

ANSWER KEY

Worksheet - 4: MOVING CHARGES AND MAGNETISM

Class: Class 12 | Subject: Physics

Q1. A proton and an alpha particle enter a uniform magnetic field perpendicularly with the same speed. The ratio of the radii of their circular paths is:

Answer: 1:2 (1 mark)

Q2. A circular coil of radius R carries a current I. The magnetic field at its center is B. The magnetic field at a point on its axis at a distance R from the center is:

Answer: $B/2\sqrt{2}$ (1 mark)

Q3. Two long parallel wires carry currents I_1 and I_2 in the same direction. The force on wire 2 due to wire 1 is F. If the current in wire 1 is doubled and the distance between the wires is halved, the force on wire 2 due to wire 1 will be:

Answer: 4F (1 mark)

Q4. A galvanometer can be converted into an ammeter by using a:

Answer: low resistance in parallel (1 mark)

Q5. The magnetic field inside a long straight solenoid carrying current is:

Answer: uniform and along the axis (1 mark)

Q6. The torque on a current loop placed in a uniform magnetic field is maximum when the angle between the area vector and the magnetic field is:

Answer: 90° (1 mark)

Q7. The force acting on a moving charge q with velocity v in a magnetic field B is given by $F = q(v \times B)$, also known as the _____ force.

Answer: Lorentz (1 mark)

Q8. To increase the current sensitivity of a moving coil galvanometer without altering its voltage sensitivity, one must decrease its _____.

Answer: resistance (1 mark)

Q9. The magnetic field due to a current carrying circular loop at its center is proportional to the _____ of the loop.

Answer: current (1 mark)

Q10. State the principle of a moving coil galvanometer. Explain how it can be converted into an ammeter.

Answer: Principle: A current-carrying coil placed in a uniform magnetic field experiences a torque, which tends to rotate the coil.

Conversion to ammeter: A low resistance (shunt) is connected in parallel with the galvanometer. This allows most of the current to pass through the shunt, protecting the galvanometer. (2 marks)

Q11. Define magnetic susceptibility. How does it vary with temperature for a paramagnetic substance?

Answer: Magnetic susceptibility (χ) is the measure of how easily a substance can be magnetized in an external magnetic field.

For a paramagnetic substance, susceptibility is inversely proportional to the absolute temperature (Curie's Law: $\chi \propto 1/T$). (2 marks)

Q12. A charged particle is moving in a uniform magnetic field. Justify why the kinetic energy of the particle remains constant.

Answer: The magnetic force ($F = qvB\sin\theta$) acts perpendicular to the velocity of the charged particle. Since the force is always perpendicular to the displacement, the work done by the magnetic force is zero ($W = F \cdot d = Fd\cos 90^\circ = 0$). As work done is zero, there is no change in the kinetic energy of the particle. (2 marks)

Q13. a) Derive an expression for the magnetic field at a point on the axis of a circular current loop.

b) Two identical circular loops, each of radius R and carrying current I , are placed coaxially with their centers separated by a distance R . Show that the magnetic field at a point midway between the centers on the axis is

approximately 0.72 times the magnetic field at the center of either loop.

Answer: a) Derivation: (i) Consider a circular loop of radius R carrying current I . (ii) Choose a point P on the axis at a distance x from the center. (iii) Consider a small element dl of the loop. (iv) The magnetic field dB due to dl is given by Biot-Savart Law: $dB = (\mu_0/4\pi) (|dl \times r|/r^3)$. (v) Resolve dB into components. The perpendicular components cancel out due to symmetry. (vi) Integrate the parallel components over the entire loop. (vii) The magnetic field at point P is $B = (\mu_0 I R^2)/(2(R^2+x^2)^{3/2})$.

b) At midpoint, $x = R/2$. Magnetic field due to one loop: $B_1 = (\mu_0 I R^2)/(2(R^2+(R/2)^2)^{3/2})$
 $= (\mu_0 I R^2)/(2(5R^2/4)^{3/2}) = (\mu_0 I R^2)/(2(5\sqrt{5}R^3)/8) = (4\mu_0 I)/(5\sqrt{5}R)$.

Total magnetic field: $B = 2B_1 = (8\mu_0 I)/(5\sqrt{5}R) \approx 0.72(\mu_0 I/2R) = 0.72 * (\text{Magnetic field at the center of either loop})$. (5 marks)