7.3 ANTENNAS AND WAVE PROPAGATION

7.3.1 Objectives and Relevance

7.3.2 Scope

7.3.3 Prerequisites

7.3.4 Syllabus

- i. JNTU
- ii. GATE
- iii. IES

7.3.5 Suggested Books

7.3.6 Websites

7.3.7 Experts' Details

7.3.8 Journals

7.3.9 Findings and Developments

7.3.10 Session Plan

7.3.11 Question Bank

- i. JNTU
- ii. GATE
- iii. IES

7.3.1 OBJECTIVES AND RELEVANCE

Through this subject, Students can understand the physical concept of Radiation and they can relate real-world situations. They can learn about various types of antennas, its working principle and design.

Since Hertz and Marconi, antennas have become increasingly important to our society until now they are indispensable. They are everywhere: at our homes and workplaces, on our cars and aircrafts. While our ships, satellites and spacecrafts bristle with them, even as pedestrians we carry them.

“With mankind’s activities expanding into space, the need for antennas will grow to an unprecedented degree. Antennas will provide the vital links to and from everything out there.

7.3.2 SCOPE

It gives about the basic concepts of the antenna parameters and also about the various antenna theorems in detail. Antennas are the basic components of any electric systems and are connecting links between the transmeter and free space and the receiver. Antenna place a vital role in finding the characteristics of the system in which antennas are employed. It gives in detail about the various types of microwave, VHF, and UHF antennas, their characteristics and the various applications. It also gives about the wave propagation in the various layers.

7.3.3 PREREQUISITES

The students should have a basic knowledge on the electro-magnetic fields, about the maxwells equations, static magnetic field, electric field currents and the basic knowledge on the vector analysis, and about the propogation of the electo magnetic waves in various mediums, polarizations concepts.

7.3.4.1 JNTU SYLLABUS

UNIT-I
OBJECTIVE
Study of the baisc concepts of the antennas and their parameters.

SYALLABUS
Antenna Basics: Introduction, Basic Antenna Parameters - Patterns, Beam Area, Radiation Intensity, Beam Efficiency, Directivty, Gain -Resolution, Antenna Apertures, Effective Height. Illustrative Problems.
Fields from Oscillating Dipole, Field Zones, Shape- Impedance considerations, Antenna Temperature, Front-to-back Ratio, Antenna Theorems, Radiation - Basic Maxwell's Equations, Retarded Potentials - Helmhotz theorem

UNIT-II
OBJECTIVE
Quantative study of Radiation using Maxwell’s Equations. Field components of Hertizian dipole and short dipole.

SYALLABUS
Thin Linear Wire Antennas: Radiation from Small Electric Dipole, Quarterwave Monopole and Halfwave Dipole - Current Distributions, Field Components, Radiated Power, Radiation Resistance, Beamwidths, Directivity, Effective Area and Effective Hight, Natural current distributions, Far fields and patterns of Thin Linear Centre-fed Antennas of different lengths, Illustrative problems. Loop Antennas - Introduction, Small Loops, Comparison of far fields of small loop and short dipole, Radiation Resistances and Directivities of Small and Large Loops (Qualitative Treatment).

UNIT - III

OBJECTIVE
Study of Arrays of antennas for increased directivity and major lobe direction.

SYALLABUS
ANTENNA ARRAYS : Point Sources - Definition, patterns, arrays of 2 Isotropic sources - different cases, Principle of Pattern Multiplication, Uniform Linear Arrays - Broadside, Endfire Arrays, EFA with Increased Directivity, Derivation of their characteristics and comparison; BSAs with Non-uniform Amplitude Distributions - General considerations and Binomial Arrays, Illustrative problems

UNIT-IV
OBJECTIVE
Study of antennas used at higher frequencies: Yogi-uda, Helical and Horn Antennas.

SYALLABUS
VHF, UHF AND MICROWAVE ANTENNAS - I : Arrays with Parasitic Elements, Yagi - Uda Arrays, Folded Dipoles and their characteristics. Helical Antennas - Helical Geometry, Helix modes, practical Design Considerations for Monofilar Helical Antenna in Axial and Normal Modes, Horn Antennas Types, Fermat's Principle, Optimum Horns, Design Considerations of Pyramidal Horns, Illustrative Problems

UNIT-V
OBJECTIVE
Study of Microstrip antennas, Reflectors, Parabolic Reflector for H.F Appliacations

SYALLABUS
VHF, UHF AND MICROWAVE ANTENNAS - II : Microstrip Antennas - Introduction, features, advantages and limitations, rectangular Patch antennas - Geometry and parameters, characteristics of microstrip antennas. Impact of different parameters on characteristics, reflector antennas - Introduction, flar sheet and corner reflectors, paraboloidal reflectors - geometry, Pattern Characteristics, Feed Methods, Reflector Types - Related Features, Illustrative problems

UNIT-VI
OBJECTIVE
Study of Lens antennas, Horn antennas, and measurement of important antenna parameters.

SYALLABUS
Lens Antennas - Introduction, Geometry of Non-metallic Dielectric Lenses, Zoning, tolerances, Applications.
Antenna Measurements: Introduction, concepts - Reciprocity, Near and Far fields, Coordinate system, sources of Errors. Patterns to be measure, pattern measurement arrangement, directivity measurement, Gain measurements (by Comparison, Absolute and 3-Antenna methods)

UNIT-VII
OBJECTIVES
Quantative study of ground wave propagation and space wave propagation and Tropospereic Propagation..

SYALLABUS
WAVE PROPAGATION - I: Introduction, Defintions, Categorizations and General Classifications, different Modes of Wave propagation, Ray/Mode concepts. Ground Wave propagation (Qualitative Treatment) Introduction, Plane Earth Reflections, Space and Surface Waves, Wave Tilt, Curved Earth Reflections. Space Wave propagation - Introduction, Field Strength variation with Distance and Height, Effect of Earth's Curvature, Absorption. Super Refraction, M-Curves and Duct Propagation, Scattering Phenomena, Tropospheric Propagation, Fading and Path Loss Calculations.

UNIT -VIII
OBJECTIVE
Study of sky wave propagation.

SYLLABUS

WAVE PROPAGATION - II: Sky Wave Propagation - Introduction, Structure of Ionosphere, Refraction andReflection of Sky Waves by Inonosphere, Ray Path, Critical Frequency, MU, LUF, OF, Virutal Hight and skip Distance, Relation between MUFand skip distance, Multi-hop propagation, Energy Loss in Ionosphere, Summary of Wave Characteristics in Different Frequency Ranges.

7.3.4.2 GATE SYLLABUS

UNIT-I
Radiation Pattern, Reciprocity Theorem, Gain

UNIT-II
Dipole Antennas, Antenna Arrays

UNIT-III
Not Applicable

UNIT-IV
Not Applicable

UNIT-V
Not Applicable

UNIT-VI
Not Applicable

UNIT-VII
Not Applicable

UNIT-VIII
Not Applicable

7.3.4.3 IES SYLLABUS

UNIT-I
Radiation Pattern, Reciprocity Theorem, Gain

UNIT-II
Dipole Antennas, Antenna Arrays

UNIT-III
Not Applicable

UNIT-IV
Not Applicable

UNIT-V
Not Applicable

UNIT-VI
Not Applicable

UNIT-VII

Not Applicable

UNIT-VIII
Not Applicable

7.3.5 SUGGESTED BOOKS

TEXT BOOKS

T1. Antennas for All Applications - John D. Kraus and Ronald J. Marhefka and Ahmad S. Khan, TMH, New-Delhi, 4th Ed., (Spdeial Indian Edition), 2010
T2. Electromagnetic Waves and Radiating Systems, E.C.Jordan and K.G.Balmain, PHI, 2nd edition, 2000

REFERENCE BOOKS

R1. Antenna Theory - C.A. Balanis, John Wiley & Sons, 3rd ed., 2005.
R2 Antennas and Wave Propagation - K.D. Prasad, Satya Prakashan, Tech India Publications, New Delhi, 2001
R3. Transmission and Propagation, V.D.Glazier and H.R.L.Lamont,The tservices text book of radio, Vol5, stanadard publishhers distributors, Delhi.
R4. Electronic and Radio Engineering-F..E.Terman, McGraw-Hill ,4th edition.1955.
R5. Antennas - John D. Kraus, McGraw-Hill, SECOND EDITION, 1988

7.3.6 WEB SITES

1. www.awpl@ece.uic.edu
2. www.eecs.tufts.edu
3. www.ryerson.ca/ualca/programs/compeng.html
4. www.peeas.ecs.umass.edu/degee/ece_degeee.html
5. www.georgefox.edu/catlog/undergrad/enge.html

7.3.7 EXPERTS' DETAILS

INTERNATIONAL

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2. Prof. V.M. Pandari Pandey
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3. Mr. I.V.S. Ramasastry
   Aurora's Engineering college,
   Bhongir.

7.3.8 JOURNALS

INTERNATIONAL

1. IEEE Antennas and propagation
2. IEEE transactions on Antennas and propagation
3. RF and Microwave Engineering
4. Microwave and antena Engineering

NATIONAL

1. IETE Technical Review
2. IETE Journal of Research

7.3.9 FINDINGS AND DEVELOPMENTS

1. A lumped circuit for Wideband impdeance matching of a Non-resonant, short dipole or monopole antenna, V. Iyer, S.N. Makarov, D.D. Hartey, F. Nekoogar and R. Luddwig, IEEE Transactions on Antenna and Propagation Vol.58, No.1, PP No 18-26, January 2010.

2. Beamforming lens antenna and high resistvity siliconwafer 60GHz WPAN, W.Lee, J.Kim, C.S.Cho, and Y.J. Yoon, IEEE Transactions on Antenna and Propagation Vol.58, No.3, PP No.706 -713, March 2010.

3. Transparent Dielectric resonator antennas for optical applications, E.H. Lim and K.W. Leung, IEEE Transactions on Antenna and Propagation Vol.58, No.4, PP No.1054- 1059, April 2010.

4. Switchatble Quad-Band antennas for cognitive radio base station application, T.Wu, R.L. Li, S.Y.Eom, S.S. Myound, IEEE Transactions on Antenna and Propagation Vol.58, No.5, PP No.1468 - 1476, May 2010.
5. A broadband folded - Quadrifilar Helical antenna employng a Novel compact planner feeding circuit. M. Caillet, M. Clenet, A. Shariha, and Y.M.M. Antar, IEEE Transactions on Antenna and Propagation Vol.58, No.7, PP No.2203-2209, July 2010.
6. Wideband Phase-reversal antenna using a Novel bandwidth Enhancement techniques , N.Yang, C.Caloz, and K.Wu, IEEE Transactions on Antenna and Propagation Vol.58, No.9, PP No.2823-2830, September 2010..
7. Circularly polarized wide slot antenna loaded with a parasitic patch, Jeen -Sheen Row and Shiao-Wen Wu, IEEE Transactions on Antenna and Propagation Vol.56, No.9, PP No.2826, 2832, September 2008.
8. Reconfigurable patch antenna for polarization Diversity, YJ Sung, IEEE Transactions on Antenna and Propagation, Vol. 56 No.9, pp no. 3053-3054, September 2008.
9. Brad band Dual linear polarized anteena for statistical detection of Breast cancer , DA Woten & MEl-Shenauce, IEEE Transactions on Antenna and Propagation, Vol.56, No.11, pp no.3576-3579, Nov 2008.
10. Printed dual spiral - loop wire antenna for broadband circular polarization.Y,Zhang and L. Zhu., IEEE Transactions on Antenna and Propagation January 2006,Vol. 54, Number 1.

7.3.10.I SESSION PLAN

The picture can't be displayed.

S.No.	Topics in JNTU Syllabus	Modules and Sub modules	Lecture No.	Suggested Books	Remarks
15	Horn Antennas-Types, Fermat's Principle, Optimum Horns, Design Considerations of Pyramidal Horns, Illustrative Problems	Types of Horn Antennas: Pyramidal and sectorial horns	L31	T1-Ch7,R1-Ch-13	
		Fermats's principle, Optimum horns	L32	T1-Ch7,R1-Ch13	
		Design Considerations of Pyramidal Horns, Problems	L33	T1-Ch7,Ch13	
UNIT-V					
16.	VHF, UHF and Microwave Antennas-II: Microstrip Antennas – Introduction, Features, Advantages and Limitations, Rectangular Patch Antennas-Geometry and Parameters,				
		Importance of Microstrip antennas and its features, advantages and limitations.	L34	T1-Ch14, R1-Ch14	
		Rectangular patch antennas geometrical structure and its characteristic parameters	L35	T1-Ch14, R1-Ch-14	
17	Characteristics of Microstrip Antennas, Impact of Different Parameters on Characteristics	Characteristics of microstrip antennas ,impact of different parameters on characteristics	L36	T1-Ch14, R1-Ch-14	
18	Reflector Antennas-Introduction , Flat sheet and Corner Reflectors.	Construction and working principles of flat and corner reflectors and applications.	L37	T1-Ch9, R1-Ch15	
19	Paraboloidal Reflectors-Geometry, Pattern characteristics, feed Methods Reflector Types-Related Features, Illustrative Problems	Geometry and construction of parabolic reflector, radiation pattern	L38	T1-Ch9, R1-Ch15	
		Different feeds for parabolic reflectors. Front feeding,Cassegrain , Gregorian Offset feeding. Problems	L39	T1-Ch9, R1-Ch15	
UNIT-VI					
20	Lense antennas Introduction, Geometry of Non-metallic Dielectric Lenses, Zoning, Tolerances Applications.	Working principle of Lens antennas, types; Non-metallic, dielectric and Zoning lenses, Construction advantages and applications.	L40	T1-Ch10	

S.No.	Topics in JNTU Syllabus	Modules and Sub modules	Lecture No.	Suggested Books	Remarks
21	Antenna Measurements –Introduction,Concepts- Reciprocity, Near and Far Fields, Coordinate System, Sources of Errors.	Measurement of basic antenna parameters reciprocity principle	L41	T1-Ch21, R1-Ch16	
		Near field and far field distance criterion radiation M/S and space coordinate system source of errors	L42	T1-Ch21, R1-Ch16	
22	Patterns to be Measured, Pattern Measurement Arrangement,Directivity Measurement, Gain Measurements (by Comparison, Absolute and 3-Antenna Methods).	Antenna patterns Pattern measurement set up Directivity M/S	L43	T1-Ch21, R1-Ch16	
		Gain M/S by comparison method, absolute method and three antenna Method	L44	T1-Ch21, R1-Ch16	
UNIT-VII					
23	Wave Propagation-I: Introduction, Definitions, Categorizations and General Classifications, Different Modes of Wave Propagations, Ray/Mode Concepts..	Basic types of wave propagation mechanism. and definitions	L45	T1-Ch23,T2-Ch16	
		Different modes of wave propagation Ray/mode concepts	L46	T1-Ch23,T2-Ch16	
24	Ground wave propagation (Qualitative Treatment) – Introduction, Plane Earth Reflections, Space and Surface Waves, Wave Tilt, Curved Earth Reflections.	Ground wave propagation Sommerfeld’s formula, Earth reflections effects	L47	T1-Ch23,T2-Ch16	
		Space and surface waves wave tilting curved earth reflections	L48	T1-Ch24,T2-Ch16	
25	Space Wave Propagation-Introduction, Field Strength variation with Distance and Height	Space wave propagation: LOS distance calculation. Variation of field strength with respect to distance and height for a space wave propagation	L49	T1-Ch24,T2-Ch16	

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II. TUTORIAL PLAN

Tutorial No	Title	Salient topics to be discussed
T1	Antenna Fundamentals	Problems based on antenna parameters: Gain, Radiation resistance and efficiency
T2	Antenna Fundamentals	Problems on directivity, aperture efficiency, affective aperture area, and effective height
T3	Thin Linear wire antennas	Problems on dipole, monopole, half wave dipole, radiation resistance of short dipole, half wave dipole & quarter wave monopole, Beamwidths, directivity, effective area and ,effective height,
T4	Thin Linear wire antennas	Problems on loop antennas,, directivity and R_r and Directivity
T5	Antenna Arrays	Problems on N-Element Linear array , side lobes, Nulls , Beam width between nulls.
T6	Antenna Arrays	Problems on broad side array, end fire array & binomial array
T7	Non-Resonant antennas.	Problems on field strength calculation of long wire antennas and rhombic antenna,
T8	Non-Resonant antennas.	Problems on helical antennas:, design of monofilalar axial mode helical antennas
T9	VHF,UHF and Microwave antennas-I	Problems on Yagi-Uda antenna array, Folded dipoles
T10	VHF,UHF and Microwave antennas-I	Problems on parabolic reflectors and corner reflectors
T11	VHF,UHF and Microwave antennas-II	Problems on Horn antennas.
T12	Wave propagation-I	Problems on ground wave propagation , sky wave propagations-critical frequency, MUF & skip distance calculations.
T13	Wave propagation-I	Calculations for flat and spherical earth cases, optimum frequency, LUHF, virtual height
T14	Wave propagation-II	Problems on free space propagation-basic transmission loss calculations
T15	Wave propagation-II	Field strength calculations

7.3.12 QUESTION BANK

UNIT-I

1. i) Define the following terms as applicable to antennas and explain their significance.
   i) Beam widths and Beam Area,
   ii) Radiation Intensity and Radiation resistance.

   ii) For an antenna radiating into the upper hemisphere with a far field pattern of 2 cosθ estimate the HPBW .BWFN, directivity and beam efficiency. **(Dec 12)**

2. Write a short notes on antenna band width. **(Nov 11)**

3 A dipole having a length of 3cm is operated at 1 GHz. The efficiency factor is 0.6. Calculate the radiation resistance, the antenna gain, and the effective. **(Nov 11)**

4 i. A transmitter is fed with 100KW of power and produces the same field strength at a given point as $\lambda/2$ dipole fed with 200KW of power. Calculate the gain of the aerial
   a. relative to $\lambda/2$dipole
   b. relative to an isotropic aerial.

   ii. An elementary doublet is 10cm long. If the 1MHz current owing through it is 2A, what is the field strength 20km away from the doublet, in a direction of maximum radiation? **(Nov 10)**

5. What is the maximum effective aperture area for a beam antenna having half- power widths of 30^0 and 25^0 in perpendicular planes intersecting in the beam axis? Assume that minor lobes are small and can be neglected.
(Nov 10)

6. i. Define antenna radiation pattern. Draw and explain its parameters.
   ii. Calculate the radiation efficiency of an antenna if the input power is 2kW, maximum directivity is 22dB, and the radiated power density at a distance of 10km in the direction of the maximum directivity is $0.2mW/m^2$
(Nov 10)

7. Explain the concept of retarded scalar and vector potentials. **(Nov 10)**

8. Determine the power density for a radiated power of 1200W at a distance of 50Km from an isotropic antenna? **(Nov 09)**

9. i. Define antenna radiation intensity. Derive the expression for it.
   ii. Calculate the radiated and dissipated power by an antenna if the input power is 1.5kW and its radiation efficiency is 95%. **(Nov 09)**

10. Defie the following terms:
   i. Directivity
   ii. Gain
   iii. Effective Aperture of Antennas. **(Nov 09)**

11. i.Define and Explain: Directivity and power gain for an antenna. What is the relation between the two? Prove that the directivity of a /2 aerial is 0.39 db more than that of short dipole.
   ii. What are principal planes? How the antenna beam width is defined in such planes?
(Nov 09, 08, Feb 0702)

12. i.Explain the following :
   a. Normalized Field Pattern
   b. Beam Solid Angle
   c. Beam Efficiency
   d. Directivity.

   ii. An antenna has a field pattern given by E (Ø) = cos θ cos 2θ for $0^0 \leq \theta \leq 90^0$.
   Find

1. the HPBW

b. Beam Width between first nulls. (FNBW) **(Nov 09, 08)**

13. Derive the expressions for Retarded Current using Maxwells Equations Approach. **(Nov 09)**

14. i.Derive the Friis Transmission Formula and explain how it affect the antenna parameters?
ii.If a certain linear antenna has an current distribution $I_z = I_0 \cos z$ along its length from $z = -\lambda/4$ to $z = \lambda/4$.Determine its effective length. **(Nov 09)**

15. i Sketch the Current distribution of a thin wire antenna for lengths
a. $l << \lambda$
b. $l = \lambda/2$
c. $\lambda/2 < l < \lambda$
d. $\lambda < l < 3\lambda/2$.
ii. How do you visualize the concept of radiation? Explain. **(Nov 09)**

16. Find the directivity of an antenna having average power $P(\theta)=A_0 \sin^2 \theta/r^2$ **(Nov 09)**

17.. The field pattern of an antenna is given by $E_n=(\sin\theta /\theta) (\sin Ø/Ø)$
a. Plot the Normalized power pattern.
b. Estimate the main beam efficiency of the antenna. **(Nov 08)**

18. i.Explain the following :
a. Normalized Field Pattern
b. Beam Solid Angle
c. Beam Efficiency
d. Directivity.
ii. An antenna has a field pattern given by $E(\theta) = \cos\theta \cos 2\theta$ for $0^0 \leq \theta \leq 90^0$.
Find
a. the HPBW
b. Beam Width between first nulls. (FNBW) **(Nov 08)**

19. i.Define and account for the presence of
a. Radial Power Flow
b. Radiation resistance for a short dipole
c. Uniform Current Distribution.
ii. Calculate the following for an antenna carrying 50A (rms) at 480 kHz having effective length of 60.96metres. Take loss resistance of the antenna= 5 ohm.
a. Radiation resistance
b. Power radiated
c. Antenna efficiency
d. Directivity and power gain
e. HPBW and BWFN. **(Nov 08)**

20. i. As related to Antennas, define and explain the following terms:
a. Directivity
b. Radiation Resistance
c. Beam Width
d. Band Width.
e. Gain
ii. Evaluate the directivity of
a. An Isotropic Source
b. Source with Bi-Directional cos θ power pattern **(Nov, Feb 08)**

21. ii. The radiation intensity of a particular antenna is given by $f(\theta,\varnothing)= \sin^2\theta$ Calculate the directivity of the antenna.

iii. Define the effective aperture and calculate the effective aperture of 0.25λ dipole. **(Nov 08)**

22. Explain the terms 'Radiation Field', 'Induction Field' and 'Electrostatic Field' by deriving the E Field of a current element through vector potential. **(Nov 08)**

23. i. What is Retarded Potential? Explain different approaches to solve radiation Problems.

ii. Explain the Lorentz Gauge Condition and show that where A is magnetic vector potential. **(Feb 08)**

24. i. State the Reciprocity Theorem for Antennas? Prove that the Self Impedance of an Antenna in transmitting and receiving mode is same.

ii. Define Directivity. Obtain the Directivity of an Isotropic Antenna, Short Dipole and Half-Wave Dipole **(Feb 08)**

25. i.Explain the following terms:

a. Beam Width
b. Omni Directional pattern
c. Side Lobe Level
d. Radiation resistance
e. Field Pattern of antenna

ii. Define the terms Directivity and Power Gain. Show that the Directivity of a short current element is 1.5 **(Feb 08, Nov 07, 02)**

26. Find the effective length of a λ/2 dipole and λ/4 monopole. Hence calculate their directivities, using the appropriate radiation resistances. **(Feb 08)**

27. i. Explain the terms "Isotropic", "Directional" and "Omni directional pattern", "Radiation Intensity".

ii. Define Effective Aperture and calculate the effective aperture of a 0.25 λ dipole. **(Feb 08)**

28. i. Draw the Dual characteristics of an antenna.

ii. Explain the Radiation from Two wire. **(Nov 07)**

29. i. Distinguish between Directive Gain and Power Gain.

ii. An antenna has a radiation resistance of 73 Ω and a lossy resistance of 7 Ω If the power gain is 20, calculate the directivity and the efficiency of the antenna. **(Nov 07)**

30. i. Define the terms:

i. Beam Width
ii. Side Lobe Level
iii. Polarization
iv. Effective Aperture Area.

ii. What is the effective length of an antenna? Determine the effective length of a half wave dipole antenna. **(Nov 07)**

UNIT-II

1.i. A 50 cm. long vertical dipole operating at 30 MHz radiates a maximum electric field of 15 mV/m at 5 km distance. Find its power radiated, input current and maximum magnetic field at the same distance.

ii Give the far-field expressions for a λ/2 vertical dipole and hence evaluate its radiation resistance. List out the expression and sketch its current distribution along the length. **(Nov/Dec 13)**

2.i. Define and explain the significance of the terms : retarded potentials and radiation resistance.

ii Starting from the far-field expressions of a short vertical centre-fed dipole,obtain an expression for its radiation resistance. **(Nov/Dec 13)**

3. i. Describe and explain the significance of the terms: Radiation Resistance and Aperture Efficiency, as applicable to antennas.

ii. For a constant current distribution on a short vertical dipole, obtain an expression for the magnetic field. Hence calculate the distance at which the radiation and induction field terms have equal amplitudes **(Nov/Dec 13)**

4.i. The normalized electric field of a typical antenna is given by cos2 θ, for $0 \le \theta \le \pi/2$, and $0 \le \emptyset \le 2\pi$. Determine its HPBW, FNBW, directivity and effective area. Sketch its pattern in vertical plane.

ii. Define all the parameters used above. **(Nov/Dec 13)**

5. i. With neat schematics, explain the configuration of an oscillating electric dipole and derive its far field expressions.

ii. For a 20 m. vertical dipole antenna, find the power radiated, radiation resistance and radiation efficiency at 1MHz with an input peak current of 500 mA and a loss resistance of 2.5 ohms. **(Dec 12)**

6. What is the effect of doubling the current into a Hertzian dipole on

i. The total radiated power

ii. The radiation intensity and

iii. The directivity **(Nov 11)**

7. i. Show that the radiation resistance of a half wave dipole is 73 Ω.

ii. With suitable representation show the equality of effective length at transmitter and receiver. **(Nov 11)**

8. i. What is Hertzian dipole? Write the relation between a current element and an electric dipole write suitable expressions.

ii. Show that the radiation feld at the surface of the earth from monopole is given by **(Nov 11)**

9. Draw the radiation pattern of an dipole Antenna and explain all its characteristics? **(Nov 10)**

10. i. Compare the Loop antenna with Short Dipole.

ii. A lossless quarter wave monopole antenna is situated above a perfectly conducting ground plane and is driven from 300 MHz source with the amplitude of 100V. Calculate the average power radiated if the antenna impedance is (36.5+j21.2) and internal resistance of source is 50. **(Nov 10)**

11. Derive the expression for radiation field of a small loop antenna of radius `a' at the centre of the co-ordinate system. **(Nov 10)**

12 i. Show that the Directivity of an elementary Dipole (Current Element) is 1.5 or 1.76dB.

ii. Calculate the power gain of a half wave Dipole whose ohmic losses and Directive gain are 7.0Ω and 1.64 respectively. **(Nov 09)**

13. Draw the diagram showing approximate current distribution along half wave dipole which is centre fed with a current of 2mA rms. Calculate the electric filled at a distance of 10km from this half wave dipole. Calculate the gain of this dipole with respect to an isotropic radiator. **(Nov 09)**

14.i. Show that the Directivity of an elementary Dipole (Current Element) is 1.5 or 1.76dB.

ii. Calculate the power gain of a half wave Dipole whose ohmic losses and Directive gain are 7.0 Ohms and 1.64 respectively. **(Nov 09)**

15. i. Find the radiation resistance of a current element ?

ii. A magnetic field strength of 5A=m is required at a point on =π/2, 2km away from an antenna in free space. Neglecting ohmic loss, how much power must the antenna transmit if its is a Hertzian dipole of length λ/25? **(Nov 09)**

16. i. An electric field strength 10μ/Am is to be measured at an observation point, 500km from a half wave dipole antenna operating at 50MHz.
   a. What is the length of dipole
   b. Calculate the current that must be fed to antenna
   c. Find the average power radiated by antenna.
   ii. Find the aperture of a short dipole. **(Nov 09)**

17. Derive the expression for radiation resistance of a small loop antenna starting from the Maxwells Equations. **(Nov 09)**

18. Show that the radiation resistance of a small loop is equal to 320 π^2 $4(A/\lambda^2)^2$ ohms where A is loop area. **(Nov 09)**

19. Obtain the relative amplitudes of radiation, induction and electrostatic fields at a distance of 2 from a short current element. **(Nov 09)**

20. i.Explain how loop aerial is used for Direction Finding? Derive the relevant expression for electric field intensity for loop aerial.
   ii. Derive an expression for radiation resistance of half wave length slot aerial using babinet's principle. Sketch the field pattern. **(Nov 09)**

21. i. Derive an expression for the Radiation Resistance of a Loop Antenna.
   ii. Find the Effective Length of a Half Wave Dipole.
   iii. A Small current element at 10MHz produces a radiated field in a direction making angle with the element. Assuming that the current is 10A. Calculate the power radiated and radiation resistance of the Antenna. **(Nov 08)**

22. i. Starting from the fundamentals, derive an expression for radiated electric field for half wave dipole andsketch the field strength pattern.
   ii. Prove that l_{eff} (transmitting) is same as l_{eff} (receiving) for any antenna where l_{eff} is effective length of an antenna. **(Feb 08)**

23. i. Derive expressions for the electric and magnetic fields radiated by a half wave length dipole antenna.
   ii. A grounded vertical antenna has an effective height of 111.3 mts and operates at a wavelength of 18.8kms,with base current of 725 amps, Find the E and H fields at a distance of 150kms and power radiated by it **(Feb 08)**

24. i. Derive the expressions for electric field in case of short current element and hence obtain the conditions for the field to be in Franhofer region.
   ii. Find the distance from a radiating element with 60Hz current such that radiation and induction fieldsare equal**.** **(Nov 07)**

25. i. Derive an expression for radiance resistance of current element starting from the expression for radiation fields.
   ii. Prove that the impedance of an isolated antenna when used for receiving is same as when used for transmitting. **(Nov 07)**

26. i. Show that the radiation resistance of a small loop is equal to $320\pi^2$ $4(A/\lambda^2)^2$ ohms where A is loop area.
   ii. What is Folded Dipole ? Find its Radiation Resistance. **(Nov 07)**

27. Obtain the relative amplitudes of radiation,induction and electro-static fields at a distance of 2 from a short current element having an uniform current of 1 mA along its length **(Feb 07)**

28. i. Explain the terms poynthing vector,impedance of free space and bring out their relation with radiation fields of an antenna.

ii. Show that the rms field strength from an antenna with gain G, radiating P watts of power is given by
E = 30 (PG)/r volts/mts, in free space. Find E at a distance of 1KM , if the radiated power is 1KW for
i. An isotropic case
ii. A half wave dipole **(Feb 07,April 05)**

29. Show that for a Hertzian dipole, the aperture area is $0.12\lambda, 2\lambda$ and for a half-wave dipole, it is $0.13\lambda/2$and for an isotropic radiator, it is $0.08\lambda/2$. Explain the relation used. **(Nov 06)**

30. Derive the EMF equation for a small loop antenna **(Nov 06)**

UNIT-III

1.i. Find the array factor and sketch the pattern of a 2-element array having equal amplitudes and phases, and having a spacing of $d = \lambda$.
ii. For a 16 element Broadside Array with $\lambda/2$ spacing, derive the array factor, and hence calculate its FNBW, First Side lobe Level, Directivity and Effective Area. **(Nov/Dec 13)**

2.i. For a 16 element uniform linear array with $d = \lambda/2$, determine the array factor and hence find the FNBW, first null position, directivity and effective area. Assume in-phase excitation.
ii. Explain the principle of pattern multiplication. How is it helpful? **(Nov/Dec 13)**

3. Explain the need for non-uniform amplitude distribution in a linear array,and hence sketch thepattern of a 4 element Binomial Array. **(Nov/Dec 13)**

4. i. Using the Principle of Pattern Multiplication, estimate and sketch the pattern of a 8 element Binomial array by computing its amplitude coefficients.
ii. Derive the Array Factor of a 4-element End fire Array with spacing and equal excitation amplitudes Compute its nulls, side lobe levels, BWFN, and sketch the pattern. **(Dec 12)**

5. Derive maxima, minima and half power point directions when two point sources are fed with current equal in magnitude but opposite in phase. **(Nov 11)**

6. Design a 4-element, broadside array of isotropic elements spaced apart with all the side lobes 25dB below the main lobe. **(Nov 11)**

7. What is Hertzian dipole? Write the relation between a current element and an electric dipole write suitable expressions. **(Nov 11)**

8 i. Derive the field components and draw the field pattern for two point source with spacing of and fed with currents of equal magnitude but out of phase by 180^0.
ii. Calculate the directions of the maxima and the nulls of the array factor of an array of two infinitesimal dipoles oriented along the z-direction, kept at z_1 = -0:125 and z_2 = 0:125 and carrying currents
$I_1 = e^{j\pi/4}$ and $I_2 = e^{-j\pi/4}$ **(Nov 10)**

9 i. Derive the expression for total far field for the two point sources with currents of unequal magnitudes and with same phase.
ii. Derive the field components and draw the field pattern for two point source with spacing of $\lambda/2$ and fed with currents of equal magnitude and phase. **(Nov 10)**

10. i. A six element receiving aerial array consists of a horizontal line of vertical dipoles equally spaced by 2.5m, the outputs of which are added in phase. What are the significant properties of the pattern. Describe the directional characteristic of this array at 400MHz and 40MHz.
ii. Derive Hansen-Wood yard condition for N element end fire array for enhancing its directivity. **(Nov 10)**

11. i. Determine the fields at any far point P for an array of n elements with equal spacing and currents equal in magnitude and phase.
    ii. What is end fire array? Derive expressions for the radiation pattern for an end fire array of `N' identical elements. **(Nov 10)**
12. i. Determine the fields at any far point P for uniform, linear array of n elements.
    ii. What is Broadside Array? Compare it with End- Fire Array. **(Nov 09)**

13. i. Derive the expression for total far field for the two point sources with currents of equal magnitudes and with same phase.
    ii. An End-fire array with elements spaced at $\lambda/2$ and with axes of elements at right angles to the line of array is required to have directivity of 36. Determine array length and width of the major lobe. **(Nov 09)**

14. i. Calculate the directivity in dB for the broadside as well as end fire array consisting 8 isotropic elements separated by $\lambda/4$ distance.
    ii. write short notes on binomial array. **(Nov 09)**

15. What is an antenna array? Discuss the characteristics of any one configuration? **(Nov 09)**

16. i. Compare Broadside array and End-fire array.
    ii. Find the length and BWFN for Broadside and End-fire array if the directive gain is 15. **(Nov 09)**

17. i. What is a Uniform Linear Array? Show that
    a. the amplitude of principal maximum to the first secondary maximum is 13.5dB if the number of elements(n) in the array is large.
    b. for all odd values of n, the smallest lobe has unity amplitude at $\psi=\pi$
    ii. Compute the width of principal lobe of
    a. BSA
    b. EFA, if array length is 10λ **(Nov 09)**

18. Derive array factor for an array of 4 isotropic elements in phase and spaced $\lambda/2$ apart. **(Nov 09)**

19. i. Design a 4 element BSA of $\lambda/2$ spacing between point source elements. The side lobe level is 26 dB to have optimum pattern.
    ii. Explain and compare different types of antenna arrays. **(Nov 09)**

20. i. Explain the principle of pattern multiplication. What is the effect of earth on the radiation pattern of antennas?
    ii. A uniform linear array consists of 16 isotropic point source with a spacing of $\lambda/4$ if the phase difference $\alpha=-90^0$. Find
    a. HPBW.
    b. Directivity.
    c. Effective aperture. **(Nov 09,Feb 08)**

21. Enumerate the advantages and disadvantages of linear arrays. **(Nov 08)**

22. i. Find the radiation Pattern of 4 isotropic elements fed in phase, spaced $\lambda/2$ apart by using pattern multiplication.
    ii. What is uniform linear array? Discuss the application of linear array. **(Nov 08)**

23. i. Derive an expression for radiated power (R_p) of a BSA with ‘n’ vertical dipoles.
    Plot the R_p in vertical and horizontal planar for a BSA of 4 dipoles.
    ii. Show the directivity of EFA (with increased directivity) is given by $1.789[4(L/\lambda)]$. **(Nov 08)**

24. i. How an unidirectional pattern is obtained in an end fire array? Explain in detail.
    ii. List out the mathematical relations for a N element half wavelength spaced binomial array. Hence find the directivity, HPBW for N=20. **(Feb 08)**

25. i. What is the necessity of an Array? Explain the three different types of arrays with regard to beam pointing direction.
ii. 64 isotropic elements are to be arranged in a binomial array form. Determine the current ratios and find polar plot of the array **(Feb 08)**

26 i. What are the various differences between binomial and linear arrays?
ii. Design a 8 element broadside array of isotropic sources of λ/2 spacing between elements. The pattern is to be optimum with a side lobe level 26db down the mainlobe maximum **(Feb 08)**

27. i. A linear broadside array consist of 4 identical equal in phase point source with λ/3 spacing. Calculate and plot the field pattern. Also find the directivity and beam width.
ii. What is optimum spacing used in parasitic array? Why? **(Nov 07)**

28. What are linear arrays. Compare Broadside array and End fire array. **(Nov 07)**

29. i. Explain the procedure for measuring the radiation pattern of a half wave dipole.
ii. What is the requirement for tapering of arrays.
iii. State the applications of arrays. **(Nov 07)**

30. i. Calculate
a. HPBW
b. Solid Angle if a linear array having 10 isotropic point source with λ/2 spacing and phase difference $\delta=90^0$.
ii. Write short notes on Hansen-Wood yard end fire array. **(Nov 07)**

UNIT-IV

1.i. With neat illustrations, explain the geometry and requirements for a helical antenna radiating into axial mode, and give the relevant design relations.
ii. For a parabolic reflector of 7.5 m diameter, at 4 GHz, find the BWFN, HPBW,Directivity and effective aperture. **(Nov/Dec13)**

2.i. Compare the radiation characteristics of travelling wave and standing wave radiators.
ii. With neat schematics, explain the geometry of a helical antenna and describe its characteristics in normal mode of radiation **(Nov/Dec13)**

3. Explain the working principle of a 3-element Yagi-Uda Antenna Array and list out its applications. **(Nov/Dec 13)**

4.i. What are off-set feeds ?
ii. Distinguish between the axial and normal modes of radiation characteristics of a helical antenna, and identify their requirements.
iii. State the Fermat's Principle, and explain its applicability to horn Antennas. What is an Optimum Horn? List out the standard horn antennas and give their applications. **(Dec 12)**

5. For what applications wideband antennas are required? List the various broadband antennas, giving typical percentage bandwidths for each? **(Nov 10)**

6. Explain end fire mode helical antenna with suitable sketches, explain its working and find its field components and also write applications of helical antenna. **(Nov 10)**

7. Sketch the radiation pattern of a helical antenna. **(Nov 10)**

8 What are the three important characteristics of UHF and microwave antennas? **(Nov 10)**

9. What are the required conditions that a helical antenna can act as array of loop and dipole? Prove it with suitable equations. **(Nov 09)**

10. What is Folded Dipole ? Find its Radiation Resistance. **(Nov 09)**

11. What is a Parasitic Element? Explain how it is used to improve the directivity of an antenna. **(Nov 09)**

9. Describe the current distribution and sketch the radiation pattern of a folded antenna. **(Nov 09)**

10 i. Draw the Yadi-Uda antenna and sketch its radiation, Write down the design equations of yagi-uda antenna.
ii. Design Yagi Uda antenna of six elements to provide a again of 12dB if the operating frequency is 200MHz.
(Nov 08)

11. Write short notes on "Helical Antenna". **(Nov 08)**

12. Explain the construction and radiation characteristics of Helical Antenna. **(Feb 08)**

13. Sketch the current distribution of folded dipole and find out input impedance when two legs have unequal diameters. **(Nov 07)**

14. What is a Parasitic Element? Describe the use of different types of parasites in TV receiving antennas. **(Nov 07)**

15. Sketch the typical geometry of a helical antenna radiating in axial mode, and list out all its parameters and basic characteristics. List out the expressions for HPBW, BWFN, directivity and axial ratio. **(Feb 07)**

16. i. With neat schematics, describe the principle of working of a 3 element yagi antenna, listing out its length and spacing requirements.
ii. Sketch the current distributions on a folded dipole, and account for its input impedance when the two legs have unequal diameters. **(Feb 07)**

17. Explain all the structural requirements of a 5-element Yagi antenna at 475 MHZ, accounting for typical spacing, length to diameter ratios and input impedance. **(Feb 07)**

18. Write notes on
i. Parasitic elements
ii. Multi director Yagi antenna **(Nov 06)**

19. i. Sketch and explain the constructional features of a helical antenna. Distinguish between axial and normal modes of a helix radiations and list out their requirements.
ii. Explain the characteristics of an active square corner reflector with the help of image principle. **(Nov 06, Mar 04)**

20. Establish voltage-current relations in the parasitic elements of a 3element Yagi-Uda array, and account for its Zin **(Nov 06,05)**

21. Distinguish between a uniform Linear array and Yagi-Uda array. Why is a Yagi array called "Super-directive" Array? **(Nov 06)**

22. With neat schematics, describe the priniciple of a 3-element yagi antenna, listing out its length and spacing requirements. .**(Nov 06)**

23. Explain all the structural requirements of a 5-element Yagi antenna at 475MHz, accounting for typical spacing,length to diameters ratios and Zin **(Nov 05, April 05)**

24. With neat schamatics,describe the principle of working of a 3-element yagi antenna ,listing out its length and spacing requirements. **(May 05)**

25. Explain how a Yagi-Uda antenna is analyzed as an EFA, listing and the necessasry mathematical relations. Why it it called a super gain antenna. **(May 05)**

26. Sketch the current distributions on a folded dipole, and account for its input impedance when the two legs have unequal diameters. **(May 05)**

27. Give the current distribution and radiation pattern of a folded dipole antenna. Explain how the radiation pattern will be modified with the addition of a reflector and two directors with such an antenna. **(May 05)**

28. Explain the difference between driven and parasitic elements in an array. **(Mar 04)**

29. What is an optimum horn? Draw a neat sketch of E-plane sectoral horn. Discuss the application and advantages of a horn . **(Nov 04)**

30. . A right handed monifiar helical antenna has 10 turns, 100 mm iameter and 70 mm turn spacing. The frefquency is 1 GHz What are HPBW, gain and polarization state?

UNIT-V

1.i. With neat schematics, describe the radiation characteristics of a rectangular microstrip patch antenna, using basic transmission line model. What are the effects of εr on its characteristics ?

ii. Explain the characteristic features and applications of a square corner reflector. Sketch its typical patterns. **(Nov/Dec 13)**

2. Write short notes on:
a) Rhombic Antennas.
b) Cassegrainian feeds.
c) Optimum horns. **(Nov/Dec 13)**

3. A paraboloidal reflector has 50 cm. diameter, and operates at 6 GHz.Evaluate its far-field distance requirement for antenna measurements,directivity, effective aperture and beamwidths. **(Nov/Dec 13)**

1. i) Give the expressions for impedance, bandwidth and directivity of rectangular patch antenna.
ii) Design a rectangular microstrip antenna using a substrate with a dielectric constant of 2.2, height h=0.1588 cm so as to resonate at 10GHz **(Dec 12)**

2. Explain why an antenna using a paraboloid reflector is likely to be a highly directive receiving antenna? **(Nov 10)**

3. With sketches describe two methods of feeding a paraboloid reflector in which the primary antenna is located at the focal point. Under what conditions this method of feed is unsatisfactory? **(Nov 10)**

4. Explain the geometry of the parabolidal reflectors? **(Nov 10)**

5. i. Calculate the 3dB beam width and power gain of a parabolic antenna at a frequency of 1.6GHz with 2.4 meter diameter and 48% antenna efficiency?
ii. With neat diagram explain the geometry of the parabolic reflector? **(Nov 10)**

6. Calculate the gain, beam width between nulls of a 2-m paraboloid reflector at 6 GHz. **(Nov 09)**

7. i. Explain why the folded dipole has a greater bandwidth than the straight dipole?
ii. Explain the principle of formation of images in an active corner reflector antenna? Sketch the image formation for 45 degree corner reflector antenna? **(Nov 09)**

8 Explain the geometry of paraboloidal reflector antennas? **(Nov 09)**

9 Show the system of images for 90^0 corner reflector if the point source is located at a distance of $\lambda/4$ from the apex. Write the expression for the array factor. **(Nov 09)**

10. Describe the characteristics of an active square corner reflector with the help of image principle. **(Nov 09)**

11. i. What is a parabolic element? How does a parasitic element act when length is greater than and smaller than $\lambda/2$.
    ii. Distinguish between Spherical and Cylindrical paraboloids. Comment on their aperture efficiency and applications. **(Nov 09)**

12. A paraboloid operating at 5 GHz, has a radiation pattern with null to null beam width of 10^0. Find the mouth diameter of the paraboloid, HPBW and power gain .**(Nov 09)**

13. With suitable characteristics compare the performance of microwave antennas? **(Nov 09)**

14. Using neat diagram explain the constructional features of a parabolic horn antenna and obtain an expression for its curved profile. **(Nov 09)**

15. Discuss about the design characteristics of pyramidal horn antenna? **(Nov 09)**

16. i. The pyramidal horn is required to have a half power width of 10^0 in both the vertical and horizontal planes. Determine the dimensions of the horn mouth and the length of the horn in wavelengths, and the directive gain?
    ii. With neat sketch explain the operation of H-plane horn antenna? **(Nov 09)**

17. Calculate the directivity of pyramidal horn antenna with an aperture with an aperture size 12cm x 12cm, operating at 3.2cm length. **(Nov 09)**

18. Obtain an expression for Directivity of Pyramidal horn in terms of its aperture dimensions. **(Nov 09)**

19. What is the principle of equality of path length? How is it applicable to horn antenna? **(Nov 08)**

20. What is an Optimum Horn? Sketch and Explain its characteristics along with dimensional relations. **(Nov 08)**

21. i. Describe the performance of paraboloids with respect to aperture blocking.
    ii. Describe the constructional details of Cassegrain antennas and sketch its radiation characteristics. **(Nov 08)**

23. A Paraboloid reflector of 1.8m diameter is used at 6 GHz. Calculate the beam width between the nulls and gains in dBs. **(Nov 08)**

24. i. A paraboloid reflector has radiation characteristics whose HPBW is 5^0. Find out its null to null beam width and power gain.
    ii. Discuss the conditions under which a parasitic dipole placed near and parallel to a driven dipole can act as a reflector. **(Nov 08)**

25. Discuss the applications of Horn Antenna. Sketch the sectorial horn **(Feb 08)**

26. i. Discuss the application of the Image antenna concept to the 90^0 corner reflector.
    ii. What is a parabolic cylinder antenna? Derive an expression for field distributions on the surface of reflector. **(Feb 08)**

27. With reference to paraboloids, explain the following: **(Feb 08)**
    a. Aperture Efficiency
    b. Front to Back Ratio
    c. Types of Feeds.

28 i. Explain how the radiation pattern of folded dipole will be modified with the addition of a reflector and two directors parasitic elements.

ii. Bring out the differences between Active and Passive Corner Reflectors. What are Retro Reflectors? **(Feb 08)**

29. Design Yagi Uda antenna of six elements to provide a again of 12dB if the operating frequency is 200MHz. **(Feb 08)**

30. i. Distinguish between Sectorial, Pyramidal and Conical horns. Explain their utility.

ii. Write short notes on "Radiation from Sectorial Horn". **(Feb 08, Feb 07, Nov 05, Apr 05)**

UNIT-VI

1. With a neat block diagram, explain the method of measurement of radiation pattern of an antenna. Identify the components to be measured and the principal planes, if it is a vertical dipole**.** **(Nov/Dec 13)**

1. i) With a neat block diagram, explain the measurement method of the Gain of a horn antenna by absolute method.

ii) Distinguish between differnt typs of lens antennas, and estimate the curvature profile of a dielectric delay lens. **(Dec 12)**

2. Write short notes on antenna band width. **(Nov 11)**

3. Explain the geometry of paraboloid reflector antennas. **(Nov 11)**

4. i. What is the major drawback of lens antenna, restricting their use to the highest frequencies?

ii. What is meant by zoning? **(Nov 10)**

5. i. An antenna of jam aircraft is being used to jam enemy radar, if the antenna has a gain of 12dB in the direction of transmission and the radiated power is 5kW, calculate the electric field intensity in the vicinity of enemy radar which is 3km away, the frequency of transmission is 4 GHz

ii. The electric field of an antenna is given by Calculate

a. the direction of the maximum radiation

b. the 3dB beam width,

c. the direction and level of the first side lobe and

d. the number of nulls in the pattern. **(Nov 10)**

6. i. Draw the neat setup for measuring gain of an antenna?

ii. What is meant by zoning? Differentiate curved surface zoning and plane surface zoning of lens antenna **(Nov 10)**

7. i. Discuss the design characteristics of pyramidal and sectorial horns?

ii. With neat sketch explain how gain measurement is carried out using direct comparison method?**(Nov 10)**

8. Briefly explain the principle of lens antenna? **(Nov 09)**

9. i. With a neat setup, explain the method of measurement of the beam width of pyramidal horn antennas in E-plane. How does it differ from H-plane measurement?

ii. Explain the basic principle of operation of lens antenna. **(Nov 09)**

10. Distinguish between Dielectric lens and Metal Plate Lens. **(Nov 09)**

11. Explain how antenna aperture efficiency can be measured? Correlate the aperture efficiency and the Directivity of an antenna. **(Nov 09)**

12. i. Describe gain measurement by reflection from ground.

ii. Mention the drawbacks in measurement of antenna parameters. **(Nov 09)**

13. i. With a neat setup, explain the method of measurement of the beam width of pyramidal horn antennas in E-plane. How does it differ from H-plane measurement?
    ii. Explain the basic principle of operation of lens antenna. **(Nov 09, 08)**

14. i. How is the field pattern of a receiving antenna experimentally determined? Explain with a neat diagram.
    ii. Distinguish between Curved Surface Zoning and Plane Surface Zoning of lens antenna. Discuss their merits and demerits. **(Nov 08)**

15. Discuss how the directivity of horn antenna can be measured. **(Nov 08)**

16. Explain the first transmission formula and its applicability for antenna gain measurements. **(Nov 08)**

17. What are different mechanisms of propagation of electromagnetic waves? Explain. **(Nov 08)**

18 What is Zoning? What are its advantages?

19. i. What is the principle of equality of path length? How is it applicable to horn antenna?
    ii. Discuss how the directivity of horn antenna can be measured **(Feb 08)**

20. i. Explain the principle of operation of Dielectric Lens Antenna.
    ii. With a neat setup, explain the absolute method of measuring the gain of an antenna **(Feb 08)**

21. i. Describe the method of measuring the gain and radiation pattern of an antenna.
    ii. A standard gain horn antenna with a power gain of 12.5 is used to measure the gain of a large directional antenna by comparison method. The test antenna is connected to the receiver and an attenuator adjusted to 23dB in order to have the same receiver output. Find out the gain of the large antenna. **(Nov 07)**

22. Calculate the minimum distance required to measure the field pattern of an antenna of diameter 2m at a frequency of 3GHz. Derive the necessary equation**.** **(Nov 07)**

23. Explain the basic principles of operation in lens antennas. Hence distinguish between the different types of lens antennas used in practice. **(Feb 07)**

24. i. Explain the gain measurement of antenna by comparison method.
    ii. Define beam width of an antenna. Explain the procedure for measuring the beam width and also the side lobe level. **(Nov 06)**

25. i. Write notes on
    i. E-plane metal plate lens antennas
    ii. Aperture blocking in lens antennas.
    ii. List out all the precautions to be taken while conducting antenna pattern measurements. **(Nov 06)**

26. Explain the method of measurement of HPBW of a horn antenna in H- plane, with a neat set up. (**Nov 06)**

UNIT-VII

1.i. Account for the propagation characteristics of Medium Wave Broadcast Signals.
  ii. Derive an expression for the variation of field strength of a space wave,with antenna heights and distance involved. What happens when the distance is large? **(Nov/Dec 13)**

2.i. Explain the effects of D and F layers of the ionosphere on propagation, and estimate the critical frequency and MUF for a layer with 10 11 /m3 electrondensity, and incident angle of 60o. What are LUF and Optimum Frequencies?

ii. Compute the free space path loss for a link distance of 30 km at a frequency of 10 GHz. Also calculate the received power, if the transmitting and receiving antennas have equal gains of 20 dB, and the transmitter power is 500 W. **(Nov/Dec 13)**

1. i. Sketch and explain the field strength variation of space waves, with distance and antenna heights, deriving expressions for the same.

ii. Find the MUF and refractive index for a sky wave signal, reflected by a layer at a height of 200 km, and having an electron density of 2.0 X 10^{11} per cubic meters, for a skip distance of 2500 km. Also calculate the corresponding angle of incidence. Explain the relations used. **(Dec 12)**

2. Describe the troposphere and explain how tropospheric ducts can be used for microwave propagation. **(Nov 11)**

3. Determine the fade margin for 30 km microwave hop. The RF frequency is 10 GHz. The terrain is water and the reliability objective is 99.99%. **(Nov 11)**

4. Show that the radiation field at the surface of the earth from a $\lambda/4$ monopole is given by $E = \frac{6.14}{r}\ \sqrt{W}$ mv/m **(Nov 11)**

5. i. Determine the height of the transmitting antenna to obtain a maximum distance of transmission up to 38 km from a 24meter high receiving antenna?

ii. What is the effect of the curvature of earth's surface on the propagation of microwave signal in a line of sight link? **(Nov 10)**

6. A communication link is to be established between the two stations using half wave length antenna for maximum directive gain. Transmitter power is 1KW, frequency of operation is 100 MHz. and distance between transmitter and receiver is 100Km.what is the maximum power received by the receiver. Explain and derive the formulas used? **(Nov 10)**

7. Explain the effect of the following on tropospheric wave propagation?
   i. Radius of curvature of path
   ii. Earths radius
   iii. Earths curvature. **(Nov 10)**

8. Discuss the phenomenon of ground wave propagation at long and medium waves. Show that this gives one of the most reliable methods of radio communications **(Nov 10)**

9. i. Write short notes on Duct propagation?

ii. Determine the fade margin for the following conditions: distance between sites D=40Km, frequency f=1.8GHz smooth terrain, humid climate and reliably objective 99.99%. **(Nov 10)**

10. Explain how tropospheric ducts are formed? **(Nov 09)**

11. i. Explain about super refraction?

ii. Determine the height of the receiving antenna to obtain a maximum transmission distance of 48.7Km from a transmitting antenna of 40meter height. **(Nov 09)**

12. i. To produce a power density of 1mW/m2 in a given direction, at a distance of 2 km, an antenna radiates a total of 180W. An isotropic antenna would have to radiate 2400W to produce the same power density at that distance. What, in decibels, is the directive gain of the practical antenna?

ii. A transmitting aerial has a radiation resistance of 50 ohms and a power gain of 20dB in the direction of a receiver 64km apart. With aerial supplied with a current of 0.5A. Determine the intensity in W/m2 and the electric field strength at the receiver. If he receiving aerial has electric field strength of 1.5m and its radiation resistance is 75ohm. Determine the maximum power available to the receiver and the overall transmission loss in dB. **(Nov 09)**

13. i. Write short notes on Duct propagation?

ii. Determine the fade margin for the following conditions: distance between sites D=40Km, frequency f=1.8GHz smooth terrain, humid climate and reliably objective 99.99%. **(Nov 09)**

14. Describe the troposphere and explain how tropospheric ducts can be used for microwave propagation? **(Nov 09)**

15. Describe the main abnormal ionospheric variations, including a brief mention of the interference that may be caused by the sporadic E layer? **(Nov 09)**

16. Write short notes on lowest usable frequency? **(Nov 09)**

17. i. Discus the salient features of Sky wave propagation.

ii. Bring out the various problems associated with this mode of propagation. How are these problems overcome? **(Nov 09)**

18. Classify radio frequencies. Explain about surface wave propagation? **(Nov 09)**

19. Calculate field strength at a distance, due to ground wave propagation?

20. i. What is Angle of Tilt? How does it affect the field strength at a distance from the transmitter?

ii. A 150m antenna transmitting at 1.2MHz by ground wave has an antenna current of 8A. What voltage is received by a receiving antenna 40kms away, with a height of 2meters? **(Nov 09)**

21. Explain the term Wave Tilt of surface waves. **(Nov 09)**

22. Discuss the factors that affect ground wave propagation. Hence show that long wave can be used for long distance communication.

23. Draw a sketch showing troposcatteric scatter and explain its basic principle. **(Nov 09)**

24. Explain the Tropospheric wave propagation. **(Nov 09)**

25. i. Prove that the radio horizon distance between transmitting and receiving antennas is given by $d_{miles}=\sqrt{2h_t}+\sqrt{2h_r}$

ii. Write short notes on ‘Troposcatter". **(Nov 09, Feb 08)**

26. i. Write short notes on ‘M Curves and their characteristics".

ii. Show that the radius of curvature of ray path is given by $2/(d\varepsilon_r/dh)$ for tropospheric waves. **(Nov 09,Feb 08)**

27. i. Show that the field strength from an antenna with gain G, radiating P watts of Power is given by $E = 1/r(30PG)^{1/2}$ v/m, if the impedance of free space is 120π .

ii. Derive the expression for power radiated in case of quarter wave monopole and find the power radiated for a peak value equal to 10A. **(Nov 09)**

28. i. What is Angle of Tilt? How does it affect the field strength at a distance from the transmitter?

ii. A 150m antenna transmitting at 1.2 MHz by ground wave has an antenna current of 8A. What voltage is received by a receiving antenna 40 kms away, with a height of 2 meters? **(Nov 09, 08)**

29. i. Describe the salient features of Ground wave propagation. Discuss the effect of frequency earth constants and curvature of earth on ground wave propagation. **(Feb 08)**

ii What is the wave tilt and how does it effects the field strength received at a distance from the transmitter?

30. Discuss the importance of ground wave propagation for communication purposes. Why ground waves are

(Feb 07, Nov 05, April 05)

31. i. Space wave propagates between transmitting and receiving stations of heights 'h_1' and 'h_2' respectively. Derive the expression for field strength.
    ii. What are the different paths used for propagating radio waves from 300 KHz and 300MHz. **(Nov 08)**

32. i. Establish the mathematical relation for
    a. Radio Horizon
    b. Radius of curvature of array path for LOS waves.
    ii. Show that the field strength due to space wave given by $E=\frac{2E_0}{d}\sin\left(\frac{2\pi h_t h_r}{\lambda d}\right)$ **(Nov 08)**

33 i. A police radio transmitter operating at a frequency 1.69 GHz is required to provide a ground wave having strength of 0.5mv/m at a distance of 16km. The transmitter antenna, having an efficiency of 50% produces a radiating field proportional of cos θ. The ground wave has $\sigma= 5x10^{-5}$ mho/cm and $\varepsilon_r=1.5$ Calculate the power transmitted.
    ii. Derive the fundamental equation for free space propagation. **(Nov 08)**

34. i. Derive an expression for the curvature of the ray path due to the changing refractive index in the troposphere.
    ii. Explain the phenomenon of duct propagation. **(Nov 08)**

    ii. Derive the fundamental equation for free space propagation. **(Feb 08)**

UNIT VIII

1.i. With the help of a neat sketch, briefly explain the functions of different blocks of a microwave bench.
  ii. Explain about measurement of attenuation using a microwave bench setup. **(Nov/Dec 13)**

1. i) Define and distinguish between the terms -(i) Critical Frequency and MUF, (ii) LUF and Optimum Frequency, (iii) Virtual height and skip distance.
   ii) Explain the significance of E and F layers of ionosphere, and account for the multi-hop propagation of sky waves. **(Dec 12)**

2. Deduce an expression for the critical frequency of an ionized region in terms of maximum ionization density? **(Nov 11)**

3. It is desired to establish radio communication between two stations on the earth by reflection of waves from the F-layer (effective height =300km). The electron density at the control point is $6x10^5$ per cc. Calculate the angle of take-off of the transmitted beam, if the distance between the two stations is 1200km. What is the maximum usable frequency of the transmitter? Assume the earth surface to be flat? **(Nov 11)**

4. Briefly describe the following terms connected with sky-wave propagation: virtual height, critical frequency, maximum usable frequency, skip distance and fading. **(Nov 10)**

5. Define maximum usable frequency and derive an expression for the same in the case of a thin ionosphere layer over a plane earth. **(Nov 10)**

6. i. What is refraction? Explain under what circumstances it occurs and what causes it?
   ii. Determine the maximum usable frequency for a critical frequency of 20MHz and an angle of incidence of $35^{0.}$

(Nov 10)

7. Write short notes on

i. D-Layer.
ii. Sporadic E-Layer.
iii. Fading. **(Nov 09, 05)**

8. Define the terms Critical Frequency, Skip Distance and MUF as applied to ionosphere. **(Nov 09)**

9 Calculate the value of frequency at which an EM wave must propagate through the D-region with an index of refraction of 0.5 and an electron density of 3.24 x 10^4 electrons/m^3. **(Nov 09)**

10. Discuss the salient features of sky wave propagation. Bring out the various problems associated with this mode of propagation. How are these problems over come? **(Mar 04)**

11. i. Discuss the propagation characteristics of EM wave.
ii. Mention the salient features of Ground wave propagation. **(Nov 08)**

12. ii. What is Critical Frequency? What is Virtual Height? Find the maximum distance that can be covered if the virtual height of the ionospheric layer is 250kms. **(Nov 08)**

13. i. Explain the following :
a. Ground Wave
b. Space Wave
c. Surface Wave.
ii. Discuss the characteristics of ionospheric layers. **(Nov 08)**

14. ii. Communication by ionosphere propagation is required for a distance of 200kms.height of the layer is 220kms and the critical frequency is 5MHz. Find MUF. **(Feb 08)**

15. i. Discuss the characteristics of F_1 and F_2 layers.
ii. Discuss the reasons for reduction of field strength in sky wave propagation. **(Nov 07)**

16. Write explanatory notes on
i. Selective fading and interference fading
ii. Optimum working frequency and LUHF

iii. Field strength calculation for radio AM broadcast waves
iv. Ionospheric abnormalities **(Feb 07,Nov 06,05)**

18. i. What are the factors that lead to fading and attenuation in ionospheric propagation **(Feb 07)**

ii. Establish the effects of D -layer in sky wave propagation. **(Feb 07, Nov 05,April 05)**

19. ii. Determine the change in the electron density of E- layer when the critical frequency changes from 4 MHz not received beyond certain range. Explain the phenomenon. **(Feb 07, Nov 06)**

20. i. Explain the following:
i. Ray path
ii. Skip distance
iii. Maximum usable frequency
iv. Faraday rotation
ii. Explain LOS propagation of radio waves **(Feb 07)**

21. i. A short wave broadcasting service is to be established covering a distance of 6000Km in three hops, each 2000 Km long. Assume that reflection takes place at a height of 250 km and that the electronic density is 5x 10 m. What frequency and the angle of incidence should be used? Explain the relations used. **(Nov 06)**

22. Define and distance between the terms MUF,LUHF, Optimum frequency. **(Nov 06)**

23. Discuss the salient features of multi hop propagation. Account for the permissible ranges of frequencies. **(Nov 05)**

24. Describe the structure of the ionosphere and the part played by each layer in it in the long distance transmission of radio signals in the HF band. **(Mar 04)**

25. Define maximum usable frequency and derive an expression for the same in the case of a thin ionospheric layer over a plane earth. Explain what is meant by the terms: skip distance, virtual height and optimum frequency. **(Mar 04)**

26. Explain the terms
    i. Critical frequency.
    ii. Virtual height
    iii. Secant law
    iv. MUF
    v. Skip distance
    vi. Ordinary and extra-ordinary waves- as per requirement to skywave propagation **(Mar 04)**

27. Compare and contrast ground wave and sky wave. Explain how propagation takes place through ionosphere **(Nov 04)**

28. Explain the terms ray path,. Skip distance and maximum unable frequency as applied to ionosphere propagation **(Nov04)**

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