WEST BENGAL STATE UNIVERSITY

B.Sc. Honours PART-II Examinations, 2016

PHYSICS-HONOURS

PAPER-PHSA-III

Time Allotted: 4 Hours | Full Marks: 100

The figures in the margin indicate full marks. Candidates should answer in their own words and adhere to the word limit as practicable.

Answer Question No. 1, *four* from Group A and any *four* taking at least *one* from Group B, Group C and Group D.

1. Answer any *ten* questions from the following: $2\times10=20$

(a) Show that the function $\psi = 3x^2 + 8y - 3z^2$ can represent an electrostatic potential in charge free region.

(b) Is the field $\vec{E} = 4y\hat{i} - 2x\hat{j} + \hat{k}$ electrostatic? How?

(c) Starting from Biot-Savart law show that $\vec{\nabla}\cdot\vec{B} = 0$.

(d) Explain the force on an electric dipole placed within an inhomogeneous electric field.

(e) Show that the dimension of L/R is time, where L is inductance and R implies resistance.

(f) State the usefulness of electrical image in solving electrostatic problems.

(g) What is magnetomotive force? What is its unit?

(h) A charged particle moves with uniform velocity $\vec{u} = 4\hat{i}$ m/s in a region where $\vec{E} = 20\hat{j}$ V/m and $\vec{B} = B_0\hat{k}$ wb/m^2. Determine B_0 such that the velocity of the particle remains constant.

(i) A series resonant circuit is called an acceptor circuit. –Explain.

(j) Explain the significance of Brewster's angle.

(k) A high tension supply of say 5 kV must have a very large internal resistance. –Why?

(l) A choke coil in series with a lamp is connected to a DC line. The lamp is seen to shine brightly. Insertion of an iron core in the choke causes no change in the lamp's brightness. Predict the corresponding observations if the connection is to an AC line.

(m) Convert Decimal (37.675) to Binary.

(n) Implement the Boolean function $X = AB + \overline{A}C$ with NAND gates.

(o) Why proper DC biasing is required for a transistor amplifier circuit?

(p) Subtract 110101 from 1110110 using 2's Compliment Scheme.

Group-A

2. (a) A point charge 'q' is placed at the centre of a hollow cylinder of radius 'a' and length 'L'. Calculate electric flux through the curved surface of the cylinder. 3

(b) Suppose there is a small spherical cavity of radius 'r_1' within a large sphere of radius 'r_2' carrying uniform charge density ρ. Show that the field within the cavity is uniform. 2

(c) Find the dipole moment about the centre of a uniformly charged disc of radius 'R' having a surface charge density σ. 3

(d) State and explain Uniqueness theorem. 2

3. (a) What are polar and non-polar molecules? 2

(b) Determine the interaction energy between two electric dipoles of moments $\vec{P}_1$ and $\vec{P}_2$ separated by a distance $\vec{r}$. Hence find the condition for minimum energy. 2+1

(c) A point charge $+q$ is placed at a distance a from an infinite earthed conducting plane. Show that the total charge induced on the conductor is $-q$. 3

(d) State the boundary conditions at the surface of separation of two dielectric media of dielectric constants ϵ_1 and ϵ_2. 2

4. (a) A point charge 2 Coulomb is located at $(4\hat{i}+3\hat{j}+5\hat{k})$ metre. Find the electric field due to it at the point $(3\hat{i}+4\hat{j}+5\hat{k})$ metre. 2

(b) Write down the solution to Laplace's equation in spherical polar coordinates assuming azimuthal symmetry. 2

(c) Write down the boundary conditions when an uncharged grounded sphere of radius a is placed in a uniform field $\vec{E}_0 = E_0\hat{z}$. 2

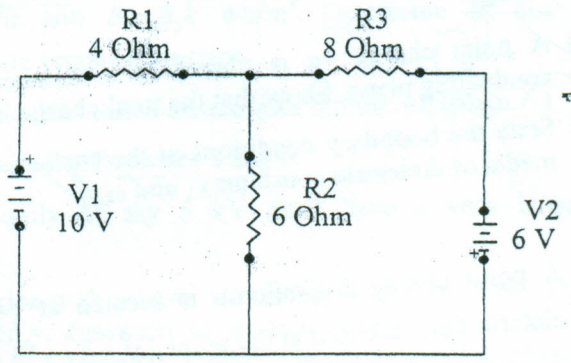
(d) Assuming the potential of form mentioned in (b) and using the boundary conditions in (c) show that the dipole moment due to induced charges on the sphere is $\vec{p} = 4\pi a^3 \epsilon_0 E_0 \hat{z}$. 4

5. (a) Establish the continuity equation relating to the charge density and the current density at a point in a medium. 2

(b) Discuss the sensitivity of a Wheatstone bridge in terms of current through the unknown resistance, positions of galvanometer and battery and internal resistance of the galvanometer. 3

(c) State and establish superposition theorem in electrical circuits. 2

(d) Using above principle to find the current through the 6 Ω resistance.



6. (a) Show that $\vec{\nabla} \times \vec{M} = \vec{J}_m$ where $\vec{M}$ is the magnetization and $\vec{J}_m$ is the magnetization current density.

(b) Examine the possibilities of magnetic field (i) $\vec{B} = 4x\hat{i} - 3y\hat{j} - z\hat{k}$ and

(ii) $\vec{B} = ax\hat{i} - (a+b)y\hat{j} - bz\hat{k}$.

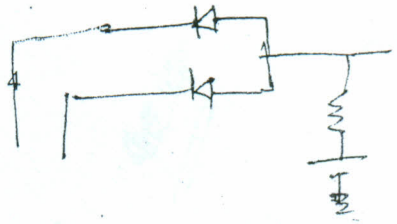
(c) A long straight conductor caries a current I. Determine the force per unit length of the conductor when it is placed in a uniform magnetic field.

(d) A sphere of radius r is so magnetized that its magnetization at any point (x, y, z) inside it with respect to its centre as origin is given by $M = (2x^3 + 3)\hat{i} + (4y^2 + 5)\hat{j}$. Find the magnetic pole density ρ_m.

7. (a) What is non-inductive winding?

(b) Show that equivalent inductance of two coils of self inductance L_1, L_2 and mutual inductance M connected in parallel is given by $L_{eq} = \dfrac{L_1 L_2 - M^2}{L_1 + L_2 \mp 2M}$

(c) Show that in an electromagnetic field we can write $\vec{E} = -\vec{\nabla}\varphi - \dfrac{\partial \vec{A}}{\partial t}$, where the symbols have usual meanings.



(d) A conducting bar of length 1.5 m, fixed at one end, rotates uniformly at the rate of 500 r.p.m. If a magnetic field of 4 Tesla is applied at right angles to the plane of rotation of the bar, calculate the e.m.f. induced between the ends of the bar. 3

Group-B

8. (a) What are the differences between voltage resonance and current resonance? 2

(b) Consider two identical, concentric stationary coils arranged at right angles to each other. They are supplied by AC sources of equal amplitude and frequency but having a phase difference $\frac{\pi}{2}$. Show that the resulting magnetic field intensity is constant. 3

(c) A circuit containing resistance R_1, inductor L_1 and capacitor C_1 connected in series gives resonance at the same frequency as the second similar combination R_2, L_2 and C_2. If two circuits are connected in series, show that the whole circuit resonate with the same frequency. 3

(d) A solenoid has $L = 50$H and $R = 30\ \Omega$. If it is connected to 100 V battery, how long will it take for the current to reach one-half of its final equilibrium value. 3

9. (a) A series LCR circuit is driven by a sinusoidal voltage. Find out the instantaneous current and also the value of the current at resonance. 3

(b) A charged capacitor C is suddenly connected across a resistor R. Show that the energy which was stored in the capacitor is now entirely dissipated in R. 2

(c) Show that when a coil of inductance L and resistance R is attached to two terminals at which an e.m.f. $e = E_0 \sin \omega t$ is maintained, the average rate of consumption of energy is $\frac{1}{2}\frac{E_0^2 R}{R^2 + \omega^2 L^2}$. 3

(d) Why does a shock from the AC mains of 220 V(rms) is more severe than the shock from the 220 V D.C. mains? 2

Group-C

10.(a) The dielectric constant of a gaseous medium is given by 2+2

$$K = \frac{\varepsilon}{\varepsilon_0} = 1 + \frac{Ne^2}{m\varepsilon_0}\sum \frac{f_k}{\omega_k^2 - \omega^2 - j\gamma_k\omega}$$, where symbols have their usual meanings. Hence deduce the Sellmeier's dispersion formula and show that under suitable conditions it reduces to Cauchy's dispersion formula.

(b) From the expressions of normal dispersion, deduce the group velocity of the wave inside the medium and explain that the group velocity is always less than c (velocity of light in vaccum). 2

(c) What do you mean by *TE*, *TM* waves? Show that *TEM* waves cannot occur in a hollow guide. 2+2

11.(a) Explain why and how Ampere's circuited law for steady current was modified in include displacement current. 3

(b) Show that the equation of continuity is contained in Maxwells' electromagnetic field equations. 4

(c) Express Poynting's theorem in the following differential form 3

$$\frac{\partial u}{\partial t} + \vec{\nabla}\cdot\vec{S} = 0$$

Where, $\vec{S}$ is the Poynting's vector and u is the total electromagnetic energy density.

Group-D

12.(a) With the help of circuit diagram explain the operation of Zener diode as a voltage regulator. 3

(b) Draw a circuit diagram of a full wave bridge rectifier using semiconductor diodes. Why one should prefer a bridge rectifier over full wave rectifier using centre tap transformer? 2+1

(c) Why is a transistor so called? 1

(d) Draw a neat circuit diagram of a *CE* amplifier with voltage divider bias and draw it's a.c. equivalent circuit. 2+1

13.(a) Explain the operation of AND gate using transistor only. 2

(b) Convert 4DF hexadecimal to binary numbers. 1

(c) Using De Morgan's law, 2

Show that $\overline{\overline{A}+B}+\overline{\overline{A}+\overline{B}}=A$.

(d) Draw a two-input XOR gate using NOR gates only. 2

(e) In the logic circuit of the following figure, A=1011 and B=1101. What is the output Y? Assuming that 0V and 5V represent logic 0 and logic 1 respectively, draw the pulse trains for A, B and Y. 2+1