RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. THIRD SEMESTER EXAMINATION, DECEMBER 2019

SECOND YEAR [BATCH 2018-21]

Date : 11/12/2019 **PHYSICS (Honours)**

Time : 11 am – 3 pm **Paper : III** Full Marks : 100

Group – A

Unit - I

Answer any two questions of the following: [2×10]

1. a) Determine the polar equation of equipotential surface for a dipole consisting of two charges of equal magnitude but of opposite polarity separated by small distance. (4)

   b) Calculate radial component of electric field for that dipole using the expression of potential. (1)

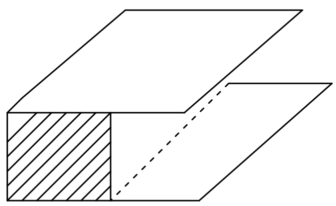
   c) Consider two dipoles one of which is held fixed. The distance between the coplanar dipole is R. If the fixed dipole makes θ_1 angle and the other one makes angle θ_2 with the line joining two dipoles at equilibrium condition, then show that $tan\theta_2 = -2tan\theta_1$. (5)

2. a) Show that Gauss's law in electrostatics leads to Laplace's equation in free space. Also show that the solution to Laplace's equation is unique in charge free region. (1+3)

   b) An uncharged grounded sphere is placed in a uniform electric field. Calculate the field and potential at an arbitrary point $p(r,\theta,\phi)$ outside the sphere. (Assume the solution of Laplace's equation if necessary) (6)

3. a) Establish the relation $\vec{D} = \epsilon_0 \vec{E} + \vec{P}$ for a parallel plale capacitor with linear dielectric within it. (symbols have their usual meaning) (2)

   b) Half of the region within the parallel plate capacitor is filled with a dielectric of dielectric constant ϵ_r, as shown in figure. Calculate $\vec{E}, \vec{D}$ *and* $\vec{P}$ in each region and the free and bound charges on all surfaces. (4)



   c) A small spherical cavity is cut in a dielectric where there is an uniform macroscopic field $\vec{E}$. If $\vec{P}$ be the uniform polarization in the dielectric them show that the electric field at the centre of the cavity is $\vec{E} + \frac{\vec{P}}{3\epsilon_0}$ (ϵ_0 is the permittivity of free space). (4)

4. a) The surface of a spherical shell of radius R is changed by a density distributton $r(\theta) = k\,cos\theta$. Find the resulting potential inside and outside the sphere. (5)

   b) Consider a point charge in front of a semi-infinite linear dielectric. Find out the image charges to replace actual electrification when someone wants to calculate electric field within the dielectric region. (3+2)

Unit – II

Answer **<u>any five</u>** **questions of the following**: [5×10]

5. a) A straight wire of infinite length carrying a current I. Show mathematically the magnetic field B at a distance r from the wire is $\vec{B} = \frac{\mu_0 I}{2\pi r}\hat{\phi}$. (4)

   b) What is Ampere' circuital law? Deduce the differential form of this law and comment on this form. (1+2+1)

   c) Two coils of self-inductance L_1 and L_2 respectively have mutual inductance M. Find an expression for their coefficient of coupling (K). (2)

6. a) Find the expression for magnetic field B at the mid point of a solenoid of radius a and length L. (4)

   b) A triangular loop carrying current 10A lies on plane $x + y + z = 4$. Calculate the magnetic moment. (3)

   c) Calculate the work done in heating the resistance during charging of capacitor of a series CR circuit applying by battery of *emf E*.Comment on the result. (2+1)

7. a) A current I passes through a rectangular loof of sides a and b. Calculate the magnetic field at the centre of the rectangular loop. (3)

   b) What do you mean by mutual inductance? Prove that $M_{21} = M_{12}$.(symbols have their usual meaning) (1+4)

   c) A spherical shell of uniform magnetization material of inner radius a and outer radius b. If the magnetization is taken along $\hat{r}$ direction. Calculate the magnetic pole strength. (2)

8. a) Show that a non-uniform magnetisation $\vec{M}$ is equivalent to a bound current density $\vec{J} = \vec{\nabla} \times \vec{M}$ (symbols have usual meaning). (5)

   b) Find the expression for magnetic vector potential $\vec{A}$ using Biot-Savart law. (3)

   c) Show that an electric field $\vec{E}$ can be written as $\vec{E} = -\vec{\nabla}\phi - \frac{\partial \vec{A}}{\partial t}$, where ϕ is the scalar potential and $\vec{A}$ is magnetic vector potential. (2)

9. a) Two magnetic media of relative permeability μ_1 and μ_2 are separated by a plane interface having current density K. Find relation between tangential component of H fields of these media. (3)

   b) Two infinitely long straight wires carry current of 1A along the x-axis and y-axis respectively. Find the magnetic field at the point (2,4,0) cm. (3)

   c) An anular ring of inner radius a and outer radius b carrying uniform charge density σ is rotating at constant angular velocity ω about its own axis. Find the magnetic dipole moment. (4)

10. a) Prove that $\vec{\nabla}.\vec{B} = 0$. (3)

    b) A steady current I flows down a long cylindrical wire of radius a. Find the magnetic field both inside and outside of the wire if current density J is proportional to the distance from the axis. (5)

    c) A parallel plate capacitor is filled with two media with constants (conductivities and permittivities) $\sigma_1, \in_1$ and $\sigma_2, \in_2$ respectively. Calculate the resistance of the system. (2)

11. a) Establish the relation between magnetisation (M) and equivalent surface current density in Rowland ring of uniform magnetisation. (3)

b) Show that the equivalent inductance of two coils of self inductance L_1 , L_2 and mutual inductance M connected in series is $L_{eq} = L_1 + L_2 \pm 2M$. (3)

c) Find out the expression of power factor in an LR circuit fed by an alternatively voltage. (4)

12. a) What do you understand by sharpness of resonance? (1)

b) Deduce the relation of Q-factor of the acceptor circuit. (2)

c) What do you mean by perfect choke? (2)

d) An *a.c.* is applied to a LCR circuit, in which a resistor of resistance R is in series with a parallel LC circuit. Calculate

i) The impedance of the circuit.

ii) The power dissipated in the circuit.

iii) The condition of resonance. (2+2+1)

Unit – III

Answer any one question of the following: [1×10]

13. a) State Poynting theorem. Deduce Poynting theorem in integral form. (1+5)

b) A parallel-plate air gap capacitor is made up two plates of area 100 cm^2 each keeps ata a distance of 0.1mm. A sine wave of amplitude 1V and frequency 1 MHz is applied across the capacitor. Find the displacement current through capacitor. (2)

c) A plane electromagnetic wave in free space has its electric field of amplitude 100V/m. Find the average intensity and magnitude of pointing vector. (2)

14. a) Write down the Maxwell's equations both in differential form and integral form. (1+3)

b) Obtain the wave equation for the electromagnetic field vectors in the conductor. Hence show that, if the fields vary harmonically, the propagating vector is necessarily complex. (2)

c) Prove that the displacement current in the direction of a parallel plate capacitor is equal to the conduction current in the connecting leads. (4)

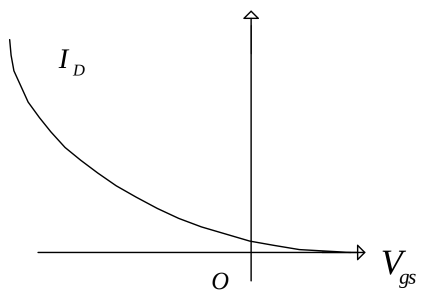
Group – B

Answer any two questions of the following: [2×10]

15. a) To use FET as a voltage controlled resistor, in which region it should be operated? (1)

b) What is the value of drain current when V_{gs} = pinch off voltage? (2)

c) The variation of drain current with gate-to-source voltage of a MOSFET is given by:



State the type of the FET with explanation. (2)

d) Describe the opetation of a Common-Source JFET amplifier with suitable circuit diagram. Obtain expression for voltage amplification in terms of FET small-signal parameters. (2+3)

16. a) Write down the basic difference between the carrier control process of BJT amd JFET. (2)

b) Show the doping profile of a BJT in the emitter, base and collector regions. Why is the width of the base region made very thin? (1+2)

c) Draw the CB input characteristics with appropriate scaling of the variables. State Early effect in this context. (1+2)

d) If $\beta = 18$, $I_E = 2mA$, calculate I_C and I_B when the BJT is used in the CE configuration. (2)

17\. a) What is load line? Explain its significance. (3)

b) What are the factors determining the choice of the Q point over the load line? (2)

c) Explain why fixed bias circuit is not capable to counter thermal runaway. (2)

d) Obtain expressions for current gain, voltage gain and power gain for a BJT considered as a two-port network. (3)

18\. a) Draw the diode characteristics in the reversed bias condition for three temperatures $T_1>T_2>T_3$, and explain the same in the breakdown region. (3)

b) Explain how a breakdown diode can be used as a voltage reference element. (2)

c) Explain how the dc output voltage of a bridge rectifier is improved when a capacitor filter is used. (2)

d) Each of the diodes of a full-wave rectifies has a forward resistance of $50\,\Omega$. The circuit gives a dc voltage drop of 30 volt across a load resistance of 1.2 $k\Omega$. Find the primary-to –total secondary turns ration of the centre-tapped transformer, the primary being fed from 220 volt(rms) mains. Also calculate the conversion efficiency. (3)

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