Antennas

1. 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

[GATE 1994: 1 Mark]

Soln. A dipole antenna is a linear antenna, usually fed in the center and producing maximum of radiation in the plane normal to the axis.

It is said to be short dipole when length is less than $\lambda/4$ and current distribution is sinusoidal.

Radiation intensity is maximum along the normal to the dipole axis.

Option (a)

2. An antenna when radiating, has a highly directional radiation pattern. When the antenna is receiving its radiation pattern
   (a) Is more directive
   (b) Is less directive
   (c) Is the same
   (d) Exhibits no directivity all

[GATE 1998: 1 Mark]

Soln. An antenna is a reciprocal device, whose characteristics are same when it is transmitting or receiving.

Thus, an antenna when radiating has a highly directive radiation pattern, the receiving antenna will also have the same pattern.

Option (c)

3. The vector $\vec{H}$ in the far field of an antenna satisfies
   (a) $\nabla.\vec{H} = 0 \; and \; \nabla \times \vec{H} = 0$
   (b) $\nabla.\vec{H} \neq 0 \; and \; \nabla \times \vec{H} \neq 0$
   (c) $\nabla.\vec{H} = 0 \; and \; \nabla \times \vec{H} \neq 0$
   (d) $\nabla.\vec{H} \neq 0 \; and \; \nabla \times \vec{H} = 0$

[GATE 1998: 1 Mark]

Soln. $\boldsymbol{\nabla.\vec{H} = 0}$,

Since, lines of magnetic flux are continuous (closed loops)

$$\nabla \times \vec{H} = \vec{J}_C + \vec{J}_D$$

$\vec{J}_C$ − **conduction current**

$\vec{J}_D$ − **Displacement current**

$$J_D = 0$$

$\nabla \times \vec{H} = \vec{J}_C$ **i.e. Non Zero**

Thus Option (c)

4. 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) 0.002 Ω
   (b) 0.01 Ω
   (c) 0.05 Ω
   (d) 0.25 Ω

[GATE 1998: 1 Mark]

Soln. Radiation resistance of loop antenna is given by

$$R_{rad} = 31,200 \left[\frac{\eta A}{\lambda^2}\right]^2$$

Where,

η − **Number of turns**

A − **Area of loop**

λ − **Operating wavelength**

$$R_{rad} \propto \eta^2$$

For,

1 turn loop, $R_{rad} = 0.01\ \Omega$

Thus,

For 5 turn loop

$$R_{rad} = 5^2(0.01)$$

$$= 0.25\ \Omega$$

Option (d)

5. An antenna in free space receives $2\mu\ W$ of power when the incident electric field is 20 mV/m rms. The effective aperture of the antenna is

(a) $0.005\ m^2$
(b) $0.05\ m^2$
(c) $1.885\ m^2$
(d) $3.77\ m^2$

[GATE 1998: 1 Mark]

Soln. RMS value of incident Electric field $(\boldsymbol{E}) = \mathbf{20}\ \boldsymbol{mV/m}$

Power density $(\boldsymbol{P_d}) = \frac{\boldsymbol{E^2}}{\boldsymbol{\eta}}$

$$= \frac{(\mathbf{20\times10^{-3}})^2}{\mathbf{120}\ \boldsymbol{\pi}} = \mathbf{1.061\times10^{-6}}\ \boldsymbol{w/m^2}$$

Received power $(\boldsymbol{P_d}) = \mathbf{2}\boldsymbol{\mu W} = \mathbf{2\times10^{-6}}\boldsymbol{W}$

Effective Aperture $(\boldsymbol{A_C}) = \frac{\boldsymbol{P_r}}{\boldsymbol{P_d}}$

$$= \frac{\mathbf{2\times10^{-6}}}{\mathbf{1.06\times10^{-6}}} = \mathbf{1.885}\boldsymbol{m^2}$$

Option (c)

6. The far field of an antenna varies with distance r as

(a) 1/r
(b) $1/r^2$
(c) $1/r^3$
(d) $1/\sqrt{r}$

[GATE 1998: 1 Mark]

Soln. The fields around the antenna may be divided into

(i) Near field (Fresnel Field)
(ii) Far field (Fraunhofer field)

Near field varies with distance

as $\mathbf{1}/\boldsymbol{r^2}$

Far field varies with distance

as $\mathbf{1}/\boldsymbol{r}$

Option (a)

7. If the diameter of a $\lambda/2$ dipole antenna is increased from $\lambda/100$ to $\lambda/50$ then its
(a) Bandwidth increases
(b) Bandwidth decreases
(c) Gain increases
(d) Gain decreases

[GATE 2000: 1 Mark]

Soln. **$\lambda/2$ dipole is a resonant (narrow band) antenna.**

Gain of the antenna is directly proportional to efficiency.

Radiation efficiency $(\boldsymbol{\eta}) = \frac{R_{rad}}{R_{rad}+R_L}$

Where

R_{rad} **– Radiation resistance**

R_L - Loss resistance

As the diameter of the dipole antenna increases (area of wire increases) the loss resistance which is proportional to $1/Area$ decreases

Thus efficiency increases

Hence gain increases

Option (c)

8. 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 receiver antenna should be
(a) Horizontally polarized
(b) Vertically polarized
(c) At 45^0 with respect to horizontal polarization
(d) At 45^0 with respect to vertical polarization

[GATE 2002: 1 Mark]

Soln. **In line of sight (LOS) communication transmit and receive antennas face each other and should have same polarization.**

When transmitting antenna is vertically polarized, then receiving antenna should also be vertically polarized

Option (b)

9. Consider a lossless antenna with a directive gain of +6 dB. If 1 mW of power is fed to it the total power radiated by the antenna will be
(a) 4 mW
(b) 1 mW
(c) 7 mW
(d) 1/4 mW

[GATE 2004: 1 Mark]

Soln. Lossless antenna with directive gain of +6dB = 4 (In linear)

Input power to antenna = 1 mW

Power radiated by antenna = 4 mW

Directive gain = $\boldsymbol{\frac{Radiated\ Power}{Antenna\ Feed\ Power} = 4}$

Thus,

Radiated power $\boldsymbol{4 \times 1\ mW = 4\ mW}$

Option (a)

10. A transmission line is feeding 1 Watt of power to a horn antenna having a gain of 10 dB. The antenna is matched to the transmission line. The total power radiated by the horn antenna into the free – space is
(a) 10 Watts
(b) 1 Watt
(c) 0.1 Watt
(d) 0.0 Watt

[GATE 2008: 1 Mark]

Soln. Power input to horn antenna = 1 W

Gain of antenna = 10 dB = 10 (Linear)

Power radiated = $\boldsymbol{10 \times 1 = 10\ watts}$

Option (a)

11. For a Hertz dipole antenna, the half power beam width (HPBW) in the E – plane is
(a) 360^0
(b) 180^0
(c) 90^0
(d) 45^0

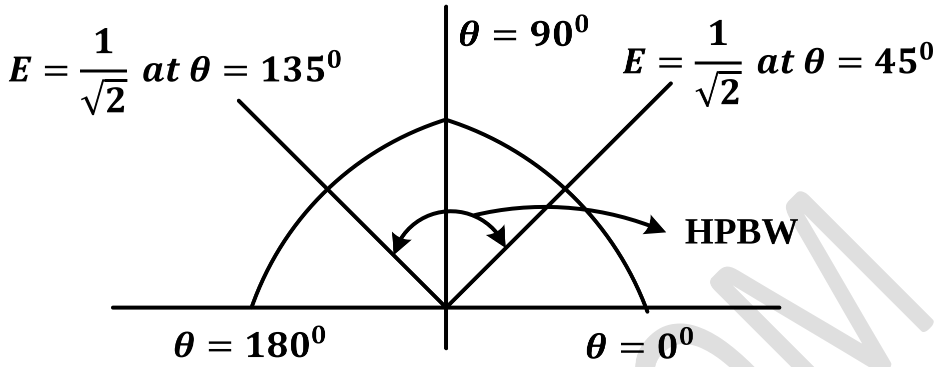
[GATE 2008: 1 Mark]

Soln. Hertzian dipole is a short linear antenna, which is assumed to carry constant current along its length.

The E_0, field component is

$E_\theta \propto \sin\theta$

Then half power beam width (HPBW) in E- plane is as shown in Fig.



So half power beam width is 90^0

12. The radiation pattern of an antenna in spherical co – ordinates is given by
$F(\theta) = cos^4\theta$; $0 \le \theta \le \pi/2$
The directivity of the antenna is
(a) 10 dB (c) 11.5 dB
(b) 12.6 dB (d) 18 dB

[GATE 2012: 1 Mark]

Soln. Given,

Radiation Pattern

$$F(\theta) = cos^4\theta \quad ; \quad 0 \le \theta \le \pi/2$$

Spherical coordinate system

Radiation intensity $U\ \alpha [F(\theta)]^2$

$$= cos^8\theta (say)$$

$$U_{max} = 1$$

Average power radiated

$$W_{rad} = \int_0^{\pi/2}\int_0^{2\pi} cos^8\theta\ \sin\theta\ d\theta\ d\phi$$

$$= \left(\frac{1}{9}\right) 2\pi = 0.697$$

$$Directivisty\ (D) = 4\pi \frac{U_{max}}{W_{rad}}$$

$$D = 4\pi\ .\frac{1}{0.697} = 18.02$$

$Directivity\ is$ **dBs** $= 10 \log_{10} (18.02) = 12.55\ dB$

Option (b)

13. 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 πΩ, the magnitude of average power density due to this antenna at a distance of 2 km from the antenna (in nW/m^2) is _______.

[GATE 2014: 1 Mark]

Soln. Given,

Electric field E at a distance of

$$1\ Km = 12mV/m$$

Also, we know that

$$E \propto \frac{1}{r}$$

Where r is the distance where E is measured so, electric field E at a distance of 2 Km

$$= \frac{12\ m\ v/m}{2} = 6\ m\ v/m$$

Also, power density due to antenna is given as

$$P_{avg} = \frac{1}{2}\ \frac{E^2}{\eta}$$

$$= \frac{1}{2}\ .\frac{6 \times 6 \times 10^{-6}}{120\pi}$$

$$= 47.7\ nW/m^2$$

Answer $= 47.7\ nW/m^2$

14. Match column A with column B.

Column A

1. Point electromagnetic source
2. Dish antenna
3. Yagi – Uda antenna

Column B

P. Highly directional

Q. End fire

R. Isotropic

	1	2	3
(a)	P	Q	R
(b)	R	P	Q
(c)	Q	P	R
(d)	R	Q	P

[GATE 2014: 1 Mark]

Soln. **1. Point electromagnetic source radiates is all directions.**

2. Dish Antenna radiates Electromagnetic Energy in any particular direction with narrow beam width and high directivity.

3. Yagi Uda antenna is a high bandwidth antenna used for TV reception

Option (b)

15. 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) Allow more power to be transmitted by the antenna

[GATE 2015: 1 Mark]

Soln. Directivity of antenna increases by adding more antenna elements in an antenna array.

Effective area (A_e) and Directivity are related by

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

Thus, as D increases effective aperture also increases.

Two Marks Questions

1. The electric field E and the magnetic field H of a short dipole antenna satisfy the condition
   (a) The r component of E is equal to zero
   (b) Both r and θ components of H are equal to zero
   (c) The θ component of E dominates the r component in the far – field region
   (d) The θ and $\emptyset$ components of H are of the same order of magnitude in the near – field region

[GATE 1988: 2 Marks]

Soln. There are six components of electromagnetic field possible for short dipole.

$$\boldsymbol{H_r,\ H_\theta,\ H_\phi,\ and\ E_r,\ E_\theta,\ E_\phi}$$

Out of these six components only following three components exist

$\boldsymbol{E_r,\ E_\theta\ and\ H_\emptyset}$ **and other components are zero.**

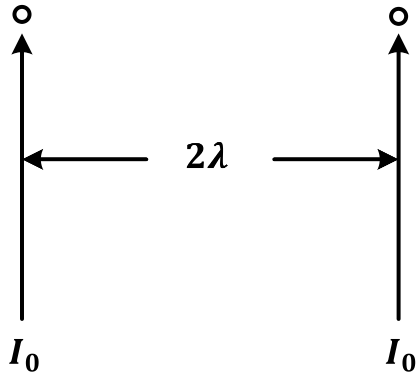
Thus, option (b) is correct

Also, option (c) is true.

2. Two isotropic antennas are separated by a distance of two wavelengths. If both the antennas are fed with currents of equal phase and magnitude, the number of lobes in the radiation pattern in the horizontal plane are
   (a) 2　　(c) 6
   (b) 4　　(d) 8

[GATE 1990: 2 Marks]

Soln. Figure shows two isotropic antennas separated by 2λ



Current in both antennas is I_0

$$d = 2\lambda \ \ and \ \ \alpha = 0$$

$$\Psi = \alpha + \beta d. cos\theta$$

$$So, \ \ \Psi = 0 + \beta d. cos\theta$$

$$= \frac{2\pi}{\lambda} \ .2\lambda. cos\theta = 4\pi \, cos\theta$$

$$2 \, cos\left(\frac{\Psi}{2}\right) = 2 \, cos(2\pi \, cos\theta)$$

θ **Varies from 0 to 2π**

Maximum at $\theta = 0, \ \frac{\pi}{3}, \ \frac{\pi}{2}, \ \frac{2\pi}{3}, \ \pi, \ \frac{4\pi}{3}, \ \frac{3\pi}{2}, \ \frac{5\pi}{3}$

So, the number of lobes in the radiation pattern in the horizontal plane = 8

Option (d)

3. In a broad side array of 20 isotropic radiators, equally spaced at a distance of $\lambda/2$, the beam width between first nulls is

(a) 51.3 degrees
(b) 11.46 degrees
(c) 22.9 degrees
(d) 102.6 degrees

[GATE 1991: 2 Marks]

Soln. The array is broad side

With n= 20 Isotropic radiators

Beam width between first nulls (BWFN)

$$= \frac{2\lambda}{n.d} \text{ Radians}$$

$$= \frac{2\lambda}{20 \cdot \lambda/2} \cdot \frac{180}{\pi} \text{ Degrees}$$

$$= \frac{36}{\pi} = 11.46^0$$

Option (b)

4. Two dissimilar antennas having their maximum directivities equal
   (a) Must have their beam widths also equal
   (b) Cannot have their beam widths equal because they are dissimilar antennas
   (c) May not necessarily have their maximum power gains equal
   (d) Must have their effective aperture areas (capture areas) also equal

[GATE 1992: 2 Marks]

Soln. Antenna efficiency is defined as

$$\eta = \frac{Radiated\ Power}{Input\ Power} = \frac{R_{rad}}{R_{rad} + R_{loss}}$$

Efficiency is also given as

$$\eta = \frac{Power\ gain}{Directive\ gain} = \frac{g_p}{g_d}$$

Radiation resistance of two antennas may be different hence efficiency may not be same. This indicates power gains may not be same.

Thus, Option (c)

5. The beam width – between – first – nulls of a uniform linear array of N equally – spaced (element spacing = d) equally – excited antennas is determined by
   (a) N alone and not by d
   (b) D alone and not by N
   (c) The ratio (N/d)
   (d) The product (Nd)

[GATE 1992: 2 Marks]

Soln. A uniform linear array can be Broadside array or End fire array.

Broadside array is an array of elements for which radiation is max or main lobe occurs perpendicular to the axis of the array.

End fire array is an array of elements for which main beam occurs along the axis of array.

For broadside array

Null to Null beam width $= \frac{2\lambda}{N.d}$

For End fire array $= 2\sqrt{\frac{2\lambda}{Nd}}$

Where N = No. of antennas in the array

d = spacing between elements

Beam width for both the arrays is determined by the product

N.d Thus, option (d)

6. 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% (c) 25%
   (b) 35.3% (d) 0%

[GATE 1996: 2 Marks]

Soln. Given,

A TEM wave has circular polarization. It is received by a dipole antenna, which is linearly polarized.

There will not be any mismatch and the wave will be received

Option (d)

7. A 1 km long microwave link uses two antennas each having 30dB gain. If the power transmitted by one antenna is 1 W at 3 GHz, the power received by the other antenna is approximately
   (a) 98.6 μ W (c) 63.4 μ W
   (b) 76.8 μ W (d) 55.2 μ W

[GATE 1996: 2 Marks]

Soln. **Given,**

Link distance $(\boldsymbol{R}) = \boldsymbol{1Km} = \boldsymbol{10^3 m}$

Antenna gain $(\boldsymbol{G_t}) = \boldsymbol{30\ dB} = \boldsymbol{1000} = \boldsymbol{G_r}$

Power transmitted $(\boldsymbol{P_t}) = \boldsymbol{1W}$

Frequency = 3 GHz

Wavelength = 10 cm = 0.1 m

$$P_d \text{ at } 1Km = \frac{P_t G_t}{4\pi R^2}$$

$$= \frac{1 \times 10^3}{4\pi \times (10^3)^2}\ w/m^2$$

$$G = \frac{4\pi A_e}{\lambda^2} \quad or \quad A_e = \frac{G\lambda^2}{4\pi}$$

$$P_r = (A_e)_r . P_d$$

$$= \frac{G_r A^2}{4\pi} \times \frac{1}{4\pi \times 10^3}$$

$$= \frac{10^3 \times (0.1)^2}{(4\pi)^2 \times 10^3} = \frac{10^{-2}}{16\pi^2} = 63.4\mu w$$

Option (c)

8. A parabolic dish antenna has a conical beam 2^0 wide. The directivity of the antenna is approximately

(a) 20 dB
(b) 30 dB
(c) 40 dB
(d) 50 dB

[GATE 1997: 2 Marks]

Soln. **Directivity of Parabolic dish is approximately given by**

$$= \frac{41253}{Beamwidth\ \theta\ plane \times Beamwidth\ in\ \phi\ plane}$$

In the given problem

$\theta_{3dB} = 2^0$

$\phi_{3dB} = 2^0$

$D = \frac{41253}{2\times 2} \cong 10000 \cong 40dB$

Option (c)

9. A transmitting antenna radiates 251 W Isotopically. A receiving antenna located 100m away from the transmitting antenna has an effective aperture of 500 cm^2. The total power received by the antenna is
   (a) 10 μ W
   (b) 1 μ W
   (c) 20 μ W
   (d) 100 μ W

[GATE 1999: 2 Marks]

Soln. Given,

Power transmitted by antenna (isotropically) = 251 W

Distance between antennas $= 100\ m$

Aperture area of receiving antenna = 500 cm ^{2}

$= 500 \times 10^{-4}\ m^2$

Power received $(P_r) = \frac{P_T}{4\pi r^2} \times Aperture$

$$= \frac{251}{4\times\pi\times(100)^2} \times 500 \times 10^{-4}$$

$= 100\ \mu w$

Option (d)

10. For an 8 feet (2.4m) parabolic dish antenna operating at 4 GHz, the minimum distance required for far field measurement is closest to
   (a) 7.5 cm
   (b) 15 cm
   (c) 15 m
   (d) 150 m

[GATE 2000: 2 Marks]

Soln. Given,

Parabolic reflector antenna

Diameter (D) = 2.4 m

Frequency (f) = 4 GHz

$$So, \quad \lambda = \frac{3 \times 10^8}{4 \times 10^9} = 7.5 \times 10^{-2}\ m$$

The measurement of antenna field is considered in Fraunhofer (far field) region. At a distance

$$R \gg \frac{2D^2}{\lambda}$$

$$or, \quad R = \frac{2 \times (2.4)^2}{7.5 \times 10^{-2}} = 153.6\ m$$

$$\cong 150\ m$$

Option (d)

11. The half – power bean widths (HPBW) of an antenna in the two orthogonal planes are 100^0 and 60^0 respectively. The directivity of the antenna is approximately equal to

(a) 2 dB
(b) 5 dB
(c) 8 dB
(d) 12 dB

[GATE 2000: 2 Marks]

Soln. Given,

Half power beam width $(\theta_{3dB}) = 100^0$

Half power beam width $(\phi_{3dB}) = 60^0$

$$Directivity\ (D) = \frac{41,200}{\theta_{3dB} \cdot \phi_{3dB}} = \frac{41,200}{100 \times 60}$$

$$= 6.85 \cong 8dB$$

Option (c)

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

(a) 25 Ω (c) 50 Ω
(b) 36.5 Ω (d) 73 Ω

[GATE 2001: 2 Marks]

Soln. Medium wave Radio transmitter operating at

$$\boldsymbol{\lambda = 492\ m}$$

Height of antenna $= \boldsymbol{124\ m \cong \lambda/4}$

Thus it is a quarter wave monopole hence

$$\boldsymbol{R_{rad} \cong 36.5\Omega}$$

Option (b)

13. In a uniform linear array, four isotropic radiating elements are spaced $\lambda/4$ apart. The progressive phase shift between the elements required for forming the main beam at 60^0 off the end – fire is

(a) $-\pi\ rad$ (c) $-\pi/4\ rad$
(b) $-\pi/2\ rad$ (d) $-\pi/8\ rad$

[GATE 2001: 2 Marks]

Soln. Uniform linear Array of N elements radiates in either broad side or end fire directions based on progressive phase shift, α between the excitation sources connected to antenna elements in the Array.

The array factor is given by

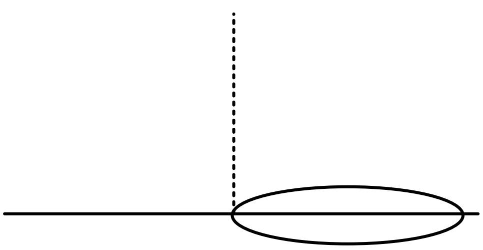
$$\boldsymbol{\Psi = \beta\ d\ cos\theta + \alpha}$$

Here distance between elements is $\boldsymbol{d = \lambda/4}$

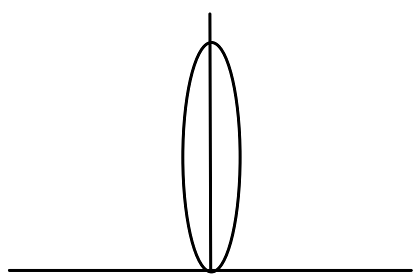
Direction of main beam is here $\boldsymbol{60^0}$**.**

when $\boldsymbol{\theta = 0}$**, with respect to axis of array, it is end fire type**

When $\boldsymbol{\theta = 90^0}$ **with respect to the axis of the array it is broad side**



End Fire



broadside

Given, the main beam is 60^0 off end fire i.e. $\theta = 60^0$

$$\Psi = \alpha + \beta\, d \cos 60^0 = 0$$

$$or, \quad \alpha = -\frac{2\pi}{\lambda} \cdot \frac{\lambda}{4}\, \frac{1}{2} = -\frac{\pi}{4}\ rad$$

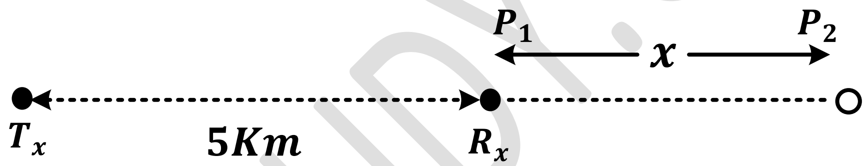
Option (c)

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

(a) 942 m
(b) 2070 m
(c) 4978 m
(d) 5320 m

[GATE 2002: 2 Marks]

Soln. Distance between transmitter and person with receiver is 5 km



From the position P_1 the person having receiver moves some distance to detect 3 dB decrease is signal strength. Field strength at P_2 is $1/\sqrt{2}$ times field strength at position 1.

E at point P_1 is E_1

E at point P_2 is E_2 $\left(E_1/\sqrt{2}\right)$

$$E_1 \alpha \frac{1}{r_1} \quad and \quad E_2 \alpha \frac{1}{r_2}$$

$$\frac{E_1}{E_2} = \frac{r_2}{r_1}$$

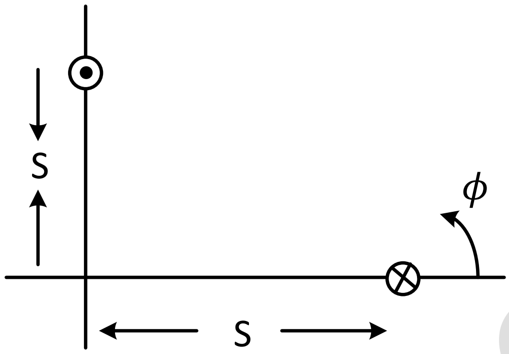
$$or, \quad r_2 = \frac{E_1}{E_2}\, r_1 = \frac{E_1}{E_1/\sqrt{2}} r_1 = \sqrt{2}\, r_1$$

$$or \quad r_2 = 7.07\ Km$$

Thus distance moved from point 1 to point 2 = 2070 m

Option (b)

15. Two identical antennas are placed in the $\theta = \pi/2$ plane as shown in Figure. The elements have equal amplitude excitation with 180^0 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 computer for $\phi = 0$ is



(a) $2\cos\left(\frac{2\pi s}{\lambda}\right)$
(b) $2\sin\left(\frac{2\pi s}{\lambda}\right)$
(c) $2\cos\left(\frac{\pi s}{\lambda}\right)$
(d) $2\sin\left(\frac{\pi s}{\lambda}\right)$

[GATE 2003: 2 Marks]

Soln. Normalized field strength of a uniform linear array is

$$\frac{E_T}{E_0} = \left|\frac{\sin N\frac{\Psi}{Z}}{\sin\frac{\Psi}{Z}}\right|$$

Where, N – Number of elements in the array

$$\Psi - \beta d\cos\phi + \alpha$$

For the given two element array

$$\frac{E_T}{E_0} = \left|\frac{\sin\Psi}{\sin\Psi/2}\right| = 2\cos(\Psi/2)$$

Where

$$\Psi = \alpha + \beta d\cos\phi$$

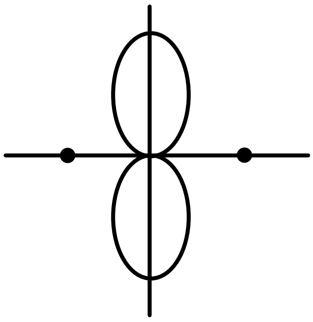
$$= \pi + \frac{2\pi}{\lambda}.S.1 = \pi + \frac{2\pi S}{\lambda}$$

$$\frac{E_T}{E_0} = 2\cos\left(\frac{\pi}{2} + \frac{\pi s}{\lambda}\right) = 2\sin\left(\frac{\pi s}{\lambda}\right)$$

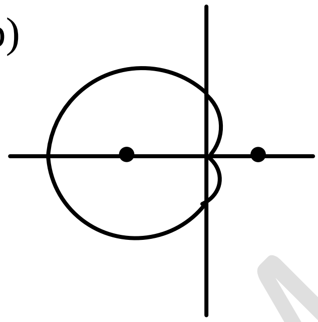
Option (d)

16. Two identical and parallel dipole antennas are kept apart by a distance of $\lambda/4$ in the H – plane. They are fed with equal currents but the right most antenna has phase shift of $+90^0$. The radiation pattern is given as

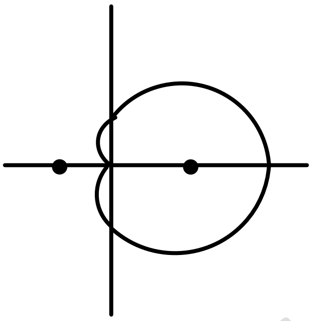
(a)



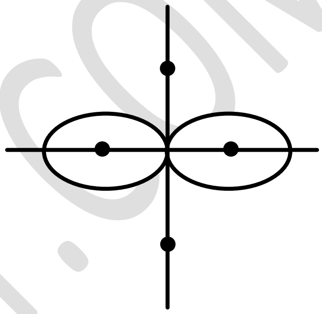
(b)



(c)

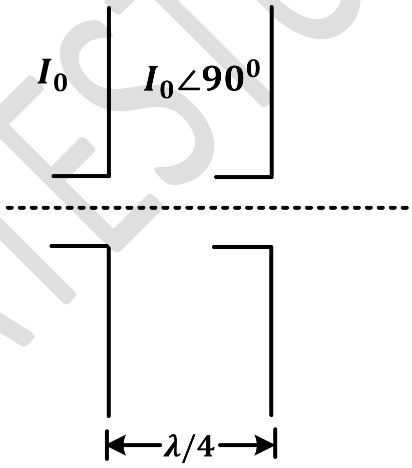


(d)



[GATE 2005: 2 Marks]

Soln. Two parallel dipoles apart



For antenna array

$$\boldsymbol{\Psi = \beta\, d\, cos\theta + \alpha}$$

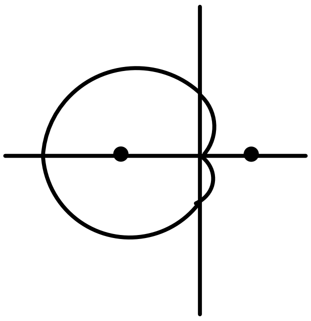
Maximum of E field occurs at $\Psi = 0$

$$\boldsymbol{\alpha + \beta\, d. cos\, \theta = 0}$$

$$\boldsymbol{or,\ \frac{\pi}{2} + \frac{\pi}{2}\, .\frac{\lambda}{4}\ cos\theta = 0}$$

$1 + cos\theta = -1 \quad or \quad \theta = 180^0$

Radiation pattern is



Option (d)

17. 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) $\frac{2\pi^2}{5}$

(b) $\frac{\pi^2}{5}$

(c) $\frac{4\pi^2}{5}$

(d) $20\,\pi^2$

[GATE 2006: 2 Marks]

Soln. Mast antenna is over perfectly conducting ground plane. It is hertz dipole.

Radiations resistance $(R_{rad}) = 40\pi^2 \left(\frac{dl}{\lambda}\right)^2$

Length of radiation = 50m

Frequency (f) = 600 KHz

Thus, wavelength $(\lambda) = 500m$

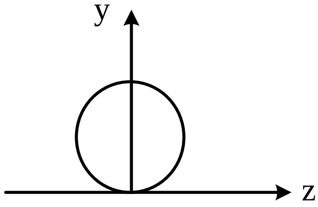
Therefore

$$R_{red} = 40\pi^2 \left(\frac{50}{500}\right)^2 = \frac{2\pi^2}{5}$$

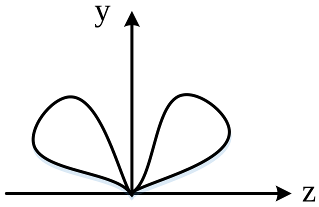
Option (a)

18. A $\lambda/2$ dipole is kept horizontally at a height of $\lambda_2/2$ dipole above a perfectly conducting infinite ground plane. The radiation pattern in the plane of the dipole ($\vec{E}\ plane$) looks approximately as

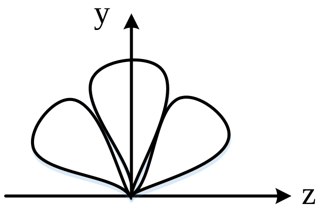
(a)



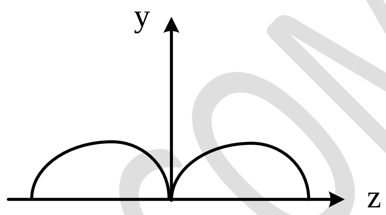
(b)



(c)

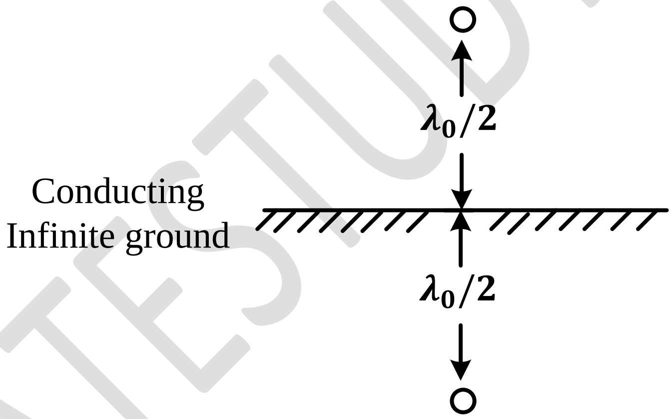


(d)



[GATE 2007: 2 Marks]

Soln. A $\lambda/2$ dipole is kept horizontally at a height of $\lambda_0/2$ above conducting ground plane



$$Here\quad d = \lambda, \qquad \alpha = \pi, \qquad thus\quad \beta d = \frac{2\pi}{\lambda}.\lambda = 2\pi$$

$$Arrey\ Factor\ is = cos\left[\frac{\beta d\ cos\phi + \alpha}{2}\right]$$

$$= cos\left[\frac{2\pi\ cos\phi + \pi}{2}\right]$$

$$= sin(\pi\ cos\phi)$$

Option (b)

19. 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

[GATE 2008: 2 Marks]

Soln. Given,

Frequency = 20 GHz

Diameter of antenna dish = 1 meter

$$\boldsymbol{Efficiency\ (\eta) = 70\%}$$

Gain of parabolic dish antenna is given by

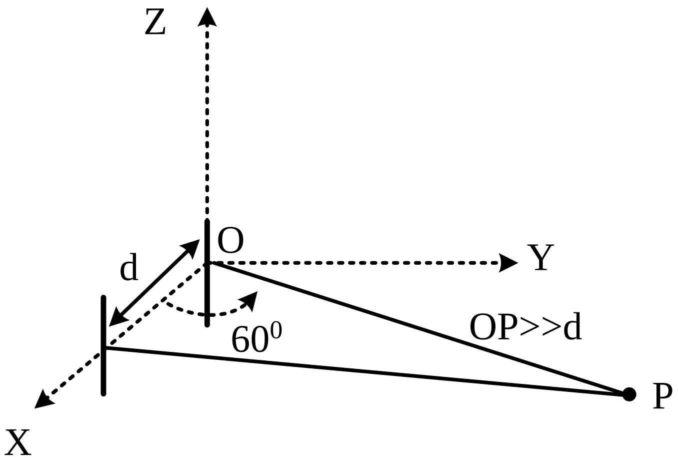
$$\boldsymbol{G = \eta\, \pi^2 \left(\frac{D}{\lambda}\right)^2}$$

$$\boldsymbol{= 0.7\,.\pi^2 \left(\frac{1}{\frac{3\times 10^8}{20\times 10^9}}\right)^2}$$

$$\boldsymbol{= 0.7\,.\pi^2 \left(\frac{200}{3}\right)^2 \cong 45\ dB}$$

Option (d)

20. Two half – wave dipole antennas placed as shown in the figure are exited with sinusoidal varying currents of frequency 3 MHz and phase shift of $\pi/2$ 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 60^0, the distance d (in meters) between the antennas is ______



[GATE 2015: 2 Marks]

Soln. **Given, Azimuth plane**

Occurs at $\theta = 90^0$

For antenna array

$$\Psi = \beta\, d\, cos\phi + \alpha$$

Where, d – spacing between the antenna

ϕ – Angle between axis of array and

α – Excitation phase line of observation

Maximum of E field occurs at $\Psi = 0$

Here $\phi = -90^0$

$$\beta = \frac{2\pi}{\lambda} = \frac{2\lambda}{\frac{3\times10^8}{3\times10^8}} = \frac{2\pi}{100}$$

Maximum of field occurs

At $\Psi = 0$

i.e. $\beta\, d\, cos\theta + \alpha = 0$

or, $\beta\, d\, cos\theta = -\alpha$

$$\beta\, d\, cos\theta = \pi/2$$

$$\frac{2\pi}{100} \times d \times cos\theta = \pi/2$$

$$since\ d = \lambda/2$$

$$\frac{2\pi}{\lambda} \times d \times cos\theta = \pi/2$$

$$d\,.cos\,60 = \frac{\lambda}{4} \quad or \quad d = \frac{2\lambda}{4} = \lambda/2$$

$$where \quad \lambda = \frac{3 \times 10^8}{3 \times 10^6} = 100m$$

21. The far – zone power density radiated by a helical antenna is approximated as:

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

The radiated power density is symmetrical with respect to ϕ and exists only in the upper hemisphere: $0 \le \theta \le \frac{\pi}{2}; 0 \le \phi \le 2\pi;\ C_0$ is a constant.

The power radiated by the antenna (in watts) and the maximum directivity of the antenna, respectively, are

(a) 1.5 C_0, 10dB
(b) 1.256 C_0, 10dB
(c) 1.256 C_0, 12dB
(d) 1.5 C_0, 12dB

[GATE 2016: 2 Marks]

Soln. Given,

Power density radiated by the antenna

$$\vec{W}_{rad} = \frac{C_0}{r^2}\,.cos^4\theta\, \hat{a}_r \quad W/m^2$$

Given that power density of the antenna is symmetrical and is upper hemisphere. Power radiated by the antenna

$$P_{rad} = \oint_s \vec{W}_{rad}\,.\vec{ds}$$

It is radiating in the upper hemisphere only

$$P_{rad} = \int_0^{\pi/2} \int_{\phi=0}^{2\pi} \frac{C_0}{r^2}\, cos^4\theta\, r^2 sin\theta d\theta d\phi$$

$$= \int_{0}^{\pi/2} \int_{\phi=0}^{2\pi} C_0 \cos^4\theta \sin\theta \, d\theta \, d\phi$$

$$= 2\pi C_0 \int_{0}^{\pi/2} \cos^4\theta \ \sin\theta \, d\theta$$

$$P_{rad} = \frac{2\pi C_0}{5} = 1.256 \ C_0 \ watt$$

$$D = 4\pi \, . \frac{U_{max}}{P_{rad}}$$

Where, U_{max}

$$U = r^2 \, W_{rad}$$

$$r^2 \, . \frac{C_0}{r^2} \ \cos^4\theta$$

$$U = C_0 \ Cos^4\theta$$

$$U = C_0$$

$$D = \frac{4\pi C_0}{1.256 \ C_0}$$

= 10
D is dB = 10 log 10
D = 10dB