Total No. of printed pages = 10

3 (Sem 3) PHY M1

2015

PHYSICS

(Major)

Paper : 3.1

(Mathematical Methods-III and Electrostatics)

Full Marks – 60

Time – Three hours

The figures in the margin indicate full marks for the questions.

GROUP–A

(Mathematical Physics)

Marks : 25

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

   (a) Define rank of a matrix.

   (b) When a symmetric matrix is said to be Hermitian ?

   (c) Find adj A if $A = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$

[Turn over

2. Check whether the total angular momentum matrix for an electron given by

$$J^2 = (3\hbar^2/4)\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \text{ is}$$

Hermitian and unitary. 2

3. Answer any *two* of the following questions : $2\times5=10$

(a) (i) If $A^2 + A - I = O$ find A^{-1}. 1

(ii) Show that the inverse of a matrix is unique. 2

Or

If A, B are two square, symmetric matrices of dimensions $n \times n$ find the condition when the product AB is symmetric.

(iii) Find the rank of the matrix 2

$$\begin{pmatrix} 3 & -1 & 2 \\ -6 & 2 & 4 \\ -3 & 1 & 2 \end{pmatrix}$$

(b) (i) Express the following quadratic form as product of matrices

$$ax^2 + by^2 + 2hxy$$ 2

(ii) What is an

(iii) Find the val

$$\begin{pmatrix} 0 & 1 \\ -1 & 0 \\ 2a & 2b \end{pmatrix}$$

is skew-symm

(c) (i) Show how ce force appear i of a particle respect to ro

(ii) "Sum of finit rigid body c rotations."

What operati matrices A, statement ?

4. Answer either [(a) an

(a) (i) Given the ma

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

and the equation Solve for x, y, z

(ii) Test whether the matrix

$$\begin{pmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{pmatrix}$$

is orthogonal or not. 2

(b) (i) Consider the following transformation in three dimensions 1+2=3

$x' = x\cos\theta + y\sin\theta$

$y' = -x\sin\theta + y\cos\theta$

$z' = z$

Write down the transformation matrix A.

Show that $A(\theta_1 + \theta_2) = A(\theta_1) + A(\theta_2)$.

(ii) Find the inverse of the matrix 2

$$\begin{pmatrix} 2 & -3 \\ 4 & 6 \end{pmatrix}$$

(c) (i) Test whether the following matrices are diagonalizable : 1½+1½=3

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

(ii) State and explain Cayley - Hamilton theorm. 2

(d) (i) Calculate the

where M = (

(ii) If A = (0

tan ½

matrix, show

I + A = (I − A

GROU

(Electro

Marks

5. Choose the correct op

(a) The induced surfa charge q as (wher

(i) $q' = q / k$

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

(b) The electric potential due to a quadrupole at distance far off from its centre varies as

(i) $1/r$ (ii) $1/r^2$

(iii) $1/r^3$ (iv) $1/r^4$

(c) Electric field at a point close to the surface of a charged conductor having charge density σ is

(i) $\sigma/4\epsilon_0$ (ii) σ/ϵ_0

(iii) $\sigma/2\epsilon_0$ (iv) $\sigma/3\epsilon_0$

(d) Unit of electric potential in terms of base units of SI is

(i) $Kg\ m^2S^{-1}$ (ii) $Kg\ m^2S^{-1}A^{-1}$

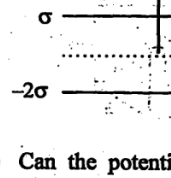
(iii) $Kg\ m^2S^{-2}$ (iv) $Kg\ m^2S^{-3}A^{-1}$

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

(a) Two charges $q_1=2\mu C$ and $q_2=3\mu C$ are placed at (0, 0, 4) and (0, 0, –4) respectively. Find the locus of points where potential is zero. 3

Or

What is the net ele
due to the two infin
as shown in the fi



(b) (i) Can the potenti
minimum in fre

(ii) Show mathem
perpendicular to
$\phi(x, y, z) =$ con

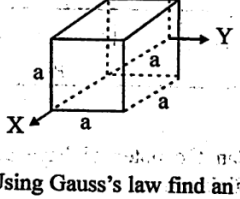
7. Answer either (a) or (b

(a) (i) Compute the c
electric field gi

$\vec{E}(x, y, z) = (x^2 + z^2$
$+ (z^2 + y^2)\hat{z}.$

Is the field con

(ii) For the electric field $\vec{E} = (Kx^{1/2})\hat{x}$ where K is a constant, compute the electric flux through the face of the cube region depicted in the figure. 2



(b) (i) Using Gauss's law find an expression for the mechanical force per unit area on the surface of a charged conductor. 2½

(ii) Derive an expression for the equilibrium of an electrified soap bubble. 2½

8. Answer any *two* questions :

(a) (i) Four charges $q_1 = q_2 = -q_3 = -q_4 = q$ are arranged at points (0, a), (0, –a), (a, 0) and (–a, 0) in x–y plane. What is the electrostatic energy needed to compose such an arrangement, bringing the charges in from infinity ? Also find the electrostatic potential in x–y plane. 2+3=5

(ii) Show that an
charges is equ
monopole, dip

(b) (i) Two concentric
a and b (b>a)
V_1 and V_2 res
equation to calc
in the region

(ii) Use Poisson's e
density in a re
function is
$V = a + 4b\ (x^2+$

(c) (i) What is meant b
Show how $\vec{E}$,
isotropic dielec
molecule a pola

(ii) Using Clausius
how can the ato
from dielectic

(d) (i) Determine the electric potential at a point on the axis of a charged disc of radius a and surface charge density σ. Show that the disc may be regarded as a point charge for far off points. 3+2=5

(ii) Two equal point charges q are placed at equal distance b from the centre of a grounded conducting sphere of radius a where b<a. Calculate the force acting on each of the charges. 5

Total No. of printed pages = 5

3 (Sem 3) PHY M2

2015

PHYSICS

(Major)

Paper : 3.2

(Current Electricity and Magnetostatics)

Full Marks – 60

Time – Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×7=7

(a) Write down the Ohm's law that relates the conductivity, current density and electric field.

(b) Two inductances of co-efficient of self induction L_1 and L_2 are joined in series. What is the net co-efficient of self induction of the combination ?

(c) What do you mean by the time constant in series R-C circuit ?

[Turn over

(d) Why no power is dissipated if a voltage of sinusoidal waveform is applied across a purely inductive or capacitive circuit ?

(e) What is copper losses in transformer ?

(f) Write down the Biot-Savart law.

(g) What is magnetic vector potential ?

2. Answer the following questions : 2×4=8

(a) Set up the e.m.f equation of series LCR a.c circuit.

(b) In a certain thermocouple $E=a\theta + b\theta^2$, where θ^oC is the temperature of the hot junction, the cold junction being at 0^oC, a = 10 microvolts / ^oC and $b = -\frac{1}{40}$ microvolt/^oC. Find the neutral temperature and the temperature of inversion.

(c) Explain the differences between a 'dead-beat galvanometer' and 'ballistic galvanometer'.

(d) Draw the circuit diagram of Anderson's bridge for the measurement of co-efficient of self induction.

3. Answer any *three* of

(a) Establish that $\vec{\nabla}$.

(b) Write a short note

(c) An alternating volt is applied to a inductance of 0.2 ohms in series. difference across inductance.

(d) The e.m.f of a th of which is kept at Find the neutral te and Thomson co-e

4. (a) Deduce an expres a long solenoid

(b) An inductor (L = 100Ω) and a cell in series. Find the current reaches 99% [ln 100=4.6]

(c) Establish the relation $\pi_2 - \pi_1 = \frac{\pi_1}{T_1}(T_2 - T_1)$

where π_1 and π_2 are Peltier co-efficients. 3

Or

Why Wheatstone bridge is not suitable for measurement of very low resistance ? Describe with circuit diagram how low resistance can be measured using Kelvin's Double Bridge. 2+8=10

5. (a) In a region the force $\vec{F} = q(\vec{v} \times \vec{B})$ on a charge q is zero. What conclusions can you draw from this ? 2

(b) Using the Biot-Savart law, obtain an expression for the magnetic field due to a long straight conductor carrying steady current. 8

Or

Define magnetic scalar potential. Obtain an expression for the magnetic scalar potential and hence magnetic field near a current carrying loop. 2+6+2=10

6. (a) Derive an expression to show the growth of electric current in a circuit with resistance and self-inductance. 5

(b) What is meant by
In an a.c circuit
series, find the c
resonance is obta

C

What is meant
Describe with c
mutual inductance
Ballistic galvanom