# West Bengal State University

## B.A./B.Sc./B.Com. ( Honours, Major, General ) Examinations, 2014

## PART – II

## PHYSICS – ( Honours )

## PAPER – III

Duration : 4 Hours Maximum 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 Question No. **1**, *four* from Group - A and any *four* taking at least *one* each from Group-B, Group-C and Group-D.

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

a) Write down the dimensions of permeability of free space.

b) What is the importance of Earnshaw's theorem in electrostatics ?

c) Check whether the given function $\phi = 4x^3 + 5y - 4z^2$ represent an electrostatic potential in a charge free region.

d) A point charge $q$ is at a distance $d$ from an infinite conducting plane. Find the work necessary to remove the charge to infinite distance from the plane.

e) Four charges $+q$, $-q$, $+q$ and $-q$ are placed in the same order on the four consecutive corners of a square of side '$a$'. Calculate the work done in interchanging the position of any *two* neighbouring charges of opposite sign.

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

g) What are the methods of measuring —

i) very low resistance ( ~ 0·01 ohm ) and

ii) very high resistance ( ~ few megaohms ) ?

h) Show that for an electromagnetic field we can write $\vec{E} = -\vec{\nabla}\phi - \frac{\partial \vec{A}}{\partial t}$ where the symbols have their usual meaning.

i) A charged particle moves with uniform velocity $\vec{v} = 4\hat{i}$ m/s in a region where electric field $\vec{E} = 20\hat{j}$ V/m and magnetic field $\vec{B} = B_0\hat{k}$ Wb/m$^2$. Find $\vec{B}$ when velocity of the particle is constant.

j) In an *a.c.* circuit the complex impedance is $z = (1 + 2\hat{j})\ \Omega$ and complex voltage is $(-4 + 7\hat{j})$ V. Find the current in the circuit.

k) Show that for a good conductor skin depth $\delta = \frac{\lambda}{2\pi}$ where, $\lambda$ is the wavelength of electromagnetic waves in the conductor.

l) The intensity of sunlight reaching the Earth's surface is about 1400 W/m$^2$. Calculate the strength of electric fields of the incoming sunlight. ( Given $\mu = 4\pi \times 10^{-7}$ H/m )

m) Define current sensitivity and charge sensitivity of a moving coil galvanometer.

n) Explain why emitter and collector of a transistor ( either *n-p-n* or *p-n-p* ) cannot be interchanged although the two terminals are made of same material.

o) Without using truth table show that

$A + BC = (A + B)(A + C)$.

p) What are BCD codes ? What is the advantage of using the codes ?

## GROUP - A

Answer any *four* questions. $4 \times 10 = 40$

2. a) What is the magnitude of electric field strength $\vec{E}$ such that an electron placed in the field, would experience an external force equal to its weight ? 2

b) State and explain Uniqueness theorem. 2

c) Find the force exerted on an electric dipole of moment $\vec{p}$ by a non-uniform electric field $\vec{E}$. 2

d) Two uniform infinite sheets of electric charge densitites + $\sigma$ and – $\sigma$ intersect at right angles. Find the magnitude and direction of the electric field and sketch the lines of $\vec{E}$. 2 + 2

3. a) State the boundary conditions at the surface of separation of two dielectric media of dielectric constant $\in_1$ and $\in_2$. 2

b) A dielectric sphere of radius '$a$' and permittivity $\in_1$ is placed in a uniform electric field $E_0 \hat{Z}$ in a medium of permittivity $\in_2$. Specifying the boundary conditions, calculate the polarisation induced in the sphere. Hence show that a conductor can be regarded as dielectric of infinite permittivity. 2 + 2 + 1

c) A point charge + $q$ is placed in front of a grounded conducting sphere of radius '$a$' at a distance $r$ from its centre. Find the location and value of the image charge. 3

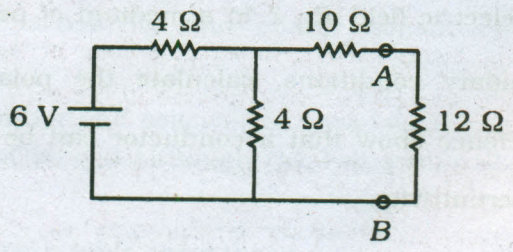
4. a) Show that the energy density in electrostatic field is given by $U = \frac{1}{2} \vec{E} \cdot \vec{D}$ where $\vec{E}$ and $\vec{D}$ are electrostatic field intensity and electric displacement vectors. 4

b) A uniformly charged sphere of radius '$R$' carries a total charge $Q$. Calculate the electrostatic energy density at a distance $r$ ( $> R$ ) from the centre of the sphere. Hence calculate the electrostatic energy of the system. 3

c) The potential at a point whose polar coordinates are ( $r$, $Q$ ) with respect to the centre of a sphere of radius '$a$' is $- A \left( r - \frac{a^3}{r^2} \right) \cos \theta$, where, $A$ is a constant. Find the surface density of charge at any point on the surface of the sphere and show that the total charge on the sphere is zero. 3

5. a) Show that Kirchhoff's first law is consistent with the principle of conservation of charge and the second law is consistent with the law of conservation of energy. 2 + 2

b) Find the Norton's equivalent of the circuit given below : 2




c) What are constant voltage and constant current sources ? 2

d) State reciprocity theorem of electrical networks ? 2

6. a) State Ampere's Circuital law. Using this law prove that the magnetic field outside a toroid is zero. 2 + 2

b) Prove that the magnetic flux is

$$\phi = \int \vec{B} \cdot \vec{ds} = \oint \vec{A} \cdot \vec{dl}$$

where $\vec{A}$ represent the magnetic vector potential. 3

c) A current distribution gives rise to the magnetic vector potential $\vec{A}(x, y, z) = 3x^2 y\hat{i} + 2xy^2\hat{j} - 3xyz\hat{k}$. Find the corresponding magnetic field $\vec{B}$ as ( 2, – 1, 3 ). 3

7. a) Deduce the differential form of Faraday's law of induction. 2

b) Self inductance of two coils are $L_1$ and $L_2$ and their mutual inductance is $M$. Starting from their energy consideration show that $M^2 \leq L_1 L_2$. What is coefficient of coupling and what is its maximum value ? 3 + 2 + 1

c) What is Eddy current ? What is its practical use ? 2

## GROUP - B

8. a) A capacitor $C$ in series with a resistor $R$ and an inductor $L$ is fully charged by connecting it to a *d.c.* source of voltage $V$. The source is now suddenly removed keeping the circuit closed.

i) Set up the instantaneous *emf* equation of the circuit.

ii) Investigate how the charge on $C$ vary with time for an oscillatory decay.

iii) Discuss how the charge on $C$ varies with time for the case of $R = 0$. 2 + 3 + 3

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

9. a) What is the physical meaning of root-mean-square ( *rms* ) value of the current ? 1

b) Which value do you get from an *a.c.* voltmeter — *rms* value or mean value and why ? 2

c) A series LCR circuit has a quality factor of 5·1 at a frequency of 100 kHz. The power dissipation of the circuit is 100 W when it draws a current of 1 amp. Determine the values of $R$, $L$ and $C$ of the circuit. 3

d) Give the physical reasons behind the fact that the impedance of an inductor increases with frequency. 2

e) What is 'Sharpness of Resonance' ? How is it relates with $Q$-factor ? 1 + 1

## GROUP - C

10. a) Explain how Maxwell modified Ampere's circuital law for steady current. 2

b) Derive the wave equation for the electric field vectors of electromagnetic wave in vacuum. 2

c) Write down Fresnel's equations for reflection and refraction of electromagnetic wave. Hence deduce Brewster's law. 2 + 2

d) In a microwave region the surface of a pure silver waveguide and that of a silver coated brass waveguide appeared to be identical — explain. 2

11. a) Write down the equation of motion of electron in radiation field. What is radiation damping ? 1 + 1

b) The dielectric constant of a gaseous medium is given by $K = \frac{\epsilon}{\epsilon_0} = 1 + \frac{N\epsilon^2}{m\epsilon_0} \sum_j \frac{t_j}{\left(\omega_j^2 - \omega^2\right) - i\gamma_j\omega}$, where the symbols have their usual meanings.

Derive the expressions for —

i) refractive index and

ii) absorption coefficient of the medium by assuming it to be dilute.

Show graphically the variation of the two quantities with the frequency of the incident wave. 2 + 2 + 2

c) The dielectric constant of water under static condition is about 80. So we expect its refractive index ( $n$ ) to be about $\sqrt{80} \approx 8{\cdot}94$. But from optics we know that $n \approx 1{\cdot}33$. Explain the discrepancy. 2

## GROUP - D

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

b) Draw the output characteristics of an *n-p-n* transistor in CE mode. Hence draw the *d.c.* load line for the transistor circuit. 2 + 2

c) Draw a neat circuit diagram of a CE amplifier with voltage divider bias and draw its *a.c.* equivalent circuit. 2 + 1

13. a) The decimal number 40 is converted to 257 in a number system. Find the base of the number system. 2

b) Establish that NAND gate is an universal gate. 2

c) What is anti-coincidence circuit ? Draw the circuit. 1 + 1

d) Prove that $ABC + A\overline{B}C + AB\overline{C} = A(B + C)$. 2

e) A three-variable truth table has high output for these input conditions : 111, 010, 100 and 110. Find the Boolean expression and corresponding logic circuit. 2