GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRONICS (10) &
ELECTRONICS AND COMMUNICATION ENGINEERING (11)
ANTENNA & WAVE PROPAGATION
SUBJECT CODE: 2161003
B.E. 6th SEMESTER

Type of course: Compulsory

Prerequisite: Higher Engineering Mathematics, Fundamental knowledge of Engineering Electromagnetics (Maxwell's equations, three basic coordinate systems and polarization).

Rationale:
UG Students of EC Engineering need to possess good understanding of the fundamentals and applications of Antenna and wave propagation, including radiation from point sources as applied to antenna, antenna types and their radiation patterns. They are expected to be able to design different antennas for specific given frequency and application. They should be acquainted with concept of arrays and antenna measurement methods. They will be practiced in study of antenna radiation patterns and in measurement of different antenna parameters. They will be able to design and analyze some basic antennas in hardware and application specific antenna in HFSS or CST.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	100

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Basic antenna concepts**: Definition and functions of an antenna, comparison between an antenna & transmission line, radio communication link with transmitting antenna and a receiving antenna, radiation patterns of antennas-field and power patterns, all antenna types.	3	9%
2	**Radiation of Electric dipole:** Potential functions and the electromagnetic field, Oscillating electric dipole-derivations for E and H field components in spherical coordinate systems, Power Radiated by a current element, Application to antennas, Radiation from quarter wave monopole and half wave dipoles, Derivation for radiation resistance, application of reciprocity theorem to antennas, equality of directional patterns and effective lengths of transmitting and receiving antennas, directional properties of dipole antennas, antenna feeding methods.	5	10%
3	**Antenna parameters and definitions:** beam area, beam width- Half-Power Beam width (HPBW)and First Null Beam width(FNBW) ,Polarisation, Radiation Intensity ,Beam Efficiency, Directivity and directive gain, radiation resistance, radiation efficiency, resolution, Antenna	5	10%

	aperture-physical and effective apertures, effective height, transmission formula, antenna field zones, Transmission loss as a function of frequency. Antenna temperature and signal to noise ratio.		
4	**Arrays of point sources :** Expression for electric fields from two, three and N element arrays- linear arrays: Broad-side array and End-Fire array- Method of pattern multiplication- Binomial array-Horizontal and Vertical Antennas above the ground plane, Effect of ground on ungrounded antenna, Schelkunoff theorems for linear arrays, Dolph-Tchebysheff distribution for linear arrays.	**6**	11%
5	**Loop Antenna:** Small loop short magnetic dipole, comparison of far field of small loop and short dipole loop antennas, field pattern of circular loop antenna & radiation resistance of loop antenna, directivity of circular loop antennas with uniform current.	**2**	3%
6	**Helical antenna:** Helical geometry, transmission radiation modes, practical design considerations, wide band characteristics of helical antenna.	**2**	3%
7	**Arrays of dipoles & apertures**: 3 element dipole Array with parasitic elements, Yagi-Uda array-function and its design, Phased arrays, frequency scanning arrays, smart antennas, long wire antennas, location methods of feeding antennas, folded dipole antennas, matching arrangements.	**4**	7%
8.	**Reflector antennas**: Parabolic reflector, paraboloidal reflector, aperture Pattern of large circular apertures with uniform illumination, off axis operation of paraboloidal reflectors, Cassegrain feed system.	4	7%
9.	**Slot patch & Horn antennas**: Slot antenna, its pattern, Babinet's principle and complementary antennas, impedance of slot antennas, and horn antenna-function and types.	3	9%
10.	**Microstrip (patch) antennas :** Rectangular and circular types-function, features analysis ,design considerations and applications	4	7%
11.	**Lens antennas**: Non-metallic Dielectric lens and artificial dielectric lens antennas, reflector lens antennas.	2	3%
12.	**Broadband & Freq. Independent antennas**: Broadband antenna, Frequency independent antenna, log periodic antennas.	2	3%
13.	**Antennas for special applications:** Antennas design consideration for satellite communication, antenna for terrestrial mobile communication systems, GPR, Embedded antennas, UWB, Plasma antenna.	2	3%
14.	**Antennas measurements**: Experimental set ups for measurement of radiation patterns, gain, phase polarization, terminal impedance.	2	3%
15.	**Radio wave propagation** : Modes of propagation, Ground Wave Propagation, Structure of troposphere and ionosphere, Characteristic of Ionospheric layers, Sky wave propagation, Definitions for Virtual height, MUF and Skip distance, OWF, Fading, ionospheric absorptions, Multi-hop propagation, Space wave propagation and Super refraction.	6	11%

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30 %	**20 %**	**20 %**	**10 %**	**10 %**	**10 %**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. "Antennas for all applications", J.D. Krauss 3RD Edition (TMH)
2. "Electromagnetic wave & radiating systems", Jordan & Balmain PHI Publication
3. "Antenna & Wave Propagation", K.D. Prasad Satyaprakash Publications
4. "Antenna Theory: Analysis and design", C. Balanis Wiley India

Course Outcome:

After learning the course the students should be able to:

1. Explain the radiation through antenna and identify different types of antennas.
2. Identify and measure the basic antenna parameters
3. Design and analyze wire and aperture antennas
4. Design and analyze matching and feeding networks for antennas
5. Design and analyze antenna arrays
6. Identify the characteristics of radio-wave propagation

List of Experiments:

Sr.No.	Experiment Title
1.	To study the variation of radiated field with distance from transmitting antenna.
2.	To demonstrate the reciprocity theorem for transmitting and receiving radiation patterns of an antenna.
3.	To plot the radiation pattern of an Omni directional antenna.
4.	To plot radiation pattern of directional antenna.
5.	To study Phenomena of Circular, Linear and Elliptical Polarization of antennas.
6.	To study and plot the radiation pattern of the dipole/Folded dipole antennas in Azimuth & Elevation planes.
7.	To study and plot the radiation pattern of the helical antenna.
8.	To study and plot the radiation pattern of the parabolic reflector.
9.	To study and plot the radiation pattern of the Log-Periodic antenna.
10.	To study and plot the radiation pattern of the Broadside antennas and Measure its Gain, Bandwidth and Beam width.
11.	To plot radiation pattern of $3\lambda/2$ dipole antenna and compare with $\lambda/2$ dipole antenna.

12.	To plot the radiation pattern of a Slot antenna.
13.	Design and simulate micro strip patch antenna in HFSS simulator.

Design based Problems (DP)/Open Ended Problem:

1. Design a Yagi-Uda six element antenna for operation at 500 MHz with a folded dipole feed. What are the lengths of a) reflectors b) driven element, c) four detector elements? What is the spacing d) between the reflector and driven element and e) between directors? What is the frequency bandwidth and gain?
2. Design a right circularly polarized axial mode helical antenna with 15 dBi gain for operation at 1600 MHz with turn spacing λ/π. Find a) the number of turns, b) turn diameter and c) axial ratio.
3. a) Calculate and plot the pattern of 90 degree corner reflector with a thin center-fed $\lambda/2$ driven antenna spaced 0.35λ from the corner. Assume that the corner reflector is of infinite extent. b) Calculate the radiation resistance of driven antenna. c) Calculate the gain of the antenna and corner reflector over the antenna alone.
4. Design an optimum log-periodic antenna to operate at frequencies from 100 to 500 MHz with 11 elements. Give a) length of longest element, b) length of shortest element, and c) gain.
5. A linear array consists of an in-line configuration of 24 $\lambda/2$ dipoles spaced $\lambda/2$. The dipoles are fed with equal currents but with arbitrary progressive phase shift δ between dipoles. What value of δ is required to put the main lobe maximum a) perpendicular to the line of the array, b) 25 degrees from broadside, and c) 50 degrees from broadside.

Major Equipment:

1. RF Synthesizer
2. RF Detector or spectrum analyzer
3. Antenna kit

List of Open Source Software/learning website:

1. **www.nptel.ac.in**
2. **www.antenna-theory.com**

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.