

1) A helical antenna is designed for satellite communication and operates at a frequency of 1.5 GHz. It has a diameter of 10 cm and a pitch of 3 cm. Calculate the transition distance from the near field to the far field for this helical antenna.

Soln.

Diameter = 10 cm
Pitch = 3 cm

$f = 1.5 \text{ GHz}$

$$\text{Transition distance} = \frac{2D^2}{\lambda}$$

$$D = 10 \text{ cm} = 0.1 \text{ m}$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{1.5 \times 10^9}$$

$$\lambda = 0.2 \text{ m}$$

$$T_D = \frac{2 \times (0.1)^2}{0.2}$$

$$T_D = 0.1 \text{ m}$$

2) A pyramidal horn antenna operates at a frequency of 10 GHz. The horn has an aperture width of 20cm and an aperture height of 15cm. If the receiver is placed 1.5m away from the antenna, determine whether it is in the near field or far field.

Soln.

$$f = 10 \text{ GHz.}$$

$$\text{Width} = 20 \text{ cm} = 0.2 \text{ m}$$

$$\text{Height} = 15 \text{ cm} = 0.15 \text{ m}$$

$$T_D = \frac{2D^2}{\lambda}$$

To find wavelength

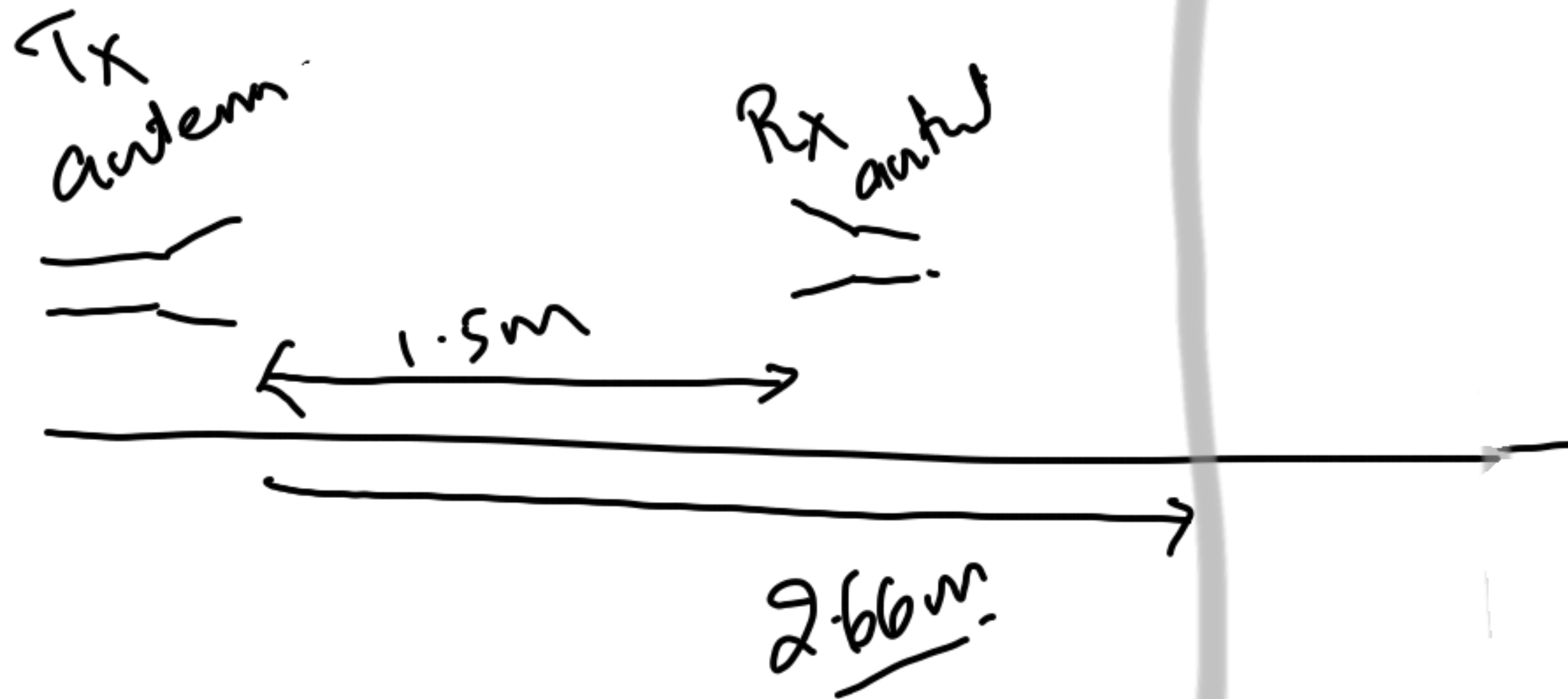
$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{10 \times 10^9}$$

$$\lambda = 0.03 \text{ m}$$

$$r_D = \frac{2 \times (0.2)^2}{0.03}$$

$$r_D = 2.66 \text{ m}$$

Near Field r_D Far field



③ A horn antenna intended for use in a wireless communication system that operates over a frequency range from 5.8 GHz to 6.2 GHz. Calculate the fractional bandwidth of the horn antenna.

Soln.

$$\text{Fractional Bandwidth}\% = \frac{f_{\text{upper}} - f_{\text{lower}}}{f_{\text{central}}} \times 100$$

$$f_{\text{upper}} = 6.2 \text{ GHz}$$

$$f_{\text{lower}} = 5.8 \text{ GHz}$$

$$f_{\text{central}} = \frac{f_{\text{upper}} + f_{\text{lower}}}{2} = \frac{6.2 \text{ GHz} + 5.8 \text{ GHz}}{2}$$

$$= \frac{12 \text{ GHz}}{2} = 6 \text{ GHz}$$

$$\text{Fractional BW}(\%) = \frac{6.2 \times 10^9 - 5.8 \times 10^9}{6 \times 10^9} \times 100$$

$$f_{\text{BW}} = \frac{0.4 \times 10^9}{6 \times 10^9} \times 100$$

$$f_{\text{BW}} = 6.67\%$$

4) A horn antenna and a parabolic reflector antenna are used in Satellite Communication System. The horn antenna has a total radiation Solid angle of 1.2 Steradians, while the parabolic reflector has a total radiation Solid angle of 0.25 Steradians.

- Calculate the directivity (D) for both antennas.
- Find the difference in directivity between the two antennas in decibels (dB)

Soln

$$D = \frac{4\pi}{\Omega_A}$$

Given.

for horn antenna,

$$\Omega_A = 1.2 \text{ Steradians.}$$

for parabolic Reflector.

$$\Omega_A = 0.25 \text{ Sr}$$

$$a) D_{\text{horn}} = \frac{4\pi}{1.2} = 10.47$$

$$D_{\text{parabolic}} = \frac{4\pi}{0.25}$$

$$D_{\text{parabolic}} = 50.26$$

b)

$$D = 10 \log_{10}(D)$$

$$D_{\text{horn}} = 10 \log_{10}(10^{-47}) = 10.2 \text{ dBi}$$

$$D_{\text{parabolic}} = 10 \log_{10}(50.26) = 17.01 \text{ dBi}$$

$$D = D_{\text{parabolic}} - D_{\text{horn}} = 17.01 - 10.2$$

$$= 6.81 \text{ dBi}$$

5) A parabolic reflector antenna operates at a frequency of 10 GHz and has a diameter of 2 meters. The antenna gain is measured to be 42 dBi. Calculate the aperture efficiency (η_{ap}) as a percentage.

Soln. $\eta_{ap} = ?$

$$f = 10 \text{ GHz}$$

$$D = 2 \text{ m}$$

$$G = 42 \text{ dBi}$$

$$\eta_{ap} \% = \frac{A_{EFF}}{A_{physm}} \times 100$$

We know th.

$$A_{EFF} = \frac{\lambda^2 G}{4\pi}$$

$$A_{physm} = \pi \left(\frac{D}{2} \right)^2$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{10 \times 10^9}$$

$$\lambda = 0.03 \text{ m}$$

$G = 42 \text{ dBi}$ to linear scale

$$G = 10^{(42/10)}$$

$$G = 15848.93$$

$$A_{\text{EFF}} = \frac{\lambda^2 G}{4\pi}$$

$$= \frac{(0.03)^2 \times 15848.93}{4\pi}$$

$$A_{\text{EFF}} = 1.135 \text{ m}^2$$

$$A_{\text{phys}} = \pi \left(\frac{D}{2} \right)^2$$

$$= \pi \left(\frac{2}{2} \right)^2 = 3.14 \text{ m}^2$$

$$\eta_{ap} = \frac{A_{EFF}}{A_{phy}} \times 100$$

$$= \frac{1.135}{3.14} \times 100$$

$$\eta_{ap} = 36.13\%$$

6) A microwave antenna used for a wireless communication system is tested.

The antenna is designed to transmit signals effectively over long distance, and its performance need to be evaluated before deployment.

Test setup:

Antenna operates at 5 GHz.

Input power: 120W.

Radiated power = 90W

a) Determine the radiation efficiency (η_e) of the antenna to assess its performance.

b). If the input power is increased to 150W, while maintaining the same efficiency Calculate the new radiated power.

Soln:

Ans.

$$\text{Input power} = 120 \text{ W}$$

$$\text{Radiated power} = 90 \text{ W}$$

(a)

$$\eta_e \% = \frac{P_{\text{radiated}}}{P_{\text{input}}} \times 100$$

$$= \frac{90}{120} \times 100$$

$$\eta_e \% = 75 \%$$

$$\text{b) } P_{\text{input}} = 150 \text{ W}$$

$$\eta_e \% = \frac{P_{\text{radiated}}}{P_{\text{input}}}$$

$$P_{\text{radiated}} = P_{\text{inp}} \times \eta_e \%$$
$$= 150 \times \frac{75}{100}$$

$$P_{\text{radia.}} = 112.5 \text{ W}$$

7) A helical antenna is used for Satellite tracking System. The antenna is designed with the following parameters.

$$\text{Directivity (D)} = 15$$

$$\text{Radiation Efficiency } (\eta) = 0.85$$

a) Calculate the gain (G) of the helical antenna

b) Convert the gain into decibels

Soln.

$$G = \eta D$$

Given

$$D = 15$$

$$\eta = 0.85$$

a)

$$\begin{aligned} \text{Gain (G)} &= 0.85 \times 15 \\ \text{Gain} &= 12.75 \end{aligned}$$

b)

$$\begin{aligned} G_{dB} &= 10 \log_{10}(G) \\ &= 10 \log_{10}(12.75) \\ G_{dB} &= 11.06 \text{ dB} \end{aligned}$$

8) A monopole antenna resonates at a frequency of 1GHz, Calculate the operating wavelength and the length of the antenna.

Soln.

$$f = 1 \text{ GHz}$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{1 \times 10^9} \\ = 0.3 \text{ m}$$

$$L = \frac{\lambda}{4} \\ = \frac{0.3}{4}$$

$$L = 0.075 \text{ m}$$

9) Given two half wave dipole antennas, where one emits electromagnetic waves with a wavelength of 220mm and the other emits EM waves with a wavelength of 450mm. Determine the length of the dipole antennas and their resonant frequencies. Based on these calculations analyse the effect of increasing the length of half-wave dipole antenna.

a) antenna with $\lambda = 220\text{mm}$

$$L = \frac{\lambda}{2} = \frac{0.220}{2} = 0.110\text{m}$$

$$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{0.220} = 1.364 \text{ GHz}$$

b) antenna with $\lambda = 450\text{mm}$

$$L = \frac{\lambda}{2} = \frac{0.450}{2} = 0.225\text{m}$$

$$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{0.450} = 667\text{MHz}$$

Increasing the size of the antenna from (0.110m) to 0.225m reduces the operating frequency from 1.364 GHz to 667MHz.

(10) A helical antenna used for Satellite Communication has the turn Spacing (S) as 3cm helix diameter (D) = 10cm. Determine the pitch angle (α) of the helical antenna.

$$\alpha = \tan^{-1}\left(\frac{S}{\pi D}\right)$$
$$= \tan^{-1}\left(\frac{0.03}{\pi \times 0.1}\right)$$

$$\alpha = 5.45^\circ$$