EE3301 ELECTROMAGNETIC THEORY

L T P C2 2 0 3

UNIT I ELECTROSTATICS – I

Sources and effects of electromagnetic fields – Coordinate Systems – Vector fields –Gradient, Divergence, Curl – theorems and applications - Coulomb's Law – Electric field intensity – Field due to discrete and continuous charges – Gauss's law and applications.

UNIT II ELECTROSTATICS – II

Electric potential – Electric field and equipotential plots, Uniform and Non-Uniform field, Utilization factor – Electric field in free space, conductors, dielectrics - Dielectric polarization – Dielectric strength - Electric field in multiple dielectrics – Boundary conditions, Poisson's and Laplace's equations, Capacitance, Energy density, Applications.

UNIT III MAGNETOSTATICS

Lorentz force, magnetic field intensity (H) – Biot–Savart's Law - Ampere's Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetization, Magnetic field in multiple media – Boundary conditions, scalar and vector potential, Poisson's Equation, Magnetic force, Torque, Inductance, Energy density, Applications.

UNIT IV ELECTRODYNAMIC FIELDS

Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Relation between field theory and circuit theory – Applications.

UNIT V ELECTROMAGNETIC WAVES

Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors- skin depth - Poynting vector – Plane wave reflection and refraction.

TEXT BOOKS:

1. Mathew N. O. Sadiku, 'Principles of Electromagnetics', 6th Edition, Oxford University Press Inc. Asianedition, 2015.

2. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition,2014.

2. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.

REFERENCES

1. V.V.Sarwate, 'Electromagnetic fields and waves', First Edition, Newage Publishers, 1993.

2. J.P.Tewari, 'Engineering Electromagnetics - Theory, Problems and Applications', Second Edition, Khanna Publishers.

3. Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series),McGraw Hill, 2010.

4. S.P.Ghosh, Lipika Datta, 'Electromagnetic Field Theory', First Edition, McGraw Hill Education(India)Private Limited, 2012.

5. K A Gangadhar, 'Electromagnetic Field Theory', Khanna Publishers; Eighth Reprint : 2015

ELECTROMAGNETIC THEORY

1. **Aim of the Subject**
    1. Ability to understand basic science, circuit theory, Electromagnetic field theory and control theory
    2. Ability to understand the concepts of faraday‟s law induced emf and Maxwell‟s equations
    3. Ability to understand magnetostatics, magnetic flux density, scalar and vector potential and its applications
    4. Ability to apply Electromagnetic theory to electrical engineering problems.

Objectives of the course

1. To introduce the basic mathematical concepts related to electromagnetic vector fields
2. To impart knowledge on the concepts of electrostatics, electrical potential, energy density and their applications.
3. To impart knowledge on the concepts of magnetostatics, magnetic flux density, scalar and vector potential and its applications.
4. To impart knowledge on the concepts of Faraday‟s law, induced emf and Maxwell‟s equations
5. To impart knowledge on the concepts of Concepts of electromagnetic waves and Poynting vector.

2. **Need and Importance for Study of the Subject**

To understand the basic science and circuit theory concept.

3. **Industry Connectivity and Latest Developments**

4. **Industrial Visit (Planned if any)**

-No-

Department of Electrical and Electronics Engineering

Detailed Lesson Plan

1. Mathew N. O. Sadiku, „Principles of Electromagnetics‟, 4 th Edition Oxford University Press Inc. First India edition, 2009.
2. Ashutosh Pramanik, „Electromagnetism – Theory and Applications‟, PHI Learning Private Limited, New Delhi, Second Edition-2009.
3. K.A. Gangadhar, P.M. Ramanthan „ Electromagnetic Field Theory (including Antennaes and wave propagation‟, 16th Edition, Khanna Publications, 2007.

REFERENCES:

1. Joseph. A.Edminister, „Schaum‟s Outline of Electromagnetics, Third Edition (Schaum‟s Outline Series), Tata McGraw Hill, 2010.
2. William H. Hayt and John A. Buck, „Engineering Electromagnetics‟, Tata McGraw Hill 8th Revised edition, 2011.
3. Kraus and Fleish, „Electromagnetics with Applications‟, McGraw Hill International Editions, Fifth Edition, 2010.
4. Bhag Singh Guru and Hüseyin R. Hiziroglu "Electromagnetic field theory Fundamentals",Cambridge University Press; Second Revised Edition, 2009.

Sl. No	Unit	Topic / Portions to be Covered	Hours Required / Planned	Cumulative Hrs	Books Referred
1	I	Sources and effects of electormagnetic fields	1	1	T1
2	I	Co-ordinate systems	1	2	T1
3	I	Vector fields	1	3	T1
4	I	Gradient, Divergence and Curl	1	4	T1
5	I	Divergence theorem, Stokes theorem and applications	1	5	T1
6	I	Coulomb‟s Law, Electric field intensity	2	7	T1
7	I	Field due to discrete and continuous charges	1	8	T1
8	I	Gauss‟s law and applications	1	9	T1
9	I	Tutorial problems	3	12	T1
10	II	Electric potential – Electric field and equipotential plots	3	15	T1
11	II	Uniform and Non-Uniform field, Utilization factor			T1
12	II	Electric field in free space, conductors, dielectrics			T1
13	II	Dielectric polarization - Dielectric strength	4	19	T1
14	II	Electric field in multiple dielectrics –			T1

		Boundary conditions			
15	II	Poisson‟s and Laplace‟s equations, Energy density			T1
16	II	Poisson‟s and Laplace‟s equations Applications	5	24	T1
17	II	Tutorial problems			T1
18	III	Lorentz law of force,magnetic field intensity, Biot-savart law, ampere law	2	26	T1
19	III	Magnetic field due to straight conductors,circular loop,infinite sheet of current	2	28	T1
20	III	Magnetic flux density B in free space,condutor,magnetic materials	1	29	T1
21	III	Magnetization, magnetic field in multiple media - Boundary conditions	1	30	T1
22	III	Scalar and vector potential	1	31	T1
23	III	Poisson‟s Equation, Magnetic force, torque,inductance	1	32	T1
24	III	Energy density, Poisson‟s Equation Applications.	1	33	T1
25	III	Tutorial problems	3	36	T1
26	IV	Magnetic Circuits -Faraday‟s laws	1	37	T1
27	IV	Transformer and motional EMF	1	38	T1
28	IV	Displacement current	2	40	T1
29	IV	Maxwell‟s aquations (differential and integral form)	4	44	T1
30	IV	Relation between field theory and circuit theory	1	45	T1
31	IV	Maxwell‟s aquations Applications.	1	46	T1
32	IV	Tutorial problems	2	48	T1
33	V	Electromagnetic wave Generation	1	49	T1
34	V	Electromagnetic wave equations	2	51	T1
35	V	Wave parameters- Velocity, intrinsic impedence,propagation constant	1	52	T1
36	V	Waves in free space in lossy and lossless Dielectrics	1	53	T1
37	V	Conductors,skin depth	1	54	T1
38	V	Poynting vector	2	56	T1
39	V	Plane wave reflection and refraction	1	57	T1
40	V	Standing Wave – Applications	1	58	T1
41	V	Tutorial problems	2	60	T1

UNIT-I
ELECTROSTATICS – I

1. **Mention the sources of electromagnetic fields.**

Sources of Electromagnetic fields are

- Stationary closed path in a time varying field.
- Time varying closed path in a static field.
- Time varying closed path in a time varying field.

2. **State Stoke's theorem and its application.**

The line integral of a vector around a closed path is equal to the surface integral of the normal component of its curl over any Surface bounded by the path.

$$\oint A\, dl = \iint \nabla \times A\, ds$$

The stoke‟s theorem applies to time varying as well as static fields. This theorem is used to convert the surface integral of curl of a vector into a closed line integral.

3. **State the physical significance of curl of a vector field.**

- Curl indicates a measure of the tendency of a vector to rotate or twist.

Curl may be described as circulation per unit area.

The curl of electric field E must be zero, for the circulation is zero.

However the curl of magnetic field is not zero.

4. **State the conditions for a vector A to be (a) solenoidal (b) irrotational**

A vector F is said to be irrotational if

A vector F is said to be solenoidal if

5. **State divergence theorem and its application.**

The line integral of the normal component of any vector field over a closed surface is equal to the integral of the divergence of this vector field over a volume enclosed by the closed surface.

$$\oiint D.ds = \iiint \nabla.D\, dv$$

The divergence theorem applies to time varying as well as static fields. This theorem is used to convert the volume integral of divergence of a vector into a closed surface integral.

6. **What is conservative field?**

Conservative field is one in which the net work done around a closed path is zero.

7. **How are unit vectors defined in Cartesian, Cylindrical and Spherical co ordinate system.**

- Cartesian co ordinate a_x, a_y and a_z
- Cylindrical co ordinate a_r ,a_φ and a_z
- Spherical co-ordinate a_r ,a_θ and a_φ

8. State Gauss law its applications.

The net electric flux passing through any closed surface is equal to the charge enclosed by that surface.

$$\Psi=\varphi$$

$$\oint D.ds = Q_{enclosed}$$

Gauss law is applied to determine the Electric field from a closed surface. Example Electric field can be determined for charged shell, two concentric shell or cylinders etc,,.

9. State Coulomb's law

The force between two small charged object separated in vacumm (or) free space by a distance ,which is large compared to their size is proportional to the charges and inversely proportional to the square of the distance between them.

$$F = \frac{Q_1 Q_2}{r^2}$$

10. Express the Matrix form the Unit vector transformation from

(i) rectangular to cylindrical co-ordinate system.

(ii) rectangular to spherical co-ordinate system.

(i) Rectangular to cylindrical co-ordinate system.

$$\begin{bmatrix} A_r \\ A_\emptyset \\ A_z \end{bmatrix} = \begin{bmatrix} cos\emptyset & sin\emptyset & 0 \\ -sin\emptyset & cos\emptyset & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix}$$

(ii) Rectangular to spherical co-ordinate system.

$$\begin{bmatrix} A_r \\ A_\emptyset \\ A_z \end{bmatrix} = \begin{bmatrix} \sin\theta \, cos\emptyset & \sin\theta \, sin\emptyset & cos\theta \\ cos\theta cos\emptyset & cos\theta sin\emptyset & -sin\theta \\ -\sin\emptyset & cos\emptyset & 0 \end{bmatrix} \begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix}$$

11. Define Electric field intensity

Electric field is defined as the force per unit positive charge.

E =F/Q N/C

12. What is line, Surface and volume charge densities

Line charge density- charge per unit length ρ_l =Q/l C/m

Surface charge density- Charge per unit area ρ_s = Q/A C/m^2

Volume charge density Charge per unit volume ρ_v =Q/Volume C/m^3

13. Convert rectangular co ordinate to Cylindrical co- ordinate system

$r = \sqrt{x^2 + y^2}$; $\emptyset = \tan^{-1}\frac{y}{x}$; z=z

Unit II

Electrostatics-II

1 .Define Potential Difference

Potential Difference is defined as work done in moving unit positive charge from one point to another point in an electric field.

2. What are Dielectrics?

Dielectrics are materials that may not conduct electricity through it but on applying electric field induced charges are produced on its faces. The valence electrons in atoms of a dielectric are tightly bound to their nucleus.

3. What is meant by Dielectric Breakdown?

As the electric field applied to dielectric increases sufficiently, the electrons in the dielectric become free. Under such large electric field, the dielectric becomes conducting due to presence of large number of free electrons. This condition is called dielectric breakdown.

4. What is meant by equipotential surface?(Nov/Dec 2011)

Equipotential surface is an imaginary surface in which all the points on the surface having the same electric potential .In an uniform electric field, equipotential surface is perpendicular to the electric field intensity.

5. A parallel plate capacitor has a charge of 10^{-6}C on each plate while the potential difference between the plates are 2000V.Calculate the value of Capacitance. (May /June 2013).

Soln: $Q=10^{-6}$C ,V=2000V

$C=Q/V$, $10^{-6}C/2000$; $C= 5\times10^{-10}$F

6. Write the boundary conditions at the interface between two perfect dielectrics.

- The tangential component of electric field is continuous i.e) Et1=Et2
- The normal component of electric flux density is continuous i.e) Dn1=Dn2

7. What are the significant physical differences between Poisson 's and laplace's equations.(Nov/Dec 2011)

Poisson"s and laplace"s equations are useful for determining the electrostatic potential V in regions whose boundaries are known.

When the region of interest contains charges poissons equation can be used to find the potential.

When the region is free from charge laplace equation is used to find the potential.

8. Define Dipole and Dipole moment (Nov/Dec 2010)

Dipole or electric Dipole is two equal and opposite charges are separated by a very small distance. The product of electric charge Q and distance l is known as Dipole moment

m=Ql.

9. Calculate the capacitance perkm between a pair of parallel wires each of diameter 1 cm at a spacing of 50 cm (Nov/Dec 2015)

UNIT 3-MAGNETOSTATICS

Part A

1. **State Biot –Savarts law.** **Nov/Dec 2014**

It states that the magnetic flux density at any point due to current element is proportional to the current element and sine of the angle between the elemental length and inversely proportional to the square of the distance between them

$$dB=\mu\ Idl\ \sin\theta / 4\pi r^2$$

2. **State amperes circuital law.** **Nov/Dec 2015**

Magnetic field intensity around a closed path is equal to the current enclosed by the path.

$$\int H\bullet dl=I$$

3. **Define magnetic moment.** **Nov/Dec 2014**

Magnetic moment is defined as the maximum torque per magnetic induction of flux density.

m=IA, where A=Area

4. **What is the point form of Ampere circuital law** **Nov/Dec 2011**

$$\nabla \times H=J$$

5. **Distinguish scalar and vector magnetic potential** **Nov/Dec 2011**

S.No	Scalar Magnetic potential	Vector Magnetic Potential
1	It is defined as the quantity whose negative gradient gives the magnetic intensity if there is no current source present	It is defined as the quantity whose curl gives the magnetic flux density
2	$H=-\nabla V_m$	$B=\nabla \times A$

6. **What is lorentz force?** **Nov/Dec 2013**

If a charged particle is moving with velocity v in the presence of both an electric field E and a magnetic field B, then the total electromagnetic force acting on it is

$$F=Q(E+ v \times B)$$

7. Write down the Magnetic Boundry Conditions. Nov/Dec 2013

i) The tangential component of Magnetic field is continuous

i.e) Ht1=Ht2

ii) The normal component of Magnetic flux density is continuous

ii.e) Bn1=Bn2

8. State Gauss law for magnetic field or State the law of conservation of magnetic flux. May/June 2012

The total magnetic flux passing through any closed surface is equal to zero.

$$\int B.ds = 0$$

9. Define magnetostatic energy density. Nov/Dec 2011

Magnetostatic energy density is defined as magnetic energy stored per volume.

$$W = \frac{1}{2} BH \ \ J/m^3$$

10. What is H due to long straight current carrying conductor. April/May 2008

The Magnetic field intensity at any point due to long straight conductor of carrying current I with a distance of d is

$$H = \frac{I}{2\pi d}$$

UNIT IV
ELECTRODYNAMIC FIELDS

1. Distinguish between transformer emf and motional emf?What is transformer action? [EE6302,A15,EE2202,N13,N09,EE 1201,M14]

Transformer Emf:

The emf induced in stationary conductor due to change in flux linked with it is called as transformer emf.

Transformer Action:

Transformer action is defined as the process by which flux linking from one coil with other coil induces emf in other coil.

Motional Emf

The emf induced due to the movement of the conductor in magnetic field is called as motional emf.

2. State ohm's law for magnetic circuits?

Ohm‟s law for magnetic circuits states that flux in a magnetic media is directly proportional to mmf

Ø α mmf

And hence, Ø=(Mmf/Ř) where Ř is reluctance.

3. Give two important equations that provide a connection between circuit theory and field theory?

KVL and KCL provide two important relationships KVL in circuit theory is,

ΣV-ΣIR=0 where V is applied voltage,I is current and R is total resistance.

KVL in magnetic circuits is given by

ΣMMF-ΣŘØ=0 where Ř is reluctance,Ø is flux

Kirchoff‟s current law for electric circuits is ΣI=0

Kirchoff‟s current law for magnetic circuits is, ΣØ=0

4. How does displacement current different from conventional current?

Conduction current	Displacement current
1.Caused in conductor by appliacation of field which is time variant or invariant	1.Caused in dielectrics by time varying fields
2.Independent of frequency	2.Low in low frequencies and high at high frequencies
3.Caused in conductors	3.Caused in capacitors

5. What is the significance of displacement current?

1. It is used to explain the propogtion of electromagnetic waves .
2. It is dependent on frequencies.At low frequencies it has low value and high frequencies it has high values.
3. It is obtained by time varying field.ExampleCurrent flow through a capacitor when alternating voltage is applied across it.

6. Compare Circuit theory and field theory?[EE 2202,N11,EE 1201,A10,EE 1201-AUTT,M11]

Circuit Theory	Field Theory
1.Two dimensional analysis	1.Three dimensional analysis
2.Frequency is used as reference.	2.Three dimensional analysis
3.Lumped components are inviolved	3.Distributed components are involved

7. State Faraday's law of electromagnetic induction?

The total emf induced n a circuit is equal to rate of change of magnetic flux linking the circuit.

$$e = -\frac{d\varnothing}{dt}$$

8. What is conduction current and displacement current density?

The ratio of displacement current to the area over which it is flowing is called as displacement current density.

$$J_D = (I_D/A) = \text{Displacement current density} = \frac{\delta D}{\delta t}$$

Where J_D is displacement current density, Id is displacement current and A is area.
The ratio of conduction current to the area over which it flows is called as conduction current density.It is given by, $J_c = \zeta E$

9. Write emf equation when moving conduction loop in time varying field? [EE 1201,M09]

When conducting loop is moving in time varying field, the induced emf is given by, It is the sum of transformer emf and motional emf.

10. Mention limitation in circuit theory?[EE 1201,A08]

1.It is useful for analysis in the low frequency only.
2.It gives only approximate results.
3.It is useful only for low poer circuits.
4.It does not consider parameters of the medium that is permittivity and permeability.

11. State Point form of Ohm's law?[EC 2253,N14,M13,EE 34,N11]

Point form of Ohm"s law is given by,

$$J_c = \zeta E$$

Where Jc=condution current density, ζ=conductivity and E=Electric field intensity.

12. Give the situations where the rate of change of flux results in non zero value?(or)Name the methods of generating emf using magnetic flux and conductors[EC 2253,A11]

Rate of change of flux will result in non zero value in the following situations when emf is induced by

1.By having stationary loop in a time varying field
2.By having a rotating loop in a stationary field.
3.By having a rotating loop in a time varying field

UNIT – V

ELECTROMAGNETIC WAVES

1. Write down the wave equations for E and H in a conducting medium.
(May 2012)

$$\nabla^2 E - \mu\varepsilon \frac{\partial^2 E}{\partial t^2} - \mu\sigma \frac{\partial E}{\partial t} = 0 \;;\quad \nabla^2 H - \mu\varepsilon \frac{\partial^2 H}{\partial t^2} - \mu\sigma \frac{\partial H}{\partial t} = 0$$

2. Calculate intrinsic impedance or characteristic impedance of free space.
(Nov 2011)

$$\eta = \frac{E}{H} = \sqrt{\frac{\mu_o}{\varepsilon_o}} = \sqrt{\frac{4\pi x10^{-7}}{8.854x10^{-12}}} = 120\pi = 377 \text{ ohms}$$

3. Define propagation constant.

The propagation constant (γ) is a complex number, and it is given by

$\gamma = \alpha + j\beta$; where α is attenuation constant , β is phase constant, $\gamma = \sqrt{j\omega\mu(\sigma + j\omega\varepsilon}$

4. Define skin depth or depth of penetration.

Skin depth or depth of penetration (δ) is defined as that of depth in which the wave has been attenuated to 1 / e or approximately 37% of its original value.

for good conductor.

$$\delta = \frac{1}{\alpha} = \sqrt{\frac{2}{\omega\mu\sigma}}$$

5.A uniform plane wave in free space is described by E = 100e$^{-(\pi z/3)}$ $\overline{a_x}$ Determine the frequency and wave length.

E=100 e$^{-(\pi z/3)}$ $\overline{a_x}$;B = $\frac{2\pi}{\lambda} = \frac{\pi}{3}$; $\lambda = 6m$; $f = \frac{e}{\lambda} = \frac{3x10^8}{6} = 50MHz$

6.Write Helmholtz's equation.

$\nabla^2 E - \gamma^2 E = 0$; where $\gamma = \sqrt{j\omega\mu(\sigma + j\omega\varepsilon)}$

7. Define Poynting vector. (M/J14)

The pointing vector is defined as rate of floe of energy of a wave as it propagates. It is the vector product of electric field and magnetic field. P = E x H

8. State Poynting theorem. (Nov 2013)

The vector product of electric field intensity at any point is a measure of the rate of energy flow per unit area at that point.

P = E x H

9. What is Brewster angle?

Brewster angle is an incident angle at which there is no reflect wave for parallel polarized wave. $\theta = \tan^{-1}\sqrt{\frac{\varepsilon_2}{\varepsilon_1}}$

Where, ε_1 is dielectric constant of medium 1, ε_2 is dielectric constant of medium 2

10. Define standing wave ratio.

It is defined as the ratio of maximum to minimum amplitudes of voltage.

$$S = \frac{E_{1s\,max}}{E_{1s\,min}} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

11.Define voltage reflection coefficient at the load end of the transmission line. (Nov 2011)

It is defined as the ratio of the magnitude of the reflected wave to that of the incident wave.

12. Calculate the characteristics impedance of free space? (Nov 2012)

$$\eta = \frac{E}{H} = \sqrt{\frac{\mu_o}{\varepsilon_o}}$$

$$= \sqrt{\frac{4\pi x10^{-7}}{8.854x10^{-12}}} = 120\pi = 377 \text{ ohms}$$

13. What is 'standing wave ratio? (Nov 2012, M/J14)

It is defined as the ratio of maximum to minimum amplitudes of voltage.

$$S = \frac{E_{1s\,max}}{E_{1s\,min}} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

14. The capacitance and inductance of an overhead transmission line are 0.0075μF/km and 0.8mH/km respectively. Determine the characteristic impedance of the line.(N/D14)

The characteristic impedance of a transmission line is equal to the square root of the ratio of the line's inductance per unit length divided by the line's capacitance per unit length

$$Z_0 = \sqrt{\frac{L}{C}}$$

$$=326.5\Omega$$

15. If a plane wave is incident normally from medium 1 to medium2, write the reflection and transmission co-efficients. (N/D14)

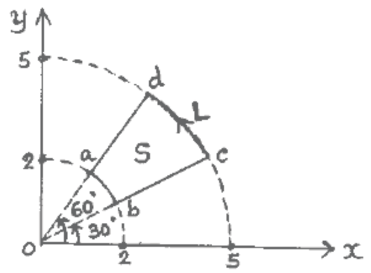
Reflection Co-efficients $Er_0 = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} Ei_0$ Transmission Co-efficients $Et_0 = \frac{2\eta_2}{\eta_2 + \eta_1} Ei_0$

Unit 1

1.	i) With neat diagrams, explain the spherical systems with co-ordinates (R, θ,ϕ)	A/M 18 M/J 14	7
	ii)Apply Coulomb's law to find the electric field intensity at any point P due to a straight uniformly charged wire of linear charge density λ C/m. The point P is at a distance of 'h' m above the wire.	A/M 18	6
2.	i) Explain the divergence of a vector field and divergence theorem.	A/M 16 18, N/D 14,16	7
	ii) By means of gauss law, determine the electric field intensity inside and outside a spherical shell of radius R. The shell contains a total charge Q uniformly distributed over the surface. Or	A/M 17 18	6
	Find the electric field intensity of a Uniformly charged sphere using Gauss law.		6
3.	i) A charge 20 μC is located at A (-6,4,7) and another charge 50 μC is at B(5,8,-2) in free space. If distances are given in metres, determine the vector force exerted by the first charge on the second one.	N/D17	7
	ii) A 50cm length co-axial cable having an inner radius 1mm and outer radius 4mmmm has its inner space between the conductors filled with air. The total charge on the inner conductor is 30nC. Find the charge density on each conductor and also state the divergence theorem and explain its significance.	N/D17	6
4.	i) A Charge of 0.3 μC is located at A(25,30,-15) in cm and a second charge of 0.5 μC is at B(-10,8,12). Find the electric field intensity at the origin.	N/D17	7
	ii) Find the total charge enclosed in an incremental volume of $10^{-9}m^3$ located at the origin. If D = e^{-x} sinya$_x$ - e^{-x} cosy+2Za$_z$ C/m^2 and also state Gauss 's law and give any two of its applications.	N/D17	6
5.	i) Find the force on a charge of Q1 of 20 μC at (0,1,2) m due to Q2 of 300 μC at (2,0,0)m	N/D16	6
	ii)A charge is distributed along a finite straight line with constant desnsity ρ c/m along x axis. Develop an expression for E at arbitrary point P	M/J16	7
6.	A charge Q1=100nC is lcated in vaccum at P1(-0.03,0.01,0.04)m. Find the force on Q1 die to i) Q2=120μC at P2(0.03,0.08,-0.02)m ii) Q3=120μC at P3(-0.09,-0.06,0.10)m iii)Q2 and Q3.	M/J16	13
7.	Verify the divergence theorem for a vector field D = 3x2ax+(3y+z)az+(3z-x)az in the region bounded by the cylinder x2+y2=9 and the planes x=0, y=0 z=0 and z=2	N/D15	13
8.	i)Show that over the closed surface of a sphere of radius b, ds =0	A/M 15	7
	ii)Show that the vector E = $(6xy+z^3)a_x+(3x^2-z)a_y+(3xz^2-y)a_z$ is irrotational and find its scalar potential.	A/M 15	6

9.	i) State and explain coulomb's law of force.	N/D14, N/D15	7
	ii) If B = ya_x+(x-z)a_y and a point Q is located at (-2,6,3) express the point Q in cylindrical and sp herical co-ordinates and B in spherical co-ordinates.	N/D14	6
10.	i)Transform the vector $\vec{A} = 3\vec{a_x} + 2\vec{a_y} - 4\vec{a_z}$ at P(x=+2,y=+3,z=3) to cylindrical coordinate.	N/D16	7
	ii) Three point charges in free space are as follows. 50nC at (0,0)m, 40nC at(3,0)m, -60nC at (0,4)m. Find the electric field intensity at (3,4)m		6
11.	Express the vector B in Cartesian and cylindrical systems. Given, B= 10/r a_r + r cosθ a_θ +a_Φ , then find B at (-3,4,0) and (5,π/2,-2).	N/D13	13
12.	i) Three concentrated charges of 0.25μC are located at the vertices of an equilateral triangle of 10cm side. Find the magnitude and direction of the force on one charge due to other two charges	A/M14	7
	ii) Check validity of the divergence theorem considering the field $\vec{D} = \frac{10y^3}{3}\vec{a_y} C/m^2$ Evaluate both sides of divergence theorem for the volume of a cube 2m on each edge centered at the origin and with the edges parallel to the axes.	A/M'14,17	6
13.	Obtain Electric field intensity of a Infinite line charge carrying uniform line charge density (or) State and prove Gauss law (or) By means of Gauss's law determine the electric field intensity at a point P distant h m from an infinite line of uniform charge ρl C/m	A/M'15,17, N/D'15 A/M15 N/D14	13
14.	Derive electric field intensity at any point due to infinite sheet of charge.		13
15.	i) Determine curl of these vector fields. **1)** $\vec{P} = x^2yz\vec{a_x} + xz\vec{a_z}$ **2)** $\vec{Q} = \rho\sin\phi\vec{a_\rho} + \rho^2 z\vec{a_\phi} + z\cos\phi\vec{a_z}$ **3)** $\vec{T} = \frac{1}{r^2}\cos\theta\vec{a_r} + r\sin\theta\cos\phi\vec{a_\theta} + \cos\theta\vec{a_\phi}$		7
	ii)Explain the different coordinate systems used to represent field		6
16.	Derive the expression for electric field intensity due to a circular surface charge.	N/D'16	13
17.	i) Transform the vector $\vec{A} = 4\vec{a_x} - 2\vec{a_y} - 4\vec{a_z}$ at P(x=+2,y=+3,z=4) to spherical coordinate.	N/D'16	6
	ii) Derive stokes theorem		7
18.	i) Determine divergence and curl of the vector $\vec{A} = x^2\vec{a_x} + y^2\vec{a_y} + z^2\vec{a_z}$		6
	ii)Write short notes on the following : (i) Gradient ii) Divergence iii) Curl	N/D13	7

19.	i)Determine the electric field intensity at *P*(-0.2, 0, - 2.3) due to a point charge of + 5*nC* at *Q*(0.2, 0.1, -2.5) in air. All dimensions are in meter		6
	ii) Using Divergence theorem, evaluate $\iint_s \vec{F}\,nds$ where $\vec{F} = 2xy\vec{i} + y^2\vec{j} + 4yz\vec{k}$ and S is the surface of the cube bounded by x=0,x=1,y=0,y=1 and z=0,z=1.		7
20.	If A=ρ cos φa_ρ+ sinφa_φ , evaluate the area A.dl around the path as shown in figure. Confirm this using stoke's theorem.		13



Unit 2

1.	i) Two point charges -4 μ C and 5 μ C are located at (2,-1,3) and (0,4,-2) respectively. Find the potential at (1,0,1) assuming zero potential at infinity.	A/M18	7
	ii) A parallel plate capacitor has a plate separation t. The capacitance with air only between the plates is C. When a slab of thickness 't' and relative permittivity is placed on one of the plates, the capacitance is 'C' show that $\frac{C'}{C} = \frac{\varepsilon' t}{(t' + \varepsilon'(t - t'))}$	A/M18	6
2.	i)Explain briefly the polarization in dielectrics.	A/M18, N/D15,17	7
	ii) Derive the expression for capacitance		6
3.	i)Explain the potential at a point in an electric field. Derive the electric field intensity at any point in a field due to a point charge.	M/J16	7
	ii)Write laplace equation in cartesian c-ordinates. And obtain the solution when V is a fuction of x only for the boundary condition V = V1 at x=x1 and V = V2 at x=x2.	M/J16	6
4.	i) Calculate the potential at a point P(0,0)m due to point charges Q1 and Q2. Q1 = 10^{-12} C is located at (0.5,0)m and Q2= -10^{-11}C located at (-0.5,0)m	M/J16	7
	ii)Derive Poisson's and laplace equation.		6

5.	i)Find the potential at r_A = 5m with respect to r_B = 15m due to point charge Q = 500pC at the origin and zero reference at infinity.	N/D16	7
	ii)Find the capacitance of a parallel plate capacitor with dielectric ε_{r1} = 1.5 and ε_{r2} = 3.5 each occupy one half of the space between the plates of area $2m^2$ and d = 10^{-3}m. Also derive the expression for the energy stored in a capacitor.	N/D16	6
6.	i) In spherical coordinate V = -25V on a conductor at r=2cm and V = 150V at r=35cm. The space between the conductor is a dielectric of ε_r=3.12. Find the surface charge densities on the conductor.	N/D16	7
	ii)Derive expression for capacitance of a parallel plate capacitor having three dielectric media.		6
7.	Obtain the electric potential due to electric dipole. Also derive an expression for capacitance of concentric spheres.	A/M 15, 17 N/D15	13
8.	i)Obtain an expression for the capacitance of a parallel plate capacitor with 2 dielectrics of relative permittivity ε1 and ε2 interposed between the plates.	A/M15	7
	ii)A positive point charge 100x10-12 C is located in air at x=0, 0.01m and another such charge at x=0, y=-0.1m. What is the magnitude and direction of E.	A/M15	6
9.	i)Four point charges of 10µC each are placed at the corners of side 1m. Determine the value of charge that is to be placed at the centre of the square so that the system is brought to equilibrium.	M/J14	7
	ii) Find the electric potential at any point given the electric field $E = \frac{2r}{\left(r^2 + a^2\right)^2} a_r$. The boundary conditions are r=inf, V=0 and at r=0 and V=100	M/J14	6
10.	i)Find the capacitance between 2 parallel conductors. The radius of conductor is 'r' separated by distance 'd' m. Both wire are carrying the current in opposite direction.	M/J14	7
	ii)Conducting cylinders at ρ=2cm and ρ=6cm are at potentials of 100V and 0V. the region between the cylinders is filled with an inhomogeneous perfect dielectric for which εr=0.3/(ρ+0.04). Find D(ρ), E(ρ), V(ρ).		6
11.	i)A dielectric slab of flat surface with εr=4 is disposed with its surface normal to a uniform field with flux density 1.5C/m2. The slab occupies a volume of 0.08m3 and is uniformly polarized. Determine 1. Polarization in the slab 2. Total dipole moment of slab	N/D14	3
	ii) The capacitance of the condenser formed by the two parallel metal sheets each $100cm^2$ in area separated by a dielectric 2mm thick is $2x10^{-4}$microfarad. A potential of 20kV is applied to it. Find a) electric flux b) Potential gradient c) Relative permittivity d) Electric flux density.		4
	iii) Derive the expression for energy density in electrostatic fields.		6

12.	i)Two point charges -10µC and 8µC are located at (2,-1,4) and (0,5,-3). Find the potential at (1,0,1) assuming zero potential at infinity.	N/D14	7
	ii)A capacitor consists of 2 parallel metal plates 30cmx30cm surface area separated by 5mm in air. Determine its capacitance. Find the total energy stored by the capacitor and the energy density if the capacitor is charged to a potential difference of 500 V.	N/D14	6
13.	State and derive electric boundary conditions for a dielectric to dielectric medium and a conductor to dielectric medium. (Or)	N/D13	13
	Step by step, develop a condition between i) Conductor and dielectric ii) Dielectric and dielectric	A/M18	
	Discuss in detail, the electric field in multiple dielectrics. (Or)	N/D 17	
	Derive the boundary conditions at the interface of two dielectric media. (Or)	A/M'16,17, N/D'17,1314, 15	
	At an interface separating dielectric1 and 2 show that the tangential com continuous across the boundary, whereas the normal component of E is at the boundary.	N/D14	
14.	(i) Determine the capacitance of concentric cylinders with mixed dielectrics.	N/D 15, A/M'13	7
	(ii) A solid sphere of radius R = 40cm has a total positive charge of 26 C uniformly distributed throughout its volume. Calculate the magnitude of the electric field at (a)0cm,(b)30cm,and (c) 60 cm from the centre of the sphere.		6
15.	i) Explain in detail about capacitance in an isolated sphere and Capacitance in co-axial cable	N/D'14	7
	(ii) Derive expression for Capacitance in parallel conductors.		6
16.	The radii of two spheres differ by 4cm and the capacitance of the spherical condenser is 53.33 p.f. if the outer sphere is earthed calculate the radii assuming air as dielectric.	A/M 14	13
17.	i) How much work is required to move a charge of 4 nC from a point 2m away to a point 0.5 m away from a point charge of 60 nC? What is the potential difference between these points?	A/M'14	7
	ii) A parallel plate capacitor has two dielectrics with relative permittivities $\varepsilon r1$ and $\varepsilon r2$. If C1 is the capacitance when two dielectrics take same thickness and C2 is the capacitance when one dielectric takes thickness 3 times of other one, find $\frac{C_1}{C_2}$		6
18.	i) State how the capacitance of a parallel plate capacitor is related to the plate area and plate separation. Determine the capacitance for plates of area 20 cm2 and separation 8.854 mm.		7
	ii) Calculate the electric potential between the plates, the electric field in the region between the plates and the energy stored when the charge of the capacitor is 44.27 nC and the value of capacitor is 2pF.		6
19.	Determine whether or not the following potential fields satisfy the Laplace equation a) $V = x^2-y^2+z^2$ b) V = rcosØ+z c) V = rcosθ+Ø		13

20.	i) A total charge of 10^{-8}C is distributed uniformly along the ring of radius 5m. Calculate the potential on the axis of the ring at a point 5m from the centre of the ring.		7
	ii) A total charge 40/3 nC is distributed around a ring of radius 2m. Find the potential at a point on the axis 5m from the plane of the ring. What would be the potential if the charge is concentrated at the centre**.**		6

Unit 3

1.	i)An iron ring with a cross sectional area of 0.2m in diameter and 10 cm^2 sectional area of the core is wound with 250 turns of wire carrying current of 4A. The relative permeability of the ring is 500.Determine the value of self inductance and the stored energy.	A/M 18	7
	ii)What is magnetization? Explain the classification of magnetic materials. Or	A/M 18	6
	Describe the classification of magnetic materials and draw a typical magnetization (B-H)curve.	N/D14	
	Give a brief note on magnetic materials.	N/D14,15,17	
2.	i)What is the maximum torque on a square loop of 1000 turns in a filed of uniform flux density of 1 tesla? The loop has 10cm sides and carries a current of 3A. What is the magnetic moment of the loop?	A/M 18	3
	ii)The magnetic circuit of an iron ring with mean radius of 10cm has a uniform cross-section of $10^{-3}m^2$. The ring is wound with two coils. If the circuit is energized by a current $i_1(t) = 3\sin\pi t$ A in the first coil with 200 turns, find the induced emf in the second coil with 100 turns. Assume that $\mu=500\mu_0$		3
	iii) Derive the expression for coefficient of coupling in terms of mutual and self inductance of the coils		7
3.	i)Derive the H due to current I flowing in a circular loop. (or)	N/D17	6
	Obtain the magnetic flux density on the axis of the circular coil carrying current I.	N/D'15,M/J16	
	ii)Find the magnetic field intensity at point P(1.5,2,3) caused by a current filament of 24Amp in a_z direction on z axis and extending from z=0 to z=6	M/J16	7
4.	i)Determine H for a solid cylindrical conductor of radius a where the current I is uniformly distributed over the cross section.	N/D16	7
	ii)Calculate the inductance of a ring shaped coil of mean diameter 20cm wound on a wooden core of 2 cm diameter containing 200 turns. Given μ_r=800	N/D 16	6
5.	i)Obtain an expression for inductance and torque of a long solenoid coil.	A/M15	6
	ii)Derive an expression for magnetic flux density and magnetic field intensity at the centre of torroidal coil.		4
	iii)A coil has 1000 turns and carries a magnetic flux of 10mWb. The resistance of the coil is 4 ohms. If it is connected to a 40Vd.c supply, estimate the energy stored in the magnetic field when the current attains its final steady state value.		3

6.	An air co-axial transmission line has a solid inner conductor of radius a and a very thin outer conductor of inner radius b Determine the inductance per unit length of the line.	N/D 15	13
7.	Determine the inductance between the two transmission lines.		13
8.	Derive an expression for the magnetic field intensity inside and outside a co-axial conductor of inner radius a , outer radius b and carrying a current of I amp in the inner and outer conductors (or)	M/J14	13
	Develop an expression for magnetic field intensity both inside and outside a solid cylindrical conductor of radius a carrying current I with uniform density and sketch the variation of field intensity as a function of distance from the conductor axis.	N/D14	13
9.	i)A very long solenoid with 2x2 cm cross section has an iron core μr =1000 and 400 turns/metre. If it carries a current of 500mA, find 1. Its self inductance/meter 2. The energy per meter stored in its field. Also explain about magnetic susceptibility.	N/D14	7
	ii) An air cored torroid with rectangular cross-section has 700 turns with inner radius of 1cm and outer radius of 2cm and height is 1.5cm. Find inductance using a) formula for square cross section of torroids b) The approximate formula for general torroid which assumes a uniform H at mean radius.		6
10.	State and explain the boundary condition for magnetic field.(or) Consider the boundary between 2 media. Show that the angles between t normal to the boundary and the magnetic flux densities on the either side the boundary satisfy the relation $\frac{\tan\theta 1}{\tan\theta 2}=\frac{\mu 1}{\mu 2}$ where μ1 znd μ2 are the permeabilities of respective media and θ1 and θ2 are the angles	N/D'17, M/J' 13, 14,15,17	13
11.	i)State and Explain Biot Savart's law	A/M 18, N/D'13, 16	7
	ii) Give the statement for Ampere's circuital law and give the expression for it. Also calculate the self inductance of infinitely long solenoid.	A/M'16 17	6
12.	Derive the expression for inductance in co-axial cable and inductance of co-axial cable with solid inner conductor.		13
13.	i) Establish the force between the current carrying parallel conductors	N/D'13	7
	ii)Derive expression for Scalar magnetic potential and Vector magnetic potential.	M/J'14, N/D 13,15	6
14.	i) Calculate the internal and external inductance per unit length of a transmission line consisting of two long parallel conducting wires of radius 'a' that carry currents in opposite direction. The axes of the wires by a distance'd', which is much longer than 'a'.		7
	ii). An iron ring with a cross sectional area of $3cm^2$ and mean circumference of 15cm is wound with 250 turns of wire carrying current of 0.3A. the relative permeability of the ring is 1500. Calculate the flux established in the ring.	A/M 18	3

	iii)Derive the expression for energy density in solenoid.		3
15.	Derive the expression for magnetic field intensity at any point due to infinite straight conductor.	N/D',16	13
16.	Derive the expression for magnetic field intensity at any point due to fini conductor.	M/J'15,17	13
17.	i) Derive an expression for the magnetic flux density B at any point alon long solenoid. Sketch the variation of B from point to point along the axi	N/D13,14	7
	ii)Obtain the expression for energy stored in magnetic field and energy density in magnetic field.	A/M'17, N/D'13 14	6
18.	State and explain Ampere's law and show that the field strength at the end of a long solenoid is one half of that at the centre.	N/D13	13
19.	Derive expression for torque developed in a rectangular closed circuit carrying current I in a uniform field.	N/D'14 A/M 16,17	13
20.	i)Explain the difference between the electrostatic field and magnetostatic field.		7
	ii)A solenoid with N_1=1000, r_1=1cm and l_1=50cm is concentric within a second coil of N_2=2000, r_2 =2 cm and l_2 = 50cm. Find the mutual inductance assuming free space conditions.		6

Unit 4

PART – B

1.	i)Explain in detail about transformer e.m.f and motional e.m.f with necessary expressions. (or) Describe the function of a transformer starting from fundamental principles	A/M18 N/D 17
	ii)The flux density in a region in cylindrical co-ordinates by B =B_0sinωt a_z for the region ρ<a. B = 0 for ρ>a. Find induced electric field inside and outside the region.	
2.	i)Describe the applications where circuit theory is used and applications where field theory is used.	N/D 17
	ii)In a material for which σ=5 and ε_r = 1 with E = 250sin10^{10}t. Find J_c and J_D and frequency at which they have equal magnitudes.	N/D 16
	iii)Calculate the maximum emf induced in a coil of 4000turns of radius 12cm rota in a magnetic field of 500 gauss. Flux is normal to the axis of revolution.	
3.	Explain the concept of emf induction in static and time varying magnetic field.	N/D 16
4.	i)A circular loop of wire is placed in a uniform magnetic field of flux density 0.5 wb/m2. The wire has 200 turns and frequency of rotation of 1000 rev/min. if the radius of the coil is 0.2m determine i) the induced emf when the plane of the coil flux lines ii)the induced emf when the plane of the coil is perpendicular to the field.	N/D 15
	ii)A conducting loop of radius 10 cm lies in z=0 plane. The associated B = 10 sin(120πt)a^2 Mwb/m2, calculate the voltage induced in the loop.	M/J14
5.	i) Find the frequency at which conduction current density and displacement current density are equal in a medium with σ=2× 10^{-4} mho/m and ε_r=81.	
	(ii) For a lossy dielectric, σ=5 s/m and ε_r=1. The electric field intensity is E=100 sin 10^{10} t. Find J_C, J_D and frequency at which both have equal magnitudes?	

6.	(i) A conducting cylinder of radius 5cm height 20cm rotates at 600 rev/sec in a radial field β =0.5 tesla. Sliding contacts at the top and bottom connect to voltmeter. Find the induced voltage.		3
	(ii) A circular cross section conductor of radius 2 mm carries a current I_c= 2.5sin $(5*10^8 t)$ 14μ A. What is the amplitude of the displacement current density if σ = 35 Ms/m t_r=1		3
	iii) Explain briefly about electromagnetic forming.		7
7.	(i) A circular loop conductor having a radius of 0.15m is placed in XY plane. This loop consist of a resistance of 20 ohm. If the magnetic flux density is B=0.5 sin 10^3t a_2 tesla. Find the current flowing through this loop.		7
	(ii) The conductor current flowing through a wire with conductivity $\sigma = 3x10^7$ s/m and relative permeability ε_r =1 is given by I_c = 3 sinωt (mA). If $\omega = 10^8$ rad/sec. find the displacement current.		6
8.	i)State and explain Faraday's law & Lenz's law. Deduce the expression for it.	A/M 18	7
	ii)Write short notes on Faraday's disc generator.		6
9.	What is meant by conduction current density? Derive the expression for it and also express using ampere's circuital law.		13
10.	i) For 1A conductor current in copper wire, find the corresponding displacement current at 100MHz. Assume for copper σ=5.8× 10^7 mho/m.		4
	ii)Given average power dissipated per unit volume of a medium is $E\left(\frac{\partial D}{\partial t}\right)\cos\phi / cm^3$, where Φ is the phase angle between E and D. Show that total average power dissipated in a parallel plate capacitor is VIcosΦ		3
	iii)A coaxial capacitor with inner radius 5mm, outer radius 6mm and length 500mm has a dielectric for which ε_r=6.7 and an applied voltage 250sin 377t(V). Determine the displacement current i_D and compare with the conduction current..		6
11.	State Maxwell's equations and obtain them in differential form and integral form using Ampere's law for static and time varying fields.	A/M'14,15,16 17, N/D'13 14,15, 16,17	13
12.	Obtain the Maxwell's equations from Faraday's law for static field and time varying fields.		13
13.	What is meant by displacement current density? Derive the expression for it.		13
14.	i)Derive the Maxwell's equations from electric Gauss law and magnetic Gauss law?		6
	ii)A parallel plate capacitor with plate area of $5cm^2$ and plate separation of 3mm has a voltage of 50sin103t V applied to its plates. Calculate the displacement current assuming $\varepsilon=2\varepsilon_0$	N/D'14,15	4
	iii)Compare the magnitude of peak values of conduction current density and current density in a good conductor for which $\sigma=10^7$mho/m, ε_r=1 when E = 1 sin 120πt. Comment on the result.		3

15.	i)Bring out the comparison of field theory and circuit theory?	N/D'12, M/J',14,15 ,17,18	7
	ii) Find the amplitude of displacement current density in air nnear a car antenna where field strength of F.M signal is E = 80cos(6.277*10^8t-2.092y) V/m		6
16.	i)Explain about Maxwell's equation for harmonically varying fields?		7
	ii)Show that the ratio of the amplitudes of the conduction current density and displacement current density is $\frac{\sigma}{\omega\varepsilon}$, for the applied field E =$E_m$cosωt. Assume μ= μ_0. What is the amplitude ratio if the applied field is $E = E_m e^{-\frac{t}{\tau}}$ where τ is real.		6
17.	(i) State and prove the boundary conditions at the interface between different media in both scalar and vector forms.		7
	(ii) What are the salient points to be noted when the boundary conditions are applied.		6
18.	Compare and explain in detail about conduction and displacement current.	A/M'15 N/D15	13
19.	Explain how the circuit equation for a series RLC circuit derived from the field relations.	N/D'14	13
20.	State and derive equation for continuity under dynamic field conditions. Derive point form of continuity for time varying fields.		13

Unit 5

1.	i)The electric field intensity associated with a plane wave travelling in a perfect dielectric medium is given by Ex(z,t) = 10 cos (2πx10^{-7}t-0.1πz) V/m. What is the velocity of propogation? ii) A uniform plane wave in air impinges at 45 angle on a lossless dielectric material with dielectric constant. The transmitted wave propogates in 30 direction with respect Determine the value of ε_r. iii)A plane travelling wave has a peak electric field intensity E as 6kV/m. If the medium is lossless with μ_r = 1 and ε_r = 3, find the velocity of the EM wave, pointing vector, impedance of the medium and the peak value of the magnetic field H	A/M 18
2.	i)Discuss group velocity, phase velocity and propogation constant of electro-magnetic wave.	M/J16
	ii)Write short notes on standing wave.	M/J16
3.	A 6580 MHz uniform plane wave is propogating in a material medium of εr = 2.25. If the amplitude of the electric field intensity of lossless medium is 500V/m. Calculate the phase constant, propogation constant, velocity, wavelength and intrinsic impedanc	N/D16
4.	i)A uniform plane wave propogating in medium has $E = 2e^{-az}\sin(10^8 t - \beta z)a_y \, V/m$. If the medium is characterized by ε_r=1, μr=20 and σ = 3s/m. Find α, β, wave velocity wave impedance and H ii)In free space E(z,t) =100sin(wt-βz)ax V/m. Find the total power passing through a square area of side 25mm in the z=0 plane	N/D15

5.	i)Show that the total power flow along a co-axial cable will be given the surface integration of the pointing vector over any closed surface.	N/D14	7
	ii)A uniform plane wave has a wavelength of 2cm in free space and 1cm in a perfect dielectric(σ=0, μ_r=1). Determine the relative permittivity of the dielectric.		6
6.	i)A transmission line having a characteristic impedance of 75 ohm is terminated in an impedance of 200+j200 ohm. If the line is 2.1 λ long and lossless, determine the input impedance.	M/J14	7
	ii)A co-axial line has an inner conductor of radius 0.1cm and an inductance of 0.5µH/m. Find the value of the characteristic impedance, capacitance and radius of the conductor of the line at 100MHz if the dielectric constant of the sponge material used as an insulation in between the inner and outer conductor is 3. Calculate the velocty of the propogation and wavelength and phase constant	M/J14	6
7.	i)Derive the electromagnetic wave equation for electric field and magnetic field. Or Derive wave equation from Maxwell's equation. Or Describe the concept of electromagnetic wave propogation in a linear, isotropic, homogenous, lossy dielectric medium	N/D14, 17	7
	ii) The current density at the surface of a thick metal plate is 100A/m^2. What is the skin depth if the current density at a depth of 0.01 cm is 28 A/m^2		6
8.	i)Obtain the electromagnetic equation for free space in electric field and magnetic field.	M/J '17, N/D 15,17	7
	ii) 9 GHz wave is propagating through a material that has a dielectric constant of 2.4 and loss tangent of 0.005. Find α, β and wave length of the material.		6
9.	Define uniform plane wave and derive the expression for it.		13
10.	Show that the intrinsic impedance for free space is 120π. Derive the necessary equation.		13
11.	Explain about the wave propagation in a lossless medium and conducting medium.	M/J'15, 16 18,N/D' 16	13
12.	i)Determine the amplitudes of reflected and transmitted fields(electric and magnetic both`0 at the interface of two regions, if E_i =1.5mV/m in region1 for which ε_{r1}=8.5, μ_r=1 and σ=0 and region 2 is a free space.		7
	ii) In a homogeneous region, where μ_r=1and ε_r = 50, the fields are given as $E = 20\pi e^{j(wt-\beta z)} a_x V/m$ and $B = \mu_0 H_m \pi e^{j(wt-\beta z)} a_y\ T$. Find ω and H_m if the Wavelength is 1.75m		6
13.	Describe about the wave propagation in good dielectrics and conductors with necessary parameters.	M/J' 16,17	13
14.	State and prove Poynting theorem.		13
15.	i)What is meant by poynting vector? Obtain the instantaneous, average and complex poynting vector.	N/D 14,17,	7

		M/J'15, 17	
	ii) A plane wave propogation through a medium with μ_r= 2 and ε_r= 8 has E= 0.5 sin (10^6t-$\boldsymbol{\beta z}$) a_xV/m. determine i) $\boldsymbol{\beta}$ ii) Wave velocity iii) H field.		6
16.	i)Obtain the expression for electromagnetic wave propagation in lossy dielectrics.	N/D'14, M/J'15	6
	ii)Explain in detail about Superconducting power transmission and Fiber optic magnetometer		7
17.	(i).Explain the Reflection of uniform plane waves	N/D17	7
	ii) A light is incident from air to glass at Brewster angle. Determine the incident and transmitted angles.		6
18.	What is meant by polarization? Explain about the different types of polarization.		13
19.	(i) Define Brewster angle and derive the expression for it.		6
	(ii) Explain the phenomena of total internal reflection and derive the expression for critical angle.		7
20.	(i) Explain skin effect from skin depth.		6
	(ii) A 800 MHz plane wave travelling has an average pointing vector of 8mW/m2. If the medium is lossless with μr = 1.5 and εr = 6, find the velocity of the wave, wavelength, impedance of the medium, r.m.s electric field E and r.m.s magnetic field H		7

1.