GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-IV

Course Title: Antenna & Wave Propagation
(Course Code: 4341106)

Diploma programmer in which this course is offered	Semester in which offered
Electronics and Communication Engineering	4th Semester

1. RATIONALE

Antennas play vital role in wireless communication as a terminal component of transmitter and receiver systems. The quality of signals at receiver depends on type of transmitting and receiving antennas, their orientation, transmitting frequency and geographical terrain. For installation & maintenance of wireless systems the basic knowledge of wave propagation theory is essential. This course will help the students to select and install antennas of desired operating frequency for the particular application. It is therefore a core engineering course for EC engineers and hence students should learn this course for efficient working in the wireless communication field.

2. COMPETENCY

The course content should be taught and with the aim to develop different types of skills so that students are able to acquire following competency

- **Identify the appropriate antenna and use them for specific wireless communication applications.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Interpret electromagnetic wave radiation by elementary antenna with related parameters.
b) Select the different antenna arrays for the specific application.
c) Select the antennas for indoor/outdoor and special applications.
d) Select the antenna positioning for specific mode of wave propagation.
e) Identify the concepts of satellite communication and its applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
2	0	2	3	30*	70	25	25	150

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

*Note:*micro project of 10 marks. It is the responsibility of the institute heads that marks for PA of theory & ESE and PA of practical for each student are entered online into the GTU Portal at the end of each semester within the dates specified by GTU*.

5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level 'of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Arranging the Antenna trainer set up and performing functional checks	I	2*
2	To study the variation of field strength of radiated with distance from transmitting antenna	I	2*
3	To plot the radiation pattern of an Omni-dirctional antenna(Polar plot on log/linear scales & Cartesian plot on log/linear scales)	I	2
4	To plot the radiation pattern of Dirctional antenna(Polar plot of Azimuth & Elevation planes on log/linear scales & Cartesian plot on log/linear scales)	I	2
5	Check the radiation pattern of half wave dipole and find HPBW.	I	2*
6	Check the radiation pattern of rhombic antenna.	II	2
7	Check radiation pattern of loop antenna.	II	2*
8	Check radiation pattern of folded dipole antenna.	II	2*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Test the performance of the Yagi –uda antenna.	II	2*
10	Test the performance of the broad side array.	II	2
11	Test the performance of the end fire array antenna.	II	2
12	Test the performance of helical antenna in horizontal and vertical planes	III	2*
13	Check the radiation pattern of parabolic reflector antenna.	III	2*
14	Test the performance of horn antenna.	III	2
15	Understand Morse code and practise using Code Practise Oscillator	III	2
16	Training of antenna using vector Network Analyser (VNA)	III	2
17	To study the types of satellites, concepts of earth station and related equipments for UPLINK/DOWNLINK communication	V	2*
18	Install and commission DTH receiver systems	V	2*
	Minimum12PracticalExercises		**??**

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

The following are some **sample**‘ Process ’and ‘Product ’related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	30
3	Follow safe practices measures	10

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
4	Record observations correctly	30
5	Interpret the result and conclude	10
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Antenna Trainer Kit , Current Probe, Mounting Stands ,RF Detector, BNC Tee ,BNC-BNC Adapter, Male and Female BNC-BNC Cables Polar Graphs, 5 Pin DIN cable, Patch Cords, RS 232 Cable & Lab Manual	All
2	Nano-VNA (vector network analyzer) , Morse code practice oscillator using 555 timer.	15, 16
3	Standard DTH receiver system.	18
4	Field strength meter , Frequency counter	15, 16

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical, electronics, pneumatic instruments and tools.

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy ' should gradually increase as planned below:

i. 'Valuing Level 'in 1st year
ii. 'Organization Level 'in 2nd year.
iii. 'Characterization Level 'in 3rd year.

1. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit–I **Basics of Electromagnetic and Antenna**	1a. Describe properties of electromagnetic waves. 1b. Explain the basic concepts of electromagnetic wave theory. 1c. Describe the basic radiating antennas. 1d. For the given application choose the relevant radiator 1e. For the given application choose the relevant radiator 1f.Calculate the basic antenna parameters using standard formulas.	1.1 Physical concept of generation of Electromagnetic wave. 1.2 Electromagnetic field and its radiation from a center fed dipole. 1.3 Antenna Terminologies • Aerial and antenna • Antenna Impedance, • Radiation Resistance • Radiation Pattern • Beam area and beam efficiency • Isotropic radiator gain, • Directivity and Gain • Radiation intensity • Half Power BW • Polarization • Antenna losses • Antenna efficiency • Effective aperture, • Effective length of antenna • Effects of antenna height • Antenna temperature, • Front to Back ratio, • Antenna field zones • Power radiated by elementary dipole using Poynting Vector

UNIT- II **Basic Antennas & Arrays.**	2a.Select antennas and antenna arrays as per their operating frequency ranges and radiation pattern for the specific applications	3.1 Radiation characteristics of wire antennas: • Resonant wire antennas (λ, 2λ), • Non Resonant (Rhombic) Antenna 3.2 Loop antenna 3.3 Folded dipole 3.4Antenna Arrays: • Principle of pattern multiplication • Uniform linear array • Broad side array • End fire array 3.5 Yagi-uda antenna
Unit–III **Antennas for Special applications**	3a. Classify antennas used in HF/VHF/ UHF band 3b. Understand the working principle of HAM radio. 3c. Distinguish the modes of operation of HAM radio.	3.1 HF/VHF/UHF antennas: • Inverted V Antenna • Helical antenna • Parabolic reflector antenna • Horn antenna 3.2 VHF/UHF antennas • Micro strip (patch) antenna, • Turnstile and super turnstile antenna • Slot antenna 3.3 HAM Radio application for emergency communication • Modes of Propagation • Crystal radio for beginners • Morse code and practise oscillator • Use of digital modes (FT8/PSK/RTTY) in HAM radio

Unit–IV **Wave Propagation**	4a.Explain the effect of ground on electromagnetic wavespropagation. 4b. Explain properties of Ionospheric layer used for electromagnetic wave propagation. 4c.Explaindifferent modesof wave propagations 4d.Select the antennas for specific mode of wave propagation considering all the aspects discussed thus far.	4.1 Ground Wave propagation 4.2 Ionosphere Layers and Sky wavepropagation: • Virtual Height • Critical frequency • Maximum usable frequency (MUF) • Skip distance • Lowest Usable frequency (LUF) • Optimum Usable frequency (OUF) 4.3 Space Wave propagation: • Tropospheric scattered propagation • Duct Propagation

Unit–V **Antennas for AdvancedCommunication**	5a. Explain the different types of satellites. 5b.Explain the different types of satellite communication systems. 5c.Explain the different types of satellite earth stations and Ground equipments for Uplink/Downlink transmission. 5d.Identify the different types of Antennas for Terrestrial Mobile communication. 5e. Explain the concept of Smart Antenna and its applications. 5f. Explain the concept of DTH receiver system.	5.1 Types of Satellites: • LEO,MEO,GEO,Elliptical • Concept of apogee, perigee, Kepler's laws. 5.2 Types of Satellite Communications • Telecommunication • Broadcasting • Data Communication 5.3 Concept of earth station and ground equipment for UPLINK/DOWNLINK communication 5.4 Terrestrial mobile communication antennas: • Base station antennas • Mobile station antennas 5.5 Smart Antennas : Need & Applications 5.6 DTH receiver system: outdoor unit, antenna system and indoor unit

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	TeachingHours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Basics of Electromagnetic and Antenna**	06	05	05	06	16

II	**Basic Antennas & Arrays.**	06	05	05	06	16
III	**Antennas for Special applications**	07	05	05	08	18
IV	Wave Propagation	04	04	04	02	10
V	Antennas for Advanced Communication	05	04	04	02	10
	Total	**28**	**28**	**23**	**24**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

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

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

- Prepare the chart of various antenna radiation patterns.
- Collect details of different types of antenna parameters used in radio/TV transmitter, cellular system, wireless radio set, Radar.
- Prepare the demonstration model of commonly used antennas.
- To prepare the chart for Morse code and phonetics.
- To prepare chart/PPT of applications of antenna as per HF/VHF/UHF and special wireless communication.
- Prepare the PPT/animations of 3-D radiation pattern and wave propagation of radio waves.
- Undertakeliteraturesurveyandinternetsearchandalsohandbook/datasheets eachfor specifications of given antenna.
- InstallandcommissionDTHsystems.
- Visit Satellite Earth Station (SAC)/ Doordarshan / AIR/ FM Radio Station.
- HAM radio demonstration workshop.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.

b) In Unit I & II, the fundamental wave propagation equations and formulas of electromagnetic wave propagation theory can be explained without mathematical derivations.

c) For Unit III, IV & V the teacher should arrange visits to different communication research laboratories as well as state of art industries to justify and reinforce the theory taught.

d) To familiarizing the working of various type of antennas demonstrate the use of radiation measuring meter , radiation generation instrument and various types of antennas as listed in unit III to the students in the lab period.

e) Introduce the latest simulation software (HFSS, CST etc.) for better understanding of radiation pattern of various types of antennas.

f) To support and enhance the understanding of the fundamental theory of wave propagation in unit I & V, use of animations and simulation software are recommended.

g) Guide student(s) in undertaking micro-projects.

h) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.

i) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature can be given to the students for ***self-learning***, but to be assessed using different assessment methods.

j) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) To prepare demonstrative models of different antennas (i.e Dish, Yagi-Uda, Dipole, Helix)

b) To prepare mobile signal strength booster for antennas.

c) To fabricate code practise oscillator on PCB using 555 timer.

d) To prepare chart for recent trends of antenna applications i.e PCB mounted miniature antennas ,Automobile antennas, Car Keys antennas, Wi fi adaptor antennas, LORA antennas, IOT gateways antennas etc.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Antennas and Wave Propagation	Kraus John D, Marhefka Ronald J. and Khan Ahmad S.	Tata McGraw-Hill Education, Fourth Edition, or latest
2.	Antennas and Wave Propagation	Raju, G. S. N.	Pearson Education India, 3rd edition or latest
3.	Antenna and Wave propagations	Prasad, K.D. and Handa, Deepak	Satya Prakashan , New Delhi, 3rd edition or latest
4.	Antenna and Wave propagations	Sisir K. Das, Annapurna Das	Tata McGraw Hill EDucation
5.	Electronic Communication Systems,	Kennedy, George and Davis, Bernard	Tata McGraw-Hill Education, 4th Edition or latest

6	A comprehensive guide for HAM radio enthusiasts	E-book by Vigyan Prasar , Delhi	http://vigyanprasar.gov.in/wp-content/uploads/A-Guide-To-ham-Radio.pdf

14. SOFTWARE/LEARNING WEBSITES

a. www.cst.com

b. https://www.qsl.net/4nec2/

c. http://www.antennamagus.com/antennas.php?page=antennas

d. http://emcos.com/Antenna-Simulation-and-Optimization

e. http://www.apparentlyapparel.com/uploads/5/3/5/6/5356442/_____practical_antenna_ handbook_fourth_edition_carr.pdf

f. http://www.nptel.com

g. https://www.ansys.com/en-in/academic/students/ansys-electronics-desktop-student

PO-COMPETENCY-CO MAPPING

Semester III	Electronic Circuits & Networks (Course Code: 4331101)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design / develop-ment of solutions	PO 4 Engineering Tools, Experimen-tation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Identify the appropriate antenna and use them for specific wireless communication applications.**						
Course Outcomes CO1 Interpret electromagnetic wave radiation by elementary antenna with related parameters.	3	3	3	3	2	2	2
CO2 Select the different antenna arrays for the specific application.	3	3	2	2	1	1	3
CO3 Select the antennas for indoor/outdoor and special applications.	3	3	2	2	1	2	2
CO 4 Select the antenna positioning for specific mode of wave propagation.	3	2	3	2	2	2	2

CO 5 Identify the concepts of satellite communication and its applications.	3	3	3	2	2	2	2

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Sr. No.	Name and Designation	Institute
1	Mr. Ujjval V. Buch ,Lecturer EC	Government Polytechnic , Ahmedabad
2	Mr. Nanubhai B. Nadoda, Lecturer EC	Government Polytechnic for Girls , Ahmedabad
3	Mrs. Monali R. Prajapati ,Lecturer EC	Government Polytechnic , Gandhinagar