PRACTICE EXAMINATION — PHYSICS (THEORY)

CLASS XII · SESSION 2026–27

Coverage: NCERT Physics Part I (Chapters 1–8) — Electrostatics, Current Electricity, Magnetic Effects of Current & Magnetism, Electromagnetic Induction & Alternating Current, Electromagnetic Waves

Time Allowed: 3 hours **Maximum Marks: 70**

General Instructions:

1. There are 33 questions in all. All questions are compulsory.
2. The paper has five sections: A, B, C, D and E.
3. Section A contains sixteen questions of 1 mark each — twelve multiple choice and four assertion–reason.
4. Section B contains five questions of 2 marks each.
5. Section C contains seven questions of 3 marks each.
6. Section D contains two case-based questions of 4 marks each.
7. Section E contains three long answer questions of 5 marks each.
8. There is no overall choice. An internal choice is provided in one question of Section B, one of Section C, one of Section D, and in all three questions of Section E.
9. Use of calculators is not permitted. Take $c = 3 \times 10^8$ m/s, $e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2N^{-1}m^{-2}$, $\mu_0 = 4\pi \times 10^{-7}$ T·m·A^{-1} wherever required. Take $\pi \approx 3.14$.

SECTION A

Multiple Choice and Assertion–Reason Questions (16 × 1 = 16 marks)

1. Two point charges +q and −4q are placed a distance r apart in air. On the line joining them, the point between the charges at which the net electric potential is zero lies at a distance from +q equal to: *[1]*

(a) r/3 (b) r/5 (c) r/4 (d) r/2

2. A short electric dipole of dipole moment p is placed in air. The electric potential at a point P on its equatorial line, at a distance r from the centre of the dipole, is: *[1]*

(a) zero (b) $p/(4\pi\varepsilon_0 r^2)$ (c) $p/(4\pi\varepsilon_0 r^3)$ (d) $2p/(4\pi\varepsilon_0 r^3)$

3. The drift velocity v_d of free electrons in a conductor varies with the applied electric field E as: *[1]*

(a) $v_d \propto E$ (b) $v_d \propto \sqrt{E}$ (c) $v_d \propto E^2$ (d) v_d is independent of E

4. A wire of resistance R is stretched uniformly so that its length is doubled. Its new resistance is: *[1]*

(a) R/4 (b) R/2 (c) 2R (d) 4R

5. A galvanometer of resistance 50 Ω gives full-scale deflection for a current of 2 mA. The resistance that must be connected in series with it to convert it into a voltmeter of range 0–10 V is: *[1]*

(a) 4050 Ω (b) 4950 Ω (c) 5000 Ω (d) 5050 Ω

6. A charged particle moves with velocity v through a region in which a uniform electric field E and a uniform magnetic field B are both present. The net force on the particle is zero if: *[1]*

(a) $E = v \times B$ (b) $E = -(v \times B)$ (c) $B = v \times E$ (d) $v = E \times B$

7. According to Curie's law, the magnetic susceptibility χ of a paramagnetic material varies with absolute temperature T as: *[1]*

(a) $\chi \propto T$ (b) $\chi \propto 1/T$ (c) $\chi \propto 1/T^2$ (d) χ is independent of T

8. In Maxwell's modification of Ampère's circuital law, the displacement current in a region arises because of the presence of: *[1]*

(a) a steady flow of free electrons (b) a time-varying electric field (c) a constant electric field (d) a steady magnetic field

9. The magnetic flux linked with a circuit varies with time as $\Phi = 5t^3 - 10t^2 + 4t + 2$, where Φ is in weber and t in second. The magnitude of the induced emf at t = 2 s is: *[1]*

(a) 16 V (b) 24 V (c) 36 V (d) 44 V

10. A coil of self-inductance L carries a steady current I. The magnetic energy stored in the coil is: *[1]*

(a) LI (b) LI^2 (c) $\frac{1}{2}LI^2$ (d) $\frac{1}{2}L^2I$

11. In a series LCR circuit connected to an AC source at resonance, the phase difference between the applied voltage and the current is: *[1]*

(a) 0 rad (b) $\pi/4$ rad (c) $\pi/2$ rad (d) π rad

12. The peak value of an alternating voltage supply is 282 V. Its rms value is approximately: *[1]*

(a) 141 V (b) 200 V (c) 220 V (d) 300 V

For Questions 13 to 16, two statements are given — one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the options below:

(a) Both A and R are true and R is the correct explanation of A.

(b) Both A and R are true but R is NOT the correct explanation of A.

(c) A is true but R is false.

(d) A is false but R is true.

13. Assertion (A): Two electric field lines can never cross each other.
Reason (R): If two field lines crossed, the electric field at the point of intersection would have two different directions, which is impossible. *[1]*

14. Assertion (A): When a switch is closed, a bulb several metres away lights up almost at once, even though the drift velocity of the free electrons is only of the order of 10^{-4} m/s.
Reason (R): On closing the switch the electric field is established all along the circuit at a speed close to that of light, so free electrons everywhere in the circuit begin to drift almost simultaneously. *[1]*

15. Assertion (A): Eddy currents set up in a copper plate swinging between the poles of a magnet damp its motion.
Reason (R): Eddy currents always flow in such a direction as to increase the magnetic flux change through the plate. *[1]*

16. Assertion (A): A step-up transformer increases the voltage, and therefore violates the law of conservation of energy.
Reason (R): In an ideal transformer, when the voltage is stepped up by a factor k, the current is stepped down by the same factor k. *[1]*

SECTION B

Very Short Answer Questions (5 × 2 = 10 marks)

17. Derive an expression for the potential energy of an electric dipole of dipole moment p placed in a uniform electric field E, with its axis making an angle θ with the field. *[2]*

18. State Kirchhoff's two rules for electrical circuits. Name the fundamental conservation principle on which each rule is based. *[2]*

19. An electron moves in a circular path of radius 2.0 cm in a uniform magnetic field of 0.01 T directed perpendicular to its velocity. Calculate the speed of the electron. *[2]*

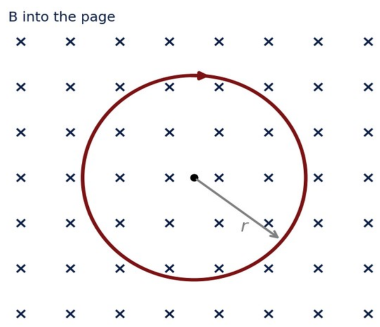

Figure for Q19

20. Distinguish between diamagnetic, paramagnetic and ferromagnetic materials on the basis of (i) their magnetic susceptibility χ, and (ii) their behaviour when placed in a non-uniform magnetic field. *[2]*

21. Define the mutual inductance of a pair of coils and write its SI unit. State two factors on which the mutual inductance of two long coaxial solenoids depends. *[2]*

OR

The current in a coil falls steadily from 5.0 A to zero in 0.1 s, and an emf of 200 V is induced in the coil while this happens. Calculate the self-inductance of the coil.

SECTION C

Short Answer Questions (7 × 3 = 21 marks)

22. Using Gauss's theorem, derive an expression for the electric field intensity at a distance r from an infinitely long straight uniformly charged wire of linear charge density λ. Draw a labelled diagram showing the Gaussian surface you use. *[3]*

23. Define drift velocity of free electrons in a conductor. Hence derive the relation between the current I flowing through a conductor and the drift velocity v_d of its free electrons. *[3]*

24. For the circuit shown below, the galvanometer G shows no deflection. *[3]*

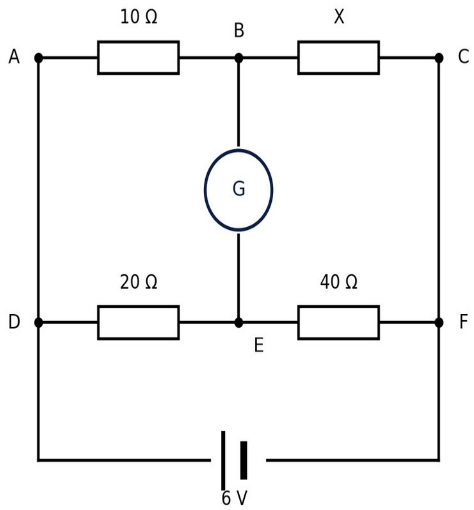

Figure for Q24

(a) Calculate the value of the unknown resistance X.

(b) Calculate the total current drawn from the 6 V battery. (The battery has negligible internal resistance.)

25. State Ampère's circuital law. Using it, derive an expression for the magnetic field at a point at a perpendicular distance r from a long straight conductor carrying a steady current I. Draw a diagram showing the Amperian loop you choose. *[3]*

26. (a) Explain, with reference to a capacitor being charged, why Ampère's circuital law in its original form is inconsistent.
(b) Define displacement current and write its expression.
(c) Write down the Ampère–Maxwell law in its modified form. *[3]*

27. A copper rod OP of length L rotates with a uniform angular velocity ω about an axis passing through the end O and perpendicular to the rod. A uniform magnetic field B acts parallel to the axis of rotation, as shown. Derive an expression for the emf induced between the two ends of the rod. *[3]*

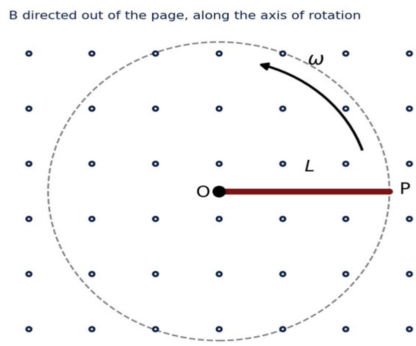

Figure for Q27

28. A series LCR circuit with R = 100 Ω, L = 0.1 H and C = 5 μF is connected to an AC source of rms voltage 141 V and angular frequency ω = 1000 rad/s. *[3]*

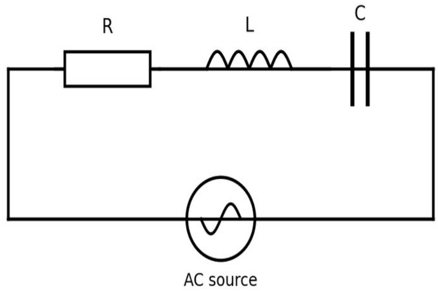

Figure for Q28

(a) Calculate the inductive reactance X_L and the capacitive reactance X_C.

(b) Calculate the impedance Z of the circuit.

(c) Find the rms current and the phase difference between the voltage and the current, stating which of the two leads.

OR

Define the quality factor (Q-factor) of a series resonant LCR circuit. Derive its expression in terms of L, C and R, and state its physical significance in a tuning circuit.

SECTION D

Case-Based Questions (2 × 4 = 8 marks)

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

Dielectrics are non-conducting substances that have no free charge carriers. When a dielectric is placed in an external electric field, the molecular dipoles within it align, and equal and opposite bound charges appear on its opposite faces. This polarisation sets up an internal field opposing the applied field, so the net field inside the dielectric is reduced. Inserting a dielectric slab between the plates of a capacitor therefore lowers the potential difference for the same charge, and raises the capacitance by the factor K, the dielectric constant. High-performance capacitors used in electric-vehicle powertrains and power grids depend on thin ceramic dielectric films that can withstand intense fields without breaking down.

(i) Define the polarisation vector P and state how it is related to the applied field E for a linear isotropic dielectric. *[1]*

(ii) A parallel plate capacitor remains connected to a battery while a dielectric slab of K = 5 is inserted between its plates. What happens to the energy stored in it? *[1]*

(iii) A parallel plate capacitor of plate area A and separation d is charged to a potential V by a battery. The battery is then disconnected and a dielectric slab of constant K, filling the space completely, is inserted. Find the ratio of the initial to the final stored energy. *[2]*

OR

(iii) Three identical capacitors, each of capacitance C, are connected as shown. Calculate the effective capacitance between the points A and B. *[2]*

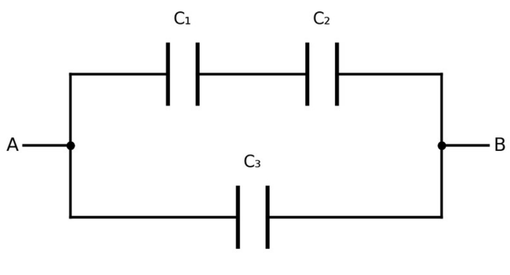

Figure for Q29 (iii) OR

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

Long-distance transmission of electrical power depends on transformers to keep energy losses down. Electrical energy generated at a power station, typically at about 11 kV, is stepped up to very high voltages such as 400 kV before being carried across hundreds of kilometres. Since the power dissipated in a transmission line is I^2R, raising the transmission voltage lowers the current in proportion and cuts the heating loss dramatically. At consumer substations, step-down transformers bring the voltage back to safe working levels of 220 V or 440 V. Real transformers, however, are not ideal: they lose energy through flux leakage, resistance of the windings, eddy currents and hysteresis in the core.

(i) State the principle on which a transformer works. *[1]*

(ii) Why is the core of a transformer made of thin laminated sheets rather than a solid block of metal? *[1]*

(iii) An ideal step-down transformer connected to a 2200 V line supplies 220 V to a load of 4400 W. Calculate the current in the primary coil and the turns ratio N_s/N_p. *[2]*

OR

(iii) State any two major sources of energy loss in a practical transformer and explain how each is minimised in design. *[2]*

SECTION E

Long Answer Questions (3 × 5 = 15 marks)

31. (a) State Gauss's law in electrostatics. Using it, derive an expression for the electric field intensity due to a uniformly charged thin spherical shell of radius R and surface charge density σ, at a point (i) outside the shell ($r > R$) and (ii) inside the shell ($r < R$).
(b) Draw a graph showing how the electric field E varies with distance r from the centre of the shell. *[5]*

OR

(a) Derive an expression for the capacitance of a parallel plate capacitor of plate area A and plate separation d, with air between the plates.

(b) Three capacitors of capacitance 4 μF, 6 μF and 12 μF are joined in series across a 24 V DC source. Calculate (i) the equivalent capacitance, (ii) the charge on each capacitor, and (iii) the potential difference across the 4 μF capacitor.

32. (a) Define the current sensitivity and the voltage sensitivity of a moving coil galvanometer, and derive an expression for each. Explain why increasing the number of turns of the coil need not increase its voltage sensitivity.
(b) Explain, with a circuit diagram in each case, how a galvanometer of resistance G, giving full-scale deflection for a current I_g, is converted into (i) an ammeter of range 0 to I, and (ii) a voltmeter of range 0 to V. *[5]*

OR

(a) Derive an expression for the force per unit length between two long straight parallel conductors carrying currents I_1 and I_2 and separated by a distance d in air. State when this force is attractive and when it is repulsive.

(b) Use this expression to define the ampere.

33. (a) Using a phasor diagram, derive an expression for the impedance of a series LCR circuit connected to an AC source $V = V_0 \sin \omega t$, and obtain the expression for the phase difference between the current and the voltage.
(b) Derive an expression for the average power dissipated in such a circuit over a complete cycle. Define the power factor, and explain what is meant by a wattless current. *[5]*

OR

(a) With the help of a neat labelled diagram, describe the construction and working of an AC generator, and derive an expression for the instantaneous emf induced in its coil.

(b) An armature coil of 100 turns, each of area 0.1 m², rotates at 3000 revolutions per minute in a uniform magnetic field of 0.05 T perpendicular to the axis of rotation. Calculate the peak value of the emf induced in the coil.

— End of Question Paper —