Code No: RT21025 **R13** SET - 1

II B. Tech I Semester Regular Examinations, Jan - 2015
ELECTRO MAGENETIC FIELDS
(Electrical and Electronics Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) Define electric field intensity and electric potential and write the relationship between them.
   b) In a certain region, the potential is given by $V = (x^2 + 3y^2 + 9z)$. Find the electric field intensity at point P(1, -2, 3) m.
   c) What is the capacitance of a parallel plate capacitor when the stored energy is 5 μJ and the voltage across the plates is 5 V?
   d) What is a dipole? Write the expression for electric potential due to a dipole.
   e) State Biot-Savart's law. Give its limitation.
   f) Define magnetic dipole and magnetic dipole moment.
   g) A solenoid with air core has 2000 turns and a length of 500 mm. Core radius is 40 mm. Find its inductance.
   h) What is Poyting vector? Write its significance. (2M+3M+3M+3M+2M+3M+3M+3M)

PART-B

2. a) Determine the electric field intensity due to infinite line charge, at a point perpendicular to its plane and at a given distance from the line charge from first principles.
   b) Find the electric field at distance 'z' above the center of a flat circular disc of radius 'r', which carries a uniform surface charge σ. (8M+8M)

3. a) The space between two large parallel plates separated by a distance d=1 mm is filled with dielectric of relative permeability 20. Determine the polarization vector of dielectric if the plates are connected to (i) 10 V battery (ii) 20 V battery (iii) 100 V battery and (iv) 50 V battery
   b) Show that the torque on a physical dipole $\overline{P}$ in a uniform electric filed $\overline{E}$ is given by $\overline{P} \times \overline{E}$. Extend this result to a pure dipole. (8M+8M)

4. a) The region is a free space enclosed by planes $z = 0$ *and* $z = 5\ cm$, and by cylinders $\rho = 3\ cm$ *and* $\rho = 7\ cm$, forms a toroid with a rectangular cross-section. A surface current, $K = 100\ \vec{z}\ A/m$ flows on the inner surface. Find the total flux and magnetic field intensity within the toroid
   b) State and explain Amperes current law and derive the same in point differential form. (8M+8M)

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5. a) State and explain Lorentz's force equation?
   b) A current filament carrying 10 A in z direction lies along the entire z axis in free space. A rectangular loop connecting A (0,2,0) to B(0,2,3) to C(0,7,3) to D(0,7,2) to A (0,2,0) lies in the x = 0 plane. The loop current is 5 mA and it flows in the z-direction in the AB segment. Find forces on side AB and on side DA. (8M+8M)

6. a) Derive the mutual inductance between an infinitely long straight wire and a one-turn rectangular coil whose plane passes through the wire and two of whose sides are parallel to the wire. Take necessary assumptions.
   b) A toroidal core is composed of a material with relative permeability 25. The boundary surfaces are $z = 0, z = 0.05, \rho = 0.05$ and $\rho = 0.08\, m$. The core is wound symmetrically with 10000 turns so that H is in $\vec{\phi}$ direction. If the current in the coil is 20 A, find the total stored energy. (8M+8M)

7. a) Show that power loss in a conductor is given as product of voltage and current using Poynting theorem.
   b) State the Faraday's laws of electromagnetic induction and derive the expressions for the transformer and motional e.m.f.s. (8M+8M)

Code No: RT21025 **R13** SET - 2

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2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) State the differences between Laplace's and Poisson's equations.
b) Why Gauss's law cannot be applied to determine electric field due to finite line charge.
c) Distinguish between the conduction current and convection current.
d) What are the boundary conditions for perfect dielectric materials?
e) What are the limitations of Ampere's circuital law?
f) What is the significance of Lorentz force equation?
g) Define statically and dynamically induced EMF.
h) Write expression for self and inductance of a solenoid and toroid.
(3M+3M+3M+3M+3M+3M+2M+2M)

PART-B

2. a) Four 3 nC charges are at corners of a 2-m square. The top corner charges positive where as the bottom corner charges are negative. Find the electric field at the center of the square. Assume $\epsilon_r = 1$
b) State and explain Coulomb's law. (9M+7M)

3. a) A parallel plate capacitor consists of two square metal plates of side 500mm and separated by a 10 mm slab of Teflon with $\varepsilon_r = 2$ and 6 mm thickness is placed on the lower plate leaving an air gap of 4mm thick between it and upper plate. If 100v is applied across the capacitor, find D, E, and V in Teflon and air.
b) Derive continuity equation.
c) State and prove the conditions on the tangential and normal components of electric flux density and electric field intensity, at the boundary between the dielectrics. (6M+5M+5M)

4. a) Show that $\nabla \times H = J$.
b) Derive expression for magnetic flux density at a point due to long current carrying filament.
(8M+8M)
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5. a) A two wire line consists of two conductors of infinite length and circular cross section of radius 10 cm and the distance between them is 1 m. The two conductors are short circuited by a straight conducting bar. What is the force on the bar, if the current through the bar is (i) 10 A and (ii) 20 A ?

   b) A rectangular loop is carrying a current of 20 A in anti clockwise direction in the presence of a magnetic field $\boldsymbol{B = (3x\vec{x} + 6y\vec{y} + 9z\vec{z})\ T}$. If the loop lies in z = 0 plane and is bounded by $\boldsymbol{x = 2, x = 4, y = 1\ and\ y = 3\ m}$. Find

   i) The force at $\boldsymbol{y = 1, x = 2\ to\ x = 4}$

   ii) The force at $\boldsymbol{y = 3, x = 2\ to\ x = 4}$ (8M+8M)

6. a) Derive an expression for mutual inductance between a straight long wire and a square loop wire in the same plane.

   b) A solenoid of 10 cm in length consists of 1000 turns having the cross section radius of 1 cm. Find the inductance of solenoid. What is the value of current required to maintain a flux of 1 milli-Wb in the toroid. Take $\mu_r = 1500$. (8M+8M)

7. a) Derive the Maxwell's equations in point and integral form for time varying fields?

   b) Starting from Faraday's law of electromagnetic induction, derive $\nabla \times E = -\frac{\partial \vec{B}}{\partial t}$. (8M+8M)

Code No: RT21025 **R13** SET - 3

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Time: 3 hours Max. Marks: 70

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2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) Verify the given potential field satisfies the Laplace equation: $V = (x^2 + 3y^2 + 9z)$.
   b) Write the limitations of Gauss law.
   c) Define polarization. Is polarization is present in conductors.
   d) Write the expression for torque developed on a dipole placed in an electric field.
   e) State Ampere's circuital law.
   f) What is a magnetic dipole? How it is differ from electric dipole.
   g) State Faraday's law of electromagnetic induction.
   h) Write the expression for energy stored in a magnetic field.
   (3M+3M+3M+3M+3M+3M+2M+2M)

PART-B

2. a) A point charge of 10 C is located at (1,1,2) in free space, while a charge of 1 C is at (4,1,3). Find the coordinates of the point at which a point charge experience no force.
   b) State and prove Gausss's Law. (8M+8M)

3. a) A conductor of circular cross section is constructed of steel whose conductivity is $6 \times 10^6\ S/m$ in the region $0 < r < 1\ mm$, copper whose conductivity $5.8 \times 10^7\ S/m$ in the region $1 < r < 2\ mm$ and nichrome whose conductivity $10^6\ S/m$ in the region $2 < r < 3\ mm$, the total current carried by the conductor is 100 A. Calculate the current density in steel, copper and nichrome
   b) A dipole with $p = 3\ \vec{z}\ \mu Cm$ is located at point (0,0,2) in free space, and the z = 0 plane is perfectly conducting. Find potential at (0,1,2), (0,2,3) and (0,3,4) (8M+8M)

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4. a) A conductor in the form of regular polygon of '*n*' sides inscribed in a circle of radius '*R*'. Show that the expression for magnetic flux density $B = \frac{\mu_0 nI}{2\pi R} tan\left(\frac{\pi}{n}\right)$ at center, where I is the current. Show also when 'n' is infinitely increased, the expression is reduced to $B = \frac{\mu_0 I}{2R}$.
   b) Derive the expression for magnetic field intensity at the center of a circular wire. (8M+8M)

5. a) Two parallel circular loops of radii 10 m and 2 m, are coaxially located and carry currents 20 A and 5 A respectively. Find the force between the loops if the axial distance between the centers of the loops is (i) 30 m (ii) 40 m
   b) Three infinitely long parallel filaments each carry 5 A in z-direction. If the filament lie in the plane x = 0 and with a 2 cm spacing between wires. Find
   i) The force per meter on left filament
   ii) The force per meter on center filament (8M+8M)

6. a) A solenoid is wound on a long former, square in section and containing no magnetic material. It is bent round into a toroid of internal and external radii 3 cm and 21 cm respectively. A straight thin cable of infinite length passes along the axis of the toroid at right angles to its plane. Find the mutual inductance between the cable and solenoid if there are 200 number of turns per meter on solenoid
   b) Obtain an expression for the self-inductance of a toroid of a circular cross-section, with *N* closely spaced turns. (8M+8M)

7. a) Explain the concept of displacement current and obtain an expression for the displacement current density.
   b) A square loop of wire has corners at (0,0,0), (1,0,0), (1,1,0) and (0,1,0) at t = 0. The loop is perfectly conducting except for a small 100 Ω resistor in one side. It is moving through the field $\boldsymbol{B = 10\cos(5\times10^3 t - 2x)\vec{z}\ \mu T}$ with a constant velocity of $\boldsymbol{30\ \vec{y}\ m/s}$. Calculate the induced EMF (8M+8M)

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2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) Given the potential field $V = 50x^2yz + 20y^2$ volts in free space. What is the electric field at a point P(1,2,-3).
   b) What is an equi-potential line? Give its properties.
   c) What is the capacitance of a parallel plate capacitor when the plate area is 1 m^2, distance between the plates is 1 mm, voltage gradient is 10^5 V/m and charge density on the plates is 2 $\mu C/m^2$?
   d) Write ohm's law in point form and give its significance.
   e) Write the relationship between magnetic flux and magnetic flux density.
   f) What is the force per meter length between two long parallel wires separated by 10 cm in air and carrying a current of 100 A in the same direction.
   g) Define self and mutual inductances
   h) State Poynting theorem. (3M+2M+3M+3M+2M+3M+3M+3M)

PART-B

2. a) Two concentric coplanar rings of radii 1 cm and 4 cm carry charges -2 nC and 3 nC respectively. Find the distance of the equilibrium point from the center of the ring.
   b) Find the work done in moving a 10 coulomb charge from infinity to the origin in electric filed $\overline{E} = \frac{50r}{(r^2+1)}\hat{a}_r$. (8M+8M)
3. a) Derive an expression for Capacitance of a parallel plate capacitor with two different media.
   b) A square parallel plate capacitor 200 mm on side with a plate spacing of 25mm is filled with a dielectric slap (ε_r =240 of the same dimensions if 100 V is applied to the capacitor) Find: (i) the polarization P in the dielectric and (ii) the energy stored by the capacitor.
   If the voltage source is now disconnected and the dielectric slap then slipped out from between the plates, find (iii) Polarization in the dielectric (iv) Energy stored in the dielectric (v) Energy stored in the capacitor. (8M+8M)
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4. a) A filamentary current of 15A is directed in from infinity to the origin on the positive x axis, and then back out to infinity along the position y axis. Use the Biot-Savart's law of find $\overline{H}$ at P (0, 0,1) ?
   b) Find the magnetic field intensity at centre of a square of sides equal to 5 m and carrying a current equal to 10 A. (8M+8M)

5. a) Two infinitely long parallel conductors are separated by a distance 'd'. Find the force per unit length exerted by one of the conductor on the other if the currents in the two conductors are I_1 and I_2.
   b) A straight solid wire segment carrying a current $4\vec{y}$ A extends from A(0,2,5) to B(0,6,5) in free space. This wire is subjected to the magnetic field of an infinite current filament lying along the z-axis and carrying 30 A in the z-direction. Find the torque on the wire segment about an origin at (0,0,2) and (0,0,0) (8M+8M)

6. a) A solenoid has dimensions L = 1 m, N = 1000 turns, diameter = 10 cm, and current I = 205 A. μ_r = 10. Find the field and the energy density inside the solenoid
   b) Using basic laws, derive the expression for the self inductance (L) of a solenoid, if 'N' is the number of turns, 'μ' is permeability, 'A' is the cross sectional area, 'l' length of the flux path. (8M+8M)

7. a) From the Maxwell's equations, derive the expression for Poynting vector. Also, explain the applications of the Poynting vector.
   b) A conductor with circular cross-section has a radius 'a' and length 'l'. It is carrying a current 'I' ampere. If the conductivity of conductor is 'σ', find the power loss in the conductor using Poynting theorem. (8M+8M)