SET NO-1

Roll No. | | | | | | | |

Candidates must write the Set No. on the title page of the answer book.

DAV PUBLIC SCHOOLS, ODISHA ZONE
HALF YEARLY EXAMINATION (2023-24)

- Please check that this question paper contains **8** printed pages.
- Set number given on the right hand side of the question paper should be written on the title page of the answer book by the candidate.
- Check that this question paper contains **33** questions.
- Write down the Serial Number of the question in the left side of the margin before attempting it.
- 15 minutes time has been allotted to read this question paper. The question paper will be distributed 15 minutes prior to the commencement of the examination. The students will read the question paper only and will not write any answer on the answer script during this period.

CLASS- XII

SUBJECT: PHYSICS (042)

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

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) All the sections are compulsory.
(4) **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.
(5) There is no overall choice. However, an internal choice has been provided in one question in **Section B,** two questions in **Section C**, one question in each CBQ in **Section D** and all three questions in **Section E**. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary

i. $c = 3 \times 10^8$ m/s

ii. $m_e = 9.1 \times 10^{-31}$ kg

iii. $e = 1.6 \times 10^{-19}$ C

iv. $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}

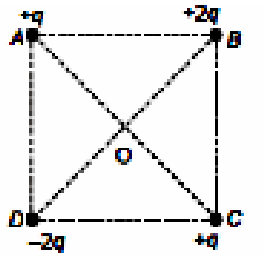
v.$h = 6.63 \times 10^{-34}$ Js

vi. $\varepsilon_0 = 8.854 \times 10^{-12} C^2 N^{-1} m^{-2}$

vii. Avogadro's number = 6.023×10^{23} per gram mole

SECTION-A

1. Four charges are arranged at the corners of a square ABCD, as shown. The force on a unit positive charge kept at the centre O is



(a) zero.
(b) along the diagonal AC.
(c) along the diagonal BD.
(d) perpendicular to side AB.

2. A charge q is placed at the midpoint of one edge of a cube. The total electric flux through the cube with side of length 'a' is

(a) $\frac{q}{\epsilon_0}$ (b) $\frac{q}{2\epsilon_0}$ (c) $\frac{q}{4\epsilon_0}$ (d) $\frac{q}{8\epsilon_0}$

3. A parallel plate air capacitor is charged to a potential difference of V volts.After disconnecting the charging battery, the distance between the plates of the capacitor is increased using an insulating handle. As a result the potential difference between the plates
(a) increases. (b) decreases. (c) does not change. (d) becomes zero.

4. The drift velocity of the free electrons in a conducting wire carrying a current I is v. If in a wire of the same metal, but of double the radius, the current be 2I, then the drift velocity of the electrons will be
(a) v/4 (b) v/2 (c) v (d) 4v

5. A steady current flows in a metallic conductor of non uniform cross section. Which of these quantities remains constant along the conductor?
(a) current (b) current density (c) electric field (d) drift speed

6. In the equation AB = C, A is the current density, C is the electric field, then B is
(a) resistivity. (b) conductivity. (c) potential difference. (d) resistance.

7. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true?
(a) The electron will be accelerated along the axis.
(b) The electron path will be circular about the axis.
(c) The electron will experience a force at 45° to the axis and hence execute a helical path.
(d) The electron will continue to move with uniform velocity along the axis of the solenoid.

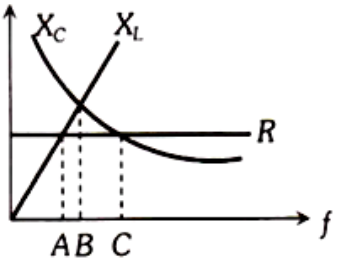
8. Three needles N_1, N_2 and N_3 are made of a ferromagnetic, a paramagnetic and a diamagnetic substance respectively. A magnet, when brought close to them, will
(a) attract N_1 strongly, but repel N_2 and N_3 weakly.
(b) attract all three of them.
(c) attract N_1 and N_2 strongly but repel N_3.
(d) attract N_1 strongly and N_2 weakly but repel N_3 weakly.

9. The current in a coil changes from 5A to 2A in 0.1s due to which an average voltage of 60V is produced in it. The self inductance of the coil is

(a) 2H (b) -2H (c) 4H (d) 0.5H

10. Two identical coaxial coils P and Q carrying equal amount of current in the same direction are brought nearer. The current in
    (a) P increases while in Q decreases. (b) Q increases while in P decreases.
    (c) both P and Q increases. (d) both P and Q decreases.

11. The figure shows variation of R, X_L and X_C with frequency'f' in a series LCR circuit. Then for what frequency point, the circuit is inductive.



    (a) A (b) B (c) C (d) A and B

12. The electromagnetic wave widely used in remote switches are also used
    (a) in the radar system. (b) in LASIK eye surgery.
    (c) in physical therapy. (d) in water purifier.

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

(a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.
(b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(c) If Assertion is true but Reason is false.
(d) If both Assertion and Reason are false.

13. **Assertion (A):**The resistivity of a semiconductor decreases with increase in temperature.
    Reason (R) : With increase in temperature the number density of charge carrier decreases.

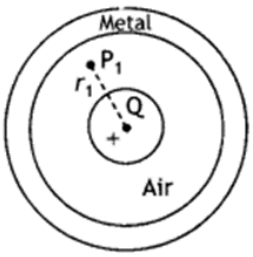
14. **Assertion (A):** When a charged particle enters perpendicular to a uniform magnetic field, work done on the charged particle is zero.
    Reason (R) : In a complete cycle the displacement of the charged particle is zero.

15. **Assertion (A):** The voltage and current in a series AC circuit are given by $V = V_0 \sin\omega t$ and $I = I_0 \cos\omega t$. The power dissipated in the circuit is zero.
    Reason(R) : Power in AC circuit is given by $P = V_{rms} I_{rms} \cos\Phi$.

16. **Assertion (A):** If a charged particle is kept in the path of electromagnetic wave, the particle oscillates.
    Reason (R):Electromagnetic waves contain both momentum and energy.

SECTION-B

17. A small metal sphere carrying charge +Q is located at the center of a spherical cavity in a large uncharged metallic spherical shell. Write the charges on the inner and outer surfaces of the shell. Write the expression for the electric field at the point P_1.



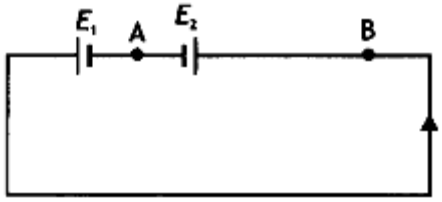
18. Two charges 3×10^{-8} C and -2×10^{-8} C are located 15 cm apart. At what point on the line joining the two charges in between them is the electric potential zero? Take the potential at infinity to be zero.

OR

(a) Determine the electrostatic potential energy of a system consisting of two charges 7 μC and –2 μC (and with no external field) placed at (–9 cm, 0, 0) and (9 cm, 0, 0) respectively.

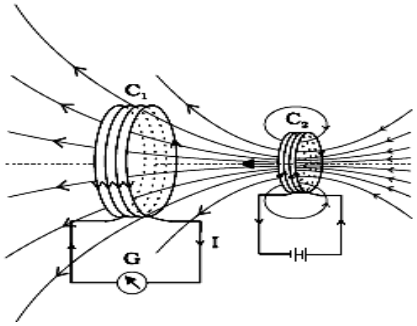
(b) How much work is required to separate the two charges infinitely away from each other?

19. The circuit in the figure shows two cells connected in opposition to each other. Cell E_1 is of emf 6 V and internal resistance 2 Ω; the cell E_2 is of emf 4 V and internal resistance 8 Ω. Find terminal potential difference across each cell. From A or B which point is at higher potential?



20. Derive an expression for radius of the circular path described by a charged particle while projected perpendicular to the direction of uniform magnetic field. Hence show that the frequency of revolution is independent of the speed of the particle.

21.



As shown in the above figure a current is induced in coil C_1 due to motion of the current carrying coil C_2.

(a) What would you do to obtain a large deflection of the galvanometer?

(b) How would you demonstrate the presence of an induced current in the absence of a galvanometer?

SECTION-C

22. An electric dipole is held in a uniform electric field.

(a) Using a suitable diagram show that it does not undergo any translational motion.

(b) Derive an expression for torque acting on it and specify its direction.

23. If 'n' mercury drops of same size each having the charge 'q' and radius 'r', coalesce to form a bigger drop of charge 'Q' and radius 'R', then how will the following vary with respect to single small drop?

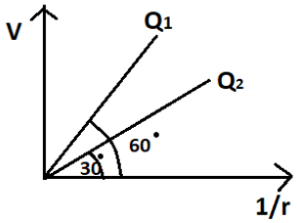
(a) Total charge on bigger drop.

(b) Potential on the bigger drop.

(c) Capacitance of the bigger drop.

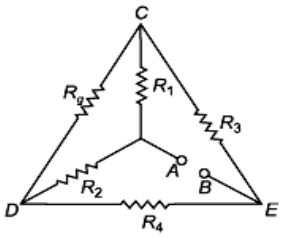
OR

(a) The figure shows the variation of potential V with $\frac{1}{r}$ for two point charges Q_1 and Q_2, where V is potential at a distance r due to a point charge. Determine the ratio $\frac{Q_1}{Q_2}$.



(b) Consider two conducting spheres of radii R_1 and R_2 with $R_1 > R_2$. If the two are at same potential, determine the ratio of charge density of the smaller sphere to that of the larger one in terms of R_1 and R_2.

24. (a) Using Kirchhoff's rules, derive the balanced condition of a Wheatstone bridge.
(b)



Find the eqivalent resistance between the two points A and B if each of the resistance is equal to R.

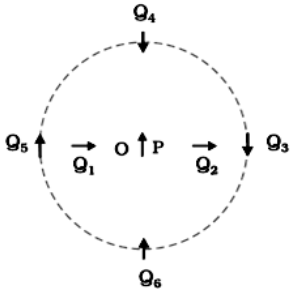
OR

'N' number of identical cells each of emf 'E' and internal resistance 'r' are joined in series out of which the second cell is connected in opposite order. The combination of cells is connected across a resistance 'R'.

(a) Draw the circuit diagram.
(b) Find the net emf of the circuit.
(c) Write the expression for current through the external resistance R.

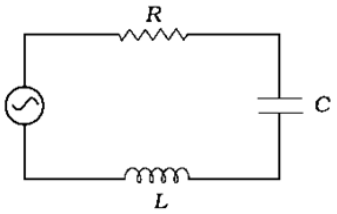
25. Derive an expression for the velocity '$\mathbf{v_C}$' of a positive ion passing undeflected through a region where crossed and uniform electric field 'E' and magnetic field 'B' are simultaneously present. Draw and justify the trajectory of identical positive ions whose velocity has a magnitude less than the magnitude of '$\mathbf{v_C}$'.

26. The figure shows a small magnetised needle P placed at a point O. The arrow shows the direction of its magnetic moment. The other arrows show different positions (and orientations of the magnetic moment) of another identical magnetised needle Q.



(a) In which configuration is the system not in equilibrium?
(b) In which configuration is the system in (i) stable, and (ii) unstable equilibrium?
(c) Which configuration corresponds to the lowest potential energy among all the configurations shown? Give reason to your answer.

27. The figure shows a series LCR circuit with L = 5.0 H, C = 80 μF, R = 40 Ω connected to a variable frequency 240 V source.



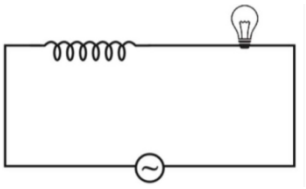
Calculate
(a) The angular frequency of the source which drives the circuit at resonance.
(b) The current at the resonating frequency.
(c) The rms potential drop across the capacitor at resonance.

28. An electromagnetic wave travelling through a medium has electric field vector given by $E_y = 4 \times 10^5 \cos (3.14 \times 10^8 t - 1.57 x)$ N/C ,where x is in m and t in s. Then find:
(a) speed of wave,
(b) refractive index of medium, and
(c) amplitude of magnetic field vector.

SECTION-D

29. **Case Study Based Questions**-

When a current flows through a coil, flux linked with it is Ø = LI, where L is a constant known as self-inductance of the coil. Any change in current sets up an induced emf in the coil. Thus, self-inductance of a coil is the induced emf set up in it when the current passing through it changes at the unit rate. It is a measure of the opposition to the growth or decay of current flowing through the coil. Also the value of self-inductance depends on the number of turns in the solenoid, its area of cross-section and the relative permeability of its core material.



(i) Self-inductance comes into play due to

(a) increase in current. (b) decay in current.

(c) Both (a) and (b) (d) flow of steady current.

(ii) If an iron rod is inserted in the core region of the coil, the brightness of the bulb

(a) increases. (b) decreases. (c) remains same. (d) first increases and then decreases.

(iii) If the ac source is replaced by a dc source in the figure, the reactance of the inductor at steady state becomes

(a) zero. (b) infinite. (c) same. (d) none of these.

(iv) Keeping other parameters constant, if diameter of the coil is doubled then the inductance becomes

(a) 2 times. (b) 4 times. (c) (1/2) times. (d) (1/4) times.

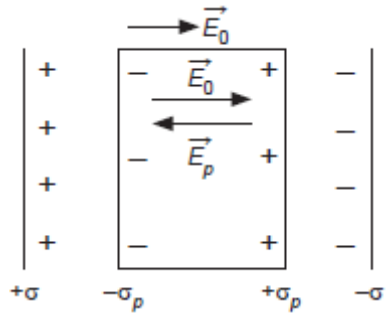
OR

(iv) The self inductance of the coil is L. If a magnetic material is introduced in the core so that the self inductance becomes (L/10), then the relative magnetic permeability of the material is

(a) 10. (b) 5. (c) 100. (d) 0.1.

30. **Case Study Based Questions-**

The induced dipole moment developed per unit volume in a dielectric slab on placing it inside the electric field is called polarisation. Let $\overrightarrow{E_0}$ be the uniform external electric field. When a dielectric slab is placed in uniform electric field, then the molecules get polarised, due to which $-\sigma_p$ (charge density due to polarisation) will appear near the positive plate and $+\sigma_p$ will appear in the dielectric near the negative plate. Therefore, due to polarization of molecules, electric field will appear in the opposite direction, and the net electric field inside the dielectric will be reduced. So, the dielectric constant is defined as the ratio of the electric field in vacuum to the electric field in medium.



(i) If the dielectric constant of the medium is 4 then magnitude of $\overrightarrow{E_p}$ is

(a) $\frac{E_0}{4}$ (b) $4E_0$ (c) $\frac{3E_0}{4}$ (d) $\frac{4E_0}{3}$

(ii) Instead of dielectric slab, if a conducting slab of thickness half of separation between the two plates is introduced, then the electric field inside the conducting slab is

(a) $\frac{\sigma}{\epsilon_0}$ (b) $\frac{2\sigma}{\epsilon_0}$ (c) $\frac{\sigma}{2\epsilon_0}$ (d) $zero$

(iii) If the separation between the two plates is 'd' and thickness of the dielectric slab of dielectric constant 2 is d/2, then the capacitance of the capacitor becomes

(a) (3/4) times the capacitance in vacuum. (b) (4/3) times the capacitance in vacuum.

(c) 2 times the capacitance in vacuum. (d) 4 times the capacitance in vacuum.

(iv) If a dielectric of dielectric constant 'K' fills the whole space between the two plates of the capacitor with battery remaining connected in the circuit, then the energy stored in the capacitor becomes

(a) K times the energy in vacuum. (b) (1/K) times the energy in vacuum.

(c) K^2 times the energy in vacuum. (d) (K+1) times the energy in vacuum.

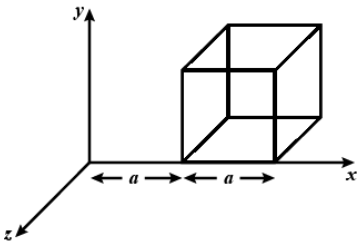
OR

(iv) The potential difference between the plates of the capacitor in vacuum is V. If the battery is disconnected and then the capacitor is completely filled by a dielectric of dielectric constant 'K', then the potential difference between the two plates becomes
(a) K V. (b) V/K. (c) K^2 V. (d) (K+1) V.

SECTION-E

31. (a) State Gauss's law. Use it to deduce the expression for the electric field due to a uniformly charged thin spherical shell at points (i) inside and (ii) outside the shell.

(b) A cube with each side 'a' is placed in an electric field $\vec{E} = 2x\hat{\imath}$, directed towards x-axis. Find out the net charge inside the cube.



OR

(a) Two point charges q and –q are placed at a distance 2a apart. Calculate the electric field at a point P situated at a distance x along the perpendicular bisector of the line joining the charges. Write the expression for electric field when x>> a.

(b) Two point charges q and 2q are located at points (0,0) and (a,a) respectively. Let $\hat{\imath}$ and $\hat{\jmath}$ be the unit vectors along x-axis and y-axis respectively. Determine the force exerted by q on 2q in terms of $\hat{\imath}$ and $\hat{\jmath}$.

32. (a) Using Biot-Savart's law, derive an expression for magnetic field at any point on axial line of a current carrying circular loop.

(b) A circular coil of 'N' turns and diameter'd' carries a current 'I'. It is unwound and rewound to make another coil of diameter '2d', current 'I' remaining the same. Calculate the ratio of the magnetic moments of the new coil and the original coil.

OR

(a) Write the expression for the force per unit length between two infinitely long straight parallel wires carrying currents in the same direction. Hence define one ampere.

(b) A wire AB is carrying a steady current of 12A and is lying on the table. Another wire *CD* carrying current 5A is held directly above AB at a height of 1mm. Find the mass per unit length of the wire *CD* so that it remains suspended at its position when left free. Give the direction of the current flowing in *CD* with respect to that in AB. (Take g =10 ms^{-2})

33. A series *LCR* circuit is connected to an ac source V= $V_m \sin\omega t$.

(a) Draw the phasor diagram to derive the expression for the impedance of the circuit.

(b) Find the phase difference between applied voltage and current. Hence ,write the expression for current.

(c) Plot a graph to show the variation of current with frequency of the source.

OR

(a) Draw the arrangements for windings of primary and secondary coil in a transformer with two coils on separate limbs of the core. State its working principle.

(b) Write assumptions used and deduce the expression for the ratio of secondary to primary voltage in terms of the number of turns and currents in the two coils.

(c) Explain why ac is preferred for long distance power transmission.

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