　　　　　UG/II/PHS/H/III/15

2015

PHYSICS

[Honours]

PAPER — III

Full Marks : 90

Time : 4 hours

The figures in the right hand margin indicate marks

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

Illustrate the answers wherever necessary

GROUP — A

Answer any **two** questions :　　　　　15 × 2

1. (a) Define electrostatic potential and electrostatic field intensity.　　　　　1 + 1

(b) Suppose the electron cloud around the nucleus of charge $+ e$ in an atom can be represented by the spherical charge distribution

$$\rho(r) = \frac{-e}{\pi r_0} e^{-2r/r_0}$$

where r_0 = Bohr radius. Calculate the total charge of the cloud.   4

(c) An electric field is represented by $\vec{E} = iy + jx$. Find corresponding potential function ϕ. Assume $\phi = 0$ for $x = y = 0$.   3

(d) Find an expression for the field and the potential due to a short electric dipole.   3 + 3

2. (a) Define the term magnetism.   1

(b) Starting from Biot-Savart law establish the relation $\vec{\nabla} \cdot \vec{B} = 0$.   4

(c) An infinitely long solenoid of radius 'a' having n_0 number of turus of wire per unit length and carrying a current I. Find the magnetic vector potential at r ($r > a$) from the axis of the solenoid.   3

(d) If $\vec{A} = \frac{1}{2}\left(\vec{a} \times \vec{r}\right)$, $\vec{a}$ = constant vector, find $\vec{B}$.   3

(e) An uniformly charged sphere rotates with a constant angular velocity. Calculate the magnetic induction at the centre of the sphere.   4

3. (a) Write down Maxwell's electromagnetic field equations and explain physical significance of each.   4

(b) What do you mean by skin depth of a conductor ? Starting from the wave equation, find the skin depth of a conductor in terms of its conductivity and frequency of the incident wave.   6

(c) What do you mean by retarded potential ? Find retarded potential of an infinite straight current carrying conductor.   5

4. (a) 'The barrier potential across a *p-n* junction diode can not be measured simply by placing a voltmeter across the diode terminals.' Explain.   2

(b) Define work-function of a metal. State Richardson's thermoionic equation. What are space charge limited current and temperature limited current ? $1 + 2 + 2$

(c) Distinguish between zener-breakdown and avalanche-breakdown.   3

(d) Draw the small signal low frequency hybrid parameter equivalent circuit of a CE amplifier and derive the expression for input impedance to show it depends on the load resistance. The h-parameters of a transistor used in CE amplifier stage are :

$h_{ie} = 1 \, K\Omega$, $h_{fc} = 55$, $h_{re} = 4 \times 10^{-4}$ and $h_{oe} = 20 \times 10^{-5} A/V$.

If the load resistance is 5 kΩ, calculate the input resistance. $1 + 2 + 2$

GROUP – B

Answer any **five** questions : 8×5

5. (a) What is meant by polarization of dielectric ? How is electric displacement vector $\vec{D}$ related to polarization vector $\vec{P}$ and electric field $\vec{E}$? $1 + 4$

(b) A conducting sphere of radius 'a' carries a charge 'q'. It is coated with a linear dielectric material of permittivity 'ε' out to a radius 'b'. Find the potential at the centre of the conductor. 3

6. (a) Derive the Lorentz dispersion equation for a gaseous medium :

$$n^2 = 1 + \frac{Ne^2}{m\varepsilon_0} \sum_k \frac{f_k}{\omega_k^2 - \omega^2 - j\gamma_k\omega}$$

Symbols used have their usual meaning. 6

(b) Why the rising and setting sun colours deep red ? 2

7. Explain why a transistor needs biasing. What is meant by stability of biasing ? What are the factors that affect the bias stability of a transistor ? Draw the self bias circuit. Why is it so called ? 2 + 2 + 2 + 1 + 1

8. A point charge q is placed at distance d from the centre of an earthed conducting sphere of

radius R. Determine, using the method of images, (i) the charge induced on the sphere and (ii) the distribution of charge over the surface of the sphere. $(3 + 1) + 4$

9. A plane polarised electromagnetic wave with its electric vector parallel to the plane of incidence is incident obliquely on the interface between two simple dielectrics. Obtain an expression for the amplitude of reflection and transmission coefficient. Hence prove Brewster's law. $3 + 3 + 2$

10. (a) Draw a typical nature of the V-I characteristics of the discharge of gas and discuss the different sections of the curve. 6

(b) While an ordinary gas is nearly a perfect insulator in plasma state if becomes highly conducting. Explain it. 2

11. (a) Explain the theory of a an induction motor. 4

(b) Find the equivalent resistance between the points A and C for the network given below, using star-delta transformation.   4
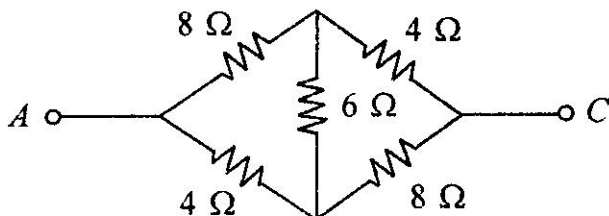
12. (a) The potential on the surface of a hollow sphere of radius a is given by $\phi_0(\theta) = A\sin^2 \theta/2$, where θ is the polar angle. Using Laplace's equation find the potential at any point inside the sphere.   4

(b) Calculate the capacitance between two long thin parallel wires in air.   3

(c) Write some applications of capacitors.   1

GROUP – C

Answer any **five** questions :   4 × 5

13. Show that the torque $(\vec{\tau})$ acting on a loop of area A and carrying a current I when placed

in a uniform magnetic field $\vec{B}$ is given by $\vec{\tau} = I\,\vec{A} \times \vec{B}$. What is the potential energy of the current loop ?   4

14. In a suspended coil galvanometer, the pole pieces are often cut so as give a cylindrical gap. Why is this done ? Calculate the torque per unit current on a rectangular coil suspended in such a gap.   2 + 2

15. Find the electrostatic self-energy of a uniformly charged sphere. Hence, assuming the electron as a uniformly charged sphere having rest mass energy $m_0 c^2$, obtain an expression for classical radius of an electron.   3 + 1

16. What is meant by Hysteresis ? Find an expression for the work done due to Hysteresis. What informations can be obtained from the Hysteresis loop ?   1 + 2 + 1

17. Obtain the multipole expansion of the electrostatic potential due to an arbitrary localized charge distribution at a point well outside the charge distribution.   4

(*Continued*)

18. (a) Compare a π filter with a T filter.   2

   (b) Justify the statement, 'A NOR gate can be used as an universal gate'.   2

19. (a) If the radius of a spherical soap bubble be 'r', show that the charge required to expand the bubble to twice its radius be $8\pi\,[\in_0 r^3(12T + 7rP)^{1/2}$ where T is the surface tension of soap solution and P is the atmospheric pressure.   3

   (b) Write down the Poisson's equation in a Dielectric-medium.   1

20. How can you connect two zener diodes 6 V and 4 V to obtain a reference voltage of 10 volt, if the supply voltage is 15 V and the load is variable. The max wattage of each diode is $\frac{1}{2}$ watt and the minimum current for each zener diode is 1 mA.   4

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5. Use origin software to draw a mean graph with given set of data with proper label and scale

5+2

6. Write a program to find the roots of a quadratic equation: $ax^2 + bx + c = 0$ and verify it for given values of a, b and c.

3+4

7. Write down a program to find the area of a circle, given by the equation : $x^2 + y^2 = a^2$ and verify it for given value of a.

3+4

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