2018

PHYSICS

(Major)

Paper : 3.1

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

GROUP—A

(Mathematical Methods)

(*Marks* : 25)

1. Answer the following questions : 1×3=3

(a) What do you mean by nilpotent matrix?

(b) What is the condition for a symmetric matrix to be a Hermitian matrix?

(c) What is unitary matrix?

2. Find the rank of the matrix

$$\begin{pmatrix} 1 & 2 & 0 \\ 2 & 4 & 0 \\ 4 & 8 & 0 \end{pmatrix}$$ 2

3. Answer any *two* of the following questions : 5×2=10

(a) *(i)* Prove that the trace of the product of a symmetric and an anti-symmetric matrix is zero. 2

(ii) Find the inverse of the matrix

$$\begin{pmatrix} 3 & -1 & 1 \\ -15 & -6 & -5 \\ 6 & -2 & 2 \end{pmatrix}$$ 3

(b) *(i)* What are proper and improper orthogonal matrices? 2

(ii) Prove that every non-singular square matrix has a unique inverse. 3

(c) *(i)* Show that every characteristic vector of a matrix has a unique characteristic root. 2

(ii) Find the matrix B such that $A = BC$, if

$$A = \begin{pmatrix} 2 & 3 & -2 \\ 4 & -1 & -2 \\ 0 & 1 & 0 \end{pmatrix} \text{ and } C = \begin{pmatrix} 1 & 2 & -1 \\ 2 & -1 & -1 \\ -1 & 2 & 1 \end{pmatrix}$$ 3

4. Answer *either (a)* and *(b)* *or (c)* and *(d)* : 5×2=10

(a) State and prove Cayley-Hamilton theorem. 5

(b) Find the eigenvalue and eigenvector of the matrix

$$A = \begin{pmatrix} 1 & 2 & 3 \\ 0 & 2 & 3 \\ 0 & 0 & 2 \end{pmatrix}$$ 5

(c) If three matrices A, B and C are given by

$$A = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}, \quad B = \frac{1}{\sqrt{2}} \begin{pmatrix} 0 & -i & 0 \\ i & 0 & -i \\ 0 & i & 0 \end{pmatrix}$$

$$\text{and } C = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

prove that $D^2 = A^2 + B^2 + C^2 = 2I$ 5

(d) Using schematic diagram, obtain the two-dimensional rotational matrix. 5

GROUP—B

(Electrostatics)

(*Marks* : 35)

5. Choose the correct answer/Answer the following questions : 1×3=3

(a) The relation $D = \varepsilon E$ is true for

(i) any medium

(ii) homogenous medium

(iii) isotropic medium

(iv) homogenous and isotropic media

(b) The induced surface charge q' is related to q as

(i) $q' = \frac{q}{k}$

(ii) $q' = q$

(iii) $q' = q\left(1 - \frac{1}{k}\right)$

(iv) $q' = q\,(1 - k)$

(where k is dielectric constant)

(c) The unit of electric potential in terms of base unit of SI is

(i) kgm^2S^{-1}

(ii) $kgm^2S^{-1}A^{-1}$

(iii) kgm^2S^{-2}

(iv) $kgm^2S^{-3}A^{-1}$

6. Answer the following questions : 2×3=6

(a) What do you mean by equipotential surfaces?

(b) If the electric field is given by $E = 8x + 4y + 3z$, calculate the electric flux through a surface of area 100 units lying in the x-y plane.

(c) What is the acceleration of a charged particle of mass m and charge q placed in an electric field E?

7. Answer any *two* of the following questions : 3×2=6

(a) Calculate the electrostatic energy of a system of charged particles.

(b) A sphere of radius R is connected by wire with a smaller sphere of radius r. If the spheres were charged with Q and q respectively, show that the electric field is higher at the surface of the smaller sphere.

(c) The potential of a certain charge configuration is expressed by $V = 2x + 3xy + y^2$ volt. Find the electric intensity at point (5, 2). What acceleration does an electron experience in the x-direction?

8. Answer any *two* questions : 10×2=20

(a) (i) Find an expression for the electric field intensity at an axial point of a charged disc. 5

(ii) What is the principle of 'method of images'? A charge Q is placed in front of an earthed conducting sphere of radius R. Calculate the potential and the field at a general point (r, θ). 5

(Continued)

(b) (i) Using Gauss' law, find an expression for electric field in a uniformly charged sphere. 5

(ii) Using Laplace's equation, obtain the expressions for potential and electric field intensity between two parallel planes. 5

(c) (i) State and prove the differential form of Gauss' law in dielectric. 5

(ii) Establish the Clausius-Mossotti relation using Laplace equations. 5

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3 (Sem-3) PHY M 2

2018

PHYSICS

(Major)

Paper : 3.2

(Current Electricity and Magnetostatics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following : 1×7=7

(a) What do you mean by electric current density?

(b) The coefficient of coupling between two coils is 0·6. What does it mean?

(c) What is thermocouple?

(d) The Wheatstone bridge principle is also applicable to AC networks. State true or false

(e) What is copper loss in transformer?

(f) If an electron initially moving in the x-direction is subjected to a magnetic field in the z-direction, in which direction the electron will be deflected?

(g) What do you mean by a magnetic dipole for a current loop?

2. Answer the following : 2×4=8

(a) Draw the circuit diagram of Anderson's bridge for the measurement of inductance.

(b) A condenser of capacitance 10 μF is charged to a potential of 100 volts. On connecting it across an unknown resistance, the voltage is found to fall to 67 volts in 40 seconds. What is the value of *R*?

(c) Express the following quantities in exponential form :

(i) j

(ii) $I - j$

(d) Explain the difference between a 'dead-beat galvanometer' and a 'ballistic galvanometer'.

3. Answer any *three* from the following : 5×3=15

(a) Find out an expression for the growth of current in a circuit containing a resistance and inductance. 5

(b) Deduce an expression for self-inductance of a long solenoid carrying current. 5

(c) Describe Peltier and Thomson effect and define thermo-electric power. 2+2+1=5

(d) An a.c. e.m.f. of 200 volts (r.m.s.) frequency 50 Hz is applied to a resistance of 100 ohms and an inductance 0·5 henry in series. Calculate the magnitude and phase of the current. 5

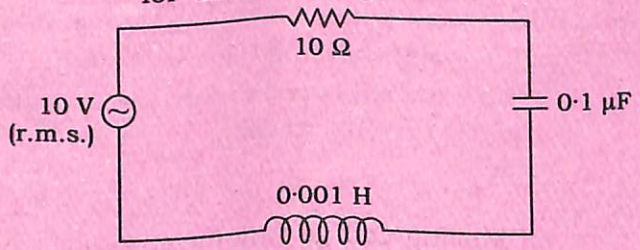
(e) State Ampere's circuital law and prove it. 5

4. Answer any *three* from the following : 10×3=30

(a) State the Kirchhoff's law for the distribution of current in a network. Apply the law to find the current in the galvanometer when the Wheatstone bridge is out of balance. 10

(b) *(i)* Define and deduce *Q*-factor. 1+6=7

(ii) Calculate the potential difference across the inductor at resonance for the following circuit : 3



(c) A circuit is made up of two parallel branches *a* and *b*. Branch *a* consists of a resistance of 60 ohms, branch *b* consists of a resistance of 20 ohms in

series with a capacitor of capacitance 80 μF. An e.m.f. of 250 volts (r.m.s.) at 50 Hz is applied to the circuit. Determine—

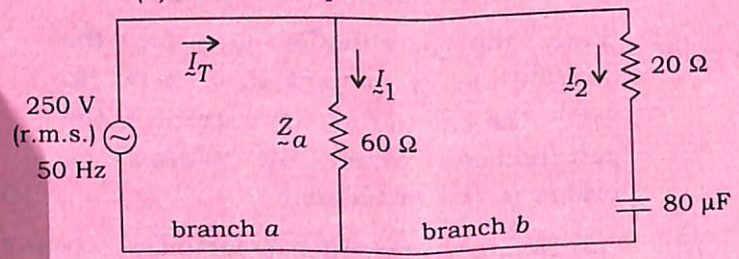
(i) the scalar admittance of the circuit;

(ii) the total r.m.s. current;

(iii) the r.m.s. current in each branch;

(iv) the power factor for the circuit;

(v) the total power absorbed. 10



(d) Find out an expression for divergence and curl of a magnetic field. 5+5=10

(e) What do you mean by magnetic scalar potential and vector potential? Derive an expression for the vector potential of current loop. 1+1+8=10

(f) Write short notes on the following : 5×2=10

(i) Moving-coil galvanometer

(ii) Self- and mutual-induction

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