PHY(H) - II
P - III

PHSA(HN)-03

West Bengal State University

B.A./B.Sc./B.Com (Honours, Major, General) Examinations, 2015

PART – II

PHYSICS — HONOURS

Paper – III

Duration : 4 Hours] [Full Marks : 100

Candidates are required to give their answers in their own words as far as practicable.

The figures in the margin indicate full marks.

Answer Questions no. 1, *four* form Group *A* and any *four* taking at least *one* from Group *B*, Group *C* and Group *D*.

1. Answer any *ten* from the following questions : $10 \times 2 = 20$

a) Show that the ratio of the dimension of electric field $\vec{E}$ and the magnetic field $\vec{H}$ is same as that of resistance.

b) Electrostatic potential at a point (x, y) is given by $V = 2x + 4y$ volts. Show that the electrostatic energy density at a point (in J/m^3) is $10\ \epsilon_0$.

c) The electrostatic field $\vec{E}$ in $(X - Y)$ plane is given by $\vec{E} = 2ax\hat{i} + by\hat{j}$. What charge density is responsible for the field ?

d) The electric field in a region of space is given by $\vec{E} = 8x\hat{i} - 4y\hat{j} - 4z\hat{k}$. Find the equation of lines of force in the plane $(Z = 0)$.

e) When a neutral dielectric is polarised, the polarisation volume charges and surface charges appear. Show that the total charge remains zero.

f) State the importance of Uniqueness theorem in electrostatics.

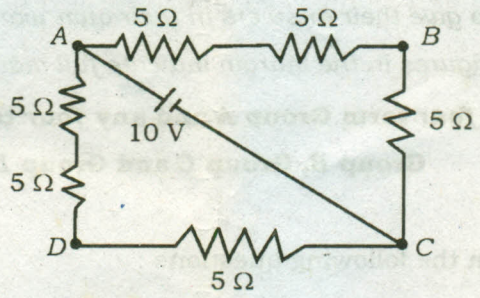
g) Obtain equation of continuity for displacement current from Maxwell's laws of electromagnetic theory.

h) What is non-inductive winding ? Give one of its uses.

i) Show that the magnetic dipole moment of a planar current carrying loop is independent of the choice of origin.

j) 'Ampere's circuital law is bound to fail for non-steady currents'. – Justify the statement.

k) Find the voltage across AB of the circuit given below :



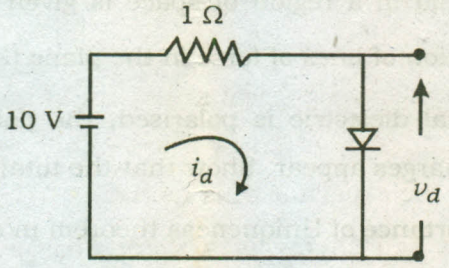
l) What are the major losses of a transformer ? How can they be minimized ?

m) What is meant by wattless current and why is it called wattless ?

n) In the given circuit current through i_d is defined as

$$i_d = v_d^2 + 2v_d \quad \text{when } v_d > 0$$
$$= 0 \quad \text{when } v_d \leq 0$$

where v_d is the voltage drop across the diode. Then find the value of v_d.



o) What is transformer utilization factor in relation to a rectifier circuit ?

p) Find the decimal equivalent of $(12{\cdot}CF)_{16}$.

Group – A

2. a) Show that the electrostatic potential due to an arbitrary charge distribution may be considered as the sum of potentials due to monopole, dipole, quadrupole and higher order multipoles. 4

b) State and explain Earnshaws's Theorem. What is its importance ? 2 + 1

c) The electric field in a certain region is given by $\vec{E} = 5r^3 \hat{r}$. Prove that charge contained within a spherical surface of radius a centred at the origin is $20\pi\epsilon_0 a^5$. 3

3. a) Using Coulomb's law of electrostatics and the principle of superposition of electric field, prove that the electric field $\vec{E}$ generated by any static charge distribution obeys the relation $\vec{\nabla} \times \vec{E} = 0$. 3

b) A change q is distributed uniformly over the surface of a thin circular insulating disc of radius a. Find the potential at a point on the rim of the disc. 4

c) The potential in a medium is given by $\phi(r) = \frac{q}{4\pi\epsilon_0} \frac{e^{-r/\lambda}}{r}$, where symbols have their usual meaning.

Obtain the corresponding electric field and charge density. 3

4. a) A right circular cone of semivertical angle α and height h has uniform polarisation P parallel to its axis of symmetry. Find the polarisation charge everywhere. 3

b) Three concentric thin spherical shells are of radii a, b, c ($a < b < c$). The first and third are connected by a wire while second is earthed. Find the capacitance of the capacitor thus formed. 3

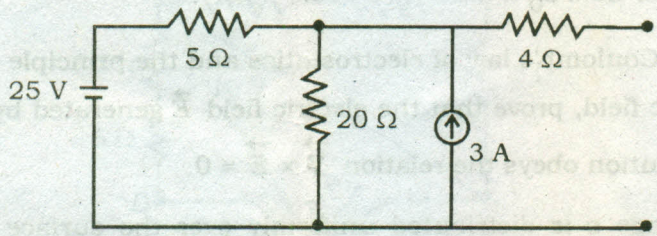
c) Show that the self energy of a point charge leads to the idea of the classical radius of an electron. Find out an expression for classical radius of an electron. 2 + 2

5. a) Explain why Wheatstone bridge principle is unsuitable for comparison of low resistances as well as high resistances. 2

b) Establish that a generator will supply maximum power to a load when the internal impedance of the generator and the load impedance are complex conjugate with each other. 3

c) State Thevenin's theorem. 2

d) Thevenize the circuit given below :



3

6. a) What do you mean by magnetic scalar potential ? 2

b) Find the magnetic vector potential $\vec{A}$ at a distance r from an infinite straight wire carrying current i. Now, check that $\vec{\nabla}.\vec{A} = 0$. 3 + 1

c) What do you mean by Lorentz force ?

Calculate the force acting on a current carrying conductor placed in a magnetic field. Assume I is the current in the conductor and $\vec{B}$ is the magnetic field. If $\vec{B}$ is uniform and the conductor is a closed loop carrying constant current, what is the force on it ? 1 + 2 + 1

7. a) What do you mean by Bohr Magnetron ? 2

b) An electron moves in a circular orbit of radius 0·5Å around the nucleus at a frequency 7×10^{15} Hz. Find the magnetic induction at the nucleus and find the equivalent magnetic moment.

(Given : Charge of electron = $1 \cdot 6 \times 10^{-19}$ C and $\mu_o = 4\pi \times 10^{-7}$ H/m). 3

c) In a certain region of space electric field is given by $\vec{E} = \hat{j}\, E_0 \cos(\omega t - kx)$. Using differential form of Faraday's law find the corresponding magnetic field $\vec{B}$. 3

d) Find the steady current density that can give rise to a magnetic field $\vec{B} = 2y\,\hat{i} - 3x\,\hat{j}$. 2

Group – B

8. a) A circuit with resistance R and inductance L is connected to a steady source of *emf* E. Calculate the time taken for current to reach 63% of its final value. 2

b) A series RC circuit is excited by a source of constant voltage V switched at time $t = 0$. What is the maximum growth rate of charge on the capacitor ? 2

c) In an oscillating circuit $L = 0.20$ henry, $C = 0.0012$ μF. Find the maximum value of R so that the circuit may oscillate. 2

d) A series combination of a resistance R and an inductance L is connected to a battery of *emf* E for long time. The battery is suddenly removed at time $t = 0$, but the circuit is kept closed. Show that the total energy dissipated in R during the decay of the current is equal to the energy originally stored in L. 2

e) A charge on a loss free capacitor of capacitance 2 μF falls to 25% of its initial value in 10 minutes when the two plates of the capacitor are joined by an unknown resistance. What is the value of the resistance ? 2

9. a) What do you mean by the term 'form factor' of an *ac* waveform ? What is its significance in *ac* waveform ? 1 + 1

b) Calculate the *rms* value of the current given by $I = 3 + 4 \sin \omega t$. 2

c) Why is 220 V *ac* more dangerous than 220 V *dc* ? 1

d) What do you mean by resonance in a series *LCR* circuit ? Why is it called an acceptor circuit ? 2 + 1

e) Why is a parallel *LC* circuit inductive but a series *LC* circuit is capacitive below resonant frequency ? 2

Group – C

10. a) State and establish Poynting's Theorem. Deduce its differential form. 1 + 2 + 1

b) Show that the average energy density in a harmonic electromagnetic field is $< u > = \frac{1}{4} \text{Re} \left[\vec{E}.\vec{D}^* + \vec{H}.\vec{B}^* \right]$

Where $\vec{D}^*$ and $\vec{B}^*$ are complex conjugates of $\vec{D}$ and $\vec{B}$. 2

c) Find the ratio between conduction current density and displacement current density for the electric field $E = E_0 e^{-j\omega t}$. 2

d) Prove that the displacement current in the direction of parallel plate capacitor is equal to the conduction current in the connecting leads. 2

11. a) Give the theory of scattering of *e.m.* radiation by bound electrons and hence derive the condition for Rayleigh scattering. 3 + 2

b) An optically transparent material cannot have a resonant frequency in the optical band. Explain. 2

c) The refractive index of water is $\frac{4}{3}$ for visible light and 9 for radio waves. Compare the reflectance of air-water in the two cases. 3

Group – D

12. a) Sketch the variation of electric field and potential as a function of distance across the junction for an open circuited P-N Junction. 2

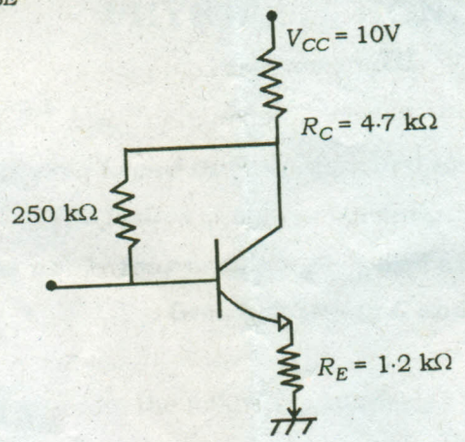
b) What is an emitter follower circuit ? Why is it so called ? 1 + 1

c) The ON/OFF state of a heating system water pump is controlled by three separately located thermostat switches, such that the pump runs only if the temperature in at least two of the locations falls below set value. Derive the simplest NAND circuits (with Boolean expression and truth table) to effect this control. Given that the switch is ON if its temperature is above this set value. 4

d) Draw a coincidence checker circuit and give its truth table. 2

13. a) What are the factors responsible for the shift of operating point (Q-point) of a transistor amplifier. 2

b) In the following circuit, find the quiescent value of I_E and V_{CE}. Given that $\beta = 90$ and $V_{BE} = 0{\cdot}7$ V. 3



c) Subtract $(0010)_2$ from $(0101)_2$ using 2's complement scheme. 2

d) i) Simplify the logic equation using logic identities,

$A(B + \overline{C}) + B(C + \overline{A}) + C(A + \overline{B})$

ii) Draw the simplified logic circuit using only NAND gates. 2 + 1