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Your JEE Guide

CBSE Class XII · Physics (042)

Sample Question Paper 3 · Session 2026-27

Time allowed: 3 hours **Maximum marks: 70**

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General instructions:

1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. Section A contains sixteen questions: twelve MCQs and four Assertion–Reasoning questions of 1 mark each. Section B contains five questions of two marks each, Section C seven questions of three marks each, Section D two case study based questions of four marks each and Section E three long answer questions of five marks each.
4. There is no overall choice. However, an internal choice has been provided in two questions in Section B, one question in Section C, and all three questions in Section E.
5. Use of calculators is not allowed.
6. You may use: $c = 3 \times 10^{8}$ m/s, $m_e = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C, $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}, $h = 6.63 \times 10^{-34}$ J s, $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}.

Section A

1.	The force between two point charges in air is F. If they are placed in a medium of dielectric constant 4 at the same separation, the force becomes: (A) F (B) 4F (C) F/2 (D) F/4	1
2.	The work done in moving a charge once around a closed path in an electrostatic field is: (A) infinite (B) zero (C) positive (D) negative	1
3.	Two 4 μF capacitors are connected in series. The equivalent capacitance is: (A) 4 μF (B) 8 μF (C) 2 μF (D) 1 μF	1
4.	The resistance of a bulb rated 220 V, 100 W is: (A) 484 Ω (B) 220 Ω (C) 48.4 Ω (D) 2.2 Ω	1

5.	The magnetic field at the centre of a circular loop of radius R carrying current I is: (A) $\frac{\mu_0 I R}{2}$ (B) $\frac{\mu_0 I}{2R}$ (C) $\frac{\mu_0 I}{2\pi R}$ (D) $\frac{\mu_0 I}{4R}$	1
6.	A radial magnetic field is used in a moving coil galvanometer so that: (A) the torque is zero (B) the galvanometer can measure AC (C) the deflection is proportional to the current (D) the coil does not rotate	1
7.	The magnetic susceptibility of a diamagnetic substance is: (A) small and negative (B) small and positive (C) large and positive (D) zero	1
8.	Eddy current losses in a transformer are reduced by using: (A) a solid copper core (B) a higher frequency (C) thicker wire (D) a laminated core	1
9.	The power factor of a series LCR circuit at resonance is: (A) $\frac{1}{\sqrt{2}}$ (B) 0.5 (C) 1 (D) 0	1
10.	The refractive index of a glass is 1.5. The speed of light in it is: (A) 4.5×10^8 m/s (B) 3×10^8 m/s (C) 1.5×10^8 m/s (D) 2×10^8 m/s	1
11.	For constructive interference of two coherent waves, the path difference must be: (A) $\frac{\lambda}{4}$ (B) $n\lambda$ (C) $(2n+1)\frac{\lambda}{2}$ (D) $\frac{n\lambda}{3}$	1
12.	An electron, a proton, a neutron and an alpha particle move with the same speed. The one with the longest de Broglie wavelength is the: (A) electron (B) alpha particle (C) neutron (D) proton	1
13.	**Assertion (A):** The mass of a nucleus is less than the total mass of its nucleons. **Reason (R):** Energy is released when nucleons bind together to form a nucleus. (A) Both Assertion (A) and Reason (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) Both A and R are false.	1

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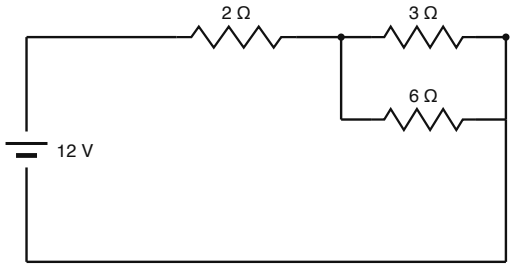
14.	**Assertion (A):** An electric dipole in a uniform electric field experiences no net force. **Reason (R):** The two charges of the dipole experience equal and opposite forces. (A) Both Assertion (A) and Reason (R) are true and R is the correct explanation of A. (B) Both A and R are true but R is not the correct explanation of A. (C) A is true but R is false. (D) Both A and R are false.	1
15.	**Assertion (A):** Optical fibres work on the principle of total internal reflection. **Reason (R):** The refractive index of the core is less than that of the cladding. (A) Both Assertion (A) and Reason (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) Both A and R are false.	1
16.	**Assertion (A):** The energy of an electron in a Bohr orbit of hydrogen is positive. **Reason (R):** An electron bound to a nucleus has positive total energy. (A) Both Assertion (A) and Reason (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) Both A and R are false.	1

Section B

17.	Two point charges of 2×10^{-7} C and 3×10^{-7} C are 30 cm apart in air. Find the force between them. **OR** Find the electric field at a distance of 2 m from a point charge of 4 nC in air. In which direction does it point?	2
18.	A battery of emf 10 V and internal resistance 3 Ω is connected to a resistor. The current is 0.5 A. Find the resistance and the terminal voltage.	2
19.	A proton moves at 3×10^{5} m/s perpendicular to a uniform magnetic field of 0.1 T. Find the radius of its path (mass of proton 1.67×10^{-27} kg).	2
20.	An ideal transformer steps down 220 V to 11 V. Find the turns ratio. If the secondary current is 2 A, what is the primary current? **OR** Why is the core of a transformer laminated? Name two energy losses in a real transformer.	2
21.	Light of wavelength 300 nm falls on a metal of work function 2.5 eV. Find the maximum kinetic energy of the emitted electrons and the stopping potential.	2

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Section C

22.	Derive an expression for the electric potential at a point at distance r from an electric dipole, making an angle θ with its axis ($r \gg a$). What is the potential on its equatorial line?	3
23.	In the circuit shown, find the current drawn from the battery, the current through the 6 Ω resistor and the power used in the 2 Ω resistor.  **OR** A wire has a resistance of 2.1 Ω at 27 °C and 2.7 Ω at 100 °C. Find its temperature coefficient of resistance. Why does the resistance of a metal increase with temperature?	3
24.	A rectangular coil of 50 turns and area 4×10^{-3} m² carries 2 A in a uniform field of 0.2 T. The normal to the coil makes 30° with the field. Find the torque on the coil. When is the torque maximum?	3
25.	A bar magnet of magnetic moment 0.32 J/T is placed in a uniform field of 0.15 T. Find its potential energy when it is in (i) stable equilibrium, (ii) unstable equilibrium. Draw the field lines of a bar magnet.	3
26.	Derive an expression for the self-inductance of a long solenoid of n turns per unit length, length l and area of cross-section A.	3
27.	Using Huygens' principle, derive Snell's law of refraction for a plane wave passing from a rarer to a denser medium.	3
28.	Find the de Broglie wavelength of an electron with kinetic energy 120 eV. Also find its momentum.	3

Section D

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29.	**Case study.** Many touch screens work as capacitors. A thin conducting layer and the user's finger act like the plates of a tiny capacitor; touching the screen changes the capacitance at that point, which the device detects. The capacitance of a parallel-plate capacitor is $C = \frac{K\varepsilon_0 A}{d}$. (i) If the distance between the plates is halved, the capacitance: (A) halves (B) doubles (C) becomes four times (D) is unchanged *[1]* (ii) What is the SI unit of capacitance? *[1]* (iii) If a dielectric slab of constant 5 fills the space between the plates, the capacitance becomes: (A) 5 times (B) 1/5 (C) 25 times (D) unchanged *[1]* (iv) A 10 μF capacitor is charged to 20 V. How much charge does it store? *[1]*	4
30.	**Case study.** A person cannot see distant objects clearly beyond 2 m, while another cannot read print held closer than 50 cm. Opticians correct such defects with lenses of suitable power, P = 1/f (f in metres). (i) The first person suffers from: (A) hypermetropia (B) myopia (C) presbyopia (D) astigmatism *[1]* (ii) Find the power of the lens the first person needs. *[1]* (iii) Which type of lens does the second person need? *[1]* (iv) Find the power of the lens that lets the second person read at 25 cm. *[1]*	4

Section E

31.	(a) Using Gauss's law, find the electric field due to an infinite plane sheet of uniform surface charge density σ. (b) Two large parallel plates carry charge densities +σ and −σ. Find the field between them and outside them. **OR** (a) Show that the current density in a conductor is $J = \sigma E$, where σ is the conductivity. (b) A copper wire of cross-section 1.0 mm² carries 1.5 A. Find the drift speed of electrons (n = 8.5 × 10^{28} m^{-3}).	5
32.	(a) Using the Biot–Savart law, derive an expression for the magnetic field on the axis of a circular current loop. (b) Show that at a distance $\sqrt{3}R$ from the centre on the axis, the field is one-eighth of the field at the centre. **OR** (a) Using Ampere's circuital law, find the magnetic field inside a toroid of N turns. (b) A toroid of mean radius 10 cm has 500 turns and carries 2 A. Find the field inside its core.	5

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33.	(a) Draw a ray diagram for a concave mirror forming a real image, and derive the mirror equation. (b) An object is 15 cm in front of a concave mirror of focal length 10 cm. Find the position and magnification of the image. **OR** (a) Distinguish between metals, semiconductors and insulators using energy band diagrams. (b) Why does the conductivity of a semiconductor increase with temperature, while that of a metal decreases?	5

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Answers and Marking Scheme

Marks for each step are shown in brackets. Any correct alternative method gets full credit.

Section A

1. **(D)** F/4. *Working:* $F \propto \frac{1}{K}$.

2. **(B)** zero. *Working:* The electrostatic field is conservative.

3. **(C)** 2 μF. *Working:* $\frac{1}{C} = \frac{1}{4} + \frac{1}{4}$.

4. **(A)** 484 Ω. *Working:* $R = \frac{V^2}{P}$.

5. **(B)** $\frac{\mu_0 I}{2R}$. *Working:* Standard result from the Biot–Savart law.

6. **(C)** the deflection is proportional to the current. *Working:* The plane of the coil is always parallel to the field, so the torque is NIAB and θ ∝ I.

7. **(A)** small and negative. *Working:* Diamagnetic materials are weakly magnetised opposite to the field.

8. **(D)** a laminated core. *Working:* Laminations break up the paths of eddy currents.

9. **(C)** 1. *Working:* At resonance Z = R, so cos ϕ = 1.

10. **(D)** 2 × 10^8 m/s. *Working:* v = c/n.

11. **(B)** $n\lambda$. *Working:* The waves arrive in phase.

12. **(A)** electron. *Working:* λ = h/mv; the electron has the least mass.

13. **(A)** Both Assertion (A) and Reason (R) are true and R is the correct explanation of A. *Working:* The released binding energy corresponds to the mass defect.

14. **(A)** Both Assertion (A) and Reason (R) are true and R is the correct explanation of A. *Working:* The equal and opposite forces add up to zero.

15. **(C)** A is true but R is false. *Working:* A is true. R is false: the core has the higher refractive index.

16. **(D)** Both A and R are false. *Working:* Both are false: bound states have negative total energy.

Section B

17. $F = \frac{9\times10^{9}\times2\times10^{-7}\times3\times10^{-7}}{(0.3)^2}$ (1) = 6 × 10^{-3} N, repulsive (1).

OR $E = \frac{9\times10^{9}\times4\times10^{-9}}{4} = 9$ N/C (1), directed radially away from the charge (1).

18. I = E/(R + r): 0.5 = 10/(R + 3), so R = 17 Ω (1). V = E − Ir = 10 − 1.5 = 8.5 V (1).

19. $r = \frac{mv}{qB}$ (1) $= \frac{1.67\times10^{-27}\times3\times10^{5}}{1.6\times10^{-19}\times0.1} \approx 3.1$ cm (1).

20. $\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{1}{20}$ (1). $V_pI_p = V_sI_s$: $I_p = \frac{11\times2}{220} = 0.1$ A (1).

OR Lamination reduces eddy currents and hence heating of the core (1). Any two: copper (I^2R) loss in windings; eddy current loss; hysteresis loss; flux leakage (1).

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21. $E = \frac{1240}{300} = 4.13$ eV (½); $K_{max} = 4.13 - 2.5 = 1.63$ eV (1); stopping potential 1.63 V (½).

Section C

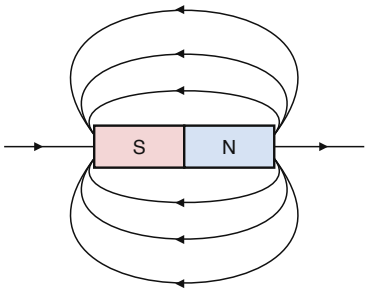
22. $V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$ with $r_1 \approx r - a\cos\theta$, $r_2 \approx r + a\cos\theta$ (1). So $V = \frac{p\cos\theta}{4\pi\varepsilon_0 r^2}$ (1). On the equatorial line θ = 90°, so V = 0 (1).

23. 3 Ω and 6 Ω in parallel give 2 Ω; total 4 Ω, so I = 3 A (1). P.d. across the pair = 3 × 2 = 6 V, so the 6 Ω carries 1 A (1). Power in 2 Ω = I^2R = 18 W (1).

OR $\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)} = \frac{0.6}{2.1 \times 73}$ (1) $\approx 3.9 \times 10^{-3}$ °C^{-1} (1). Electrons collide more often with the more strongly vibrating ions, so the relaxation time decreases (1).

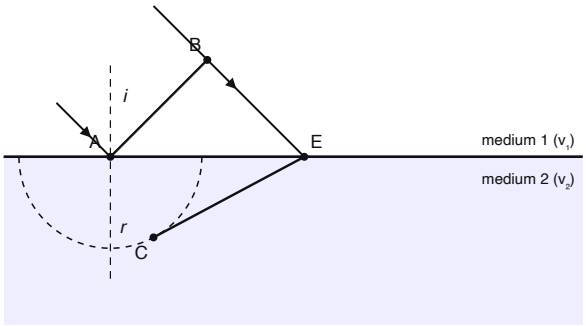
24. τ = NIAB sin θ (1) = 50 × 2 × 4 × 10^{-3} × 0.2 × ½ = 0.04 N m (1). It is maximum when the plane of the coil is parallel to the field (θ = 90°) (1).

25. U = −mB cos θ. (i) θ = 0°: U = −0.048 J (1). (ii) θ = 180°: U = +0.048 J (1). Diagram (1):



26. B = $\mu_0 nI$ inside (1). Total flux linkage $N\Phi = (nl)(\mu_0 nI)A$ (1). $L = \frac{N\Phi}{I} = \mu_0 n^2 Al$ (1).

27. Figure (1):



While the disturbance at B travels BE = $v_1 t$, the wavelet from A grows to AC = $v_2 t$; the refracted wavefront is the tangent EC (1). $\sin i = \frac{v_1 t}{AE}$, $\sin r = \frac{v_2 t}{AE}$, so $\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = n_{21}$ (1).

28. $p = \sqrt{2mK} = \sqrt{2 \times 9.1 \times 10^{-31} \times 120 \times 1.6 \times 10^{-19}} \approx 5.9 \times 10^{-24}$ kg m/s (1½). $\lambda = \frac{h}{p} \approx 1.12 \times 10^{-10}$ m (1½).

Section D

29. (i) (B) doubles.
(ii) The farad (F).

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(iii) (A) 5 times.
(iv) Q = CV = 200 μC.

30. (i) (B) myopia.
(ii) f = –2 m, so P = –0.5 D (concave lens).
(iii) A convex (converging) lens.
(iv) u = –25 cm, v = –50 cm: $\frac{1}{f} = -\frac{1}{50} + \frac{1}{25} = \frac{1}{50}$, f = 50 cm, P = +2 D.

Section E

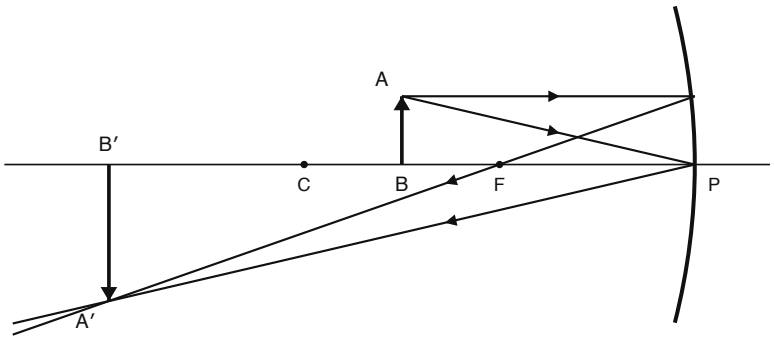
31. (a) Take a cylindrical Gaussian surface through the sheet with flat faces of area A (1). Flux = 2EA = σA/ε$_0$ (1), so $E = \frac{\sigma}{2\varepsilon_0}$, normal to the sheet (1). (b) Between the plates the two fields add: $E = \frac{\sigma}{\varepsilon_0}$ (1); outside they cancel: E = 0 (1).

OR (a) Drift speed $v_d = \frac{eE\tau}{m}$ (1); $J = nev_d = \frac{ne^2\tau}{m}E$ (1); with $\sigma = \frac{ne^2\tau}{m}$, J = σE (1). (b) $v_d = \frac{I}{neA} = \frac{1.5}{8.5\times10^{28}\times1.6\times10^{-19}\times10^{-6}} \approx 1.1 \times 10^{-4}$ m/s (2).

32. (a) Each element dl gives $dB = \frac{\mu_0 I dl}{4\pi(R^2+x^2)}$; the components perpendicular to the axis cancel (1). Summing the axial components, $B = \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$ along the axis (2). (b) With $x = \sqrt{3}R$: $B = \frac{\mu_0 I R^2}{2(4R^2)^{3/2}} = \frac{\mu_0 I}{16R} = \frac{1}{8}\cdot\frac{\mu_0 I}{2R}$ (2).

OR (a) Take a circular loop of radius r inside the toroid: B(2πr) = μ$_0$NI (2), so $B = \frac{\mu_0 NI}{2\pi r}$; outside and in the hollow, B = 0 (1). (b) $B = \frac{4\pi\times10^{-7}\times500\times2}{2\pi\times0.1} = 2\times10^{-3}$ T (2).

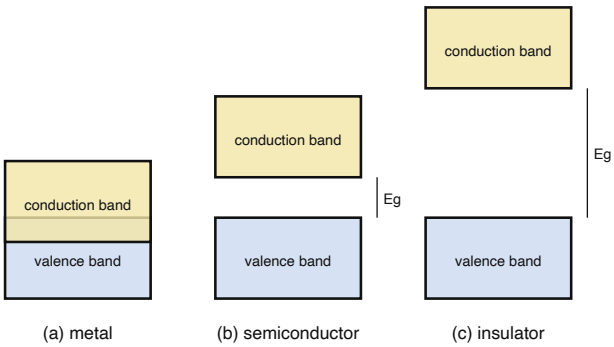
33. (a) Diagram (1):



From the similar triangles formed by the ray through F and the ray parallel to the axis, $\frac{B'A'}{BA} = \frac{B'F}{FP}$ and $\frac{B'A'}{BA} = \frac{B'P}{BP}$; with sign conventions this gives $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ (2). (b) $\frac{1}{v} = -\frac{1}{10} + \frac{1}{15}$, v = –30 cm; m = –v/u = –2 (real, inverted, enlarged) (2).

OR (a) Diagrams (1½):

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In metals the bands overlap; in semiconductors the band gap is small (about 1 eV); in insulators it is large (more than 3 eV) (1½). (b) In a semiconductor, heating frees more electrons into the conduction band (1); in a metal the number of carriers is fixed and more frequent collisions reduce conductivity (1).

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