ELECTROMAGNETIC THEORY AND TRANSMISSION LINES

Subject Code: **(EC501PC)**
Regulations : R16 JNTUH
Class :III Year B.Tech ECE I Semester

Department of Electronics and communication Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

Ibrahimpatnam -501 510, Hyderabad

ELECTROMAGNETIC THEORY AND TRANSMISSION LINES

COURSE PLANNER SUBJECT CODE: (EC501PC)

I. COURSE OVERVIEW:

The course covers the basics of the electrostatic field—Gauss's law; boundary conditions; capacitance; Laplace's and Poisson's equations; energy, forces, and torques. The steady electric current. The magneto static field, vector potential; Ampere's and Biot-Savart laws; inductance; energy, forces, and torques. Quasi static fields; electromagnetic induction. It also deals with the propagation of Electromagnetic (EM) waves through guided and unguided media.

II. PREREQUISITE:

- Basic Mathematics,
- Electronic Devices and circuits (EDC)
- Electric Circuit Analysis (ECA)
- Signals and Systems (S&S)

III. COURSE OBJECTIVE:

1.	To introduce the concept of co-ordinate systems and types to analyze the motion of object and their applications in free space to student. To learn the Basic Laws, Concepts and proofs related to Electrostatic Field and Magneto static Fields, and apply them to solve physics and engineering problems
2.	To distinguish between static and time-varying fields, and understand the significance and utility of Maxwell's Equations and Boundary Conditions, and gain ability to provide solutions to communication engineering problems.
3	To analyze the characteristics of Uniform Plane Waves (UPW), determine their propagation parameters and estimate the same for dielectric and dissipative media.
4	To conceptually understand the UPW Polarization features and Poynting Theorem, and apply them for practical problems.
5	To determine the basic Transmission Line Equations and telephone line parameters and estimate the distortions present.
6	To understand the concepts of RF Lines and their characteristics, Smith Chart and its applications, acquire knowledge to configure circuit elements, QWT and HWTs, and to apply the same for practical problems.

IV. COURSE OUTCOME:

SL. NO	DESCRIPTION	BLOOM'S TAXANOMY LEVEL
1.	Distinguish between the static and time-varying fields, establish the corresponding sets of Maxwell's Equations and Boundary Conditions, and use them for solving engineering problems.	L1 Remember

2.	Analyze the Wave Equations for good conductors and good dielectrics, and evaluate the UPW Characteristics for several practical media of interest.	L3,L4,L5,L6
3.	Establish the proof and estimate the polarization features, reflection and transmission coefficients for UPW propagation, distinguish between Brewster and Critical Angles, and acquire knowledge of their applications.	L3,L4
4	Determine the Transmission Line parameters for different lines, characterize the distortions and estimate the characteristics for different lines.	L1,L4
5	Analyze the RF Line features and configure them as SC, OC Lines, QWTs and HWTs, and design the same for effective impedance transformation.	L4,L5,L6
6	Study the Smith Chart profile and stub matching features, and gain ability to practically use the same for solving practical problems.	L1,L4,L6

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES (PO)		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems (**Fundamental Engineering Analysis Skills**).	3	Assignments, Tutorials
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences(**Engineering Problem Solving Skills**).	3	Assignments
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations(**Social Awareness).**	3	Mini Projects
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions(**Creative Skills**).	2	Projects
PO5	**Modern tool usage:**Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations(**Software and Hardware Interface**).	3	Projects
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice(**Social Awareness).**	2	Development of Prototype, Projects
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and	3	Oral Discussions

	environmental contexts, and demonstrate the knowledge of, and need for sustainable development(**Social Awareness).**		
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice(**Professional Integrity).**	1	Inventions and case studies
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings **(Team work).**	2	Development of Prototype, Projects
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions(**Communication Skills).**	3	Presentations
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments (**Practical Engineering Analysis Skills**).	2	Development of Prototype, Projects
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change(**Continuing Education Awareness).**	3	Seminars, Discussions

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

	Program Specific Outcomes (PSO)	Level	Proficiency assessed by
PSO1	**Professional Skills:** An ability to understand the basic concepts in Electronics & Communication Engineering and to apply them to various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc.,in the design and implementation of complex systems.	3	Lectures, Assignments
PSO2	**Problem-solving skills:** An ability to solve complex Electronics and communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.	2	Tutorials
PSO3	**Successful career and Entrepreneurship:** An understanding of social- awareness & environmental-wisdom along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.	3	Seminars and Projects

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

VII. SYLLABUS:

Unit – I

Electrostatics: Coulomb's law, Electric field Intensity, Fields due to different charge distributions, Electric Flux Density, Gauss law and its Applications, Electric Flux Density, Gauss law and its Applications, Electric Potential, Relation Between E and V, Maxwell's Two equations for Electrostatic Fields, energy Density, Maxwell's Two equations for Electrostatic Fields, energy Density, Illustrative Problems. Convection and Conduction Currents, Dielectric Constant, Isotropic and Homogeneous Dielectrics, Continuity Equation and Relaxation Time, Poisson's and Laplace's Equations, Capacitance- Parallel plate, Co-axial and Spherical capacitors, Illustrative Problems.

Unit-II

Magneto-statics: Biot-Savart Law, Ampere's circuital Law and Applications, Magnetic Flux Density, Maxwell's Two Equations for Magneto static fields, Magnetic Scalar and Vector Potentials, Forces due to Magnetic Fields, Ampere's force Law, Forces due to Magnetic Fields, Ampere's force Law, Forces due to Magnetic Fields, Ampere's force Law, Inductances and Magnetic Energy, Illustrative Problems. Maxwell's Equations (Time Varying Fields): Faraday's Law and Transformer emf, Inconsistence of Ampere's Law and Displacement Current density, Maxwell's Equations indifferent Final Forms and Word Statements, Conditions at a boundary Surface: Dielectric-dielectric, dielectric-conductor Interfaces, Illustrative Problems.

Unit-III

EM Wave Characteristics-I: Wave Equations for conducting and Perfect Dielectric Media, Uniform Plane Waves-Definition, All Relations between E and H, Sinusoidal Variations, Wave Propagation in Lossless and Conducting Media, Conductors and Dielectrics-Characterization, Wave Propagation in good conductors and Good Dielectrics, Polarization, Illustrative Problems. **EM Wave Characteristics-II:** Reflection and Refraction of Plane waves-Normal and Oblique Incidences for Perfect Dielectric, Brewster angle, Critical Angle, Total Internal Reflection, Surface Impedance, Poynting Vector Poynting Theorem-Applications, Power Loss in Plane Conductor, Illustrative Problems.

Unit-IV

Transmission Lines-I: Types, Parameters, Transmission line Equations, Primary and Secondary Constants, Expressions for Characteristic Impedance, Propagation Constant, Phase and Group Velocities, Infinite Line Concepts, Losslessness/Low Loss Characterization, Distortion-Condition for Distortionlessness and Minimum Attenuation, Loading- Types of loading, Illustrative Problems.

Unit-V

Transmission Lines-II: Input Impedance Relations, SC and OC Lines, Reflection Coefficient, VSWR, UHF Lines as Circuit Elements, $\lambda/4$, $\lambda/2$ and $\lambda/8$ Lines- Impedance Transformations, Significance of Zmin and Zmax , Smith Chart-Configuration and Applications, Single and Double Stub Matching, Illustrative Problems.

TEXT BOOKS:

1. Elements of Electromagnetic- Matthew N.o. Sadiku, 4thEd. Oxford Univ. Press.
2. Electromagnetic waves and Radiating Systems- E.C. Jordan and K.G. Balmain, 2ndEd., 2000, PHI.

3. Transmission lines and Networks- Umesh Sinha, Satya Prakashan, 2001, (Tech, India Publications), New Delhi.

REFERENCE BOOKS:

1. Engineering Electromagnetic- Nathan Ida, 2ndEd., 2005, Springer (India) Pvt. Ltd., New Delhi.
2. Engineering electromagnetic- William H. Hayt Jr. and John A. Buck, 7thEd., 2006, TMH.
3. Electromagnetic Field theory and Transmission Lines-G. Sashibushana Rao, Wiley India, 2013.

NPTEL Web Course:

1. http://nptel.ac.in/courses/117101056/
2. https://onlinecourses.nptel.ac.in/noc18_ee04
3. nptel.ac.in/downloads/117101057/
4. www.nptelvideos.in/2012/12/transmission-lines-and-em-waves.html

NPTEL Video Course:

1. https://www.youtube.com/watch?v=pGdr9WLto4A
2. www.nptelvideos.in/2012/12/transmission-lines-and-em-waves.html

UGC-NET/GATE SYLLABUS

Electrostatics; Maxwell's equations: differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector; Plane waves and properties: reflection and refraction, polarization, phase and group velocity, propagation through various media, skin depth; Transmission lines: equations, characteristic impedance, impedance matching, impedance transformation, S-parameters, Smith chart;

ESE SYLLABUS

Elements of vector calculus, Maxwell's equations-basic concepts; Gauss', Stokes' theorems; Wave propagation through different media; Transmission Lines-different types, basics, Smith's chart.

VIII. COURSE PLAN (WEEK-WISE):

Session	Week	TOPIC	Course Learning Outcome	Reference
	UNIT – 1			
1.	1	Coulomb's Law, Electric Field Intensity	Know basic Law	1.Elements of Electromagnetics – Matthew N.O. Sadiku 2. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck.
2.		Fields due to Different Charge Distributions	**Understanding**	
3.		Electric Flux Density	**Compose** the Knowledge	
4.		Gauss Law and Applications	**Gathering** Knowledge	
5.	2	Electric Potential, Relations Between E and V	**Understanding**	
6.		Maxwell's Two Equations for Electrostatic Fields	**Gathering** Knowledge	
7.		Energy Density, Convection and Conduction Currents, Dielectric Constant	**Gathering** Knowledge	
8.		Isotropic and Homogeneous Dielectrics, Continuity Equation, Relaxation Time	**Compose** the Knowledge	
9.	3	Poisson's and Laplace's Equations, Capacitance – Parallel Plate, Coaxial	**Know :**Poisson Equation	
10.		Spherical Capacitors	**Understanding**	
11.		Review of Unit-I		
12.		***Mock Test – I***		
	UNIT – 2			
13.	4	**Magneto Statics :** Biot-Savart's Law	know	1.Elements of Electromagnetics – Matthew N.O. Sadiku 2. Engineering Electromagnetics – William H. Hayt Jr. and
14.		Ampere's Circuital Law and Applications	**Gathering** Knowledge	
15.		Magnetic Flux Density	**Gathering** Knowledge	
16.		Maxwell's Two Equations for Magneto static Fields	**Compose** the Knowledge	
		Tutorial / Bridge Class # 1		

17.	5	Magnetic Scalar and Vector Potentials	**Gathering** Knowledge	John A. Buck.
18.		Forces due to Magnetic Fields, Ampere's Force Law	**Understanding**	
19.		Inductances & Magnetic Energy, Illustrative Problems.	**Gathering** Knowledge	
20.		Maxwell's Equations (Time Varying Fields): Faraday's Law and Transformer emf	**Compose** the Knowledge	
		Tutorial / Bridge Class # 2		
21.	6	Inconsistency of Ampere's Law , Displacement Current Density, Maxwell's Equations in Different Final Forms	**Understanding**	
22.		Maxwell's Equations in Word Statements	**Gathering** Knowledge	
23.		Conditions at a Boundary Surface: Dielectric-Dielectric	**Gathering** Knowledge	
24.		Dielectric-Conductor Interfaces, Illustrative Problems	**Compose** the Knowledge	
		Tutorial / Bridge Class # 3		
	UNIT – 3:			
25.	7	**EM Wave Characteristics - I:** Wave Equations for Conducting Media	**Know**	1.Elements of Electromagnetics – Matthew N.O. Sadiku 2. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck.
26.		Wave Equations for Perfect Dielectric Media.	**Gathering** Knowledge	
27.		Uniform Plane Waves – Definition, All Relations between E & H. Sinusoidal Variations.	**Gathering** Knowledge	
28.		Wave Propagation in Lossless and Conducting Media	**Understanding**	
29.		Wave Propagation in Lossless and Conducting Media	**Compose** the Knowledge	
		Tutorial / Bridge Class # 4		
30.	8	Conductors & Dielectrics – Characterization	**Gathering** Knowledge	
		Wave Propagation in Good Conductors	**Understanding**	
31.		Wave Propagation in Good Dielectrics, Polarization	**Understanding**	
32.		Revision		
33.		Revision		

		Tutorial / Bridge Class # 5		
	I Mid Examinations (Week 9)			
34.	9	**EM Wave Characteristics – II:** Reflection and Refraction of Plane Waves	**Gathering** Knowledge	1.Elements of Electromagnetics – Matthew N.O. Sadiku 2. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck.
35.		Normal and Oblique Incidences, for Perfect Conductor		
36.		Reflection and Refraction of Plane Waves – Normal and Oblique Incidences, for Perfect Dielectrics	**Compose** the Knowledge	
37.		Brewster Angle, Critical Angle and Total Internal Reflection, Poynting Theorem, Power loss in plane Conductor	**Gathering** Knowledge	
		Tutorial / Bridge Class # 6		
	UNIT – 4			
38.	10	**Transmission Lines - I** : Transmission line Types, Parameters, Transmission Line Equations		
39.		**Transmission Lines - I** : Transmission line Types, Parameters, Transmission Line Equations Primary & Secondary Constants	**Understanding**	
40.		Primary & Secondary Constants	**Gathering** Knowledge	
41.		Primary & Secondary Constants		
		Tutorial / Bridge Class # 7		
42.	11	Expressions for Characteristic Impedance, Propagation Constant, Phase and Group Velocities,	**Understanding**	
43.		Expressions for Characteristic Impedance, Propagation Constant, Phase and Group Velocities.	**Compose** the Knowledge	
44.		Expressions for Characteristic Impedance, Propagation Constant, Phase and Group Velocities,	**Compose** the Knowledge	
45.		Infinite Line Concepts Losslessness /Low Loss Characterization	**Compose** the Knowledge	
		Tutorial / Bridge Class # 8		
46.	12	Infinite Line Concepts Losslessness /Low Loss Characterization	**Gathering** Knowledge	
47.		Distortion – Condition for Distortion lessness Minimum Attenuation, Loading - Types of Loading.	**Gathering**	

			Knowledge	
48.		Distortion – Condition for Distortion lessness Minimum Attenuation, Loading - Types of Loading.	**Compose** the Knowledge	
49.		Revision		
		Mock Test – II		
	UNIT – 5			
50.	13	**Transmission Lines – II:** Input Impedance Relations	Know	1. Networks, Lines and Fields – John D. Ryder, PHI, 2nd ed., 1999. 2. Transmission Lines and Networks – Umesh Sinha, Satya Prakashan
51.		**Transmission Lines – II:** Input Impedance Relations	**Gathering** Knowledge	
52.		SC and OC Lines, Reflection Coefficient, VSWR	**Understanding**	
53.		SC and OC Lines, Reflection Coefficient, VSWR	**Understanding**	
		Tutorial / Bridge Class # 9		
54.	14	UHF Lines as Circuit Elements; $\lambda/4$, $\lambda/2$, $\lambda/8$ Lines	**Gathering** Knowledge	
55.		UHF Lines as Circuit Elements; $\lambda/4$, $\lambda/2$, $\lambda/8$ Lines	**Compose** the Knowledge	
56.		Impedance Transformations	**Gathering** Knowledge	
57.		Significance of Z_{min} and Z_{max}	**Understanding**	
		Tutorial / Bridge Class # 10		
58.	15	Smith Chart – Configuration and Applications	**Gathering** Knowledge	
59.		Smith Chart – Configuration and Applications	**Compose** the Knowledge	
60.		Single and Double Stub Matching,	**Compose** the Knowledge	
61.		Revision		
		Tutorial / Bridge Class # 11		
62.	16	Revision		
63.		Revision		
64.		Revision		
		Tutorial / Bridge Class # 12		

IX. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO 4	PO 5	PO6	PO7	PO8	PO9	PO1 0	PO11	PO1 2	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	2	2	2	2	2	2	2	1	2
CO2	3	2	2	2	2	3	2	3	2	2	3	2	3	1	3
CO3	2	3	3	3	3	2	3	2	3	3	2	3	3	1	2
CO4	2	3	2	2	2	2	2	2	3	3	2	3	2	1	2
CO5	3	2	3	3	3	3	3	3	3	3	3	2	2	1	3
CO6	3	2	3	3	3	3	3	3	2	2	3	3	3	1	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

X. JUSTIFICATIONS FOR CO-PO MAPPING

XI. QUESTION BANK (JNTUH)

UNIT I

Long Answer Questions

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	(a) State coulomb's law in vectorial form and list out its applications and limitations. (b) A charge, Q1 = -10 nC is at the origin in free space. If the x-component of E is to be zero at the point (3, 1, 1), what charge, Qt should be kept at the point (2, 0, 0)?	Apply	2
2	(a) Explain the concept of electric field intensity. (b) A point charges of 500 _c each are placed at the corners of a square of $3\sqrt{2}$ m side. The square is located in the Z = 0 plane between $x = \pm\frac{3}{\sqrt{2}}$ m in free space. Find the force on a point charges of 30 μc at (0, 0, 4) m.	Apply	1

3	a) State and explain Coulomb's Law. b) List and explain applications integral of Gauss's Law.		1
4	A parallel plate capacitor has a plate area of 1.5 sq.m and a plate separation of 5mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 3mm with a relative permittivity of 6 and the second has a thickness of 2mm with relative permittivity 4. Find the capacitance?	Apply	2
5	a) State and explain Gauss's law. b) Four concentrated charges Q1 = 0.3 μ c, Q2 = 0.2 μc, Q3 = -0.3 μc, Q4 = 0.2 μc are located at the vertices of a plane rectangle. The length of rectangle is 5 cm and breadth of the rectangle is 2 cm. Find the magnitude and direction of resultant force on Q1. [6+10]	Apply	1
6	(a) Derive the concept of electric field intensity from Columb's law. (b) Derive an expression for electric field intensity at any point 'P' at a radial height 'h' from a finite line charge of λ c/m. extending along the z-axis from 32 to 33 distance 'P' in the x-y plane.	Understand	3
7	(a) State and explain Coulomb's law of electrostatic field in vector form. (b) It is required to hold four equal point charges to each in equilibrium at the corners of a square. Find the point charge, which will do this if placed at the center of the square.	Understand	1
8	(a) Explain coulomb's law. (b) Two small identical conducting spheres have charge of 2nC and -0.5nC respectively. When they are placed 4 cm apart what is the force between them. If they are brought into contact and then separated by 4 cm what is the force between them.	Apply	1
9	Define the Laplacian Equation for Cartesian coordinates and harmonic condition in a region.		3

Short Answer Questions

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	State coulomb's law in vectorial form and list out its applications and limitations	Understand	1
2	Define Stokes Theorem.	Understand	2
3	Define Gauss Law and Poisson Equation.	Knowledge	2
4	Define Electric Field Intensity	Knowledge	2
5	Give the relationship between the D and E	Understand	2

6	List out the application of Guass law.	Understand	1
7	Define Permitivity and Permeability.	Knowledge	2
8	Give the relationship between the D , V and F.	Understand	2

UNIT II

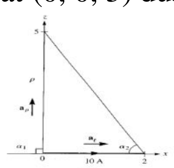
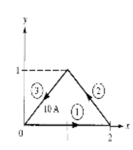
Long Answer Questions

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	A conducting filament carries current I from point A (0, 0, a) to point B(0, 0, b). show that at point P(x, y, 0). $$H = \frac{1}{4\pi\sqrt{x^2+y^3}}\left[\frac{b}{\sqrt{x^2+y^2+b^2}} - \frac{a}{\sqrt{x^2+y^2+a^2}}\right]a_y$$ An infinitely long conducting filament is placed along the x axis and carries current 10 mA in the a_x direction. Find **H** at (-2, 3, 3).	Apply	2
2	Write down the Maxwell's equations for Static Electric and Magnetic fields with remarks	Understand	3
3	Write the short notes on Biot Savart's Law and Ampere's Circuit Law with required equations.	Understand	2
4	Derive the third Maxwell equation using Ampere's Law and explain two applications of Ampere's Law.	Understand	3
5	Derive with neat diagram the special case of BIOT SAVART Law when the conductor is infinite in length	Understand	2
6	Calculate **H** at (3m, -6m, 2m) due to a current element of length 2 mm located at the origin in free space that carries current 16 mA in the +y direction	Apply	2
7	(a) Describe the characteristics of vector magnetic potential. (b) If the vector magnetic potential with in a cylindrical conductor of radius 'a' $A = \frac{\mu_o I r^2}{4\pi a^2} a_z$, find H.	Understand	2
8	A conductor of length 100 cm moves at right angles to uniform field of strength 10000 lines per cm^2 with a velocity of 50 m/s. Calculate emf induced in it when the conductor moves at an angle 300 to the direction of the field.	Understand	2
9	a) Explain behavior of conductors in an electric field. b) A dipole at the origin in free space has $P = 95\Pi\varepsilon_0 U z$ C-m. Find (a) V at P(x.y,z) in Cartesian coordinate. c) E at P(x,y,z) in Cartesian coordinate.	Apply	3

10	a) Explain the concept of electric field intensity. b) A point charges of 500 μC each are placed at the corners of a square of $3\sqrt{2}$ m side. The square is located in the Z = 0 plane between $x = \pm\frac{3}{\sqrt{2}}$ m in free space. Find the force on a point charges of 30 μC at (0, 0, 4) m.	Apply	3
11	a) Derive an expression for the electric field intensity due to an infinite length line charge along the z-axis at an arbitrary point Q (x, y, z). b) A charge of -0.3μC is located at A (25, -30, 15) Cm and a second charge of 0.5 μ C is located at B (-10, 8, 12) Cm. Find the electric field strength, E at: i. The origin and ii. Point P (15, 20, 50) cm.	Apply	2
12	Establish Gauss Law in point form and integral form hence deduce the Laplace's and Poissions's equations.	Knowledge	1
13	Show that the torque acting on an dipole of movement p due to an electric field E is p×E Compute the torque for a dipole consisting of 1 μc charges in an electric field E = 103 (z $a_x - a_y - a_z$) separated by 1 mm and located on the z-axis at the origin.	Understand	2
14	(a) Prove the Maxwell's equation $\nabla.B = 0$. (b) If H = 10 cos (10^{10}t − βx) a_z A/m, find B, D, E and β when μ = 2×10^{-5} H/m $\in = 1.2\times10^{-10} F/m$, σ = 0.	Apply	2
15	A parallel plate capacitor has a plate area of 1.5 sq.m and a plate separation of 5mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 3mm with a relative permittivity of 6 and the second has a thickness of 2mm with relative permittivity 4. Find the capacitance?	Apply	3
16	a) Derive an expression for Ohm's Law in Point form. b) Find the relative permittivity of dielectric material used in parallel capacitor if C =45nF, d = 0.4mm and S =0.35 m^2. (b) d = 0.6 mm, E =700 kv/m and ρ =35 μ C/m 2, D =75 μC/m 2 and energy density is 35 J/m ^{3}.	Apply	2
17	(a) Using Ampere's Circuital law, find the magnetic field intensity in the case of a closely wound torroidal coil. (b) A single-phase circuit comprises two parallel conductors A and B, each 1 cm diameter and spaced 1 m apart. The conductors carry currents of +100 and -100 amps respectively. Determine the field intensity at the surface of each conductor and also in space exactly midway between A and B.	Apply	2
18	(a) Explain duality between D and J (b) Find the total current in a circular conductor of radius 4 mm if the	Apply	3

	current density varies according to $J = 10^4 A/m^2$.		
19	A parallel plate capacitor has a plate area of 1.5 sq.m. and a plate separation of 5 mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 3 mm with a relative permittivity of 6 and the second has a thickness of 2 mm with relative permittivity 4.Find the capacitance. Derive the formula uses.	Apply	3
20	(a) For a pure dipole paz C- m at the origin in free space, find the potential at a point A (b) What is the electric field at (x=0,y=0,z=5m) due to a pure dipole $1a_z$ μc-m at the origin?	Apply	2
21	Calculate the capacitance of a parallel plate capacitor with following details. Plate area = 150 sq.cm. Dielectric εr1 = 3, d12 = 4mm Dielectric εr2 = 5, d12 = 6 mm. If 200 V is applied across the plates what will be the voltage gradient across each dielectric.	Understand	3

Short Answer Questions

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Define the magnetic field dH at point due to current element I dI.	Knowledge	2
2	Name three boundary conditions related to materials.	Knowledge	3
3	Define the Maxwell equations in integral form.	Knowledge	3
4	State the BIOT-SAVART'S Law (dH or H) in Line and surface current.	Understand	2
5	Define Maxwell equations in the Differential form.	Understand	3
6	Name two applications of AMPERE'S Law in symmetrical conditions	Understand	3
7	The conducting triangular loop in Fig. carries a current of 10A. Find H at (0, 0, 5) due to side 1 of the loop.   (a) Conducting Trianglular Loop (b) Side 1 of the loop	Understand	2
8	Describe Conductor Dielectric Boundary Condition.	Knowledge	3
9	Define continuity equation and derive relaxation time equation?	Knowledge	2

UNIT III

Long Answer Questions

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	(a) Derive expression for attenuation constant of EM wave. (b) A medium like copper conductor which is characterized by the parameters σ =5.8 × 10^7 mho/m, $\varepsilon_r = 1$, μ_r = 1 supports a uniform plane wave of frequency 60 Hz. Find attenuation constant, propagation constant, Intrinsic impedance, wavelength and phase velocity of wave.	Apply	3
2	Explain the concept of vector magnetic potential and derive the expression for the same.	Knowledge	3
3	a) Explain the relationship between magnetic flux and magnetic flux density. b) State and prove Maxwell's Divergence equation for static magnetic field.	Knowledge	2
4	A conductor of length 100 cm moves at right angles to uniform field of strength 10000 lines per cm^2 with a velocity of 50 m/s. Calculate emf induced in it when the conductor moves at an angle 300 to the direction of the field.	Apply	3
5	A steady current of 10 A is established in a long straight hollow aluminum conductor having inner and outer radius of 1.5 cm and 3 cm respectively. Find the value of B as function of radius. Also define the law used.	Apply	3
6	A conductor of length 4m, with current held at 10A in the $\bar{a}_y$ direction laid along the y - axis between $y = \pm 2.$ If the field is $\bar{B} = 0.05\ \bar{a}_x$, T find the work done in moving the conductor parallel to itself at constant speed to x = y = 2m. Derive the formula used.	Understand	3
7	A conductor is in the form of a Regular polygon of n sides inscribed in a circle of radius R. Show that the expression for B at the center for a current is given by $\lvert B \rvert = \left(n\mu_0 I/2\pi R\right) Tan^{\pi}/n.$	Apply	2
8	Two narrow circular coils A and B have a common axis and are placed 10 cms apart. Coil A has 10 turns of radius 5cm with a current of 1A passing through it.Coil B has a single turn radius 7.5 cm If the magnetic field at the centre of coil A is to be zero, what current should be passed through coil B.	Apply	3
9	Explain the wave propagation in Lossy Dielectric.	Knowledge	3
10	Explain and elaborate the conditions of Lossless Dielectrics and free space.	Knowledge	2

Short Answer Questions

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Define skin depth with illustration of waveform.	Knowledge	2

2	Give the general expression of α, β, γ in wave propagation.		3
3	Express Intrinsic Impedance in wave propagation and give relation between E and H.		3
4	Write short notes on plane waves in good conductor.		3
5	A plane wave in a nonmagnetic medium has $E = 50\sin(10^8 t + 2z)\,a_y$ V/m. Find direction of wave propagation, λ, f.	Knowledge	2
6	Define Poynting's Theorem and give expression of time average Poynting Vector.		4

UNIT IV

Long Answer Questions

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Obtain the general solution of Transmission line?	Understand	4
2	Explain about waveform distortion and distortion less line condition?	Apply	4
3	Explain about reflection loss?	Understand	3
4	Discuss in details about inductance loading of telephone cables and derive the attenuation constant and phase constant andvelocity of signal transmission (v) for the uniformly loaded cable?	Knowledge	4
5	Derive the equation of attenuation constant and phase constant of TL in terms of R,L, C, G?	Understand	4
6	Explain in details about the reflection on a line not terminated in its characteristic impedance (z0)?	Knowledge	4
7	Explain in following terms (i) Reflection factor (ii) Reflection loss (iii) Return loss	Knowledge	4
8	Explain about physical significance of TL?	Understand	5
9	Derive the equation for transfer impedance?	Understand	4
10	Derive the expression for input impedance of lossless line?	Knowledge	4
11	Explain about telephone cable?	Understand	4

Short Answer Questions

Sl.. No.	Question	Blooms Taxonomy Level	Course Outcome
1	What is group velocity?	Understand	5
2	What is patch loading?	Understand	5
3	What do you understand by loading of transmission lines?	Understand	5
4	Define Characteristic impedance?	Understand	4

5	What is frequency distortion?	Knowledge	4
6	Calculate the load reflection coefficient of open and short circuited lines?	Knowledge	4
7	Calculate the characteristic impedance for the following line arameters R = 10.4 ohms /km L = 0.00367 H/km C = 0.00835µf /km G = 10.8x10-6 mhos /km	Apply	5
8	Define phase distortion?	Understand	4
9	Write the equation for the input impedance of a TL?	Knowledge	4
10	Define propagation constant?	Knowledge	4
11	Write the condition for a distortion less line?	Understand	5
12	When does reflection take place on a TL?	Understand	4
13	What is transfer impedance? State its expression?	Understand	4
14	What is difference between lumped and distributed parameters?	Understand	4
15	Draw the equivalent circuit of a TL?	Knowledge	5
16	Write the Campbell's formula for propagation constant of a loaded line?	Understand	5
17	What is the need for loading?	Understand	4
18	Define reflection factor?	Understand	4
19	Define reflection loss?	Knowledge	4
20	What is meant by reflection co – efficient?	Knowledge	5
21	State the properties of infinite line?	Knowledge	5

UNIT V

Long Answer Questions

Sl. No.	Question	Blooms Taxonomy Level	Course Outcome
1	Explain about half wave transformer?	Understand	5
2	Application of smith chart?		5
3	Explain about voltage and current waveform of dissipation less line?	Understand	5
4	Derive the expression for the input impedance of the dissipation less line and the expression for the input impedance of a quarter wave line. Also discuss the application of quarter wave line?	Analyse	5
5	Explain single stub matching on a transmission line and derive the expression and the length of the stub used for matching on a line?	Understand	5
6	Design a single stub match for a load of 150+j225 ohms for a 75 ohms line at 500 MHz using smith chart?	Apply	5
7	A 30 m long lossless transmission line with characteristic impedance (zo) of 50 ohm is terminated by a load impedance (ZL) = 60 + j40 ohm. The operating wavelength is 90m. find the input impedance and SWR using smith chart?	Apply	4
8	Explain double stub matching on a transmission line and derive the	Understand	4

	expression and the length of the stub used for matching on a line?		
9	Explain about Lamda/ 8 wave transformer?	Understand	5
10	Explain about properties of smith chart?	Understand	5

Short Answer Questions

S.No	Question	**Blooms Taxonomy Level**	Course Outcome
1	Name few applications of half – wave line?	Understand	5
2	Find the VSWR and reflection co – efficient of a perfectly matched line with no Reflection from load?	Understand	5
3	Explain the use of quarter wave line for impedance matching?	Understand	4
4	What is the need for stub matching in transmission lines?	Understand	5
5	Why do standing waves exist on TL?	Knowledge	4
6	Define Node and antinodes?	Knowledge	5
7	What are constant S circles?	Knowledge	6
9	What are the advantages of double stub matching over single stub matching?	Knowledge	6
11	Derive the relationship between standing wave ratio and reflection co – efficient?	Knowledge	5
12	Explain the use of quarter wave line for impedance matching?	Knowledge	5
13	Write the expression for the characteristic impedance Ro' of the matching quarter –wave section of the line?	Knowledge	5
14	Give the applications of smith chart?	Understand	6
15	Define standing wave ratio?	Knowledge	6
16	Give the analytical expression for input impedance of dissipation less line?	Understand	6
17	Design a quarter wave transformers to match a load of 200 to a source resistance of 500. The operating frequency is 200 MHz?	Understand and apply	6
18	Define skin effect?	Understand	4

OBJECTIVE QUESTIONS:

UNIT-1

1. (1) For a good conductor

a) σ = infinity , $\sigma << w\varepsilon$, b) $\sigma = 0$, $\sigma >> w\varepsilon$, c) $\sigma =1$, $\sigma << w\varepsilon$, (d) $\sigma = 0$, $\mu = \mu_r$

(2) The skin depth or penetration depth is having expression

(a) $\delta = 1/\beta$ (b) $\delta = 1/\alpha + i\beta$ (c) $\delta = 1/\alpha$ (d) $\delta = 0$

(3) A uniform plane wave propagating in a medium has E = 2 e^{-az} sin (10^8 t - βz) ay V/m. If the medium is characterized by ε_r = 1, μ_r = 20, and σ = 3 mhos/m, find α

(a) 61.4 Np/m, (b) 71.4 Np/m (c) 51.4 Np/m (d) 80 Np/m

(4) What is the relation between θ_η and θ is

(a) $\theta_\eta = 2\theta$ (b) $\theta_\eta = \theta$ (c) $2\theta_\eta = \theta$ (d) $1/2\ \theta_\eta = \theta$

(5) The displacement current is expressed by

(a) $I_d = \int J_d \cdot ds$ (b) $I_d = J_d .ds$ (c) $I_d = dJ_d / dt$ (d) $I_d = J_d / ds$

(6) The wavelength can be expressed as

(a) $\lambda = 2\pi\beta$ (b) $\lambda = 2\pi/\beta$ (c) $\lambda = 2\pi/c$ (d) $\lambda = \beta/2\pi$

(7) A standing wave

a) Progresses with less than light velocity b) progresses with more than light velocity

c) progresses with equal to light velocity d) does not progress.

(8) The range of reflection coefficient is

a) 0 to 1 b) 0 to infinity c) -1 to 1 d) 1 to infinity

(9) As per the boundary condition,

a) The normal component of E is continuous across the boundary.

b) The tangential component of E is continuous across the boundary.

c) The tangential component of D is continuous across the boundary.

d) The normal component of H is continuous across the boundary

10. Hysteresis and eddy current losses in loading coils leads to

a) Increase in L b) Decrease in L c) Increase in R d) decrease in R

UNIT-2

1. Transverse magnetic (TM) waves have
   a. Magnetic field component H in the direction of propagation
   b. Electric field component E in the direction of propagation
   c. Magnetic field component H in the direction of propagation and no component of electric field E in this direction
   d. Electric field component E in the direction of propagation and no component of magnetic field H in this direction.

2. The velocity of electromagnetic wave in a good conductor is

a. 3 x 10^8 m/s b. more than 3 x 10^8 m/s c. very low d. High

3. A uniform plane wave is one in which

a $\vec{E} \times \vec{H} = 0$ b $\vec{E} \cdot \vec{H}$ c. $\vec{E}$ and $\vec{H}$ are perpendicular d $\vec{E}$ and $\vec{H}$ lie in a plane

4. The Depth of penetration of EM wave in medium having conductivity σ at a frequency of 1 MHz is 25 cm. The depth of penetration at a frequency of 4 MHz will be
A. 6.25 cm B. 12.50 cm C. 50 cm D. 100 cm

5. In a 100 turn coil, if the flux through each turn is $(t^3 - 2t)mW_b$, the magnitude of the induced emf in the coil at a time of 4 sec is
A. 46 mV B. 56 mV C. 4.6 V D. 5.6 V

6. In a conductor which of the following relations hold good?
A. ∇ x D = r B. ∇ . D = r C. ∇ x D = 0 D. ∇ . D = 0

7. A material has conductivity of 10^{-2} mho/m and a relative permittivity of 4. The frequency at which conduction current in the medium is equal to displacement current is
A.45 MHz B.90 MHz C.450 MHz D. 900 Mhz

8. For static magnetic field Maxwell's curl equation is given by

A. $\nabla \cdot \vec{B} = \mu_0 \vec{J}$ B. $\nabla \times \vec{B} = 0$ C. $\nabla \times \vec{B} = \mu_0 \vec{J}$ D. $\nabla \times \vec{B} = \mu_0 / \vec{J}$

9. Which one of the following statement is not a correct for a plane wave with $\vec{H} = 0.5e^{-0.1x} \cos(10^6 t - 2x) a_z$ A/m

A. The wave frequency is 10^{-6} r.p.s. B. The wavelength is 3.14 m

C. The wave travels $+x$ direction D. Wave is polarized in the z direction.

10. A uniform plane wave is one in which
A. $\vec{E} \times \vec{H} = 0$ B. $\vec{E} \cdot \vec{H}$ C. $\vec{E}$ and $\vec{H}$ are perpendicular, D. $\vec{E}$ and $\vec{H}$ lie in a plane

UNIT 3

1. Which of the following relations is valid

A. $\nabla \times \nabla \times \vec{A} = \nabla(\nabla \cdot \vec{A}) - \nabla^2 A$, B. $\nabla \times \nabla \times \vec{A} = \nabla(\nabla \times \vec{A}) - \nabla^2 A$

C. $\nabla \times \nabla \times \vec{A} = \nabla^2 A - (\nabla \vec{A})$ D. none of the above

2. If the electric field intensity associated with a uniform plane electromagnetic wave travelling in a perfect dielectric medium is given by $E(z, t) = 10 \cos(2p \times 10^7 t - 0.1\, pz)$ volt/metre, then the velocity of the travelling wave is

A.3.0×10^8 m/sec B.2×10^8 m/sec C.6.28×10^7 m/sec D.2×10^7 m/sec

3. The intrinsic impedance of free space
A. increases with increase of frequency B. decreases with increase of frequency
C. is independent of frequency D. None

4. For a good conducting medium the intrinsic impedance is

A. $\sigma\omega\mu \angle p/2$ B. $\omega\mu / \sigma \angle 45°$ C. $\omega\mu/\sigma \angle p/2$ D. $\omega\mu/\sigma \angle 0°$

5. A uniform wave have components

A. in the perpendicular direction E existing while H is zero
B.in the direction of propagation E existing while H is zero
C.E and H are zero in direction perpendicular to direction of propagation
D.E and H existing only in direction perpendicular to direction of propagation

6. The electric flux and field intensity inside a conducting sphere is

A. minimum B. Maximum C. Uniform D. Zero

7. Curl of gradient A is

A.∇ x (∇A) = 1 B.∇ x (∇A) = ∞ C.∇ x (∇A) = 0 D.∇ x (∇A) = - ∞

8. For a plane good conductor, skin depth varies

A. directly as square root of permeability B. directly as square root of frequency
C. inversely as permittivity D.inversely as square root of conductivity

9. The attenuation factor a and phase shift factor β for a wave propagated in a good dielectric having $\frac{\sigma}{\omega\varepsilon} >> 1$ are given by

A. a = $\frac{\sigma}{2}$ μ/ε , β = ωμ/εB.a = β = $\frac{\sigma}{2}$ μ/εC.a = μ/ε , β = ωμ/ε D.a = β = ωμ/ε

10. A time varying magnetic field produces……………………. field

UNIT 4

1. Ex = cos(ωt +βz) represents a wave travelling in the ___________________

(a)-ve x-direction (b)+ve x-direction (c)+ve z-direction (d)-ve z-direction

2.An electromagnetic wave is to pass through an interface separating two media having dielectric constants ε_1 and ε_2 respectively. If $\varepsilon_1 = 4\varepsilon_2$, the wave will be totally reflected if angle of incidence is

(a) 0^0 (b) 30^0 (c) 45^0 (d) 60^0

3. The Snell's law of refraction gives -------------

4. The instantaneous rate of energy flow per unit area at a point is

(a) E x H (b) $B \bullet \nabla D$ (c) $B \bullet \nabla D \bullet \nabla$ (d)) (2 $EHx\nabla\nabla$

5. When electromagnetic waves are reflected at an angle from a wall, their wavelength along the wall is

(a) shortened because of the Doppler effect (b) the same as in free space

(c) greater than in the actual direction of propagation

(d) same as the wavelength perpendicular to the wall

6. At the cut-off wave length, the wave between the walls of parallel plane guide

(a) is travel almost parallel to the axis of the guide

(b) is travel perpendicular to the axis of the guide

(c) is travel in zig-zag path (d) has no wave motion

7. If the time dependence of voltage is given as e^{-jwt}, then $V_o e^{-\gamma z}$ will represent

(a) forward travelling wave (b) backward travelling wave (c) standing wave

(d) refracted wave

8. A lossless line of length 500m has L=10µH/m and C=0.1pF/m at 1 MHz. The electrical length of the line is

(a) 360^0 (b) 270^0 (c) 180^0 (d) 90^0

9. For an open circuited line which is not true

(a) Zin = -jZo cotβl (b) 1 = Γ (c) 1 = Γ *l* 1 = Γ *l* (d) S = ∞

10. Short-circuited stubs are preferred to open-circuited stubs because the latter are

(a) more difficult to make and connect

(b) made of a transmission line with a different characteristic impedance

(c) liable to radiate (d) incapable of giving a full range of reactances

11. For transmission-line load matching over a range of frequencies, it is best to use a

(a) balun (b) broadband directional coupler

(c) double stub (d) single stub of adjustable position

UNIT -5

1. (Nov 1998) What determines the velocity factor in transmission line ?

a) The termination impedance b) The center conductor resistivity

c) Dielectrics in the line d) The termination impedance

2. A transmission line has a capacitance of 25 pF / ft. and an inductance of 0.15 mH / ft. Determine the characteristic impedance of the line.

a) 100 W b) 75 W c) 77.5 W d) 50 W

3. What is the impedance of most waveguide?

a) 300 ohms b) 75 ohms c) 600 ohms **d) 50 ohms**

4. Who developed the Smith Chart?

a) James N. Smith b) Philip S. Char **c) Philip H. Smith** d) Gunn Chart

5. The ratio of incident and reflected voltage waves representing transmission and reflection coefficients used to characterize a linear microwave device.

a) Z Parameter b) Y Parameter **c) S Parameter** d) H Parameter

6. An open circuit line greater than wavelength L/4 but less than wavelength L/2 in length will exhibit ______ reactance.

a) capacitive b) minimum **c) inductive** d) maximum

7. How can SWR be minimized?

a) using filters b) using limiter c) using Smith Chart **d) using stubs**

8. What is a short (< l/4) length of transmission line, shorted at one end and attached at the appropriate distance from the load for the purpose of matching a complex load to the transmission line?

a) quarter-wave transformer **b) stub** c) balun d) network

9. A type of transmission line consisting of an inner conductor surrounded by, but insulated from an outer conductor.

a) strip line b) Micro strip line **c) Coaxial cable** d) balanced line

10. For a parallel-resonant circuit, a l / 4 stub must be ______ at the ends.

a) shorted b) open c) complex d) loaded

XII. GATE QUESTIONS / UGC - NET:

1. Z_L = 200 Ω and it is desired that Z_i = 50 Ω The quarter wave transformer should have a characteristic impedance of

   A. 100 Ω

   B. 40 Ω

   C. 10000 Ω

   D. 4 Ω

2. A broadside array consisting of 200 cm wavelength with 10 half-wave dipole spacing 10 cm. And if each array element feeding with 1 amp. current and operating at same frequency then find the half power beamwidth

   A. 4°

   B. 2°

   C. 10°

   D. 15°

3. The input impedance of short-circuited line of length l where $\lambda/4 < l < \lambda/2$, is

   A. Resistive

B. Inductive

C. Capacitive

D. none of the above

4. A wave is propagated in a waveguide at frequency of 9 GHz and separation is 2 cm between walls find cut off wavelength for dominant mode.

A. 4 cm

B. 1 cm

C. 2 cm

D. 8 cm

4. Charge needed within a unit sphere centred at the origin for producing a potential field, $V = -\frac{6r^5}{\varepsilon_0}$ for $r \leq 1$ is

A. 12

B. 60

C. 120

D. 180

5. A rectangular metal waveguide filled with a dielectric of relative permittivity $\varepsilon_r = 4$, has the inside dimensions 3 x 1.2 cm, the cut off frequency for the dominant mode is

A. 2.5 GHz

B. 5 GHz

C. 10 GHz

D. 12.5 GHz

6. A wave is propagated in a waveguide at frequency of 9 GHz and separation is 2 cm between walls Calculate group velocity for dominant mode.

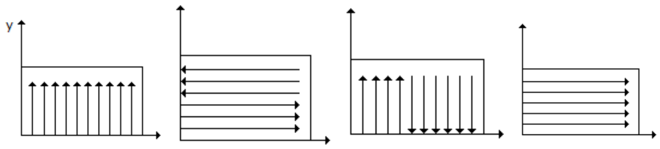
A. 1.8×10^8 m/sec

B. 5×10^8 m/sec

C. 3×10^8 m/sec

D. 1.5×10^8 m/sec

7. Which one of the following does represents the electric field lines for the TE_{02} mode in the cross section of a hollow rectangular metallic waveguide?

A. 

8. The velocity of electromagnetic wave in a good conductor is

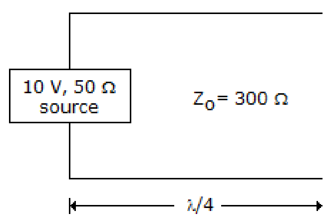
   A. 3×10^8 m/s

   B. more than 3×10^8 m/s

   C. very low

   D. High

1. Consider a 300 Ω, quarter wave long at 1 GHz transmission line as shown in figure. It is connected to a 10 V, 50 Ω source at one end is left open circuited at the other end. The magnitude of the voltage at the open circuit end of the line is



   A. 10 V

   B. 5 V

   C. 60 V

   D. 60/7 volt

2. Which of the following laws of electromagnetic theory is associated with the force experienced by two loops of a wire carrying currents?

   A. Maxwell's law

   B. Coulomb's law

   C. Ampere's law

   D. Laplace's law

3. The shunt admittance of a transmission line is given by

   A. $\gamma = R + j\omega L$

   B. $\gamma = R - j\omega L$

   C. $\gamma = G + j\omega C$

   D. $\gamma = j\omega GC$

4. The force in a magnetic field is given by $F = qvB$

   A. F and q are perpendicular and v and B are perpendicular

   B. F and q only are perpendicular to each other

C. F and v, F and B are mutually perpendicular to each other and v and B at any angle between them

D. All the four components are perpendicular to each other

5. An electromagnetic wave is incident normally on a dielectric boundary. It is

A. totally reflected

B. partially reflected and partially refracted

C. totally absorbed

D. none of the above

14. Two co-axial cylindrical sheets of charge are present in free space $f_s = 5$ c/m^2 at $r = 2$ m and □$_s$ = -2 c/m^2 at $r = 4$ m, The displacement flux density $\vec{D}$ at $r = 3$ m is

A. $\vec{D} = 5\,\vec{a}_r$ c/m^2

B. $\vec{D} = \frac{2}{3}\,\vec{a}_r$ c/m^2

C. $\vec{D} = \frac{10}{3}\,\vec{a}_r$ c/m^2

D. $\vec{D} = \frac{8}{3}\,\vec{a}_r$ c/m^2

15. When the phase velocity of an EM wave depends on frequency in any medium, the phenomenon is called

A. Scattering

B. Polarization

C. Absorption

D. Dispersion

16. Circular polarized waves result when

A. magnitudes are the same

B. phases are the same

C. magnitudes are same and phase difference is 90°

D. magnitudes are same and phase difference is zero

17. For a distortionless line, the parameters are related as

A. R/G = L/C

B. R/L = 1

C. R/G = C/L

D. RG = LC

18. A field $\vec{A} = 3x^2yz\,\hat{a}_x + x^3z\,\hat{a}_y + (x^3y - 2z)\,\hat{a}_z$ can be

A. harmonic

B. divergence less

C. solenoidal

D. rotational

19. Phase velocity of waves propagating in a hollow metal waveguide is

A. greater than the group velocity

B. less than the velocity of light in free space

C. equal to the velocity of light in free space

D. equal to group velocity

20. If a plane electromagnetic wave satisfies the equation $\frac{\partial^2 E_x}{\partial z^2} = c^2 \frac{\partial^2 E_x}{\partial t^2}$, the wave propagates in the (at an angle of 45° between the *x* and *z* direction)

A. *x*-direction

B. *z*-direction

C. *y* direction

D. *xy* plane

21. Radiowaves are electromagnetic waves having frequency range

A. 0.001 to 50 H

B. 0.001 to 50 kHz

C. 0.002 to 50 MHz

D. 0.001 to 10^{16} Hz

XIII. WEBSITES:

a. https://www.scribd.com/doc/165060122/MCQ-in-Electronics-Transmission-Lines

b. http://www.gcebargur.ac.in/sites/gcebargur.ac.in/files/Electromagnetic%20Theory%20Objective%20Type%20Questions.pdf
c. http://emwtl.blogspot.in/p/notes.html
d. http://nptel.ac.in/courses/117101056/

Books Written

1. "**Electromagnetic Waves**", McGraw Hill Education India 2006
2. " **Transmission Lines** " Ed. with V. Ramchandran and K. Shankar, IETE Publication, Tata McGraw Hill 1998.

e-Content:

1. "Electromagnetic Waves and Transmission Lines", 60 Video Lectures, NPTEL, MHRD, Govt. of India 2007.
2. "Electromagnetic Waves and Transmission Lines", Interactive Web course for UG programme, NPTEL, MHRD, Govt. of India 2007.

XIV. EXPERT DETAILS:

Raghunath K. Shevgaonkar

Department of Electrical Engineering
IIT Bombay, Powai
Mumbai 400 076, India
Email : rks[AT]ee.iitb.ac.in
Phone (Internal(O)) : (0091 22) - 2576 7440
Phone (Internal(R)) : 8440
Office room no: 206
Fax: (0091 22) - 25723707

XV .JOURNALS:

International

1. journal of electromagnetic waves and applications
2. electromagnetics journal
3. journal of electromagnetic analysis and applications

National

1. http://www.tandfonline.com/toc/tewa20/current
2. http://www.aemjournal.org/index.php/AEM
3. https://www.hindawi.com/journals/ijap/citations/
4. http://www.scirp.org/journal/jemaa/

XVI. LIST OF TOPICS FOR STUDENT SEMINARS:

1. Electromagnetic Field Theory
2. Electromagnetic Interferences (EMI)

3. Electromagnetic Inverse Problems
4. Electromagnetic Launch
5. Electromagnetic Material Modeling
6. Electromagnetic Compatibility and Electromagnetic Environment

XVII. CASE STUDIES / SMALL PROJECTS:

1. Electromagnetic Devices
2. Electrocardiograph (ECG)
3. Electroencephalograph (EEG)
4. Electromagnetic Breaker
5. Electromagnetic Compatibility
6. Electromagnetic Compatibility (EMC)