JEPPIAAR ENGINEERING COLLEGE

Jeppiaar Nagar, Rajiv Gandhi Salai – 600 119

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

QUESTION BANK

VI SEMESTER

EC6602 – ANTENNA AND WAVE PROPAGATION

Regulation – 2013(Batch: 2015 -2019)

Academic Year 2017 – 2018

Prepared by

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SUBJECT : EC6602 – ANTENNA AND WAVE PROPAGATION

YEAR /SEM : III/VI

UNIT I FUNDAMENTALS OF RADIATION				
Definition of antenna parameters – Gain, Directivity, Effective aperture, Radiation Resistance, Band width, Beam width, Input Impedance. Matching – Baluns, Polarization mismatch, Antenna noise temperature, Radiation from oscillating dipole, Half wave dipole. Folded dipole, Yagi array.				
PART – A				
CO Mapping : C313.1				
Q.No	**Questions**	**BT Level**	**Competence**	**PO**
1	What is retarded potential? (Nov/Dec 2016)	BTL-4	Analyzing	PO1
2	What do you mean by an isotropic radiator?	BTL-2	Understanding	PO1,PO2,PO3
3	What do you understand by static, induction and radiation field produced by an antenna?(May 2015)	BTL-1	Remembering	PO1,PO2
4	Define directivity of an antenna (May 2012).	BTL-1	Remembering	PO1
5	Define effective aperture (area) of an antenna (May 2012) (May 2015).	BTL-1	Remembering	PO1
6	Define the radiation resistance of an antenna. What is the importance of this quantity? (May 2015 &Nov/Dec 2015)	BTL-3	Applying	PO1
7	What is self-impedance of an antenna?	BTL-1	Understanding	PO1,PO2
8	Define the bandwidth of an antenna.	BTL-1	Remembering	PO1,PO2
9	Define the directive gain of an antenna	BTL-3	Applying	PO1
10	Calculate the radiation resistance of current element of length $\lambda/20$ (May2012).	BTL-1	Remembering	PO1
11	Define the antenna efficiency.	BTL-1	Remembering	PO1
12	Define beam solid angle.	BTL-1	Remembering	PO1
13	Define Half power beam width (HPBW) of an antenna (Dec 2012).	BTL-1	Remembering	PO1,PO2,PO3
14	Define the term ‘Front to back ratio.	BTL-1	Remembering	PO1

15	Define Beam Width between First Null.	BTL-4	Analyzing	PO1
16	What are parasitic elements and where are they used?	BTL-1	Remembering	PO1
17	State the need for BALUN.	BTL-2	Understanding	PO2
18	What is the effective area of a half wave dipole operating at 1 GHz? (May 2013)	BTL-1	Remembering	PO1
19	Draw the E plane and H plane radiation pattern of a dipole. (May 2014)	BTL-1	Remembering	PO1,PO2
20	What are dB_i and dB_d ? Write their significances. (Dec 2013)	BTL-6	Creating	PO1,PO2
21	What is meant by polarization?	BTL-1	Remembering	PO1,PO2
22	Design a 3 element Yagi-Uda antenna to operate at a frequency of 200 MHz. (May 2013)	BTL-1	Remembering	PO1,PO2
23	Define antenna temperature.	BTL-6	Creating	PO1,PO2,PO3
24	Define folded dipole.	BTL-1	Remembering	PO1,PO2
25	The radial component of the radiated power density of an antenna is given by $W_{rad} = a_r W_r = a_r A_o \sin\theta / r^2 (W/m^2)$, where A_o is the peak value of the power density, θ Is the usual spherical coordinate, and a_r is the radial unit vector. Determine the total radiated power ? (May 2016)	BTL-2	Understanding	PO1
26	The radiation resistance of an antenna is 72 Ohms and the loss resistance is 8 Ohms. What is the directivity (in dB), if the power gain is 15? (May 2016)	BTL-1	Remembering	PO1,PO2
27	Define the brightness temperature of the antenna. (Nov/Dec 2015)	BTL-1	Remembering	PO1
	Define gain of an antenna. Mention the relationship between gain and aperture of an antenna. (April/May 2017)			
28	The voltage induced by the application of an electric field of strength 2 Volts/meter is 0.7. Calculate the effective length of the element. (Nov/Dec 2016)	BTL-1	Remembering	PO1
29	What is the significance of gain of an antenna?(Nov/Dec 2015)	BTL-1	Remembering	PO1
30	Determine the electric field intensity at a distance of 10 km from a dipole antenna of directive gain of 6 dB and radiating power of 20 kW. (April/May 2017)	BTL-1	Remembering	PO1
31	Draw the radiation pattern for isotropic, directional and omnidirectional antenna. (April/May 2017)	BTL-1	Remembering	PO1
	PART – B			
1	Define and explain in detail theterms“RadiationResistance”, “gain”, “Directivity”,Effective aperture” and “Polarization of	BTL-4	Analyzing	PO1

	an antenna". **(Dec 2012)**			
2	Derive the electric and magnetic field components of Hertzian dipole. **(Dec 2012)**	BTL-2	Understanding	PO1,PO2,PO3
3	What are Hertzian dipoles? Derive the Electric and Magnetic field quantities of infinitesimal dipole and radiation pattern. **(Dec 2011)**	BTL-1	Remembering	PO1,PO2
4	Explain the following parameters of an antenna 1)Beam solid angle. 2)Radiation pattern 3)Gain 4)Polarization 5)Bandwidth **(Dec 2011)**	BTL-1	Remembering	PO1
5	(i)Show that the directivity of an alternating current element is 1.76dB. ii)Show that at distance $r = 0.159\lambda$ the induction field is equal to radiation field for a current element.	BTL-1	Remembering	PO1
6	(i)Calculate the radiation efficiency of an antenna if the input power is 100W and the power dissipated in it is 1W. (ii)Discuss on linear, elliptical and circular polarization of antenna.	BTL-3	Applying	PO1
7	i)An antenna has loss resistance 25 ohms, power gain of 30 and directivity 42. Calculate the radiation resistance. (ii)Explain self impedance and mutual impedance of an antenna.	BTL-1	Remembering	PO1,PO2
8	(i) Derive the radiation resistance of an Oscillating Electric Dipole. **(Dec 2013)**(ii) Define and explain the polarization and its significance in antenna analysis.	BTL-1	Remembering	PO1,PO2
9	Derive the field quantities and radiation resistance of a half wavelength dipole.	BTL-3	Applying	PO1
10	With necessary illustrations explain the radiation characteristics of Yagi Uda antenna.	BTL-1	Remembering	PO1
11	Derive an expression for the power radiated by the current element and calculate the radiation resistance.	BTL-1	Remembering	PO1
12	Define the following parameters and their dependence on antenna performance 1) Radiation pattern 2)Input impedance 3)Polarization	BTL-1	Remembering	PO1
13	Derive the expression for the far field component of a half wave dipole antenna.	BTL-1	Remembering	PO1,PO2,PO3

UNIT II APERTURE AND SLOT ANTENNAS				
Radiation from rectangular apertures, Uniform and Tapered aperture, Horn antenna , Reflector antenna , Aperture blockage , Feeding structures , Slot antennas ,Microstrip antennas – Radiation mechanism – Application ,Numerical tool for antenna analysis				
PART – A				
CO Mapping : C313.2				
Q.No	**Questions**	**BT Level**	**Competence**	**PO**
1	What is retarded potential? (Nov/Dec 2016)	BTL-4	Analyzing	PO1
2	What do you mean by an isotropic radiator?	BTL-2	Understanding	PO1,PO2,PO3
3	What do you understand by static, induction and radiation field produced by an antenna?(May 2015)	BTL-1	Remembering	PO1,PO2
4	Define directivity of an antenna (May 2012).	BTL-1	Remembering	PO1
5	Define effective aperture (area) of an antenna (May 2012) (May 2015).	BTL-1	Remembering	PO1
6	Define the radiation resistance of an antenna. What is the importance of this quantity? (May 2015 &Nov/Dec 2015)	BTL-3	Applying	PO1
7	What is self-impedance of an antenna?	BTL-1	Remembering	PO1,PO2
8	Define the bandwidth of an antenna.	BTL-1	Remembering	PO1,PO2
9	Define the directive gain of an antenna	BTL-3	Applying	PO1
10	Calculate the radiation resistance of current element of length $\lambda/20$ (May2012).	BTL-1	Remembering	PO1
11	Define the antenna efficiency.	BTL-1	Remembering	PO1
12	Define beam solid angle.	BTL-1	Remembering	PO1
13	Define Half power beam width (HPBW) of an antenna (Dec 2012).	BTL-1	Remembering	PO1,PO2,PO3
14	Define the term ‘Front to back ratio.	BTL-1	Remembering	PO1
15	Define Beam Width between First Null.	BTL-4	Analyzing	PO1
16	What are parasitic elements and where are they used?	BTL-1	Remembering	PO1
17	State the need for BALUN.	BTL-2	Understanding	PO2
18	What is the effective area of a half wave dipole operating at 1 GHz? (May 2013)	BTL-1	Remembering	PO1
19	Draw the E plane and H plane radiation pattern of a dipole. (May 2014)	BTL-1	Remembering	PO1,PO2
20	What are dB_i and dB_d ? Write their significances. (Dec 2013)	BTL-6	Creating	PO1,PO2
21	What is meant by polarization?	BTL-1	Remembering	PO1,PO2
22	Design a 3 element Yagi-Uda antenna to operate at a frequency of 200 MHz. (May 2013)	BTL-1	Remembering	PO1,PO2
23	Define antenna temperature.	BTL-6	Creating	PO1,PO2,PO3
24	Define folded dipole.	BTL-1	Remembering	PO1,PO2
25	The radial component of the radiated power density of an antenna is given by	BTL-2	Understanding	PO1

	$W_{rad} = a_r W_r = a_r A_o \sin\theta / r^2 (W/m^2)$, where A_o is the peak value of the power density, θ Is the usual spherical coordinate, and a_r is the radial unit vector. Determine the total radiated power ? (May 2016)			
26	The radiation resistance of an antenna is 72 Ohms and the loss resistance is 8 Ohms. What is the directivity (in dB), if the power gain is 15? (May 2016)	BTL-1	Remembering	PO1,PO2
27	Define the brightness temperature of the antenna. (Nov/Dec 2015)	BTL-1	Remembering	PO!
	Define gain of an antenna. Mention the relationship between gain and aperture of an antenna. (April/May 2017)			
28	The voltage induced by the application of an electric field of strength 2 Volts/meter is 0.7. Calculate the effective length of the element. (Nov/Dec 2016)	BTL-1	Remembering	PO1
29	What is the significance of gain of an antenna?(Nov/Dec 2015)	BTL-1	Remembering	PO1
30	Determine the electric field intensity at a distance of 10 km from a dipole antenna of directive gain of 6 dB and radiating power of 20 kW. (April/May 2017)	BTL-1	Remembering	PO1
31	Draw the radiation pattern for isotropic, directional and omnidirectional antenna. (April/May 2017)	BTL-1	Remembering	PO1
PART – B				
1	Define and explain in detail theterms“RadiationResistance”, “gain”, “Directivity”,Effective aperture” and “Polarization of an antenna”. **(Dec 2012)**	BTL-4	Analyzing	PO1
2	Derive the electric and magnetic field components of Hertzian dipole. **(Dec 2012)**	BTL-2	Understanding	PO1,PO2,PO3
3	What are Hertzian dipoles? Derive the Electric and Magnetic field quantities of infinitesimal dipole and radiation pattern. **(Dec 2011)**	BTL-1	Remembering	PO1,PO2
4	Explain the following parameters of an antenna 1)Beam solid angle. 2)Radiation pattern 3)Gain 4)Polarization 5)Bandwidth **(Dec 2011)**	BTL-1	Remembering	PO1
5	Show that the directivity of an alternating current element is 1.76dB. ii)Show that at distance $r = 0.159\lambda$ the induction field is equal to radiation field for a current element.	BTL-1	Remembering	PO1
6	Calculate the radiation efficiency of an antenna if the input power is 100W and the power dissipated in it is 1W. (ii)Discuss on linear, elliptical and circular polarization of antenna.	BTL-3	Applying	PO1

7	An antenna has loss resistance 25 ohms, power gain of 30 and directivity 42. Calculate the radiation resistance.	BTL-1	Remembering	PO1,PO2
8	Derive the radiation resistance of an Oscillating Electric Dipole. **(Dec 2013)**(ii) Define and explain the polarization and its significance in antenna analysis.	BTL-1	Remembering	PO1,PO2
9	Derive the field quantities and radiation resistance of a half wavelength dipole.	BTL-3	Applying	PO1
10	With necessary illustrations explain the radiation characteristics of Yagi Uda antenna.	BTL-1	Remembering	PO1
11	Derive an expression for the power radiated by the current element and calculate the radiation resistance.	BTL-1	Remembering	PO1
12	Define the following parameters and their dependence on antenna performance 1) Radiation pattern 2)Input impedance 3)Polarization	BTL-1	Remembering	PO1
13	Derive the expression for the far field component of a half wave dipole antenna.	BTL-1	Remembering	PO1,PO2,PO3

UNIT III ANTENNA ANTENNAS

N element linear array, Pattern multiplication, Broadside and End fire array – Concept of Phased arrays, Adaptive array, Basic principle of antenna Synthesis-Binomial array

PART – A

CO Mapping : C313.3

Q.No	Questions	BT Level	Competence	PO
1	What is an antenna array?	BTL-4	Analyzing	PO1
2	What is end-fire array?	BTL-2	Understanding	PO1,PO2,PO3
3	What is broad-side array?	BTL-1	Remembering	PO1,PO2
4	What is relationship between directivity and HPBW?	BTL-1	Remembering	PO1
5	What do you mean by tapering of array?	BTL-1	Remembering	PO1
6	Define adaptive array.	BTL-3	Applying	PO1
7	What is the main advantage of Binomial array?	BTL-1	Remembering	PO1,PO2
8	Define uniform linear array.	BTL-1	Remembering	PO1,PO2
9	What are null directions in radiation pattern?	BTL-3	Applying	PO1
10	Why we go for non-uniform amplitude distribution?	BTL-1	Remembering	PO1
11	Distinguish between uniform and non-uniform arrays.	BTL-1	Remembering	PO1
12	A uniform linear array contains 50 isotropic radiator with an inter element spacing of $\lambda/2$. Find the directivity of broadside forms of arrays. (May 2013)	BTL-1	Remembering	PO1

13	What are the advantages of antenna arrays? (May 2014)	BTL-1	Remembering	PO1,PO2,PO3
14	What is the advantage of pattern multiplication?	BTL-1	Remembering	PO1
15	Define Phased arrays.	BTL-4	Analyzing	PO1
16	State Huygen's principle. (Dec 2013) (May 2015)	BTL-1	Remembering	PO1
17	State the principle of pattern multiplication (Dec 2012) (Nov/Dec 2015)	BTL-2	Understanding	PO2
18	How number of array elements effect directivity?	BTL-1	Remembering	PO1
19	Write the disadvantages of binomial arrays.	BTL-1	Remembering	PO1,PO2
20	A uniform linear array of 4 isotropic elements with an inter element spacing of $\lambda/2$. Find the BWFN and directivity of end fire arrays.	BTL-6	Creating	PO1,PO2
21	What is binomial array?	BTL-1	Remembering	PO1,PO2
22	What is uniform Array?	BTL-1	Remembering	PO1,PO2
23	Write the techniques followed for array synthesis.	BTL-6	Creating	PO1,PO2,PO3
24	Define antenna synthesis.	BTL-1	Remembering	PO1,PO2
25	What are the advantages of Dolph-Tschebyscheff method?	BTL-2	Understanding	PO1
26	Draw the radiation pattern of an isotropic point sources of same amplitude and opposite phase that are $\lambda/2$ apart along X-axis symmetric with respect to origin. (May 2016)	BTL-1	Remembering	PO1,PO2
27	Using pattern multiplication find the radiation pattern for the broadside array of 4 elements, spacing between each element is $\lambda/2$. (April/May 2017)	BTL-1	Remembering	PO1
28	Draw the radiation pattern of an isotropic point sources of same amplitude and same phase that are $\lambda/2$ apart along X axis symmetric with respect to origin. (April/May 2017)	BTL-2	Understanding	PO1
29	What is the basic principle of antenna synthesis? (Nov/Dec 2016)	BTL-1	Remembering	PO1
30	State Huygen's principle. (Dec 2013)	BTL-1	Remembering	PO1
	PART – B			
1	Write a note on binomial array?	BTL-4	Analyzing	PO1
2	Draw the pattern of 10 element binomial array with spacing between the elements of $3\lambda/4$ and $\lambda/2$. (May 2013)	BTL-2	Understanding	PO1,PO2,PO3
3	Derive the expressions for field pattern of broad side array of *n* point sources. (May 2013)	BTL-1	Remembering	PO1,PO2
4	Two identical radiators are spaced $d = 3\lambda/4$ meters apart and fed with currents of equal magnitude but with 180^0 phase difference. Evaluate the resultant radiation and identify the direction of maximum & minimum radiation.	BTL-1	Remembering	PO1

5	For a 2 element linear antenna array separated by a distance $d = 3\lambda/4$, derive the field quantities and draw its radiation pattern for the phase difference of 45^0. (Dec 2012)	BTL-1	Remembering	PO1
6	Derive the expressions for field pattern of end-fire array of *n* sources of equal amplitude and spacing. (May 2012)	BTL-3	Applying	PO1
7	An antenna array consists of two identical isotropic radiators spaced by a distance of d=$\lambda/4$ meters and fed with currents of equal magnitude but with a phase difference β. Evaluate the resultant radiation for $\beta = 0^0$ and thereby identify the direction of maximum radiation. (Dec 2011)	BTL-1	Remembering	PO1,PO2
8	Describe a broadside array. Deduce an expression for the radiation pattern of a broadside array with two point sources.	BTL-1	Remembering	PO1,PO2
9	Plot the radiation pattern of a linear array of 4 isotropic elements spaced λ/2 apart and fed out of phase with equal currents.	BTL-3	Applying	PO1
10	Derive Array factor of an Uniform linear array. Explain the significance of array factor. (Dec 2013)	BTL-1	Remembering	PO1
11	Compare End fire and Broadside array. (May 2014)	BTL-1	Remembering	PO1
12	Explain in detail about: 1) adaptive arrays 2) Phased arrays.	BTL-1	Remembering	PO1
13	Obtain the expression for the field and the radiation pattern produced by a N element array of infinitesimal with distance of separation $\lambda/2$ and currents of unequal magnitude and phase shift 180 degree. (May 2016)	BTL-1	Remembering	PO1,PO2,PO3
14	Using pattern multiplication determine the radiation pattern for 8 element array separated by the distance $\lambda/2$.	BTL-1	Remembering	PO1
15	Write short notes on tapered array and phased array. (May 2016)	BTL-1	Remembering	PO1,PO2
16	Develop a treatise on the following forms of arrays: (Nov/Dec 2015)(i)Linear array(ii)Two-element array(iii)Uniform array(iv)Binomial array	BTL-6	Creating	PO1,PO2
17	Derive and draw the radiation pattern of 4 isotropic sources of equal amplitude and same phase. (April/May 2017) (Nov/Dec 2016)	BTL-1	Remembering	PO1,PO2
18	Describe the principle of phased arrays and explain how it is used in beam forming.(April/May 2017) (Dec2016)	BTL-1	Remembering	PO1,PO2

UNIT IV SPECIAL ANTENNAS_				
Principle of frequency independent antennas –Spiral antenna, Helical antenna, Log periodic. Modern antennas-Reconfigurable antenna, Active antenna, Dielectric antennas, Electronic band gap structure and applications, Antenna Measurements-Test Ranges, Measurement of Gain, Radiation pattern, Polarization, VSWR.				
PART – A				
CO Mapping : C313.4				
Q.No	**Questions**	**BT Level**	**Competence**	**PO**
1	What is a resonant antenna?	BTL-4	Analyzing	PO1
2	Which antenna is suitable for extraterrestrial communication?	BTL-2	Understanding	PO1,PO2,PO3
3	Compare the radiation pattern of resonant and non-resonant antenna.	BTL-1	Remembering	PO1,PO2
4	What is a non-resonant antenna?	BTL-1	Remembering	PO1
5	What are the two modes of radiation of helical antenna?	BTL-1	Remembering	PO1
6	What are the main advantages of indoor antenna measurements?	BTL-3	Applying	PO1
7	What is LPDA?	BTL-1	Remembering	PO1,PO2
8	Mention the requirements of an Anechoic Chamber. (Dec 2013)	BTL-1	Remembering	PO1,PO2
9	What is the antenna used for mobile and wireless hand set applications? Give reason.	BTL-3	Applying	PO1
10	Write the difference between active and passive antenna.	BTL-1	Remembering	PO1
11	Mention the applications of electronic band gap structure in antennas.	BTL-1	Remembering	PO1
12	What is wide band antenna? Give an example.	BTL-1	Remembering	PO1
13	What are the drawbacks of outdoor antenna measurements?	BTL-1	Remembering	PO1,PO2,PO3
14	Sketch the radiation pattern of normal mode helical antenna.	BTL-1	Remembering	PO1
15	Why is log periodic antennas called so? (Dec 2011)	BTL-4	Analyzing	PO1
16	List out the applications helical antenna. (May 2010)	BTL-1	Remembering	PO1
17	Mention the types of feed method for micro strip antenna? (May 2012) (May 2013)	BTL-2	Understanding	PO2
18	What are the special features of anechoic chamber? (Dec 2012)	BTL-1	Remembering	PO1
19	What do you meant by spiral antenna	BTL-1	Remembering	PO1,PO2
20	Which antenna is used for VHF communication? (Dec2012)	BTL-6	Creating	PO1,PO2
21	Why frequency independent antennas are called so? (May 2014)	BTL-1	Remembering	PO1,PO2
22	Mention the advantages of reconfigurable antenna.	BTL-1	Remembering	PO1,PO2

23	State Rumsey principle on frequency independence.(May 2016) (April/May 2017) (Nov/Dec 2016)	BTL-6	Creating	PO1,PO2,PO3
24	What is reconfigurable antenna?	BTL-1	Remembering	PO1,PO2
25	List the different ranges of antenna measurements	BTL-2	Understanding	PO1
26	Why antenna measurements are usually done in Fraunhofer zone? (May 2016)	BTL-1	Remembering	PO1,PO2
27	What are the advantages of helical antenna	BTL-1	Remembering	PO1
28	Compare and contrast wedges and pyramids. (Nov/Dec 2016)			
29	Design a 3 element Yagi-Uda antenna to operate at a frequency of 200 MHz. (May 2013)	BTL-1	Remembering	PO1
30	Why frequency independent antennas are called so? (May 2014)	BTL-1	Remembering	PO1
PART-B				
1	What is the importance of Helical antenna? Explain the construction and operation of Helical antenna with neat sketch. Highlight some of its applications. (May 2015) (May 2014) (May 2013) (Dec 2012) (Nov/Dec 2016)	BTL-4	Analyzing	PO1
2	With neat block diagram explain how Radiation pattern and Gain of an antenna can be measured. (May 2013, Dec 2013) (Nov/Dec 2016)	BTL-2	Understanding	PO1,PO2,PO3
3	Explain the principle of operation of Log periodic antenna with neat schematic diagram. (May 2015) (Nov/Dec 2015) (Nov/Dec 2016)	BTL-1	Remembering	PO1,PO2
4	Discuss in detail how a spiral antenna behaves as a frequency independent antenna. (May 2014)	BTL-1	Remembering	PO1
5	How is VSWR measured? Explain. (May 2014)	BTL-1	Remembering	PO1
6	Explain in detail about (i) Polarization measurement (ii) Gain Measurement (May 2012, May 2014)	BTL-3	Applying	PO1
7	Write notes on: (i) Reconfigurable antenna (ii) Electronic band gap (iii) Active antenna.	BTL-1	Remembering	PO1,PO2
8	Design a Log-Periodic dipole array with 7 dBi gain and a 4 to 1 bandwidth. Specify apex angle α, scale constant k and the number of elements. (Nov/Dec 2015)	BTL-1	Remembering	PO1,PO2
9	Explain the design procedure for the construction of log periodic antenna.	BTL-3	Applying	PO1
10	Explain the measurement procedure for the measurement of VSWR and radiation pattern. (May 2016)	BTL-1	Remembering	PO1
11	With a neat sketch design a quad-helix earth station antenna. Calculate the directivity and the effective	BTL-1	Remembering	PO1

	aperture. (Nov/Dec 2015)			
12	Design a log periodic dipole antenna to cover all the VHF TV channels from 55 MHz to 220 MHz. The required directivity is 9 dB and input impedance is 50 Ohms. The elements should be made of aluminium tubing with 2.0 cm outside diameters for the largest element and the feeder line and 0.48 cm for the smallest element. These diameters yield identical (l/d) ratios for smallest and largest elements. (April/May 2017)	BTL-1	Remembering	PO1
13	Show the experimental setup for measuring the unknown load impedance using VSWR method and explain. (April/May 2017)	BTL-1	Remembering	PO1,PO2,PO3
14	Explain the concept of electronic band gap structure and give any four applications of EBG. (April/May 2017)	BTL-1	Remembering	PO1
15	Explain in detail about log periodic antennas. What is the need for feeding from end with shorter dipoles and the need for transposing the lines? Also discuss the effects of decreasing α. (Nov/Dec 2016)	BTL-1	Remembering	PO1,PO2

UNIT V PRPAGATION OF RADIO WAVES

Modes of propagation , Structure of atmosphere , Ground wave propagation , Tropospheric propagation , Duct propagation, Troposcatter propagation , Flat earth and Curved earth concept Sky wave propagation – Virtual height, critical frequency , Maximum usable frequency – Skip distance, Fading , Multi hop propagation

PART – A

CO Mapping : C313.5

Q.No	Questions	BT Level	Competence	PO
1	What is radio horizon and optical horizon?	BTL-4	Analyzing	PO1
2	What is meant by wave tilt in ground wave propagation?	BTL-2	Understanding	PO1,PO2,PO3
3	Give the salient features of ground wave propagation.	BTL-1	Remembering	PO1,PO2
4	What is gyro frequency? What is its significance in sky wave propagation? (Dec 2013)	BTL-1	Remembering	PO1
5	What is troposcatter propagation?	BTL-1	Remembering	PO1
6	What is duct propagation? (Nov/Dec 2016)	BTL-3	Applying	PO1
7	Write down the Sommer field equation for ground wave field strength.	BTL-1	Remembering	PO1,PO2
8	What is skip distance and maximum usable frequency? (Dec 2012)	BTL-1	Remembering	PO1,PO2
9	What is magneto-ionic splitting?	BTL-3	Applying	PO1
10	Why is diversity reception necessary?	BTL-1	Remembering	PO1
11	Give the salient features of E layer.	BTL-1	Remembering	PO1

12	Define critical frequency. (April/May 2017)	BTL-1	Remembering	PO1
13	What are the effects of ground on low frequency wave transmission? (May 2014)	BTL-1	Remembering	PO1,PO2,PO3
14	How are critical frequency and maximum usable frequency related?	BTL-1	Remembering	PO1
15	What is optimum working frequency? (Dec2012) (May 2015)	BTL-4	Analyzing	PO1
16	State secant law.	BTL-1	Remembering	PO1
17	What are the causes for abnormalities in the ionosphere?	BTL-2	Understanding	PO2
18	What is free space loss factor? (Dec 2013)	BTL-1	Remembering	PO1
19	Give any four factors that influence radio wave propagation.	BTL-1	Remembering	PO1,PO2
20	Find the maximum distance that can be covered by a space wave, when the antenna heights are 60m and 120m. (May 2013) (Nov/Dec 2015)	BTL-6	Creating	PO1,PO2
21	Differentiate Virtual height from actual height. (May 2014)	BTL-1	Remembering	PO1,PO2
22	What is meant by Faraday rotation? (Dec 2011) (May 2015)	BTL-1	Remembering	PO1,PO2
23	How the virtual height of ionosphere can be measured?	BTL-6	Creating	PO1,PO2,PO3
24	What is Fading? And how it is compensated? (May 2013)	BTL-1	Remembering	PO1,PO2
25	Find the range of LOS system when the receive and transmit antenna heights are 10m and 100m respectively. (May 2016)	BTL-2	Understanding	PO1
26	What are the features of troposcatter propagation? (May 2016)	BTL-1	Remembering	PO1,PO2
27	A HF radio link is established for a range of 2000 Km. If the reflection region of the ionosphere is at a height of 200 Km and has f_C of 6MHz, calculate MUF. (Nov/Dec 2015)	BTL-1	Remembering	PO!
28	Mention the important characteristics of D layer.			
29	Draw the various layers of atmospheric structure. (April/May 2017)	BTL-1	Remembering	PO1
30	Find the critical frequency of an ionosphere layer which has an electron density of 1.24×10^8 cm^{-3}. (Nov/Dec 2016)	BTL-1	Remembering	PO1
	PART-B			
1	Describe the Troposcatter propagation.	BTL-4	Analyzing	PO1
2	Explain the effect of Earth's magnetic field on EM wave propagation. **(May 2015) (May 2013)**	BTL-2	Understanding	PO1,PO2,PO3
3	Describe the theory of propagation of EM wave through the ionosphere in the presence of external magnetic field and show that the medium acts as doubly refracting crystal. **(May 2013)**	BTL-1	Remembering	PO1,PO2

4	Explain the mechanism of tropospheric propagation. **(May 2015)**	BTL-1	Remembering	PO1
5	Why do we use high frequency waves in sky wave propagation? Explain the mechanism of propagation. **(Dec 2012)**	BTL-1	Remembering	PO1
6	Describe the troposphere and explain how ducts can be used for microwave propagation.	BTL-3	Applying	PO1
7	Explain the terms: MUF, Skip distance, Virtual height, Duct propagation, fading. **(May 2015) (Dec 2012) (Dec 2011)**	BTL-1	Remembering	PO1,PO2
8	Explain in detail about ground wave propagation and its different mechanisms with their characteristics. **(May 2012)**	BTL-1	Remembering	PO1,PO2
9	Draw the structure of ionosphere and explain the mechanism of ionosphere propagation and its electrical properties. **(May 2015)**	BTL-3	Applying	PO1
10	Establish the relationship between critical frequency and maximum electron density in ionosphere.	BTL-1	Remembering	PO1
11	Describe the structure of the atmosphere and specify the factors affecting the radio wave propagation. **(May 2012)**	BTL-1	Remembering	PO1
12	Derive the expression for refractive index of the ionosphere neglecting earth's magnetic field effects.	BTL-1	Remembering	PO1
13	Describe the space wave propagation and explain the importance of line of sight propagation.	BTL-1	Remembering	PO1,PO2,PO3
14	Explain the following terms with diagram: (1) Super Refraction (2) Critical frequency (3) Skip Zone **(May 2014)**	BTL-1	Remembering	PO1
15	Discuss the factors that are involved in the propagation of radio waves.	BTL-1	Remembering	PO1,PO2
16	In the ionospheric propagation, consider that the reflection takes place at a height of 400 km and the maximum density in the ionosphere corresponds to a refractive index of 10 MHz. determine the ground range for which this frequency if the MUF. Take earth's curvature in to consideration.	BTL-4	Analyzing	PO1
17	Describe the structure of the atmosphere and explain each layer in detail.**(May 2016)**	BTL-2	Understanding	PO1,PO2,PO3
18	Disucss the effect of the earth's magnetic field on ionosphere radio wave propagation.	BTL-1	Remembering	PO1,PO2
19	Describe the troposphere and explain how ducts can be	BTL-1	Remembering	PO1

	used for microwave propagation.**(May 2016)**			
20	Derive the expressions for phase velocity and group velocity of sky wave. **(Nov/Dec 2015)**	**BTL-1**	**Remembering**	**PO1**
21	Explain how the EM waves are propagated in troposphere layer and discuss the principle of troposcatter propagation. **(April/May 2017)**	**BTL-4**	**Applying**	**PO1**
22	Explain the effect of EM waves in curved earth and flat earth configuration. **(April/May 2017)**	**BTL-2**	**Remembering**	**PO1,PO2**
23	Draw the electron density profile chart of an ionosphere and explain. Also derive an expression for the effective relative dielectric constant of the ionosphere. Explain about reflection and refraction of waves in ionosphere. **(Nov/Dec 2016)**	**BTL-1**	**Remembering**	**PO1,PO2**
24	Explain the attenuation characteristics for ground wave propagation.	**BTL-1**	**Applying**	**PO1**
25	Explain LOS propagation and troposcatter propagation.	**BTL-1**	**Applying**	**PO1**

UNIT I FUNDAMENTALS OF RADIATION

Definition of antenna parameters – Gain, Directivity, Effective aperture, Radiation Resistance, Band width, Beam width, Input Impedance. Matching – Baluns, Polarization mismatch, Antenna noise temperature, Radiation from oscillating dipole, Half wave dipole. Folded dipole, Yagi array.

PART – A

1. What is retarded potential? (Nov/Dec 2016)

If an alternating current is flowing in a short element, the effect of current is not felt instantaneously at a distant point, but only after some time interval equal to the time required for the fields to propagate through the distance. The potential obtained considering retardation time are known as retarded potential. They are very important in radiation calculation.

2. What do you mean by an isotropic radiator?

It is a hypothetical loss less radiator having equal radiation in all directions. E.g. point source

3. What do you understand by static, induction and radiation field produced by an antenna?(May 2015)

The field terms which vary inversely as the cube of the distance [α 1/r3] are known as electrostatic fields. They are important only near the current elements and does not contribute anything for radiation.

Induction field: The field term that varies inversely as the square of the distance [$\alpha\ 1/r^2$] is known as induction field. It predominates at points close to current element where distance is small.

Radiation field: The field term that varies inversely as distance “r” is called as radiation fields or “far fields” that accounts for the radiation of electromagnetic waves from the antenna.

4. Define directivity of an antenna (May 2012).

The *directivity* or *gain* of an antenna is defined as the ratio of the maximum value of the power radiated per unit solid angle to the average power radiated per unit solid angle: that is,

$$G = \frac{(dP/d\Omega)_{\max}}{P/4\pi}.$$

Thus, the directivity measures how intensely the antenna radiates in its preferred direction than a isotropic radiator would when fed with the same total power.

5. Define effective aperture (area) of an antenna (May 2012) (May 2015).

It is defined as the area over which the antenna collects energy from the incident wave and delivers it to the receiver load.

$$A_e = \frac{received\ \ power\,(watt)}{power\ \ flow\ per\ square\ meter\,(watts/sqm)\ for\ \ the\ incident\ \ wave}$$

6. Define the radiation resistance of an antenna. What is the importance of this quantity? (May 2015 &Nov/Dec 2015)

Radiation resistance is defined as a fictitious or hypothetical resistance that would dissipate an amount of power equal to the radiated power. Total power radiated by the antenna can be determined using the radiation resistance.

$$power\ radiated = R_r \times (I_{rms})^2$$
$$R_r = radiation\ \ resistance$$
$$I_{rms} = rms\ value\ of\ \ the\ \ current\ \ in\ \ antenna$$

7. What is self-impedance of an antenna?

Impedance at the point where transmission line is connected is referred to as feed point impedance or antenna input impedance. If the antenna is loss less and isolated, then the self impedance of the antenna is equal to the antenna input impedance.

8. Define the bandwidth of an antenna.

The band width of antenna is defined as “The range of frequencies within which the performance of the antenna, with respect to some characteristics [input impedance, beam, width, polarization, side lobe level, gain etc.] confirms to a specified standard.

9. Define the directive gain of an antenna.

Directive gain in a given direction, is defined as the ratio of the radiation intensity in that direction to the average radiated power. $g_d(\theta,\phi) = \frac{\Phi(\theta,\phi)}{\Phi_{av}} = \frac{4\pi\,\Phi(\theta,\phi)}{W_r}$

In decibels the directive gain is denoted by $G_d = 10\log_{10}(g_d)$

10. Calculate the radiation resistance of current element of length $\lambda/20$ (May2012).

$$R_r = 80\pi^2\left(\frac{dl}{\lambda}\right)^2$$

$$dl = \frac{\lambda}{20}$$

$$R_r = 1.974\,ohms$$

11.Define the antenna efficiency.

Antenna efficiency is defined as the ratio of power radiated to the total input power supplied by to the antenna and is denoted by η.

$$\eta = \frac{power\ radiated}{Total\ power\ supplied} = \frac{I^2 R_r}{I^2\left[R_r + R_l\right]}$$

$R_r = Radiation\ resistance$

$R_l = loss\ resistance$

12. Define beam solid angle.

The beam area or beam solid angle Ω_A for antenna is given by integral of the normalized power pattern over a sphere.

$$\Omega_A = \int_0^{2\pi}\int_0^{\pi} P_n(\theta,\phi)\ d\Omega \qquad steradian$$

$P_n(\theta,\phi) = Normalized\ power\ pattern$

Beam solid angle is also given approximately by

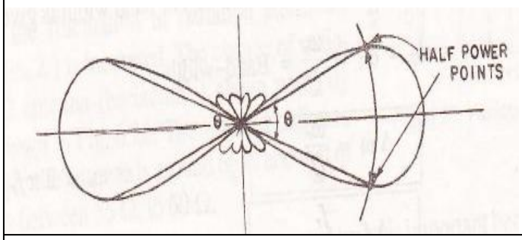
$$\Omega_A = \theta_{HP}\ \phi_{HP} \qquad steradian$$

$\theta_{HP} = HPBW\ in\ E-plane\ or\ \theta\ plane$

$\phi_{HP} = HPBW\ in\ H-plane\ or\ \phi\ plane$

13. Define Half power beam width (HPBW) of an antenna (Dec 2012).

Antenna Beam Width is a measure of directivity of an antenna. It is an angular width in degrees, measured on the radiation pattern (main lobe) between points where the radiated power has fallen to half its maximum value.

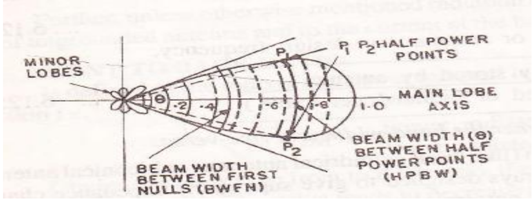


14. Define the term 'Front to back ratio.

$$Front\ to\ back\ ratio = \frac{power\ radiated\ in\ the\ desired\ direction}{power\ radiated\ in\ the\ opposite\ direction}$$

15. Define Beam Width between First Null.

Beam width between first null (BWFN) is the angular width in degrees, measured on the radiation pattern between first null points on either side of the main lobe.



16. What are parasitic elements and where are they used?

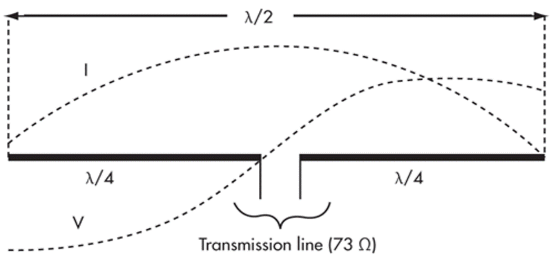
Reflector and director are passive elements which are not connected to the feeder line directly, but they are simply grounded and are called parasitic elements. The parasitic elements receive their excitation from the nearby driven element. They are used in Yagi-uda array for TV reception.

17. State the need for BALUN.

A Balun is used to transform the balanced input of the antenna into unbalanced impedance so that an unbalanced transmission line can be connected to it. (To connect an unbalanced line (e.g., Coaxial cable) to a balanced antenna (e.g., Dipole antenna)).

18. How a dipole antenna can be formed from a 2 wire open circuited transmission line? (Dec 2013)

A half wave length dipole antenna can be formed from a two wire transmission line as shown in figure.



19. What is the effective area of a half wave dipole operating at 1 GHz? (May 2013)

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

$$f = 1GHz$$

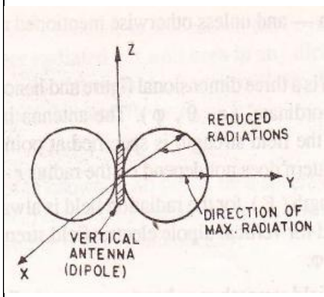
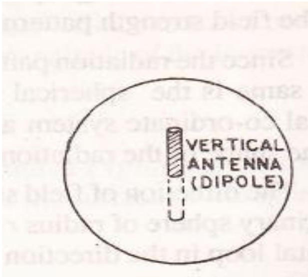
$$\lambda = \frac{3\times10^8}{1\times10^9} = 0.3m$$

$$g_d = directive\ gain = 1.644$$

$$A_e = \frac{0.3^2}{4\pi}\times 1.644 = 0.012m^2$$

20. Draw the E plane and H plane radiation pattern of a dipole. (May 2014)

E plane pattern is referred to as vertical pattern and H plane pattern is referred to as horizontal pattern.

Vertical Pattern:	**Horizontal pattern:**
	

21. What are dB_i and dB_d ? Write their significances. (Dec 2013)

dBi is the amount of focus applied by an antenna with respect to an "Isotropic Radiator" (a dispersion pattern that radiates the energy equally in all directions onto an imaginary sphere surrounding a point source). Thus an antenna with 2.1 dBi of gain focuses the energy so that some areas on an imaginary sphere surrounding the antenna will have 2.1 dB more signal strength than the strength of the strongest spot on the sphere around an Isotropic Radiator.

dBd refers to the antenna gain with respect to a reference dipole antenna. A reference dipole antenna is defined to have 2.15 dBi of gain.

dBi = dBd + 2.15 and dBd = dBi - 2.15

22. What is meant by polarization?

Polarization of an antenna means the orientation of the electric field (E-vector) of the electromagnetic wave being radiated by the transmitting antenna in the far field.

23. Design a 3 element Yagi-Uda antenna to operate at a frequency of 200 MHz. (May 2013)

Length of driven element $= \frac{478}{f_{MHz}} = \frac{478}{200} = 2.39\ feet$

Length of reflector $= \frac{492}{f_{MHz}} = \frac{492}{200} = 2.46\ feet$

Length of director $= \frac{461.5}{f_{MHz}} = \frac{461.5}{200} = 2.31\ feet$

Element spacing $= \frac{142}{f_{MHz}} = \frac{142}{200} = 0.71\ feet$

24. Define antenna temperature.

It is defined as the temperature of far or distant regions of space and near surroundings which are coupled to the antenna through radiation resistance.

25. Define folded dipole.

A folded dipole consists of two parallel $\lambda/2$ dipoles connected to each other at the ends. It is fed at the centre of one of the dipoles and the other dipole is shorted.

the centre of one of the dipoles and the other dipole is shorted.

26. The radial component of the radiated power density of an antenna is given by $W_{rad} = a_r W_r = a_r A_o \sin\theta / r^2 (W/m^2)$, **where** A_o **is the peak value of the power density,** θ

Is the usual spherical coordinate, and a_r **is the radial unit vector. Determine the total radiated power ? (May 2016)**

For a closed surface, a sphere of radius r is chosen. To find the total radiated power, the radial component of the power density is integrated over it's surface. Therefore,

$$W_t = \oint_S W_{rad} . \hat{n}\, da$$

$$= \int_0^{2\pi}\int_0^{\pi} \left[a_r A_0 \frac{\sin\theta}{r^2} \right] .a_r r^2 \sin\theta d\theta d\phi = \pi^2 A_0 \, Watts$$

27. The radiation resistance of an antenna is 72 Ohms and the loss resistance is 8 Ohms. What is the directivity (in dB), if the power gain is 15? (May 2016)

$$\frac{R_r}{R_r + R_l} = \frac{g_p}{g_d}$$

$$\frac{72}{72+8} = \frac{15}{g_d}$$

$$g_d = 15 \times \frac{80}{72} = 16.67$$

$$Directivity = \text{maximum } directive gain = 10\log(g_d) = 0.169 dB$$

28. Define the brightness temperature of the antenna. (Nov/Dec 2015)

The amount of energy radiated is usually represented by an equivalent temperature T_B, better known as brightness temperature, and it is defined as

$$T_B(\theta,\emptyset) = \varepsilon(\theta,\emptyset) T_m = (1 - |\Gamma|^2) T_m$$

where

T_B = brightness temperature (equivalent temperature; K)

ε = emissivity (dimensionless)

T_m = molecular (physical) temperature (K)

$\Gamma(\theta,\emptyset)$ = reflection coefficient of the surface for the polarization of the wave

Since the values of emissivity are $0 \le \varepsilon \le 1$, the maximum value the brightness temperature can achieve is equal to the molecular temperature.

The brightness temperature emitted by the different sources is intercepted by antennas, and it appears at their terminals as an antenna temperature.

29. What is the significance of gain of an antenna?(Nov/Dec 2015)

Although the gain of the antenna is closely related to the directivity, it is a measure that takes into account the efficiency of the antenna as well as its directional capabilities. If the efficiency is not 100 percent, the gain is less than the directivity. Thus, the gain

G = kD (dimensionless), where k = efficiency factor of antenna (0 < k < 1), dimensionless

This efficiency has to do only with ohmic losses in the antenna. In transmitting, these losses involve power fed to the antenna which is not radiated but heats the antenna structure.

30. Determine the electric field intensity at a distance of 10 km from a dipole antenna of directive gain of 6 dB and radiating power of 20 kW. (April/May 2017)

$$Directive\ gain = g_d(\theta,\phi) = \frac{P_d(\theta,\phi)}{P_{avg}}$$

$$P_{avg} = \frac{P_{rad}}{4\pi r^2}$$

$$P_d(\theta,\phi) = \frac{1}{2}\frac{|\overline{E}|^2}{\eta_0} = \frac{|\overline{E}|^2}{240\pi}$$

$$g_d = 6dB$$

$$Anti\log\left(\frac{6}{10}\right) = 3.98$$

$$|\overline{E}| = \sqrt{g_d(\theta,\phi)\times\frac{P_{rad}}{4\pi r^2}\times 240\pi} = \sqrt{3.98\times\frac{20\times10^3}{(10\times10^3)^2}\times 60} = 0.2185\ V/m$$

31. Define gain of an antenna. Mention the relationship between gain and aperture of an antenna. (April/May 2017)

Directive gain in a given direction, is defined as the ratio of the radiation intensity in that direction to the average radiated power. $g_d(\theta,\phi) = \frac{\Phi(\theta,\phi)}{\Phi_{av}} = \frac{4\pi\ \Phi(\theta,\phi)}{W_r}$

Effective aperture is defined as the area over which the antenna collects energy from the incident wave and delivers it to the receiver load.

$$A_e = \frac{received\ \ power\ (watt)}{power\ \ flow\ per\ square\ meter\ (watts/sqm)\ for\ \ the\ incident\ \ wave}$$

Relationship between directive gain and effective aperture is:

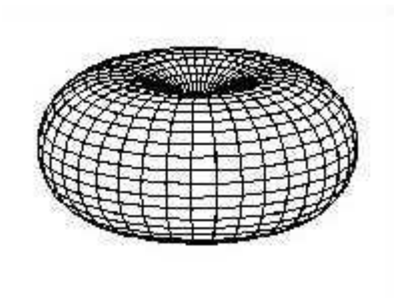
$$A_e = \frac{\lambda^2}{4\pi} g_d$$

32. The voltage induced by the application of an electric field of strength 2 Volts/meter is 0.7. Calculate

the effective length of the element. (Nov/Dec 2016) $$h_e = \frac{V_{oc}}{E} = \frac{0.7}{2} = 0.35m$$
33. Draw the radiation pattern for isotropic, directional and omnidirectional antenna. (April/May 2017)

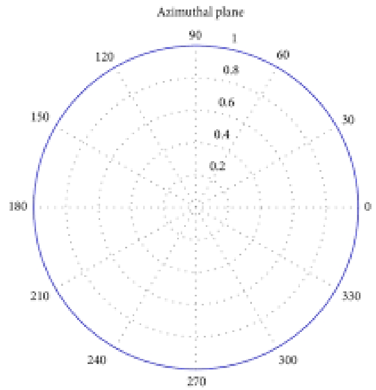
In radio communication, an omnidirectional antenna is a class of antenna which radiates radio wave power uniformly in all directions in one plane, with the radiated power decreasing with elevation angle above or below the plane, dropping to zero on the antenna's axis. This radiation pattern is often described as "doughnut shaped".

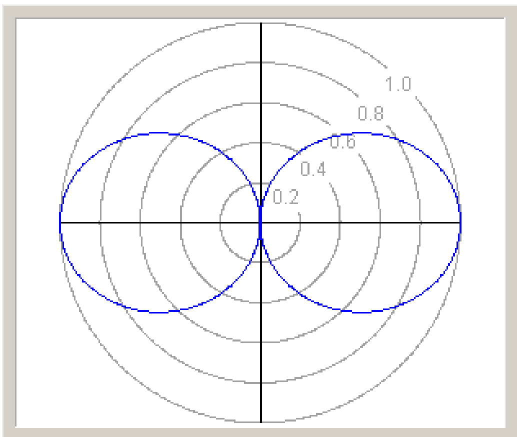
Omnidirectional antenna radiation pattern 3D



An isotropic antenna, which radiates equal power in all directions has a "spherical" radiation pattern.

Both E plane and H-plane pattern is full circle.





Directional antenna: example

PART B

1. Define and explain in detail the terms “Radiation Resistance”, “gain”, “Directivity”,

“Effective aperture” and “Polarization of an antenna”. **(Dec 2012)**

Refer page no.12 –John D Kraus “Antenna for All Applications”

2. Derive the electric and magnetic field components of Hertzian dipole. **(Dec 2012)** Refer page no.18 –John D Kraus "Antenna for All Applications"
3. What are Hertzian dipoles? Derive the Electric and Magnetic field quantities of infinitesimal dipole and radiation pattern. **(Dec 2011)** Refer page no.34 –John D Kraus "Antenna for All Applications"
4. Explain the following parameters of an antenna 1)Beam solid angle. 2)Radiation pattern 3)Gain 4)Polarization 5)Bandwidth **(Dec 2011)** Refer page no.22 –John D Kraus "Antenna for All Applications"
5. (i)Show that the directivity of an alternating current element is 1.76dB. (ii)Show that at distance $r = 0.159\lambda$ the induction field is equal to radiation field for a current element.
6. (i)Calculate the radiation efficiency of an antenna if the input power is 100W and the power dissipated in it is 1W. (ii)Discuss on linear, elliptical and circular polarization of antenna. Refer page no.25 –John D Kraus "Antenna for All Applications"
7. (i)An antenna has loss resistance 25 ohms, power gain of 30 and directivity 42. Calculate the radiation resistance. (ii)Explain self impedance and mutual impedance of an antenna. Refer page no.41–John D Kraus "Antenna for All Applications"
8. (i) Derive the radiation resistance of an Oscillating Electric Dipole. **(Dec 2013)** Refer page no.46 –John D Kraus "Antenna for All Applications" (ii) Define and explain the polarization and its significance in antenna analysis. Refer page no.63 –John D Kraus "Antenna for All Applications"
9. (i) Define the following parameters and their dependence on antenna performance 1) Radiation pattern 2)Input impedance 3)Polarization Refer page no.38 –John D Kraus "Antenna for All Applications" (ii) Derive the magnetic field components of a dipole having the dimension $l<<\lambda/2$ **(May 2014)** Refer page no.54 –John D Kraus "Antenna for All Applications"

10. (i) Explain the terms:

1) Beam Solid Angle 2)Antenna Temperature 3) Reciprocity of Antenna **(May 2014)**

Refer page no.27 –John D Kraus "Antenna for All Applications"

(ii) Derive the current and vector potential of a Hertzian dipole.

Refer page no.27 –John D Kraus "Antenna for All Applications"

11. Derive the field quantities and radiation resistance of a half wavelength dipole. **(Dec 2011)**

Refer page no.72 –John D Kraus "Antenna for All Applications"

12. With necessary illustrations explain the radiation characteristics of Yagi Uda antenna. **(May 2014)**

Refer page no.112 –John D Kraus "Antenna for All Applications"

13. Derive an expression for the power radiated by the current element and calculate the radiation resistance. (**April/May 2017**)

Refer page no.18 –John D Kraus "Antenna for All Applications"

14. Derive the expression for the far field component of a half wave dipole antenna. (**April/May 2017)(Nov/Dec 2016)**Refer page no.72 –John D Kraus "Antenna for All Applications"

UNIT II APERTURE AND SLOT ANTENNAS

Radiation from rectangular apertures, Uniform and Tapered aperture, Horn antenna , Reflector antenna , Aperture blockage , Feeding structures , Slot antennas ,Microstrip antennas – Radiation mechanism – Application ,Numerical tool for antenna analysis

PART – A

1. Mention any three aperture antennas.

Slot antenna, horn antenna, lens antenna.

2. State uniqueness theorem (May 2012)

Uniqueness theorem states that, for a given set of sources and boundary conditions in a lossy medium, the solution to Maxwell's equations is unique.

3. State Snell's law of refraction.

$$\frac{\sin\theta_t}{\sin\theta_i} = \sqrt{\frac{\epsilon_{r1}}{\epsilon_{r2}}}$$

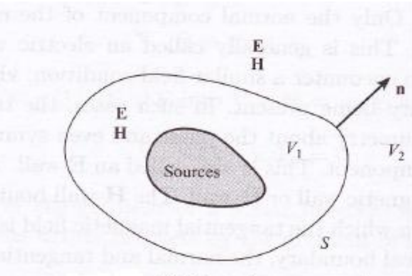
$\theta_i = angle\ of\ incidence, \theta_t = angle\ of\ refraction$

$\epsilon_{r1} = relative\ dielectric\ constant\ of\ region 1$

$\epsilon_{r2} = relative\ dielectric\ constant\ of\ region 2$

4. What is field equivalence principle? (May 2014)

According to the field equivalence principle, the fields in V_2 due to the sources in V_1 can also be generated by an equivalent set of virtual sources on surface **S**, given by $J_S = n \times H$ and $M_S = E \times n$ where **E** and **H** are the fields on the surface **S** produced by the original set of sources in volume V. The set of virtual sources produce null fields everywhere in V_1. Here, M_S represents the magnetic surface current density and J_S represents electric surface current density.



Fields and sources

5. Give the applications of lens antenna.

They are used in the higher end of the microwave spectrum and millimetre wave frequencies.

6. What is slot radiator? What is its operating principle?

When a slot in a large metallic plane is coupled to an R.F source, it behaves like a diploe antenna mounted over a reflecting surface. The slot is coupled to a feed line in such a manner that E-field lies along the short axis of the slot.

7. State Babinet's principle & how it gives rise to the concept of complementary antenna? (May 2013)(Nov 2017)

Babinet's principle states that the sum of the field at a point behind a plane having a screen and the field at the same point when a complimentary screen is substituted, is equal to the field at the point when no screen is present. This principle can be applied to slot antenna analysis.

8. What is a corner reflector?

A corner reflector is made up of two flat-plate reflectors joined together to form a corner. The corner reflector is generally used in conjunction with a dipole or dipole array kept parallel to the corner line. Corner reflector gives a higher directivity.

9. What are the features of pyramidal horn antenna? (May 2015)

The pyramidal horn is obtained by flaring all the sides of a rectangular wave guide to form a pyramid-shaped horn with a rectangular aperture.

- It is one of the most often used horn antennas.
- It is used as a primary feed for reflector antennas.
- It is used as standard gain reference antennas in antenna measurements.

10. What is the principle of E-plane metal plate lens antenna?

In this, outgoing wave front is speeded up by the lens material. When the feed antenna is kept at the focal point of the lens antenna, the spherical wave fronts are collimated forming a plane wave front.

11. What is a sectoral horn?

Horn antenna is a wave guide one end of which is flared out.

- If flaring is along the direction of electric field, it is called sectoral E-plane horn.

If flaring is along the direction of magnetic field, it is called sectoral H-plane horn

12. Give two examples for microwave antenna.

Horn antenna, Lens antenna

13. What is ‘zoning’ in lens antenna?

Zoning is a method used to reduce the bulk (weight) of the antenna. The lens is divided in to several circular zones and the dielectric material is removed from each zone such that the electrical path length between adjacent zones differs by an integer multiple of a wave length.

14. What are the two methods of ‘zoning’ in dielectric lens antenna?

Zoning the non-refracting surface, zoning the refracting surface

15. What are the drawbacks of lens antenna?

- Due to the reflection at the dielectric-air interface, a matching quarter wave transformer is required which limits the band width of the lens antenna to the bandwidth of the matching device.
- A lens antenna is generally heavy and bulky.

16. What is the main advantage of Cassegrain reflector configuration?

- The main advantage is that the primary feed horn and the associated receiver or transmitter can be located conveniently behind the main reflector.
- The necessity of running long transmission lines or waveguides is also eliminated.
- Since the horn feed is kept behind the main reflector, one can afford to have a much larger aperture for the horn.

17. What is the main disadvantage of Cassegrain reflector configuration?

The main disadvantage of Cassegrain reflector configuration is the large aperture blockage by the sub-reflector. Hence, Cassegrain reflector configuration is used only for very large aperture antennas having gain greater than 40dB.

18. What are the different types of lens antenna?

Dielectric lens antenna, Metallic lens antenna, Zoned lens antenna, Stepped lens antenna.

19. Distinguish between sectorial horn and pyramidal horn.

- Horn antenna is a wave guide one end of which is flared out. In pyramidal horn, the flaring is along E and H. It has the shape of a truncated pyramid.
- In sectoral horn, the flaring is along E or H. If flaring is along the direction of electric field, it is called sectoral E-plane horn. If flaring is along the direction of magnetic field, it is called sectoral H-plane horn.

20. What is a microstrip antenna?

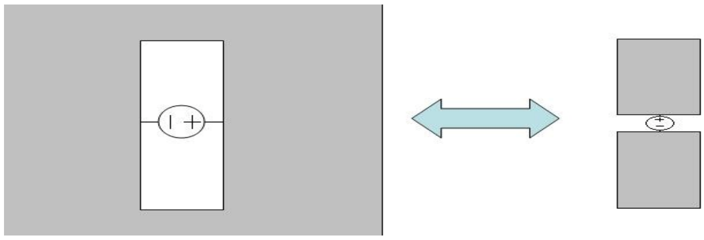
A microstrip patch antenna consists of a thin metallic patch etched on the dielectric substrate using PCB technology.it is also referred as printed antenna. Its performance depends on shape (can be square, rectangular, triangular, circular) and size.

21. What is pill box antenna?

- This is a reflector antenna which has a cylindrical reflector enclosed by two parallel conducting plates perpendicular to the cylinder, spaced less than one wavelength apart.
- It is excited by a probe through a coaxial line. It produces a wide beam in E-plane and narrow beam in H-plane.
- This is used in ship-to-ship radars.

22. On what principle slot antenna works? Explain the principle. (May 2016)

Babinet’s principle. This principle relates the radiated fields and impedance of an aperture or slot antenna to that of the field of its dual antenna. The dual of a slot antenna would be if the conductive material and air were interchanged - that is, the slot antenna became a metal slab in space. An example of dual antennas is shown in Figure



Dual antennas - (left) the slot antenna, (right) the dipole antenna.

23. Mention any three curved reflector shapes.

Parabolic, Parabolic cylinder, Hyperboloid

24. What are the features of microstrip antennas? (Dec 2011) (May 2015) (Nov/Dec 2015) (April/May 2017)

These are antennas made from patches of conducting material on a dielectric substrate above a ground plane.

Advantages: Small size, low cost, low weight, ease of installation.

Applications: They are used in space crafts, aircrafts, telemetry, satellite communications and defense radar systems.

25. The aperture dimensions of a pyramidal horn are 12x6 cm and operating at a frequency of 10 GHz. Find the beam width and directivity. (May 2013)

Frequency = 10 GHz

$$\lambda = \frac{3\times10^8}{10\times10^9} = 3cm$$

$$d = 12cm \quad and \quad w = 6cm$$

$$Beamwidth: \phi_E = 56\frac{\lambda}{d} = 14^0$$

$$\phi_H = 67\frac{\lambda}{w} = 33.5^0$$

$$power\ gain = \frac{4.5wd}{\lambda^2} = 36 = 15.56dB$$

$$Directivity = \frac{7.5wd}{\lambda^2} = 60$$

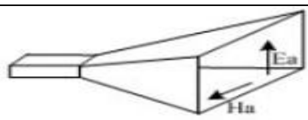
26. What is the principle of dielectric lens antenna?

In this, outgoing wave front is delayed by the lens material. When the feed antenna is kept at the focal point of the lens antenna, the spherical wave fronts are collimated forming a plane wave front.

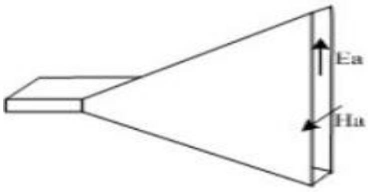
27. What are the different types of horn antenna. (April/May 2017) (Nov/Dec 2016)

E-Plane sectoral horn, H-plane sectoral horn, Pyramidal horn, Conical

H-plane sectoral horn

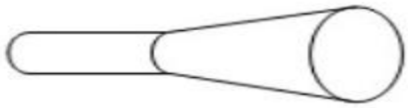


Pyramidal horn



horn

E-plane sectoral horn



Conical Horn Antenna

28.Name some numerical tools that can be used to analyze an antenna. (Nov/Dec 2016)

Newton's method, Lagrange interpolation polynomial, Gaussian elimination, or Euler's method.

29. The impedance of an infinitesimally thin λ/2 antenna (L=0.5λ and L/D=∞) is 73+j42.5 Ω. Calculate the terminal impedance of an infinitesimally thin λ/2 slot antenna.(Nov/Dec 2015)

$$Z_S = \frac{{\eta_0}^2}{4Z_C} = \frac{(377)^2}{4(73+j42.5)} = \frac{35532.25}{(73+j42.5)} = 363.52 - j\,211.64\,\Omega$$

30. How can we eliminate minor lobes? (Nov/Dec 2016)

- Side lobe levels in the general forward direction may be reduced overall by the placement on the reflector of Mylar strips coated with graphite or carbon impregnated sponge material
- Wider angle side lobes in the forward direction may be reduced further by attaching "choke blinders" to the exciter feed
- The radiation behind the reflector or horn antenna is attributed to the field diffracted by the edges. For this reason, most of the techniques aimed at reducing the back radiation concentrate on the edge geometry

PART B

1. (i) Write an essay on aperture antennas.

(ii) Compare flat reflector and corner reflector antennas.

Refer page no.134–John D Kraus "Antenna for All Applications"

2. Explain the radiation mechanism of horn antenna with diagram. Draw the different types of horn structures. **(May 2015) (Dec 2012) (Dec 2011)**

Refer page no.162–John D Kraus "Antenna for All Applications"

3. (i) Explain how a paraboloidal antenna gives a highly directional pattern?

(ii)Explain in detail about the feeding structures of parabolic reflector antenna. **(May 2013) (Dec 2011)**

Refer page no.134–John D Kraus "Antenna for All Applications"

4. Write in detail about: (i) Slot antenna (ii) Lens antenna **(May 2013) (May 2012)** Refer page no.96–John D Kraus "Antenna for All Applications"
5. Explain the principle of reflector antenna and discuss on different types of feed used with neat diagram. **(May 2015) (May 2014) (Dec 2012) (Nov/Dec 2016)** Refer page no.136–John D Kraus "Antenna for All Applications"
6. With necessary illustrations explain the radiation characteristics of microstrip antenna with different types of feeding structures and mention its application. **(Dec 2011)** Refer page no.145–John D Kraus "Antenna for All Applications"
7. (i) Explain the radiation mechanism of Cassegrain reflector antenna With necessary diagrams. (ii)How is aperture blockage in reflector antennas avoided? **(May 2012)** Refer page no.136–John D Kraus "Antenna for All Applications"
9. Explain the construction and principle of pyramidal horn antenna. A pyramidal horn antenna having aperture dimension of a=5.2cm and b=3.8cm is used at a frequency of 10GHz. Calculate its gain and half power beam widths. **(Dec 2013)** Refer page no.166-John D Kraus "Antenna for All Applications"
10. (i) Discuss the various feed techniques for Rectangular patch antenna with neat diagrams. (ii) Find the diameter of a dish antenna that will form a beam having 0.5deg, half power beam width (HPBW) at a frequency of 8.2GHz. Assuming an efficiency constant of 0.6, calculate the antenna gain and effective aperture. **(Dec 2013)** Refer page no.152–John D Kraus "Antenna for All Applications"
11. Discuss the geometry of a parabolic reflector and the significance of f/D ratio. Explain its feed configurations.**(May 2016)** Refer page no.138–John D Kraus "Antenna for All Applications"
12. Discuss the construction and design of a Yagi-Uda array. Show that the impedance of a folded dipole is 300 Ohms. **(May 2016)** Refer page no.168–John D Kraus "Antenna for All Applications"
13. Discuss the construction of the rectangular Horn antenna and draw the measured E- and H-plane field patterns of rectangular horn as a function of flare angle and horn length. **(Nov/Dec 2015)** Refer page no.175–John D Kraus "Antenna for All Applications"
15. (i) Explain the principle of reflector antenna and the different types of feed used in a reflector antenna. (**April/May 2017**) Refer page no.137–John D Kraus "Antenna for All Applications" (ii) Explain the working principle of microstrip patch antenna. (**April/May 2017**)

Refer page no.154–John D Kraus “Antenna for All Applications”

16.(i) A pyramidal horn antenna with the aperture length of 10λ cm is fed by a rectangular waveguide in TE_{10} mode. Determine the design parameters of the antenna operating at 2.5 GHz.

(**April/May 2017**)

(ii)Compare the slot and dipole antenna. (**April/May 2017**)

Refer page no.98–John D Kraus “Antenna for All Applications”

17. Explain in detail the radiation from a slot antenna and their feed systems. **(Nov/Dec 2016)**

Refer page no.92–John D Kraus “Antenna for All Applications”

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UNIT III ANTENNAS ARRAYS

N element linear array, Pattern multiplication, Broadside and End fire array – Concept of Phased arrays, Adaptive array, Basic principle of antenna Synthesis-Binomial array

PART – A

1. What is an antenna array?

- Antenna array is system of a similar antennas oriented similarly to get greater directivity in a desired direction.
- Antenna array is a radiating system consisting of several spaced and properly phased (current phase) radiators.

2. What is end-fire array?

End-fire array is defined as an array in which the principal radiation direction is along the array axis. i.e., maximum radiation is along the axis of the array.

3. What is broad-side array?

Broadside array is defined as an array in which the principal radiation direction is perpendicular to the array axis.

4. What is relationship between directivity and HPBW?

If HPBW is greater; directivity is less and vice-versa.

5. What do you mean by tapering of array?

- The techniques used in reduction of side lobe level are called as tapering.
- It is found that minor lobes are reduced if the center source radiates more strongly than the end sources (non-uniform current distribution). Hence tapering is done from center to end according to some prescription.

6. Define adaptive array.

Adaptive arrays have an awareness of their environment and adjust to it in a desired fashion. Thus an adaptive array can automatically steer its beam toward a desired signal while steering a null toward an undesired or interfering signal. In a more versatile adaptive array the output of each element is sampled, digitized and processed by a computer. Such an array may be called as smart antenna.

7. What is the main advantage of Binomial array?

- No side lobes in the radiation pattern of Binomial array.

- Half Power Beam width is more.

8. Define uniform linear array.

Uniform linear array is one in which the elements are fed with a current of equal amplitude (magnitude) with uniform progressive phase shift along the line.

9. What are null directions in radiation pattern?

Direction in which radiation is not present is defined as null direction.

10. Why we go for non-uniform amplitude distribution?

We go for non- uniform amplitude distribution to reduce side lobe levels.

11. Distinguish between uniform and non-uniform arrays.

Uniform linear array is one in which the elements are fed with a current of equal amplitude.

Non-uniform linear array is one in which the elements are fed with currents of un equal amplitude.

12. A uniform linear array contains 50 isotropic radiator with an inter element spacing of $\lambda/2$. Find the directivity of broadside forms of arrays. (May 2013)

N=50 d= $\lambda/2$

Array length=N d= $l = 25\lambda$

Directivity of Broadside array = $2\left(\frac{l}{\lambda}\right)$ =50

13. What are the advantages of antenna arrays? (May 2014)

A radiating system composed of several spaced and properly phased radiators is called as an Antenna array. Antenna array is used to have higher directivity. So this system is used in long distance communication.

14. What is the advantage of pattern multiplication?

- Simple method for obtaining radiation pattern of arrays.
- Makes it possible to sketch rapidly, almost by inspection, the radiation pattern of complicated arrays without making lengthy calculations.

15. Define Phased arrays.

An array of many elements with the phase (also amplitude) of each element being a variable, providing control of the beam direction and pattern shape including side lobes.

16. State Huygen's principle. (Dec 2013) (May 2015)

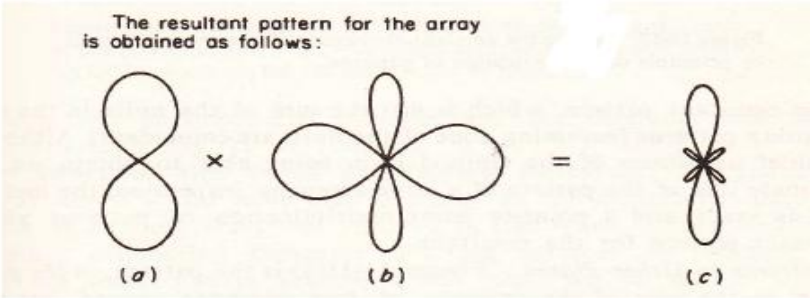
Huygen's principle states that, 'each point on a primary wave front can be considered to be a new source of a secondary spherical wave and that a secondary wave front can be constructed as the envelope of these waves.

17. State the principle of pattern multiplication (Dec 2012) (Nov/Dec 2015)

The total field pattern of an array of non-isotropic but similar sources is the product of individual source pattern and the pattern of an array of isotropic point sources each located at the phase center of the individual source and having the same relative amplitude and phase, while the total phase pattern is the sum of the phase patterns of the individual source and the array of isotropic point sources.

Array pattern = Element pattern * Array Factor

For example, radiation pattern of a four element array in which the spacing between units is $\frac{\lambda}{2}$ and the currents are in phase ($\alpha = 0$) is obtained as,



(a) Unit pattern (b) Array Factor (c) Array pattern

18. How number of array elements effect directivity?

As number of array element increases; the beam width will be lesser and this will result better directivity.

19. Write the disadvantages of binomial arrays.

- The beam width of the main lobe is large which is undesirable.
- The directivity is small.
- High excitation levels are required for the centre elements of large arrays.

20. A uniform linear array of 4 isotropic elements with an inter element spacing of $\lambda/2$. Find the BWFN and directivity of end fire arrays.

n=4 d= $\lambda/2$

Array length= nd =$l = 2\lambda$

BWFN = $2\sqrt{\frac{2\lambda}{nd}}$ = 2

Directivity of end fire array = $4\left(\frac{l}{\lambda}\right)$ =8

21. What is binomial array?

Binomial array is an array whose elements are excited according to the current distribution determined by the binomial coefficient, nc_r, where n is number array elements

22. What is uniform Array?

Array elements are fed with a current of equal amplitude (magnitude) with uniform progressive phase shift along the line

23. Write the techniques followed for array synthesis.

1) Schelkunoff polynomial method 2) Fourier transform method 3) Dolph-Tchebyscheff or Chebyshev method 4) Taylor's method 5) Laplace transform method 6) Woodward-Lawson method.

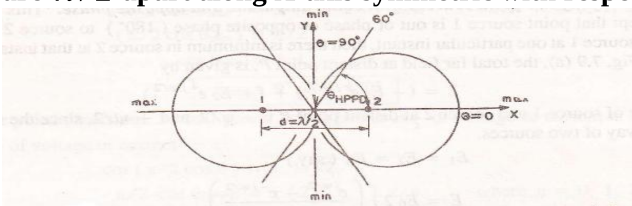
24. Define antenna synthesis.

Synthesis of an antenna array is the determination of antenna system details for a given input and for a required output.

25. What are the advantages of Dolph-Tschebyscheff method?

- It provides a minimum beam width for a specified side lobe level.
- It provides pattern which contains side lobes of equal level.
- The amplitude distribution is not highly tapered and hence it is more practical.

26. Draw the radiation pattern of an isotropic point sources of same amplitude and opposite phase that are $\lambda/2$ apart along X-axis symmetric with respect to origin. (May 2016)

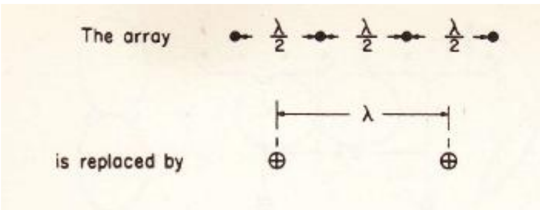


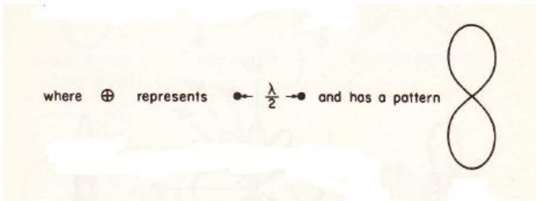
Two point sources with equal amplitude and opposite phase spacing λ/2.

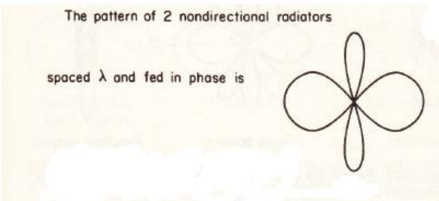
Normalized total field of two element array of isotropic point sources of same amplitude and opposite phase that are $\lambda/2$ apart is,

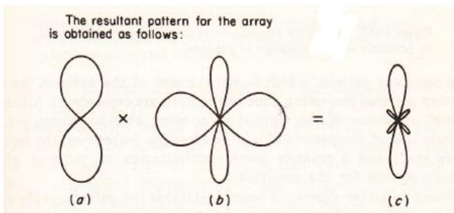
$$E_{nor} = \sin\left(\frac{\frac{2\pi}{\lambda} \times \frac{\lambda}{2}\cos\theta}{2}\right) = \sin\left(\frac{\pi}{2}\cos\theta\right)$$

27.Using pattern multiplication find the radiation pattern for the broadside array of 4 elements, spacing between each element is λ/2. (April/May 2017)









28.Draw the radiation pattern of an isotropic point sources of same amplitude and same phase that are λ/2 apart along X axis symmetric with respect to origin. (April/May 2017)

$$E_{nor} = \cos\left(\frac{\frac{2\pi}{\lambda} \times \frac{\lambda}{2}\cos\theta}{2}\right) = \cos\left(\frac{\pi}{2}\cos\theta\right)$$

<u>Calculation of maximum, minimum and half power direction of the field pattern:</u>

<u>Maxima directions</u>

Normalized total field is maximum when $\cos\left(\frac{\pi}{2}\cos\theta\right) = \pm 1$

$$\left(\frac{\pi}{2}\cos\theta_{max}\right) = \pm n\pi \quad where\ n = 0,1,2......$$

$$\left(\frac{\pi}{2}\cos\theta_{max}\right) = 0 \quad when\ n = 0$$

$$\theta_{max} = 90^0 \ \ and\ \ 270^0$$

The field is maximum in the directions where $\theta = 90^0 \ \ and\ \ 270^0$

Minima directions

Normalized total field is minimum when $\cos\left(\frac{\pi}{2}\cos\theta\right) = 0$

$$\left(\frac{\pi}{2}\cos\theta_{min}\right) = \pm(2n+1)\frac{\pi}{2} \quad where\ n = 0,1,2......$$

$$\left(\frac{\pi}{2}\cos\theta_{min}\right) = \pm\frac{\pi}{2} \quad when\ n = 0$$

$$(\cos\theta_{min}) = \pm 1$$

$$\theta_{min} = 0^0 \ \ and\ \ 180^0$$

The field is minimum in the directions where $\theta = 0^0 \ \ and\ \ 180^0$

Half Power Directions:

At half power points, power is half the maximum and voltage or current is $\frac{1}{\sqrt{2}}$ times the maximum.

Normalized total field is $\cos\left(\frac{\pi}{2}\cos\theta\right) = \pm\frac{1}{\sqrt{2}}$

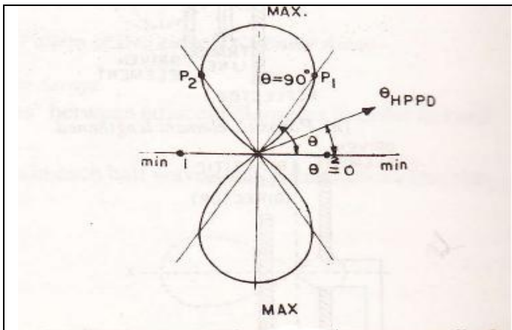
$$\left(\frac{\pi}{2}\cos\theta_{HPPD}\right) = \pm(2n+1)\frac{\pi}{4} \quad where\ n = 0,1,2......$$

$$\left(\frac{\pi}{2}\cos\theta_{HPPD}\right) = \pm\frac{\pi}{4} \quad when\ n = 0$$

$$(\cos\theta_{HPPD}) = \pm\frac{1}{2}$$

$$\theta_{HPPD} = 60^0 \ \ and\ \ 120^0$$

The field is $\frac{1}{\sqrt{2}}$ times the maximum in the directions where $\theta = 60^0 \ \ and\ \ 120^0$



(b). Field pattern of Fig. i.e. same amplitude and phase with $d = \lambda/2$.

29. What is the basic principle of antenna synthesis? (Nov/Dec 2016)

- Line source synthesis (Fourier transform, woodward-lanson sampling)
- Linear array synthesis (Fourier series, woodward-lanson sampling)
- Low sidelobe synthesis (Dolph-Chebyshev, Taylor)

30. State Huygen's principle. (Dec 2013)

Huygen's principle states that, 'each point on a primary wave front can be considered to be a new source of a secondary spherical wave and that a secondary wave front can be constructed as the envelope of these waves.

PART-B

1. (i) Write a note on binomial array?

(ii) Draw the pattern of 10 element binomial array with spacing between the elements of $3\lambda/4$ and $\lambda/2$. **(May 2013)**

Refer page no.193–John D Kraus "Antenna for All Applications"

2. Derive the expressions for field pattern of broad side array of *n* point sources. **(May 2013)**

Refer page no.178–John D Kraus "Antenna for All Applications"

3. Two identical radiators are spaced $d = 3\lambda/4$ meters apart and fed with currents of equal magnitude but with 180^0 phase difference. Evaluate the resultant radiation and identify the direction of maximum & minimum radiation. **(May 2015)**

Refer page no.165–John D Kraus "Antenna for All Applications"

5. Derive the expressions for field pattern of end-fire array of *n* sources of equal amplitude and spacing. **(May 2012)**

Refer page no.168–John D Kraus "Antenna for All Applications"

6. An antenna array consists of two identical isotropic radiators spaced by a distance of d= $\lambda/4$ meters and fed with currents of equal magnitude but with a phase difference β. Evaluate the resultant radiation for $\beta = 0^0$ and thereby identify the direction of maximum radiation. **(Dec 2011)**

Refer page no.172–John D Kraus "Antenna for All Applications"

7. Describe a broadside array. Deduce an expression for the radiation pattern of a broadside array with two point sources.
Refer page no.163–John D Kraus "Antenna for All Applications"

8. Plot the radiation pattern of a linear array of 4 isotropic elements spaced $\lambda/2$ apart and fed out of phase with

equal currents. Refer page no.176–John D Kraus "Antenna for All Applications"
9. (i) Derive Array factor of an Uniform linear array. Explain the significance of array factor. **(Dec 2013)** (ii) Compare End fire and Broadside array. **(May 2014)** Refer page no.165–John D Kraus "Antenna for All Applications"
10. Explain in detail about: 1) adaptive arrays 2) Phased arrays. Refer page no.152–John D Kraus "Antenna for All Applications"
11. Obtain the expression for the field and the radiation pattern produced by a N element array of infinitesimal with distance of separation $\lambda/2$ and currents of unequal magnitude and phase shift 180 degree. **(May 2016)** Refer page no.175–John D Kraus "Antenna for All Applications"
12. (i)Using pattern multiplication determine the radiation pattern for 8 element array separated by the distance $\lambda/2$. (ii) Write short notes on tapered array and phased array. **(May 2016)** Refer page no.152–John D Kraus "Antenna for All Applications"
13. Develop a treatise on the following forms of arrays: **(Nov/Dec 2015)** (i)Linear array (ii)Two-element array (iii)Uniform array (iv)Binomial array Refer page no.145–John D Kraus "Antenna for All Applications"
14. Derive and draw the radiation pattern of 4 isotropic sources of equal amplitude and same phase. **(April/May 2017) (Nov/Dec 2016)** Refer page no.156–John D Kraus "Antenna for All Applications"
15. (i) Describe the principle of phased arrays and explain how it is used in beam forming. **(April/May 2017) (Nov/Dec 2016)** (ii)Write short notes on binomial arrays. **(April/May 2017) (Nov/Dec 2016)** Refer page no.172–John D Kraus "Antenna for All Applications"

UNIT IV **SPECIAL ANTENNAS**
Principle of frequency independent antennas –Spiral antenna, Helical antenna, Log periodic. Modern antennas-Reconfigurable antenna, Active antenna, Dielectric antennas, Electronic band gap structure and applications, Antenna Measurements-Test Ranges, Measurement of Gain, Radiation pattern, Polarization, VSWR
PART – A
1. What is a resonant antenna? • Resonant antennas are those which correspond to a resonant transmission line that is an exact number of

half wave length long and is open at both ends.

- These are unterminated antennas and are used for fixed frequency operation.
- In resonant antennas standing wave exists. i.e, forward wave (incident wave) and backward wave (reflected wave) exists.
- The radiation patterns of resonant antenna are bidirectional due to incident and reflected waves.

2. Which antenna is suitable for extraterrestrial communication?

Helical antenna

3. Compare the radiation pattern of resonant and non-resonant antenna.

Resonant antenna - bidirectional radiation pattern

Non-resonant antenna – unidirectional radiation pattern

4. What is a non-resonant antenna?

- Non- resonant antennas are also called as travelling wave antenna.
- Non-resonant antenna corresponds to a transmission line that is excited at one end, terminated correctly at the other end.
- No reflected waves are produced and all the incident waves are absorbed.
- Waves travel only in one direction and hence only unidirectional radiation patterns are produced.

It is a wideband antenna and it is not sharply tuned to one frequency

5. What are the two modes of radiation of helical antenna?

(i) normal mode (ii) axial mode

6. What are the main advantages of indoor antenna measurements?

- Absence of electromagnetic interference (EMI)
- Protection of expensive equipments from environmental severities

7. What is LPDA?

LPDA is log periodic dipole array. It is unidirectional broadband, multi element, narrow beam, frequency independent antenna that has impedance and radiation characteristics that are regularly repetitive as a logarithmic function of frequency.

8. Mention the requirements of an Anechoic Chamber. (Dec 2013)

An Anechoic Chamber can be made reflection-free or echo-free by lining all the surfaces of the chamber with absorbing material. It can be made dust free and error free environment.

9. What is the antenna used for mobile and wireless hand set applications? Give reason.

Helical antenna operating in the normal mode is used for mobile and wireless hand set applications. A normal mode helical antenna is compact and has an Omni directional radiation pattern in the plane normal to the axis of the helix.

10. Write the difference between active and passive antenna.

Active antenna: Includes an antenna element and amplifiers. It is possible to use long cables and still maintain performance.

Passive antenna: Includes only an antenna element, no amplifiers. It is useful only for short runs of coaxial cable. Cable loss will deteriorate system performance.

11. Mention the applications of electronic band gap structure in antennas.

- The band gap feature of EBG structure has found useful application in suppressing the surface waves in microstrip antenna designs. Hence the antenna gain and efficiency are increased while the back lobes are reduced.
- EBG is used in microstrip antenna designs for size reduction and radiation pattern control.
- EBG structures are used to reduce the mutual coupling and eliminate scan angle in the microstrip antenna arrays.
- It is used to improve the performance of wire antennas, high gain antennas and slot antennas.

12. What is wide band antenna? Give an example.

Antennas which maintain certain required characteristics like gain, front to back ratio, SWR, Polarization input impedance and radiation pattern over wide range of frequencies are called wide band or broad band antennas. Log periodic antenna is a broadband antenna.

13. What are the drawbacks of outdoor antenna measurements?

- Susceptible to EMI
- Ground and other reflections Cannot be controlled fully
- They have uncontrolled environment

14. Sketch the radiation pattern of normal mode helical antenna.

Radiation is maximum in the direction normal to the helix axis.

15. Why is log periodic antennas called so? (Dec 2011)

It is an array antenna which has structural geometry such that its impedance is periodic with the logarithm of the frequency.

16. List out the applications helical antenna. (May 2010)

- Used for satellite and space communication.
- Used in radio astronomy.
- In the ballistic missiles and satellites used as telemetry links.

17. Mention the types of feed method for micro strip antenna? (May 2012) (May 2013)

Using (i) micro strip transmission line (ii) Coaxial transmission line

18. What are the special features of anechoic chamber? (Dec 2012)

- Used for indoor measurements.
- A closed chamber made reflection free or echo free by lining all the surfaces of the chamber with absorbing material.
- Main component of an anechoic chamber is the absorber.
- Absorbers are made in the form of pyramids or wedges. Absorbers have very low reflection coefficient over a wide range of frequency for normal incidence.

19. What do you meant by spiral antenna?

Spiral is a geometrical shape found in nature. A spiral can be geometrically described using polar coordinates. Let (r,θ) be a point in the polar coordinate system. The equation $r = r_o e^{a\theta}$, where, r_o and 'a' are positive constants, describes a curve known as a logarithmic spiral or an equiangular spiral.

20. Which antenna is used for VHF communication? (Dec2012)

Helical antenna

21. Why frequency independent antennas are called so? (May 2014)

An antenna in which the impedance, radiation pattern and directivity remain constant as a function of frequency is called as frequency independent antenna. Eg; Spiral antenna.

22. Mention the advantages of reconfigurable antenna.

- Ability to support more than one wireless standard: good isolation between different wireless standards.
- Lower front end processing: no need for front end filtering and good out-of-band rejection.
- Act as a single element or as an array.
- Provide narrow band or wideband operation.

23. State Rumsey principle on frequency independence.(May 2016) (April/May 2017) (Nov/Dec 2016)

Rumsey's principle is that the impedance and radiation pattern properties of an antenna will be frequency independent if the antenna shape is specified only in terms of angles.

Example: Planar log spiral antenna

24. What is reconfigurable antenna?

Reconfigurable antenna has the ability to radiate more than one pattern at different frequencies and polarizations. It is the only solution for increased functionality of the antenna (direction finding, beam steering and Radiation pattern control)

25. List the different ranges of antenna measurements.

The ranges used for antenna parameter measurements: Outdoor range, Indoor range, Reflection range, Slant range, Elevated range, Compact range, Near field range, Ground range and Radar cross section range.

26. Why antenna measurements are usually done in Fraunhofer zone? (May 2016)

Antenna measurements are usually done in Fraunhofer zone, because,

- The far field region(Fraunhofer zone) determines the antenna's radiation pattern.
- The radiation pattern does not change shape with distance (although the field still die off as $1/r$) and this region is dominated by radiated fields, with the E-field and H-field orthogonal to each other and the direction of propagation.

Also, antennas are used to communicate wirelessly over long distances.

28. Compare and contrast wedges and pyramids. (Nov/Dec 2016)

Wedge Shaped RF Absorber

- The Wedge RF Absorber is designed primarily for use in chambers where RF energy is directed in a particular path such as energy propagation along a tapered chamber where the energy is directed to conventional pyramidal absorber on the back wall.

- A feature of the Wedge RF Absorber is that its reflectivity performance at normal or near normal angles of incidence is similar or close to the standard RF absorber products.

- However its wedge shape does make the product sensitive to polarisation. Consequently, the reflectivity values of Wedge RF absorber are 2 to 4 dB less than the equivalent depth Pyramidal RF Absorber.

Pyramidal Shaped RF Absorber

- This is the most widely used absorber product and is generally found in Anechoic Chambers and in Free Space Chambers used for Antenna Pattern Measurements (APM) and Radar Cross Section (RCS) measurements etc. Larger absorbers are also used in some EMC chambers.

- The pyramidal shape produces an impedance gradient which results in high performance / reflectivity levels in Anechoic Chambers at both normal and off-normal angles of incidence.

29. Design a 3 element Yagi-Uda antenna to operate at a frequency of 200 MHz. (May 2013)

Length of driven element $= \frac{478}{f_{MHz}} = \frac{478}{200} = 2.39\ feet$

Length of reflector $= \frac{492}{f_{MHz}} = \frac{492}{200} = 2.46\ feet$

Length of director $= \frac{461.5}{f_{MHz}} = \frac{461.5}{200} = 2.31\ feet$

Element spacing $= \frac{142}{f_{MHz}} = \frac{142}{200} = 0.71\ feet$

30. Why frequency independent antennas are called so? (May 2014)

An antenna in which the impedance, radiation pattern and directivity remain constant as a function of frequency is called as frequency independent antenna. Eg; Log Periodic antenna

PART B

1. What is the importance of Helical antenna? Explain the construction and operation of Helical antenna with neat sketch. Highlight some of its applications. **(May 2015) (May 2014) (May 2013) (Dec 2012) (Nov/Dec 2016)**

Refer page no.362–John D Kraus "Antenna for All Applications"

2. With neat block diagram explain how Radiation pattern and Gain of an antenna can be measured. **(May 2013, Dec 2013) (Nov/Dec 2016)**Refer page no.331–John D Kraus "Antenna for All Applications"

3. Explain the principle of operation of Log periodic antenna with neat schematic diagram. **(May 2015) (Nov/Dec 2015) (Nov/Dec 2016)**

Refer page no.348–John D Kraus "Antenna for All Applications"

4. Discuss in detail how a spiral antenna behaves as a frequency independent antenna. (**May 2014)**

Refer page no.396–John D Kraus "Antenna for All Applications"

5. (i) How is VSWR measured? Explain. **(May 2014)**

(ii) With suitable geometry describe the Radiation pattern.

Refer page no.387–John D Kraus "Antenna for All Applications"

6. Explain in detail about (i) Polarization measurement (ii) Gain Measurement **(May 2012, May 2014)**

Refer page no.389–John D Kraus "Antenna for All Applications"

9. Write notes on: (i) Reconfigurable antenna (ii) Electronic band gap (iii) Active antenna.

Refer page no.391–John D Kraus "Antenna for All Applications"

11. (i) Explain the design procedure for the construction of log periodic antenna.

Refer page no.362–John D Kraus "Antenna for All Applications"

(ii) Discuss the construction equation for the helical antenna. **(May 2016)**

Refer page no.348–John D Kraus "Antenna for All Applications"**13.** With a neat sketch design a quad-helix earth station antenna. Calculate the directivity and the effective aperture. **(Nov/Dec 2015)**

Refer page no.371–John D Kraus "Antenna for All Applications"

14. Describe the procedure for the measurement of i) Antenna gain ii) VSWR. **(May 2011)**

Refer page no.387–John D Kraus "Antenna for All Applications"

15. Design a log periodic dipole antenna to cover all the VHF TV channels from 55 MHz to 220 MHz. The required directivity is 9 dB and input impedance is 50 Ohms. The elements should be made of aluminium tubing with 2.0 cm outside diameters for the largest element and the feeder line and 0.48 cm for the smallest element. These diameters yield identical (l/d) ratios for smallest and largest elements. **(April/May 2017)**

Refer page no.387–John D Kraus "Antenna for All Applications"

16. (i) Show the experimental setup for measuring the unknown load impedance using VSWR method and explain. **(April/May 2017)**

Refer page no.389–John D Kraus "Antenna for All Applications"

(ii) Explain the concept of electronic band gap structure and give any four applications of EBG. **(April/May 2017)**

Refer page no.375–John D Kraus "Antenna for All Applications"

17. Explain in detail about log periodic antennas. What is the need for feeding from end with shorter dipoles and the need for transposing the lines? Also discuss the effects of decreasing α. **(Nov/Dec 2016)**

Refer page no.362–John D Kraus "Antenna for All Applications"

UNIT V PROPAGATION OF RADIO WAVES

Modes of propagation , Structure of atmosphere , Ground wave propagation , Tropospheric propagation , Duct propagation, Troposcatter propagation , Flat earth and Curved earth concept Sky wave propagation – Virtual height, critical frequency , Maximum usable frequency – Skip distance, Fading , Multi hop propagation

PART – A

1. What is radio horizon and optical horizon?

- Radio horizon is the range by which a direct ray from transmitting antenna reaches receiving antenna.
- Optical horizon is the distance over which Tx antenna optically 'see' the Rx antenna.

Radio horizon is about 4/3 times the optical horizon.

2. What is meant by wave tilt in ground wave propagation?

The ground or surface wave will be attenuated due to ground attenuation i.e. due to diffraction and tilt in the wave front. As the wave progress over the curvature of the earth, the wave front starts gradually tilting more and more. This increase in the tilt of wave causes more short circuit of the electric field component and hence the field strength goes on reducing, ultimately at some appreciable distance from the transmitting antenna, the surface wave dies because of the losses.

3. Give the salient features of ground wave propagation.

The ground wave propagation is due to ground wave, which is guided along the surface of the earth.

The waves must be vertically polarized to prevent short-circuiting of electric component. Since the earth's attenuation increases with increase of frequency, ground wave propagation is limited up to 2MHz only.

4. What is gyro frequency? What is its significance in sky wave propagation? (Dec 2013)

In ionospheric layer the vibration of electron will make a path of very narrow ellipse due to the smaller amplitude of vibration. The tendency continues until the frequency is lowered to a point at which cyclotron resonance occurs. The electrons then will follow a spiral path of steadily increasing radius along which the velocity also increases. This occurs at 1400 KHz and is termed as Gyro frequency.

5. What is troposcatter propagation?

Forward scatter propagation or simply scatter propagation is of practical importance at VHF, UHF and microwaves. UHF and microwave signals were found to be propagated much beyond the line of sight propagation through the forward scattering due to tropospheric irregularities. It uses certain properties of troposphere and is also known as troposcatter.

6. What is duct propagation? (Nov/Dec 2016)

The ground surface and atmospheric layer form a duct or sort of "leaky wave guide" which guides the electromagnetic wave between its walls. When frequency is high, the region where the refractive index is usually high, traps the energy and causes it to travel along the earth surface as happens in a wave-guide. This type of propagation is called duct propagation. It also referred to as super refraction.

7. Write down the Sommer field equation for ground wave field strength.

$$E_g = \frac{AE_0}{r}$$

$E_g = ground\ wave\ field\,strength$

$E_0 = Field\ strength\ at\,unit\ dis\tan ce\ \ from Tx\,antenna\ neglecting\,earth's\ losses$

$r = Dis\tan ce\ of\ the\ point\ \ from\,Tx\ antenna\ and\ A = Attenuation\ factor$

8. What is skip distance and maximum usable frequency? (Dec 2012)

- Skip distance is the minimum distance from the transmitter at which a sky wave of given frequency is returned to earth by the ionosphere.

The frequency which makes a given distance corresponds to the skip distance is the MUF for those two points.

9. What is magneto-ionic splitting?

The earth magnetic field splits up the incident radio waves into two components of the ordinary and the extraordinary waves. The waves have elliptical polarization and rotate in opposite direction. They have different energy absorption and velocities. The phenomenon of splitting of wave into two different components by the earth's magnetic field is called as magneto-ionic splitting.

10. Why is diversity reception necessary?

Due to the general fading, there is a considerable variation in the strength of short wave signals received by common receivers through ionosphere. The diversity receiving systems provide a high and intelligible level of received signals at all times.

11. Give the salient features of E layer.

(i) Height of E layer is 90 to 140km above the earth's surface
(ii) Ionization is by X rays radiation
(iii) During night E layer is weakly ionized
(iv) Maximum electron density is at 110km and have the value 4×10^5 /cc

(v) Critical frequency is about 3MHz to 5MHz
(vi) E layer is most useful for long distance radio propagation during day hours and
(vii) The main function of E layer is to reflect some HF waves in day hours

12. Define critical frequency. (April/May 2017)

The highest frequency of wave that will be reflected from a given layer is known as critical frequency of the given layer.

$$f_c = 9\sqrt{N_m} \quad where\ N_m\ is\ \max imum\ electron\ density$$

13. What are the effects of ground on low frequency wave transmission? (May 2014)

The ground wave (or surface wave) is a wave that is guided along the surface of the earth. Earth attenuation is low for low frequency wave transmission.

14. How are critical frequency and maximum usable frequency related?

The maximum usable frequency and critical frequency can be related by the equation of

$$f_{MUF} = f_c\left(1+\frac{D^2}{4h^2}\right)^{\frac{1}{2}}$$

Where f_{MUF} = Maximum usable frequency

f_c = Critical frequency

D = Propagation distance, h = Height of the ionosphere layer

15. What is optimum working frequency? (Dec2012) (May 2015)

The frequency normally used for ionospheric transmission is known as the optimum working frequency. It is chosen to be about 85% of MUF. It is also known as optimum Traffic frequency.

16. State secant law.

$$f_{muf} = f_c \sec i \Rightarrow SecantLaw$$
$$f_{muf} = \max imum\ usable\ \ frequency$$
$$f_c = critical\ \ frequency$$
$$i = angle\ of\ \ vertical\ incidence$$

17. What are the causes for abnormalities in the ionosphere.

Sudden ionospheric disturbances, Ionospheric storms, Sun spot cycle, Tides and winds in the Ionosphere, Fading, Whistles, Ionospheric Cross-modulation, Atmospheric Noise

18. What is free space loss factor? (Dec 2013)

The factor $[\lambda/(4\pi R)]^2$ is called free space loss factor where λ is the wavelength and R is the distance between transmitting and receiving antenna. This factor is due to the propagation. It represents the attenuation of the signal due to the spreading of the power as a function of distance.

19. Give any four factors that influence radio wave propagation.

1) Earth's characteristics 2) Frequency of operation 3) Height of transmitting antenna 4) Polarization of transmitting antenna

20. Find the maximum distance that can be covered by a space wave, when the antenna heights are 60m

and 120m. (May 2013) (Nov/Dec 2015)

$$d_{max} = \sqrt{17h_t} + \sqrt{17h_r}$$
$$d_{max} = \sqrt{17 \times 120} + \sqrt{17 \times 60} \quad km$$

=77.1 km

21. Differentiate Virtual height from actual height. (May 2014)

Virtual height is defined as the height to which a short pulse of energy sent vertically upward and travelling with the speed of light would reach taking the same two ways travel time as does the actual pulse reflected from the layer

22. What is meant by Faraday rotation? (Dec 2011) (May 2015)

Rotation of the plane of polarization is defined as Faraday rotation. It is also defined as the process of rotation of polarization ellipse of EM wave in a magneto-ionic medium. This process occurs in the ionospheric regions when a plane wave enters the ionosphere.

It is a variable effect and leads to loss of signal power at the receiving antenna due to polarization mismatch.

23. How the virtual height of ionosphere can be measured?

- Virtual height can be measured using ionosonde.
- Ionosonde is the instrument used to measure the virtual height of the ionosphere. This instrument transmits an RF pulse vertically in to the ionosphere from the ground. This pulse is reflected from the ionosphere and is received by the ionosonde.

The time delay between the transmitted and the received pulse is measured which is a measure of the virtual height of the ionosphere.

24. What is Fading? And how it is compensated? (May 2013)

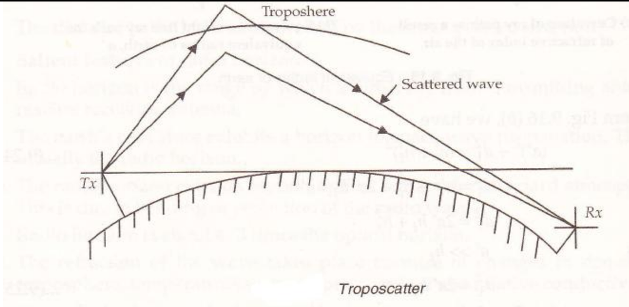
Fading is the change in signal strength at the receiver due to variation in ionospheric conditions and Multipath reception. Fading due to rapid fluctuations can be reduced by diversity reception techniques. The commonly employed diversity reception techniques are: Frequency diversity, Space diversity, polarization diversity and Time diversity.

25. Find the range of LOS system when the receive and transmit antenna heights are 10m and 100m respectively. (May 2016)

$$d_{max} = (\sqrt{17h_t} + \sqrt{17h_r})\, km$$
$$d_{max} = \left(\sqrt{17 \times 10} + \sqrt{17 \times 100}\right) km \quad = 54.27\, km$$

26. What are the features of troposcatter propagation? (May 2016)

- Referred to as Forward scatter propagation or simply scatter propagation
- of practical importance at VHF,UHF and microwave frequencies
- Signals propagate much beyond LOS distance
- atmospheric air turbulence, irregularities in the refractive index divert a small fraction of the transmitted radio energy toward a receiving station



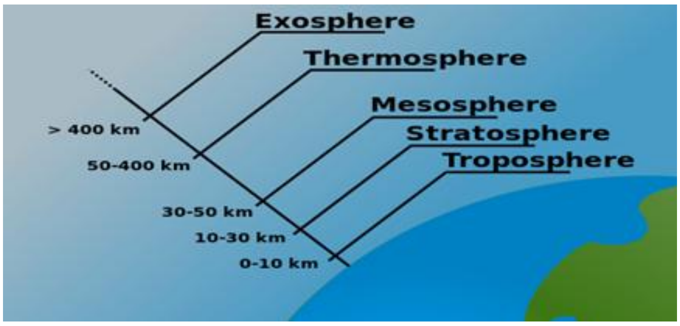
27. A HF radio link is established for a range of 2000 Km. If the reflection region of the ionosphere is at a height of 200 Km and has f_C of 6MHz, calculate MUF. (Nov/Dec 2015)

$$f_{MUF} = f_c\sqrt{1+\left(\frac{D}{2h}\right)^2} = 6\times10^6\sqrt{1+\left(\frac{2000}{2\times200}\right)^2} = 6\times10^6\sqrt{26} = 30.54\text{ MHz}$$

28. Mention the important characteristics of D layer.

(i) Height of D layer is 50 to 90 km above the earth surface
(ii) Ionized by photo ionization of O_2 molecules
(iii) Present in day time only
(iv) Has a ionic density of 400/cc and electron density is maximum at noon
(v) Reflects very low frequency (VLF) and low frequency (LF) wave
(vi) High frequency communication is not possible via D layer and
(vii) Critical frequency is about 100kHz at vertical incidence

29. Draw the various layers of atmospheric structure. (April/May 2017)



Note:

The ionosphere is not a distinct layer like the others mentioned above. Instead, the ionosphere is a series of regions in parts of the mesosphere and thermosphere where high-energy radiation from the Sun has knocked electrons loose from their parent atoms and molecules. The electrically charged atoms and molecules that are formed in this way are called ions, giving the ionosphere its name and endowing this region with some special properties.

30. Find the critical frequency of an ionosphere layer which has an electron density of $1.24\text{x}10^8$ cm^{-3}. (Nov/Dec 2016)

$$f_{cr} = \sqrt{81N_{max}} = \sqrt{81X1.24X10^8} = 100.219\ KHz$$

PART B

1. (i) Describe the Troposcatter propagation. (ii) Explain the effect of Earth's magnetic field on EM wave propagation. **(May 2015) (May 2013)** (Refer Page no 687 .Electromagnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
2. Describe the theory of propagation of EM wave through the ionosphere in the presence of external magnetic field and show that the medium acts as doubly refracting crystal. **(May 2013)** (Refer Page no 698. Electromagnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
3. (i) Explain the mechanism of tropospheric propagation. **(May 2015)** (ii) Why do we use high frequency waves in sky wave propagation? Explain the mechanism of propagation. **(Dec 2012)** (Refer Page no 710. Electromagnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
4. i) Describe the troposphere and explain how ducts can be used for microwave propagation. (ii)Explain the terms: MUF, Skip distance, Virtual height, Duct propagation, fading. **(May 2015) (Dec 2012) (Dec 2011)** (Refer Page no 561. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
5. Explain in detail about ground wave propagation and its different mechanisms with their characteristics. **(May 2012)** (Refer Page no 781. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
8. Derive the expression for refractive index of the ionosphere neglecting earth's magnetic field effects. (Refer Page no 721. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
9. (i) Describe the space wave propagation and explain the importance of line of sight propagation. (ii) Explain the following terms with diagram: (1) Super Refraction (2) Critical frequency (3) Skip Zone **(May 2014)** (Refer Page no 654. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
10. (i) Discuss the factors that are involved in the propagation of radio waves. (ii) Draw a 2 ray model of Sky wave propagation and explain it in detail. **(Dec 2013)** (Refer Page no 734. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
11.(i) In the ionospheric propagation, consider that the reflection takes place at a height of 400 km and the maximum density in the ionosphere corresponds to a refractive index of 10 MHz. determine the ground range for which this frequency if the MUF. Take earth's curvature in to consideration. (Refer Page no 721. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
12. (i) Disucss the effect of the earth's magnetic field on ionosphere radio wave propagation. (ii)Describe the troposphere and explain how ducts can be used for microwave propagation.**(May 2016)** (Refer Page no 784. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)

15. Explain how the EM waves are propagated in troposphere layer and discuss the principle of troposcatter propagation. **(April/May 2017**
16. (i) Explain the effect of EM waves in curved earth and flat earth configuration. **(April/May 2017)** (Refer Page no 598. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
17. Draw the electron density profile chart of an ionosphere and explain. Also derive an expression for the effective relative dielectric constant of the ionosphere. Explain about reflection and refraction of waves in ionosphere. **(Nov/Dec 2016)** (Refer Page no 569. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
18. (i) Explain the attenuation characteristics for ground wave propagation. **(8)** (Refer Page no 719. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)
(ii) Explain LOS propagation and troposcatter propagation. **(8)** **(Nov/Dec 2016)** (Refer Page no 786. Electro magnetic waves and radiating Systems .By. C.JORDAN and G.BALMAIN)

COURSE DELIVERY PLAN-THEORY

Faculty Name :B. ARUN VIJAYAKUMAR	**Programme/Branch: BE/ECE**
Academic Year:2017-2018	**Year/Semester/Batch:III/VI/2015-2019**
Subject Code/Subject Name:EC6602/AWP	**Regulation:2013**

A. Details of the relevant POs & PSOs supported by the course	
PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and electronics 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 sciences, 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.
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	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PSO I	Competence in using modern electronic tools in hardware and software co-design for networking and communication applications.
PSO II	Promote excellence in professional career and higher education by gaining knowledge in the field of Electronics and Communication Engineering
PSO III	Understand social needs and environmental concerns with ethical responsibility to become a successful professional.

B. Details of COs Mapping with PO/PSOs identified for the course

Course Outcome	Course Description	Program Outcomes/Program Specific Outcome														
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C313.1	**Explain** the fundamentals of radiation parameters of antenna	3	3	3	2	2	1	1	-	-	2	1	3	3	3	2
C313.2	**Analyze** various aperture antennas	3	3	3	2	2	2	1	-	-	1	1	2	3	3	2
C313.3	**Design** the antenna arrays	3	2	3	2	2	1	1	-	-	1	1	1	3	3	1
C313.4	**Recognize** the radiation characteristics of special antennas	3	2	2	2	2	1	1	-	-	1	1	1	3	3	2
C313.5	**Discuss** the mechanisms of atmospheric effects on the radio wave propagation	3	3	3	2	2	2	1	-	-	1	1	2	3	3	2

C. Syllabus of the course

UNIT I FUNDAMENTALS OF RADIATION

Definition of antenna parameters – Gain, Directivity, Effective aperture, Radiation Resistance, Band width, Beam width, Input Impedance. Matching – Baluns, Polarization mismatch, Antenna noise temperature, Radiation from oscillating dipole, Half wave dipole. Folded dipole, Yagi array.

UNIT II APERTURE AND SLOT ANTENNAS

Radiation from rectangular apertures, Uniform and Tapered aperture, Horn antenna , Reflector antenna , Aperture blockage , Feeding structures , Slot antennas , Microstrip antennas – Radiation mechanism – Application ,Numerical tool for antenna analysis

UNIT III ANTENNA ARRAYS

N element linear array, Pattern multiplication, Broadside and End fire array – Concept of Phased arrays, Adaptive array, Basic principle of antenna Synthesis-Binomial array

UNIT IV SPECIAL ANTENNAS

Principle of frequency independent antennas –Spiral antenna, Helical antenna, Log periodic. Modern antennas-Reconfigurable antenna, Active antenna, Dielectric antennas, Electronic band gap structure and applications, Antenna Measurements-Test Ranges, Measurement of Gain, Radiation pattern, Polarization, VSWR

UNIT V PROPAGATION OF RADIO WAVES

Modes of propagation , Structure of atmosphere , Ground wave propagation , Tropospheric propagation , Duct propagation, Troposcatter propagation , Flat earth and Curved earth concept Sky wave propagation – Virtual height, critical frequency , Maximum usable frequency – Skip distance, Fading , Multi hop propagation.

D. Content Beyond Syllabus:

1. FIFA Antenna
2. Loop Antenna

F. Delivery Resources:

Text Book(s):

T1: John D Kraus,” Antennas for all Applications”, 3rd Edition, Mc Graw Hill, 2005.

Reference Book(s):

R1: Edward C.Jordan and Keith G.Balmain” Electromagnetic Waves and Radiating Systems” Prentice Hall of India, 2006

R2: R.E.Collin,”Antennas and Radiowave Propagation”, Mc Graw Hill 1985.

R3: Constantine.A.Balanis “Antenna Theory Analysis and Design”, Wiley Student Edition, 2006.

R4: John J.D’Azzo & Constantine H.Houpis, “Linear Control System Analysis and Design“”, Tata Mc Graw-Hill, Inc., 1995.

R5: H.Sizun “Radio Wave Propagation for Telecommunication Applications”, First Indian Reprint, Springer Publications, 2007

On line learning materials (and Others if any):

1. nptel.ac.in/courses/112105126/21