K.S.R. COLLEGE OF ENGINEERING (Autonomous)

SEMESTER - VI

16EC611	ANTENNA AND WAVE PROPAGATION	L	T	P	C
Objective(s):		3	0	0	3

- *To gain knowledge about antenna fundamentals and radiation properties.*
- *To understand the concept of antenna arrays and special antennas*
- *To learn the various radio wave propagation.*

UNIT – I ELECTROMAGNETIC RADIATION AND ANTENNA FUNDAMENTALS09 Hrs

Review of electromagnetic theory: Vector potential -Retarded case - Hertizian dipole - Half-wave dipole - Quarter-wave monopole - Antenna characteristics: Radiation pattern - Beam solid angle - Directivity- Gain - Input impedance - Polarization - Bandwidth - Reciprocity - Effective aperture -Effective length - Antenna temperature.

UNIT – II ANTENNA ARRAYS 09 Hrs

Expression for electric field from two, three and N element arrays - Linear arrays: Broad-side array and End-fire array - Method of pattern multiplication - Binomial array - Phased arrays, Frequency scanning arrays - Adaptive arrays.

UNIT - III ANTENNA TYPES 09 Hrs

Loop antennas: Radiation from small loop and its radiation resistance -Helical antenna: Normal mode and axial mode operation-Yagiuda antenna- Log periodic antenna – Rhombic antenna- Horn antenna- Reflector antennas and their feed systems - Micro strip antenna.

UNIT – IV SPECIAL ANTENNAS AND ANTENNA MEASUREMENTS 09Hrs Antenna for special applications: Antenna for terrestrial mobile communication systems - GPR - Embedded antennas - UWB - Plasma antenna - Smart antennas. Antenna measurements: Radiation pattern, Gain, Directivity, Polarization, Impedance, Efficiency.

UNIT – V WAVE PROPAGATION 09 Hrs

Ground wave propagation: Attenuation characteristics - Calculation of field strength- Space wave propagation: Reflection from ground for vertically and horizontally polarized waves - Reflection characteristics of earth- Resultant of direct and reflected ray at the receiver- Duct propagation - Sky wave propagation: Structure of the ionosphere- Effective dielectric constant of ionized region- Mechanism of refraction- Refractive index- Critical frequency- Skip distance-Maximum usable frequency - Fading - Diversity reception.

Total hours: 45

Text Books:

1. Prasad K. D "Antennas and Wave Propagation"- Tech India Publications, 2009.
2. John D Kraus and Ronalatory Marhefka, Ahmed S Khan "Antennas and Wave Propagation "Tata McGraw-Hill Book Company 4thEdition, Reprint 2010.

References:

1. Ballanis "Antenna Theory" John Wiley & Sons 3rd Edition 2012
2. E.C.Jordan and Balmain"Electro Magnetic Waves and Radiating Systems" PHI Reprint 2003.
3. R.E.Collins 'Antennas and Radio Propagation "McGraw-Hill 1987.
4. D.Ganeshrao, B.Somanathan Nair, Deepa Reghunath "Antennas and Radio-Wave Propagation" Sanguine technical publishers Ist Edition, 2007

K.S.R. COLLEGE OF ENGINEERING (Autonomous), TIRUCHENGODE – 637 215
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE / LESSON PLAN SCHEDULE

NAME : R.SATHEESKUMAR **Class: III-ECE (A, B SECTION)**
SUBJECT: 16EC611 - ANTENNA AND WAVE PROPAGATION
TEXTBOOKS:

1. Prasad K. D "Antennas and Wave Propagation"- Tech India Publications, 2009.
2. John D Kraus and Ronalatory Marhefka, Ahmed S Khan "Antennas and Wave Propagation "Tata McGraw-Hill Book Company 4thEdition, Reprint 2010.

REFERENCES:

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C). LEGEND:

L	-	Lecture	BB	-	Black Board
Tx	-	Text	OHP	-	Over Head Projector
pp	-	Pages	Rx	-	Reference

Sl. No.	Lecture Hour	Topics to be covered	Teaching Aid Required	Book No. / Page No.
UNIT-I ELECTROMAGNETIC RADIATION AND ANTENNA FUNDAMENTALS				
1.	L 1	Review of electromagnetic theory, Vector potential, Retarded case	BB	Tx 1/pp 274-277, 415-416, Rx 2/pp90, Rx 4/pp349
2.	L 2	Hertizian dipole	OHP	Tx 1/pp 423-438, Rx 2/pp 321, Tx2/pp 70 - 85
3.	L 3	Half-wave dipole antenna, quarter wave and Monopole antenna.	BB	Tx 1/pp 452-461, Rx 1/pp 162, Tx 2/pp 157
4.	L 4	Antenna characteristics: Radiation pattern, Beam solid angle, Directivity, Gain	BB	Tx 1/pp530-534,536,544-548,539,572-574, Tx 2/pp 09-23, Rx 1/pp28,39,58
5.	L 5	Input impedance, Polarization, Bandwidth,	BB	Tx 1/pp578, 572-574, Rx 1/pp 73,64, Tx 2/pp 447,48
6.	L 6	Reciprocity	BB	Tx 1/pp 556-559, Tx 2/pp 259,655, Rx 1/pp 63,127
7.	L 7	Effective aperture	BB	Tx 1/pp 548 – 553, Rx 1/pp 81-84, Rx 2/pp 44, 517
8.	L 8	Effective length, Antenna temperature.	BB	Tx 1/pp 554-556, 579-582, Rx 2/pp518, Tx 2/pp 25 – 30,44 – 45
9.	L 9	**Beam width** ,Problems	BB	**Tx 1/pp 574, Rx 4/pp 13**
UNIT-II ANTENNA ARRAYS				
10.	L 10, L 11	Expression for electric field from two ,three and N element arrays	BB	Tx 1/pp 606-611,614-626, Tx 2/pp 100-107,115-121, Rx 1/pp 250-266
11.	L 12, L 13	Linear Array :Broad side & End fire array	BB	Tx 1/pp 602-604, Rx 1/pp 262-266, Rx 4/pp 89-92

12.	L 14	Method of Pattern Multiplication	BB	Tx 1/pp 611-614, Rx 1/pp 151-153, Rx 4/pp 99
13.	L 15	Binomial Array	BB	Tx 1/pp 635-637, Rx 1/pp 290-294
14.	L 16	Phased arrays	BB	Tx 1/pp 626, Tx 2/pp 216-220
15.	L 17	Frequency scanning arrays, Adaptive arrays	BB	Tx 2/pp 221-227
16.	L 18	**Stacked array,** Problems	BB	**Tx 1/pp 650, Tx 2/pp 442**
UNIT-III ANTENNA TYPES				
17.	L 19	Loop antenna:-Radiation from small loop and its radiation resistance	BB	Tx 1/pp 718 – 740, Tx 2/pp 248 – 257, Rx 1/pp 204-210
18.	L 20	Helical Antenna: Normal mode ,Axial mode operation	BB	Tx 1/pp 791 -796, Rx 1/pp 505-512, Tx 2/pp 297, Rx 4/pp 182
19.	L 21	Yagi-Uda Antenna	BB	Tx 1/pp 777-781, Rx 1/pp 513-533
20.	L 22	Log periodic Antenna	BB	Tx 1/pp 822-828, Tx 2/pp 435-440, Rx 1/pp 542-566
21.	L 23	Rhombic Antenna	BB	Tx 1/pp 710-716, Rx 1/pp 502-505
22.	L 24	Horn Antenna	BB	Tx 1/pp 797-799, Rx 1/pp 651-696, Tx 2/pp 283-294
23.	L 25	Reflector Antennas and their feed systems	BB	Tx 1/pp 829-839, Rx 1/pp 785-830
24.	L 26	Micro strip antenna	BB	Tx 1/ pp 809-810, Rx 1/pp 722-726, Tx 2/pp 500-512
25.	L 27	**Lens Antenna,** Problems	BB	**Tx 1/pp 839, Rx 1/pp 7**
UNIT-IV SPECIAL ANTENNAS AND ANTENNA MEASUREMENTS				
26.	L 28	Antenna for special application: Antenna for terrestrial mobile communication systems, GPR	BB	Tx 2/pp 584, Rx 4/pp 227-231, Rx 1/pp 175,242
27.	L 29	Embedded antennas	BB	Tx 2/pp 586, Rx 4/pp 233
28.	L 30	UWB, Plasma antenna	BB	Tx 2/pp 586-590, Rx 4/pp 233-235
29.	L 31	Smart antenna	BB	Tx 2/pp 224-227,
30.	L 32	Antenna measurements: Radiation pattern	BB	Tx 1/pp 848-851
31.	L 33	Gain and Directivity Measurements	BB	Tx 1/pp 852-855,859, Tx 2/pp 738-744
32.	L 34	Polarization	BB	Tx 1/pp 859-860, Tx 2/pp 744-746
33.	L 35	Impedance, Efficiency	BB	Tx 1/pp 845-848,857-859, Tx 2/pp 746-753
34.	L 36	**Turnstile Antenna,** Problems	BB	**Tx 1/pp 811, Tx 2/pp 534**
UNIT-V WAVE PROPAGATION				
35.	L 37	Ground wave propagation: Attenuation characteristics, Calculation of field strength	BB	Tx 1/pp 1107-1110, Tx 2/pp 782

36.	L 38	Space Wave Propagation: Reflection from ground for vertically and horizontally polarized waves	BB	Tx 1/pp 1152-1157, Tx 2/pp 799-803
37.	L 39	Reflection characteristics of earth- Resultant of direct and reflected ray at the receiver	BB	Tx 1/pp 1157-1159, Tx 2/pp 803-813
38.	L 40	Duct propagation	BB	Tx 1/pp 1160-1162, Rx 4/pp 271-276
39.	L 41	Sky wave propagation: Structure of the ionosphere	BB	Tx 1/pp 1112,1115-1116, Tx 2/pp 815-816
40.	L 42	Effective dielectric constant of ionized region, Mechanism of refraction	OHP	Tx 1/pp 1117-1119,1121, Tx 2/pp 816-822
41.	L 43	Refractive index, Critical frequency, Skip distance, Maximum usable frequency	BB	Tx 1/pp 1119-1121,1122-1123,1144-1145,1139-1143, Tx 2/pp822-828
42.	L 44	Fading, Diversity reception.	BB	Tx 1/pp 1147-1148, Tx 2/pp 812-813, Rx 4/pp 324
43.	L 45	**Whistlers,** Problems	BB	**Tx 1/pp 1149, Rx 4/pp 320**

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
16EC611 ANTENNA & WAVE PROPAGATION
QUESTION BANK

UNIT-I (CO1)
ELECTROMAGNETIC RADIATION AND ANTENNA FUNDAMENTALS

1. **Define an antenna. (Remembering)**
Antenna is a transition device or a transducer between a guided wave and a free space wave or vice versa. Antenna is also said to be an impedance transforming device.
2. **What is vector potential? State the expression for vector potential for time varying field. (Remembering)**
The vector potential is a quantity with magnitude and a direction. This is useful to find the magnetic flux density B and intensity H.
The vector potential can be expressed as,
$$A = \frac{\mu}{4\pi}\int \frac{Idl}{r}$$
Where, μ = Permeability
Idl = current element
r = distance between point "P" to the current element
3. **What are retarded Vector potentials?Give its expression. (Remembering) (AU-June 2014) (AUT-June 2015)**
There is a finite time delay for propagation of an electromagnetic wave from a source point to the observation point.The effect of this propagation delay is introduced in vector and scalar potentials by simply substituting the time variable 't' by a variable {t-r/c}.The potentials at the observation point are delayed or retarded by this time delay are known as retarded potentials.
The expression for retarded vector potential is,
$$[A] = \frac{\mu}{4\pi}\int \frac{J(t-r/c)}{r} dv$$
4. **What do you understand by retarded current? (Remembering)**
Since, the short electric dipole is so short, the current which is flowing through the dipole is assumed to be constant throughout its length. The effect of this current is not felt instantaneous at a distance point but only after an interval equal to the time required for the wave to propagate over the distance "r" is called the retardation time.
5. **Show an expression for retarded current. (Understanding)**
$[I]=I_m \sin\omega[t-r/c]$
Where r =distance travelled
c=velocity of propagation
[I]=Retarded current and the bracket indicate that it is retarded current
t-r/c=retarded time as phase of the wave at point P is retarded with respect to the phase of the current in the element by an angle ωr/c.
6. **Define retardation time?(Remembering)**
It is the time for the wave to propagate over the distance r. It is given by r/c.
7. **What are wire antennas and give its applications? (Remembering)**
Dipole antenna, loop antenna, helix antenna are some of the wire antennas, It can be used on automobiles, buildings, ships, aircrafts, spacecraft etc...
8. **What is a Short Dipole? (Remembering)**
A short dipole is one in which the field is oscillating because of the oscillating voltage and current. It is called so because, the length of the dipole is short and the current is almost constant throughout the entire length of the dipole. It is also called as Hertzian Dipole, which is a hypothetical antenna and is defined as a short isolated conductor carrying uniform alternating current.
9. **How radiations are created from a short Dipole? (Remembering)**
The dipole has two equal charges of opposite sign oscillating up and down in a harmonic motion. The charges will move towards each other and electric filed lines were created. When the charges meet at the midpoint, the field lines cut each other and new field are created. This process is spontaneous and so more fields are created around the antenna. This is how radiations are obtained from a short dipole.
10. **Why a short dipole is also called an elemental dipole? (Remembering)**
A short dipole that does have a uniform current will be known as the elemental dipole. Such a dipole will generally be considerably shorter than the tenth wavelength maximum specified for a short dipole.
Elemental dipole is also called as elementary dipole, elementary doublet and Hertzian dipole.

11. What is an infinitesimal dipole? (Remembering)

When the length of the short dipole is vanishingly small, then such a dipole is called a infinitesimal dipole. If dl is the infinitesimally small length and I be the current, the Idl is called as the current element.

12. What is oscillating electric dipole? (Remembering)

It represents alternating current element. A current element refers to filamentary current I flowing along an element'dl' length.

13. Define Hertizian dipole? (Oscillating dipole) (Remembering)

Hertizian dipole is defined as a short linear conductor or short electric dipole, whose length is very short compared to wavelength (l < current is assumed to be constant throughout its length.

It is an infinitesimal current element Idl which does not exist in real life.

14. What is the significance of Radiation Resistance of an antenna? (Remembering)(AU-Dec 2015)

Radiation resistance is a fictitious resistance which when inserted in series with the antenna will consume the same amount of power as it is actually radiated. The antenna appears to the transmission line as a resistive component and this is known as the radiation resistance.

The radiation resistance of antenna depends on antenna configuration, Ratio of length and diameter of conductor used, location of the antenna with respect to ground and other objects.

15. What are the two important fields used in the Hertizian dipole antenna? (Remembering)

The ***induction field*** which varies inversely as square of distance from the antenna is called ***near field***. This field will predominate at points close to the current element or antenna.

The ***radiation field*** which varies inversely as distance is known as ***far field or distant field***. This field is of great significance at a large distance.

16. What is an elementary dipole and how does it differ from the infinitesimal dipole. (Remembering)

A short dipole that does have a uniform current will be known as the elemental dipole. Such a dipole will generally be shorter than the one tenth of a wave length.

When the length of the short dipole is vanishingly small, then such a dipole is called a infinitesimal dipole. If dl be the infinitesimally small length and I be the current, then Idl is called as the current element.

17. Why a short dipole is called an oscillating dipole? (Remembering)

A short dipole is initially in neutral condition and the moment a current starts to flow in one direction, one half of the dipole require an excess of charge and the other a deficit because a current is a flow of electrical charge. Then, there will be a voltage between the two halves of the dipole. When the current changes its direction this charge unbalance will cause oscillations. Hence an oscillating current will result in an oscillating voltage. Since, in such dipole, electric charge oscillates, it may be called as **oscillating electric dipole.**

18. What is meant by isotropic radiator? (Remembering) (AU-June 2014, Dec 2014)

An isotropic radiator is a fictitious radiator and is defined as a radiator which radiates fields uniformly in all directions. It is also called as isotropic source or Omni directional radiator or simply unipole.

19. Define induction field (Remembering)

The induction field will predominate at points close to the current element, where the distance from the centre of the dipole to the particular point is less. This field is more effective in the vicinity of the current element only. It represents the energy stored in the magnetic field surrounding the current element or conductor. This field is also known as near field.

20. Define Radiation field (Remembering)

The radiation field will be produced at a larger distance from the current element, where the distance from the centre of the dipole to the particular point is very large. It is also called as distant field or far field.

21. At what distance from the dipole is the induction field equal to the radiation field? (Remembering)

As the distance from the current element or the short dipole increases ,both induction and radiation fields emerge and start decreasing .However, a distance reaches from the conductor at which both the induction and radiation field becomes equal and the particular distance depends upon the wavelength. The two fields will thus have equal amplitude at that particular distance.

22. How same antenna be used satisfactorily for transmission as well as reception? (Remembering)

Ordinary antennas can be used to transmit and receive the signal at different times. Radar types antennas can be used to transmit and receive the signal at the same time.

23. Identify the expression for the effective aperture of a short dipole. (Applying)

The effective aperture of a short dipole is given by

$$Ae = 0.119\lambda^2$$

24. What is a dipole antenna? (Remembering)

A dipole antenna may be defined as a symmetrical antenna in which the two ends are at equal potential relative to the midpoint.

The dipole is usually fed at the centre having maximum current at the centre. That is maximum radiation is in the plane normal to the axis.

25. What is a half wave dipole? (Remembering)

A half wave antenna is the fundamental radio antenna of metal rod or tubing or thin wire which has a physical length of half wavelength ($\lambda/2$) in free space at the frequency of operation.

It is one of the simplest antenna and is frequently employed as an element of the antenna array.

26. Show the expression for the effective aperture of a Half wave Dipole. (Understanding)

The effective aperture of a half wave dipole is given by $Ae = 0.13\lambda 2$

27. What is the radiation resistance of a half wave dipole? (Remembering)

The radiation resistance of a half wave dipole is given by Rr=73 ohm

28. What is a monopole antenna? (Remembering)

A monopole antenna consists of one half of a dipole (usually a short vertical) antenna mounted above the earth or group (reflecting plane).

It is also called as Marconi antenna or Quarter wave monopole. It is fed by a coaxial cable connected to its base.

29. How half wave dipole antenna differs from monopole dipole antenna? (Remembering)

The only difference between a $\lambda/2$ antenna and a $\lambda/4$ antenna is that the dipole radiates power more or less in all directions where as monopole radiates power in a hemisphere surface (Half of the sphere)

30. What is a quarter wave monopole? (Remembering)(AU-Dec 2013, June 2014)

One-quarter wavelength long .it is also called as Marconi antenna.

A quarter wave monopole antennas is half of a dipole antenna placed over a grounded plane

31. Calculate the physical height of a half wave dipole ($\lambda/2$) having antenna Q of 30 and bandwidth of 10 MHz.

f = Q X BW=30 X10MHz=300MHz.

$\lambda = c / f$;**ans: 0.5 m**

32. What is the effective area of a half wave dipole operating at 1GHz? (Remembering)

Given: $f = 1 \times 10^9$ Hz

Effective area, $Ae = 0.1309\,\lambda^2 = 0.1309\,(c/f)^2 = 0.1309(0.3) =$ **0.039**

33. What are the parameters that determine the overall pattern of an antenna array?(Remembering)

- ✓ Gain,
- ✓ Directivity,
- ✓ Input impedance,
- ✓ Band width,
- ✓ Polarization and Antenna temperature

34. Define radiation pattern. (Remembering) (AU-June 2014)

A graph which shows the variation in actual field strength of electromagnetic field at all points which are at equal distance from antenna otherwise it is a mathematical function or graphical representation of the radiations from an antenna.

The energy radiated in a particular direction by an antenna is measured in terms of **Field Strength**. (E Volts/m)

35. List out the different types of radiation pattern of an antenna. (Analyzing)

There are two types of radiation pattern, they are,

Field radiation pattern:

If the radiation of the antenna is expressed in terms of the field strength E (in v/m), then it is called field strength pattern (or) Field radiation pattern.

Power radiation pattern:

When the radiation in a given direction is expressed in terms of power per unit solid angle, the pattern is called power radiation pattern.

36. List out the types of field radiation pattern. (Analyzing)

There are two types of field radiation pattern. They are,

E-plane pattern or vertical pattern:

When the magnitude the normalized field strength is plotted versus Θ with constant Φ, the pattern is called **E-plane pattern or vertical pattern.**

H-plane pattern or horizontal pattern:

When the normalized field strength is plotted versus Φ with constant Θ=π/2, the pattern is called**H-plane pattern or horizontal pattern**

37. Define power density. (Remembering)

The power density P_d (Θ, Φ) is defined as power flow per unit area and is a function of the direction (Θ, Φ).

The power density can be expressed in terms of the magnitude of the electric field intensity as,

$$P_d(\Theta, \Phi) = \frac{1}{2}\frac{|E(\theta,\phi)|^2}{\eta_O} = \frac{1}{2}\frac{|E(\theta,\phi)|^2}{120\pi}$$

38. Define Beam area or Beam solid angle. (Remembering) (AUT-Dec 2016)

It is the solid angle through which all the power radiated to the free space. It is a three dimensional angle formed by the major lobe.

Mathematically, Beam area Ω_A is defined as the integral of the normalized power pattern over a sphere.

$$\Omega_A = \int_0^{2\pi}\int_0^{\pi} Pn(\theta,\varphi)d\Omega$$

Where, $P_n(\Theta,\Phi)$ = normalized power

Ω_A = beam solid angle

$d\Omega$ = Solid angle = $r^2 \sin\Theta\, d\Theta d\Phi$ steradian

39. Compare radian and Steradian. (Evaluating)

Radian –One radian is defined as the plane angle with its vertex at centre of circle with radius "r" that is subtended by an arc whose length is also r**.**

Steradian- One Steradian is defined as a solid angle with its vertex at the centre of the sphere with radius "r" that is subtended by a spherical surface area equal to that of a square with each side equal to r.

40. How is the 'STERADIAN' defined and how is it used? (Remembering)

Steradian are a measure of the angular 'area' subtended by a two dimensional surface about the origin in three dimensional space, just as a radian is a measure of the angle subtended by a one dimensional line about the origin in two dimensional (plane) space. Steradian are equivalently referred to as 'square radians. It is used to measure the solid angle.

41. Motive radiation intensity (Analyzing)

The radiation intensity of an antenna does not depend on the distance from the radiation (or) antenna. It is denoted by "U".

The radiation intensity is defined as "power radiated per unit solid angle", expressed in W/S_r (i.e., watts/steradian).$U(\Theta, \Phi) = r^2 P_d(\Theta, \Phi)$

42. Show the expression for average radiation intensity. (Remembering)

The radiation intensity U (Θ, Φ) is expressed in watts per steradian and is defined as time average power per unit solid angle. The average value of the radiation intensity is given by,

$$U_{avg} = \frac{P_{rad}}{4\pi}$$

Where $P_{rad} = \iint U(\theta,\phi)d\Omega$ $d\Omega = \sin\Theta d\Theta d\Phi$

43. Show the expression for average power radiated. (Remembering)

The expression for average power radiated is given by,

$$P_{avg} = \frac{Prad}{4\pi r^2}\ W/m^2$$

44. Define Directivity? (Remembering) (AUT-Dec 2016)

The directivity of an antenna is defined as the ratio of the maximum power density to the average power radiated.

$$G_{Dmax} = \frac{Pdmax}{\frac{Prad}{4\pi r^2}}$$ $G_{Dmax} = U_{max}/U_{avg} = 4\pi\, U_{max}/P_{rad}$

45. Define gain (Remembering)

The ratio of maximum radiation intensity in given direction to the maximum radiation intensity from a reference antenna produced in the same direction with same input power. i.e

Maximum radiation intensity from test antenna

Gain (G)= --

Maximum radiation intensity from the reference antenna with same input power

46. Show the relationship between Gain and Directivity? (Understanding)

G=kD.

Where, G=gain, k=Efficiency factor (0 to 1) and D=Directivity

47. What is the significance of gain of an antenna? (Remembering) (AU-Dec 2015)

Gain is one of the most important parameters of an antenna.

It is an actual or realized quantity which is less than the directivity 'D' due to ohmic losses in the antenna.

The ratio of the gain to the directivity is the antenna efficiency factor. Thus

$$G=KD$$

48. Distinguish between power gain and directive gain.(Analyzing) OR
Define power gain and write down the relation between directive gain and power gain. (Remembering) (AU-Dec 2014) (AUT-June 2016)

POWER GAIN	DIRECTIVE GAIN
1. The ratio of the power radiated in a particular direction (θ, φ), to the actual power input to the antenna is called "Power gain ".	1. The directive gain is defined as the ratio of the power density Pd(θ, φ), to the average power radiated.
2. $G_{pmax} = \eta_r G_{Dmax}$	2. $G_{Dmax} = \frac{4\pi\ Umax}{Prad}$

49. What is meant by antenna impedance? (Remembering)

The antenna impedance is impedance at the point where the transmission line carrying RF power from the transmitter is connected since at this point input to the antenna is supplied. It is called antenna impedance.

50. Define self-impedance. (Remembering)

Self-impedance of an antenna is defined as its input impedance with all other antennas are completely removed i.e., away from it.

51. Define mutual impedance. (Remembering) (AUT-Dec 2015)

The presence of nearby antenna no.2 induces a current in the antennas no.1 indicates that presence of antenna no.2 changes the impedance of the antenna no.1. This effect is called mutual coupling and results in mutual impedance.

52. What is meant by Polarization? And its types. (Remembering)

The polarization of the radio wave can be defined by direction in which the electric vector E is aligned during the passage of at least one full cycle. Also polarization can also be defined the physical orientation of the radiated electromagnetic waves in space.

The polarizations are three types. They are

- ✓ Elliptical polarization,
- ✓ circular polarization and
- ✓ Linear polarization.

53. Define polarization mismatch. (Remembering) (AUT-June 2017)

- ➢ When antenna is connected in horizontal, it exhibit vertical polarized wave
- ➢ When antenna is connected in vertical, it exhibit horizontal polarized wave

54. Define axial ratio (Remembering)

The ratio of length of the major and minor axes of the polarization ellipse is called the Axial Ratio. (AR).

$$\text{Axial Ratio (AR)} = \frac{\text{Length of major axes}}{\text{Length of the minor axes}} = \frac{E_{max}}{E_{min}}$$

55. Define bandwidth (Remembering)

It is a width or range of frequency over which the antenna maintains certain required characteristics like gain, pattern, polarization & impedance.

In general, the antenna bandwidth mainly depends on its impedance and pattern.

$$\text{Bandwidth (BW)} = \Delta\omega = \omega_2 - \omega_1$$

56. What is meant by Quality factor? (Remembering)

It is defined as the ratio of the energy stored in the antenna to the energy radiated per cycle by damping processes.

The bandwidth of the antenna is inversely proportional to 'Q' factor of antenna.

Q = "Q" factor of antenna

$$Q = 2\pi \frac{\text{Total energy stored by antenna}}{\text{Energy radiated per cycle}}$$

57. What is meant by reciprocity Theorem? (Remembering) (AU-Dec 2013)

If an e.m.f is applied to the terminals of an antenna no.1 and the current measured at the terminals of the another antenna no.2, then an equal current both in amplitude and phase will be obtained at the terminal of the antenna no.1 if the same e.m.f is applied to the terminals of antenna no.2.

58. Show the important applications of reciprocity theorem? (Understanding)

- ✓ Equality of directional patterns
- ✓ Equality of directivities
- ✓ Equality of effective lengths
- ✓ Equality of antenna impedances

59. What is meant by effective aperture or effective area? (Remembering)

Area over which an antenna extracts electromagnetic energy from the incident electromagnetic waves is called **effective area (or) effective aperture**.

Effective aperture is defined as the ratio of power radiated (or) received by the antenna to the power density of the incident wave.

Effective aperture A_e = power received/power density = P_r/S

60. Define effective length(Remembering)

It represents the effectiveness of an antenna as radiator or collector of electromagnetic energy. The distance through which an antenna can radiate or receive effectively is called as Effective length.

61. Classify the fields around the antenna or in dipole antenna. (Analyzing)

- ✓ Near field or Fresnel Zone
- ✓ Far field or Fraunhofer zone

62. What are the approaches used for finding potentials for electromagnetic field?(Remembering)

- ✓ Maxwell approach
- ✓ Heuristic approach

63. Define Beam efficiency? (Remembering)

The total beam area (WA) consists of the main beam area (WM)plus the minor lobe area (Wm) Thus WA = WM+ Wm .

The ratio of the main beam area to the total beam area is called beam efficiency.

Beam efficiency = SM = WM / WA.

64. What is meant by antenna beam width? (Remembering) (AUT-Dec 2017)

Antenna beam width is a measure of directivity of an antenna. Antenna beam width is an angular width in degrees, measured on the radiation pattern (major lobe) between points where the radiated power has fallen to half its maximum value .This is called as "beam width" between half power points or half power beam width.(HPBW).

65. What are the different types of Effective aperture? (Remembering)

- ✓ Scattering aperture
- ✓ Loss aperture
- ✓ Collecting aperture
- ✓ Physical aperture.

66. Define different types of aperture?(Remembering)

Scattering aperture (As.)

It is the ratio of the reradiated power to the power density of the incident wave.

Loss aperture(A_l).

It is the area of the antenna which dissipates power as heat.

Collecting aperture (A_c).

It is the addition or summation of above three apertures.

Physical aperture(Ap).

This aperture is a measure of the physical size of the antenna.

67. Define scattering aperture ratio. (Remembering)

The ratio between scattering aperture to the effective aperture is called as scattering aperture ratio.

Scattering aperture ratio $\beta = A_s/A_e$

68. Define absorption ratio. (Remembering)

The ratio between maximum effective apertures to the physical aperture is called absorption ratio

Absorption ratio $=A_{em}/A_p$

Where, A_{em} = Maximum effective aperture

A_p = physical aperture

69. Define Aperture efficiency? (Remembering)

The ratio of the effective aperture to the physical aperture is the aperture efficiency.

i.e Aperture efficiency h_{ap} = Ae/ Ap (dimensionless).

70. What is meant by effective length of an antenna?(Remembering) (AU-Dec 2013)

It represents the effectiveness of an antenna as radiator (or) collector of electromagnetic energy. An antenna can radiate of receiver effectively to that of particular distance called as effective length.

It is denoted by L_e. Mathematically, it is the ratio between open circuit voltages to the incident field strength.

$$L_e = \frac{V}{E}$$

Where V = Open circuit incident voltage

E = Incident field strength

71. Show the expression for effective length of an antenna. (Understanding)

$$L_e = \frac{2\sqrt{AeRl}}{\sqrt{Z}}$$

Where, A_e = effective aperture

R_l = load resistance, Z = impedance

72. Construct the relationship between effective aperture and directivity. (Applying)

The relationship between effective aperture and directivity is given by,

$$D == \frac{4\pi}{\lambda^2} A_{e\max}$$

Where D = directivity

A_{emax}= effective aperture

73. Define antenna temperature. (Remembering)

The antenna temperature is a parameter that depends on the temperature of the regions the antenna is 'looking at'.

Both the antenna temperature (T_A) and radiation resistance (R_r) are single valued scalar quantities.

The expression for antenna temperature is,

$$T_A = \frac{SA_e}{K}$$

Where S = Power density per unit bandwidth

A_e= effective aperture, K = Boltzman's constant = $1.38*10^{-23}$

74. Show the relationship between antenna temperature and solid angle. (Understanding)

$$T_A = \frac{\Omega_S}{\Omega_A} T_S$$

Where Ω_A = antenna beam solid angle in steradian

Ω_S = Source solid angle in steradian

T_A = Antenna noise temperature

T_S = source temperature in °K

75. What is meant by equivalent noise temperature of an antenna (Te)? (Remembering)

It is defined as that fictional temperature at the input of the network which would account for the noise ΔN at that output.

(ΔN----additional noise introduced by the network itself)

76. Show the expression for noise figure of an antenna. (Understanding)

The noise figure (F) related with effective noise temperature is

$$F = 1 + \frac{Te}{To}$$

$T_e = T_o$ (F-1)

Where F = Noise figure (no dimension)

T_o = 290° K

77. What is meant by radiation resistance? (Remembering) (AUT-Dec 2017)

The antenna is a radiating device in which the power is radiated in to space in the form of electromagnetic waves.

It is defined as the fictitious resistance which when inserted in series with the antenna will consume the same amount of power as it is actually radiated. The antenna appears to the transmission line as a resistive component nd this is known as the radiation resistance.

78. What is meant by front to back ratio? (Remembering)

It is defined as the ratio of the power radiated in desired direction to the power radiated in the opposite direction.

i.e FBR = Power radiated in desired direction / power radiated in the opposite direction.

79. Define antenna efficiency?(Remembering)

The efficiency of an antenna is defined as the ratio of power radiated to the total input power supplied to the antenna.

Antenna efficiency = Power radiated / Total input power

80. Show the expression for radiation efficiency. (Remembering)

The expression for radiation efficiency is given by,

$$\eta_r = \frac{P_{rad}}{P_{rad} + P_{loss}}$$

Where $P_{rad} = I^2_{rms}R_{rad}$

$P_{loss} = I^2_{rms}R_{loss}$

81. What is meant by cross field? (Remembering)

Normally the electric field E is perpendicular to the direction of wave propagation. In some situation the electric field E is parallel to the wave propagation that condition is called Cross field.

82. What is duality of antenna? (Remembering)

It is defined as an antenna is a circuit device with a resistance and temperature on the one hand and the space device on the other with radiation patterns, beam angle ,directivity gain and aperture.

83. Distinguish between isotropic source and Omni directional source.(Analyzing)

An **isotropic source** radiates equally in all directions in both azimuth and elevation angles. Power density is uniformly distributed around a large sphere cantered on the antenna.

An **Omni directional** source radiates uniformly in all azimuth directions but has a deep null in the orthogonal elevation direction.

84. An antenna has the field pattern given by $E(\theta) = \cos^2\theta$ for $0° \leq \theta \leq 90°$. Find HPBW. (Remembering)

$E(\theta)$ at half power = 0.707

Thus, $0.707 = \cos^2\theta$

So, $\cos\theta = \sqrt{0.707}$

$\theta = \cos^{-1}(\sqrt{0.707})$

$\theta = 33^0$ **HPBW = 2θ =2X33⁰ = 66⁰**

85. Find the Radiation resistance of λ/8 wire dipole in free space. (Remembering)

Given: dl = λ/8

Radiation Resistance, $R_r = 80\pi^2 (dl/\lambda)^2$

$= 80\pi^2 (\lambda/8/\lambda)^2$

R_r= 12.32 Ohm

86. What are the field zones? (Remembering)

The fields around an antenna may be divided into two principal regions.

- ✓ Near field zone (Fresnel zone)
- ✓ Far field zone (Fraunhofer zone)

87. If the radiation resistance of an antenna is 65 ohms and loss resistance is 10 ohms, find its efficiency. (Remembering) (AUT-June 2017)

Given: R_r = 65 ohms

R_l = 10 ohms

Efficiency $(\eta) = \frac{Rr}{Rr + Rl} = \frac{65}{65 + 10}$ X 100 **η = 86.67 %**

88. Define Half Power Beam Width. (Remembering)(AUT-June 2015)

HPBW is defined as the angular separation between directions where the field reduces to $1/\sqrt{2}$ of its maximum value.

Half Power Beam Width (HPBW) is half of Beam Width between first nulls.

$$\text{HPBW} = \frac{BWFN}{2}$$

89. Evaluate the radiation resistance of an antenna which is radiating 1000W and drawing current of 5A. (Evaluating)(AUT-June 2016)

$$R = \frac{P}{I^2}$$

R=1000/5² =40Ω

90. Write down the expressions for magnetic vector potential using three standard current distributions. (Remembering) (AUT-Dec 2015)

For volume current, $A = \frac{\mu}{4\pi}\int \frac{J}{r} dV (volts/metre)$

For line current, $A = \frac{\mu}{4\pi}\int \frac{I}{r} dl (volts/metre)$

For surface, $A = \frac{\mu}{4\pi}\int \frac{K}{r} dS (volts/metre)$

16 MARKS

1. Derive the expression for vector potential in detail. **(Applying) (AUT-Dec 2017)**
2. Derive the expression for the retarded vector potential for sinusoidal current element. **(Appling) (AUT-June 2016,Dec 2017)**
3. Derive the electric and magnetic field quantities radiated from a Hertizian dipole antenna**. (Remembering) (AUT-June 2016, June 2017)**
4. Define radiation resistance. Derive the Expression for power radiated and find the radiation resistance of Hertizian dipole antenna. **(Remembering)**
5. Derive the Expression for far field component of a dipole antenna whose length is λ/2. **(Applying)(AUT-June 2015, Dec 2015, June 2016)**
6. Derive radiation resistance for a half wavelength dipole. **(Creating) (AUT-Dec 2015, June 2016,Dec 2017)**
7. Derive the Expression for power radiated and find the radiation resistance of an quarter wave and monopole dipole antenna.**(Applying) (AUT-June 2015)**
8. Explain the following parameters of an antenna: **(Understanding)**
   (i) Beam solid angle**(AUT-June 2015, Dec 2015)**
   (ii) Radiation pattern **(AUT-June 2017)**
   (iii) Gain
   (iv) Polarization **(AUT-June 2017)**
   (v) Bandwidth
9. Explain in detail about Effective aperture and derive its equation in different conditions. **(Evaluating) (AUT-June 2017)**
10. Explain the following parameters of an antenna:**(Understanding)**
    (i) Antenna Temperature **(AUT-June 2017)** (ii) Input impedance **(AUT-June 2015)**
    (iii) Directivity **(AUT-June 2017)**
11. State and prove the reciprocity theorem with respect to antenna. Also mention its application. **(Evaluating) (AUT-June 2015)**
12. Derive the relationship between effective aperture**(AUT-Dec 2017)** and directivity of an antenna.**(Applying) (AUT-Dec 2015)**
13. What is the effective length of an antenna? Determine the effective length of a quarter wave monopole.**(Remembering) (AUT-June 2016)**
14. Derive the expression for the gain of half wave dipole antenna. **(Creating) (AUT-June 2016)**
15. Calculate the physical height of a half wave dipole with antenna quality factor Q of 28 and bandwidth of 10 MHz. **(Evaluating) (AUT-June 2017)**
16. Problems and exercises.
17. An antenna has radiation resistance of 72Ω and loss resistance of 8Ω and power gain of 12dB. Estimate the antenna efficiency and directivity. **(AUT-Dec 2017)**

UNIT-II (CO2)
ANTENNA ARRAYS

1. What is point source? (Remembering)

It is the waves originate at a fictitious volume less emitter source at the center 'O 'of the observation circle.

2. What is meant by antenna array? (Remembering)

It can be achieved by combining the individual antenna radiations in desired direction and canceling the radiation in undesired direction. Such a system is called an antenna array.

It may also be defined as "A radiating system consisting of several spaced and properly phased radiators".

3. List out the salient features of antenna array? (Remembering)

An antenna is a system of similar antennas oriented similarly to get **greater directivity** in a desired direction.

It will also provide high gain in a desired direction of an antenna.

4. What is meant by uniform linear array? (Remembering)

An array is linear when the elements of the array are spaced equally along the straight line. If the elements are fed with currents of equal magnitude and having a uniform progressive phase shift along the line, then it is called uniform linear array.

5. What are the types of antenna array? (Remembering)

- ✓ Broad side array.
- ✓ End fire array
- ✓ Collinear array.
- ✓ Parasitic array

6. What is Broad side array?(Remembering) (AUT-June 2015,Dec 2017)

Broad side array is defined as an arrangement in which the principal direction of radiation is perpendicular to the array axis and also the plane containing the array element. For Broad side array the phase difference adjacent element is d = 0.

Elements are placed parallel to each other and perpendicular to array axis and elements is fed with current of equal magnitude and same phase.

7. Define End fire array(Remembering) (AU-Dec 2013) (AUT-Dec 2017)

End fire array is defined as an arrangement in which the principal direction of radiation is coincides with the array axis.

For End fire array $\delta = -\beta d$

Where $\beta = 2\pi/\lambda$

d = Distance between the elements

8. What is collinear array? (Remembering)

In this array the antenna elements are arranged coaxially by mounting the elements end to end in straight line or stacking them one over the other with radiation pattern circular symmetry.

Eg.Omni directional antenna.

9. What is parasitic array? (Remembering)

In this array the elements are fed parasitically to reduce the problem of feed line.

The array of antennas in which the parasitic elements get the power through electromagnetic coupling with driven element which is in proximity with the parasitic element is known as parasitic array.

Eg.Yagi-uda antenna.

10. What is meant by similar Point sources? (Remembering)

Whenever the variation of the amplitude and the phase of the field with respect to the absolute angle for any two sources are same then they are called similar point sources. The maximum amplitudes of the individual sources may be unequal.

11. What is meant by identical Point sources? (Remembering)

Similar point sources with equal maximum amplitudes are called identical point sources.

12. What is meant by array factor? (Remembering)

It is ratio of the magnitude of the resultant field to the magnitude of the maximum field.

$$\text{Array factor} = = \frac{|E_T|}{|E_{max}|} \quad E_{max} = 2E_o$$

The factor by which the array increases the field strength over that of single element radiating the same total power.

13. Define beam width of major lobe? (Remembering)

It is defined the angle between the first nulls (or) it is defined as twice the angle between the first null and the major lobe maximum direction.

Beam width (BW) = 2 X angle between first null and maximum of major lobe

BW = 2 γ

14. What are the different conditions can be applied to the antenna array? (Remembering)

- ✓ Two point sources with currents of equal magnitudes and with same phase
- ✓ Two point sources with currents of equal magnitudes and with opposite phase
- ✓ Two point sources with currents of unequal magnitudes and with opposite phase

15. Distinguish between broad side and End fire array. (Analyzing) (AUT-June 2016, Dec 2016)

BROAD SIDE ARRAY	END FIRE ARRAY
In this number of identical antennas are set up along a line drawn perpendicular to their respective axis.	In this number of identical antennas are spaced equally along a line parallel to their respective axis.
Individual elements are fed with current of equal amplitude and phase	Individual elements are fed with current of equal amplitude and out of phase
Radiates perpendicular to the axis	Radiates parallel or along the axis.
Narrow beam width	Wide Beamwidth

16. What is mean by Half Power Point Direction (HPPD)? (Remembering)

At half power points, power is ½ (or) voltage and currents is $1/\sqrt{2}$ times the maximum value.

i.e.,, $E = \pm 1/\sqrt{2}$

17. List out the various properties used in BSA and EFA. (Analyzing)

- ✓ Major lobe
- ✓ Magnitude of major lobe
- ✓ Nulls

- ✓ Side lobe
- ✓ Beam width of major lobe
- ✓ Half power beam width
- ✓ Directivity

18. What is the principle of the pattern multiplication? (Remembering) OR
What is the pattern multiplication and draw the pattern of 2 point sources separated by λ/2. (Remembering) (AU-Dec 2015) (AUT-Dec 2016)

The total field pattern of an array of non isotropic but similar sources is the product of the

- ✓ Individual source pattern and
- ✓ The array pattern of isotropic point sources each located at the phase center of the individual source having the same amplitude and phase. While the total phase pattern is the sum of the phase patterns of the individual source pattern and array pattern.

Total field (E)=$\{E_i(\theta,\varphi) x E_a(\theta,\varphi)\}$ x $\{E_{pi}(\theta,\varphi)+E_{pa}(\theta,\varphi)\}$

19. What is the advantage of pattern multiplication? (Remembering) (AUT-June 2016)

- ✓ Useful tool in designing antenna
- ✓ It approximates the pattern of a complicated array without making lengthy computations.

20. List out some disadvantages of uniform linear array. (Remembering)

- ✓ When the array length is increased to increase directivity, secondary or minor lobes also appear.
- ✓ But this has to be reduced to a minimum desired level in comparison to principal (or) main lobes because considerable amount of power is wasted in these directions.

21. What is Binomial array? (Remembering)(AU-Dec 2014)

The amplitude of the radiating sources is arranged according to the coefficients of successive terms of the binomial series and therefore it is named as binomial array.

$$(a+b)^n = a^n + \frac{n}{1}a^{n-1}b + \frac{n(n-1)}{1\cdot 2}a^{n-2}b^2 + \cdots + \frac{n(n-1)\ldots(n-k+1)}{1\cdot 2\ldots k}a^{n-k}b^k + \cdots b^n$$

22. What is the need for the Binomial array? (Remembering)

The need for a binomial array is

- ✓ In uniform linear array as the array length is increased to increase the directivity, the secondary lobes also occurs.
- ✓ For certain applications, it is highly desirable that secondary lobes should be eliminated completely or reduced to minimum desirable level compared to main lobes.

23. Mention some disadvantages in binomial array. (Creating)(AUT-Dec 2015)

- ✓ HPBW increases and hence directivity decreases.
- ✓ For the design of a large array, larger amplitude ratio of sources is required.

24. Define power pattern. (Remembering)

Graphical representation of the radial component of the pointing vector with constant radius as a function of angle is called power density pattern or power pattern.

25. What is tapering of arrays? (Remembering)

Tapering of array is a technique used for reduction of unwanted side lobes .The amplitude of currents in the linear array source is non-uniform; hence the central source radiates more energy than the ends. Tapering is done from center to end.

26. Show the difference between isotropic and non-isotropic source? (Understanding)

- ✓ Isotropic source radiates energy in all directions but non isotropic source radiates energy only in some desired directions.
- ✓ Isotropic source is not physically realizable but non-isotropic source is physically realizable.

27. What is meant by Broadband antenna? (Remembering)

Antenna 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 antenna.EG: Log-periodic.

28. A uniform linear array contains 50 isotropic radiation with an inter element spacing of λ/2. Find the directivity of broadside form of arrays. (Remembering)

Given data n=50 d= λ/2

Directivity D=2L/ **λ**=2*nd/ λ=2*50* **λ/ 2*λ=50**

29. What is mean by tuning of array?(Remembering)

The radiation pattern is unidirectional; the relative phases of the currents are changed by adjusting the spacing between the elements.

30. Compare broad side array & Hansen Woodward array. (Understanding)

S.NO	BROAD SIDE ARRAY	HANSEN WOODYARD ARRAY

1.	Antenna is fed in phase d = 0	Antenna elements are fed with ±βd
2.	Maximum radiation is perpendicular along the direction of array axis	Maximum radiation is along the array axis
3.	Beam width of major lobe is twice the reciprocal of array axis,+2l/nd	Beam width is greater than that for that of a broad side array with increased directivity

31. What is mean by phased array?(Remembering)

The array in which the phase and the amplitude of most of the elements is variable, provided that the direction of maximum radiation and pattern shape along with the side lobe is controlled.

32. What is mean by frequency scanning array?(Remembering) (AU-Dec 2013)

The array in which the phase change is controlled by varying the frequency. The is found to be the simplest phased array as at each element separate phase control is not necessary.

33. What is mean by retro array?(Remembering)

The array which automatically reflects an incoming signal back to the source.It acts as a retro reflector similar to the passive square corner reflector.

34. What is mean by adaptive array?(Remembering)

An array which automatically turn the maximum beam in the desired direction while turn the null in the undesired direction. The adoptive array adjust itself in the desired direction with awareness of its environment.

35. What are the conditions to obtain end fire array pattern? (Remembering)

End fire array is defined as an arrangement in which the principal direction of radiation coincides with the array axis.

For end fire array, $\delta = -\beta d$

Where, δ = Phase difference of the current fed between the sources of the end fire array

d = Distance between the elements

36. List the features of adaptive arrays. (Analyzing)(AUT-June 2015)

An adaptive antenna is type of smart antenna, its "smart" because it improves on the traditional antenna by adjusting for traffic patterns at a given time to **increase signal strength and quality.**

37. Give the formula for First null beam width of a broad side array. (Remembering) (AUT-Dec 2015)

The first nulls occur at l=±1 and the beam width between first nulls (BWFN) for such an array is given by,

$$BWFN = \frac{2}{L_\lambda}\, rad = \frac{114.6}{L_\lambda}\, deg\ .$$

38. Illustrate beam forming. (Understanding) (AUT-Dec 2015)

It is the method used to create the radiation pattern of the antenna array by adding constructively the phases of the signals in the direction of the targets/mobiles desired and nullifying the pattern of the targets/mobiles which are undesired/interfering targets. This can be done with a simple FIR tapped delay line filter. The weights of the FIR filter may also be changed adaptively and used to provide optimal beam forming and actual beam pattern formed.

39. What is meant by front to back ratio? (Remembering) (AUT-Dec 2015)

The **Front-to-Back Ratio** is a parameter used in describing directional radiation patterns for antennas. If an antenna has a unique maximum direction, the front-to-back ratio is the ratio of the gain in the maximum direction to that in the opposite direction (180 degrees from the specified maximum direction).

This parameter is usually given in dB.

FBR=Power radiated in desired direction/power radiated in the opposite direction

40. Criticize the two types of point sources. (Evaluating) (AUT-Dec 2017)

- Isotropic,
- non-isotropic point source

<u>16 MARKS</u>

1. What is an antenna array? What are the types of antenna arrays, for each type explain it with array diagram and radiation pattern.**(Remembering)**
2. Derive the expression for electric field of an array of 2-point sources. **(Applying) (AUT-Dec 2015)**
3. Derive an expression for antenna array factor. **(Applying) (AUT-Dec 2016)**
4. Derive and draw the field pattern of array of two point sources with equal amplitude and phase.**(Applying) (AUT-June 2016, Dec 2016,Dec 2017)**
5. Draw the radiation pattern of array of two point sources with equal amplitude and opposite phase by calculating the maximum, minimum and half power point directions. **(Creating)**
6. Derive the total far field pattern for uniform linear array with 'n' isotropic sources. **(Remembering)**

7. A linear broadside array consists of 4 equal isotropic in phase point sources with λ/3 spacing. Find the directivity and Beam width. **(Remembering) OR**
Derive the expression for maxima, minima and beam width of a broad side array. **(Applying)**
8. Derive the expressions for field pattern of End-fire array of N sources of equal amplitude and spacing. **(Remembering)(AUT-June 2015, June 2017)**
9. Two identical vertical radiators are spaced d=λ/4 meters apart and fed with currents of equal magnitude but with a phase difference 'β'. Evaluate the resultant radiation for β=0° and thereby identify the direction of maximum and minimum radiation.**(Evaluating)**
10. For a 2-element linear antenna array separated by a distance d = 3λ/4, derive the field quantities and draw the radiation pattern for the phase difference 45°. **(Remembering)**
11. Explain the principle of pattern multiplication with suitable examples. **(Evaluating) (AUT-June 2015, Dec 2015, June 2016, Dec 2016,Dec 2017)**
12. What is binomial array? Draw the pattern of 10 element binomial array with spacing between the Elements of 3 λ/4 and λ/2. **(Remembering) (AUT-June 2016, Dec 2017)**
13. Illustrate binomial array and phased array antenna **(AUT-June 2017)** with example.**(Understanding) (AUT-June 2015, June 2016)**
14. Explain the following: **(Understanding)**
(i) Adaptive array (ii) Frequency scanning array **(AUT-June 2015)**
15. Prove that the directivity of increased end fire array is 1.789 times greater than the directivity of Ordinary end fire array. **(Understanding) (AUT-June 2016)**
16. A uniform linear array consists of 16 isotropic point sources with a spacing of λ/4. If the phase difference is -90 degree, calculate the directivity, HPBW, Beam solid angle. **(Evaluating) (AUT-June 2017)**
17. Compare broadside array with end fire array. **(Understanding) (AUT-June 2017)**
18. Explain how to compare the different cases of the array containing two isotropic sources. (Understanding) (AUT-Dec 2017)
19. Problems and exercises.

UNIT-III (CO3)
ANTENNA TYPES

1. What is a loop antenna? (Remembering) (AUT-Dec 2016)

A loop antenna is a radiating coil of any convenient cross-section of one or more turns carrying radio frequency current. It may assume any shape (e.g. rectangular, square, triangular and hexagonal).

2. Show an expression of radiation resistance of a small loop. (Understanding)

Radiation resistance of a small loop is given by

$$R_r = 31{,}200\,(NA/\lambda^2)^2\,\Omega,$$

Where N- Number of turns.
A – Area of the small loop

3. How to increase the radiation resistance of a loop antenna? (Remembering)

The radiation resistance of a loop antenna can be increased by:

- ✓ Increasing the number of turns
- ✓ Inserting a ferrite core of very high permeability with loop antenna's circumference which will raise the magnetic field intensity called ferrite loop.

4. What are the types of loop antennas? (Remembering)

Loop antennas are classified into:

- ✓ Electrically small (circumference <l/10)
- ✓ Electrically large (dimension comparable to l)

5. What are Electrically Small loop antennas? (Remembering)

Electrically Small loop antennas is one in which the overall length of the loop is less than one-tenth of the wavelength. Electrically Small loop antennas have small radiation resistances that are usually smaller than their loop resistances. They are very poor radiators and seldom employed for transmission in radio communication.

6. What are electrically large loop antennas? (Remembering)

Electrically Large loop antennas is one in which the overall length of the loop approaches the wavelength.

7. Why loop antenna called as magnetic dipole? (Remembering)

If the dimensions of the loop antenna are small as compared with wavelength, then the radiation pattern of the loop is similar to that of the elementary dipole. The loop is surrounded by a magnetic field at right angles to the loop everywhere. Hence small loop antenna is called magnetic dipole.

8. List out the uses of loop antenna. (Analyzing) (AUT-Dec 2017)

Various uses of loop antenna are:

- ✓ It is used as receiving antenna in portable radio and pagers

- ✓ It is used as probes for field measurements and as directional antennas for radio wave navigation.
- ✓ It is used to estimate the direction of radio wave Propagation.

9. What are the applications of loop antenna?(Remembering)(AU-Dec 2013) (AUT-June 2015)

Loops are effectively used in radio receivers,

- ✓ Used in aircraft receivers,
- ✓ Used as probes for field measurements,
- ✓ Used as receiving antenna in portable radio and pagers,
- ✓ Used to estimate the direction of radio wave propagation,
- ✓ Used in UHF transmitter.

10. What are the disadvantages of loop antenna? (Remembering)

- ✓ Only suitable for LF & MF except for a very small distance.
- ✓ Transmission efficiency is poor & hence cannot be used for UHF unless design is changed.
- ✓ Spurious induced voltages are produced, if nearby loop, wires& conductors are present.

11. What is meant by aperture antenna? (Remembering)

An aperture antenna contains some sort of opening through which electromagnetic waves are transmitted or received. Examples of aperture antennas include slots, waveguides, horns, reflectors & lenses.

12. Define helical antenna. (Remembering)

Helical antenna is defined as a broad band VHF and UHF antenna to provide circular polarization characteristics.

Helical antenna consists of a helix of thick copper wire (or) tubing wound in the shape of a screw thread and used with a flat metal called a ground plane or ground plate. The helix is fed by a co-axial cable and is connected between helix and ground plane.

13. What are the parameters to be considered for the design of a helical antenna? (Remembering) (AUT-Dec 2017)

The parameters to be considered for the design of a helical antenna are:

- ✓ Bandwidth
- ✓ Gain
- ✓ Impedance
- ✓ Axial Ratio

14. What are the types of radiation modes of operation for a helical antenna? (Remembering) (AUT-June 2016)

The two types of radiation modes of operation possible for a helical antenna are:

Normal mode of operation (or) perpendicular mode

In this mode, the radiation field is maximum in Broadway (i.e.,) in the direction normal to the helix axis and is circularly polarized waves.

Here the dimensions of the helix is small compared with wavelength (i.e.,) $NL<<\lambda$.

Axial mode of operation (or) Beam mode of radiation

The radiation field is maximum along the helical axis and the polarization is circular or nearly circular.

When the helix circumference (D) and spacing (S) are appreciable of the order of one wavelength.

15. What is a normal mode of helix antenna? (Remembering)

Radiation field is maximum in the direction normal to the helix axis &wave is nearly or exactly circularly polarized wave. Mode is said to be normal if the dimensions of helix is small compared with the wavelength.($d<<\lambda$).

16. What is an axial mode of helix antenna? (Remembering)

The radiation field is maximum along the helical axis and the polarization is circular or nearly circular.

When the helix circumference (D) and spacing (S) are appreciable of the order of one wavelength

17. How the axial mode is improved? (Remembering)

When the helix circumference D & spacing S of order of one wavelength. Axial mode of radiation is produced by raising helix circumference (C/λ) of order of one wavelength & spacing is approximately of $\lambda/4$.

18. Define pitch angle of a helical antenna. (Remembering) (AU-Dec 2014) (AUT-June 2017)

Pitch angle is the angle between a line tangent to the helix wire and the plane normal to the helix axis.

$$\tan\alpha = S/C = \frac{S}{\pi D}$$

$$\alpha = \tan^{-1}\left(\frac{S}{\pi D}\right)$$

19. List out the limitations of normal mode of operation? (Analyzing)

- ✓ It has narrow bandwidth.
- ✓ Efficiency is very small.

20. List out the advantages of helical antenna. (Analyzing)

- ✓ N-turn helix is an end fire array of "n" sources.
- ✓ Helix not only has a nearly uniform resistance input over a wide bandwidth but it also operates as a super gain end fire array over the same bandwidth.
- ✓ It is non critical with respect to conductor size and turn spacing, therefore can achieve circular polarization over a wide bandwidth.
- ✓ It is easy to use in arrays because of almost negligible mutual impedance.

21. List out the applications of helical antenna. (Analyzing)(AU-Dec 2013)

The applications of helical antenna are:

- ✓ It became the workhouse of space communications for telephone, television and data, being employed both on satellites and at ground stations
- ✓ Many satellites including weather satellites, data relay satellites all have helical antennas
- ✓ It is on many other probes of planets and comets, including moon and mars, being used alone, in arrays or as feeds for parabolic reflectors, its circular polarization and high gain and simplicity making it effective for space application.

22. What is YagiUda antenna? (Remembering)

It is an array of a driven element, a reflector and one or more directors. If three-element array are used then such a type of Yagiuda is referred to as **beam antenna.**

This is the most common antenna used for TV reception. The gain of the antenna is around 7 db and its radiation pattern is very much directive in one direction(normally receiving direction).

23. What do you mean by parasitic element? (Remembering)

The passive elements which are not connected directly connected to the transmission line but are electrically coupled are called as parasitic elements.

24. What do you mean by driven elements? (Remembering)

Driven elements are an active element where the power from the transmitter is fed or which feeds the received power to the receiver.

25. Why folded dipole antenna is used in Yagi antenna? (Remembering)

The folded dipole has high input impedance. If the distance between the driven and parasitic element is decreased, it will load the driven element so input impedance of driven element reduces. But this will be compensated.

26. What is the function or action of reflector in Yagiuda antenna? (Remembering)

The radiation coming from the front at the reflector is absorbed and it retransmits the radiation towards the dipole in such a way that it adds with the incoming signal.

For any radiations coming from the back side, reflector retransmits the radiation in such a way that it is out of phase with the direct radiation from back side at dipole and hence they cancel each other.

27. What is the function or action of director in Yagiuda antenna? (Remembering)

For the radiation coming from the front, the director generates its own radiation in such a way that it adds with this radiation at dipole and increases signal strength.

For radiations coming from the back side, director generates its own radiation such that it cancels the radiation from back at dipole.

28. List out the optimum specification of a three element of YagiUda antenna. (Analyzing)

- ✓ Length of driven element=0.45λ to 0.49 λ
- ✓ Length of director= 0.4 λ to 0.45 λ
- ✓ Length of reflector= 0.5 λ
- ✓ Spacing b/w reflector & driven element= 0.1 λ to 0.25 λ
- ✓ Spacing b/w director & driven element= 0.2 λ to 0.4 λ

29. List out the various design parameters in 3-element Yagi array antenna. (Remembering)

- ✓ Reflector length = 500/f (mHz) feet (or) 152/f(mHz) meters
- ✓ Driven element length = 475/f (mHz) feet (or) 143/f(mHz) meters
- ✓ Director length = 455/f (mHz) feet (or) 137/f(mHz) meters

30. List the merits & demerits of YagiUda antenna.(Analyzing)

Merits:

- ✓ Light weight & low cost
- ✓ High directivity
- ✓ Unidirectional radiation
- ✓ Simple construction

Demerits:

- ✓ It is sensitivity to frequency
- ✓ Bandwidth is reduced if we increase number of elements.

31. Show the various applications of YagiUda antenna.(Analyzing)

- ✓ Used in television reception
- ✓ Used as a transmitter for low frequency applications

32. Design a three element Yagi-Uda antenna to operate at a frequency of 200 MHA. (Creating)

Given: f = 200MHZ

λ = C/f

$$\approx \frac{3*10^8}{200*10^6} = 1.50m$$

The length of the driven element L_d = 478/f(MHZ) = 478/200 = **2.39 feet**

Length of the reflector L_r = 492/f(MHZ) = 492/200 = **2.46 feet**

Length of the director L_d = 461.5/f(MHZ) = 461.5/200 = **2.30 feet**

Element spacing S = 142/f(MHZ) = 142/200 = **0.71 feet**

33. What is a frequency independent antenna? (Remembering) (AU-June 2014)

If the structure of the antenna is defined in terms of angles only, then it comes under the category of frequency independent antenna.

In any frequency independent antenna, the characteristic like impedance, radiation pattern and directivity are independent of frequency.

Eg, Log periodic antenna, Spiral antenna

34. Why log periodic antenna is called so? (Remembering)

The log periodic antenna is called so because it has impedance and radiation characteristics that are regularly repetitive as a logarithmic function of frequency.

35. What is LPDA? (Remembering)

LPDA means log periodic dipole array. It is defined as an antenna whose electrical properties repeat periodically with logarithm of the frequency.

It is a broad band narrow beam antenna, and it is frequency independent antenna.

36. Define design ratio or scale factor in LPDA. (Remembering)

The dipole lengths and the spacing between two adjacent dipoles are related through parameter called design ratio (or) scale factor denoted by τ.

Thus the relationship between S_n and S_{n+1} and L_n and L_{n+1} is given by,

$$\frac{S_n}{S_{n+1}} = \frac{L_n}{L_{n+1}} = \tau$$

37. What are the different regions in log periodic antenna and how are they differentiated? (Remembering)

- ✓ Inactive transmission line region – $L< \lambda/2$ – high capacitive impedance
- ✓ Active region – $L = \lambda/2$ – offers resistive impedance
- ✓ Inactive reflective region – $L>\lambda/2$ – offers inductive impedance

38. List the design parameters of a Log periodic antenna. (Analyzing) (AUT-June 2017)

- ✓ Apex angle α
- ✓ Design ratio τ
- ✓ Spacing factor σ

39. Show the expression for α, τ, σ of Log periodic antenna. (Understanding)

Design ratio: Relates the position of a dipole elements from the origin

Spacing factor: Ratio of the separation b/w adjacent dipoles to the length of the dipole.

σ=1- τ/4 tan α/2 or $L_n/L_{n+1}=R_n/R_{n+1}$

Acute angle: $\alpha=2\tan^{-1}(1-\tau/4\sigma)$ where τ=Design ratio= $S_n/2L_n$

40. What are the applications of log periodic antenna? (Remembering)

- ✓ HF communication
- ✓ Television reception
- ✓ All round monitoring

41. What is rhombic antenna? (Remembering)

An antenna which consists of four straight wires arranged in the shape of diamond, suspended horizontally above the surface of the earth is called as a rhombic antenna. It is otherwise called as diamond antenna or traveling wave antenna.

42. List some special features of rhombic antenna. (Remembering)

- ✓ The terminating resistance used may have the value 600Ω to 800Ω.
- ✓ Terminating resistance is a non inductive with a negligible value of capacitance.
- ✓ For low power systems, the ordinary resistor can be used as the terminating resistor.
- ✓ The typical value of power loss is 35 to 50% in terminating resistor leading to a power gain of 50 to 60.

43. Show the design parameters of a rhombic antenna? (Understanding)

- ✓ Length of legs L, L = λ/2 $Sin^2β$
- ✓ Tilt angle ***θ*** where β = 90^o - Θ
- ✓ Height above the ground h, h = λ/4 sin β

44. What are the two types of rhombic antenna design? (Remembering) (AU-June 2014)

Alignment design

In this approach, the main lobe radiation is aligned with the required angle of elevation β

Maximum field intensity design

The relative field intensity E in the vertical plane coincident with the rhombic main axis.

45. What are the advantages of rhombic antenna? (Remembering)

- ✓ It is a highly directional broad band antenna with greatest radiated (or) received power.
- ✓ The input impedance and radiation pattern are constant over a considerable large range of frequencies.
- ✓ Highly used for radio communication because of its high efficiency.
- ✓ It can be used for short wave application with very low height.
- ✓ Simple construction and low cost.

46. What are the limitations of rhombic antenna? (Remembering)

- ✓ It needs a larger space for installation
- ✓ Due to minor lobes transmission efficiency is low.

47. What are the applications of rhombic antenna? (Remembering)

- ✓ HF transmission and reception
- ✓ Point to point communication.
- ✓ Microwave application
- ✓ Radio communication

48. What is horn antenna?(Remembering)

The horn antenna is most widely used simplest form of the microwave antenna.

The horn antenna serves as a feed element for large radio astronomy communication dishes and satellite tracking throughout the world. The horn antenna is most useful for broad band signals.

As it is widely used at microwave frequencies 3 GHz to 30 GHz, it may be considered as an aperture antenna.

49. Define horn antenna as a waveguide. (Remembering)

A horn antenna may be regarded as a flared out or opened out waveguide. When one end of the waveguide is excited and the other end is kept open, it radiates in open space in all directions.

The radiation is much greater through waveguide than the two wire transmission line.

50. What are the limitations of horn antenna as a waveguide? (Remembering)

- ✓ In the waveguide, a small amount of power in the incident wave is radiated and the large amount of power is reflected back by the open circuit end.
- ✓ Also the impedance matching with the free space is not perfect.
- ✓ At the edges of the waveguide, diffraction takes place which results in poor radiation.
- ✓ Also the radiation pattern is non-directive.

51. List out the advantages of terminating the waveguide into electromagnetic horn. (Remembering)

- ✓ Properly shaped gradual transition takes place.
- ✓ Proper impedance matching with free space occur.
- ✓ Total power incident will be radiated in forward direction and therefore the radiation increased.
- ✓ As the edges are flared out (gradual tapering) the diffraction at the edges reduces and thus directivity improves.

52. List out the different types of horn antenna. (Remembering)(AUT-Dec 2015, Dec 2016)

Based on the flaring and type of waveguide there are four types of the horn antennas. They are

- ✓ E plane sectoral horn
- ✓ H plane sectoral horn
- ✓ Pyramidal horn

| Rectangular horn antenna since it is fed with rectangular waveguide

- ✓ Conical horn
- ✓ Biconical horn

| Circular horn antenna since it is fed with circular waveguide

53. What do you meant by sectoral horn and its types?(Remembering)

If flaring (opened out) is done only in one direction, then it is called as a sectoral horn.

E plane sectoral horn

E plane sectoral horn is obtained when flaring is done in the direction of the electric field vector.

H plane sectoral horn

In this type, the flaring is done in the direction of the magnetic field vector.

54. What do you meant by pyramidal horn?(Remembering)

When the flaring is done along both the walls (E & H) of the rectangular waveguide in the direction of both the electric and magnetic field vectors, then it is called as a pyramidal horn.

55. State Huygen's Principle. (Understanding)

The Huygen's principle states that every point on primary wavefront acts as a new source of the secondary spherical wave and the spherical wavefront can be obtained as a envelop of the secondary waves.

56. What are the features of Pyramidal horn antenna? (Remembering)

In pyramidal horn antenna,

- ✓ Flaring is done along both the electric and magnetic field vectors.
- ✓ It is most widely used electromagnetic horn since it has characteristics as a combination of both E-plane and H-plane sectorial horns.

57. What are the advantages of horn antenna? (Remembering)

- ✓ The directivity of the pyramidal horn and conical horn is highest as they have more than one flare angle.
- ✓ It can be represented over a wide range of high frequency as ther is no resonant element in the antenna.

58. List the applications of horn antenna.(Analyzing)

- ✓ Short radar system
- ✓ Parabolic reflector as feeder
- ✓ Microwave applications

59. What is the basic concept of reflector antenna? (Remembering) (AU-Dec 2014)

Reflector type of antennas or Reflectors is widely used to modify the radiation pattern of a radiating element.

For example, backward radiations from an antenna may be eliminated with a plane sheet reflector of large enough dimensions. By means of a reflector of suitable size and shape, a beam of desired characteristics may be produced.

60. What are the different types of reflector antenna?(Remembering)

- ✓ Flat sheet reflector or Plane reflector
- ✓ Corner reflector---- Active corner, Passive corner
- ✓ Parabolic reflector
- ✓ Hyperbolic reflector
- ✓ Elliptical reflector
- ✓ Circular reflector

61. What is Flat sheet Reflector or plane reflector?(Remembering)

It has a large flat sheet near a linear dipole antenna. It provides backward radiation. It provides substantial gain in the forward direction by reducing the space between the antenna and the sheet.

Advantages:

Advantage of the plane reflector is that dipole backward radiations are reduced and the gain in the forward direction increases.

Disadvantages:

There is radiation in back and side directions.

62. What are Corner Reflector and its types?(Remembering)

In order to overcome the limitations of plane reflector, the shape of the plane reflector is modified in which two plane reflectors are joined to form a corner with some angle. The reflector thus formed is known as corner reflector.

There are two types,

- ✓ Active corner reflector antenna
- ✓ Passive corner reflector antenna

63. What is Active Corner Reflector antenna?(Remembering)

When the driven element is used in conjunction with the corner reflector, it is called as active corner reflector antenna.

64. What is Passive Corner Reflector antenna?(Remembering)

When the corner reflector without driven element is called as passive corner reflector.

65. What are the Uses of Corner Reflector?(Remembering)

- ✓ Used on the vessel's mask at a height of at least 4.6m above sea level.
- ✓ Used on ships as Radar Reflectors.
- ✓ Used in automobile and bicycle tail lights.

66. What are the applications of corner reflector?(Remembering)

- ✓ In Television
- ✓ Point to point communication

- ✓ Radio Astronomy applications.

67. Define Image theory?(Remembering)

The image theory states that a given charge configuration above an infinite grounded perfect conducting plane may be replaced by the charge configuration itself, its image and an equipotential surface in plane of the conducting plane.

68. What is meant by parabolic reflector? (Remembering)

The parabolic structure is used to improve the overall radiation characteristics of the reflector antenna.

69. Define principle of parabolic reflector. (Remembering)

A parabola is a locus of a point which moves in such a way that the distance of the point say 'p' from focus (fixed point 'F') plus the distance from the straight line (Directrix) is constant.

70. Define f/D ratio. (Remembering)

The ratio of focal length to aperture (i.e.,f/D) is known as "f over D ratio" and it is an important characteristics of parabolic reflector (f/D varies from 0.25 to 0.50).

71. What is meant by spill over and back lobe radiation? (Remembering) (AU-June 2014)

Spill Over:

Some of the desired rays are not captured by the reflector antenna and this constitute spill over.

Back lobe radiation:

Some radiation from the primary radiator occurs in the forward direction in addition to the desired parallel beam. This is known as back lobe radiation.

72. List out the different types of paraboloid reflectors. (Remembering)

- ✓ Truncated paraboloid or cur paraboloid
- ✓ Parabolic right cylinder
- ✓ Pill box or cheese antenna

73. What are primary antenna and secondary antennas in parabolic reflectors? Give examples?(Remembering)

Primary antenna

A source of radiation placed at the focus.

Secondary antennas

Antennas that are not radiators by themselves are called secondary antennas (Reflector).

For example: Cassegrain, Hyperbolic antennas.

74. What are the various types of feeds used for parabolic reflectors? (Remembering) (AUT-Dec 2015)

- ✓ Dipole antenna
- ✓ Horn feed
- ✓ End fire feed
- ✓ Cassegrain feed

75. List out the advantages of Cassegrain feed system? (Remembering)

- ✓ It reduces the split over and therefore minor lobe radiations.
- ✓ With this system, focal length greater than the physical focal length can be achieved.
- ✓ The system has ability to place a feed at convenient place.
- ✓ Using this system, beam can be broadened by adjusting one of the reflector surfaces.

76. List out the disadvantages of Cassegrain feed system? (Remembering)

- ✓ It is clear that there is a region of blocked rays in front of Cassegrain reflector.
- ✓ Therefore some of the radiation from the parabolic reflector is blocked by the hyperboloid reflector creating region of blocked rays.
- ✓ But for small dimensions parabolic reflector it is the main drawback of the Cassegrain feed system.

77. What are the applications of parabolic reflector antenna? (Remembering)

- ✓ Microwave communication
- ✓ Radio astronomy
- ✓ Satellite transmission and reception

78. What is meant by Microstrip patch antenna?(Remembering)

The antenna which is made of metal patches placed on dielectric and fed by Microstrip (or) coplanar transmission line is called Microstrip antenna (or) patch antenna.

The patch is supported by a dielectric sheet, known substrate, the thickness of which is in the range of 0.005λ to 0.05λ.

This antenna is mostly used with poor polarization purity and very narrow band width. As it is low profile antenna it is affected by the spurious feed radiations.

79. List some characteristics of Microstrip antenna. (Remembering)

- ✓ The number of different dielectric substrate can be used in the Microstrip antenna.

- ✓ The value of the dielectric constant typically varies in the range of 2.2≤ ε_r≤12.
- ✓ It provides larger bandwidth, better efficiency and loosely bound fields, hence the thick substrate are most desirable.

80. What are the features of Microstrip antenna? (Remembering)

Microstrip antennas are,

- ✓ Compact, low profile and light weight.
- ✓ Cheap and easily developed.
- ✓ Thin and planar structure.
- ✓ Compatible with feed and matching network.
- ✓ Mountable on missiles, rocket and satellite.

81. What are the various shapes of patch in Microstrip antenna? (Remembering)

The radiating patch may be

- ✓ Square,
- ✓ Circular,
- ✓ Elliptical,
- ✓ Rectangular or any shape.

82. Classify the types of feeding structures used for Microstrip patch antennas. (Analyzing) (AUT-June 2015)

- ✓ Inset feed
- ✓ Fed with a Quarter-wavelength transmission line
- ✓ Coaxial cable or Probe feed
- ✓ Coupled (Indirect) feed
- ✓ Aperture feed

83. What are the advantages of patch or Microstrip antenna? (Remembering)

- ✓ Small size and weight
- ✓ Ease of installation
- ✓ Linear and circular polarization is possible
- ✓ Narrow beam of radiation

84. List out the disadvantages of patch or Microstrip antenna. (Remembering)

- ✓ Narrow bandwidth
- ✓ Low efficiency
- ✓ Low gain
- ✓ Extraneous radiation from feeds and junctions
- ✓ Poor end fire radiator except tapered slot antennas
- ✓ Low power handling capacity
- ✓ Surface wave excitation
- ✓ Poor polarization purity

85. What are the applications of patch or Microstrip antenna? (Remembering)

- ✓ Used in spacecraft and aircraft systems – where size, weight, cost, Performance, ease of installation and aerodynamics profiles are constraints, low profile antennas are required.
- ✓ Used for beam scanning and beam steering purposes.
- ✓ Used in telemetry communication antenna on missiles
- ✓ Successfully used in satellite communication

86. What is meant by resonant and non-resonant antennas? (Remembering) (AU-Dec 2014)

Resonant antenna:

In resonant antenna, the standing wave exists due to incident and reflected waves and therefore the pattern is bidirectional.

Non-resonant antenna:

In non-resonant antenna, all the incident waves are absorbed in the terminating impedance and there is no reflected wave. Therefore the pattern is unidirectional.

87. How is a high frequency dipole antenna fed and matched with driving source? (Remembering) (AUT-June 2016)

<u>16 MARKS</u>

1. Explain the principle of operation and applications of loop antenna. **(Remembering) (AUT-Dec 2015)**
2. Derive the expressions for the radiated field and radiation resistance due to a loop antenna. **(Applying) (AUT-June 2017, Dec 2017)**
3. Draw and explain the function of Helical antenna and various modes of radiation. Highlight some of its applications. How does it differ from other antennas? **(Understanding) (AUT-June 2015, Dec 2016, Dec 2017) OR**

Illustrate the working principle of helical antenna in axial mode. **(Understanding) (AUT-Dec 2015, June 2016)**

4. Explain the principle of operation and constructions of multi element Yagi-Uda array with neat schematic diagram. **(Evaluating) OR**
   Explain the construction of Yagi antenna. Discuss the design aspects and advantages**. (Evaluating)(AUT-June 2015)**
5. What is frequency independent antenna? Why it is called so? Give examples. **(Remembering)OR**
   With a suitable diagram explain the construction and principle of operation of a log-periodic antenna. **(Understanding) (AUT-June 2016, Dec 2016)**
6. With necessary illustrations explain the radiation characteristics of multi element log periodic antenna and mention its possible applications. **(Evaluating) (AUT-Dec 2015)OR**
7. Explain the log periodic principle using log periodic dipole array and derive the expression for apex angle (α) of LPDA.**(Understanding)**
8. Explain in detail about the working principle and design considerations of rhombic antenna? **(Evaluating) (AUT-June 2015, Dec 2015) OR**
   Explain the construction and working of V antenna and rhombic antenna**. (Understanding) (AUT-Dec 2016)**
9. Discuss in detail about horn antenna. **(Creating)**
10. Explain the radiation mechanism and features of Microwave Horn antenna with diagram. **(Evaluating) (AUT-Dec 2016) OR**
    Propose the significance of microstrip antenna**. (Understanding) (AUT-Dec 2017)**
11. Explain the principle of rectangular horn antenna with a neat sketch. Draw various types of horn structure. **(Understanding)OR**
    Describe the radiation patterns and fields on the axis of an E – plane and H – plane sectorial horn. **(Creating)**
12. Explain the special features of parabolic reflector antenna and discuss on different types of feed used with neat diagram.**(Understanding) (AUT-June 2015, June 2017, Dec 2017)**
13. Compare flat reflector and corner reflector antennas.**(Analyzing)**
14. With necessary illustrations explain the radiation characteristics of Microstrip antenna and mention its possible application. **(Evaluating) (AUT-June 2016, June 2017)**
15. Problems and exercises.

UNIT-IV (CO4)
SPECIAL ANTENNAS AND ANTENNA MEASUREMENTS
TWO MARKS

1. **Give the abbreviation and importance of GPR? (Remembering) (AUT-June 2015)**
   GPR – **G**round **P**enetrating **R**adar
   It is the technique used to identify and detect objects or structures under the ground surface the structures may be metallic or non metallicobjects. This technique is most useful to detect underground anomalies with are either natural or man-made.
2. **What are the drawbacks involved in GPR? (Remembering)**
   - ✓ Interpretation of radargrams is generally non-intuitive to the novice.
   - ✓ Considerable expertise is necessary to effectively design, conduct, and interpret GPR surveys.
   - ✓ Relatively high energy consumption can be problematic for extensive field surveys.
3. **List out the application of GPR. (Remembering)**
   - ✓ In the Earth sciences it is used to study bedrock, soils, groundwater, and ice.
   - ✓ In environmental remediation, GPR is used to define landfills, contaminant plumes, and other remediation sites
   - ✓ In archaeology it is used for mapping archaeological features and cemeteries.
   - ✓ GPR is used in law enforcement for locating clandestine graves and buried evidence.
   - ✓ GPR is often used on the Channel 4 television programme*Time Team* which uses the technology to determine a suitable area for examination by means of excavations.
4. **What is plasma antenna? (Remembering)**
   Plasma is an ionized gas which behaves as a conductor when it is highly energized. A plasma antenna can be obtained by replacing metallic conducting elements of a convention antenna with plasma. It is much lighter.
5. **Why plasma antenna is used? (Remembering)**
   Length of the plasma antenna change by applied RF power. Rapid reconfiguration of the resonant length. Increase the bandwidth of antenna. Minimizing signal degradation and increases the efficiency of antenna.
   Plasma antennas can be energized and de-energized in micro seconds.An un-energized plasma antenna can be difficult to detect by hostile radar.

6. **What are the important features of plasma antenna? (Remembering)**
   - ✓ Ability to focus a single beam.
   - ✓ Can communicate signals in very short pulse.
   - ✓ Reconfigurable for frequency, bandwidth, gain, length of plasma column and radius of glass tube.
   - ✓ Can transmit and receive for same apertures if the frequencies are widely separated.
7. **What are the important characteristics of plasma antenna? (Remembering)(AU-Dec 2013)**
   - ✓ Gas ionizing process can manipulate resistance and when deionized, the gas has infinite resistance and doesn't interact with RF radiation.
   - ✓ After sending pulse, it can be deionized and eliminates **"ringing effect".**
   - ✓ It can be operate up to 90GHz.
8. **What are the different types of plasma antenna? (Remembering)**
   - ✓ Laser induced antenna
   - ✓ Plasma antennas using tube structures
   - ✓ Explosively formed plasma dielectric antennas.
9. **What is meant by laser induced antenna? (Remembering)**

   The transmission was realized along a plasma channel that was created by the atmosphere breakdown.

   The atmosphere breakdown was created by the focused laser emission.

   The laser is used to designate the path of antenna while an electrical discharge is employed to create and sustain the plasma.
10. **What is meant by Plasma antennas using tube structures? (Remembering)**

    Using tube structures, we can achieve low base-band noise for HF and VHF transmission.

    When the plasma creating voltage is turned off, the antenna effectively disappears.
11. **What is meant by plasma dielectric antenna? (Remembering)**

    A simple explosive charge design, called a plasma cartridge, can be used to generate a column of ionized gas.

    In this design, 1 to 3 gram of seeded explosive charge which contained, Fe, Pb, C, N, K, Cl and O was used to create plasma.

    Due to high temperature generated by the explosive material, the surrounding gases become ionized, forming a plasma column.
12. **List out the advantages of plasma antenna. (Remembering)**
    - ✓ Plasma posses a high level of conductivity.
    - ✓ Based on the frequency used, a plasma antenna may be able to receive signals that would be detectable by the older types of antenna, as well as boost signals that are then transmitted out to either point.
    - ✓ A plasma antenna is much less susceptible to electrical damage and can often be repaired much faster if some event does occur to temporary interfere with its function.
13. **List out the various disadvantages of plasma antenna. (Remembering)**
    - ✓ The semi-conductor version of the plasma antenna is limited to high frequencies, which makes certain applications difficult.
    - ✓ For example, Wi-Gig routers operating at 60 GHz cannot penetrate walls.
    - ✓ The ionizer increases power consumption. More energy is required to ionize the gases or to make the silicon chips release electrons.
    - ✓ Plasma volumes must be stable and repeatable. When a gas is ionized, not all 100% of the gas will ionize to become plasma.
14. **What are the applications of plasma antenna? (Remembering)**
    - ✓ Military applications for its stealth, weight and easily reconfiguration.
    - ✓ Unmanaged air vehicle sensor antennas.
    - ✓ Detection and tracking of ballistic missiles.
    - ✓ Telemetry
    - ✓ Broad band communication
    - ✓ Ground penetrating radar
    - ✓ Wind shear detection and collision avoidance.
15. **What is UWB? (Remembering)**

    Ultra wide band antennas are used for digital applications with a lot of inventions in modern telecommunication systems all the communication systems have been shifting from analog to digital communication systems
16. **List out the various applications of UWB Antenna. (Remembering)**

- ✓ Ultra-wideband characteristics are well-suited to short-distance applications, such as PC peripherals.
- ✓ High-data-rate UWB may enable wirelessmonitors, the efficient transfer of data from digital camcorders, wireless printing of digital pictures from a camera
- ✓ UWB is used for real-time location systems; its precision capabilities and low power make it well-suited for radio-frequency-sensitive environments, such as hospitals.

17. What are the different forms of GPR antennas? (Remembering)

- ✓ Monostatic
- ✓ Bistatic
- ✓ Time domain
- ✓ Crossed dipole

18. What is mean by embedded antenna? (Remembering)

An embedded antenna is nothing but a metallic conductor embedded in a dielectric material. The main purpose of embedding a metallic conductor in a dielectric is for packaging and reducing size of antenna. Also it helps in protecting against environmental conditions.

19. What is meant by antenna measurements? (Remembering)

Antenna measurements are useful for the application oriented specific designs of the antennas.

In general, the antenna measurements are carried out using the test antenna in the receiving mode.

20. List out the types of antenna measurement? (Analyzing) (AUT-June 2016)

- ✓ Impedance measurement
- ✓ Pattern measurement
- ✓ Polarization measurement
- ✓ Gain and directivity measurement
- ✓ Efficiency measurement

21. What are the different ranges present in antenna measurement?(Remembering)

- ✓ **Elevated range**---Both transmit & test antennas are situated above the ground at the same elevated height.
- ✓ **Reflection range**---The signal reflected off the ground is used to create constructive interference and hence a uniform wavefront in the region of the antenna under test.
- ✓ **Slant range**---Transmit antenna is kept very close to the ground & the test antenna along with its positioned is mounted on a non-conducting tower.
- ✓ **Indoor range**---It is not desirable to have reflecting surfaces in an antenna range.
- ✓ **Compact range**---Achieved using a reflector.

22. Show the different types of radiation pattern measurements? (Understanding)

- ✓ Far field measurements
- ✓ Near field measurements.

23. What do you mean by near field and far field of an antenna? (Remembering)

In antenna field near to the radiator is the near field or Fresnel zone

In antenna large distance as far field or Fraunhofer zone.

$$R=2L^2/\lambda$$

24. What are the possible errors in antenna measurements? (Remembering)

The possible errors in antenna measurements are

- ✓ Phase error,
- ✓ Amplitude error,
- ✓ Reflections,
- ✓ Man made error,
- ✓ Atmospheric abnormalities,
- ✓ Impedance mismatch,
- ✓ Incorrect use of cables,

25. What are the types of measurement ranges? (Remembering)

The types of measurements ranges are,

- ✓ Elevated ranges,
- ✓ Ground reflection ranges,
- ✓ Anechoic chamber,
- ✓ Compact antenna test ranges.
- ✓ Near field ranges,

26. List out the methods used for the measurement of gain of an antenna?(Analyzing)(AUT-June 2015, Dec 2016, June 2017)

- ✓ Absolute method
- ✓ Comparison method
- ✓ Partial gain method

- ✓ Radar Techniques.

27. What are the two methods of antenna impedance measurements?(Remembering)

- ✓ Bridge method for low frequency,
- ✓ Standing wave ratio method for high frequencies or slotted line methods.

28. What are the methods to measure Phase of an antenna?(Remembering)

- ✓ Direct method,
- ✓ Reference antenna method
- ✓ Differential method.

29. What are the methods to measure Efficiency of an antenna? (Remembering)

- ✓ Directivity/Gain method
- ✓ Radiometric method,
- ✓ Random field method
- ✓ Wheeler cap method.

30. List out the three methods used for measuring the polarization? (Analyzing)

- ✓ Polarization-Pattern method
- ✓ Linearly component method
- ✓ Circular Component method

31. What is the basic behind the slotted line method for impedance measurement? (Remembering)

The slotted line method of impedance measurement is based on the well known characteristics of travelling waves i.e. input impedance may be uniquely determined from the knowledge of voltage or current standing wave ratio, the spacing between the voltage or current minimum and the reference point at which the impedance is desired.

32. What is mean by standard gain antenna?(Remembering)

The antenna whose gain is accurately known and can be used for the gain measurement of other antennas.

33. Define polarization ratio or ellipticity?(Remembering)

The ratio of maximum to the minimum field intensity is known as polarization ratio or ellipticity

34. What are near and far field measurements? (Remembering)

The ***induction field*** which varies inversely as square of distance from the antenna is called ***near field***. This field will predominate at points close to the current element or antenna.

The ***radiation field*** which varies inversely as distance is known as ***far field or distant field***. This field is of great significance at a large distance.

35. List out the features of UWB antenna. (Remembering)

- ✓ Bandwidth of the UWB technique is huge. This very wide bandwidth means a fine time resolution.
- ✓ This main feature of the UWB technology provides the capability of accurate positioning which has already been used in the radar applications and is now underway in the wireless communications.
- ✓ Besides from the high performance of the UWB technique at low cost, another major feature of this technique is the very low transmit power.
- ✓ Moreover, the UWB method is robust against fading. This robustness further reduces the required transmit power of this technology.

36. Examine the special features of embedded antennas. (Remembering)(AUT-June 2016)

Good quality, low-profile, highly efficient antennas for multiple applications.

Embedded Antennas can be designed and used on printed-circuit boards (PCBs), or stamped metal antennas made from sheet metal, even ceramic designs such as Ceramic Patch antennas.

Embedded/internal antennas can be further customized by cable length and quality i.e. type, thickness, insulation, center-fed, end-fed etc.

37. What is smart antenna? (Remembering) (AUT-Dec 2016)

Smart antennas (also known as adaptive array antennas, multiple antennas and, recently, MIMO) are antenna arrays with smart signal processing algorithms used to identify spatial signal signature such as the direction of arrival (DOA) of the signal, and use it to calculate beam forming vectors, to track and locate the antenna beam on the mobile/target. Smart antennas should not be confused with reconfigurable antennas, which have similar capabilities but are single element antennas and not antenna arrays.

38. What are categories of smart antennas? (Remembering) (AUT-June 2017)

Switched beam: continually switches between antenna and connecting each of the receiving channels.

Adaptive beam array: automatically turns in desired directions and nulls are formed in undesired direction.

39. Interpret the application of smart antenna. (Understanding) (AUT-Dec 2017)

- Phased array antenna type is mainly targeted for point to point wireless systems for example wireless local loops. They are also used for microcellular Base Stations.
- Adaptive antenna arrays are used for indoor systems where in received signals arrive via widely separated paths. It is used where phased array smart antenna does not provide needed gain

16 MARKS

1. Discuss in detail about special purpose antenna.**(Creating)**
2. Explain in detail about Antenna for terrestrial mobile communication systems. **(Understanding) (AUT-Dec 2017)**
3. With neat sketch describe the embedded and plasma antennas **(AUT-June 2016)**. Mention its applications and advantages. **(Remembering)(AUT-June 2015, Dec 2015, Dec 2016, Dec 2017)**
4. Summarize the concept about UWB Antenna **(AUT-June 2017)** and GPR**(AUT-June 2016)** and mention its advantages and disadvantages.**(Applying)**
5. Discuss in detail about Smart antennas.**(Creating) (AUT-June 2017)**
6. Explain in detail about**(Understanding)**
   (i) Directivity measurement **(AUT-Dec 2017)**
   (ii) Gain Measurement **(AUT-Dec 2015, June 2016, Dec 2016, Dec 2017)**
7. With neat block diagram how Radiation pattern of an antenna can be measured. **(Remembering)(AUT-June 2015, Dec 2015, June 2016, Dec 2016, June 2017, Dec 2017)**
8. Write short notes on**(Remembering)**
   (i)Polarization **(AUT-June 2015, June 2017)**
   (ii) Impedance
   (iii) Efficiency
9. Problems and exercises.

UNIT V
WAVE PROPAGATION

1. What is propagation of waves? (Remembering)

Wave propagation is the process of communication involves the transmission of information from one location to another.

2. List the various modes of radio wave propagation.(Analyzing) (AUT-June 2017)

- ✓ Sky wave propagation or Ionospheric propagation
- ✓ Space wave propagation
- ✓ Ground wave propagation or surface wave propagation

3. List out the applications of wave propagation.(Analyzing)

- ✓ Radio direction finding
- ✓ Radar application
- ✓ Satellite control & application
- ✓ Control of a machine from remote place
- ✓ Transmission of information over a required distance

4. Define Sky wave. (Remembering)

Waves that arrive at the receiver after reflection in the ionosphere is called sky wave. In this propagation type the electromagnetic wave is refracted back by the ionosphere to the earth's surface.

5. Define Ground wave Propagation. (Remembering)

The propagation of electromagnetic waves near the surface of the earth including propagation in the troposphere is called ground wave propagation.

Here, the transmitting and receiving antennas are close to the surface of the earth and are vertically polarized.

Example: useful for communication VLF, LF and MF.

6. What are the types of Ground wave? (Remembering)

Ground wave classified into two types.

- ✓ Space wave
- ✓ Surface wave.

7. What is meant by Space Wave? (Remembering)

It is made up of direct wave and ground reflected wave. Also includes the portion of energy received as a result of diffraction around the earth surface and the reflection from the upper atmosphere.

8. What is meant by Surface Wave? (Remembering)

Wave that is guided along the earth's surface like an EM wave is guided by a transmission is called surface wave. Attenuation of this wave is directly affected by the constant of earth along which it travels.

9. List out the features of ground wave propagation. (Remembering)

- ✓ Ground waves propagate by gliding over the surface of the earth.
- ✓ It exists for vertically polarized antennas.
- ✓ Ground wave field strength varies with the characteristics of the earth.
- ✓ Ground waves required relatively high transmitting power.
- ✓ They are not affected by the changes in atmospheric conditions.

10. What are the uses of ground wave propagation? (Remembering)

- ✓ It is suitable for very low frequency (VLF), low frequency (LF) and medium frequency (MF) communications.
- ✓ Frequency range used is 15 kHz to 2 MHz.
- ✓ It can be used for radio navigation, maritime mobile communications and for broad casting.

11. What is free space propagation?(Remembering)

Free space implies an infinite space without any medium or objects that can interact with the electromagnetic waves.

12. What is space wave propagation?(Remembering)

In space wave propagation, the radio wave travels directly from the transmitting antenna to the receiving antenna. It is otherwise called as **line of sight propagation.**

13. Why space wave propagation is called as line of sight propagation?(Remembering)

For space wave propagation the transmitting and receiving antennas must be able to see each other. There must be a line of sight path between them. That's why space wave propagation is called as line of sight propagation.

14. What are all the factors affecting ground reflection?(Remembering)

- ✓ Angle of incidence
- ✓ Polarization of wave
- ✓ Electrical properties(conductivity & dielectric constant) of the ground
- ✓ Frequency of the propagating wave

15. What are the uses of surface wave propagation? (Remembering)

- ✓ It is suitable for short distance communication
- ✓ The frequency ranges from few kHz to several MHz.
- ✓ For AM broadcast applications, a vertical monopole above the ground is used to radiate power in the MW frequency band.

16. Define wave tilt. (Remembering)

Wave tilt is defined as the change of orientation of the vertically polarized wave at the surface of the earth.

17. List out the salient features of wave tilt of surface wave. (Remembering)

- ✓ Wave tilt occurs at the surface of the earth. It depends on conductivity and permittivity of the earth.
- ✓ It causes power dissipation.
- ✓ Wave tilt changes the original vertically polarized wave into elliptically polarized wave.

18. What is meant by Diffraction? (Remembering)

The bending of the path of electromagnetic waves around sharp edges and corners of obstacles appearing in their path is known as diffraction.

19. Define Tropospheric wave.(Remembering)

Waves that arrive at the receiver after reflection from the troposphere region is called Tropospheric wave. (ie 10 Km from Earth surface).

20. Define Refractive index? (Remembering)

The refractive index is a measure for how much speed of radio waves is reduced inside the medium. It is the ratio between the phase velocities of a wave in the reference medium to the phase velocity in the medium itself.

$$\eta_r = c/v_{ph}$$

Where c= velocity of wave in air medium

v_{ph}=Phase velocity of wave

21. What is Snell's law? (Remembering)

The ratio between the sine angle of incident wave to the sine angle of refracted wave at the surface of a medium is constant. $\mu = \sin i / \sin r$

22. What is Tropospheric Scatter?(Remembering) (Remembering)

Tropospheric scatter is a mechanism by which propagation is possible by the scatterand diffracted rays. This scattering takes place in the Tropospheric region.

Due to this scatter, receivers even at shadow zone gets large filed strength.

23. What is meant by line of sight? (Remembering)

Line of sight is defined as the distance that is covered by a direct wave from the transmitting antenna to the receiving antenna.

24. Define radio horizon. (Remembering)

It is defined as the locus of the distant point at which direct rays from the antenna become tangential to a planetary surface. The horizon is a circle on a spherical surface.

25. Define optical horizon. (Remembering)

It is the maximum distance between the two antennas along the surface of the earth, for which the line AB just touches the surface of the earth.

Optical horizon, $d = r_o (\Theta_1 + \Theta_2)$

Where, r_o = radius of the earth

26. List out the uses of troposcatter. (Remembering)

- ✓ Troposcatter is used to establish communication links in the UHF and microwave frequency bands.
- ✓ Distance coverage is upto 1000km
- ✓ Bandwidth utilized is few MHz.

27. List out the application of troposcatter. (Remembering)

- ✓ Troposcatter link can be used in multi-channel telephony.
- ✓ Television applications.

28. What is Ionosphere?(Remembering)

Ionosphere is the region of upper atmosphere that extends from about 30 miles above the surface of the earth to about 250 miles.

29. Define plasma frequency. (Remembering)

Plasma frequency is defined as the natural frequency of oscillations of charged particles in plasma region. Plasma is a completely ionized gas at very high temperature consisting of the charged nuclei and negative electrons.

30. What is meant by fading and how fading can be compensated? (Remembering)(AU-June 2013) (AUT-June 2015)

Variation of signal strength occurs on line of sight paths as a result of the atmospheric conditions and it is called fading .It cannot be predicted properly.

To minimize the fading Diversity reception techniques is used.

31. Show the different types of fading.(Understanding)

- ✓Slow fading,
- ✓Fast fading
- ✓Selective fading
- ✓Skip fading
- ✓Absorption fading
- ✓Polarization fading
- ✓Interference fading.

32. Define Ionosonde?(Remembering)

The measurement of virtual height is normally carried out by means of an instrument called as ionosonde

33. Classify the different types of layers present in ionosphere.(Analyzing) OR Outline some ionosphere abnormalities.(AUT-June 2016)

- ✓D layer
- ✓E layer
- ✓Sporadic E layer and F layer

34. Define Ionospheric storms?(Remembering)

Ionospheric storms are nothing but disturbances in the earth's magnetic fields. The reason behind Ionospheric storms is high absorption of sky waves and abnormal changes in critical frequency of E and F_2 layers. Ionospheric storms are associated with both solar equations as well as rotation of the sun.

35. Define secant law?(Remembering)

$$F_{muf} = F_c \sec i$$

Where F_{muf} is greater than Fc by a factor seci.

This is known as secant law, which gives the maximum frequency used for sky wave communication.

36. Define maximum Usable Frequency.(Remembering)(problem based on MUF formula AU-Dec 2015)(AUT-June 2016)

It is defined as the highest frequency of wave that is reflected by a particular Ionospheric layer at an angle of incidence other than normal (vertical incidence).

It depends on the time of a day, distance, direction, season and solar activity.

$$f_{muf} = f_c\sqrt{\frac{d^2}{4h^2}+1}$$

Where, h-height of the layer,

d -Distance b/w transmits and receive antenna

f_c- critical frequency

37. Define skip distance.(Remembering)(AU-Dec 2013) (AU-Dec 2014)

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

$$d_s = 2h\sqrt{\frac{f^2{}_{muf}}{f^2{}_c}-1}$$

Where, h = Height of the layer from earth

f_{muf} = Maximum usable frequency

f_c= Critical frequency

38. Define Optimum frequency?(Remembering)

Optimum frequency for transmitting between any two points is therefore selected as some frequency lying between about 50 and 85 percent of the predicted maximum usable frequency between those points.

39. Define critical frequency?(Remembering) (AUT-Dec 2016)

It is the highest frequency of the wave that is reflected back from ionospheric layer and it is determined by the maximum electron density of that layer.

Critical Frequency, $F_c=9\sqrt{N_{max}}$

Where N_{max}= Maximum electron density of the layer

40. Define virtual height?(Remembering)

The virtual height is defined as the apparent height of an Ionospheric layer estimated from the time interval between the transmitted signal and the Ionospheric echo at the receiver at vertical incidence, provided the velocity of propagation is $3*10^8$ m/s over the entire path.

It is defined as the height that is reached by a short pulse of energy which has the same time delay as the original wave.

Virtual height > Actual height

41. What is meant by diversity reception?(Remembering)

To minimize the fading and to avoid the multi path interference thetechnique used are diversity reception. It is obtained by following ways.

- ✓ Space diversity reception.
- ✓ Frequency diversity reception.
- ✓ Polarization diversity.

42. Define Space diversity Reception.(Remembering)

This method exploits the fact that signals received at different locations donot fade together. It requires antenna spaced at least 100 l apart are referred andthe antenna which high signal strength at the moment dominates.

43. Define frequency diversity Reception.(Remembering)(AUT-Dec 2015)

This method takes advantage of the fact that signals of slightly differentfrequencies do not fade synchronously. This fact is utilized to minimize fading in radio telegraph circuits.

44. Define polarization diversity reception.(Remembering)

It is used in normally in microwave links, and it is found that signaltransmitted over the same path in two polarizations have independent fadingpatterns. In broad band dish antenna system, Polarization diversity combinedwith frequency diversity reception achieves excellent results.

45. What is the critical frequency for reflection at vertical incidence if the maximum value of electron density is $1.24*10^6 cm^{-3}$?(Remembering)

Given $N_{max}=1.24*10^6 cm^{-3}$

Criticalfrequency,$f_c=9\sqrt{N_{max}}$

$=9\sqrt{1.24*10^6 cm^{-3}}$

$= 10.02x10^3$ KHz

f_c= 10.02 MHz.

46. Define gyro frequency.(Remembering)(AU-Dec 2013)

Gyro frequency is defined as the lowest natural frequency at which charged particles follow spiral path in a fixed magnetic field.

It is expressed as

$$f_g = \frac{1}{2\pi}\left(\frac{QeB}{m}\right)$$

Where, B = magnetic flux density in wb/m^2

Q_e = charge of the particles in coulombs

m = mass of the particles in kg

47. Define cutoff frequency?(Remembering)

The frequency at which the attenuation of a waveguide increases sharply and below which a traveling wave in a given mode cannot be maintained. A frequency with a half wavelength that is greater than the wide dimension of a waveguide.

48. Define Magneto-Ions Splitting.(Remembering)

The phenomenon of splitting the wave into two different components(ordinary and extra-ordinary) by the earth's magnetic field is called Magneto-Ions Splitting.

49. Define LUHF?(Remembering)

The lowest useful HF for a given distance and transmitter power is definedas the lowest frequency that will give satisfactory reception for that distanceand power.It depends on

- ✓ The effective radiated power
- ✓ Absorption character of ionosphere for the paths between transmitterand receiver.
- ✓ The required field strength which in turn depends upon the radionoise at the receiving location and type of service involved.

50. Define group delay? (Remembering)

Group delay is a measure of the time delay of the amplitude envelopes of the various sinusoidal components of a signal through a device under test, and is a function of frequency for each component.

51. What is standing wave ratio? (Remembering)

It is the ratio of maximum voltage to minimum voltage.SWR is used as an efficiency measure for transmission lines, electrical cables that conduct radio frequency signals, used for purposes such as connecting radio transmitters and receivers with their antennas, and distributing cable television signals.

$$\mathbf{VSWR = V_{max}/V_{min}}$$

52. What is meant by duct propagation?(Remembering)(AU-June 2014) (AUT-Dec 2015, Dec 2016)

Ducts are formed between the layers of different temperature and water vapour contents in air. Duct guides EM waves between its walls.The higher frequency or microwaves are continuously refracted in the duct and reflected by the ground.

In duct region, Variation of modified refractive index with height is minimum.

53. What is meant by Faraday rotation?(Remembering)(AUT-June 2015)

The rotation of the plane of polarization of a plane wave when it passes through the ionosphere is known as the Faraday rotation. The wave entering the ionosphere will split into ordinary and extra ordinary waves/modes.

When these modes re-emerge from the ionosphere they recombine into a single plane wave again.

Finally the plane of polarization will usually have changed, this phenomenon is known as Faraday's rotation.

54. What are the factors that affect radio wave propagation? (Remembering)(AU-June 2014, Dec 2014) (AUT- Dec 2017)

There are several factors that affect the radio wave propagations are,

- ✓ Earth's characteristics in terms of conductivity, permittivity and permeability.
- ✓ Curvature of the earth, Roughness of the earth
- ✓ Frequency of operation
- ✓ Polarization and height of the transmitting antenna
- ✓ Characteristics if ionosphere

55. Find the maximum distance that can be covered by a space wave, when the antenna heights are 60 m and 120 m. (Remembering) (AUT-June 2017)

$$d=1.4142[\sqrt{ht}+\sqrt{hr}] = 1.4142\,[\sqrt{60}+\sqrt{120}]$$

$$\mathbf{d= 26.446\ m}$$

<u>16 MARKS</u>

1. Explain in brief about various types of wave propagation.**(Understanding) (AUT-Dec 2017)**
2. Explain the important features of ground wave propagation? **(Understanding)**

3. Explain attenuation characteristics of ground wave propagation and obtain expression for field strength. **(Understanding) (AUT-Dec 2016)**
4. Discuss the effects of earth surface on ground wave propagation. **(Creating)(AUT-June 2015)**
5. Describe about troposphere and explain how ducts can be used for radio wave or Microwave propagation. **(Creating)(AUT-June 2015, June 2017)**
6. Derive an expression for Reflection from ground for vertically and horizontally polarized waves. **(Applying)**
7. Write short notes on Reflection characteristics of earth and derive the expression for field in resultant of direct and reflected ray at the receiver. **(Applying)**
8. What is ionosphere? Discuss in detail about the structure of ionosphere?**(Remembering) (AUT-June 2017,Dec 2017) OR**

   Describe the structure of the atmosphere and specify the factors affecting the radio wave propagation. **(Creating) OR**

   Draw a neat sketch and explain the different ionized regions of ionosphere above the earth's surface. **(Understanding) (AUT-Dec 2016)**
9. Describe the composition of the ionosphere. Derive the expression for the effective dielectric constant of an Ionospheric medium.**(Creating)**
10. Obtain the expression for the refractive index of an Ionospheric layer**.(Remembering)**
11. Explain the mechanism of refraction in ionosphere propagation with neat diagram.**(Understanding)(AUT-June 2015) OR**

    Why do we use high frequency waves in sky wave propagation? Explain the mechanisms of propagation. **(Evaluating) (AUT-June 2017)**
12. Discuss in detail about fading and diversity reception. Explain its types. **(Creating) (AUT-Dec 2016) OR**

    Distinguish between fading and diversity. **(Analyzing) (AUT-Dec 2017)**
13. Explain the following: **(Understanding)**
    (i)Maximum Usable Frequency (MUF) **(AUT-June 2015, Dec 2015, June 2016, Dec 2016)**
    (ii) Attenuation characteristics for ground wave propagation
14. Explain the following term in detail: **(Understanding)**
    (i) Refractive index
    (ii) Critical frequency **(AUT-Dec 2015)**
    (iii) Skip distance **(AUT-June 2015, Dec 2015, June 2016, Dec 2016)**
    (iv) Diversity Reception **(AUT-June 2015, June 2017)**
    (v) Virtual heights **(AUT-Dec 2015, Dec 2016)**
    (vi) Optimum working frequency **(AUT-June 2016)**
15. What is space wave propagation? Explain the atmospheric effects in space wave propagation. **(Understanding) (AUT-June 2016)**
16. Describe in detail about the reflection of radio waves by the surface of earth.**(Remembering) (AUT-June 2016)**
17. Write short notes on **(AUT-Dec 2015)**
    (i) Selective and interference fading
    (ii) Lowest usable high frequency
    (iii) Field strength calculation for radio AM broad cast waves
18. Derive an expression for calculating field strength at a distance in space wave propagation. **(Evaluating) (AUT-Dec2017)**
19. Problems and exercises.