Indian Institute of Technology Hyderabad

GATE Problems in Antenna and Wave Propogation

Teaching Learning Center IIT Hyderabad

1) A medium wave radio transmitter operating at a wavelength of 492 m has a tower antenna of height 124m. What is the radiation resistance of the antenna?

(A) $25\,\Omega$ (B) $36.5\,\Omega$ (C) $50\,\Omega$ (D) $73\,\Omega$

2) In a uniform linear array, four isotropic radiating elements are spaced $\frac{\lambda}{4}$ apart. The progressive phase shift between the elements required for forming the main beam at $60°$ off the end-fire is

(A) $-\pi$ radians (C) $-\frac{\pi}{4}$ radians

(B) $-\frac{\pi}{2}$ radians (D) $-\frac{\pi}{8}$ radians

3) For a Hertz dipole antenna, the Half Power Beam Width (HPBW) in the E-plane is

(A) $360°$ (B) $180°$ (C) $90°$ (D) $45°$

4) At 20 GHz, the gain of a parabolic dish antenna of 1 meter diameter and 70% efficiency is

(A) 15 dB (B) 25 dB (C) 35 dB (D) 45 dB

5) For an antenna radiating in free space, the electric field at a distance of 1 km is found to be 12 mV/m. Given that intrinsic impedance of the free space is $120\pi\Omega$, the magnitude of average power density due to this antenna at a distance of 2 km from the antenna (in nW/m^2) is ....

6) Match Column A with Column B.

Column A	Column B
1.Point electromagnetic source	P.Highly directional
2.Dish antenna	Q.End fire
3.Yagi-Uda antenna	R.Isotropic

(A) $1 \rightarrow$ P, $2 \rightarrow$ Q, $3 \rightarrow$ R

(C) $1 \rightarrow$ Q, $2 \rightarrow$ P, $3 \rightarrow$ R

(B) $1 \rightarrow$ R, $2 \rightarrow$ P, $3 \rightarrow$ Q

(D) $1 \rightarrow$ R, $2 \rightarrow$ Q, $3 \rightarrow$ P

7) In spherical coordinates, let $\hat{a}_\theta$, $\hat{a}_\phi$ denote unit vectors along the θ, ϕ directions.

$$\text{E} = \frac{100}{r}\sin\theta\cos(\omega t - \beta r)\hat{a}_\theta \text{V/m}$$

and

$$\text{H} = \frac{0.265}{r}\sin\theta\cos(\omega t - \beta r)\hat{a}_\theta \text{A/m}$$

represent the electric and magnetic field components of the EM wave at large distance r from a dipole antenna, in free space. The average power (W) crossing the hemispherical shell located at $\text{r} = 1\text{km}, 0 \leqslant \theta \leqslant \frac{\pi}{2}$ is ....

8) The directivity of an antenna array can be increased by adding more antenna elements, as a larger number of elements

(A) improves the radiation efficiency

(B) increases the effective area of the antenna

(C) results in a better impedance matching

(D) allows more power to transmitted by the antenna

9) An antenna pointing in a certain direction has a noise temperature of 50K. The ambient temperature is 290K. The antenna is connected to a pre-amplifier that has a noise figure of 2dB and an available gain of 40dB over an effective bandwidth of 12MHz. The effective input noise temperature T_e for the amplifier and the noise power P_{ao} at the output of the preamplifier, respectively, are

(A) $T_e = 169.36K$, $P_{ao} = 3.73 \times 10^{-10}W$

(C) $T_e = 182.5K$ $P_{ao} = 3.85 \times 10^{-10}W$

(B) $T_e = 170.8K$, $P_{ao} = 4.56 \times 10^{-10}W$

(D) $T_e = 160.62K$ $P_{ao} = 4.6 \times 10^{-10}W$

10) Two lossless X-band horn antennas are separated by a distance of 200λ. The amplitude reflection coefficients at the terminals of the transmitting and receiving antennas are 0.15 and 0.18, respectively. the maximum directivities of the transmitting and receiving antennas (over the isotropic antenna) are 18dB and 22dB, respectively. Assuming that the input power in the lossless transmission line connected to the antenna is 2W, and that the antennas are perfectly aligned and polarization matched, the power (in mW) delivered to the load at the receiver is.........

11) The far-zone power density radiated by a helical antenna is approximated as:

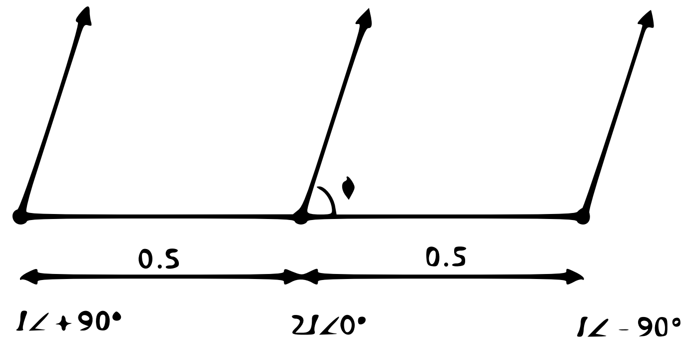

Fig. 1.

$$\vec{W}_{rad} = \vec{W}_{average} \approx \hat{a}_r C_0 \frac{1}{r^2} \cos^4\theta$$

The radiated power density is symmetrical with respect to ϕ and exists only in the upper hemisphere: $0 \leqslant \theta \leqslant \frac{\pi}{2}; 0 \leqslant \phi \leqslant 2\pi$; C_0 is a constant. The power radiated by the antenna (in watts) and the maximum directivity of the antenna, respectively, are

(A) $1.5C_0$, 10dB

(C) $1.256C_0$, 12dB

(B) $1.256C_0$, 10dB

(D) $1.5C_0$, 12dB

12) Two half-wave dipole antennas placed as shown in the figure are excited with sinusoidally varying currents of frequency 3MHZ and phase shift of $\frac{\pi}{2}$ between them (the element at the origin leads in phase). If the maximum radiated E-field at the point P in the *x-y* plane occurs at an azimuthal angle of 60°, the distance d(in meters) between the antennas is ....

13) The electric field of a plane wave propogating in a lossless non-magnetic medium is given by the following expression

$$E(z,t) = a_x 5\cos(2\pi \times 10^9 t + \beta z) + a_y 3\cos(2\pi \times 10^9 t + \beta z - \frac{\pi}{2})$$

The type of the polarization is

(A) Right Hand Circular (C) Right Hand Elliptical

(B) Left Hand Elliptical (D) Linear

14) The electric field intensity of a plane wave travelling in free space is given by the following expression

$$E(x,t) = a_y 24\pi \cos(\omega t - k_0 x)(\text{V/m})$$

In this field, consider a square area 10cm × 10cm on a plane x+y=1. The total time-averaged power (in mW) passing through the square area is ....

15) Consider a wireless communication link between a transmitter and a receiver located in free space, with finite and strictly positive capacity. If the effective areas of the transmitter and the receiver antennas, and the distance between them are all doubled, and everything else remains unchanged, the maximum capacity of the wireless link

(A) increases by a factor of 2

(B) decreases by a factor of 2

(C) remains unchanged

(D) decreases by a factor of $\sqrt{2}$

16) A half wavelength dipole is kept in the x-y plane and oriented along $45°$ from the x-axis. Determine the direction of null in the radiation pattern for $0 \leqslant \phi \leqslant \pi$. Here the angle $\theta(0 \leqslant \theta \leqslant \pi)$ is measured from the z-axis, and the angle $\phi(0 \leqslant \phi \leqslant 2\pi)$ is measured from the x-axis in the x-y plane.

(A) $\theta = 90°, \phi = 45°$ (C) $\theta = 90°, \phi = 135°$

(B) $\theta = 45°, \phi = 90°$ (D) $\theta = 45°, \phi = 135°$

17) A parabolic dish antenna has a conical beam $2°$ wide, the directivity of the antenna is approximately

(A) 20 dB (B) 30 dB (C) 40 dB (D) 50 dB

18) The vector H in the far field of an antenna satisfies

(A) $\nabla.\vec{H} = 0$, $\nabla \times \vec{H} = 0$ (C) $\nabla.\vec{H} = 0$, $\nabla \times \vec{H} \neq 0$

(B) $\nabla.\vec{H} \neq 0$, $\nabla \times \vec{H} \neq 0$ (D) $\nabla.\vec{H} \neq 0$, $\nabla \times \vec{H} = 0$

19) The radiation resistance of a circular loop of one turn is 0.01Ω. The radiation resistance of five turns of such a loop will be

(A) 0.002Ω (C) 0.05Ω

(B) 0.01Ω (D) 0.25Ω

20) An antenna in free space receives 2μW of power when the incident electric field is 20mV/m rms. The effective aperture of the antenna is

(A) 0.0005m^2 (C) 1.885m^2

(B) 0.05m^2 (D) 3.77m^2

21) The frequency range for satellite communication is

(A) 1kHz to 100kHz (C) 10MHz to 30MHz

(B) 100kHz to 10kHz (D) 1GHz to 30GHz

22) If the diameter of $\frac{\lambda}{2}$ dipole antenna is increased from $\frac{\lambda}{100}$ to $\frac{\lambda}{50}$, then its

(A) bandwidth increases (C) gain increases

(B) bandwidth decreases (D) gain decreases

23) For an 8 feet (2.4m) parabolic disk antenna operating at 4 GHz, the minimum distance required for far field measurement is closest to

(A) 7.5 cm (C) 15 m

(B) 15 cm (D) 150 m

24) Two identical antennas are placed in the $\theta = \frac{\pi}{2}$ plane as shown in Fig. 2. The elements have equal amplitude excitation with $180°$ polarity difference, operating at wavelength λ. The correct value of the magnitude of the far-zone resultant electric field strength normalized with that of a single element, both computed for $\phi = 0$, is

(A) $2\cos\left(\dfrac{2\pi s}{\lambda}\right)$ (C) $2\cos\left(\dfrac{\pi s}{\lambda}\right)$

(B) $2\sin\left(\dfrac{2\pi s}{\lambda}\right)$ (D) $2\sin\left(\dfrac{\pi s}{\lambda}\right)$

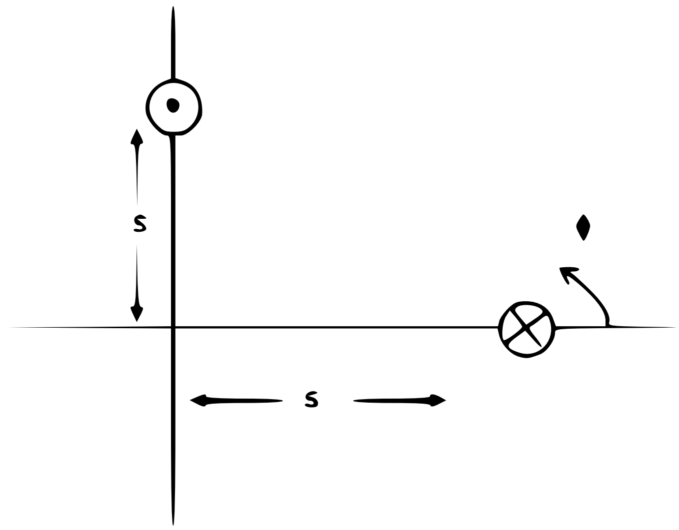

Fig. 2.

25) Consider a lossless antenna with a directive gain of +6db. If 1mW of power is fed to it the total power radiated by the antenna will be

(A) 4mW (B) 1mW (C) 7mW (D) $\dfrac{1}{4}$mW

26) A transmission line is feeding 1 Watt of power to a horn antenna having a gain of 10dB. The antenna is matched to the transmission line. The total power radiated by the horn antenna into the free-space is:

(A) 10 Watts (C) 0.1 Watt

(B) 1 Watt (D) 0.01 Watt

27) A mast antenna consisting of a 50 meter long vertical conductor operates over a perfectly conducting ground plane. It is base-fed at a frequency of 600 kHz. The radiation resistance of the antenna in Ohms is:

(A) $\dfrac{2\pi^2}{5}$ (C) $\dfrac{4\pi^2}{5}$

(B) $\dfrac{\pi^2}{5}$ (D) $20\pi^2$

28) The radiation pattern of an antenna in spherical co-ordinates is given by

$$F(\theta) = \cos^4\theta; 0 \leqslant \theta \leqslant \frac{\pi}{2}$$

The directivity of the antenna is

(A) 10dB (C) 11.5dB

(B) 12.6dB (D) 18dB

29) A radio wave is incident on a layer of ionospher at an angle of 30 degree with the verti-

cal. If the critical frequency is 1.2 MHz, the maximum usable frequency is

(A) 1.2 MHz
(C) 0.6 MHz

(B) 2.4 MHz
(D) 1.386 MHz

30) In a broad side array of 20 isotropic radiators, equally spaced at a distance of $\frac{\lambda}{2}$, the beam width between first nulls is

(A) 51.3 degrees
(C) 22.9 degrees

(B) 11.46 degrees
(D) 102.6 degrees

31) The beam width between first null of uniform linear array of N equally spaced (element spacing = d), equally excited antennas is determined by

(A) N alone and not by d
(C) the ratio, $\left(\frac{N}{d}\right)$

(B) a alone and not by N
(D) the product, (Nd)

32) For a dipole antenna

(A) the radiation intensity is maximum along the normal to the dipole axis

(B) the current distribution along its length is uniform irrespective of the length

(C) the effective length equals its physical length

(D) the input impedance is independent of the location of the feed-point

33) An antenna, when radiating, has a highly directional radiation pattern, when the antenna is receiving, its radiation pattern

(A) is more effective
(C) is the same

(B) is less directive
(D) exhibits no directivity at all

34) A transverse electromagnetic wave with circular polarization is received by a dipole antenna. Due to polarization mismatch, the power transfer efficiency from the wave to the antenna is reduced to about

(A) 50% (B) 35.3% (C) 25% (D) 0%

35) A 1km long microwave link uses two antennas each having 30dB gain. If the power transmitted by one antenna is 1W at 3GHz, the power received by the other antenna is approximately

(A) 98.6μW
(C) 63.4μW

(B) 76.8μW
(D) 55.2μW

36) A transmittin antenna radiates 251W isotropically. A receiving antenna, located 100m away from the transmitting antenna, has an effective aperture of $500cm^2$. The total received by the antenna is

(A) 10μW
(C) 20μW

(B) 1μW
(D) 100μW

37) A person with areceiver is 5km away from the transmitter. What is the distance that this person must move further to detect a 3-dB decrease in signal strength?

(A) 942m
(C) 4978m

(B) 2070m
(D) 5320m

38) The line-of-sight communication requires the transmit and receive antennas to face each

other. If the transmit antenna is vertically polarized, for best reception the receive antenna should be

a) horizontally polarized

b) vertically polarized

c) at $45°$ with respect to horizontal polarization.

d) at $45°$ with respect to vertical polarization.

39) Two dipoles are so feed and oriented in free space that they produce the following electromagnetic waves:

$$E_x = 10e^{f\left(\omega t - \frac{z\pi}{3}\right)} \text{volts/metre}$$

$$E_x = j10e^{f\left(\omega t - \frac{z\pi}{3}\right)} \text{volts/metre}$$

(A) Write down the expression for the corresponding magnectic field strength vector.

(B) Calculate the frequency of the wave.

(C) Given the complete description of the polarization of the wave.

40) Elements of a linear array of three equally spaced (element spacing = 0.5λ) vertical mast radiators, are excited as given in Fig. 3. For the horizontal plane radiation pattern of the array, determine the direction of the major lobe (main lobe or principal lobe), and calculate its half-power beam width in degrees.

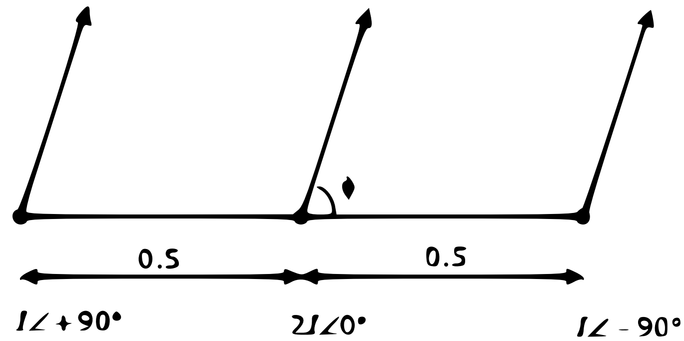

Fig. 3.

41) In the radiation pattern of a 3-element array of isotropic equally spaced at distances of $\frac{\lambda}{4}$ it is required to place a null at an angle of 33.56 degrees off the end-fire direction. Calculate the progressive phase shifts to be applied to the elements.Also calculate the angle at which the main beam is placed for this distribution.