EMT & TL Course File

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Course coordinator **Program Coordinator** **HOD**

GEETHANJALI COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF *ELECTRONICS AND COMMUNICATION ENGINEERING*

(Name of the Subject) : ElectroMagnetic Theory and Transmission Lines **Course file**

JNTU CODE - A40411 **Programme :** ***UG***

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

II Year B.Tech. ECE-II Sem

L	T/P/D	C
4	-/-/-	4

(A40411) ELECTROMAGNETIC THEORY AND TRANSMISSION LINES

Course Objectives:

The course objectives are:

- To introduce the student to the fundamental theory and concepts of electromagnetic waves and transmission lines, and their practical applications.
- To study the propagation, reflection, and transmission of plane waves in bounded and unbounded media.

UNIT–I:

Electrostatics: Coulomb's Law, Electric Field Intensity – Fields due to Different Charge Distributions, Electric Flux Density, Gauss Law and Applications, Electric Potential, Relations Between E and V, Maxwell's Two Equations for Electrostatic Fields, Energy Density, Illustrative Problems. Convection and Conduction Currents, Dielectric Constant, Isotropic and Homogeneous Dielectrics, Continuity Equation, Relaxation Time, Poisson's and Laplace's Equations; Capacitance – Parallel Plate, Coaxial, Spherical Capacitors, Illustrative Problems.

UNIT–II:

Magnetostatics: Biot-Savart's Law, Ampere's Circuital Law and Applications, Magnetic Flux Density, Maxwell's Two Equations for Magnetostatic Fields, Magnetic Scalar and Vector Potentials, 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, Inconsistency of Ampere's Law and Displacement Current Density, Maxwell's Equations in Different Final Forms and Word Statements, Conditions at a Boundary Surface : Dielectric-Dielectric and 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 & H, Sinusoidal Variations, Wave Propagation in Lossless and Conducting Media, Conductors & 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 both Perfect Conductor and Perfect

Dielectrics, Brewster Angle, Critical Angle and Total Internal Reflection, Surface Impedance, Poynting Vector and Poynting Theorem – Applications, Power Loss in a Plane Conductor., Illustrative Problems.

UNIT–IV:

Transmission Lines - I: Types, Parameters, Transmission Line Equations, Primary & 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; ?/4, ?/2, ?/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 Electromagnetics – 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 Electromagnetics – Nathan Ida, 2ndEd., 2005, Springer (India) Pvt. Ltd., New Delhi.
2. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck, 7thEd., 2006, TMH.
3. Electromagnetic Filed Theory and Transmission Lines – G. Sashibhushana Rao, Wiley Inia, 2013.
4. Networks, Lines and Fields – John D. Ryder, 2ndEd., 1999, PHI.

Course Outcomes:

Upon successful completion of the course, students will be able to:

- Study time varying Maxwell's equations and their applications in electromagnetic problems.
- Determine the relationship between time varying electric and magnetic field and electromotive force.
- Analyze basic transmission line parameters in phasor domain.

3. Vision of the Department

To impart quality technical education in Electronics and Communication Engineering emphasizing analysis, design/synthesis and evaluation of hardware/embedded software using various Electronic Design Automation (EDA) tools with accent on creativity, innovation and research thereby producing competent engineers who can meet global challenges with societal commitment.

4. Mission of the Department

i. To impart quality education in fundamentals of basic sciences, mathematics, electronics and communication engineering through innovative teaching-learning processes.

ii. To facilitate Graduates define, design, and solve engineering problems in the field of Electronics and Communication Engineering using various Electronic Design Automation (EDA) tools.

iii. To encourage research culture among faculty and students thereby facilitating them to be creative and innovative through constant interaction with R & D organizations and Industry.

iv. To inculcate teamwork, imbibe leadership qualities, professional ethics and social responsibilities in students and faculty.

5 a) Program Educational Objectives of B. Tech (ECE) Program :

I. To prepare students with excellent comprehension of basic sciences, mathematics and engineering subjects facilitating them to gain employment or pursue postgraduate studies with an appreciation for lifelong learning.

II. To train students with problem solving capabilities such as analysis and design with adequate practical skills wherein they demonstrate creativity and innovation that would enable them to develop state of the art equipment and technologies of multidisciplinary nature for societal development.

III. To inculcate positive attitude, professional ethics, effective communication and interpersonal skills which would facilitate them to succeed in the chosen profession exhibiting creativity and innovation through research and development both as team member and as well as leader.

b) Program Outcomes of B.Tech ECE Program:

1. An ability to apply knowledge of Mathematics, Science, and Engineering to solve complex engineering problems of Electronics and Communication Engineering systems.
2. An ability to model, simulate and design Electronics and Communication Engineering systems, conduct experiments, as well as analyze and interpret data and prepare a report with conclusions.
3. An ability to design an Electronics and Communication Engineering system, component, or process to meet desired needs within the realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
4. An ability to function on multidisciplinary teams involving interpersonal skills.
5. An ability to identify, formulate and solve engineering problems of multidisciplinary nature.
6. An understanding of professional and ethical responsibilities involved in the practice of Electronics and Communication Engineering profession.
7. An ability to communicate effectively with a range of audience on complex engineering problems of multidisciplinary nature both in oral and written form.
8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
9. A recognition of the need for, and an ability to engage in life-long learning and acquire the capability for the same.
10. A knowledge of contemporary issues involved in the practice of Electronics and Communication Engineering profession
11. An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.
12. An ability to use modern Electronic Design Automation (EDA) tools, software and electronic equipment to analyze, synthesize and evaluate Electronics and Communication Engineering systems for multidisciplinary tasks.
13. Apply engineering and project management principles to one's own work and also to manage projects of multidisciplinary nature.

6. Course objectives & outcomes:

Objectives: a. To introduce the student to the fundamental theory and concepts of Electromagnetic waves and transmission lines, and their practical applications

b. To study the propagation, reflection, and transmission of plane waves in bounded and unbounded media.

Outcomes: Upon successful completion of the course, students will be able to

a. Study time varying Maxwell's equations and their applications in electromagnetic problems.
b. Determine the relation between time varying electric and magnetic field and electromotive force
c. Analyze basic transmission line parameters in phasor domain
d. Use Maxwell's equations to describe the propagation of electromagnetic waves in free space
e. Show how waves propagate in dielectrics and lossy media
f. Demonstrate the reflection and refraction at boundaries

7. How this course fits into Curriculum:

This course covers all the basic laws which govern the Electric and Magnetic fields in both static and time varying conditions. The students will solve a variety of problems related to these concepts which are applicable to many real time phenomena which involve Electric and Magnetic fields. Maxwell's Equations are the most required laws which are necessary to solve complex design issues in propagation of Electromagnetic waves through different media. These concepts are covered extensively in this course. The second part of the course covers concepts of transmission lines and their characteristics. Solving problems on these concepts help the students to design transmission lines terminated with suitable stubs to minimize reflections. The concepts are essential to students to design any communication system

8. Prerequisites : **1. Three dimensional Coordinate Systems**
2. Vector Calculus

9. Instructional Learning Outcomes

At the end of each unit, students should be able to
Introduction: Distinguish between scalars & vectors, Familiar with Dot and Cross products and related problems
Co-ordinate systems-Types, Cartesian Co-ordinate system
Cylindrical Co-ordinate system, Transformation between Cartesian and Cylindrical
Spherical Co-ordinate system, Transformation among the three co-ordinate systems
Solve Problems on transformations

Solve Problems on surface areas
Vector Calculus, Del operator, Gradient and related mathematical formulae
Curl, Laplacian and related mathematical formulae
UNIT I: Coulomb's law, Electric field intensity
Solve Problems on coulomb's law
Continuous Charge Distribution-Line, surface and volume charges, Electric field for line charge
Electric field intensity for surface charge, problems
Electric field intensity for Volume charge, problems
Electric flux density, Gauss Law and applications
Electric potential, relation between E and V
Maxwell's Two equations for electrostatic fields, Energy density
Solve Problems on energy density
Convection and conduction currents and related problems
Dielectric constant, Isotropic and homogeneous dielectrics,
Continuity equation, relaxation time
Poisson's and Laplace's equation
Capacitance: Parallel plate, coaxial, Spherical capacitors
UNIT II: Biot Savart's law , Ampere's circuit law and applications
Magnetic flux density, Maxwell's two equations magneto static fields
Magnetic scalar and vector potentials, Related problems
Forces due to magnetic fields, problems
Ampere's force law, problems
Inductances and magnetic energy
Solve Problems on the above topics
Faraday's law and transformer emf
Inconsistency of Ampere's law and Displacement current density
Maxwell's equations in final forms and word statements
Maxwell's equations in phasor form
Conditions at a boundary surface: Dielectric – Dielectric
Conditions at a boundary surface: Dielectric – conductor interfaces
UNIT III: Wave equations for conducting and perfect dielectric media
Uniform plane waveforms – Definition
All relations between E&H, sinusoidal variations
Wave propagation in lossless and conducting media
Conductors & dielectrics – Characterization
Wave propagation in good conductors and good dielectrics, Polarization
Reflection and refraction of plane waves-Normal incidence for perfect conductor
Reflection and refraction of plane waves- Normal Incidence for perfect dielectric
Reflection and refraction of plane waves- oblique Incidence for perfect conductor
Reflection and refraction of plane waves- oblique Incidence for perfect dielectric
Brewster angle, critical angle and total internal reflection
Surface impedance, poynting vector and poynting theorem
Applications of poynting theorem, Power loss in a plane conductor
Solve Problems on the above topic
UNIT IV: Types of Transmission lines, parameters
Transmission line equations, Primary and secondary constants
Expression for characteristic impedance, propagation constant

Phase and group velocities, infinite line concepts, Losslessness/ low loss characterization
Distortion- condition for distortionless transmission
Minimum attenuation, loading-types of loading
Solve Problems on the above topics
UNIT V: Input impedance relations, SC and OC lines
Reflection coefficient, VSWR
UHF lines as circuit elements
Quarter wavelength, Half wave length-impedance transformations
Smith chart – configuration and applications, Single and double stub matching

10. Course mapping with POs

1. An ability to apply knowledge of Mathematics, Science, and Engineering to solve complex engineering problems of Electronics and Communication Engineering systems.	
2. An ability to model, simulate and design Electronics and Communication Engineering systems, conduct experiments, as well as analyze and interpret data and prepare a report with conclusions.	√
3. An ability to design an Electronics and Communication Engineering system, component, or process to meet desired needs within the realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.	
4. An ability to function on multidisciplinary teams involving interpersonal skills.	
5. An ability to identify, formulate and solve engineering problems of multidisciplinary nature.	√
6. An understanding of professional and ethical responsibilities involved in the practice of Electronics and Communication Engineering profession.	
7. An ability to communicate effectively with a range of audience on complex engineering problems of multidisciplinary nature both in oral and written form.	
8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.	√
9. A recognition of the need for, and an ability to engage in life-long learning and acquire the capability for the same.	
10. A knowledge of contemporary issues involved in the practice of Electronics and Communication Engineering profession	
11. An ability to use the techniques, skills and modern engineering tools necessary for	

engineering practice.	
12. An ability to use modern Electronic Design Automation (EDA) tools, software and electronic equipment to analyze, synthesize and evaluate Electronics and Communication Engineering systems for multidisciplinary tasks.	
13. Apply engineering and project management principles to one's own work and also to manage projects of multidisciplinary nature.	

11. Class Time Table

Hard copy available

12. Individual Time Table

Hard copy available

13. Lecture schedule with methodology being used/adopted

S.L. no	Unit No	Period No	Date	Topics to be covered in one period	Reg/ Additional	Teaching LCD/OHP /BB
1	I	1		Different 3-D co-ordinate systems	Additional	BB/OHP
2		2		Different 3-D co-ordinate systems, problems	Additional	BB/OHP
3		3		Vector Calculus, Del operator, Gradient, Curl, Laplacian	Additional	BB/OHP
4		4		Divergence and stoke's Theorems	Additional	BB/OHP
5		5		Coulomb's law	Regular	BB/OHP
6		6		Fields due to different charge distributions	Regular	BB/OHP
7		7		Electric field intensity	Regular	BB/OHP
8		8		Electric flux density, Gauss Law and applications	Regular	BB/OHP
9		9		Electric potential, relation between E and V	Regular	BB/OHP
10		10		Electric potential, relation between E and V	Regular	BB/OHP
11		11		Maxwell's Two equations for electrostatic fields,	Regular	BB/OHP
12		12		Energy density, related problems	Regular	BB/OHP
13		13		Convection and conduction currents, the dielectric constant	Regular	BB/OHP
14		14		Isotropic and homogeneous dielectrics,	Regular	BB/OHP
15		15		Continuity equation, relaxation time	Regular	BB/OHP
16		16		Poisson's and Laplace's equation	Regular	BB/OHP
17		17		Capacitance: Parallel plate, coaxial, Spherical capacitors	Regular	BB/OHP
18	II	1		Biot Savart's law	Regular	BB/OHP
19		2		Ampere's circuit law and applications	Regular	BB/OHP
20		3		Magnetic flux density, Maxwell's two equations magneto static fields	Regular	BB/OHP
21		4		Magnetic scalar and vector potentials, Related problems	Regular	BB/OHP
22		5		Forces due to magnetic fields, problems	Regular	BB/OHP
23		6		Ampere's force law, problems	Regular	BB/OHP
24		7		Inductances and magnetic energy	Regular	BB/OHP
25		8		Problems on the above topics	Regular	BB/OHP
26		9		Faraday's law and transformer emf	Regular	BB/OHP
27		10		Inconsistency of Ampere's law and Displacement current density	Regular	BB/OHP
28		11		Maxwell's equations in different final forms and word statements	Regular	BB/OHP
29		12		Conditions at a boundary surface: Dielectric – Dielectric	Regular	BB/OHP
30		13		Conditions at a boundary surface: Dielectric – conductor interfaces	Regular	BB/OHP
31		14		Problems on the above topics	Regular	BB/OHP

32	III	1		Wave equations for conducting and perfect dielectric media	Regular	BB/OHP
33		2		Uniform plane waveforms - Definition	Regular	BB/OHP
34		3		All relations between E&H, sinusoidal variations	Regular	BB/OHP
35		4		Wave propagation in lossless and conducting media	Regular	BB/OHP
36		5		Conductors & dielectrics – Characterization	Regular	BB/OHP
37		6		Wave propagation in good conductors and good dielectrics	Regular	BB/OHP
38		7		Polarization	Regular	BB/OHP
39		8		Problems on the above topics	Regular	BB/OHP
40		9		Reflection and Refraction of plane waves at the perfect conductor–Normal Incidence	Regular	BB/OHP
41		10		Reflection and Refraction of plane waves at the perfect dielectric–Normal Incidence	Regular	BB/OHP
42		11		Reflection and Refraction of plane waves at the perfect conductor–oblique ncidence	Regular	BB/OHP
43		12		Reflection and Refraction of plane waves at the perfect dielectric–oblique Incidence	Regular	BB/OHP
44		13		Brewster angle, critical angle and total internal reflection	Regular	BB/OHP
45		14		Surface impedance, poynting vector and poynting theorem	Regular	BB/OHP
46		15		Applications of poynting theorem	Regular	BB/OHP
47		16		Power loss in a plane conductor	Regular	BB/OHP
48		17		Problems on the above topics	Regular	BB/OHP
49	IV	1		Types of Transmission lines, parameters	Regular	BB/OHP
50		2		Transmission line equations, Primary and secondary constants	Regular	BB/OHP
51		3		Expression for characteristic impedance, propagation constant	Regular	BB/OHP
52		4		Phase and group velocities, infinite line concepts	Regular	BB/OHP
53		5		Losslessness/ low loss characterization	Regular	BB/OHP
54		6		condition for distortionless transmission	Regular	BB/OHP
55		7		Minimum attenuation, loading-types of loading	Regular	BB/OHP
56	V	1		Input impedance relations, SC and OC lines	Regular	BB/OHP
57		2		Reflection coefficient, VSWR	Regular	BB/OHP
58		3		UHF lines as circuit elements	Regular	BB/OHP

59		4		Quarter wavelength, Half wave length-impedance transformations	Regular	BB/OHP
60		5		Impedance circle diagram	Additional	BB/OHP
61		6		Smith chart – configuration and applications	Regular	BB/OHP
62		7		Single and double stub matching	Regular	BB/OHP

14. Detailed notes

A detailed note is available as Notes and in OHP slides.

15. Additional topics

- **a.** Three dimensional Cartesian Co-ordinate systems
- **b.** Three dimensional Cylindrical Co-ordinate systems
- **c.** Three dimensional spherical Co-ordinate systems
- **d.** Transformation from one Co-ordinate system to other
- **e.** Gradient, Divergence, Curl and Laplacian operations
- **f.** Stoke’s and Divergence Theorems
- **g.** Impedance Circle diagram

Notes on all the above topics is available as notes and in OHP slides

16. University Question papers of previous years

Code No: 114CU **R13**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B.Tech II Year II Semester Examinations, May-2015

ELECTROMAGNETIC THEORY AND TRANSMISSION LINES

(Electronics and Communication Engineering)

Time: 3 Hours **Max. Marks: 75**

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 25 marks. Answer all questions in Part A.
Part B consists of 5 Units. Answer any one full question from each unit.
Each question carries 10 marks and may have a, b, c as sub questions.

Part- A **(25 Marks)**

1.a) State Coulomb's Law [2M]
b) Write expression for E at point P for different types of charge distributions. [3M]
c) Write applications of Ampere's circuital Law. [2M]
d) Write Maxwell's equations in integral form. [3M]
e) Write the wave equation for free space and conducting medium. [2M]
f) Write the expressions for Brewster angle, critical angle and total internal reflection. [3M]
g) Draw the equivalent circuit of a two wire transmission line. [2M]
h) What are the losses in transmission lines? [3M]
i) Write the applications of smith chart. [2M]
j) What are the advantages of stub matching? [3M]

Part-B **(50 Marks)**

2.a) State Gauss's law. Deduce Coulomb's law from Gauss's law.
b) Given $V= 5x^3y^2z$ and $\varepsilon=2.25\varepsilon_0$, find i) E at point P (-3, 1, 2) ii) ρ_v at P. [5+5]

OR

3.a) Derive continuity equation.
b) Define and explain the following:
i) Electric flux density D ii) Electric field intensity E. [6+4]

4. State Ampere's circuit law. A hollow conducting cylinder has inner radius *a* and outer radius *b* and carries current *I* along the positive *z*-direction. Find **H** everywhere. [10]

OR

5.a) Using Ampere's circuital law, find H due to any an infinite sheet of current.
b) Write the differences between displacement current density and conduction current density. [5+5]

6.a) Explain the concepts of conduction, convection and displacement current in materials.
b) What are "isotropic" and "homogeneous" dielectric materials? [5+5]

OR

7.a) State and prove Poynting theorem.
b) Define Brewster angle and discuss the Brewster and degree of polarization.[5+5]

8.a) Derive an expression for reflection when a wave is incident on a dielectric obliquely with parallel and perpendicular polarization.

b) A medium is characterized by $\sigma = 0$; and $\mu = 2\mu_0$ and $\varepsilon = 5\varepsilon_0$. If $H = 2\cos(\omega t - 3y)$ az A/m, calculate W and E. [5+5]

OR

9.a) Derive the relationship between secondary constants and primary constants of a transmission line.

b) What is meant by distortion? Derive the conditions for a distrortionless transmission line. [5+5]

10.a) Explain the reflection coefficient and voltage standing wave ratio of a transmission line.

b) Describe the applications and characteristics of $\lambda/2$ and $\lambda/4$ lossless transmission line elements. [5+5]

OR

11.a) Explain VSWR and Reflection Coefficient. Derive Expression for the same.

b) A 30m long lossless transmission line with $Z_0 = 50\Omega$ operating at 2 MHz is terminated by a load $Z_L = 120 + j40$ on the line. Find:
i) the reflection coefficient ii) the VSWR and the input impedance.
Velocity of signal on the line is $v = 0.6C$(C = velocity in free space) (Use smith's chart). [4+6]

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Code No: 43038 **Set No. 3**

II B.Tech I Semester Supplimentary Examinations, May/Jun 2009
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks
* * * * *

1. (a) Define electric field intensity in terms of point charge and describe its salient features.
   (b) Two point charges $Q_1 = 5.0$ C and $Q_2 = 1.0$ nC are located at (-1, 1, -3) m and (3, 1, 0) m respectively. Determine the electric field at Q_1 and Q_2. [8+8]

2. (a) An infinitely long current element on x-axis carries a current of 1.0 mA in a_x direction. Determine **H** at the point P(5, 2, 1).
   (b) If the magnetic field is $\mathbf{H} = \frac{0.01}{\mu_0}\mathbf{a}_x$, A/m, what is the force on a charge of 1.0 pc moving with a velocity of $10^6\,\mathbf{a}_x$ m/s. [8+8]

3. (a) State boundary conditions in vector form.
   (b) z < 0 defines region 1 and z > 0 defines region 2 and region 1 is characterized by $\mu_{r_1} = 2.0$ and region 2 is characterized by $\mu_{r_2} = 4.0$. If the magnetic field in region 1 is given by $\mathbf{H}_1 = 4.0\mathbf{a}_x + 1.5\mathbf{a}_y - 3.0\mathbf{a}_z$, A/m, find $\mathbf{H}_2$ and $\mathbf{H}_2$. [8+8]

4. A uniform plane wave in empty space has the electric field $E\,(z) = a_x\,100\,e^{-j\,\beta_o z}\;\;V/m$. Its frequency is 20 MHz:
   (a) What is its direction of travel and amplitude.
   (b) Find **B, H**
   (c) Express **E, B, H** in real-time form. [4+6+6]

5. (a) Explain the wave propagation characteristics in good conductors?
   (b) Obtain the wave equations for conducting medium. [8+8]

6. What are the field components for TM waves? Derive them draw sketches for TM_{10} mode. [16]

7. (a) Explain the various primary constants for two wire transmission line.
   (b) Calculate the characteristic impedance, the attenuation constant and phase constant of a transmission line if the following measurements have been made on the line $Z_{OC} = 540\Omega$ and $Z_{SC} = 560\Omega$. [8+8]

8. For a typical open wire telephone cable the primary constants R = 10Ω/km, G = 0.4×10^{-6}mho/km, L = 0.0037H/km, C = 0.0083μF/km. Determine Zo and the propagation constant at a frequency of 1KHz. [16]

Code No: 43038 **Set No. 4**

II B.Tech I Semester Supplimentary Examinations, May/Jun 2009
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What is the capacitance between two concentric spheres and obtain an expression for it.
   (b) Find the capacitance per unit length of a coaxial conductor with outer radius of 5 mm and the inner radius of 0.5 mm of the dielectric has $\in_r = 5.0$. [8+8]

3. Write short notes on:
   (a) Current densities
   (b) Maxwell's equations in good conductors
   (c) Importance of auxiliary relation. [5+5+6]

4. The conductivity of silver is $\sigma = 3 \times 10^7$ mho/m at microwave frequencies:
   (a) Find the skin depth at 10 GHz
   (b) Calculate the frequency at which skin depth in sea water is one meter. [8+8]

5. (a) Explain the different types of polarization of a uniform plane wave?
   (b) Find Skin Depth and surface resistance of a aluminum at 100MHz having conductivity $\sigma = 5.8 \times 10^7$ mho/m $\mu_r = 100$. [8+8]

6. (a) Derive the expression for attennation factor for TE mode in guided waves.
   (b) Find the cutoff frequency for TE_{12} mode in a rectangular wave guide whose dimensions are a=b=1cm. [10+6]

7. (a) Explain the various primary constants for parallel wires?
   (b) Calculate the characteristic impedance, the attenuation constant and phase constant of a transmission line if the following measurements have been made on the line $Z_{OC} = 550\Omega$ and $Z_{SC} = 560\Omega$. [8+8]

8. Write short notes on:
   (a) Quarter wave line($\lambda/4$)
   (b) Smith chart. [16]

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Code No: 43038 **Set No. 1**

II B.Tech I Semester Supplementary Examinations, May/Jun 2009
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) State coulomb's law in vectorial form and list out its applications and limitations.
   (b) A charge, Q_1 = -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, Q_t should be kept at the point (2,0, 0)? [8+8]

2. (a) Describe the characteristics of vector magnetic potential.
   (b) If the vector magnetic potential with in a cylindrical conductor of radius 'a' is $A = \frac{\mu_o I\, r^2}{4\pi a^2}\, a_z$, find **H**. [8+8]

3. (a) Prove the Maxwell's equation $\nabla \cdot B = 0$.
   (b) If $H = 10 \cos\left(10^{10} t - \beta x\right)\, a_z$ A/m, find **B, D, E** and β when $\mu = 2\times10^{-5}$ H/m, $\in = 1.2 \times 10^{-10} F/m$, $\sigma = 0$. [8+8]

4. (a) Derive expression for attenuation constant of EM wave.
   (b) A medium like copper conductor which is characterized by the parameters $\sigma = 5.8 \times 10^7$ mho/m, $\in_r = 1$, $\mu_r = 1$ supports a uniform plane wave of frequency 60 Hz. Find attenuation constant, propagation constant, intrinsic impedance, wavelength and phase velocity of wave. [8+8]

5. State and prove Poynting Theorem. [16]

6. (a) Derive the expression for attennation factor for TE mode in guided waves.
   (b) Find the cutoff frequency for TE_{12} mode in a rectangular wave guide whose dimensions are a=b=1cm. [10+6]

7. For a loss less two wire transmission line, show that:

   (a) The phase velocity is $\frac{1}{\sqrt{LC}}$

   (b) The characteristic impedance $Z_0 = \frac{120}{\sqrt{\varepsilon_r}} \cosh^{-1}\left(\frac{d}{2a}\right)$, where 'd' is the separation between the lines & 'a' is the radius of conducting line. [8+8]

8. (a) A loss less transmission line of length 100m has an indutance of 28 μ H and a capacitance of 20μF. Find:

      i. Propagation velocity

      ii. Phase constant at an operating frequence of 100 KHz.

      iii. Characteristic impedance of the line.

   (b) Derive Transmission line estimation. [8+8]

Code No: 43038 **Set No. 2**

II B.Tech I Semester Supplimentary Examinations, May/Jun 2009
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Describe the properties of conductors.

   (b) If the polarization $P = 3a_x$ nC/m^2 in an homogeneous and isotropic dielectric material whose $\chi_e = 4.5$, find out E in the material. [8+8]

2. (a) Determine the magnetic field intensity, H at the center of a square current element. The length of each side 2 m and the current, I = 1.0 Amp.

(b) What is the current that produces a magnetic field inside a conductor of circular cross-section is given by
$H = \frac{1}{r}\left[\frac{1}{K^2}\ \sin\ Kr - \frac{r}{K_1}\ \cos\ Kr\right] a_{\phi}, A/m$ [8+8]

3. (a) Write Maxwell's equation in time varying differential form in a general medium.

   (b) If the electric field strength, **E** of an electromagnetic wave in free space is given by $\mathrm{E} = 2\ \cos\ \omega\left(t - \frac{z}{v_0}\right)\mathrm{a}_y$ V/m, find the magnetic field, H. [8+8]

4. A uniform plane wave in a medium of $\in_1$, μ_1, σ_1 is incident normally upon a second medium of $\in_2$, μ_2, σ_2. Find:

   (a) reflection coefficient for electric and magnetic field and transmission coefficient for electric and magnetic field.

   (b) Find the same when EM wave in air is incident normally upon copper sheet at 1 MHz (for copper, $\in = \in_0$, $\mu = \mu_0$, $\sigma = 5.8{\times}10^7$ mho/m. [16]

5. (a) Derive the expression for intrinsic impedance in a uniform plane wave in Lossy dielectric?

   (b) Calculate the attenuation constant and phase constant for a uniform plane wave with frequency of 10GHz in polythelene for which $\mu = \mu_0$, $\varepsilon_r = 2.\ 3$ and $\sigma = 256\ \times\ 10^{-4}$ mho/m. [8+8]

6. (a) What is the power transmitted in a lossless waveguide?

   (b) Find the broad wall dimension of a rectangular waveguide when the cut-off frequency for TE_{21} mode is 3GHz. [8+8]

7. (a) Derive the expressions for attennation constant, phase shift constant and phase velocity of wave propagating in a distortion less transmission line.

   (b) A loss less line has characteristics impedance of 70Ω & phase constantof 3rad/m at 100MHz. Calculate the inductance & capacitance per meter of the line. [8+8]

8. (a) Derive the expression for input impedance of a line when it is terminated by:

      i. Z_0

      ii. Shorted line

      iii. Open line.

      Also draw the variation of the impedance with respect to electrical lamps of the line for the above cases.

   (b) Express the maximum & minimum input impedance of a line in terms of VSWR. [10+6]

Code No: 33041 **Set No. 1**

II B.Tech I Semester Supplimentary Examinations, May/Jun 2009
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
⋆⋆⋆⋆⋆

1. (a) Using Gauss's law derive expressions for electric field intensity and electric flux density due to an infinite sheet of conductor of charge density ρ C/cm
   (b) A parallel plate capacitance has 500mm side plates of square shape separated by 10mm distance. A sulphur slab of 6mm thickness with $\in_r = 4$ is kept on the lower plate find the capacitance of the set-up. If a voltage of 100 volts is applied across the capacitor, calculate the voltages at both the regions of the capacitor between the plates. [8+8]

2. (a) Define magnetic potential, magnetic flux and permeability of a medium.
   (b) Find magnetic field strength, H, on the axis of a circular current loop of radius 'a', at a point P(0,0,h).
   (c) State the Maxwell's equations for magneto static fields. [4+8+4]

3. (a) Explain boundary conditions for dielectric - dielectric and dielectric - conductor interfaces.
   (b) Let $\mu = 3 \times 10^{-5} H/m, \in= 1.2x10^{-10} f/m$ and $\sigma = 0$ every where. If $H = 2cos(10^{10}t - \beta x)\bar{a}_z$ A/m. use Maxwells equations to find B. [8+8]

4. (a) Explain uniform plane wave propagation
   (b) A lossy dielectric has an intrinsic impedance of $200\angle 30^0\Omega$ at a particular frequency. If at that frequency, the plane wave propagating through the dielectric has the magnetic field component H=$10e^{-\alpha x}$ cos(Wt-1/2x)ay A/m. Find α *and* δ [8+8]

5. (a) State and explain Poynting theorem.
   (b) A plane wave traveling in free space has an average poynting vector of 5 $watts/m^2$. Find the average energy density. [8+8]

6. (a) Explain about attenuation in parallel-plate wave guides. Also draw attenuation versus frequency characteristics of waves guided between parallel conducting plates.
   (b) Derive the relation $\lambda = \frac{\lambda_c \quad \lambda_g}{\sqrt{\lambda_g^2 + \lambda_c^2}}$
   where λ is free space wave length, λ_g is the wave length measured in the guide, and λ_c is the cut off wave length. [8+8]

7. (a) Define the i/p impedance of a transmission line and derive the expression for it.

(b) The characteristic impedance of a certain line is 710, $14^0 \Omega and \tau = 0.007 +$ j0.028 perkm. The line is terminated in a 300 Ω resistor. Calculate the i/p impedance of the line if its length is 100 km [8+8]

8. (a) Explain clearly why the short circuited stub are preferred over to a open circuited stubs?

   (b) Derive the expression for the input impedance of a loss-less line. Hence evaluate $Z_{SC} and Z_{OC}$ and sketch their variation with line length. [6+10]

Code No: 33041

Set No. 2

II B.Tech I Semester Supplimentary Examinations, May/Jun 2009
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) State and Prove Gauss's law. List the limitations of Gauss's law.

   (b) Derive an expression for the electric field strength due to a circular ring of radius 'a' and uniform charge density, ρ_L C/m, using Gauss's law. Obtain the value of height 'h' along z-axis at which the net electric field becomes zero. Assume the ring to be placed in x-y plane.

   (c) Define Electric potential. [6+8+2]

2. (a) State Ampere's circuital law. Specify the conditions to be met for determining magnetic field strength, H, based on Ampere's circuital law

   (b) A long straight conductor with radius 'a' has a magnetic field strength $H = (Ir/2\pi a^2)\,\hat{a}_\phi$ within the conductor $(r < a)$ and $H = (I/2\pi r)\,\hat{a}_\phi$ outside the conductor $(r > a)$ Find the current density J in both the regions $(r < a \; and \; r > a)$

   (c) Define Magnetic flux density and vector magnetic potential. [4+8+4]

3. In a source less medium the which J=0 and $\rho_v = 0$, assume the rectangular coordinates system in which E and H are functions only of z and t. The medium has permittivity $\in$ and permeability μ

   (a) If E=Ex ax and H=Hy ay. begin with max wells equations and determine the second order partial differential equation that Ex must satisfy

   (b) Show that Ey=5 $(300t + bz)^2$ is a solution of that equation for a particular value of b. [8+8]

4. For uniform plane waves in fresh lake water ($\sigma = 10^{-3}$ mho/m $\in \; = 80 \;\; \in_0 \;\; and\, \mu = \mu_0$)

   (a) Find α, β, η and for two frequencies 100 MHz and 10 KHz

   (b) Repeat the same for sea - water $(\sigma = 4mho/m \;\; \in = 80 \;\; \in_0 \;\; and \;\; \mu = \mu_0)$ for two frequencies10,000 MHz and 25 KHz [8+8]

5. (a) State and prove Poynting theorem.

   (b) In a non-magnetic medium E = 4 sin(($2\pi \times \; 10^7$ t - 0.8 $\times$) a_z V/m. Find

      i. the time-average power carried by the wave

      ii. total power crossing 100 cm^2 of plane 2x+y = 5. [8+8]

6. (a) Explain the causes for attenuation in parallel plane wave guides.

   (b) Define and explain the significance of the following terms as applicable to parallel plane guides:

      i. Wave impedance

      ii. Phase and group velocities

      iii. Principal wave and its characteristics [8+8]

7. (a) List out types of transmission lines and draw their schematic diagrams.

   (b) Draw the directions of electric and magnetic fields in parallel plate and coaxial lines

   (c) A transmission line in which no distortion is present has the following parameters $Z_o = 60\Omega, \alpha = 20mNP/m, V = 0.7V_0$. Determine R, L, G, C and wavelength at 0.1GHz. [5+5+6]

8. (a) Derive the expression for the input impedance of an uniform transmission line Terminated with load Z_L. Hence discuss the properties of a quarter wave length and half Wavelength lines assuming the line to be loss less.

   (b) Describe the consternation of Smith chart and give its applications. [8+8]

II B.Tech I Semester Supplimentary Examinations, May/Jun 2009
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks
⋆ ⋆ ⋆ ⋆ ⋆

1. (a) State and prove Gauss's law. Express Gauss's law in both integral and differential forms.
   (b) Discuss the salient features and limitations of Gauss's law .
   (c) Derive Poisson's and Laplace's equations starting from Gauss's law. [6+4+6]

2. (a) State Ampere's circuital law. Specify the conditions to be met for determining magnetic field strength, H, based on Ampere's circuital law
   (b) A long straight conductor with radius 'a' has a magnetic field strength $H = (Ir/2\pi a^2)\,\hat{a}_\phi$ within the conductor $(r < a)$ and $H = (I/2\pi r)\,\hat{a}_\phi$ outside the conductor $(r > a)$ Find the current density J in both the regions $(r < a \; and \; r > a)$
   (c) Define Magnetic flux density and vector magnetic potential. [4+8+4]

3. (a) Explain faraday?s law for time varying fields.
   (b) Verify that the displacement current in the parallel plate capacitor is the same as the conduction current in the connecting wires. [8+8]

4. The inner and outer dimensions of a coaxial copper transmission line are 2 and 7 mm respectively. Both conductor have thickness much greater then δThe dielectric is lossless and the operating frequency is 400 MHz. Calculate the resistance per meter langth of the
   (a) Inner conductor
   (b) Outer conductor
   (c) Transmission Line [5+5+6]

5. (a) Define plane of incidence , Horizontal polarization, Vertical polarization, for the case of a plane wave incident on a dielectric obliquely.
   (b) Derive an expression for reflection when a wave is incidence on a dielectric obliquely with parallel polarization. [8+8]

6. (a) Account for the presence of TE, TM and TEM waves in parallel plane wave guides and explain their significance.
   (b) Assuming z-direction of propagation in a parallel plane wave guide, determine the expressions for the transverse field components in terms of partial derivatives of $E_z \; and \; H_z$. [8+8]

7. (a) A 100Ω Lines of 1km. is terminated by a 200Ω load and fed by a generator of 10V and Internal impedance of 50Ω. Find the load voltage and load power at $3x10^5$ rad/sec.

   (b) A distortion less Line of 80Ω has $\dot{\alpha}$ = 20 milli Nep/m, and a velocity of 60% of Light velocity. Find the primary constants at 50 MHz. [8+8]

8. (a) Explain the principal of Impedance matching with quarter wave Transformer?

   (b) A 50 Ω loss less line connects a signal of 50 KHz to a load of 140 Ω. The load power is 75mW. calculate [8+8]

      i. Voltage Reflection coefficient
      ii. VSWR,
      iii. Position of $V_{Max}, I_{max}, V_{min} and I_{min}$.

Code No: 33041 **Set No. 4**

II B.Tech I Semester Supplimentary Examinations, May/Jun 2009
ELECTROMAGNETIC WAVES AND TRANSMISSION LINES
(Electronics & Instrumentation Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. (a) Using Gauss's law derive expressions for electric field intensity and electric flux density due to an infinite sheet of conductor of charge density ρ C/cm

   (b) A parallel plate capacitance has 500mm side plates of square shape separated by 10mm distance. A sulphur slab of 6mm thickness with $\in_r = 4$ is kept on the lower plate find the capacitance of the set-up. If a voltage of 100 volts is applied across the capacitor, calculate the voltages at both the regions of the capacitor between the plates. [8+8]

2. (a) State Biot- Savart law

   (b) Derive an expression for magnetic field strength, H, due to a finite filamentary conductor carrying a curent I and placed along Z- axis at a point 'P' on y-axis. Hence deduce the magnetic field strength for the length of the conductor extending from - ∞ to + ∞. [4+12]

3. (a) Write down Maxwell?s equations in their general integral form. Derive the corresponding equations for fields varying harmonically with time

   (b) In free space D = D_m sin (ωt + βz) a_x use Maxwell?s equations to find B. [8+8]

4. (a) Explain wave propagation in a conducting medium.

   (b) A large copper conductor ($\sigma = 5.8 \times 10^7 s/m, \varepsilon r = \mu r = 1$)support a unifom plane wave at 60 Hz. Determine the ratio of conduction current to displacement current compute the attenuation constant. Propagation constant, intrinsic impedance, wave length and phase velocity of propagation. [8+8]

5. (a) Explain the difference between the Intrinsic Impedance and the Surface Impedance of a conductor. Show that for a good conductor , the surface impedance is equal to the intrinsic impedance.

   (b) Define and distinguish between the terms perpendicular polarization, parallel polarization, for the case of reflection by a perfect conductor under oblique incidence. [8+8]

6. (a) For a parallel plane wave guide having z-propagation, explain the nature of variation and sketch the variation of E and H for TM_{10} waves

   (b) Starting from the characteristic equation for propagation constant, establish the mathematical relations for the characteristics of TE and TM waves in a parallel plane guide.. [8+8]

7. (a) List out the applications of transmission lines.

   (b) Draw an equivalent circuit of a two wire transmission line

   (c) A lossy cable which has R = 2.25 Ω /m, L = 1.0 μ H/m, C = 1 pF/m and G = 0 operates f = 0.5 GHz. Find out the attenuation constant of the line [5+5+6]

8. (a) Derive the expression for the input impedance of an uniform transmission line Terminated with load Z_L. Hence discuss the properties of a quarter wave length and half Wavelength lines assuming the line to be loss less.

   (b) Describe the consternation of Smith chart and give its applications. [8+8]

17. Question Bank

UNIT-I

1. (a) State 'Coulomb's law' in electrostatics and write its Applications.
   (b) Obtain an equation for force on a point charge 'Q' due to 'N' point charges in the field.

2. (a) Define different charge distributions.
   (b) Write any five applications of electrostatics.

3. (a) Define electric field strength.
   (b) Derive an expression for electric field intensity due to infinite line charge located along z-axis from -∞ to ∞.

4. (a) Obtain an expression for electric field intensity due to infinite surface charge sheet.
   (b) An infinite charge sheet in XY-plane extending from -∞ to ∞ in both directions has a uniform charge density 10nC/m².find electric field at z=1cm.
   (c) A sphere of volume 0.1m³ has a charge density of 8pC/m³.find electric field intensity at (2,0,0) if centre of sphere is at (0,0,0).

5. (a) State ‘Coulomb’s law’.

(b) Point charges Q_1 and Q_2 are respectively located at (4,0,-3) and (2,0,1).if Q_1=4nc find another point charge when

i) Electric field intensity on a charge at a point (5,0,6) has no z-component.

ii) Force on a charge at a point (5,0,6) has no x-component.

6. (a) Three equal charges of 2μc are in space at (0,0,0),(2,0,0) and (0,2,0) respectively. find the net force on Q_4=5μc at (2,2,0)

(b) Two point charges Q_1=5c,Q_2=1nc are located at (-1,1,3)m and (3,1,0)m respectively. Determine the electric field at Q_1.

7. (a) Define electric potential.

(b) Two point charges -4μC and 5μC are located at (2,-1,3) and (0,4,-2) respectively. find the potential at (1,0,1) assuming zero potential at infinity.

(c) Derive an expression for ‘V’ due to charged disc

(or)

Prove potential $V=(\rho_s/2\varepsilon_o)[\sqrt{a^2+h^2} - h]$

Where h=potential at a distance from centre of Disc to the point ‘p’.

a=radius of the disc.

8. (a) Define electric flux and electric flux density.

(b) A point charge Q=10nC is at origin in the free space, find the electric flux density (D) at p(1,0,1).

9. (a) State and prove ‘Gauss’s law’ in electrostatics.

(b) Write any three applications of it.

10. (a) Derive the two Maxwell’s equations in electrostatics.

(or)

(a) Write differential form of Gauss’s law.

(b) Obtain the relationship between electric field intensity ($\bar{E}$) and electric potential (V).

11. (a) What is energy density and derive an expression for it.

(b) Three point charges -1nC, 4nC, 3nC are located at (0,0,0), (0,0,1), (1,0,0).find energy in the system.

12. Explain the properties of conductors and derive relation between I & J.

13.. Write short notes on dielectric materials?

14. a) State and explain continuity equation of current in integral and point forms?

b) What is relaxation time and derive expression for it?

15. a) Define capacitance & derive expression for same of parallel plate capacitor?

b) A parallel plate capacitor consists of two square metal plates with 500mm side & separated 10mm. A slab of sulphur (ε_r =4) 6mm thick is placed on the lower plate & air gap of 4mm. Find the capacitance of capacitor?

16. a) Derive the expression for capacitance of co-axial cable.

b) Derive the expression for capacitance of spherical capacitor?

17. a) Derive the expression for capacitance of composite parallel plate capacitor.

b) A parallel plate capacitor with air as a dielectric has a plate area of $36\Pi cm^2$ and the separation between the plates of 1mm.It is charged to 100V by connecting across a battery. If the battery is disconnected & plate separation is increased to 2mm. Calculate the change in

i) potential difference across the plates ii) energy stored.

18. a) State & prove the uniqueness theorem?

b) Explain & derive the boundary conditions for conductor-free space interface?

19. Derive poission's and laplace's equations? And write applications?

20. a) Derive an expression for energy stored of parallel plate capacitor.

b) A parallel plate capacitor consists of square metal plates of side 500mm and separated by 10mm slab of Teflon with ε_r=2 and 6mm thickness is placed on the lower plate leaving an air gap of 4mm thick between it & upper plate. If 100V is applied across the capacitor find D, E & V in Teflon & air?

UNIT-II

1(a) State Biot-savart's law?

b) Derive an expression for H of infinitely long straight conductor with line current placed along z-axis?

2. a) State and prove Amperes circuit law?

b) Derive an expression for H in case of Solonoid and Toroid using Amperes circuit law?

3) Derive an expression for H in case of infinitely long co-axial transmission line using Amperes circuit law?

4) (a) Define following i) Magnetic field Intensity ii) Magnetic flux density

b) Define different current distributions?

5) Derive two Maxwell's equations for static magnetic field?

6) Obtain an equation for force in magnetic field and explain?

7) Explain different potentials in static magnetic field with suitable expressions?

8) Derive an expression for H and B for finite length conductor carrying line current placed along z-axis?

9) (a) Define inductance and derive an expression for it ?

b) Obtain an expression for inductance in case of solenoid and toroid?

10) Explain the boundary conditions in static magnetic fields?

11) Derive four Maxwell's equations for static electromagnetic fields?

12) Explain the inconsistency of amperes circuit law?

13) State and prove faraday's law?

14) Explain boundary conditions for static electric fields?

15) Explain boundary conditions for static magnetic fields?

16) Derive four Maxwell's equations for time –varying electromagnetic fields?

18. Assignment Questions

Assignment No. 1

1 (a) Define electric field intensity in terms of point charge and describe its salient features.

(b) Two point charges Q1 = 5.0 C and Q2 = 1.0 nC are located at (-1, 1, -3) m and (3, 1,

0) m respectively. Determine the electric field at Q1 and Q2.

2 (a) State and explain Coulomb's law. Obtain an expression in vector form.

(b) Two uniform line charges of density 8nC/m are located in a plane with y = 0 at x = ±4m. Find the E- field at a point P(0m, 4m, 10m)

3. Find the force on a 100µC charge at (0, 0, 3)m if four like charges of 20µC are located on x and y axes at ± 4m.

4 (a) State and prove Gauss's law. Express Gauss's law in both integral and differential forms.

(b) Discuss the salient features and limitations of Gauss's law .

5. Given a point charge of $200\,\pi\,\varepsilon_o$ C at (3,-1,2), a line charge of $40\,\pi\,\varepsilon_o$ C/m on the x-axis, and a surface charge of $8\,\varepsilon_o$ C/m^2 on the plane x = -3, all in free space, find the potential at P(5,6,7) if V=0 at Q(0,0,1)

6. Find the capacitance per unit length of a coaxial conductor with outer radius of 5 mm and the inner radius of 0.5 mm of the dielectric has $\epsilon_r = 5.0$

7. A parallel plate capacitance has 500mm side plates of square shape separated by 10mm distance. A sulphur slab of 6mm thickness with $\epsilon_r = 4$ is kept on the lower plate. Find the capacitance of the set-up. If a voltage of 100 volts is applied across the capacitor, calculate the voltages at both the regions of the capacitor between the plates.

8. In a cylindrical conductor of radius 2mm, the current density varies with distance from the axis according to $J = 10^3\, e^{-400\rho}$ A/m^2. Find the total current I.

9. Conducting plates at z=1 cm and z= 5 cm are held at potentials of - 8 V and 6 V respectively. If the region between the plates is a homogeneous dielectric with $\varepsilon=5\varepsilon_0$, Find **a**) The capacitance between the plates per unit area; **b**) V(z) and **c**) D(z).

10. Two conducting planes are located at z=0 and 6 mm. In the region $0<z<2$ mm, there is a perfect dielectric for which $\varepsilon_{r1}=2$; for $2<z<5$ mm, let $\varepsilon_{r2}=5$. Find the capacitance per square meter of surface area if the region for which $5<z<6$ mm is **a**) air; **b**) ε_{r1} **c**) ε_{r2}

Assignment No. 2

1 Find magnetic field strength**, H**, on the axis of a circular current loop of radius'a', at a point P(0,0,h).

2 An infinitely long current element on X-axis carries a current of 1.0 mA in $\mathbf{a_x}$ direction. Determine **H** at the point P(5, 2, 1).

3 In the region $0< \rho <0.5$ m in cylindrical coordinates the current density is $4.5\, e^{-2\rho}\, \mathbf{a_z}$ A/m^2 And **J** = 0 elsewhere. Use Ampere's Law to find '**H**'

4. A long straight conductor with radius 'a' has a magnetic field strength $\mathbf{H} = (I_r/2\pi a^2)\, \mathbf{a_\varphi}$ within the conductor (r < a) and $\mathbf{H} = (I/2\pi r)\, \mathbf{a_\varphi}$ outside the conductor (r > a). Find the current density **J** in both the regions (r <a and r > a)

5. Find the magnetic field strength, **H** at the centre of a square conducting loop of side '2a' in Z=0 plane if the loop is carrying a current **I** in anti clock wise direction

6. State Maxwell's equations in their general deferential form and derive their form for harmonically varying field.

7. Explain boundary conditions for dielectric - dielectric and dielectric - conductor interfaces.

8. In free space **D** = Dm Sin (wt +β z)$\mathbf{a_x}$. Determine B and displacement current density.

9. Verify that the displacement current in the parallel plate capacitor is the same as the conduction current in the connecting wires.

10. Region 1, for which μr1 = 3 is defined by X < 0 and region 2, X < 0 has μr2 = 5 given H1 = 4 $\mathbf{a_x}$ + 3$\mathbf{a_y}$ -6 $\mathbf{a_z}$ (A/m). Determine H2 for X > 0 and the angles that H1 and H2 make with the interface.

Assignment No. 3

1. Derive expression for attenuation constant of EM wave.
2. A medium like copper conductor which is characterized by the parameters σ = 5.8 X 10^7 ʊ/m, ε_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.
3. Explain the wave propagation characteristics in good conductors
4. Explain the different types of polarization of uniform plane wave
5. The conductivity of silver is σ = 3 X 10^7 ʊ/m at microwave frequencies
   a) Find the skin depth at 10 GHz
   b) Calculate the frequency at which skin depth in sea water is one meter
6. State and prove poynting theorem
7. Derive an expression for reflection when a wave is incidence on a dielectric obliquely with parallel polarization.
8. Derive expression for Reflection and Transmission coefficients of an EM wave when it is incident normally on a dielectric.
9. Explain about
   a) Brewster angle
   b) Critical angle
   c) Total internal reflection
10. Define and distinguish between the terms perpendicular polarization, parallel polarization, for the case of reflection by a perfect conductor under oblique incidence

Assignment 4

1. Derive the general Transmission Line equations for parallel wire type lines.
2. Explain about line distortions and derive the condition for distortion-less line.
3. Derive the expression for attenuation constant, Phase shift constant and phase velocity of wave propagating in a distortion less transmission line
4. A loss less line has characteristic impedance of 70 Ω & Phase constant of 3 rad/m at 100 MHz. Calculate the inductance & capacitance per meter of the line.
5. Show that a finite length transmission line terminated by its characteristic impedance is equivalent to infinite line

Assignment 5

1. Draw the equivalent circuits of a transmission lines when
   i. length of the transmission line, $L < \lambda/4$, with shorted load
   ii. when $L < \lambda/4$, with open end
   iii. When $L = \lambda/4$ with open end
2. A low transmission line of 100 Ω characteristic impedance is connected to a load of 400 Ω. Calculate the reflection coefficient and standing wave ratio. Derive the Relationships used.
3. Define the reflection coefficient and derive the expression for the i/p impedance in terms of reflection coefficient.
4. Explain about the properties of smith chart.
5. Calculate the characteristic impedance, attenuation constant and phase constant of a transmission line if the following measurements have been made on the line $Z_{oc} = 550$ Ω and $Z_{sc} = 560$ Ω

19. Unit wise Quiz Questions and long answer questions

20. Tutorial problems

Tutorial sheets are available in Hard copy

21. Known gaps ,if any and inclusion of the same in lecture schedule

-Nil-

22. Discussion topics, if any

23. References, Journals, websites and E-links, if any

<u>References:</u>

1. Engineering Electromagnetics- Nathan Ida, 2^{nd} ed., 2005, Springer (India) Pvt Ltd, New Delhi
2. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck, 7 ed., 2006, TMH
3. Networks, Lines and Fields – John D. Ryder., 2^{nd} ed, 1999, PHI
4. Electromagnetic Field Theory and Transmission Lines – G.S.N.Raju, Pearson Edn, Pvt Ltd, 2005
5. Problems & Solutions of Engineering Electromagnetics by Experienced Teachers, CBS Publishers and Distributors, New Delhi

<u>Journals:</u>

1. Journal of Electromagnetic Waves and Applications
2. Progress In Electromagnetics Research (PIER) Journal

Websites:

http://iucee.org/iucee/course/view.php?id=151.

Course module on EMTL by Nannapaneni Narayana Rao is taken from this website

24. Quality Measurement Sheets

a. **Course end Survey**
b. **Teaching Evaluation**

25. Student List

II Year A-section

14R11A0401	ADITYA B
14R11A0402	ADULLA JANARDHAN REDDY
14R11A0403	ANDE HEMANTH REDDY
14R11A0404	ANKATI NAVYA
14R11A0405	ASHFAQ AZIZ AHMED
14R11A0406	BANDI SANDHYA
14R11A0407	BASWARAJ SHASHANK YADAV
14R11A0408	BITLA SRIKANTH REDDY
14R11A0409	BUDDANA DHARANI KUMAR
14R11A0410	CHEBARTHI RAMYA GAYATHRI
14R11A0411	CHETLAPALLI NAGA SAI
14R11A0412	DASARI DHAMODHAR REDDY
14R11A0413	G AYESHA SULTANA
14R11A0414	G MADHURI
14R11A0415	G RISHI RAJ
14R11A0416	G VAMSHI KRISHNA
14R11A0417	G VENKATESH YADAV
14R11A0418	GONDA RISHIKA
14R11A0419	GUDE GOPI
14R11A0420	JAGGANNAGARI MANOJKUMAR
14R11A0421	JAGGARI SRINIJA REDDY
14R11A0422	JALAGAM NANDITHA
14R11A0423	JAMMIKUNTLA SHIVA CHARAN
14R11A0424	JATAPROLU LAKSHMI
14R11A0425	JEKSANI SHREYA
14R11A0426	K VIJAY KUMAR
14R11A0427	KAALISETTY KRISHNA
14R11A0428	KAKARLA MOUNICA
14R11A0429	KARRE PRIYANKA
14R11A0430	KL N SATYANARAYANA
15R15A0401	RAMIDI SANDEEP REDDY
15R15A0402	ODDARAPU HARISHBABU
15R15A0403	KOLUKURI BHARGAVI
15R15A0404	ADEPU MOUNIKA
14R11A0431	KONDA KRITISH KUMAR
14R11A0432	KOPPULA RAHUL
14R11A0433	KURUGANTI RUNI TANISHKA
14R11A0434	L THRILOK
14R11A0435	MANDULA SANTOSHINI
14R11A0436	MATLA PRINCE TITUS
14R11A0437	NARSETTI SAIPRAVALIKA

14R11A0438	NIKITHA RAGI
14R11A0439	P VIJAYA ADITYA VARMA
14R11A0440	PASHAM VIKRAM REDDY
14R11A0441	PELLURI KARAN KUMAR
14R11A0442	PERURI CHANDANA
14R11A0443	PODUGU SRUJANA DEVI
14R11A0444	RAJNISH KUMAR
14R11A0445	RAJU PAVANA KUMARI
14R11A0446	RAMIDI NITHYA
14R11A0447	RAMOJI RAJESH
14R11A0448	S ALEKHYA
14R11A0449	SARANGA SAI KIRAN
14R11A0450	SHAIK SAMEER ALI
14R11A0451	SOUMYA MISHRA
14R11A0452	SRIRAMOJU MANASA
14R11A0453	THAMADA ARUN KUMAR
14R11A0454	T S SANTHOSH KUMAR
14R11A0455	V BAL RAJ
14R11A0456	V POOJA
14R11A0457	V SRIVATS VISHWAMBER
14R11A0458	V VISHNU VARDHAN REDDY
14R11A0459	VENNAMANENI VAMSI
14R11A0460	YERASI TEJASRI
15R15A0405	AVANCHA PRAVALIKA
15R15A0406	NELLUTLA VISHAL CHAITANYA
15R15A0407	VEMUNA JAMEENA

II Year B-section

14R11A0461	ADDAKULA SURESH
14R11A0462	AGARTI MADHU VIVEKA
14R11A0463	AKULA SAI KIRAN
14R11A0464	ANUMULA SNIGDHA
14R11A0465	B DIVYA
14R11A0466	B MANOHAR
14R11A0467	BANDARI MAMATHA
14R11A0468	BINGI DIVYA SUDHA RANI
14R11A0469	BIRE BHAVYA
14R11A0470	CH SAI BHARGAVI
14R11A0471	CHAVALI SUMA SIREESHA
14R11A0472	CHELLABOINA SHIVA KUMAR
14R11A0473	CHETTY AKHIL CHAND
14R11A0474	CHINTAPALLI MADHAV REDDY
14R11A0475	CHIVUKULA VENKATA
14R11A0476	D NAGA SUMANVITHA
14R11A0477	D VAMSI
14R11A0478	DHARMENDER KEERTHI
14R11A0479	EADARA NAGA SIRISHA
14R11A0480	ERANKI SAI UDAYASRI
14R11A0481	GANGA STEPHEN RAVI KUMAR
14R11A0482	GUNDAM SHRUTHI
14R11A0483	GUNDREVULA SAMEERA
14R11A0484	K NAGA REKHA
14R11A0485	KANDADI VARSHA
14R11A0486	KURELLI SAI VINEETH KUMAR
14R11A0487	MADDIKUNTA SOMA SHEKAR
14R11A0488	MAMILLA SAI NISHMA
15R15A0408	ERUKALA NIKITHA
15R15A0409	PUNGANUR JAYACHANDRA
15R15A0410	GALIPALLY BHARGAVA
15R15A0411	PADMA ARUNRAJ
15R15A0412	JAMALAPURAM NAVEEN

14R11A0489	MARELLA NAGA LASYA PRIYA
14R11A0490	MARKU VENKATESH
14R11A0491	MOHAMED KHALEEL
14R11A0492	MOHAMMED WASEEM AKRAM
14R11A0493	MOTURI DIVYA
14R11A0494	MUDIUM KOUSHIKA
14R11A0495	MYLAPALLI RAMBABU

14R11A0496	NAGU MOUNIKA
14R11A0497	NEELAM SNEHANJALI
14R11A0498	NIDAMANURI VENKATA VAMSI
14R11A0499	NIKHIL KUMAR N
14R11A04A0	ORUGANTI HARSHINI
14R11A04A1	PARAMKUSAM NIHARIKA
14R11A04A2	PASAM ABHIGNA
14R11A04A3	PATI VANDANA
14R11A04A4	PODISHETTY MANOGNA
14R11A04A5	PONAKA SREEVARDHAN
14R11A04A6	R NAVSHETHA
14R11A04A7	R PRANAY KUMAR
14R11A04A8	RAMIDI ROJA
14R11A04A9	RUDRA VAMSHI
14R11A04B0	S SHARAD KUMAR
14R11A04B1	SAGGU SOWMYA
14R11A04B2	TADELA SARWANI
14R11A04B3	THOTA SAI BHUVAN
14R11A04B4	VALLAPU HARIKRISHNA
14R11A04B5	VECHA PAVAN KUMAR
14R11A04B6	Y SAI VISHWANATH
15R15A0413	MACHANNI BALAKRISHNA
15R15A0414	ANABOINA MAHENDER
15R15A0415	ANABOINA SHIVA SAI
15R15A0416	VEMULA VINITHA
15R15A0417	CHEVU NAGESH

II Year C-section

14R11A04B9	ANAMALI REETHIKA
14R11A04C0	ARUMILLI LEKYA
14R11A04C1	ARUMUGAM ASHWINI
14R11A04C2	BASAVARAJU MEGHANA
14R11A04C3	BEERAM TEJASRI REDDY
14R11A04C4	BHARAT SAKETH
14R11A04C5	BOMMANA HARIKADEVI
14R11A04C6	BYRAGONI ROJA
14R11A04C7	CANDHI SHASHI REKHA
14R11A04C8	CH RENUKA
14R11A04C9	CHAGANTI MOUNICA
14R11A04D0	CHITTARLA LOKESH GOUD
14R11A04D1	D LAVANYA
14R11A04D2	D MANIKANTA
14R11A04D3	DASARI VENKATA NAGA SAISH
14R11A04D4	DODDA MANOJ
14R11A04D5	E RAHUL CHOWDHARY
14R11A04D6	GOWRISHETTY VINEETHA
14R11A04D7	GUNTUPALLI RAVI TEJA
14R11A04D8	KONDURI LAKSHMI ANUSHA
14R11A04D9	K SASIDHAR
14R11A04E0	KANAKA RAMYA PRATHIMA
14R11A04E1	KASTURI SHIVA SHANKER
14R11A04E2	KODHIRIPAKA DHENUSRI
14R11A04E3	KOLA AISHWARYA
14R11A04E4	KONDOJU AKSHITHA
14R11A04E5	KOUDAGANI ALEKHYA REDDY
14R11A04E6	KUMMARIKUNTA PRASHANTH
14R11A04E7	KURVA SAI KUMAR
14R11A04E8	M AJAY KRISHNA
15R11A0418	KOTA RAJESH
15R11A0419	N MOUNIKA
15R11A0420	ARTHI SHARMA

14R11A04E9	M MRIDULA GAYATRI
14R11A04F0	MANGALAPALLI SRAVANTHI
14R11A04F1	MERUGU PALLAVI
14R11A04F2	MITHIN VARGHESE
14R11A04F3	MOHD EESA SOHAIL
14R11A04F4	MUCHUMARI HARSHA
14R11A04F5	MUNUGANTI PRADHYUMNA

II Year D-section

14R11A04F6	N DURGA RAJ
14R11A04F7	N SAKETH
14R11A04F8	N SANDHYA
14R11A04F9	NALLAGONI SRAVANTHI
14R11A04G0	P MANMOHAN SHASHANK
14R11A04G1	PRABHALA SRUTHI
14R11A04G2	PRAYAGA VENKATA SATHYA
14R11A04G3	R SAILESH
14R11A04G4	SAMBANGI POOJA
14R11A04G5	SAMEENA
14R11A04G6	SANGOJI SAI CHANDU
14R11A04G7	SURANENI NAMRATHA
14R11A04G8	TADAKAPALLY VIVEK REDDY
14R11A04G9	THUMUKUMTA VAMSHI TEJA
14R11A04H0	TIRUNAGARI SRAVAN KUMAR
14R11A04H1	TRIPURARI SOWGANDHIKA
14R11A04H2	TUNIKI MADHULIKA REDDY
14R11A04H3	U SAI MANASWINI
14R11A04H4	VAIDYA KEERTHI MALINI
14R11A04H5	VANGETI PRAVALLIKA
14R11A04H6	VASIREDDY VENKATA SAI
14R11A04H7	VELDURTHY SAI KEERTHI
14R11A04H8	WILSON DAVIES
15R11A0421	RAJPET SHIRISHA
15R11A0422	MALOTH RAMESH NAIK
15R11A0423	PAILLA PREM RAJ REDDY

14R11A04H9	A SIRISHA
14R11A04J0	ABHIJEET KUMAR
14R11A04J1	ADULLA PRANAV REDDY
14R11A04J2	AINAPARTHI
14R11A04J3	AMBATI SHIVA SAI
14R11A04J4	ANU PRASAD
14R11A04J5	B SAI APOORVA
14R11A04J6	B SRI KRISHNA SAI KIREETI
14R11A04J7	CHITTOJU LAKSHMI
14R11A04J8	CHOWDARAPALLY SANTOSH
14R11A04J9	D SAHITHI
14R11A04K0	DEVULAPALLI SAI CHAITANYA
14R11A04K1	DUSARI ANUSHA
14R11A04K2	GOLLAPUDI SRIKETH
14R11A04K3	GOLLIPALLY TEJASREE
14R11A04K4	GOUTE SHRAVAN KUMAR
14R11A04K5	GUDA PRATHYUSHA REDDY
14R11A04K6	JUNNU RAVALI
14R11A04K7	K DEVI PRIYANKA
14R11A04K8	KANDULA MANI
14R11A04K9	KARRA AVINASH
14R11A04L0	KASULA PRADEEP GOUD
14R11A04L1	KOMARAKUNTA SHASHANK
14R11A04L2	KOTHAKOTA PHANI RISHITHA
14R11A04L3	MADHADI NIKHIL KUMAR
14R11A04L4	MANDUMULA RAGHAVENDRA
14R11A04L5	MOHD HAMEED
14R11A04L6	MOHD SHAMS TABREZ
14R11A04L7	MORSU GANESH REDDY
15R15A0424	ARURI REJENDER
15R15A0425	KALALI BHAVANI
15R15A0426	JANUGANI SAI KRISHNA
15R15A0427	SATHENDER KUMAR YADAV
14R11A04L8	MUKKERA VARUN
14R11A04L9	NAGULAPALLY MANOHAR
14R11A04M0	NAMBURI LAKSHMI MANJUSHA

14R11A04M1	NIROGI SURYA PRIYANKA
14R11A04M2	NUNE SAI CHAND
14R11A04M3	PALLETI SUSHMITHA
14R11A04M4	PANCHAYAT SHAMILI
14R11A04M5	POOSA JAI SAI NISHANTH
14R11A04M6	PRANAV RAJU A
14R11A04M7	RAYCHETTI CHANDRASENA
14R11A04M8	REBBA BHAVANI
14R11A04M9	S BHARATH SAGAR
14R11A04N0	S V N SURYA TEJASWINI
14R11A04N1	SAMA MANVITHA REDDY
14R11A04N2	SHAMALA MEGHANA
14R11A04N3	SMITHA KUMARI PATRO
14R11A04N4	T L SARADA RAMYA
14R11A04N5	T VINAY KUMAR
14R11A04N6	TABELA OMKAR
14R11A04N7	TADACHINA SAINATH REDDY
14R11A04N8	VANGA MOUNIKA
14R11A04N9	VARRI PRASHANTHI
14R11A04P0	VASARLA SAI TEJA
14R11A04P1	VISHWANATHAM ANUSHA
14R11A04P2	Y SRI SAI ADITYA
14R11A04P3	YAKKALA ASHIKA
14R11A04P4	YALAVARTHY MAHIMA
14R11A04P5	YALLAPRAGADA SAI TEJASRI
14R11A04P6	YARASI SAI RAMYA REDDY
15R15A0428	KADEM PRAVEEN
15R15A0429	ARROJU AKHIL
15R15A0430	CH POOJA
15R18A0401	G SHREEHARSHA REDDY

26. Group-Wise students list for discussion topics

Group 1

14R11A0401	ADITYA B
14R11A0402	ADULLA JANARDHAN REDDY
14R11A0403	ANDE HEMANTH REDDY
14R11A0404	ANKATI NAVYA
14R11A0405	ASHFAQ AZIZ AHMED
14R11A0406	BANDI SANDHYA
14R11A0407	BASWARAJ SHASHANK YADAV
14R11A0408	BITLA SRIKANTH REDDY
14R11A0409	BUDDANA DHARANI KUMAR
14R11A0410	CHEBARTHI RAMYA GAYATHRI
14R11A0411	CHETLAPALLI NAGA SAI
14R11A0412	DASARI DHAMODHAR REDDY
14R11A0413	G AYESHA SULTANA
14R11A0414	G MADHURI
14R11A0415	G RISHI RAJ

Group 2

14R11A0471	CHAVALI SUMA SIREESHA
14R11A0472	CHELLABOINA SHIVA KUMAR
14R11A0473	CHETTY AKHIL CHAND
14R11A0474	CHINTAPALLI MADHAV REDDY
14R11A0475	CHIVUKULA VENKATA
14R11A0476	D NAGA SUMANVITHA
14R11A0477	D VAMSI
14R11A0478	DHARMENDER KEERTHI
14R11A0479	EADARA NAGA SIRISHA
14R11A0480	ERANKI SAI UDAYASRI
14R11A0481	GANGA STEPHEN RAVI KUMAR
14R11A0482	GUNDAM SHRUTHI
14R11A0483	GUNDREVULA SAMEERA

Group 3

14R11A04D0	CHITTARLA LOKESH GOUD
14R11A04D1	D LAVANYA
14R11A04D2	D MANIKANTA
14R11A04D3	DASARI VENKATA NAGA SAISH
14R11A04D4	DODDA MANOJ
14R11A04D5	E RAHUL CHOWDHARY
14R11A04D6	GOWRISHETTY VINEETHA
14R11A04D7	GUNTUPALLI RAVI TEJA
14R11A04D8	KONDURI LAKSHMI ANUSHA
14R11A04D9	K SASIDHAR
14R11A04E0	KANAKA RAMYA PRATHIMA
14R11A04E1	KASTURI SHIVA SHANKER REDDY
14R11A04E2	KODHIRIPAKA DHENUSRI
14R11A04E3	KOLA AISHWARYA
14R11A04E4	KONDOJU AKSHITHA
14R11A04E5	KOUDAGANI ALEKHYA REDDY

Group 4

14R11A04J5	B SAI APOORVA
14R11A04J6	B SRI KRISHNA SAI KIREETI
14R11A04J7	CHITTOJU LAKSHMI
14R11A04J8	CHOWDARAPALLY SANTOSH
14R11A04J9	D SAHITHI
14R11A04K0	DEVULAPALLI SAI CHAITANYA
14R11A04K1	DUSARI ANUSHA
14R11A04K2	GOLLAPUDI SRIKETH
14R11A04K3	GOLLIPALLY TEJASREE
14R11A04K4	GOUTE SHRAVAN KUMAR
14R11A04K5	GUDA PRATHYUSHA REDDY
14R11A04K6	JUNNU RAVALI
14R11A04K7	K DEVI PRIYANKA
14R11A04K8	KANDULA MANI
14R11A04K9	KARRA AVINASH
14R11A04L0	KASULA PRADEEP GOUD
14R11A04L1	KOMARAKUNTA SHASHANK
14R11A04L2	KOTHAKOTA PHANI RISHITHA