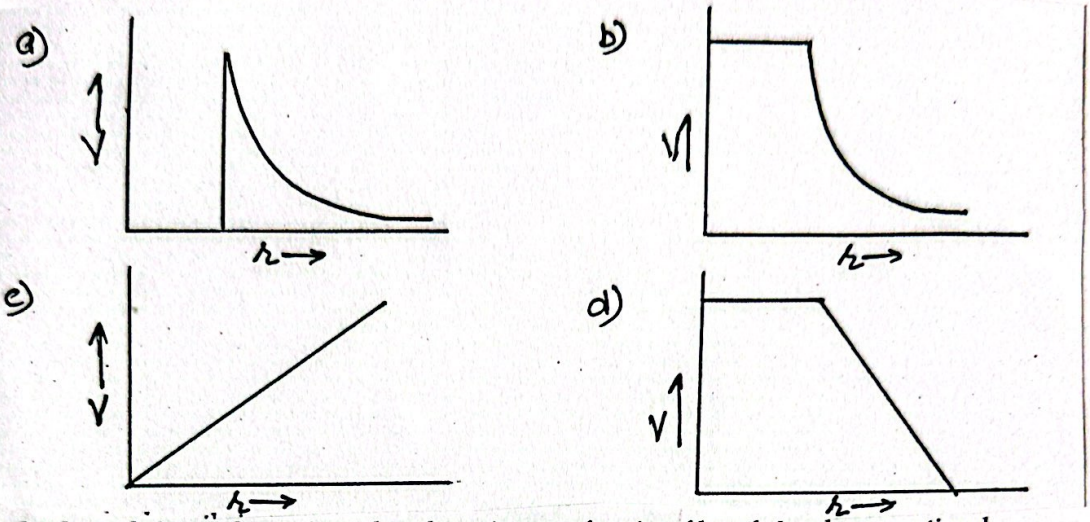
Q6. Which of the following has its permeability less than that of free space?

a) Copper b) Aluminum c) Copper chloride d) Nickel

The capacitance of a capacitor becomes $\frac{7}{6}$ times its original value of a dielectric slab if thickness $t = \frac{2}{3}d$ if introduced in between the plates, where d is the separation between the plates. The dielectric constant of the slab is

a) $\frac{14}{11}$ b) $\frac{11}{14}$ c) $\frac{7}{11}$ d) $\frac{11}{7}$

Q8. In the case of charged metallic sphere, potential (V) changes with respect to distance (r) from the centre as



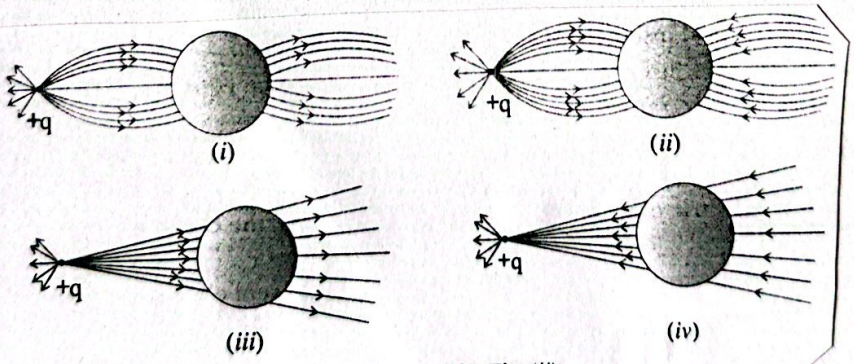
Q9. If n, e, r and m have their usual meanings, then the resistance of a wire of length l and crosssectional area A is given by

a) $\frac{ne^2A}{3m\tau l}$ b) $\frac{ml}{n^2\tau A}$ c) $\frac{m\tau l}{n^2 l}$ d) $\frac{ne^2\tau A}{2ml}$

Q10. The current sensitivity of a galvanometer increases by 20%. If its resistance also increases by 25%, the voltage sensitivity will

a) decrease by 1% b) increase by 5% c) increase by 10% d) decrease by 4%

Q11. A point positive charge is brought near an isolated conducting sphere. The electric field is best given by



(a) Fig (i) (b) Fig (ii)

(c) Fig (iii) (d) Fig (iv)

Q12. A current of 10 A is flowing from east to west in a long straight wire kept on a horizontal table. The magnetic field developed at a distance of 10 cm due north on the table is:

a) 2×10^{-5} T, acting downwards b) 2×10^{-5} T, acting upwards

c) 4×10^{-5}, T, acting downwards d) 4×10^{-5} T, acting upwards

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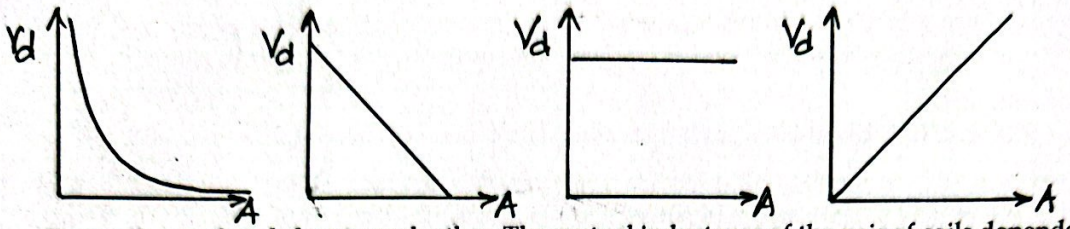
Q13. A steady current flows through a metallic wire whose area of cross-section (A) increases continuously from one end of the wire to the other. The magnitude of drift velocity (v_d) of the free electrons as a function of 'A' can be shown by



Q14. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon the

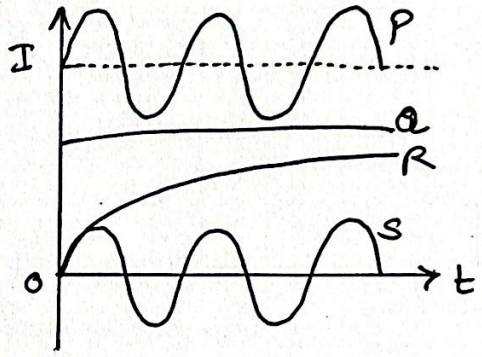
a) Rate at which current change in the two coils

b) Relative position and orientation of the coils

c) Rate at which voltage induced across two coils

d) Currents in the two coils

Q15. The figure shows variation of current (I) with time (t) in four devices P, Q, R and S. The device in which an alternating current flows is



a) P b) Q c) R d) S

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as:

a) Both Assertion (A) and Reason (R) true and Reason (R) is the correct explanation of Assertion (A).

b) Both Assertion (A) and Reason (R) are true but Reason (R) is not a correct explanation of Assertion (A).

c) Assertion (A) is true but Reason (R) is false.

d) Assertion (A) is false and Reason (R) is also false.

Q16. **Assertion (A) :** When radius of a circular loop carrying a steady current is doubled, its magnetic moment becomes four times.

Reason (R) : The magnetic moment of a circular loop carrying steady current is proportional to the area of the loop.

Q17. **Assertion (A) :** Transformers are used only in alternating current source not in direct current.

Reason (R) : Only a.c. can be stepped up or down by means of transformers.

Q18. **Assertion (A) :** Electric field is always normal to equipotential surfaces and along the direction of decreasing order of potential.

Reason (R) : Negative gradient of electric potential is electric field.

Section - B

Q19. Nichrome and copper wires of same length and same radius are connected in series. Current I is passed through them. Which wire gets heated up more? Justify your answer.

Q20. a) On the basis of electron drift, derive an expression for resistivity of a conductor in terms of number density of free electrons and relaxation time. On what factors does resistivity of a conductor depend?

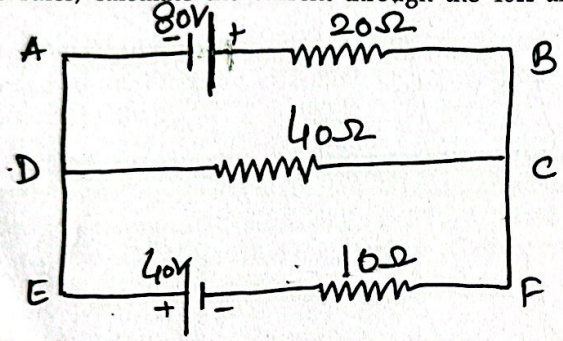
b) Why alloys like constantan and manganin are used for making standard resistor?

Q21. Two long straight parallel conductors carry steady current I_1 and I_2 separated by a distance d. If the currents are flowing in the same direction, show how the magnetic field set up in one produces and attractive force on the other. Obtain the expression for this force. Hence define one ampere.

OR

Deduce the expression for the torque acting $\vec{\tau}$ acting on a plannar loop of area $\vec{A}$ and carrying current I placed in a uniform magnetic field $\vec{B}$. If the loop is free to rotate, what would be its orientation in stable equilibrium?

Q22. Using Kirchhoff's rules, calculate the current through the 40Ω and 20Ω resistors in the following circuit.



Q23. Write charges $2\mu C$ and $-2\mu C$ are placed at points A and B 6cm apart.

a) Identify an equipotential surface of the system.

b) What is the direction of the electric field at every point on this surface?

Q24. A wire of length l is in the form of a circular loop A of one turn. This loop is reshaped into loop B of three turns. Find the ratio of the magnetic fields at the centres of loop A and loop $B$for the same current through them.

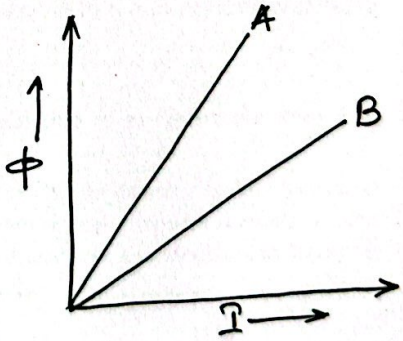
OR

a) How does the mutual inductance of a pair of coils change when

(i) distance between the coils is increased and

(ii) number of turns in the coils in increased

b) A plot of magnetic flux ∅ versus current (I), is shown in the figure for two inductors A and B. Which of the two has large value of self – inductance?



Q25. A series LCR circuit is connected to an ac source (200 V, 50Hz). The voltages across the resistor; capacitor and inductor are respectively 200 V, 250 V and 250 V.

a) The algebraic sum of the voltages across the three elements is greater than the voltage of the source. How is this paradox resolved?

b) Given the value of the resistance of R is 40Ω, calculate the current in the circuit.

Section - C

Q26. Derive an expression for the capacitance of a parallel plate capacitor when a dielectric slab of dielectric constant K and thickness $t = \frac{d}{2}$ but of same area as that of the plates is inserted between the capacitor plates. (d = separation between the plates)

Q27. Derive an expression for self inductance of a long air-cored solenoid of length *l*, cross-section area A and having number of turns N.

Q28. A charge Q is distributed over the surfaces of two concentric hollow spheres of radii r and R (R > >r), such that their surface charge densities are equal. Derive the expression for the potential at the common centre.

OR

a) Draw equipotential surfaces corresponding to the electric field that uniformly increases in magnitude along with the z-directions.

b) Two charges -q and +q are located at point (0, 0, -a) and (0, 0, a). What is the electrostatic potential at the points $(0, 0, \pm z)$ and (x, y, 0)?

Q29. An α- particle and a proton of the same kinetic energy are in turn allowed to pass through a magnetic field $\vec{B}$, acting normal to the direction of motion of the particles. Calculate the ratio of radii of the circular paths described by them.

Q30. A galvanometer of resistance G is converted into a voltmeter to measure upto V volts by connecting a resistance R_1 in series with the coil. If a resistance R_2 is connected in series with it, then it can measure upto V/2 volts. Find the resistance, in terms of R_1, and R_2, required to be connected to convert it into a voltmeter that can read upto 2 V. Also find the resistance G of the galvanometer in terms of R_1 and R_2.

OR

To convert a given galvanometer into a voltmeter of ranges 2V, V and $\frac{V}{2}$ volt, resistance R_1, R_2 and R_3, ohm respectively, are required to be connected in series with the galvanometer. Obtain the relationship between R_1, R_2 and R_3.

Section - D

Q31. a) Define torque acting on a dipole of dipole moment $\vec{p}$ placed in uniform electric field $\vec{E}$. Express it in the vector from and point out the direction along which it acts.

b) What happens if the field is non-uniform?

c) What would happen if the external field $\vec{E}$ is increasing (i) parallel to $\vec{p}$ and (ii) anti-parallel to $\vec{p}$?

OR

a) Use Gauss' law to obtain an expression for the electric field due to an infinitely long thin straight wire with uniform linear charge density λ.

b) An infinitely long positively charged straight wire has a linear charge density λ. An electron is revolving in a circle with a constant speed v such that the wire passes through the centre, and is perpendicular to the plane, of the circle. Find the kinetic energy of the electron in terms of magnitudes of its charge and linear charge density λ on the wire.

Q32.

a) Describe a simple experiment (or activity) to show that the polarity of emf induced in a coil is always such that it tends to produce an induced current which opposes the change of magnetic flux that produces it.

b) The current flowing though an inductor of self inductance L is continuously increasing. Plot a graph showing the variation of

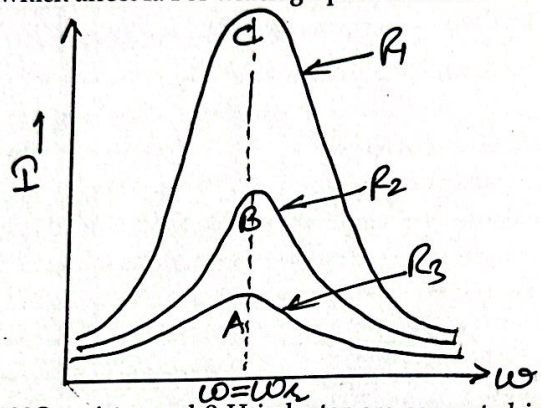
i) Magnetic flux versus the current

ii) Induced emf versus dI/dt

iii) Magnetic potential energy stored versus the current.

OR

a) What do you understand by 'sharpness of resonance' for a series LCR resonant circuit? How is it related with the quality factor 'Q' of the circuit? Using the graphs given in the diagram, explain the factors which affect it. For which graph is the resistance (R) minimum?



b) A 2 μF capacitor, 100Ω resistor and 8 H inductor are connected in series with an ac source. Find the frequency of the ac source for which the current drawn in the circuit is maximum.

If the peak value of emf of the source is 200 V, calculate the (i) maximum current, and (ii) inductive and capacitive reactance of the circuit at resonance.

Q33.

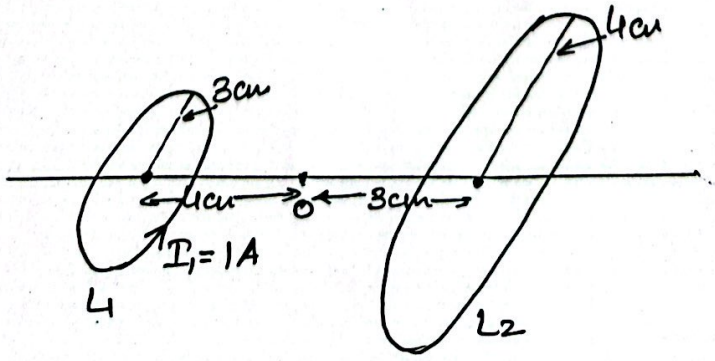
a) A straight thick long wire of uniform circular cross-section of radius 'a' is carrying a steady current I. The current is uniformly distributed across the cross-section. Use Ampere's circuital law to obtain a relation showing the variation of the magnetic field (B) inside and outside the wire with distance r, ($r \leq a$) and ($r > a$) of the field point from the centre of its cross-section. What is the magnetic field at the surface of this wire? Plot a graph showing the nature of this variation.

b) Calculate the ratio of magnetic field at a point a/2 above the surface of the wire to that at a point a/2 below its surface. What is the maximum value of the field of this wire?

OR

a) Using Biot-Savart's law, derive an expression for magnetic field at any point on axial line of a current carrying circular loop. Hence, find magnitude of magnetic field intensity at the centre of circular coil.

b) Two co-axial circular loops L_1 and L_2 of radii 3 cm and 4 cm are placed as shown. What should be the magnitude and direction of the current in the loop L_2 so that the net magnetic field at the point O be zero?



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Section - E

Q34.

Read the paragraph given below and answer the questions that follow:

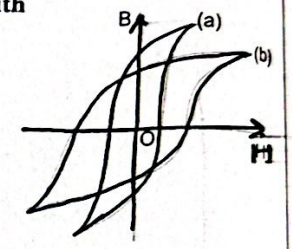
Ferromagnetism: In the absence of an external magnetic field, some of the electrons in a ferromagnetic material have their magnetic dipole moments aligned by mean of a quantum physical interaction called exchange coupling, producing regions (domains) within the material with strong magnetic dipole moments. An external field $\vec{B}_{ext}$ can align the magnetic dipole moment of those regions, producing a strong net magnetic dipole moment for the material as a whole, in the direction of $\vec{B}_{ext}$. This net magnetic dipole moment can partially persist when field $\vec{B}_{ext}$ is removed. If $\vec{B}_{ext}$ is nonuniform, the ferromagnetic material is attracted to region of greater magnetic field. These properties are called *ferromagnetism*. Exchange coupling disappears when a sample's temperature exceeds its Curie temperature, and then the sample has only paramagnetism.

(i) Susceptibility is positive and small for

(a) paramagnetic substances (b) ferromagnetic substances

(c) non-magnetic substances (d) diamagnetic substances

(ii) The B—H curves (a) and (b) shown in the figure are associated with



(a) a diamagnetic and a paramagnetic substance respectively

(b) a paramagnetic and a ferromagnetic substance respectively

(c) soft iron and steel respectively

(d) steel and soft iron respectively

(iii) If bar magnet of pole strength m and magnetic moment M is cut equally in five parts parallel to its axis and again four equal parts perpendicular to its axis then the pole strength and magnetic moments of each piece are, respectively,

(a) $\frac{m}{20}, \frac{m}{20}$ (b) $\frac{m}{4}, \frac{M}{20}$

(c) $\frac{m}{5}, \frac{M}{20}$ (d) $\frac{m}{5}, \frac{M}{4}$

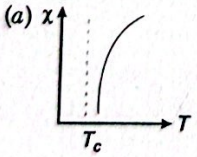
(iv) If the magnetizing field on a ferromagnetic material is increased, its permeability

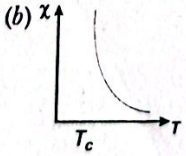
(a) is decreased (b) is increased

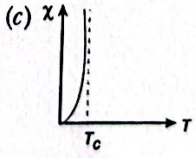
(c) is unaffected (d) may be increased or decreased

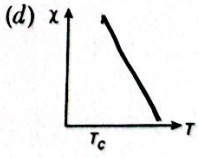
OR

The variation of magnetic susceptibility with the temperature of a ferromagnetic material can be plotted as

(a) 

(b) 

(c) 

(d) 

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Q35) *Read the paragraph given below and answer the questions that follow:*

Electrical Energy Transmission and Distribution:

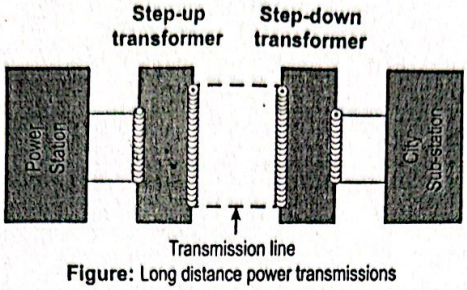

Figure: Long distance power transmissions

The large-scale transmission and distribution of electrical energy over long distances is done with the use of transformers. The voltage output of the generator is stepped-up. It is then transmitted over long distances to an area sub-station near the consumers. There the voltage is stepped down. It is further stepped down at distributing sub-stations and utility poles before a power supply of 240 V reaches our homes.

(*i*) **Which of the following statement is true?**

(*a*) Energy is created when a transformer steps up the voltage.

(*b*) A transformer is designed to convert an AC voltage to DC voltage.

(*c*) Step–up transformer increases the power for transmission.

(*d*) Step–down transformer decreases the AC voltage.

(*ii*) **If the secondary coil has a greater number of turns than the primary,**

(*a*) the voltage is stepped-up ($V_s > V_p$) and arrangement is called a step-up transformer

(*b*) the voltage is stepped-down ($V_s < V_p$) and arrangement is called a step-down transformer

(*c*) the current is stepped-up ($I_s > I_p$) and arrangement is called a step-up transformer

(*d*) the current is stepped-down ($I_s < I_p$) and arrangement is called a step-down transformer

OR

We need to step-up the voltage for power transmission, so that

(*a*) the current is reduced and consequently, the I^2R loss is cut down

(*b*) the voltage is increased , the power losses are also increased

(*c*) the power is increased before transmission is done

(*d*) the voltage is decreased so V^2/R losses are reduced

(*iii*) **A power transmission line feeds input power at 2300 V to a step down transformer with its primary windings having 4000 turns. The number of turns in the secondary in order to get output power at 230 V are**

(*a*) 4 (*b*) 40

(*c*) 400 (*d*) 4000

(*iv*) **The metal/alloy that is more suitable for making cores of transformers is**

(*a*) steel (*b*) soft iron (*c*) copper (*d*) brass