ECT302	ELECTROMAGNETICS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course aims to impart knowledge on the basic concepts of electric and magnetic fields and its applications.

Prerequisite:MAT102 Vector Calculus

Course Outcomes: After the completion of the course the student will be able to

CO 1 K2	To summarize the basic mathematical concepts related to electromagnetic vector fields.
CO 2 K3	Analyse Maxwell's equation in different forms and apply them to diverse engineering problems.
CO3 K3	To analyse electromagnetic wave propagation and wave polarization
CO4 K3	To analyse the characteristics of transmission lines and solve the transmission line problems using Smith chart.
CO5 K3	To analyse and evaluate the propagation of EM waves in Wave guides.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	3	1	1								2
CO2	3	3	1	1								2
CO3	3	3	1	1								2
CO4	3	3	1	1								2
CO5	3	3	1	1								2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember K1			
Understand K2	20	20	40
Apply K3	30	30	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): To summarize the basic mathematical concepts related to electromagnetic vector fields. (K2)

1. State and explain divergence theorem. Give a geometrical explanation.

2. Find the curl of the vector A =2rcosϕ a_ρ +r a_ϕ in cylindrical coordinates

3. Show that curl grad **F** and div curl **F** are identically zero.

4.Show that $V = \frac{1}{4\pi\xi_o}\frac{Q}{r}$ where $r = (x^2 + y^2 + z^2)^{1/2}$ satisfies Laplace's equation.

Course Outcome 2 (CO2): Analyse Maxwell's equation in different forms and apply them to diverse engineering problems. (K3)

1. State and explain Maxwell's equations in the integral and differential forms.

2. Derive the solution of uniform plane wave in lossy dielectric medium.

Course Outcome 3 (CO3): To analyse electromagnetic wave propagation and wave polarization (K3)

1. Derive an expression for reflection coefficient of a plane wave under oblique incidence with parallel polarization at a dielectric interface.

2. Explain wave polarization and different polarisation with example.

3. Derive the expression for Brewster angle for parallel polarised wave.

Course Outcome 4 (CO4): To analyse the characteristics of transmission lines and solve the transmission line problems using Smith chart. (K3)

1.A transmission line of length 0.2 λ and characteristic impedance 100Ω is terminated with a load impedance of 50+200j . Find input impedance, reflection coefficient at load end, reflection coefficient at the input end and VSWR.

2. A lossless transmission line has a characteristic impedance of 50Ω and phase constant of 3 Rad/ m at 100 MHz . Find Inductance per meter and Capacitance per meter of the transmission line .

3. A 50 + j200 Ω load is connected to a 100Ω lossless transmission line . Using Smith chart , find i. Reflection coefficient at load ii. VSWR

Course Outcome 5 (CO5): To analyse and evaluate the propagation of EM waves in Wave guides.(K3)

1.For TE10 mode of propagation in a rectangular wave guide, with length 8cm and

6 cm respectively , find the following when frequency of operation is 6 GHz .

i. Cut off frequency

ii. Cut off wavelength

iii. Guide wavelength

iv. Phase constant

v. Phase velocity

vi. Group velocity

vii. Wave impedance

2.A rectangular wave guide has a dimension of 3cm x 5cm , and is operating at a frequency of 10 GHz . Calculate the cutoff wavelength, cutoff frequency , guide wavelength , phase velocity and group velocity . and the wave impedance for TE10 mode.

3.Derive the expression for Electric and magnetic field intensities for TM mode of propagation of rectangular waveguide.

SYLLABUS

MODULE 1 :

Introduction to Electromagnetic Theory. Review of vector calculus- curl, divergence gradient. Rectangular, cylindrical and spherical coordinate systems. Expression of curl divergence and Laplacian in cartesian, cylindrical and spherical coordinate system. Electric field and magnetic field, Review of Coulomb's law, Gauss law and Amperes current law. Poisson and Laplace equations, Determination of E and V using Laplace equation.

MODULE 2 :

Derivation of capacitance and inductance of two wire transmission line and coaxial cable. Energy stored in Electric and Magnetic field. Displacement current density, continuity equation. Magnetic vector potential. Relation between scalar potential and vector potential. Maxwell's equation from fundamental laws. Boundary condition of electric field and magnetic field from Maxwells equations.Solution of wave equation.

MODULE 3 :

Propagation of plane EM wave in perfect dielectric, lossy medium, good conductor, media-attenuation, phase velocity, group velocity, skin depth. Reflection and refraction of plane electromagnetic waves at boundaries for normal & oblique incidence (parallel and perpendicular polarization), Snell's law of refraction, Brewster angle.

MODULE 4 :

Power density of EM wave, Poynting vector theorem. Polarization of electromagnetic wave-linear, circular and elliptical polarisation.

Uniform lossless transmission line - line parameters.Transmission line equations, Voltage and Current distribution of a line terminated with load .Reflection coefficient and VSWR. Derivation of input impedance of transmission line.

MODULE 5 :

Transmission line as circuit elements (L and C). Development of Smith chart - calculation of line impedance and VSWR using smith chart.

The hollow rectangular wave guide –modes of propagation of wave-dominant mode, group velocity and phase velocity -derivation and simple problems only

Text Books

1. John D. Kraus, Electromagnetics, 5/e, TMH, 2010.
2. Mathew N O Sadiku, Elements of Electromagnetics, Oxford University Press, 6/e, 2014.
3. William, H. Hayt, and John A. Buck. Engineering Electromagnetics. McGraw-Hill, 8/e McGraw-Hill, 2014.

Reference Books

1. Edminister, "Schaum's Outline of Elctromagnetics", 4/e, McGraw-Hill, 2014.

2. Jordan and Balmain , Electromagnetic waves and Radiating Systems, PHI, 2/e,2013

3.Martin A Plonus , Applied Electromagnetics, McGraw Hill, 2/e,1978.

4. Nannapaneni Narayana Rao, Elements of Engineering Electromagnetics, Pearson, 6/e, 2006.

5. Umran S. Inan and Aziz S. Inan, Engineering Electromagnetics, Pearson, 2010.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to Electromagnetic Theory. Review of vector calculus- curl, divergence gradient.	3
1.2	Rectangular, cylindrical and spherical coordinate systems. Expression of curl divergence and Laplacian in cartesian , cylindrical and spherical coordinate system.	3
1.3	Electric field and magnetic field.Review of Coulomb's law , Gauss law and Amperes current law.	2
1.4	Poisson and Laplace equations, Determination of E and V using Laplace equation.	2
2	**Module 2**	
2.1	Derivation of capacitance and inductance of two wire transmission line and coaxial cable.	2
2.2	Energy stored in Electric and Magnetic field.	1
2.3	Displacement current density, continuity equation. Magnetic vector potential. Relation between scalar potential and vector potential.	3
2.4	Maxwell's equation from fundamental laws.	2
	Boundary condition of electric field and magnetic field from Maxwell's equations.	1
2.5	Solution of wave equation	1
3	**Module 3**	
3.1	Propagation of plane EM wave in perfect dielectric, lossy medium, good conductor, media-attenuation, phase velocity, group velocity, skin depth.	4
3.2	Reflection and refraction of plane electromagnetic waves at boundaries for normal & oblique incidence (parallel and perpendicular polarization), Snell's law of refraction, Brewster angle.	4
4	**Module 4**	

4.1	Power density of EM wave, Poynting vector theorem.	2
4.2	Polarization of electromagnetic wave-linear, circular and elliptical polarisation.	2
4.3	Uniform lossless transmission line - line parameters. Transmission line equations	3
4.4	Voltage and Current distribution of a line terminated with load .Reflection coefficient and VSWR.Derivation of input impedance of transmission line.	3
5	**Module 5**	
5.1	Transmission line as circuit elements (L and C).	1
5.2	Development of Smith chart - calculation of line impedance and VSWR using smith chart.	3
5.3	The hollow rectangular wave guide –modes of propagation of wave-dominant mode, group velocity and phase velocity -derivation and simple problems only	4

Assignments:

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, (**Model Question Paper)**

Course Code: ECT302

Course Name: ELECTROMAGNETICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer ALL Questions. Each Carries 3 mark.

1	Define Curl of a vector field. Explain its physical significance.	K2
2	Obtain Coulomb's law from Gauss' law	K2
3	Write Poisson's and Laplace's Equation with applications	K1
4	A Parallel plate capacitor with plate area of $5cm^2$ and a plate separation of 3mm has a voltage $50\sin 10^3 t$ Volt applied to its plates. Calculate the displacement current assuming $\varepsilon = 2\varepsilon_0$.	K3
5	List all Maxwell's equations in integral form	K1

6	Explain the significance of skin depth.		K2
7	What is Snell's law?		K1
8	What is wave polarisation? What are the different types of polarisation?		K1
9	State the relation between standing wave ratio and reflection coefficient.		K1
10	How a quarter wave dissipationless line can be used for impedance matching?.		K2

PART – B

Answer one question from each module; each question carries 14 marks.

Module - I

11 a.	Derive the equation for curl of a vector field in Cartesian co-ordinate system.	7	CO1 K2
b.	A Spherical volume charge distribution is given by $\rho = \rho_0(1 - \frac{r^2}{a^2}); r \le a$ $\rho = 0; r > a$ Find the electric field intensity E; i) inside and ii) outside the charge distribution	7	CO1 K3

OR

12	Interpret the following i) $\nabla \times B = \mu_0 J$ ii) $\nabla \times E = 0$ where B and J stands for magnetic flux density and electric current density	7	CO1 K3
b.	Apply Ampere's circuital law to the case of an infinitely long coaxial cable carrying a uniformly distributed total current I. Compute the magnetic field intensity existing in different parts of the cable.	7	CO1 K3

Module - II

13 a.	Derive the expression of capacitance of two wire transmission line.	7	CO2 K2
b.	Show that the energy stored in a system of n point charges is given by	7	

$W_E = \frac{1}{2}\sum_{i=1}^{n} Q_i V_i$ where V_i is the potential of the point charge Q_i. CO2 K3

OR

14a Define vector magnetic potential and show that $B = \nabla \times A$, where B is the magnetic flux density and A is the vector magnetic potential at any point. 7 CO2 K2

b State and prove boundary conditions for E and H in accordance with Maxwell's equations. 7 CO2 K2

Module - III

15 a. Derive the expression for reflection coefficient for a wave of perpendicular polarization , travelling from one medium to another at oblique incidence . 7 CO3 K2

b. In a lossy dielectric medium,characteristic impedance of the medium is 173 +j100 Ω , Expression of Magnetic field of a plane wave is given by 7 CO3 K3

$10\, e^{-\alpha x}\cos(\omega t - 0.5x)a_z$ A/m . Find

i. Direction of propagation

ii. Loss tangent

iii. Attenuation constant

iv. Phase constant

v. Skin depth

OR

16 a Derive continuity equation from fundamental laws. 7 CO3 K2

b Find the skin depth, δ at a frequency of 1.6 MHz in aluminium, where

σ=38.2MS/m and μ_r= 1. Also find the propagation constant, γ and the wave

	velocity v .	7	CO3 K3

Module - IV

17a	Derive the equation for transmission and reflection coefficients of an electromagnetic wave incident normally on the boundary between two different regions.	7	CO4 K2
b	Derive an expression for net outward power flow associated with an electromagnetic wave, from a surface.	7	CO4 K2

OR

18 a.	Derive standard Transmission line equations.	7	CO4 K2
b.	Given two dielectric media,the first medium is free space and the second medium has $\varepsilon_2 = 4\varepsilon_0$ and $\mu = \mu_0$. Find the reflection coefficient for oblique incidence at $\theta_1 = 30^o$ for i) perpendicular polarisation and ii) parallel polarisation	7	CO4 K3

Module - V

19 a.	A rectangular wave guide has a dimension of 3cm x 5cm , and is operating at a frequency of 10 GHz . Calculate the cutoff wavelength, cutoff frequency , guide wavelength , phase velocity and group velocity . and the wave impedance for TE10 mode.	7	CO5 K3
b.	At a frequency of 80 MHz, a lossless transmission line has a characteristic impedance of 300Ω and a wavelength of 2.5m. Find: i) L ii) C iii) If the line is terminated with a parallel combination of 200Ω and 5pF, determine the reflection co-efficient and the standing wave ratio.	7	CO5 K3

OR

20 a	A 50 + j200 Ω load is connected to a 100Ω lossless transmission line . Using smith chart , find	7	

	i. Reflection coefficient at load	ii. VSWR	iii. Load admittance		CO5 K3
b	Derive the expression for Electric and magnetic field intensities for TM mode of propagation of rectangular waveguide.			7	CO5 K2