Code: Phy/ EM-4/MEC/002

Electromagnetism: Magnetic Effect of Electric Current

Typical Questions (Set-2)

No of Questions: 37 **Time Allotted: 4 Hours**

All questions are compulsory

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

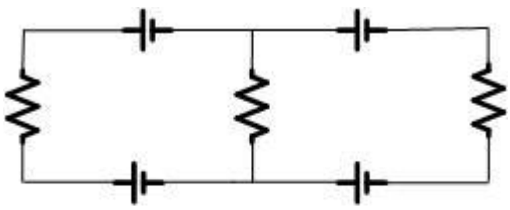
[b. It is advised to attempt question under examination conditions**]**

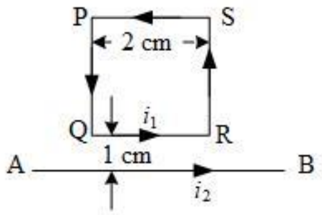
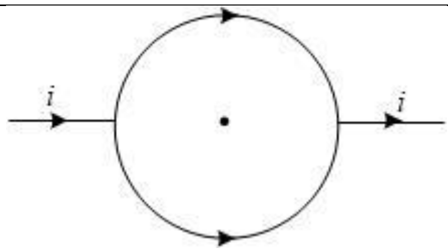
Important Note: 1. Capacitors are implementation aspect of concepts of electrostatics. The capacitors are integral part of any electrical system or circuit and any kind of application of electricity.

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-01	Each of the batteries shown in the figure has an emf equal to 5 V. Show that the magnetic field B at the point P is zero for any set of value of the resistance. 
Q-02	A straight long wire carries a current of 20 A. Another wire carrying equal current is placed parallel to it. If the force acting on a length of 10 cm of the second wire is 2.0×10^{-5}N, what is the separation between them?
Q-03	Three coplanar parallel wires, each carrying a current of 10 A along the same direction, are placed with a separation 5.0 cm between the consecutive ones. Find the magnitude of the magnetic force per unit length acting on the wire?
Q-04	Q-28, HCV-II, Ch-35, Ex, pp. 251
Q-04	Two parallel wires separated by a distance of 10 cm carry current of 10 A and 40 A along the same direction. Where should a third current carrying wire be so that it experiences no magnetic force?
Q-05	Figure shows a part of an electric circuit. The wires AB, CD and EF are long and have identical resistances. The separation between the neighbouring wires is 1.0 cm. The wires AE and BF have negligible resistance and the ammeter reads 30 A. Calculate the magnetic force per unit length of AB and CD.
Q-06	A long straight wire is fixed horizontally and carries a current of 50.0 A. A second wire having linear mass density 1.0×10^{-4}kg-m^{-1} is placed parallel and directly above the wire at a separation of 5.0 mm. What current should second wire carry such that the magnetic repulsion can balance its weight?

Q-07	A square loop PQRS carrying a current of 6,0 A is placed near a long wire carrying current 10 A as shown in the figure. (a) Show that magnetic force acting on the part PQ is equal and opposite to that on the part RS. (b) Find the magnetic force on the loop. 
Q-08	A circular loop of one turn carries a current 5.00 A. If the magnetic field B at the center is 2.000 mT, find the radius of the loop.
Q-09	A current carrying circular coil of 100 turns and radius 5.0 cm produces a magnetic field of 6.0×10^{-5} T at its center. Find the value of the current.
Q-10	An electron makes 3×10^5 revolutions per second in a circle of radius 0.5 angstrom. Find the magnetic field B at the center of the circle.
Q-11	A conducting circular loop of radius a is connected to two long, straight wires. The straight wires carry a current i as shown in the figure. Find the magnetic field at the center of the loop. 
Q-12	Two circular coils of radii 5.0 cm and 10 cm carry equal currents of 2.0 A. The coils have 50 1nd 100 turns respectively and are placed in such a way that their planes as well as the centers coincide. Find the magnitude of the magnetic field B at the common center of the coils if the currents in the coils are – (a) In the same sense (b) In the opposite sense
Q-13	Two circular coils of radii 5.0 cm and 10 cm carry equal currents of 2.0 A. The coils have 50 and 100 turns respectively and are placed in such a way that their planes as well as the centers coincide. If the outer coil is rotated through 90^0 about a diameter, what be the magnitude of the magnetic field B at the center?
Q-14	A circular loop of radius 20 cm carries a current of 10 A. An electron crosses the plane of the loop with a speed of 2.0×10^6 m/s. The direction of motion makes an angle of 30^0 with the axis of the circle and passes through its center. Find the magnitude of the magnetic force on the electron at the instant it crosses the plane.
Q-15	A circular loop of radius R carries a current I. Another circular loop of radius $r(\ll R)$ carries a current i and is placed at the center of the larger loop. The plane of the two circles are at right angle to each other. Find the torque acting on the smaller loop.
Q-16	A circular loop of radius r carrying a current i is held at the center of radius of another circular loop of radius $R(\gg r)$ carrying a current I. The plane of the smaller loop makes an angle of 30^0 with that of the larger loop. If the smaller loop is held fixed in this position by applying a single force at a point on its periphery, what would be minimum of this force?
Q-17	Find the magnetic field B due to a semicircular wire of radius 10.0 cm carrying a current of 5.0 A, at its center of curvature.
Q-18	A piece of wire carrying a current of 6.00 A is bent to form a circular arc of radius 20.0 cm and it subtends an angle of 120^0 at the center. Find the magnetic field B due to this piece of wire at the center.
Q-19	A circular loop of radius r carries a current i. How should a long, straight wire carrying a current $4i$ be placed in the plane of the circle so that magnetic field at the center of the loop becomes zero?

Q-20	A circular coil of 200 turns has a radius of 10 cm and carries a current of 2.0 A. (a) Find the magnitude of the magnetic field B at the center of the coil (b) At what distance from the center along the axis of the coil will the field drop to half of its value at the center. Given that $\sqrt[3]{4} = 1.5874 \ldots$
Q-21	A circular loop of radius 4.0 cm is placed in a horizontal plane carries an electric current of 5.0 A in the clockwise direction as seen from the above. Find the magnetic field – (a) At a point 3.0 cm above the center of the loop (b) At a point 3.0 cm below the center of the loop.
Q-22	A charge of 3.14×10^{-6} C is distributed uniformly over a circular ring of radius 20.0 cm. The ring rotates about its axis with an angular velocity of 60.0 rad/s. Find the ratio of the electric field to the magnetic field at a point on the axis at a distance of 5.00 cm from the center.
Q-23	A thin but long, hollow, cylindrical tube of radius r carries a current i along its length. Find magnitude of the magnetic field at a distance $\frac{r}{2}$ from the surface of the tube – (a) Inside the tube (b) Outside the tube
Q-24	A long cylindrical tube of inner and outer radius a and b carries a current i uniformly distributed over the cross-section. Find the magnitude of the magnetic field at a point – (a) Just inside the tube (b) Just outside the tube.
Q-25	A long, cylindrical wire of radius b carries a current i distributed over its cross-section. Find the magnetic field B at a point at a distance a from the axis.
Q-26	A solid wire of radius 10 cm carries a current of 5.o A distributed uniformly over its cross section. Find magnitude of the magnetic field B at a point at a distance (a) 2 cm, (b) 10 cm and (c) 20 cm away from the axis. Sketch a graph of B versus x for $0 < x < 20$ cm.
Q-27	Sometimes we show an idealized magnetic field which is uniform in a given region and falls to zero sharply. One such field is represented in figure. Using Ampere's Law over the path PQRS show that such a field is not possible.
Q-28	To large metal sheets carry surface currents as shown in the figure. The current through a strip of width dl is Kdl where K is a constant. Find the magnetic field at the points P, Q and R.
Q-29	To large metal sheets carry surface currents as shown in the figure. The current through a strip of width dl is Kdl where K is a constant. A particle having charge q and mass m is projected from the point Q in the direction going into the plane of the diagram. It is found to describe a circle of radius r between the two plates. Find the speed of the charged particle.
Q-30	The magnetic field B inside a long solenoid, carrying a current 5.00 A, is 3.14×10^{-2} T. Find the number of turns per unit length of the solenoid.
Q-31	A long solenoid is fabricated by closely winding a wire of radius of 0.5 mm over a cylindrical nonmagnetic frame so that the successive turns nearly touch each other. What would be the magnetic field B at the center of the solenoid if it carries a current of 5A?
Q-32	A copper wire having resistance 0.01 ohm in each meter is used to wind 400 turns solenoid of radius 1.0 cm and length 20 cm. Find the emf of a battery which when connected across the solenoid will cause a magnetic field of 1.0×10^{-2} T near the center of the solenoid.

Q-33	A tightly wound solenoid of radius a and length l has n turns per unit length. It carries an electric current i. Consider a length dx of the solenoid at a distance x from one end. This contains ndx turns and may be approximated as a circular current $indx$. (a) Write the expression of magnetic field at the center of the solenoid due to this circular current. Integrate the expression under proper limits to find the magnetic field at the center of the solenoid. (b) Verify that if $l \gg a$, the field tends to $B = \mu_0 ni$ and if $a \gg l$, the field tends to $B = \frac{\mu_0 nil}{2a}$. Interpret these results.
Q-34	A tightly-wound, long solenoid carries a current of 2.00 A. An electron is found to execute a uniform circular motion inside the solenoid with a frequency of 1.00×10^8rev/s. Find number of turns per meter in the solenoid.
Q-35	A tightly wound, long solenoid has n turns per unit length, a radius r and carries a current i. A particle having a charge q and mass m is projected from a point on the axis in a direction perpendicular to the axis. What can be the maximum speed for which the particle does not strike the solenoid.
Q-36	A tightly wound, long solenoid is kept with its axis parallel to a large metal sheet carrying a surface current. The surface current through a width dl of the sheet is Kdl and number of turns per unit length of the solenoid is n. The magnetic field near the center of the solenoid is found to be zero. (a) Find the current in the solenoid. (b) If the solenoid is rotated to make its axis perpendicular to the metal sheet, what would be the magnitude of the magnetic field near its center?
Q-37	A capacitor of capacitance 100 μF is connected to a battery of 20 volts for a long time and then disconnected from it. It is now connected across a long solenoid having 4000 turns per meter. It is found that potential difference across the capacitor drops to 90% of its maximum value in 2.0 seconds. Estimate the average magnetic field produced at the center of the solenoid during this period.

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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