Aryaman Goswamy
XII-K

SS4

HALF YEARLY EXAM 2024

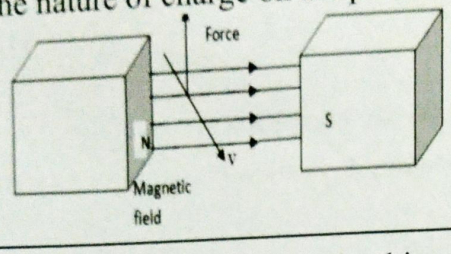
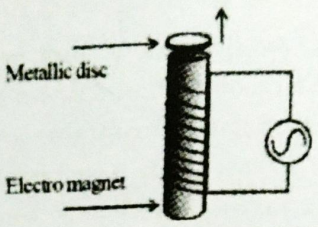
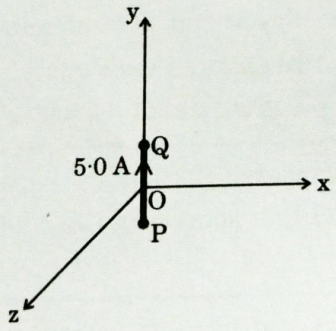
PHYSICS (SET I)

TIME DURATION:3 HRS **M.M: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 short answer questions 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 one 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.**

S. NO	QUESTIONS	MARKS
	Section A	
1	A thin plastic rod is bent into a circular ring of radius R. It is uniformly charged with charge density λ. What is the magnitude of the electric field at its centre?	1
2	Ten capacitors, each of capacitance 1 μF, are connected in parallel to a source of 100 V. Find the total energy stored in the system ?	1
3	Electrons drift with speed vd in a conductor with potential difference V across its ends. If V is reduced to V/2 what will be their drift speed?	1
4	An electron enters a uniform magnetic field with speed v. It describes a semicircular path and comes out of the field. What is the final speed of the electron ?	1

5	A charged particle enters into a uniform magnetic field and experiences an upward force as indicated in the figure. What is the nature of charge on the particle?  	1
6	When AC is switched on the thin metallic disc is found to be thrown up in air. Give the reason.  	1
7	A bar magnet of pole strength (m) and magnetic moment (M) is cut perpendicular to its axis in two equal halves. What is the new pole strength (m) and magnetic moment (M) of each part.	1
8	A circular coil of radius 10 cm is placed in a magnetic field $B = (1{\cdot}0i + 0{\cdot}5j)$mT such that the outward unit vector normal to the surface of the coil is $(0{\cdot}6i + 0{\cdot}8j)$. What is the magnetic flux linked with the coil?	1
9	A 2.0 cm segment of wire, carrying 5.0 A current in positive y-direction lies along the y-axis, as shown in the figure. What is the magnetic field at a point (3 m, 4 m, 0) due to this segment (part of a circuit) ?  	1
10	A galvanometer of 50 ohms is converted into a voltmeter of range (0-2V) using a resistor of 1KΩ . If it is to be converted into a voltmeter of range (0-10V), find the resistance required?	1
11	The resistance of a wire is10Ω. Its length is increased by 10% by stretching. What is the new resistance ?	1

12	An electric current is passed through a circuit containing two wires of the same material, connected in parallel. If the lengths and radii of the wires are in the ratio of 3: 2 and 2: 3, then what is the ratio of the current passing through the wire ?	**1**

The following questions from 13 to 16 consist of two statements each, labelled Assertion (A) and the other labelled Reason (R). While answering these questions, you are required to choose any of the following from options (a), (b), (c) & (d).

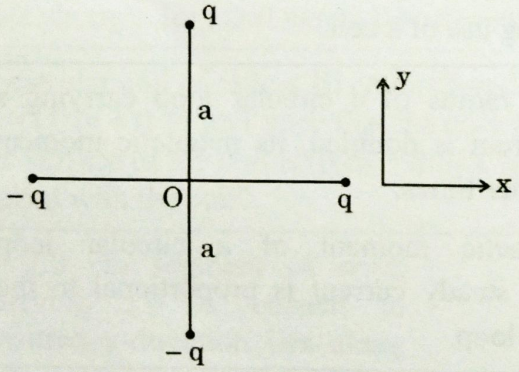
(a) If both A and R are true & R is the correct explanation of A.

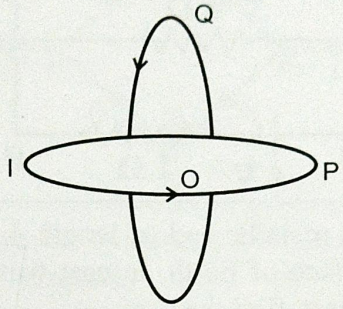
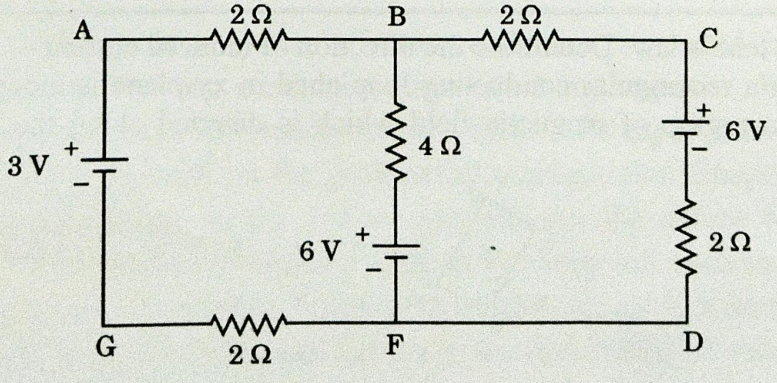
(b) If both A and R are true & R is NOT the correct explanation of A.

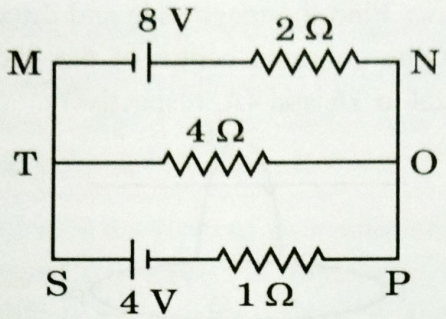
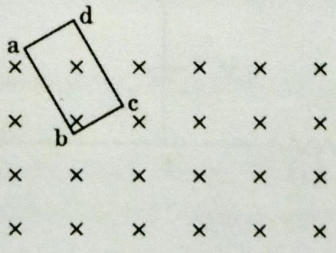
(c) If A is true but R is false.

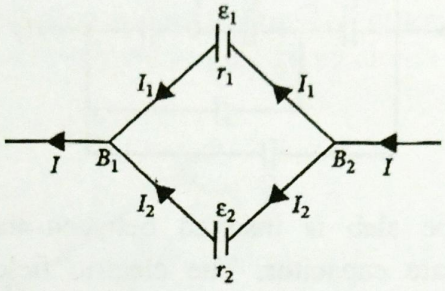
(d) If A is false and R is also false.

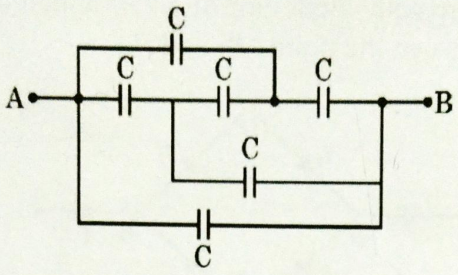
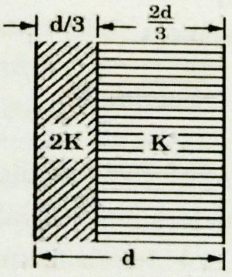
13	Assertion (A): The internal resistance of a cell is constant. Reason (R) : Ionic concentration of the electrolyte remains same during use of a cell.	**1**
14	Assertion (A): When the radius of a circular loop carrying a steady current is doubled, its magnetic moment becomes four times. Reason (R): The magnetic moment of a circular loop carrying a steady current is proportional to the area of the loop.	**1**
15	Assertion (A): Lenz's law is the consequence of the law of conservation of energy. Reason (R) : There is no power loss in an ideal inductor.	**1**
16	Assertion (A): A planar loop of irregular shape carrying current is subjected to a magnetic field acting perpendicular to the plane of the loop. If the wire is flexible, the loop takes a circular shape. Reason (R): The force acting on each point of a current carrying loop, in a magnetic field perpendicular to its plane, is radially outward.	**1**

Section B		
17	An alpha particle is projected with velocity $\vec{v} = (3.0\times10^5\,\text{m/s})\,\hat{i}$ into a region in which magnetic field $\vec{B} = (0.4\text{T})\,\hat{i} + (0.3\text{T})\,\hat{j}$ exists. Calculate the acceleration of the particle in the region. $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors along x, y and z axis respectively and charge to mass ratio for alpha particle is 4.8×10^7 C/kg.	**2**
18	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.	**2**
19	Two identical dipoles are arranged in x-y plane as shown in the figure. Find the magnitude and the direction of net electric field at the origin O. 	**2**
20	A small magnetised needle P is placed at the origin of the x-y plane with its magnetic moment pointing along the y-axis. Another identical magnetised needle Q is placed in two positions, one by one. Case 1: at (a, 0) with its magnetic moment pointing along x-axis. Case 2: at (0, a) with its magnetic moment pointing along the y-axis. (a) In which case is the potential energy of P and Q minimum? (b) In which case is P and Q not in equilibrium? Justify your answers.	**2**

20	OR Two identical loops P and Q each of radius 5 cm are lying perpendicular planes such that they have a common centre as shown in the figure. Find the magnitude and direction of the net magnetic field at the common centre of the two coils, if they carry currents equal to 3A and 4A, respectively.  	
21	i. A solenoid with an iron core and a bulb is connected to a dc source. How does the brightness of the bulb change, when the iron core is removed from the solenoid? ii. Two identical loops, one of Cu and another of constantan are removed from a magnetic field within the same time interval. In which loop does the induced current be greater?	**2**
	Section C	
22	The figure shows a circuit with three ideal batteries. Find the magnitude and direction of currents in the branches AG, BF and CD.  	**3**

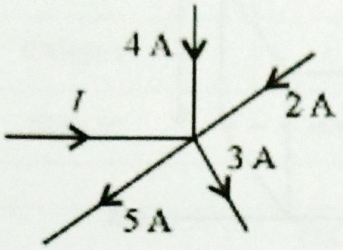
22	OR Use Kirchhoff's rule to determine the currents flowing through the branches MN, TO and SP in the circuit shown in the figure.  	
23	A horizontal straight metallic rod of length 4 m is held at some height above the surface of Earth, in east-west direction. If it is allowed to fall from rest, find the : (a) emf induced in the rod 2 s after it starts falling, (b) polarity of the emf induced, and (c) the end of the rod which is at the higher potential. The horizontal component of Earth's magnetic field at the place is $0{\cdot}3 \times 10^{-4}$ Wb/m^2 and take g = 10 m/s^2.	**3**
24	The electric field in a region is givenby $\vec{E}=(10x+4)\hat{i}$ where x is in m and E is in N/C. Calculate the amount of work done in taking a unit charge from (i) (5m, 0) to (10m, 0) (ii) (5m, 0) to (5m, 10m)	**3**
25	State lenz's law. Determine the direction of induced current when a rectangular conducting loop abcd in xy-plane is moved into a region of magnetic field which is directed along the z-axis.  	**3**

26	Two cells of emf ε_1 and ε_2 having internal resistance r_1 and r_2 respectively are connected in parallel as shown. Deduce the expressions of the equivalent emf of a cell which can replace the combination between the points B_1 and B_2.  	**3**
27	A bar magnet of magnetic moment 6 J T^{-1} is aligned at 60° with a uniform external magnetic field of 0.44 T. Calculate (a) the work done in turning the magnet to align its magnetic moment (i) normal to the magnetic field, (ii) opposite to the magnetic field, and (b) the torque on the magnet in the final orientation in case (ii).	**3**
28	(a) The susceptibility of a magnetic material is 0.9853. Identify the type of magnetic material. (b) Show diagrammatically the behaviour of magnetic field lines in the presence of (i) paramagnetic and (ii) diamagnetic substances.	**3**
	Section D	
29	A capacitor is a system of two conductors separated by an insulator, The two conductors have equal and opposite charges with a potential difference between them. The capacitance of a capacitor depends on the geometrical configuration (shape, size and separation) of the system and also on the nature of the insulator separating the two conductors. They are used to store charges. Like resistors, capacitors can be arranged in series or parallel or a combination of both to obtain desired value of capacitance.	**4**

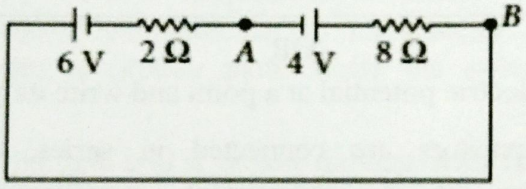
	(i) Find the equivalent capacitance between points A and B in the given diagram.  (ii) A dielectric slab is inserted between the plates of a parallel plate capacitor, The electric field between the plates decreases. Explain. (iii) A capacitor A of capacitance C, having charge Q is connected across another uncharged capacitor B of capacitance 2C. Find an expression for (a) the potential difference across the combination and (b) the charge lost by capacitor A. OR (iii) Two slabs of dielectric constants 2K and K fill the space between the plates of a parallel plate capacitor of plate area A and plate separation d as shown in figure. Find an expression for capacitance of the system.  	
30	In 1942, a German physicist Kirchhoff extended Ohm's law to complicated circuits and gave two laws, which enable us to determine current in any part of such a circuit. According to Kirchhoff's first rule, the algebraic sum of the currents meeting at a junction in a closed electric circuit is zero. The current flowing in a conductor towards the Junction is taken as positive and the current flowing away from the junction is taken as	**4**

negative. According to Kirchhoff's second rule, in a closed loop, the algebraic sum of the emf's and algebraic sum of the products of current and resistance in the various arms of the loop is zero. While traversing a loop, if negative pole of the cell is encountered first, then its emf is negative, otherwise positive.

(i) The value of current I in the given circuit is



(ii) Potential difference between A and B in the circuit shown here is



(iii) Kirchhoff's 1st law follows

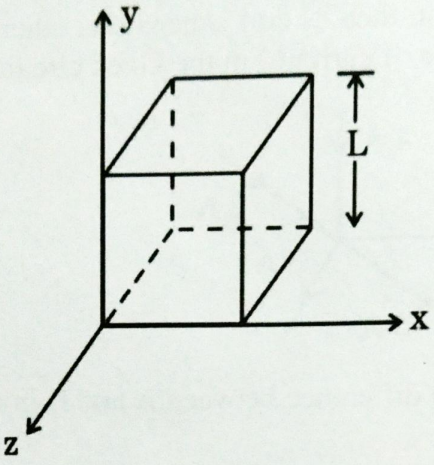
(a) law of conservation of energy
(b) law of conservation of charge and energy
(c) law of conservation of momentum
(d) Newton's third law of motion

(iv) Kirchhoff 's II law is based on

(a) law of conservation of momentum of electron
(b) law of conservation of charge and energy
(c) law of conservation of energy
(d) none of these.

Section E

31	(i)	Define electric flux and write its SI unit.	**5**
	(ii)	Use Gauss law to obtain the expression for the Electric field due to a uniformly charged infinite plane sheet.	

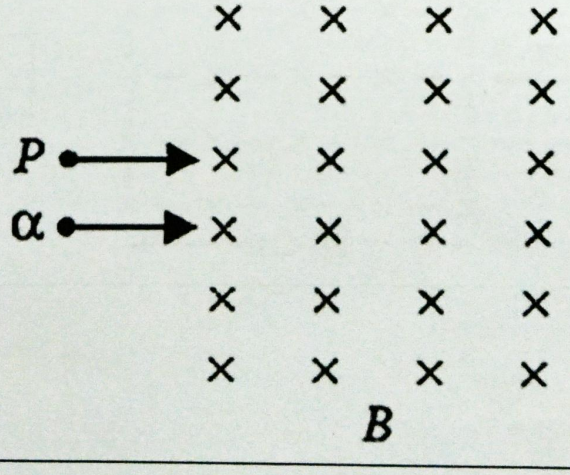
	(iii) A cube of side L is kept in space, as shown in the figure. An electric field E = (Ax + B)i N/C exists in the region. Find the net charge enclosed by the cube.  	
31	OR (i) Define electric potential at a point and write its SI unit. (ii) Two capacitors are connected in series. Derive an expression of the equivalent capacitance of the combination. (iii) Two point charges +q and -q are located at points (3a, 0) and (0, 4a) respectively in x-y plane. A third charge Q is kept at the origin. Find the value of Q, in terms of q and a, so that the electrostatic potential energy of the system is zero.	
32	Three particles are projected into identical magnetic fields as per table. Answer the following. Show the working in each case. i. Which of the particles will revolve along the circular paths with maximum frequency? ii. Identify the particle/s that will follow a spiral path. iii. Which particle/s revolves around the curved path of maximum radius?	**5**

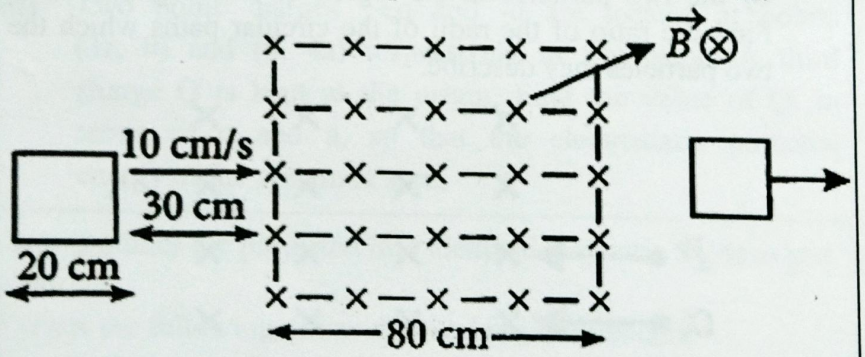
Particle	Proton	Deuteron	Alpha particle
Speed of projection	10^6 m/s	10^6 m/s	10^6 m/s
Angle between v and B	30°	90°	60°
Charge q	e	e	2e
Mass M	m	2m	4m

OR

a) A particle of charge 'q' and mass 'm' is moving with velocity $\vec{v}$. It is subjected to a uniform magnetic field $\vec{B}$ directed perpendicular to its velocity. Show that it describes a circular path. Write the expression for its radius.

(b) An α-particle and a proton moving with the same speed enter the same magnetic field region at right angles to the direction of the field. Show the trajectories followed by the two particles in the region of the magnetic field. Find the ratio of the radii of the circular paths which the two particles may describe.



33	(a) Define self-inductance of a coil. Write its SI unit. (b) Derive the expression for self-inductance of a long solenoid of cross-sectional area 'A', length 'l' having 'n' turns per unit length. (c) Explain the meaning of the term mutual inductance. Consider two concentric circular coils, one of radius r_1 and the other of radius r_2 ($r_1 < r_2$) placed coaxially with centres coinciding with each other. Obtain the expression for the mutual inductance of the arrangement.	5
	OR	
33	A square loop of side 20 cm is initially kept 30 cm away from a region of uniform magnetic field of 0.1 T as shown in the figure. It is then moved towards the right with a velocity of 10 cm s^{-1} till it goes out of the field. Plot a graph showing the variation of (i) magnetic flux (ϕ) through the loop with time (t). (ii) induced emf (ε) in the loop with time t. (iii) induced current in the loop if it has resistance of 0.1 Ω.  	5