



KG REDDY
College of Engineering
& Technology

Antennas and Wave Propagation (EC601PC)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

R-16

ANTENNAS AND WAVE PROPAGATION

III B.Tech

2019-20

Course File Prepared by

T Gayatri M.Tech,(Ph.D)
Associate Professor

HOD HEAD

DEPT. OF ELECTRONICS & COMMUNICATIONS
K.G. REDDY COLLEGE OF ENGINEERING &
TECHNOLOGY
CHILKUR (V), MOINABAD, R.R. DIST. 507 104

PRINCIPAL

PRINCIPAL
K.G. Reddy College of Engineering & Technology
Chilkur(V), Moinabadi (M), R.R. Dist.

T Gayatri, Associate Professor ECE DEPT

Department of Electronics and Communication Engineering

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Department of Electronics and Communication Engineering

CO-PO Attainment

Academic Year: 2018-2019

III B.Tech Semester-II

Section: A

Course Code: EC601PC

Course Name: AWP

Course Instructor: T Gayatri

CO-PO & PSO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1	2	2		1				1			1			1
CO2	3		1	1		1				1			1		1	1
CO3	2	3	1	2												
CO4	2									1			1			1
CO5	3	1				1				1			1	1		1

Attainment Levels: H: Substantial (High) M: Moderate (Medium) L: Slight (Low)

Course Outcomes: Students will be able to

- CO1 Describes basic parameters of antenna design (K2)
- CO2 Interpret various antennas and solve their parameters. (K3)
- CO3 Illustrate antenna measurements and arrange a setup to carry out the antenna pattern measurements in the laboratory. (K5)
- CO4 Explain antenna arrays. (K2)
- CO5 Summarize different wave propagations, infer their characteristics, and estimate the parameters involved. (K6)

K1-Remembering, K2-Understanding, K3-Applying, K4-Analyzing, K5-Evaluating, and K6-Creating

Program Outcomes(POs)

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science and engineering sciences.
PO3	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.
PO4	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.
PO5	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.
PO6	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.
PO7	Environment sustainability: Understand the impact of the professional engineering solutions in the societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	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.

PO11	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.
PO12	Lifelong learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broader context of technological change.

Program Specific Outcomes (PSOs)

PSO1	Problem Solving Skills – Graduates will be able to apply their knowledge in emerging electronics and communication engineering techniques to design solutions and solve complex engineering problems.
PSO2	Professional Skills – Graduate will be able to think critically, communicate effectively, and collaborate in teams through participation in co and extra-curricular activities.
PSO3	Successful Career – Graduates will possess a solid foundation in Electronics and Communications engineering that will enable them to grow in their profession and pursue lifelong learning through post-graduation and professional development.
PSO4	Society Impact – Graduate will be able to work with the community and collaborate to develop technological solutions that would promote sustainable development in the society.

Course Coordinator

Module Coordinator

Program Coordinator / HOD



Academic Year: 2018-2019
Course Name: AWP

Mid Examination: I
Course Code: EC601 PC

III B, Tech Semester: II Section-
Name of the Faculty: T. Gayatri

Question Number(QN)	Type of Question	Objective: Fill in the Blank(M)										CO1	CO2	CO3		
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10					
1	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
2	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
4	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
7	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
8	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
9	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
10	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
11	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
12	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
13	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
14	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
15	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
16	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
17	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
18	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
19	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
20	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
21	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
22	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
23	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
24	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
25	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
26	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
27	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
28	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
29	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
30	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
31	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
32	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
33	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
34	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
35	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
36	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
37	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
38	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
39	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
40	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
41	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
42	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
43	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
44	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
45	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
46	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
47	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
48	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
49	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
50	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
51	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
52	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
53	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
54	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
55	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
56	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
57	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
58	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
59	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
60	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
61	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
62	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
63	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
64	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
65	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
66	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
67	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
68	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
69	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
70	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
71	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
72	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
73	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
74	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
75	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
76	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
77	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
78	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
79	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
80	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
81	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
82	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
83	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
84	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
85	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
86	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
87	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
88	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
89	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
90	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
91	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
92	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
93	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
94	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
95	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
96	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
97	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
98	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
99	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
100	Multiple Choice	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

COs	Attainment %	Target Attainment %
CO1	100.00	58.00
CO2	100.00	58.00
CO3	100.00	58.00

Attainment Level	Threshold Value
H 3	58% of students got >=49% marks
M 2	48% of students got >=49% marks
L 1	38% of student got >=49% of marks

CO Attainment = (%of Student Attained * Marks allotted to the question) / Total Marks Allotted for

CO Attainment for Semester End Examination

III B.Tech II Semester	Academic Year: 2018-19
Course Code: EC601PC	Course Name: AWP
Name of the Faculty: T Gayatri	

Course Outcomes: Students will be able to

- CO1 Describes basic parameters of antenna design. (K2)
- CO2 Interpret various antennas and solve their parameters. (K3)
- CO3 Illustrate antenna measurements and arrange a setup to carry out the antenna pattern measurements in the laboratory. (K5)
- CO4 Explain antenna arrays. (K2)
- CO5 Summarize different wave propagations, infer their characteristics, and estimate the parameters involved. (K6)

Sl.No.	University Roll Number	Marks/Grade Point obtained
		100% (O Grade) 40% (C Grade)
1	16QM1A0401	F
2	16QM1A0402	B+
3	16QM1A0404	F
4	16QM1A0406	F
5	16QM1A0407	B+
6	16QM1A0409	B+
7	16QM1A0410	B+
8	16QM1A0412	A
9	16QM1A0414	F
10	16QM1A0415	A
11	16QM1A0416	A
12	16QM1A0418	B+
13	16QM1A0419	F
14	16QM1A0420	F
15	16QM1A0421	A
16	16QM1A0422	B
17	16QM1A0425	B
18	16QM1A0426	B
19	16QM1A0427	F
20	16QM1A0428	B+
21	16QM1A0429	B+
22	16QM1A0431	B+
23	16QM1A0432	F
24	16QM1A0433	A
25	16QM1A0434	A
26	16QM1A0435	B
27	16QM1A0436	B
28	16QM1A0438	A
29	16QM1A0439	B
30	16QM1A0441	A
31	16QM1A0442	B
Total No. of Students		31
Students more than 40 % marks		23
Attainment percentage		74.19
Attainment Level		3

Rationale:

1. Since question wise student marks are not provided by Affiliating university, these marks are kept separate. If results are available with question wise marks, CO wise analysis might have been done.

2. As we expect that each student must at least get 40% marks and he may secure with pass percentage.

% of Marks Secured in a Subject/Course	Letter Grade (UGC Guidelines)	Grade Points
Greater than or equal 80	O (Outstanding)	10
80 and less than 90%	A+ (Excellent)	9
70 and less than 80%	A (Very Good)	8
60 and less than 70%	B+ (Good)	7
50 and less than 60%	B (Average)	6
40 and less than 50%	C (Pass)	5
Below 40%	F (FAIL)	0
Absent	Ab	0

Grade Wise Students Performance

Letter Grade (UGC Guidelines)	Total No. of students obtained	% of students obtained
O (Outstanding)	0	0.00
A+ (Excellent)	0	0.00
A (Very Good)	8	25.81
B+ (Good)	8	25.81
B (Average)	7	22.58
C (Pass)	0	0.00
F (FAIL)	8	25.81
Ab	0	0.00

Attainment Level	Threshold Value
H - 3	58% of students got >=40% marks.
M - 2	48% of students got >=40% marks.
L - 1	38% of student got >=40% of marks

Gap Analysis

Achieved Attainment %	Target Attainment %	Target in Level	Attainment in Level	Gap= Target in Level- Attainment in Level
74.19	58.00	3	3	0

Action Taken Report

COs	Action Taken
CO1, CO2, CO3, CO4, CO5	Attained

Department of Electronics and Communication Engineering
Overall CO Attainment

Academic Year: 2018-2019
 Course Code: EC601PC
 Course Instructor: T Gayatri

I B.Tech Semester-II

Section: A
 Course Name: AWP

Overall Attainment

COs	Total Mid Examination Attainment %	Semester End Examination Attainment %	Total Attainment %	Attained Level
CO1	100.00	74.19	82	3
CO2	100.00	74.19	82	3
CO3	100.00	74.19	82	3
CO4	100.00	74.19	82	3
CO5	100.00	74.19	82	3
Average Attainment	96.19	74.19	81	3

Overall Atainment	81
Overall Attained Level	3

Attainment Level	Thresold Value
H	3
M	2
L	1

Section-A
CO-PO Attainment

Academic Year: 2018-2019
Course Name: AWP

III B. Tech Semester: II
Name of the Faculty: T. Gayatri

Course Code: EC601PC

CO	PO1		PO2		PO3		PO4		PO5		PO6		PO7		PO8		PO9		PO10		PO11		PO12		PSO1		PSO2		PSO3		PSO4			
	Planned	Attained																																
CO1	2	1.64	1	0.82	2	1.64	2	1.64	2	1.64	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82		
CO2	3	2.46	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82		
CO3	2	1.64	3	2.46	1	0.82	2	1.64	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82		
CO4	2	1.64	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82		
CO5	3	2.46	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82	1	0.82		
Total	12.00	9.83	5.00	4.10	4.00	3.28	5.00	4.10	4.00	3.28	3.00	2.46	3.00	2.46	3.00	2.46	3.00	2.46	3.00	2.46	4.00	3.28	4.00	3.28	4.00	3.28	4.00	3.28	4.00	3.28	4.00	3.28		
Attainment %	81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93		81.93			
Average Attainment Level	H		H		H		H		H		H		H		H		H		H		H		H		H		H		H		H			
Attainment Level	2.40		1.97		1.00		0.82		0.80		0.66		1.00		0.82		0.60		0.49		0.60		0.66		0.80		0.20		0.16		0.00		0.80	

Attainment Level	Threshold Value
H	3
M	2
L	1

Attainment Level	Threshold Value
H	58% of students got >=40% marks.
M	48% of students got >=40% marks.
L	38% of student got >=40% of marks

Department of Electronics and Commuication Engineering
Mid Total CO Attainment

Academic Year: 2018-2019
Course Code: EC601PC
Course Instructor: T Gayatri

III B.Tech Semester-II

Section: A
Course Name: AWP

Overall Mid Attainment

COs	Mid Examination- I Attainment %	Mid Examination- II Attainment %	Total Mid Attainment %	Attained Level
CO1	100.00		100.00	3
CO2	100.00		100.00	3
CO3	100	100.00	100.00	3
CO4		100.00	100.00	3
CO5		100	100.00	3
Overall Mid Attainment			100.00	3

Attainment Level	Thresold Value
H	3
M	2
L	1

Course Coordinator

Module Coordinator

Program Coordinator / HOD

Action Taken Report	
COs	Action Taken
All Cos	Attained

KG Reddy College of Engineering and Technology
(Approved by AICTE, Affiliated to JNTU Hyderabad)

Section-A

CO-PO Attainment

III B. Tech Semester: I

Course Code: AS20418

Academic Year: 2019-2020

Course Name: AWP

Name of the Faculty: A.SAIDA

CO attainment	PO1		PO2		PO3		PO4		PO5		PO6		PO7		PO8		PO9		PO10		PO11		PO12		PO13		PO14		
	Planned	Attained																											
CO1	3.00	3.00	2.00	1.70	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	3.00	2.54	2.00	1.70	2.00	1.70	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO3	2.00	1.70	2.00	1.70	2.00	1.70	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO4	2.00	1.70	2.00	1.70	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO5	2.00	1.70	2.00	1.70	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	10.00	8.94	6.00	5.09	4.00	3.37	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Attainment %		89.36		84.80		84.80		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00	84.80
Attained Level		H		H		H		H		#DIV/0!	H																		
Average Attainment	2.00	1.79	1.20	1.02	0.80	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.34

Attainment Level	Threshold Value
H	55% of students get >=40% marks.
M	45% of students get >=40% marks.
L	35% of student get >=40% of marks.

HOD

PRINCIPAL



6 Micro lesson plan

Si. No.	Topic	Scheduled date	Original date
L1	Introduction about subject	28/12/19	28/12/19
L2	Introduction to Antenna, function of & IMP properties of antenna	28/12/19	28/12/19
L3	Antenna fundamentals, Isotropic radiator Basic antenna parameters, radiation patterns	2/1/19	2/1/19
L4	Field radiation pattern, power radiation pattern, radian, steradian, beam solid angle Beam area	2/1/19	2/1/19
L5	Radiation intensity, directivity & resolution Beam efficiency, directive gain	5/1/19	5/1/19
L6	Beam width, bandwidth, i/p impedance of antenna	5/1/19	5/1/19
L7	self & mutual impedance of antenna aperture Effective height,	8/1/19	5/1/19
L8	Field from oscillating dipole, field zones & shape-impedance considerations	9/1/19	8/1/19
L9	FBR, antenna theorems; radiation temperature & polarization	9/1/19	9/1/19
L10	Retarded potentials, Helmholtz theorem Thin linear wire antennas	19/1/19	9/1/19
L11	Radiation from alternating current element significant of field components	19/1/19	19/1/19
L12	The Hertzian dipole-radiation b/w a current element & electric dipole	21/1/19	19/1/19
L13	Power radiated by current element Quarter wave monopole and half wave	21/1/19	21/1/19
L14	Short linear antenna, radiated resistance, beam width & directivity.	22/1/19	21/1/19
L15	Effective area & height, natural current distribution on thin wire antenna	22/1/19	21/1/19
L16	Small loop antennas, comparison of far fields of small loop and short dipole	28/1/19	21/1/19
L17	UNIT-II VHF, UHF & microwave antennas-I introduction,	29/1/19	22/1/19
L18	dipole array with parasitic elements	2/2/19	22/1/19
L19	folded dipole antennas, different types, advantage & application	2/2/19	28/1/19
L20	Yagi-uda antenna, general characteristics & its calculations, advantage & disadvantage	4/2/19	29/1/19
L21	Helical antenna & its geometry & Its modes of radiation.	4/2/19	2/2/19
L22	Practical design consideration for monofilar helical antenna	5/2/19	2/2/19



L23	application & advantages of helical antenna	12/2/19	4/2/19
L24	Horns antennas, types of horn antennas-rectangular & circular horn antenna	12/2/19	4/2/19
L25	Fermat's principle, Optimum horn	13/2/19	5/2/19
L26	Design consideration of pyramidal horns & illustrative problems	13/2/19	5/2/19
L27	UNIT-III VHF, UHF & microwave antennas-II micro strip antennas, feature advantage, disadvantage.	15/2/19	12/2/19
L28	Rectangular patch antennas-geometry, feed method of microstrip antenna	16/2/19	13/2/19
L29	Characteristics of microstrip antennas & its application, Impact of different parameter on characteristics	23/2/19	13/2/19
L30	Reflector antennas- introduction plane reflector or flat sheet reflectors, Reflector antennas geometry	5/3/19	15/2/19
L31	corner reflectors, Design equation & method of image for square corner reflector	5/3/19	16/2/19
L32	Principle of paraboloidal reflector, paraboloid or microwave dish	5/3/19	23/2/19
Mid Term Examination I			
L33	Pattern characteristics, f/d ratio, spill over, back lobe & types of paraboloid	11/3/19	5/3/19
L34	Feed methods, cassegrain, offset feed systems, Related feature	11/3/19	5/3/19
L35	Lens antennas -introduction, principle of lens antenna, feed system of lens antenna	13/3/19	11/3/19
L36	Geometry of metallic & non-metallic dielectric lenses	13/3/19	13/3/19
L37	Zoning & tolerance of lens antenna & its application	14/3/19	13/3/19
L38	UNIT-IV antenna array: point source, Patterns introduction	14/3/19	14/3/19
L39	array of 2 isotropic sources with equal magnitude & same phase	16/3/19	14/3/19
L40	array of 2 isotropic sources with equal magnitude but opposite phase	18/3/19	16/3/19
L41	N element uniform linear arrays, array of N element-BSA, properties	18/3/19	18/3/19
L42	N element uniform linear arrays, array of N element-EFA, properties.	19/3/19	19/3/19
L43	Principle of pattern multiplication, binomial arrays	20/3/19	20/3/19
L44	array of N element-EFA with increased directivity,	23/3/19	23/3/19
L45	BSA s with non-uniform amplitude	25/3/19	25/3/19



	distribution, comparison of BSA & EFA	25/3/19	27/3/19
L46	Antenna measurement, Concept-reciprocity near and far field	27/3/19	27/3/19
L47	coordinate system, source of error in measurement,	27/3/19	30/4/19
L48	Measurement of radiation pattern, directivity and gain.	30/4/19	1/4/19
L49	UNIT-VWave propagation-I introduction, definitions, categorization	30/4/19	1/4/19
L50	General classification and different modes of wave propagation,	1/4/19	1/4/19
L51	Ray/mode concept & ground wave propagation, Plane earth reflection, space and surface,	1/4/19	2/4/19
L52	Wave tilt curved earth reflection, Field strength variation with distance and height,	2/4/19 ⁿ	
L53	radio horizon-LOS, Effect of earth curvature, tall building & hills absorption super refraction	2/4/19	2/4/19
L54	M-curve & duct wave propagation scattering phenomena	2/4/19	10/4/19
L55	Tropospheric propagation and its adv& disadvantage	10/4/19	10/4/19
L56	Wave propagation-II sky wave propagation-introduction	10/4/19	12/4/19
L57	Structure of atmosphere- structure of troposphere, ionosphere	12/4/19	12/4/19
L58	Char of different ionosphere layers, Reflection of sky wave by ionosphere ray path-low & high frequency	12/4/19	15/4/19
L59	Critical frequency, MUF, LUF, derivation for the expression of f_{MUF}	15/4/19	15/4/19
L60	Virtual height & skip distance relation between MUF & skip distance	15/4/19	16/4/19
L61	Multi-hop propagation and lowest usable high frequency	16/4/19	18/4/19
L62	Gap: Phased array, Slot antenna and Babinet's principle complementary antenna	17/4/19	18/4/19
L63	Beyond: Resonant & Non Resonant antennas	18/4/19	17/4/19

Mid Term Examination II



13 ASSIGNMENT TOPICS WITH MATERIALS

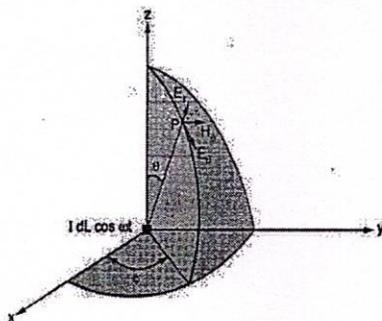
UNIT-I

1. Derive the Radiation resistant and power from a current element in free space?

Ans: To calculate the electromagnetic field radiated in the space by a short dipole, the retarded potential is used. A short dipole is an alternating current element. It is also called an oscillating current element.

In general, a current element $I dL$ is nothing but an element of length dL carrying filamentary current I . This length of a thin wire is assumed to be very short, so that the filamentary current can be considered as constant along the length of an element. The important usage of this approximation is observed in case of current carrying antenna. In such cases, an antenna can be considered as made up of large numbers of such elements connected end to end. Hence if the electromagnetic field of such small element is known, then the electromagnetic field of any long antenna can be easily calculated.

Let us study how to calculate the electromagnetic field due to an alternating current element. Consider spherical co-ordinate system. Consider that an alternating current element $I dL \cos \omega t$ is located at the centre as shown.



The aim is to calculate electromagnetic field at point P placed at a distance R from the origin. The current element $I dL \cos \omega t$ is placed along the z-axis.

Let us write the expression for vector potential \vec{A} at point P, using previous knowledge. The vector potential \vec{A} is given by,

$$\vec{A}(r) = \frac{\mu}{4\pi} \int \frac{\vec{J}\left(t - \frac{r}{v}\right)}{R} dv'$$

Here the vector potential is retarded in time by r/v sec, where v is the velocity of propagation. As the current element is placed along the z-axis, the vector potential will also have only one component in positive z-direction. Hence, we can write,

$$A_z = \frac{\mu}{4\pi} \int \frac{I\left(t - \frac{r}{v}\right)}{R} dv' \quad \dots (2)$$



From equation (2) it is clear that the component of vector potential A_z can be obtained by integrating the current density J over the volume. This includes integration over the cross-section area of an element of wire and integration along its length. But the integration of the current density J over cross-section area yields current I . Now this current is assumed to be constant along the length dL , the integration of J over the length dL gives value IdL . Thus, mathematically we can write.

$$\int_V \bar{J} \left(t - \frac{r}{v} \right) dv = I dL \cos \omega \left(t - \frac{r}{v} \right) \quad \dots (3)$$

Substituting the value of integration from equation (3) in equation (2), the vector potential in z-direction is given by, $A_z = \frac{\mu}{4\pi} \frac{IdL \cos \omega \left(t - \frac{r}{v} \right)}{r}$... (4)

Now the magnetic field is given by $\mu \bar{H} = \nabla \times \bar{A}$... (5)

As we are using spherical co-ordinate system, to find the curl of \bar{A} , we must find the component of \bar{A} in r , θ and ϕ directions. From the Fig. 18, it is clear that,

$$\begin{aligned} A_r &= A_z \cos \theta \\ A_\theta &= -A_z \sin \theta \\ A_\phi &= 0 \end{aligned} \quad \dots (6)$$

Hence is given by,

$$\nabla \times \bar{A} = \frac{1}{r \sin \theta} \left[\frac{\partial}{\partial \theta} (A_\phi \sin \theta) - \frac{\partial A_\theta}{\partial \phi} \right] \bar{a}_r + \frac{1}{r} \left[\frac{1}{\sin \theta} \frac{\partial}{\partial \phi} A_r - \frac{\partial}{\partial r} (r A_\phi) \right] \bar{a}_\theta + \frac{1}{r} \left[\frac{\partial}{\partial r} (r A_\theta) - \frac{\partial}{\partial \theta} (A_r) \right] \bar{a}_\phi \quad \dots (7)$$

Now note that $A_\phi = 0$ and because of symmetry $\partial/\partial\phi = 0$ as no variation along ϕ direction. Thus, first two terms in equation (7) can be neglected being zero.

Putting values of A_θ and A_r , from equation (5), we get,

$$\nabla \times \bar{A} = \frac{1}{r} \left[\frac{\partial}{\partial r} \{ r (-A_z \sin \theta) \} - \frac{\partial}{\partial \theta} \{ A_z \cos \theta \} \right] \bar{a}_\phi$$

Substituting value of A_z ,

$$\nabla \times \bar{A} = \frac{\mu}{r} \left[\frac{\partial}{\partial r} \left\{ (-r) \sin \theta \frac{IdL \cos \omega \left(t - \frac{r}{v} \right)}{4\pi r} \right\} - \frac{\partial}{\partial \theta} \left\{ \cos \theta \frac{IdL \cos \omega \left(t - \frac{r}{v} \right)}{4\pi r} \right\} \right] \bar{a}_\phi \quad \dots (8)$$

Hence the magnetic field \bar{H} is given by, $\bar{H} = \frac{1}{\mu} [\nabla \times \bar{A}]$

Putting value of $(\nabla \times \bar{A})$ from equation (9) we get,

$$\bar{H} = \frac{IdL \sin \theta}{4\pi} \left[\frac{-\omega \sin \omega \left(t - \frac{r}{v} \right)}{rv} + \frac{\cos \omega \left(t - \frac{r}{v} \right)}{r^2} \right] \bar{a}_\phi \quad \dots (10)$$



Equation (10) indicates that the magnetic field \vec{H} exists only in η direction.

$$H_{\phi} = \frac{I dL \sin \theta}{4\pi} \left[\frac{-\omega \sin \omega \left(t - \frac{r}{v} \right)}{rv} + \frac{\cos \omega \left(t - \frac{r}{v} \right)}{r^2} \right] \quad \dots (11)$$

Let $(t - r/v) = t'$, substituting the value in equation (11), we get,

$$H_{\phi} = \frac{I dL \sin \theta}{4\pi} \left[\frac{-\omega \sin \omega t'}{rv} + \frac{\cos \omega t'}{r^2} \right] \quad \dots (12)$$

After calculating the magnetic field, now let us calculate the electric field given by,

$$\nabla \times \vec{H} = \epsilon \frac{\partial \vec{E}}{\partial t}$$

$$\therefore \partial \vec{E} = \frac{1}{\epsilon} (\nabla \times \vec{H}) dt$$

Separating variables & integrating with respect to corresponding variables, we get,

$$\vec{E} = \frac{1}{\epsilon} \int \nabla \times \vec{H} dt \quad \dots (13)$$

Let us calculate each term of $\nabla \times \vec{H}$ separately.

From the definition of curl of a vector, the component in \vec{a}_r direction is given by

$$(\nabla \times \vec{H})_r = \frac{1}{r \sin \theta} \left[\frac{\partial H_{\phi} \sin \theta}{\partial \theta} - \frac{\partial H_{\theta}}{\partial \phi} \right]$$

But $\partial/\partial \phi = 0$

$$(\nabla \times \vec{H})_r = \frac{1}{r \sin \theta} \left[\frac{\partial}{\partial \theta} (H_{\phi} \sin \theta) \right]$$

Substituting value of H_{η} from equation (12),

$$(\nabla \times \vec{H})_r = \frac{1}{r \sin \theta} \left[\frac{\partial}{\partial \theta} \left\{ \frac{I dL \sin \theta}{4\pi} \left[\frac{-\omega \sin \omega t'}{rv} + \frac{\cos \omega t'}{r^2} \right] \sin \theta \right\} \right]$$

$$\therefore (\nabla \times \vec{H})_r = \frac{1}{r \sin \theta} \cdot \frac{I dL}{4\pi} \left[\frac{-\omega \sin \omega t'}{rv} + \frac{\cos \omega t'}{r^2} \right] \left\{ \frac{\partial}{\partial \theta} \sin^2 \theta \right\}$$

$$\therefore (\nabla \times \vec{H})_r = \frac{I dL}{(r \sin \theta) 4\pi} \left[\frac{-\omega \sin \omega t'}{rv} + \frac{\cos \omega t'}{r^2} \right] (2 \sin \theta \cos \theta)$$

$$\therefore (\nabla \times \vec{H})_r = \frac{2 I dL \cos \theta}{4\pi} \left[\frac{-\omega \sin \omega t'}{vr^2} + \frac{\cos \omega t'}{r^3} \right] \quad \dots (14)$$



Let us calculate the component in \hat{a}_θ direction $(\nabla \times \vec{H})_\theta = \frac{1}{r} \left[\frac{1}{\sin \theta} \frac{\partial H_r}{\partial \phi} - \frac{\partial (r H_\phi)}{\partial r} \right]$

But again $\partial/\partial \phi = 0$

$$(\nabla \times \vec{H})_\theta = \frac{1}{r} \left[-\frac{\partial}{\partial r} \{ r H_\phi \} \right]$$

Substituting value of H_ϕ from equation (11),

$$(\nabla \times \vec{H})_\theta = \frac{-I dL \sin \theta}{4\pi r} \frac{\partial}{\partial r} \left[\frac{-r \omega \sin \omega \left(t - \frac{r}{v} \right)}{rv} + \frac{r \cos \omega \left(t - \frac{r}{v} \right)}{r^2} \right]$$

$$\therefore (\nabla \times \vec{H})_\theta = \frac{-I dL \sin \theta}{4\pi r} \frac{\partial}{\partial r} \left[\frac{-\omega \sin \omega \left(t - \frac{r}{v} \right)}{v} + \frac{\cos \omega \left(t - \frac{r}{v} \right)}{r} \right]$$

$$\therefore (\nabla \times \vec{H})_\theta = \frac{I dL \sin \theta}{4\pi r} \left[\frac{-\omega \cos \omega \left(t - \frac{r}{v} \right)}{v} \left[-\frac{\omega}{v} \right] + \frac{1}{r^2} \left[(r) \sin \omega \left(t - \frac{r}{v} \right) \left(\frac{\omega}{v} \right) - \cos \omega \left(t - \frac{r}{v} \right) \right] \right]$$

$$\therefore (\nabla \times \vec{H})_\theta = \frac{I dL \sin \theta}{4\pi} \left[\frac{\omega^2 \cos \omega \left(t - \frac{r}{v} \right)}{v^2 r} + \frac{\omega \sin \omega \left(t - \frac{r}{v} \right) \cos \omega \left(t - \frac{r}{v} \right)}{v r^2} - \frac{\cos \omega \left(t - \frac{r}{v} \right)}{r^3} \right] \dots (15)$$

Finally, the component of $\nabla \times \vec{H}$ in \hat{a}_ϕ direction is zero.

From equation (13), the component of \vec{E} in \hat{a}_r direction is given by

$$E_r = \frac{1}{\epsilon} \int (\nabla \times \vec{H})_r dt$$

Putting value of $(\nabla \times \vec{H})_r$ from equation (14),

$$\begin{aligned} E_r &= \frac{1}{\epsilon} \int \frac{2I dL \cos \theta}{4\pi} \left[\frac{-\omega \sin \omega t'}{v r^2} + \frac{\cos \omega t'}{r^3} \right] dt \\ &= \frac{1}{\epsilon} \int \frac{2I dL \cos \theta}{4\pi} \left[\frac{-\omega \sin \omega \left(t - \frac{r}{v} \right)}{v r^2} + \frac{\cos \omega \left(t - \frac{r}{v} \right)}{r^3} \right] dt \\ &= \frac{2I dL \cos \theta}{4\pi \epsilon} \left[\frac{\omega \cos \omega \left(t - \frac{r}{v} \right) \left(\frac{1}{\omega} \right)}{v r^2} + \frac{\sin \omega \left(t - \frac{r}{v} \right) \left(\frac{1}{\omega} \right)}{r^3} \right] \\ &= \frac{2I dL \cos \theta}{4\pi \epsilon} \left[\frac{\cos \omega \left(t - \frac{r}{v} \right)}{v r^2} + \frac{\sin \omega \left(t - \frac{r}{v} \right)}{\omega r^3} \right] \end{aligned}$$

Put $(t - r/v) = t'$

$$\therefore E_r = \frac{2IdL \cos \theta}{4\pi\epsilon} \left[\frac{\cos \omega t'}{vr^2} + \frac{\sin \omega t'}{\omega r^3} \right] \quad \dots (16)$$

Similarly, from equation (13), the component of \vec{E} in \vec{a}_θ direction is given by,

$$E_\theta = \frac{1}{\epsilon} \int (\nabla \times \vec{H})_\theta dt$$

Substituting the value of $(\nabla \times \vec{H})_\theta$ from equation (15),

$$\begin{aligned} E_\theta &= \frac{1}{\epsilon} \int \frac{-IdL \sin \theta}{4\pi r} \left[\frac{\omega^2 \cos \omega \left(t - \frac{r}{v} \right)}{v^2 r} + \frac{\omega \sin \omega \left(t - \frac{r}{v} \right) \cos \omega \left(t - \frac{r}{v} \right)}{vr^2} - \frac{\cos \omega \left(t - \frac{r}{v} \right)}{r^3} \right] dt \\ \therefore E_\theta &= \frac{-IdL \sin \theta}{4\pi\epsilon} \int \left[\frac{\omega^2 \cos \omega \left(t - \frac{r}{v} \right)}{v^2 r} + \frac{\omega \sin \omega \left(t - \frac{r}{v} \right) \cos \omega \left(t - \frac{r}{v} \right)}{vr^2} - \frac{\cos \omega \left(t - \frac{r}{v} \right)}{r^3} \right] dt \\ \therefore E_\theta &= \frac{-IdL \sin \theta}{4\pi\epsilon} \left[\frac{\omega^2 \sin \omega \left(t - \frac{r}{v} \right) \left(\frac{1}{\omega} \right)}{v^2 r} + \frac{-\omega \cos \omega \left(t - \frac{r}{v} \right) \left(\frac{1}{\omega} \right) \sin \omega \left(t - \frac{r}{v} \right) \left(\frac{1}{\omega} \right)}{vr^2} - \frac{\sin \omega \left(t - \frac{r}{v} \right) \left(\frac{1}{\omega} \right)}{r^3} \right] \\ \therefore E_\theta &= \frac{-IdL \sin \theta}{4\pi\epsilon} \left[\frac{\omega \sin \omega \left(t - \frac{r}{v} \right) \cos \omega \left(t - \frac{r}{v} \right) \sin \omega \left(t - \frac{r}{v} \right)}{v^2 r} \right] \\ \therefore E_\theta &= \frac{IdL \sin \theta}{4\pi\epsilon} \left[\frac{-\omega \sin \omega t'}{v^2 r} + \frac{\cos \omega t'}{vr^2} + \frac{\sin \omega t'}{\omega r^3} \right] \quad \dots (17) \end{aligned}$$

2. Explain the Significance of field components:

In this section, the significance of each term in the expressions for the field components are describe. Let us rewrite the expressions for the field components.

There is only one component for the magnetic field, in \vec{a}_ϕ direction given by,

$$H_\phi = \frac{IdL \sin \theta}{4\pi} \left[\frac{-\omega \sin \omega t'}{rv} + \frac{\cos \omega t'}{r^2} \right]$$

There are two components for the electric field, in \vec{a}_r and \vec{a}_θ direction, given by,

$$\begin{aligned} E_r &= \frac{2IdL \cos \theta}{4\pi\epsilon} \left[\frac{\cos \omega t'}{vr^2} + \frac{\sin \omega t'}{\omega r^3} \right] \\ E_\theta &= \frac{IdL \sin \theta}{4\pi\epsilon} \left[\frac{-\omega \sin \omega t'}{v^2 r} + \frac{\cos \omega t'}{vr^2} + \frac{\sin \omega t'}{\omega r^3} \right] \end{aligned}$$

Consider expression for the component H_n .



1. The first term varies inversely with distance r. This term is called radiation or distant field.
2. The second term varies inversely with the square of distance r. This term is called induction field. When distance r is small, the points are very close to the current element and the induction field term is dominating. But when the points are far away from the current element, then for such larger distances induction field term is negligible as compared to the radiation field.
3. The amplitudes of both the terms in H_n have equal amplitudes. The condition at which the amplitudes are equal is given by $1/r^2 = \omega/rv$
 $r = v / \omega = v / 2\pi f = (v/f) / 2\pi = \lambda / 2\pi = \lambda/6$

4. In the induction field term t is replaced by the retarded time $t - r/v$. The term can be written as

$$\frac{IdL \sin \theta \cos \omega t'}{4\pi r^2}$$

Basically, this expression is similar to the expression for the magnetic field strength due to the current element derived from Bior-Savart law, extended for alternating current $I \cos \omega t$.

5. For steady currents, the radiation field term is absent.
6. The radiation field term indicates flow of energy away from the current element while the induction field term indicates the energy stored in the field during one quarter of the cycle which is returned back during next cycle.

Now consider the expressions of the components E_r and E_θ .

- The component E_θ has both the induction field and radiation terms along with a term which varies inversely with the cube of a distance r.
- The component E_r , has only induction term along with a term which varies inversely with the cube of a distance r.
- In both the field component expressions the term which varies inversely with cube of a distance r is called electrostatic field or simply electric field.

3. Explain the Power Radiated by a Current Element

Ans: Consider a current element placed at a centre of a spherical co-ordinate system. Then the power radiated per unit area at point P can be calculated by using Poynting theorem. The power flow per unit area is given by Poynting vector. According to Poynting theorem, the instantaneous power is given by,

$$P = E \times H \quad \dots (1)$$



The components of the Poynting vector are given by,

$$P_{\theta} = -E_r H_{\phi} \quad \dots (2)$$

$$P_{\phi} = E_{\theta} H_r$$

But we know that when current element is placed at the origin, then the E_r component of the electric field is zero. In other words, the Poynting vector will have only θ and r components. Let us rewrite the field components of the electric and magnetic fields due to the current element, replacing v by c for the propagation in free space,

$$E_r = \frac{2 I dL \cos \theta}{4 \pi \epsilon} \left[\frac{\cos \omega t'}{c r^2} + \frac{\sin \omega t'}{\omega r^3} \right],$$

$$E_{\theta} = \frac{I dL \sin \theta}{4 \pi \epsilon} \left[\frac{-\omega \sin \omega t'}{c^2 r} + \frac{\cos \omega t'}{c r^2} + \frac{\sin \omega t'}{\omega r^3} \right],$$

$$H_{\phi} = \frac{I dL \sin \theta}{4 \pi} \left[\frac{-\omega \sin \omega t'}{r c} + \frac{\cos \omega t'}{r^2} \right]$$

The θ component of the instantaneous Poynting vector is given by $P_{\theta} = -E_r H_{\phi}$

Using property $2 \sin \theta \cos \theta = \sin 2\theta$,

$$\begin{aligned} &= \frac{I^2 dL^2 \sin 2\theta}{16 \pi^2 \epsilon} \left[\frac{\omega \sin 2\omega t'}{2c^2 r^3} - \frac{\cos^2 \omega t'}{c r^4} + \frac{\omega \sin^2 \omega t'}{\omega c r^4} - \frac{\sin 2\omega t'}{2\omega r^5} \right] \\ &= \left[\frac{I^2 dL^2 \sin 2\theta}{16 \pi^2 \epsilon} \right] \left[\frac{\omega \sin 2\omega t'}{2c^2 r^3} + \frac{1}{c r^4} (\sin^2 \omega t' - \cos^2 \omega t') - \frac{\sin 2\omega t'}{2\omega r^5} \right] \end{aligned}$$

Consider middle term inside the second square bracket

$$\begin{aligned} \frac{1}{c r^4} [\sin^2 \omega t' - \cos^2 \omega t'] &= \frac{1}{c r^4} \left[\frac{1 - \cos 2\omega t'}{2} - \left(\frac{1 + \cos 2\omega t'}{2} \right) \right] \\ &= \frac{1}{c r^4} \left[\frac{-2 \cos 2\omega t'}{2} \right] \\ &= \frac{-\cos 2\omega t'}{c r^4} \end{aligned}$$

Putting value of the term considered back in the original expression,

$$P_{\theta} = \left[\frac{I^2 dL^2 \sin 2\theta}{16 \pi^2 \epsilon} \right] \left[\frac{\omega \sin 2\omega t'}{2c^2 r^3} - \frac{\cos 2\omega t'}{c r^4} - \frac{\sin 2\omega t'}{2\omega r^5} \right] \quad \dots (3)$$

The average value of $\sin 2\omega t'$ and $\cos 2\omega t'$ terms over a complete cycle is zero. This clearly indicates that for any value of r , the average of P_{θ} is always zero over a complete cycle. Thus, there will be the power flow back and forth in θ -direction only. Hence in θ -direction, there is no net or average flow of power.



Let us calculate now radial component of the Poynting vector,

$$\begin{aligned}
 P_r &= E_\theta H_\phi \\
 &= \left[\frac{I^2 dL^2 \sin^2 \theta}{16\pi^2 \epsilon} \right] \left[\frac{\omega^2 \sin^2 \omega t'}{c^3 r^2} - \frac{\omega \sin \omega t' \cos \omega t'}{c^2 r^3} - \frac{\omega \sin \omega t' \cos \omega t'}{c^2 r^3} + \frac{\cos^2 \omega t'}{c r^4} - \frac{\omega \sin^2 \omega t'}{\omega c r^4} + \frac{\sin \omega t' \cos \omega t'}{\omega r^5} \right] \\
 &= \left[\frac{I^2 dL^2 \sin^2 \theta}{16\pi^2 \epsilon} \right] \left[\frac{\omega^2 \sin^2 \omega t'}{c^3 r^2} - \frac{\omega \sin 2\omega t'}{2c^2 r^3} - \frac{\omega \sin 2\omega t'}{2c^2 r^3} + \frac{\cos^2 \omega t'}{c r^4} - \frac{\sin^2 \omega t'}{\omega c r^4} + \frac{\sin 2\omega t'}{2\omega r^5} \right] \\
 &= \left[\frac{I^2 dL^2 \sin^2 \theta}{16\pi^2 \epsilon} \right] \left[\frac{\omega^2}{c^3 r^2} \left(\frac{1 - \cos 2\omega t'}{2} \right) - \frac{\omega \sin 2\omega t'}{2c^2 r^3} - \frac{\omega \sin 2\omega t'}{2c^2 r^3} + \left(\frac{1 + \cos 2\omega t'}{2c r^4} \right) \left(\frac{1 - \cos 2\omega t'}{2c r^4} \right) + \frac{\sin 2\omega t'}{2\omega r^5} \right] \\
 &= \left[\frac{I^2 dL^2 \sin^2 \theta}{16\pi^2 \epsilon} \right] \left[\frac{\omega^2 (1 - \cos 2\omega t')}{2c^3 r^2} - \frac{\omega \sin 2\omega t'}{c^2 r^3} + \frac{\cos 2\omega t'}{2c r^4} + \frac{\cos 2\omega t'}{2c r^4} + \frac{\sin 2\omega t'}{2\omega r^5} \right] \\
 &= \left[\frac{I^2 dL^2 \sin^2 \theta}{16\pi^2 \epsilon} \right] \left[\frac{\omega^2 (1 - \cos 2\omega t')}{2c^3 r^2} - \frac{\omega \sin 2\omega t'}{c^2 r^3} + \frac{\cos 2\omega t'}{c r^4} + \frac{\sin 2\omega t'}{2\omega r^5} \right] \\
 \text{Rearranging the terms,} \\
 P_r &= \left[\frac{I^2 dL^2 \sin^2 \theta}{16\pi^2 \epsilon} \right] \left[\frac{\sin 2\omega t'}{2\omega r^5} + \frac{\cos 2\omega t'}{c r^4} - \frac{\omega \sin 2\omega t'}{c^2 r^3} + \frac{\omega^2 (1 - \cos 2\omega t')}{2c^3 r^2} \right] \quad \dots (4)
 \end{aligned}$$

Again, the average value of the $\sin 2\omega t'$ and $\cos 2\omega t'$ terms is zero over a complete cycle. Hence the average radial power is given by

$$\begin{aligned}
 P_r &= \left[\frac{I^2 dL^2 \sin^2 \theta}{16\pi^2 \epsilon} \right] \left[\frac{\omega^2}{2r^2 c^3} \right] \\
 \therefore P_r &= \frac{\omega^2 I^2 dL^2 \sin^2 \theta}{32\pi^2 r^2 c^3 \epsilon} \\
 \therefore P_r &= \frac{1}{2\epsilon c} \left(\frac{\omega I dL \sin \theta}{4\pi c} \right)^2
 \end{aligned}$$

But for free space intrinsic impedance $\eta_0 = 1/\epsilon c$

$$\therefore P_r = \frac{\eta_0}{2} \left(\frac{\omega I dL \sin \theta}{4\pi c} \right)^2 \quad \dots (5)$$

The power component represented by equation (3) is in radial direction. Hence it is called radial power. Equation (5) represents the average power flow. The radiation terms in the expressions of the fields contribute to this average power flow. When the point is away from the current element at far distance, the radiation term contributes to the average power. But when the point is very close to the current element, the terms related to the induction and electrostatic fields are dominant and only $1/r$ terms contribute to the average power flow. From the expressions of E_θ and H_ϕ , the amplitudes of the radiation fields only can be obtained. The amplitude from E_θ component is given by,

$$E_\theta = \frac{\omega I dL \sin \theta}{4\pi \epsilon_0 r^2}$$



$$E_{\theta} = \frac{(\omega/v) I dL \sin \theta}{(2\pi)(\epsilon v) 2r}$$

But $\lambda = \frac{2\pi v}{\omega}$ and $\eta = \frac{1}{\epsilon v}$

$$E_{\theta} = \frac{\eta I dL \sin \theta}{2\lambda r} \quad \dots (6)$$

Similarly, amplitude from H_{ϕ} component is given by,

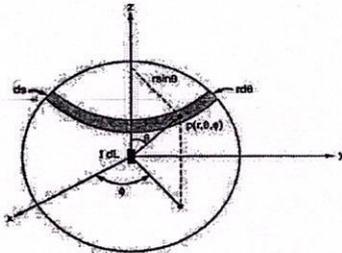
$$H_{\phi} = \frac{\omega I dL \sin \theta}{4\pi r c}$$

$$H_{\phi} = \frac{I dL \sin \theta}{2\lambda r} \quad \dots (7)$$

The radiation terms of E_{θ} and H_{ϕ} are in time phase and are related by

$$\frac{E_{\theta}}{H_{\phi}} = \eta \quad \dots (8)$$

The total power radiated by the current element can be obtained by integrating the radial Poynting vector over a spherical surface. Consider a spherical shell with the current element $I dL$ placed at the centre of the spherical co-ordinate system as shown. The point P at which power radiated is to be calculated is independent of an azimuthal angle η so the element of area ds on the spherical shell is considered as strip.



The element of area ds is given by $ds = 2\pi r^2 \sin \theta d\theta$

... (9). The total power radiated is calculated by integrating average radial power over the spherical surface,

$$\text{Power} = \oint_{\text{surface}} P_r ds \quad \dots (10)$$

$$\begin{aligned} &= \oint_{\text{surface}} \left[\frac{\eta_0}{2} \left(\frac{\omega I dL \sin \theta}{4\pi r c} \right)^2 (2\pi r^2 \sin \theta d\theta) \right] \\ &= \oint_{\text{surface}} \left(\frac{\eta_0}{2} \right) \left(\frac{\omega^2 I^2 dL^2 \sin^2 \theta}{16\pi^2 r^2 c^2} \right) (2\pi r^2 \sin \theta) d\theta \\ &= \oint_{\text{surface}} \frac{\eta_0 \omega^2 I^2 dL^2}{16\pi c^2} \sin^3 \theta d\theta \\ &= \frac{\eta_0 \omega^2 I^2 dL^2}{16\pi c^2} \oint_{\text{surface}} \sin^3 \theta d\theta \quad \dots (11) \end{aligned}$$

In spherical co-ordinate system, θ varies from 0 to π . Hence putting limits of integration as,

$$\text{Power} = \frac{\eta_0 \omega^2 I^2 dL^2}{16\pi c^2} \int_0^{\pi} \sin^3 \theta d\theta$$

$$\therefore \text{Power} = \frac{\eta_0 \omega^2 I^2 dL^2}{8\pi c^2} \int_0^{\pi} \sin^3 \theta d\theta \dots \int_0^{\pi} \sin^n \theta d\theta = 2 \int_0^{\pi/2} \sin^n \theta d\theta$$



Using the reduction formula for calculating integral,

$$\int_0^{\pi/2} \sin^n x \, dx = \left[\frac{n-1}{n} \right] \left[\frac{\pi}{2} \right] \quad \text{if } n \text{ is even}$$

$$= \left[\frac{n-1}{n} \right] \quad \text{if } n \text{ is odd}$$

Hence n is 3 i.e. odd, hence we can write,

$$\int_0^{\pi/2} \sin^3 \theta \, d\theta = \frac{3-1}{3} = \frac{2}{3}$$

Substituting this value in the expression of power, we get,

$$\text{Power} = \frac{\eta_0 \omega^2 I^2 dL^2}{8\pi c^2} \left(\frac{2}{3} \right)$$

$$\therefore \boxed{\text{Power} = \frac{\eta_0 \omega^2 I^2 dL^2}{12\pi c^2}} \quad \dots (12)$$

The power represented by equation (12) is in terms of maximum or peak current. We know that,

$$I_{\text{eff}} = \frac{I_m}{\sqrt{2}}$$

or $I_m = \sqrt{2} I_{\text{eff}}$

Thus, the power can be expressed in terms of effective current as

$$\text{Power} = \frac{\eta_0 \omega^2 (\sqrt{2} I_{\text{eff}})^2 dL^2}{12\pi c^2}$$

$$\therefore \boxed{\text{Power} = \frac{\eta_0 \omega^2 I_{\text{eff}}^2 dL^2}{6\pi c^2}} \quad \dots (13)$$

For free space $\eta_0 = 120\pi$ and $\frac{\omega}{c} = \frac{2\pi}{\lambda}$ i.e. $\frac{\omega^2}{c^2} = \frac{4\pi^2}{\lambda^2}$

Substituting values of η_0 and ω^2/c^2 in above equation (13), we get,

$$\text{Power} = \frac{(120\pi) \left(\frac{4\pi^2}{\lambda^2} \right) I_{\text{eff}}^2 dL^2}{6\pi}$$

$$\therefore \text{Power} = \frac{80\pi^2 I_{\text{eff}}^2 dL^2}{\lambda^2}$$

$$\therefore \boxed{\text{Power} = 80\pi^2 \left(\frac{dL}{\lambda} \right)^2 I_{\text{eff}}^2} \quad \dots (14)$$

Antenna propagation Assignment

~~XXXXXXXXXXXX~~

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ECE-A

VENKATESH

1. Derive the Friis transmission equation and discuss the terms isotropic, omni-directional and principle patterns

A. Friis transmission equation:-

If we include transmitter and receiver antenna gains, ratio of the received power to transmit power will be given by

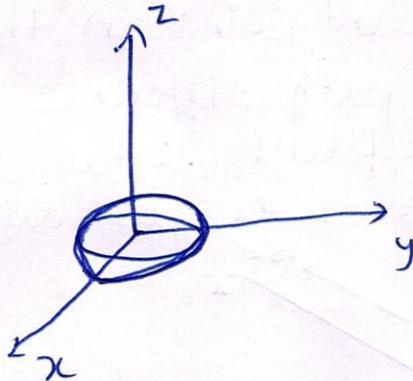
$$P_r = P_T \frac{G_T \times A_{eff}}{4\pi r^2}$$
$$= P_T G_T \times 4\pi \frac{A_{eff}}{\lambda^2} \times \lambda^2$$
$$\frac{A_{eff}}{(4\pi r)^2}$$

$$P_r = P_T \frac{G_T \times G_R \times \lambda^2}{(4\pi r)^2}$$

Isotropic pattern:-

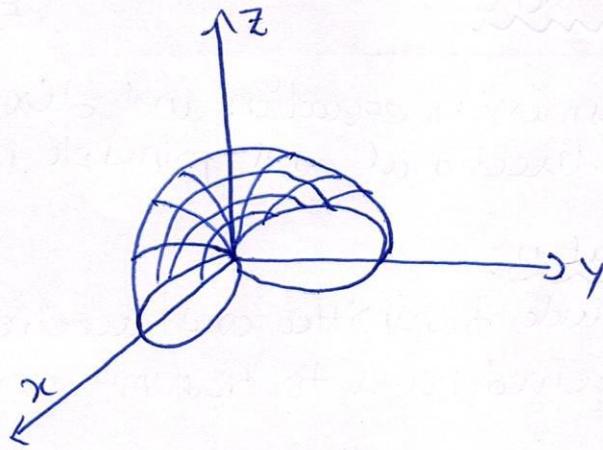
An isotropic antenna is defined as a hypothetical lossless antenna having equal radiation in all directions i.e. it radiates uniformly in all directions.

It is considered as an ideal antenna and it is not physically realizable.



omni-directional pattern:-

In this the antenna having a essentially non-directional pattern in a given plane and a directional pattern in orthogonal plane. It has donut doughnut shape.



principle pattern:

The radiation pattern or antenna pattern is a graphical representation of the radiation properties of the antenna as a function of space.

2. Explain the design considerations of pyramidal Horns
 A. pyramidal Horns Antenna

* As electromagnetic horn must generate a field of constant phase across its opening end with a large aperture relative to wave guide. This increases directivity

* Consider the cross section of pyramidal horn as shown in figure.

* The phase varies at different points on the aperture from the origin since the path difference Length of wave is different from different distances from apex to the aperture. Assume δ as the path difference.

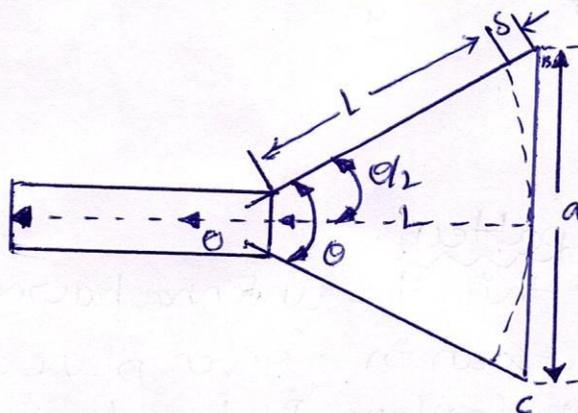


Fig:-
 pyramidal
 Horn
 antenna

From the geometry of figure, we have

$$\cos \frac{\theta}{2} = \frac{L}{L+s} \quad \text{--- ①}$$

$$\text{and } \tan \frac{\theta}{2} = \frac{a/2}{L} \quad \text{--- ②}$$

$$\text{Hence } \theta = 2 \cos^{-1} \left(\frac{L}{L+s} \right) = 2 \tan^{-1} \left(\frac{a}{2L} \right) \quad \text{--- ③}$$

From right angle triangle OBC

$$(L+d)^2 = L^2 + \left(\frac{a}{2} \right)^2 \text{ or } L^2 + s^2 + 2LS = L^2 + \frac{a^2}{4}$$

for very small value of s , s^2 is insignificant

$$2LS = \frac{a^2}{4} \text{ or } L = \frac{a^2}{8s} \quad (s \ll L)$$

characteristics:-

1. If L is kept constant and the value of a and θ are increased, then the directivity of horn increases
2. Further increase in the value of θ approximates equation to unity i.e

$$\frac{L}{L+s} = 1 \text{ where } s \text{ is ignored.}$$

3. At the maximum value of θ , maximum directivity occurs where the value of s is limited to a value of s_0

$$\cos \frac{\theta}{2} = \frac{L}{L+s_0}$$

$$\rightarrow \text{optimum } s = s_0 = \frac{L}{\cos \frac{\theta}{2}} - L$$

$$\rightarrow \text{optimum length} = L = \frac{s_0 \cos \frac{\theta}{2}}{1 - \cos \frac{\theta}{2}}$$

* for optimum flare horn, half power beamwidth

$$\text{HPBW}_{\text{(H-plane)}} = \frac{67^\circ \lambda}{aH}$$

$$\text{HPBW}_{(\text{E-plane})} = \frac{56^\circ \lambda}{a_e}$$

* For rectangular horn

$$A_p = a_e a_H$$

$$a_H = 2L \tan \frac{\theta_H}{2}, \quad a_e = 2L \tan \frac{\theta_G}{2}$$

$$\text{Directivity } D = \frac{4\pi A_e}{\lambda^2}$$

* For conical horn,

$$A_p = \pi r^2$$

* For a rectangular pyramidal rectangular horn

$$D \approx 10 \log (7.5 a_{e\lambda} a_{H\lambda})$$

3. A sheet antenna with a uniform current distribution in free space has $I_{dl} = 3 \times 10^{-4} \text{ Am}$. Calculate the far field E_θ component for $\theta = 90^\circ$, $\phi = 0^\circ$, $d = 10 \text{ cm}$ and $r = 200 \text{ cm}$

A. Given

$$I_{dl} = 3 \times 10^{-4} \text{ Am}, \quad \theta = 90^\circ, \quad \phi = 0^\circ, \quad d = 10 \text{ cm}, \quad r = 200 \text{ cm}$$

Far field component, $|E_\theta| = ?$

$$E_\theta = \int \frac{I_{dl}}{2\lambda r} \sin \theta e^{-\frac{2\pi r}{\lambda}}$$

$$|E_\theta| = \frac{120\pi I_{dl} \sin \theta}{2\lambda r}$$

$$= \frac{120\pi (3 \times 10^{-4}) \sin 90^\circ}{2(10 \times 10^{-2})(200 \times 10^2)} = 2.827$$

$$\therefore |E_\theta| \approx 2.8 \text{ V/m}$$

4. Derive the expression for power radiated and radiation resistance of alternating current element

A. Radiation:- The phenomenon in which energy is emitted from a source and travels through the surrounding medium is referred to as radiation.

Electrical field component:-

From Maxwell equation:

$$\nabla \times H = \frac{\partial D}{\partial t} = \epsilon \frac{\partial E}{\partial t} \quad (\because D = \epsilon E) \quad \text{--- (1)}$$

$$(\nabla \times H)_r = \epsilon \cdot \frac{\partial E_r}{\partial t}$$

$$= \frac{1}{r \sin \theta} \left[\frac{\partial}{\partial \theta} (H_\phi \sin \theta) - \frac{\partial}{\partial \theta} (H_\theta) \right]$$

$$(\nabla \times H)_\theta = \epsilon \cdot \frac{\partial E_\theta}{\partial t}$$

$$(\nabla \times H)_\theta = \frac{1}{r} \left[\frac{1}{\sin \theta} \left(\frac{\partial H_r}{\partial \theta} \right) - \frac{\partial}{\partial r} (r H_\phi) \right]$$

$$(\nabla \times H)_\phi = \epsilon \cdot \frac{\partial E_\phi}{\partial t} = \frac{1}{r} \left[\frac{\partial}{\partial \theta} (H_\theta r) - \frac{\partial H_r}{\partial \theta} \right]$$

sub H_r, H_θ, H_ϕ in eq (1), then

$$(\nabla \times H)_r = \epsilon \cdot \frac{\partial E_r}{\partial t}$$

$$= \frac{1}{r \sin \theta} \left[\frac{\partial}{\partial \theta} (H_\phi \sin \theta) - \frac{\partial}{\partial \theta} (H_\theta) \right]$$

$$\epsilon \cdot \frac{\partial E_r}{\partial t} = \frac{1}{r \sin \theta} \times \left[\frac{\partial}{\partial \theta} \left(\frac{I_m d l \sin \theta}{4\pi} \left(\frac{-\omega \sin \omega t'}{v r} + \frac{\cos \omega t'}{r^2} \right) \sin \theta \right) \right]_0$$

$$(H_\theta = 0)$$

solving the eqn we get

Electrical field component

$$E_r = \frac{2 I_m d l \cos \theta}{4\pi \epsilon} \left[\frac{\cos \omega t'}{v r^2} + \frac{\sin \omega t'}{\omega r^3} \right]$$

$$E_\theta = \frac{I_m d l \sin \theta}{4\pi \epsilon} \left[-\frac{\sin \omega t'}{v r^2} + \frac{\cos \omega t'}{v r^2} + \frac{\sin \omega t'}{\omega r^3} \right]$$

$$\epsilon\phi = 0$$

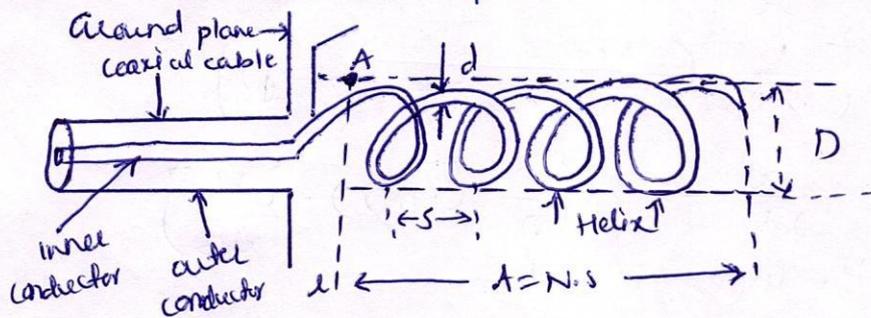
$$t' = \left(t - \frac{r}{c} \right)$$

5. sketch the geometry of helical antenna, and explain the principle of working in normal mode.

A. A helical antenna is an antenna which contains a conducting wire or tubing wound in the form of screw head forming helix.

* Helical antenna are firmly fixed on top of a ground plane called ground plate which is made of sheet or of radial and concentric conductors.

* the feedline is connected in the middle of ground plane and bottom of the helix shown in figure.

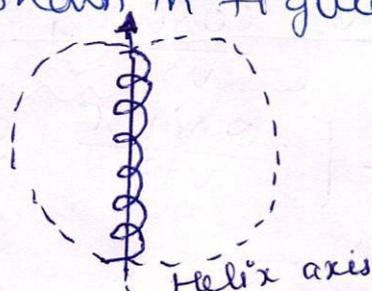


$$L (\text{length}) = \sqrt{s^2 + (\pi D)^2}$$

$$\alpha (\text{pitch angle}) = \tan^{-1} \left(\frac{s}{\pi D} \right)$$

Normal mode of Radiation:- This mode occurs when the dimensions of helix are very small compared to the operating wavelength, that is, $N\lambda \ll \lambda$.

* The radiation is maximum in the broad side direction as shown in figure.



* The broadside direction means, the direction \perp^{er} to the helix axis.

* The radiation is usually circularly or nearly so circularly polarized wave.

* The antenna sets as a sheet dipole or monopole so the bandwidth becomes narrow and its radiation efficiency is poor.

* Consider a helix in a 3-D spherical coordinate system is shown in figure.

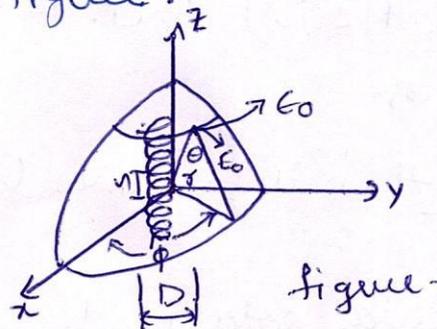


figure.

The far field in small Loop is given as

$$E_{\phi} = \frac{120\pi^2 [I] \sin\theta \left[\frac{A}{\lambda^2}\right]}{r} \quad \text{--- (1)}$$

The far field of sheet dipole is given as

$$E_{\theta} = j \frac{60\pi [I] \sin\theta \left[\frac{S}{\lambda}\right]}{r} \quad \text{--- (2)}$$

* The performance of helical antenna is measured in terms of Axial Ratio (AR). Axial ratio is defined as the ratio of far fields of sheet dipole to the small Loop

$$AR = \left| \frac{E_{\theta}}{E_{\phi}} \right|$$

$$AR = \left| \frac{j60\pi [I] \sin\theta \left(\frac{S}{\lambda}\right)}{120\pi^2 [I] \sin\theta \left(\frac{A}{\lambda^2}\right)} \right| = \frac{SA}{2\pi A} \quad \because |j|=1$$

we know that, $A = \frac{\pi D^2}{4}$

$$AR = \frac{S\lambda}{2\pi \left(\frac{\pi D^2}{4}\right)}$$

$$AR = \frac{2S\lambda}{\pi^2 D^2}$$

case i): - If $AR = 0$, then elliptical polarization becomes linear horizontal polarization

case ii): - If $AR = 1$ ratio is 1 then it becomes circular polarization.

case iii): - If $AR = \infty$, then it becomes linear vertical polarization

pitch angle for circular polarization

$$\alpha = \tan^{-1} \left(\frac{c}{2\lambda} \right).$$

6. Explain or compare different feeding methods that are associated with parabolic reflectors.

A. The parabolic reflector antenna has two dimensional fundamental components namely a source of primary radiation at focus and a reflector.

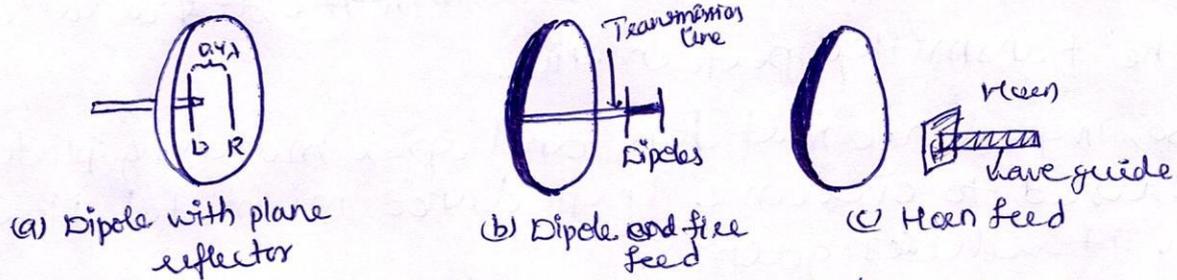
* The source is known as the primary radiation or feed radiator or feed and the reflector is known as second radiator.

* There are several possible feeds to the parabolic reflector.

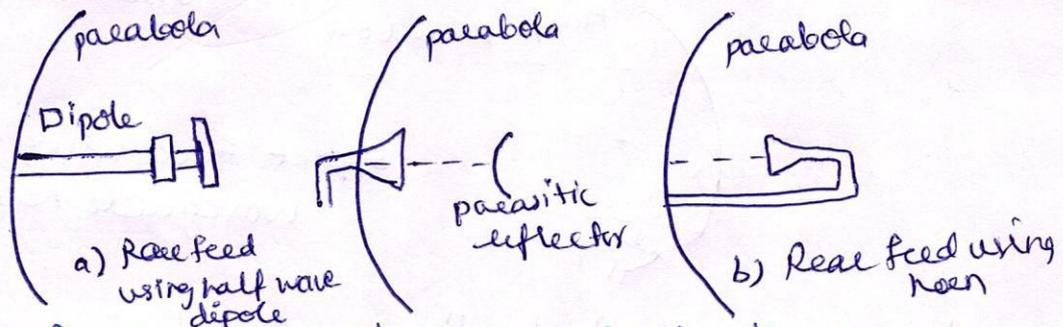
Feed Methods:-

parabolic Reflector:- Feed using parasitic reflector is the simplest type of feed. These include another dipole, a plane sheet, half cylinder or a hemisphere

* Dipole antenna is not much suitable for the feed. However, a dipole with a parasitic reflector is fed with a coaxial line as feed system. The spacing b/w driven element and parasitic element is 0.125λ and for a plane reflector it is 0.4λ .



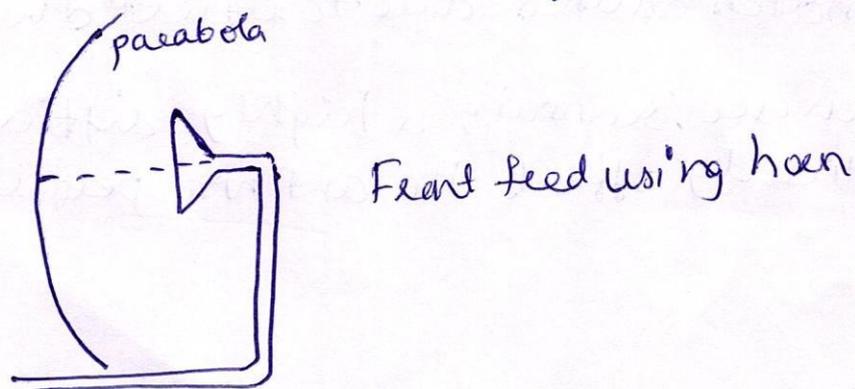
2. Rear feed: - Rear feed of parabolic reflector using half wave dipole and horn antenna as shown



* In rear feed system, the transmission line is not in center and hence generates an asymmetrical radiation pattern.

* It is a very compact system in which the length of the transmission line is very less. Hence, it has minimum line loss.

3. Front feed: - The front feed of parabolic reflector using horn antenna as shown in figure.



* This feed method obstructs the aperture and result in impedance mismatch in the feed.

* the reflections from the dish causes standing waves in transmission line which further adds to the impedance mismatch. It results in the degradation of the transmitter performance.

* So, impedance matching and apex matching plates are used to overcome impedance mismatch. However it reduces gain.

4. Offset feed:- The offset feed of the parabolic reflector using waveguide horn as shown in figure.



offset feed using waveguide horn

* In this feed, only half the parabola is used. The feed reflector is placed at the focus.

* A hog horn is used as feed to overcome the aperture blocking effect caused due to the dependency of the secondary-reflector dimension on the distance b/w feed and sub reflectors.

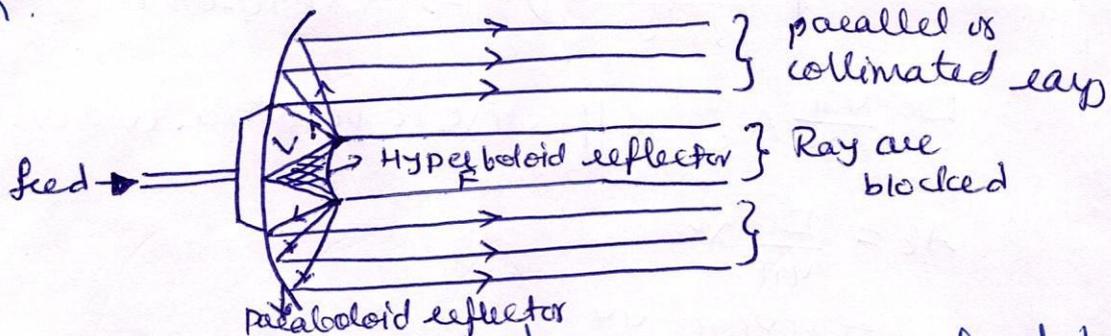
* It also eliminates the problem of impedance mismatch caused due to reflected waves.

* However, scanning is highly difficult and drastically affects the antenna performance.

5. Cassegrain feed: - Cassegrain feed method for feeding parabolic reflector is named after the mathematician professor Cassegrain.

* In Cassegrain feed the parabolic reflector with Cassegrain feed mechanism has the feed at the vertex of paraboloid instead at the focus.

* The parabolic reflector with Cassegrain feed is shown.



* Thus, the hyperboloid ^{sub} reflector acts as a feed point placed at focus of paraboloid reflector.

* The use of Cassegrain feed system reduces the transmission line length of feed and minimize losses.

7. For a parabolic reflector of 7.5m diameter at 4 GHz find the BWFN, HPBW, Directivity and effective aperture.

A. Given that

$$\text{Diameter } d = 7.5 \text{ m}$$

$$\text{operating frequency } f = 4 \text{ GHz}$$

BWFN :-

The BWFN of a paraboloid is given by

$$\text{BWFN} = \frac{140\lambda}{d} \quad \left(\lambda = \frac{c}{f} \right)$$

$$= \frac{140 \times \frac{3 \times 10^8}{4 \times 10^9}}{7.5 \text{ m}}$$

$$\text{BWFN} = 1.4 \text{ degree}$$

$$\text{HPBW} = \frac{70\lambda}{d} = \frac{1.4 \text{ degree}}{2}$$

$$= 0.7 \text{ degree}$$

Directivity:-

The directivity of paraboloid is given by

$$D = \pi^2 \left(\frac{d}{\lambda}\right)^2$$

$$= \pi^2 \left(\frac{7.5 \times 4 \times 10^9}{3 \times 10^8}\right)^2 \Rightarrow 98696.044$$

$D = \frac{4\pi}{\lambda^2} A_e$ effective aperture and directivity

$$A_e = \frac{D}{4\pi} \lambda^2$$

$$= \frac{98696.044}{4\pi} \times \left(\frac{3 \times 10^8}{4 \times 10^9}\right)^2$$

$$A_e = 44.178.$$

8. Explain the effect of D and F layers of the ionosphere on propagation and estimate the critical frequency and estimate MUF for a layer with 10^{14} m^{-3} electron density and incident angle of 60°

A. Given that

$$N_{\text{max}} = 10^{14} / \text{m}^3$$

$$\theta = 60^\circ$$

The critical frequency in terms of electron density is expressed as

$$f_c = \sqrt{81 N_{\text{max}}}$$

$$= \sqrt{81 \times 10^{14}}$$

$$f_c = 2846049.894 \text{ Hz}$$

$$f_c = 2.846 \text{ MHz}$$

The maximum usable frequency is given by

$$f_{MUF} = f_o \sec \theta$$

$$= 2.846 \times 10^6 \times \sec 60^\circ$$

$$f_{MUF} = 5.728 \text{ MHz}$$

9. Write short notes on following
a) Duct propagation b) Fading

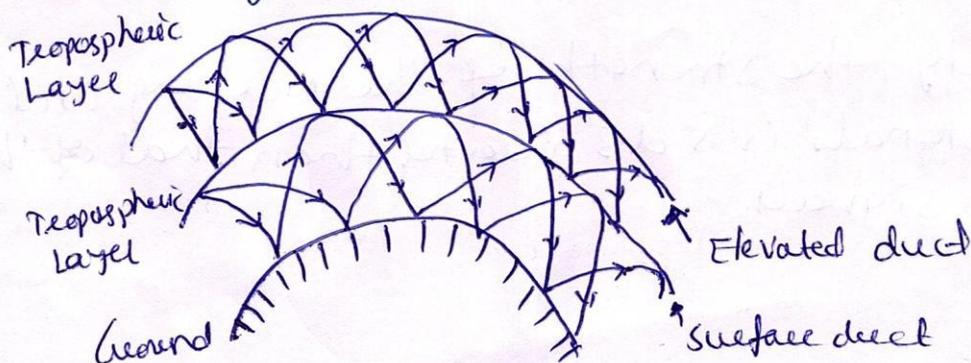
A. Duct propagation:-

* The waves of UHF, VHF and microwave frequencies are neither propagated along the surface of earth nor reflected by ionosphere. However, in the tropospheric region, the waves are transmitted beyond the LOS distances due to refraction.

* A normal or standard atmosphere is one where the dielectric constant is assumed to decrease uniformly with height to a value of unity at a height at which air density is considerably zero.

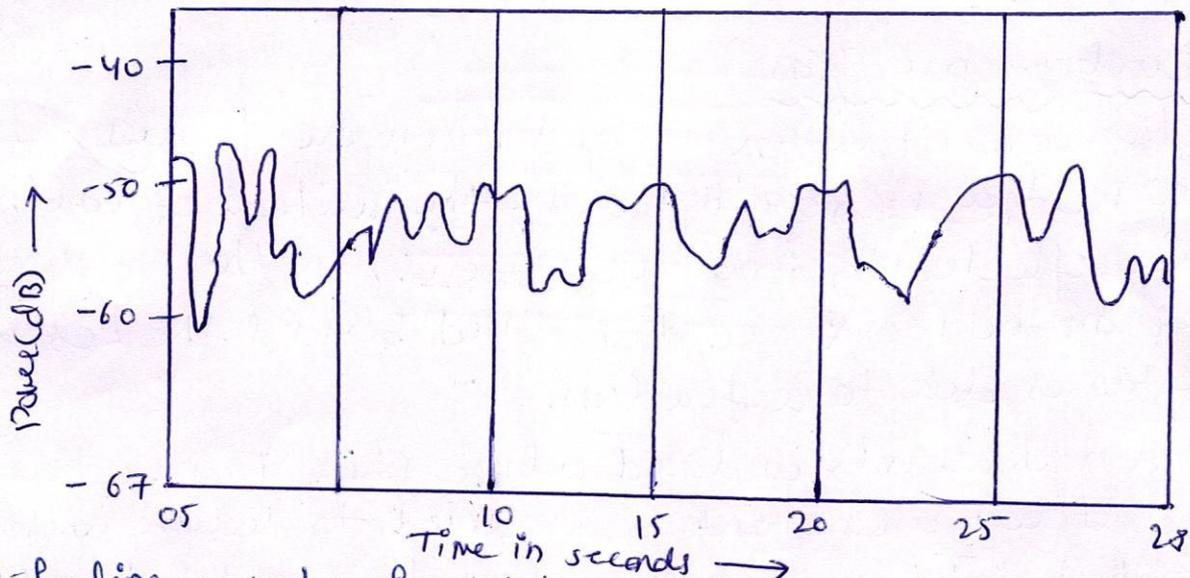
* Ducts are formed in regions where $\frac{dn}{dh}$ is -ve. Temperature inversion is one of the important factors for formation of duct.

* A duct can be formed b/w two layers of troposphere or in the middle of troposphere and earth's surface as shown in figure.



Fading:-

It is defined as the lowering of the signal strength with the variations in the refractive index. Variations in the refractive index occur due to the abrupt change in the temperature, pressure and humidity. Fading phenomenon having Rayleigh nature is shown in figure.



* fading can be fast / slow path / single path / multi-path
short term / long term.

* the time duration required for the factor multi path propagation is 0.01 sec. And the signal in long-term fading varies in the order of 10 dB.

* In general the effect of signal strength in summer is 10 dB greater than that of the winter.

* similarly, the strength of the morning and evening signals is 5 dB greater than that of the afternoon signals.

10. Find the array factor and sketch the pattern of a 2 element array having equal amplitudes, phases and having a spacing of $d = \lambda$.

A. Array factor for a 2 element array with equal amplitude phase is expressed as:

$$AF = \left| \frac{E_t}{2E_0} \right| = \cos\left(\frac{\beta d \cos\theta}{2}\right)$$

$$\text{since } \beta = \frac{2\pi}{\lambda}$$

$$AF = \cos\left(\frac{2\pi d}{\lambda} \frac{\cos\theta}{2}\right)$$

$$AF = \cos\left(\frac{\pi d}{\lambda} \cos\theta\right)$$

Given that spacing b/w two point sources is λ i.e. $d = \lambda$

$$AF = \cos\left(\frac{\pi \lambda}{\lambda} \cos\theta\right)$$

$$AF = \cos(\pi \cos\theta)$$

Radiation pattern:-

The field pattern can be obtained by finding the direction of maxima, minima and half power points.

Direction of Maxima:-

The direction of total fields is maxima when E_t is maximum i.e. $\cos\left(\frac{\beta d \cos\theta}{2}\right)$ is maximum.

$$\cos\theta = \pm 1$$

$$\cos\left(\frac{\beta d \cos\theta}{2}\right) = \pm 1$$

For $d = \lambda$ and $\beta = \frac{2\pi}{\lambda}$ we get

$$\cos\left(\frac{2\pi}{\lambda} \lambda \cos\theta_{\max}\right) = \pm 1$$

$$\cos(\pi \cos \theta_{\max}) = \pm 1$$

$$\pi \cos \theta_{\max} = \cos^{-1}(\pm 1) = \pm n\pi, n=0,1,2, \dots$$

At $n=0$, $\pi \cos \theta_{\max} = 0$

$$\cos \theta_{\max} = 0$$

$$\theta_{\max} = 90^\circ \text{ and } 270^\circ$$

Direction of minima:-

$$\cos(\pi \cos \theta_{\min}) = 0$$

$$\pi \cos \theta_{\min} = \cos^{-1}(0) = \pm (2n+1) \frac{\pi}{2}, n=0,1,2, \dots$$

At $n=0$, $\pi \cos \theta_{\min} = \pm \frac{\pi}{2}$

$$\cos \theta_{\min} = \pm \frac{1}{2}$$

$$\theta_{\min} = 60^\circ \text{ and } 240^\circ$$

Half power point Direction (HPPD):-

$$E = \pm \frac{1}{\sqrt{2}} \text{ i.e.}$$

$$\cos(\pi \cos \theta)_{\text{HPPD}} = \cos^{-1}(\pm \frac{1}{\sqrt{2}})$$

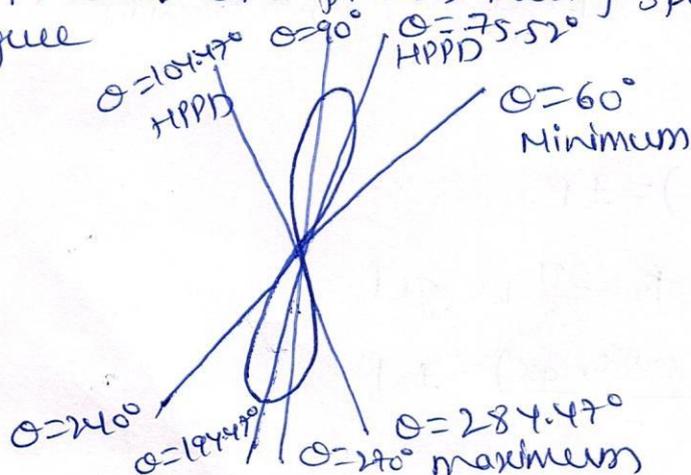
$$= \pm (2n+1) \frac{\pi}{4}, n=0,1,2, \dots$$

At $n=0$

$$\pi \cos \theta_{\text{HPPD}} = \pm \frac{\pi}{4}$$

$$\cos \theta_{\text{HPPD}} = \pm \frac{1}{4} \Rightarrow \theta_{\text{HPPD}} = 75.52^\circ \text{ or } 104.47^\circ$$

The field pattern for two elements array with equal amplitudes and phases having spacing of $d=\lambda$ as shown in figure



1a) An Antenna has a field pattern given by $E(\theta) = \cos^2 \theta$ for $0 \leq \theta \leq 90^\circ$. Find the half power beam width.

A. Given that

Field pattern $E(\theta) = \cos \theta \cos 2\theta$, $0^\circ \leq \theta \leq 90^\circ$

At half power beam width

$$|E(\theta)| = \frac{1}{\sqrt{2}}$$

$$|\cos \theta \cos 2\theta| = \frac{1}{\sqrt{2}}$$

$$\cos \theta (2 \cos^2 \theta - 1) = 0.707$$

$$2 \cos^3 \theta - \cos \theta = 0.707$$

$$2 \cos^3 \theta - \cos \theta - 0.707 = 0$$

$$\cos \theta = 0.937, -0.468, -0.468$$

$$\theta = \cos^{-1}(0.937), \cos^{-1}(-0.468), \cos^{-1}(-0.468)$$

$$\theta = 20.45^\circ, 117.9^\circ, 117.9^\circ$$

0 must lie b/w 0° and 90°

$$\theta = 20.45^\circ$$

$$\text{HPBW} = 2\theta \Rightarrow 2 \times 20.45^\circ$$

$$\text{HPBW} = 40.9^\circ$$

b) Define any three antenna parameters

A. 1. Radiation Intensity: - It is defined as power radiated from an antenna per unit solid angle. Its units are Watts/steradian or Watts/radian² and denoted by U i.e.

$$U(\theta, \phi) = \frac{P_r(\theta, \phi)}{d\Omega}$$

2. Beam efficiency: It is defined as the ratio of power transmitted within one solid angle Ω_1 to the power transmitted by the antenna.

3. Directivity: It is ratio of maximum radiation intensity of the subject antenna to the radiation intensity of an isotropic antenna radiating same total power.

$$D = \frac{U_{\max}}{U_{\text{av}}} = \frac{4\pi U_{\max}}{U_T}$$

c. what is folded dipole antenna?

A. Folded dipole antenna is the important transformation of conventional half wave dipole.

* It consists of two parallel half wave dipole folded and connected together at their ends.

* of these two, one is continuous and other split at the centre to provide feed as shown.

* the radiation fields of two poles are parallel.

d. why is an electromagnetic horn antenna as well matched antenna?

A. In electromagnetic horn antenna, the flaring angle helps to match the antenna impedance with free space impedance for better radiation. It eliminates the standing wave ratio and provides greater directivity so, electromagnetic horn antenna is well matched antenna.

e. what is Fermat's principle?

A. It states that when a light ray moves from one fixed

point to another fixed point, through any number of reflections, the total path followed by a light ray should be stationary. For reflection and refractions at plane surfaces, the total path followed by light ray should be minimum and at curved surfaces, the total path followed by light ray should be maximum.

f. List the advantages of Cassegrain feed.

A. Advantages:-

1. Minor lobes and spill over are reduced.
2. The feed can be placed at desired and convenient location.
3. Equivalent focal length can be maintained to value much greater than physical length.
4. The beam can be scanned broadened, by moving any one of reflecting surfaces.

g. Find the near and far field distances for a reflector antenna with diameter $D = 0.5\text{ m}$ at 300 GHz .

A. Given that

$$d = 0.5\text{ m}$$

$$f = 300\text{ GHz}$$

The distance at which reactive near field of a reflector antenna starts is given by

$$r_{\text{nf}} \leq 0.62 \sqrt{\frac{d^3}{\lambda}} \quad \lambda = \frac{c}{f}$$

$$r_{\text{nf}} \leq 0.62 \sqrt{\frac{0.5^3}{10^{-3}}}$$

$$r_{\text{nf}} \leq 6.93\text{ m}$$

The distance at which radiating near field starts is

$$r_{ff} \leq \frac{2d^2}{\lambda}$$

$$\leq \frac{2 \times (0.5)^2}{10^{-3}} \leq 500 \text{ m}$$

$$r_{ff} \leq 500 \text{ m}$$

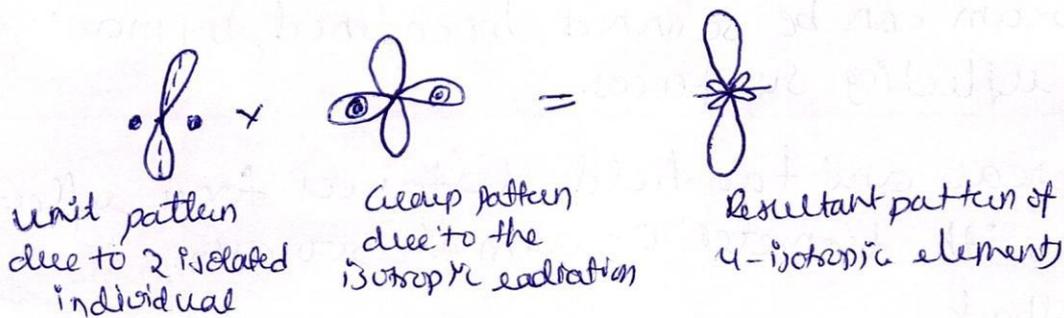
The distance at which far field region starts is

$$r_{ff} \geq \frac{2d^2}{\lambda}$$

$$r_{ff} \geq 500 \text{ m}$$

h. Draw the radiation pattern of an array of four isotropic elements spaced $\lambda/2$.

A. The radiation pattern of an array of four isotropic elements spaced by $\lambda/2$ is given by



i. what is impact of imperfect earth on surface wave?

- A.
- * The surface waves or ground waves get attenuated due to the earth imperfection. The attenuation increases with the frequency.
 - * The tilt in the wave progresses as long the curvature of earth. As a result, the horizontal component of electric field decays, reducing the strength of E-field.

Q. calculate the maximum distance at which signal from transmitting antenna with 144m height would be received by the receiving antenna of 25m height

A Given that

$$h_r = 25\text{m}$$

$$h_t = 144\text{m}$$

The maximum line of sight transmission distance's

$$d_{\max} = \sqrt{2R} [\sqrt{h_t} + \sqrt{h_r}]$$

$$= \sqrt{2 \times 6.4 \times 10^6} [\sqrt{144} + \sqrt{25}]$$

$$= 60821.04\text{m}$$

$$= 60.82\text{km}$$

$$d_{\max} = 60.82\text{km}$$

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				QM	
Name of the Exam:	I Mid Examinations			Marks:	10
Year-Sem& Branch:	III-II & ECE	Duration:	60 Min		
Subject:	AWP	Date & Session			
Answer ANY TWO of the following Questions				2X5=10	

Q.NO	Question	Bloom's Taxonomy Level	Course Outcome
1	a).Define Antenna. Explain classification of antennas based on Radiation pattern b). Explain Maxwell's approach to relate potentials, fields and their sources	Applying	CO-1
2	Explain the following terms with respect to antenna i) Radiation pattern ii) Power gain iii) Antenna field zones iii) Beam solid angle v) Effective length	Remember	CO-1
3	Explain types of Horn antennas with design principle.	Understanding	CO-2
4	Explain features, Advantages, Disadvantages, applications, Characteristics and Geometry of microstrip antennas with neat sketches.	Understanding	CO-2

R13

Code No: 115DQ

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY, HYDERABAD
B. Tech III Year I Semester Examinations, November/December - 2016

ANTENNAS AND WAVE PROPAGATION
(Common to ECE, ETM)

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) What is meant by Beam Area? [2]
- b) What is meant by Polarization? [3]
- c) Why folded dipole antenna is used in yagi antenna? [2]
- d) What is axial mode of radiation? [3]
- e) What is Lunenburg lens? [2]
- f) What are the various feeds used in reflectors? [3]
- g) Define isotopic source. [2]
- h) What is reciprocity of an antenna? [3]
- i) What are the types of Ground wave? [2]
- j) What are the factors that affect the propagation of radio waves? [3]

PART - B

(50 Marks)

2. Find the radiation resistance of elementary dipole with linear current distribution. [10]
OR
3. Derive the expression for far field components of a small loop antenna. [10]
4. What is Yagi-uda Antenna? Explain the construction and operation of Yagi-uda Antenna. Also explain its general characteristics. [10]
OR
5. Explain the Half-Wavelength Folded Dipole. [10]
6. Describe the parabolic reflector used at micro frequencies. [10]
OR
7. Explain the different types of lens antennas. [10]
8. State reciprocity theorem for antennas. Prove that the self-impedance of an Antenna in transmitting and receiving antenna are same. [10]
OR
9. What is linear array? Compare Broad side array and End fire array. [10]
10. Deduce an expression for the critical frequency of an ionized region in terms of its Maximum ionization density. [10]
11. Describe the troposphere and explain how ducts can be used for Microwave propagation. [10]

---ooOoo---