Code: Phy/ EM-3/Mag/003

Electromagnetism: Current Electricity – Typical Questions (Part-3)

Magnetism and Magnetic Properties

No of Questions: 85 **Time Allotted: 9- Hours (in 3 parts)**

All questions are compulsory

[Note: a. Figures are conceptual only and not to the scale**]**

[b. Solutions may be taken up in Three parts as, Part I: 1 to 30 of Three Hours;**]**

[Part II: 31 to 60 of Three Hours; and Part III: 61 to 85 of Three Hours**]**

[c. It is advised to attempt question under examination conditions**]**

Important Note:

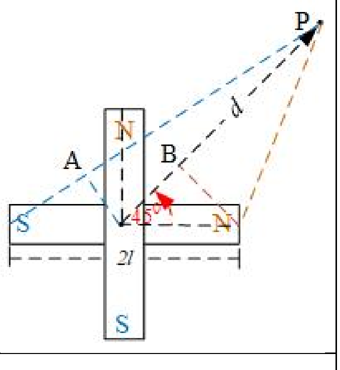
1. Magnetism is an important and inseparablepart of current electricity and its applications.

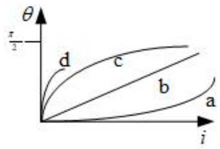
2. A student at a stage to refer to these questions and illustrations is expected to have attained a reasonable understanding of concepts and visualization. Moreover, forward journey involves integration of concepts on a wider canvas. Therefore, illustrations have been made a bit crisp. This would help students to harness their understanding at a faster rate.

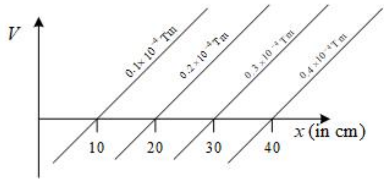
3. Avoid fatigue due to long and continuous sitting in solving such problems. Take a reasonable break to refresh before taking next part. Gradually, capability to withstand fatigue will grow to enable you to take up bigger challenges.

4. Electromagnetism is a subject so closely intertwined that discretization of problems on Magnetism and Magnetic Effect of Electric Current fails as one goes ahead. This is brought out in footnote of illustration of such problems.

Q-1	Can we make a single north pole or single south pole?
Q-2	Do two distinct poles actually exist at two nearby points in a magnetic pole?
Q-3	An iron needle is attracted to the ends of a bar magnet but not to the middle region of the magnet. Is the material making up the ends of bar magnet different from that of the middle region?
Q-4	Compare the direction of the magnetic field inside the solenoid with that of the field there if the solenoid is replaced by its equivalent magnetic dipoles and sketch the magnetic field lines near the center of the dipole. Identify the difference.
Q-5	Sketch the magnetic field lines for a current-carrying circular loop near its center. Replace the loop by an equivalent diploe near its center and sketch the magnetic field lines near the center of the dipole. Identify the difference.
Q-6	The force on a north pole, $\vec{F} = m\vec{B}$, is parallel to the field $\vec{B}$. Does it contradict our earlier knowledge that a magnetic field can exert force only perpendicular to itself?
Q-7	Two bar magnets are placed close to each other with clear opposite poles facing each other. In absence of other forces, the magnets are pulled towards each other and their kinetic energy increases. Does it contradict our earlier knowledge that magnetic forces cannot do any work and hence cannot increase kinetic energy?

Q-8	Magnetic scalar potential is defined as $U(\vec{r}_2) - U(\vec{r}_1) = \int_{\vec{r}_1}^{\vec{r}_2} \vec{B}.d\vec{l}$. Apply this equation to a closed curve enclosing a long straight wire. The RHS of the above equation is then $(-)\mu_0 i$ by Ampere's Law. We see that $U(\vec{r}_2) - U(\vec{r}_1)$ even when $\vec{r}_2 = \vec{r}_1$.
Q-9	Can the earth's magnetic field be vertical at a place? What will happen to a freely suspended magnet at such a place? What is the value of the dip there?
Q-10	Can the dip at a place be (a) zero (b) 90^0?
Q-11	The reduction factor K of a tangent galvanometer is written on the instrument. The manual says that the current is obtained by multiplying this factor to $\tan\theta$. The procedure works well at Bhubaneshwar. Will the procedure work if the instrument is taken to Nepal? If there is some error, can it be corrected by correlating the manual or the instrument will have to be taken back to the factory?
Q-12	A circular loop carrying a current is replaced by an equivalent magnetic dipole. A point on the axis of the loop is in (a) End-on position (b) Broadside-on position (c) both (d) none
Q-13	A circular loop carrying a current is replaced by an equivalent magnetic pole. A point on the loop is in (a) End-on position (b) broadside-on position (c) both (d) none
Q-14	When a current in a circular loop is equivalently replaced by a magnetic dipole (a) The pole strength m is fixed (b) The distance d between the poles is fixed (c) The product md is fixed (d) None of the above
Q-15	Let r be the distance of a point on the axis of a bar magnet from its center. The magnetic field at such a point is proportional to (a) $\frac{1}{r}$ (b) $\frac{1}{r^2}$ (c) $\frac{1}{r^3}$ (d) None of these
Q-16	Let r be the distance of a far point on the axis of a magnetic dipole from its center. The magnetic field at such a point is proportional to (a) $\frac{1}{r}$ (b) $\frac{1}{r^2}$ (c) $\frac{1}{r^3}$ (d) None of these
Q-17	Two short magnets of equal dipole moments M are fastened at the center as shown in the figure. Magnitude of the magnetic field at a distance d from the center on the bisector of the right angle is (a) $\frac{\mu_0}{4\pi}\frac{M}{d^3}$ (b) $\frac{\mu_0}{4\pi}\frac{\sqrt{2}M}{d^3}$ (c) $\frac{\mu_0}{4\pi}\frac{2\sqrt{2}M}{d^3}$ (d) $\frac{\mu_0}{4\pi}\frac{2M}{d^3}$ 
Q-18	Magnetic meridian is (a) A point (b) A line along north-south (c) A horizontal plane (d) A vertical plane
Q-19	A compass needle which is allowed to move in a horizontal plane is taken to a geomagnetic pole. It (a) Will stay in north-south direction only (b) Will stay in east-west direction only (c) Will become rigid showing no deflection (d) Will stay in position

Q-20	A dip circle is taken to geomagnetic equator. The needle is allowed to move in a vertical plane perpendicular to the magnetic meridian. The needle will stay – (a) In horizontal direction only (b) In vertical direction only (c) In any direction except vertical and horizontal (d) In any direction it is released
Q-21	Which of the following four graphs may best represent the current-deflection relation in a tangent galvanometer? 
Q-22	A tangent galvanometer is connected directly to an ideal battery. If the number of turns in the coil is doubled the deflection will (a) Increase (b) Decrease (c) Remain unchanged (d) Either increase or decrease
Q-23	If the current is doubled, the deflection is also doubled in (a) A tangent galvanometer (b) A moving-coil galvanometer (c) Both (d) None
Q-24	A very long bar magnet is placed with its north pole coinciding with the center of a circular loop carrying an electric current i. The magnetic field due to the magnet at a point on the periphery of the wire is B. The radius of the loop is α. The force on the wire is – (a) Very nearly $2\pi\alpha iB$ perpendicular to the plane of the wire (b) $2\pi\alpha iB$ in the plane of the wire (c) $\pi\alpha iB$ along the magnet (d) Zero
Q-25	Pick the correct options (a) Magnetic field is produced by electric current only. (b) Magnetic poles are only mathematical assumptions having no real existence (c) A north pole is equivalent to a clockwise current and south pole is equivalent to an anticlockwise current (d) A bar magnet is equivalent to a long, straight current
Q-26	A horizontal circular loop carries a current that looks clockwise when viewed from the above. It is replaced by an equivalent magnetic dipole consisting of a south pole S and a north pole N. (a) The line SN should be along a diameter of the loop. (b) The line SN should perpendicular to the plane of the loop. (c) The south pole should be below the loop. (d) North pole should be below the loop.
Q-27	Consider a magnetic dipole kept in the north-south direction. Let P_1, P_2, Q_1, Q_2 be four points at the same distance from the dipole towards north, south, east and west of the pole respectively. The direction of the magnetic field due to the dipole are the same at – (a) P_1 and P_2 (b) Q_1 and Q_2 (c) P_1 and Q_1 (b) P_2 and Q_2
Q-28	Consider a magnetic dipole kept in the north-south direction. Let P_1, P_2, Q_1, Q_2 be four points at the same distance from the dipole towards north, south, east and west of the pole respectively. The direction of the magnetic field due to the dipole are opposite at – (a) P_1 and P_2 (b) Q_1 and Q_2 (c) P_1 and Q_1 (b) P_2 and Q_2
Q-29	To measure the magnetic moment of a bar magnet, one may use – (a) A tangent galvanometer (b) A deflection galvanometer if the earth's horizontal field is known

	(c) An oscillation magnetometer if the earth's horizontal field is known (d) Both deflection galvanometer and oscillation magnetometer if the earth's horizontal field is known
Q-30	A long bar magnet has a pole strength of 10 Am. Find the magnetic field at a point on the axis of the magnet at a distance 5 cm from the north pole of the magnet.
Q-31	Two long bar magnets are placed with their axes coinciding in such a way that the north pole of the first magnet is 2.0 cm from the south pole of the second. If both the magnets have pole strength of 10 Am, find the force exerted by one magnet on the other.
Q-32	A uniform magnetic field of 2.0×10^{-3} T exists in the space. Find the change in the magnertic scalar potential as one moves through 50 cm along the field.
Q-33	Figure shows some of the equipotential surfaces of the magnetic scalar potential. Find the magnetic field B at a point in the region. All equipotential lines are inclined to X-axis at $\theta = 30^0$ 
Q-34	The magnetic field at a point, 10 cm away from a magnetic pole, is found to be 2.0×10^{-4} T. Find the magnetic moment of the dipole if the point is (a) In the end-on position of the dipole (b) In Broadside-on position of the pole
Q-35	Show that the magnetic field at a point due to a magnetic dipole is perpendicular to the magnetic axis if the line joining the point with the center of the dipole makes an angle of $\tan^{-1}(\sqrt{2})$ with the magnetic axis.
Q-36	A bar magnet has a length of 8 cm. The magnetic field at a point at a distance 3 cm from the center in the broadside-on position is found to be 4×10^{-6} T. Find the pole strength of the magnet.
Q-37	A magnetic dipole of the magnetic moment 1.44 A.m^2 is placed horizontally with the north pole pointing towards north. Find the position of the neutral point if the horizontal component of the earth's magnetic field is 18 μT.
Q-38	A magnetic dipole of the magnetic moment 0.72 A.m^2 is placed horizontally with the north pole pointing towards south. Find the position of the neutral point if the horizontal component of the earth's magnetic field is 18 μT.
Q-39	A magnetic dipole of the magnetic moment $0.72\sqrt{2}$ A.m^2 is placed horizontally with the north pole pointing towards east. Find the position of the neutral point if the horizontal component of the earth's magnetic field is 18 μT.
Q-40	The magnetic moment of the assumed dipole at the earth's center is 8.0×10^{22} Am^2. Calculate the magnetic field B at the geomagnetic-poles of the earth. Radius of the earth is 6400 km.
Q-41	If the earth's magnetic field has a magnitude 3.4×10^{-5} T at the magnetic center of the earth, what would be its value at the earth's geomagnetic poles?
Q-42	The magnetic field due to the earth has a horizontal component of 26 μT at a place where the dip is 60^0. Find the vertical component and magnitude of the field.
Q-43	A magnetic needle is free to rotate in a vertical plane which makes an angle of 60^0 with the magnetic meridian. If the needle stays in a direction making an angle of $\tan^{-1}\left(\frac{2}{\sqrt{3}}\right)$ with the horizontal, what would be the dip at that place?
Q-44	The needle of a dip circle shows an apparent dip of 45^0 in a particular position and 53^0 when the circle is rotated through 90^0. Find the true dip.

Q-45	A tangent galvanometer shows a deflection of 45^0 when 10 mA of current is passed through it. If the horizontal component of the earth's magnetic field is $B_H = 3.6 \times 10^{-5}$ T and radius of the coil is 10 cm, find the number of turns in the coil.
Q-46	A moving-coil galvanometer has a 50-turn coil of size 2 cm × 2cm. It is suspended between the magnetic poles producing a magnetic field of 0.5 T. Find the torque on the coil due to the magnetic field when a current of 20 mA passes through it.
Q-47	A short magnet produces a deflection of 37^0 in a deflection magnetometer in Tan-*A* position when placed at a separation of 10 cm from the needle. Find the ratio of the magnetic moment of the magnet to the earth's horizontal magnetic field.
Q-48	A short magnet of magnetic moment is placed 10 cm from the needle of deflection magnetometer in Tan-B position. The magnetometer of the previous problem is used with the same magnet in Tan-*B* position. Ratio of magnetic moment to the earth's magnetic field is 3.75×10^3 Am^2/T. Where should the magnet be placed to produce a 37^0 deflection of the needle?
Q-49	A deflection magnetometer is placed with its arms in north-south direction. How and where should a short magnet having $\frac{M}{B_H} = 40$ Am^2T^{-1} be placed so that the needle can stay in any position?
Q-50	A bar magnet takes $\frac{\pi}{10}$ second to complete oscillation in an oscillation magnetometer. The moment of inertia of the magnet about its axis of rotation is 1.2×10^{-4} $kg.m^2$ and earth's horizontal magnetic field is 30 μT. Find the magnetic moment of the magnet.
Q-51	The combination of the two bar magnets makes 10 oscillations per second in an oscillation magnetometer when like poles are tied together and 2 oscillations per second when unlike poles are tied together. Find the ratio of the magnetic moments of the magnets. Neglect any induced magnetism.
Q-52	A short magnet oscillates in an oscillation magnetometer with a time period of 0.10 s where the earth's horizontal magnetic field is 24 μT. A downward current of 18 A is established in a vertical wire placed 20 cm east of the magnet. Find the new time period.
Q-53	A bar magnet makes 40 oscillations per minute in an oscillation magnetometer. An identical magnet is demagnetized completely and is placed over the magnet in the magnetometer. Find the time taken for 40 oscillations by this combination. Neglect any induced magnetism.
Q-54	A short magnet makes 40 oscillations per minute when used in an oscillation magnetometer at a place when the earth's horizontal magnetic field is 25 μT. Another short magnet of magnetic moment 1.6 Am^2 is placed 20 cm east of the oscillating magnet. Find the new frequency of oscillation if the magnet has its north pole (a) towards north and (b) towards south.
Q-55	When a dielectric is placed in an electric field, it gets polarized. The electric field in a polarized material is less than the applied field. When a paramagnetic substance is kept in a magnetic field, the field in the substance is more than the applied field. Explain reason of the opposite behavior.
Q-56	The property of diamagnetism is said to be present in all materials. Then, why are some materials paramagnetic or ferromagnetic?
Q-57	Do permeability and relative permeability have the same dimensions?
Q-58	A rod when suspended in a magnetic field stays east-west direction. Can we be sure that the field is in the east-west direction? Can it be in the north-south direction?
Q-59	Why cannot we make permanent magnet from paramagnetic material?
Q-60	Can we have magnetic hysteresis in paramagnetic or diamagnetic substances?
Q-61	When a ferromagnetic material goes through a hysteresis loop, its thermal energy is increased. Where does this energy come from?
Q-62	What are the advantages of using soft iron as a core instead of steel, in the coils of galvanometers?

Q-63	To keep valuable instruments away from the earth's magnetic field, they are enclosed in iron boxes. Explain.
Q-64	A parametric material is placed in a magnetic field. Consider the following statements: (A) If the magnetic field is increased, the magnetization is increased. (B) If the temperature is increased, the magnetism is increased. (a) Both A and B are true. (b) A is true but B is false (c) B is true but A is false (d) Both A and B are false.
Q-65	A paramagnetic material is kept in a magnetic field. The field is increased till the magnetization becomes constant. If the temperature is now decreased, the magnetization - (a) Will increase (b) Decrease (c) Remain constant (d) May increase or decrease
Q-66	A ferromagnetic material is placed in an external magnetic field. The magnetic domains (a) Increase in size (b) Decrease (c) May increase or decrease in size (d) Have no relation with the field
Q-67	A long straight wire carries a current i. The magnetizing field intensity H is measured at a point P close to the wire. A long, cylindrical iron rod is brought close to the wire so that the point P is at center of the rod. The value H at P will – (a) Increase many times (b) Decrease many times (c) Remain almost constant (d) Become zero
Q-68	The magnetic susceptibility is negative for – (a) Paramagnetic materials only (b) Diamagnetic materials only (c) Ferromagnetic materials only (d) Paramagnetic and ferromagnetic materials
Q-69	The desirable properties for making permanent magnets are – (a) High retentivity and high coercive force (b) High retentivity and low coercive force (c) Low retentivity and high coercive force (d) Low retentivity and low coercive force
Q-70	Electromagnets are made of soft iron because soft iron has – (a) High retentivity and high coercive force (b) High retentivity and low coercive force (c) Low retentivity and high coercive force (d) Low retentivity and low coercive force
Q-71	Pick the correct options – (a) All electrons have magnetic moment (b) All protons have magnetic moment (c) All nuclei have magnetic moment (d) All atoms have magnetic moment
Q-72	The permanent magnetic moment of the atoms of a material is not zero. The material – (a) Must be paramagnetic (b) Must be diamagnetic (c) Must be ferromagnetic (d) May be paramagnetic
Q-73	The permanent magnetic moment of the atoms of a material is zero. The material – (a) Must be paramagnetic (b) Must be diamagnetic (c) Must be ferromagnetic (d) May be paramagnetic
Q-74	Which of the following pairs has quantities of the same dimensions? (a) Magnetic field B and magnetizing field intensity H (b) Magnetic field B and intensity of magnetization I (c) Magnetizing field intensity H and intensity of magnetization I (d) Longitudinal strain and magnetic susceptibility
Q-75	When ferromagnetic material goes through a hysteresis loop, the magnetic susceptibility –

	(a) Has no fixed value (b) May be zero (c) May be infinity (d) May be negative
Q-76	Mark out the correct options- (a) Magnetism occurs in all materials (b) Diamagnetism results from partial alignment of permanent magnetic moment (c) The magnetizing field intensity H is always zero in space (d) The magnetic field of induced magnetic moment is opposite to the applied field
Q-77	The magnetic intensity H at the center of a long solenoid carrying a current of 2.0 A is found to be 1500 Am^{-1}. Find the number of turns per centimeter of the solenoid.
Q-78	The magnetic intensity H at the center of a long solenoid carrying a current of 2.0 A is found to be 1500 Am^{-1}. A rod is inserted as the core in the current-carrying solenoid. (a) What is the magnetic intensity H at the center? (b) If the magnetization I of the core is found to be 0.12 Am^{-1}, find the susceptibility of the material of the rod. (c) Is the material paramagnetic, diamagnetic or ferromagnetic?
Q-79	The magnetic field inside a long solenoid having 50 turns/cm is increased from 2.5×10^{-3}T to 2.5 T when an iron core of cross-sectional area 4 cm^2 is inserted into it. Find – (a) The current in the solenoid (b) The magnetization I of the core (c) The pole strength developed in the core.
Q-80	A bar magnet of length 1 cm and cross-sectional area 1.0 cm^2 produces a magnetic field of 1.5×10^{-4}T at a point in end-on position at a distance 15 cm away from the center. (a) Find the magnetic moment M of the magnet (b) Find the magnetization I of the magnet (c) Find the magnetic field B at the center of the magnet
Q-81	The susceptibility of annealed iron at saturation is 5500. Find the permeability of annealed iron at saturation.
Q-82	The magnetic field B and the magnetic intensity H in a material are found to be 1.6 T and 1000 $A.m^{-1}$ respectively. Calculate the relative permeability and susceptibility χ of the material.
Q-83	The susceptibility of magnetism at 300 K is 1.2×10^{-5}. At what temperature will the susceptibility increase to 1.8×10^{-5}
Q-84	Assume that each iron atom has a permanent magnetic moment equal to 2 Bohr magnetization (1 Bohr magnetization equals 9.27×10^{-24} Am^2). The density of atoms in iron is 8.52×10^{28} $atoms.m^{-3}$. (a) Find the maximum magnetization I in a long cylinder of iron. (b) Find the maximum magnetic field B on the axis inside the cylinder
Q-85	The coercive force for a certain permanent magnet is 4.0×10^4 A/m. This magnet is placed in a long solenoid of 40 turns/cm and a current is passed in the solenoid to demagnetize it completely. Find the current.

Important Note: You may encounter need of clarification on contents and analysis or an inadvertent typographical error. We would gratefully welcome your prompt feedback on mail ID: subhashjoshi2107@gmail.com. If not inconvenient, please identify yourself to help us reciprocate you suitably.

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