CMR ENGINEERING COLLEGE
Kandlakoya (V), Medchal Road, Hyderabad – 501401

Department of Electronics and Communication Engineering

COURSE FILE

Sub: ELECTROMAGNETIC WAVES AND FIELDS **A.Y.2022-23**

Year: 3rd YEAR B.Tech I Semester

CONTENTS

Contents of Course file

1. Vision & Mission of the Department:

Vision

To promote excellence in technical education and scientific research in Electronics And Communication engineering for the benefit of society.

Mission

- To impart excellent technical education with state of art facilities inculcating values and lifelong learning attitude.
- To develop core competence in our students imbibing professional ethics and team spirit.
- To encourage research benefiting society through higher learning

2. PEOs & POs

PEO

1. Excel in professional career & higher education in Electronics & Communication Engineering and allied fields through rigorous quality education.
2. Exhibit professionalism, ethical attitude, communication skills, team work in their profession and adapt to current trends by engaging in lifelong learning.
3. Solve real life problems relating to Electronics & Communications Engineering for the benefits of society.

PSO

1. Ability to apply concepts of Electronics & Communication Engineering to associated research areas of electronics, communication, signal processing, VLSI, Embedded systems
2. Ability to design, analyze and simulate a variety of Electronics & Communication functional elements using hardware and software tools along with analytic skills

POs

1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
2	**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.
3	**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.
4	**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.
5	**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**.**
6	**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**.**
7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	**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.
11	**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.
12	**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.

3. Mapping of course out comes with POs

Course Name: Electromagnetic Fields and Waves (EC402PC):

Course Code.CO No. EC402PC	Course Outcomes (CO's)
At the end of the course student will be able to	
CO.1	To learn Basic Laws, Concepts and Proofs related to electrostatic fields and magneto static fields, and apply them to solve physics and engineering problems
CO.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 problem
CO.3	To analyze the characteristics of uniform plane waves determine their propagation parameters and estimate the same for dielectric and dissipative media.
CO.4	To conceptually understand the UPW polarization features and Poynting theorem and apply them for practical problems
CO.5	To conceptually understand the waveguides and to determine the characteristics of rectangular waveguides, microstrip lines

Course Outcome (CO)-Program Outcome (PO) Matrix:

CO's/ PO's	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO.1	3	3	2	-	-	-	-	-	-	-	-	-
CO.2	3	3	-	-	-	-	-	-	-	-	-	-
CO.3	-	2	3	2	-	-	-	-	-	-	-	-
CO.4	-	-	3	2	-	-	-	-	-	-	-	-
CO.5	-	-	3	2	-	-	-	-	-	-	-	-

Course Outcome (CO)-Program Specific Outcome (PSO) Matrix:

CO's/ PSO's	PSO1	PSO2
CO.1	2	3

CO.2	3	2
CO.3	3	3
CO.4	2	3
CO.5	3	2

4. Syllabus Copy and Suggested/Reference Books

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

II Year B.Tech ECE-II SEM **T/P/C 3 0 0 3**

ELECTROMAGNETIC FIELDS AND WAVES

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. 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.

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.

UNIT – III: 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 Forms, Conditions at a Boundary Surface - Dielectric-Dielectric and Dielectric-Conductor Interfaces.

UNIT – IV: EM Wave Characteristics: Wave Equations for Conducting and Perfect Dielectric Media, Uniform Plane Waves – Definitions, Relation 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 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.

UNIT – V: Waveguides: Electromagnetic Spectrum and Bands. Rectangular Waveguides – Solution of Wave Equations in Rectangular Coordinates, TE/TM mode analysis, Expressions for Fields, Characteristic Equation and Cut-off Frequencies, Dominant and Degenerate Modes, Sketches of TE and TM mode fields in the cross-section, Phase and Group Velocities, Wavelengths and Impedance Relations, Equation of Power Transmission, Impossibility of TEM Mode. Microstrip Lines – Zo Relations, Effective Dielectric Constant.

TEXT BOOK:

1. Engineering Electromagnetics – William H. Hayt Jr. and John A. Buck, 8th Ed., McGrawHill,2014

2. Principles of Electromagnetics – Matthew N.O. sadiku and S.V. Kulkarni, 6th Ed., Oxford University Press, Aisan Edition, 2015.

REFERENCE BOOK:

1.Electromagnetic Waves and Radiating Systems – E.C. Jordan and K.G. Balmain, 2ndEd., 2000, PHI.

2. Engineering Electromagnetics – Nathan Ida, 2nd Ed., 2005, Springer (India) Pvt. Ltd., New Delhi.

5. INDIVIDUAL TIME TABLE

SUBJECT: EMFW SECTION:II (A&B) NAME: N . LAKSHMI DEVI

DAY/TIME	9.10-10.10	10.10-11.00	11.00-11.50	11.50-12.40	12.40-01.20	01.20-2.10	2.10-3.00	3.00-3.50
MON			EMFW-A		LUNCH			
TUE	EMFW-A							
WED		EMFW-B						
THU						EMFW-B		
FRI	EMFW-B					EMFW-A		
SAT		EMFW-A				EMFW-B		

6. SESSION PLAN

UNIT No.	UNIT Title	No. of Lectures Required
Unit-I	Electrostatics	17
Unit-II	Magnetostatics	8
Unit-III	Maxwell's Equations (Time Varying Fields)	8
Unit-IV	EM Wave Characteristics	15
Unit-V	Waveguides	9

7. Detailed Lecture Plan

Name of the topic	Sub topics	No. of classes	Text books	Remarks
UNIT I				
ELECTROSTATICS	Introduction, coordinate systems	L1	T1	
	Vector calculus	L2	T1,R2	
	Differential vector component	L3	T1,R1	
	Lapalcian, poission's euations	L4	T1,R2	
	Coulomb's Law	L5	T1,R1	
	Electric Field Intensity – Fields due to Different Charge Distributions	L6	T1,R1	
	Electric Flux Density, Gauss Law and Applications	L7, L8	T1,R1	
	Electric Potential, Relations Between E and V, Maxwell's Two Equations for Electrostatic Fields,	L9,L10	T1,R1	
	Energy Density	L11	T1,R2	
	Convection and Conduction Currents	L12	T1,R2	
	Dielectric Constant, Isotropic and Homogeneous Dielectrics	L13	T1,R1	
	Continuity Equation, Relaxation Time	L14	T1,R1	
	Poisson's and Laplace's Equations; Capacitance – Parallel Plate	L15	T1,R1	
	Coaxial, Spherical Capacitors	L16	T1,R1	
	Illustrative Problems	L17	T1,R1	
	No. of classes required: **17**			
UNIT II				
	Biot-Savart's Law	L18	T1	
	Ampere's Circuital Law and	L19,L20	T1	

Magnetostatics	Applications			
	Magnetic Flux Density, Maxwell's Two Equations for Magnetostatic Fields	L21	T2,R1	
	Magnetic Scalar and Vector Potentials	L22,L23	**T1,R1**	
	Forces due to Magnetic Fields,	L24	**T2**	
	Ampere's Force Law	L25	**T1**	
			T1,T2,R1	
	No. of classes required:8			
UNIT III				
Maxwell's Equations (Time Varying Fields	Faraday's Law and Transformer EMF	L26	**T1,R1**	
	Inconsistency of Ampere's Law and Displacement Current Density	L27,L28	**T1,R1**	
	Maxwell's Equations in Different Final Forms and Word Statements	L29	**T1,R1**	
	Conditions at a Boundary Surface - Dielectric-Dielectric and Interfaces.	L30,L31	**T2,R1**	
	Conditions at a Boundary Surface- Dielectric-Conductor Interfaces.	L32,L33	**T1**	
	No. of classes required:8			
UNIT IV				
EM Wave Characteristics	Wave Equations for Conducting and Perfect Dielectric Media	L34	**T2,R1**	
	Uniform Plane Waves – Definition, All Relations Between E & H	L35,L36	**T1,R1**	
	Sinusoidal Variations	L37	**T1,R1**	
	Wave Propagation in Lossless and Conducting Media	L38	**T2,R1**	

	Conductors & Dielectrics – Characterization	L39	**T1,R1**	
	Wave Propagation in Good Conductors and Good Dielectrics	L40,L41	**T2,R1**	
	Polarization	L42	**T1,R2**	
	Reflection and Refraction of Plane Waves – Normal and Oblique Incidences for both Perfect Conductor and Perfect Dielectrics	L43,L44	**T2,R1**	
	Brewster Angle, Critical Angle and Total Internal Reflection	L45	**T1,R1**	
	Surface Impedance, Poynting Vector and Poynting Theorem – Applications	L46,L47	**T2,R1**	
	Illustrative Problems	L48	**T1,R2**	
	No. of classes required:15			
UNIT V				
Waveguides	Electromagnetic Spectrum and Bands	L49	**T2,R2**	
	Rectangular Waveguides – Solution of Wave Equations in Rectangular Coordinates	L50	**T1,R2**	
	TE/TM mode analysis Expressions for Fields, Characteristic Equation and Cut-off Frequencies	L51	**T1,R2**	
	Dominant and Degenerate Modes, Sketches of TE and TM mode fields in the cross-section	L52,L53	**T1,R2**	
	Phase and Group Velocities, Wavelengths and Impedance Relations	L54	**T1,R2**	
	Equation of Power Transmission, Impossibility of TEM Mode	L55	**T2,R2**	
	Microstrip Lines – Zo Relations, Effective Dielectric Constant.	L56,L57	**T1,R2**	
	No. of classes required:09			

	Total No. of Classes :57

8. Session Execution Log:

S.NO	Units	No. of Lectures Taken	Covered/ Not Covered
1	Unit I	17	Covered
2	Unit II	8	Covered
3	Unit III	8	Covered
4	Unit IV	15	Covered
5	Unit V	9	Covered

9. Assignment Questions

ELECTROMAGNETIC FIELDS AND WAVES MID –I ASSIGNMENT-QUESTIONS

SET - I

1. State and Explain Colomb's law
2. Explain the types of charge distributions
3. Explain the types of capacitors
4. State Maxwell's equations in integral form and word form
5. State and derive Maxwell's equations in Differential form.

SET –II

1. Explain work done and electric potential and derive the relation between electric potential and electric field
2. Derive the expression of energy density and explain?
3. Derive poisons and current continuity equations?
4. Obtain the Magnetic field intensity of an infinite long coaxial cable?
5. Explain about magnetic flux, magnetic flux density and scalar magnetic potential with necessary equations?

SET-III

1. Derive and explain the electric field intensity due to surface charge and volume charge
2. State and explain Gauss law
3. Explain electric flux density for infinite line charge and also using gauss law
4. Explain ampere circuit law
5. Explain applications of ampere circuit law

ELECTROMAGNETIC FIELDS AND WAVES

MID- II ASSIGNEMNT QUESTIONS

SET-I

1. What is the inconsistency in ampere circuit law explain?
2. Define and derive an expression for cut off frequency of rectangular wave guide
3. Derive the boundary conditions for dielectric to conducting media
4. Define uniform plane wave and derive Helmholtz equations with solutions
5. Explain pointing theorem?

SET-II

1. Explain pointing vector
2. Explain the propagation of TE waves in rectangular waveguide
3. Explain the dominant modes in rectangular wave guide
4. Explain mode of propagation of TE and TM waves?
5. Define skip distance , Brewster angle , transmission coefficient and reflection coefficient

SET-III

1. What is the inconsistency in ampere circuit law explain?
2. Define and derive an expression for cut off frequency of rectangular wave guide
3. Explain the dominant modes in rectangular wave guide
4. Explain mode of propagation of TE and TM waves?
5. Define uniform plane wave and derive Helmholtz equations with solutions

10. Sample assignment script

(Attached separately)

11. Unit-wise course material

(Attached separately)

12.Mid exam question papers

MID-1

(Attached separately)

MID – II

1 A) What is the inconsistency in ampere circuit law explain?

B). Define and derive an expression for cut off frequency of rectangular wave guide

2. Derive the boundary conditions for dielectric to conducting media

3A) Define uniform plane wave and derive Helmholtz equations with solutions

B) Explain pointing vector

4A) Explain the propagation of TE waves in rectangular waveguide

B) Explain mode of propagation of TE and TM waves?

13. SCHEME OF EVALUATION:

1. A)Ampere circuit law statement :1 Mark
   Proof/ Derivation: 1.5 Marks
   B) Definition :1 Mark
   Derivation: 1 Mark
   Formula: 0.5 Mark
2. Boundary conditions statements :1 Mark
   Diagram: 0.5 Mark
   Boundary conditions consideration: 1 Mark
   Derivation / Proof: 2.5 Marks
3. A) Uniform plane wave definition:0.5 Mark
   Wave Equations Derivation: 1 Mark
   Solutions of wave equations: 1 Mark
   B)Pointing vector equation :1 mark
   Derivation: 1.5 Marks
4. A) Maxwell's equations :1 Marks
   Derivation: 1.5 Marks
   B) Dominant mode definition: 0.5 Mark
   TE modes: 1 Mark

TM modes: 1 Mark

14.SAMPLE MID ANSWER SCRIPT

(Attached Separately)

15.MATERIAL COLLECTED FROM INTERNET/WEBSITES

EMTL NOTES.rar

16.POWER POINT PRESENTATIONS

EMTL NOTES.rar

17.PREVIOUS QUESTION PAPERS

UNIT - I

1. Given that potential V=10sinθcosΦ/r2 find the electric flux density D at (2,π/2,0)
2. Derive an expression for the electric field due to a straight and infinite uniformly charged wire of length 'L' meters and with a charge density of +λ c/m at a point P which lies along the perpendicular bisector of wire.
3. Explain poisons and Laplace's equations.
4. A uniform line charge ρL =25Nc/m lies on the x=3m and y=4m in free space .Find the electric field intensity at a point (2,3,15)m.
5. Obtain the expression for the energy stored in a capacitor.
6. Drive an expression for energy stored and energy density in an electrostatic field.
7. Derive an expression for the capacitance of two wire transmission line.
8. Derive an expression for capacitance of concentric spheres.
9. Derive an expression for capacitance of co-axial cable.
10. Explain and derive the polarization of a dielectric materials.
11. List out the properties of dielectric materials.
12. Derive an expression for series and parallel plate capacitor.
13. The electric field in a spherical co-ordinate is given by E=rρr/5ε. Show that closed ∫E.dS=∫(▼.E)Dv.
14. State and proof divergence theorem and strokes theorem.

15. Check validity of the divergence theorem considering the field D=2xy ax +x2ay c/m2 and the rectangular parallelepiped formed by the planes x=0,x=1,y=0,y=2 & z=0,z=3.
16. A vector field D=[5r2/4]Ir is given in spherical co-ordinates. Evaluate both sides of divergence theorem for the volume enclosed between r=1&r=2.
17. Given A= 2r cosΦ+Riφ in cylindrical co-ordinates for the contour x=0to1 y=0to1 , verify stoke's theorem.
18. Explain three co-ordinate system.
19. State and proof gauss law .and explain applications of gauss law.

UNIT – II

1. Derive the expressions for magnetic field intensity due to finite and infinite line.
2. Derive the expressions for magnetic flux intensity due to solenoid of the coil.
3. Derive the expressions for magnetic field intensity due to toroidal coil and circular coil.
4. Derive an expression for energy stored and energy density in magnetic field.
5. Derive an expression for self inductance of two wire transmission line.
6. Derive an expression for force between two current carrying conductors.
7. Derive an expression for co-efficient of coupling.
8. Explain Magnetic materials and scalar and vector magnetic potentials.
9. Derive the expressions for boundary conditions in magnetic fields.
10. Derive the expression for torque developed in a rectangular closed circuit carrying current I a uniform field.

UNIT - III

1. Explain the relation between field theory and circuit theory.
2. Derive an expression for displacement, conduction current densities. Also obtain an expression for continuity current relations
3. Derive all the maxwells equations. i)Maxwells equation from electric Gauss law.

ii) Maxwells equation from magnetic Gauss law. iii)Maxwells equation from Amperes law.

iv) Maxwells equation from Faradays law.

4.State and explain Faradays and Lenzs law of induction and derive maxwells equation.

UNIT IV

1. A uniform plane wave of 200 MHz, traveling in free space Impinges normally on a large block of material having εr =4 , μr =9 and σ =0. Calculate transmission and reflection co efficient of interface.

2. What are the different ways of EMF generation? Explain with the governing equations and suitable practical examples.

3. With necessary explanation, derive the maxwell's equation in differential and integral forms
4. Write short notes on faradays law of electromagnetic induction.

5. What do you mean by displacement current? write down the expression for the total current density

6. In a material for which σ=5 s/m and εr=1 and E=250 sin 1010t (V/m). find the conduction and displacement current densities.

7. Find the total current in a circular conductor of radius 4mm if the current density Varies according to J=104/R A/m2 .

8. The magnetic field intensity in free space is given as H=H0sinθ ay t A/m. where θ=ωt-βz and β is a constant quantity. Determine the displacement current density.

9. Show that the ratio of the amplitudes of the conduction current density and displacement current density is σ/ωε,for the applied field amplitude ratio if the applied field is E=Em e-t/λ where λ is real.

10. Calculate the attenuation constant and phase constant for the uniform plane wave with the frequency of 10GHz in a medium for which μ=μ0, εr=2.3 and σ=2.54x10^-4Ω/m

11. Derive the expression for the attenuation constant ,phase constant and intrinsic impedance for a uniform plane wave in a good conductor.

12. Derive the one dimensional general wave equation and find the solution for wave equation.

13. Discuss about the plane waves in lossy dielectrics.

14. Discuss about the plane waves in lossless dielectrics.

15. Briefly explain about the wave incident

(i) Normally on perfect conductor

(ii) Obliquely to the surface of perfect conductor.

16. Briefly explain about the wave incident

(i) Normally on perfect dielectrics

(ii) Obliquely to the surface of perfect dielectrics.

17. Assume that Eland H waves, traveeling in free space, are normally Incident on the interface with a perfect dielectric with $\varepsilon_r=3$ .calculate the magnitudes of incident, reflected and transmitted E and H waves at the interface.

UNIT -V

1. Derive the field equations for Rectangular Waveguide in TE mode starting from Maxwell's equations.

2. Determine the equations of Fields of Rectangular waveguide in TM mode starting from Maxwell's equations.

3. Write a brief notes about the microstrip lines. Mention the expressions for characteristic impedance, Q factor and dielectric losses existing in microstrip line.

4. Why TEM wave is not possible in Rectangular waveguide?

18. REFERENCES (TEXT BOOKS/WEBSITES/JOURNALS)

WEBSITES:

1. NPTEL VIDEO LECTURES:
   https://nptel.ac.in/courses/108/106/108106073/

2. COURSERA:

   https://www.coursera.org/lecture/electrodynamics-introduction/1-1-introduction-to-electromagnetism-qiIQb

3. MIT OPEN COURSEWARE:

   https://ocw.mit.edu/courses/physics/8-311-electromagnetic-theory-spring-2004/index.htm

EXPERT DETAILS

The Expert Details which have been mentioned below are only a few of the eminent ones known Internationally, Nationally and Locally. There are a few others known as well.

INTERNATIONAL

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JOURNAL:

INTERNATIONAL

1. **Journal of Electromagnetic waves and applications - https://www.tandfonline.com/toc/tewa20/current**
2. **Electromagnetics https://www.tandfonline.com/toc/uemg20/current**
3. IEEE Transactions on Electromagnetic Compatibility
4. IEEE Transactions on Microwave Theory and Techniques
5. IEEE Transactions on Antennas and Propagation