HALF-YEARLY EXAMINATION — PHYSICS (THEORY)

CLASS XII · SESSION 2026–27

Syllabus: NCERT Physics Part I — Electrostatics, Current Electricity, Magnetic Effects of Current & Magnetism, Electromagnetic Induction & Alternating Current, Electromagnetic Waves

Time Allowed: 2 hours **Maximum Marks: 50**

General Instructions:

1. All questions are compulsory. There is an internal choice in Section E.
2. Section A contains 10 MCQs of 1 mark each, including two assertion–reason questions.
3. Section B contains 4 very short answer questions of 2 marks each.
4. Section C contains 6 short answer questions of 3 marks each.
5. Section D contains 1 case-study based question of 4 marks with sub-parts.
6. Section E contains 2 long answer questions of 5 marks each, with an internal choice in each.
7. Use of calculators is not permitted.
8. Take $c = 3 \times 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2N^{-1}m^{-2}$, $1/4\pi\varepsilon_0 = 9 \times 10^9$ N m^2 C^{-2}, $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1} wherever required. Take $\pi \approx 3.14$, $\sqrt{2} = 1.414$, $\sqrt{10} = 3.162$.

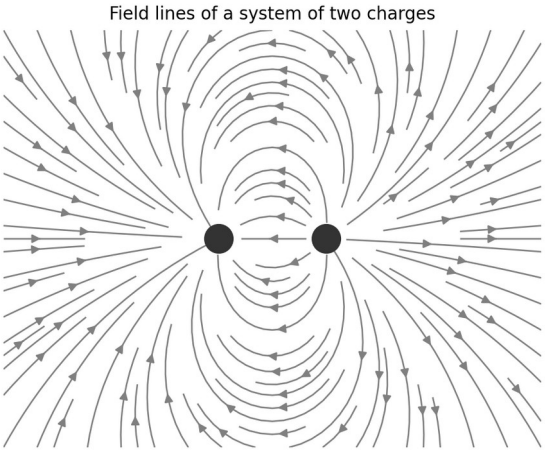
SECTION A

Multiple Choice and Assertion–Reason Questions (10 × 1 = 10 marks)

1. Two point charges +q and +4q are held fixed a distance r apart on the x-axis. At what distance from the +q charge, on the line joining them, is the resultant electric field zero? *[1]*

(a) r/3 (b) r/2 (c) r/5 (d) 2r/3

2. The figure below shows the electric field lines of a system of two point charges. Which statement correctly describes the charges? *[1]*



(a) Left charge positive, right charge negative (b) Left charge negative, right charge positive (c) Both charges positive (d) Both charges negative

3. Three capacitors of capacitance 2 μF, 3 μF and 6 μF are connected in series across a battery. Their equivalent capacitance is: *[1]*

(a) 11 μF (b) 1 μF (c) 6 μF (d) 1/11 μF

4. Assertion (A): The electric potential is the same at every point inside and on the surface of a charged conductor. Reason (R): The electric field inside a conductor is zero under electrostatic conditions. *[1]*

(a) Both A and R true, R is the correct explanation of A (b) Both A and R true, R is NOT the correct explanation of A (c) A true, R false (d) A false, R true

5. The order of magnitude of the drift velocity of free electrons in a typical current-carrying copper conductor is: *[1]*

(a) 10^2 m/s (b) 10^{-2} m/s (c) 10^{-4} m/s (d) 10^8 m/s

6. A Wheatstone bridge with resistances P, Q, R, S in its four arms is balanced when: *[1]*

(a) the galvanometer current is maximum (b) P/Q = R/S (c) all four resistances are equal (d) the galvanometer is short-circuited

7. A straight current-carrying conductor is placed in a uniform magnetic field. The magnetic force on it is maximum when the angle between the current direction and the field is: *[1]*

(a) 0° (b) 45° (c) 90° (d) 180°

8. A bar magnet of magnetic moment m is held with its axis perpendicular to a uniform magnetic field B. The magnitude of the torque acting on it is: *[1]*

(a) zero (b) mB (c) mB/2 (d) 2mB

9. A bar magnet is moved rapidly towards a stationary coil connected to a galvanometer. According to Lenz's law, the induced current in the coil will: *[1]*

(a) oppose the motion of the magnet (b) support the motion of the magnet (c) remain zero (d) flow in a direction independent of the motion

10. Assertion (A): Electromagnetic waves carry energy and momentum as they travel through space.
Reason (R): In an electromagnetic wave, the electric field E and magnetic field B oscillate in phase, perpendicular to each other and to the direction of propagation. *[1]*

(a) Both A and R true, R is the correct explanation of A (b) Both A and R true, R is NOT the correct explanation of A (c) A true, R false (d) A false, R true

SECTION B

Very Short Answer Questions (4 × 2 = 8 marks)

11. An electric dipole of dipole moment 4×10^{-9} C·m is placed at an angle of 30° to a uniform electric field of magnitude 10^5 N/C. Calculate the torque acting on the dipole. *[2]*

12. Using the concept of drift velocity of free electrons, explain briefly why the resistivity of a metallic conductor increases with an increase in temperature. *[2]*

13. State the right-hand thumb rule for finding the direction of the magnetic field due to a straight current-carrying conductor. Draw a neat diagram to illustrate the rule for a vertical wire carrying current upward. *[2]*

14. Name the part of the electromagnetic spectrum used in (i) treatment of cancer tumours, and (ii) RADAR systems for aircraft detection. Arrange the two in increasing order of wavelength. *[2]*

SECTION C

Short Answer Questions (6 × 3 = 18 marks)

15. A large conducting plate carries a uniform surface charge density σ on each of its faces. Using Gauss's theorem, derive an expression for the electric field intensity at a point just outside the plate. Draw a labelled diagram showing the Gaussian surface you use. *[3]*

16. Derive an expression for the energy stored in a parallel plate capacitor of capacitance C charged to a potential difference V. Hence obtain the expression for the energy density in terms of the electric field E. *[3]*

17. A battery of emf 12 V and internal resistance 2 Ω is connected to an external resistance of 4 Ω. Calculate:
(i) the current in the circuit,
(ii) the terminal potential difference of the battery,
(iii) verify part (ii) using the potential drop across the external resistance. *[3]*

18. Using the Biot–Savart law, derive an expression for the magnetic field at a point P on the axis of a circular current loop of radius a carrying current I, at a distance x from its centre. *[3]*

19. Explain briefly how a bar magnet may be treated as equivalent to a solenoid carrying current. Using this idea, state (do not derive) the expressions for the magnetic field due to a bar magnet of dipole moment m, at a point on (i) its axial line and (ii) its equatorial line, at a distance r from its centre (r much greater than the magnet's length). *[3]*

20. State Faraday's laws of electromagnetic induction. Derive an expression for the motional emf induced in a straight conducting rod of length l moving with velocity v perpendicular to a uniform magnetic field B. *[3]*

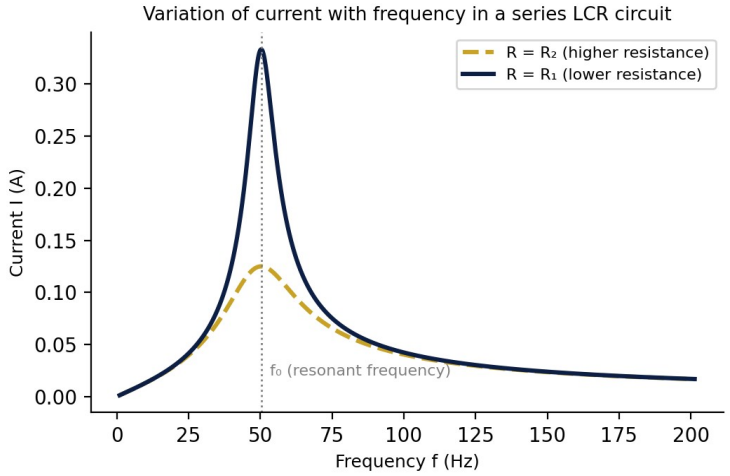
SECTION D

Case Study Based Question (1 × 4 = 4 marks)

21. Read the following passage and answer the questions that follow.

In a series LCR circuit connected to an AC source, the current depends on the frequency of the applied voltage. At a particular frequency, called the resonant frequency f_0, the inductive reactance becomes equal to the capacitive

reactance, so the impedance of the circuit is minimum (equal to R) and the current is maximum. The sharpness of this resonance depends on the resistance in the circuit — a lower resistance gives a sharper, taller peak, while a higher resistance gives a broader, flatter peak. The graph below shows current versus frequency for two values of resistance, R_1 and R_2 ($R_1 < R_2$), for the same L and C.



(i) Write the expression for the resonant frequency f_0 of a series LCR circuit in terms of L and C. *[1]*

(ii) At resonance, what is the value of the circuit's impedance, and what is the phase difference between current and voltage? *[1]*

(iii) From the graph, which curve — R_1 or R_2 — shows the sharper resonance, and why? *[1]*

(iv) A series LCR circuit has L = 0.5 H and C = 20 μF. Calculate its resonant frequency. *[1]*

SECTION E

Long Answer Questions (with internal choice) (2 × 5 = 10 marks)

22. Derive an expression for the capacitance of a parallel plate capacitor of plate area A and separation d, when a dielectric slab of thickness t (t < d) and dielectric constant K is inserted between the plates. *[5]*

OR

Derive an expression for the electric potential energy of a system of two point charges q_1 and q_2 separated by a distance r, in the absence of an external electric field. Extend your result to a system of three point charges q_1, q_2, q_3.

23. Derive an expression for the torque experienced by a rectangular current-carrying loop of area A, carrying current I, placed in a uniform magnetic field B. Hence explain the working principle of a moving coil galvanometer. *[5]*

OR

Define self-inductance and mutual inductance. Derive an expression for the self-inductance of a long solenoid of length l, cross-sectional area A and number of turns N, wound on a core of relative permeability μ_r.

— End of Question Paper —