# SNS COLLEGE OF TECHNOLOGY

**Coimbatore – 35**

**An Autonomous Institution**

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A++' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

## DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

19ECT311 / Wireless Communication

III ECE/ VI SEMESTER

Unit II - **MOBILE RADIO PROPAGATION**

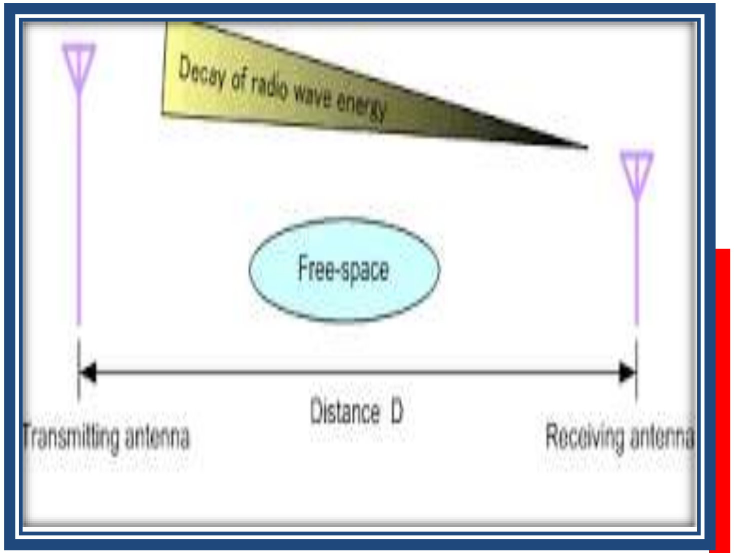
**Topic 1 :** Free space propagation model

# INTRODUCTION

- Propagation is a term used to describe the signal transmitted from the sending station to receiving stations
- To ensure satisfactory performance of a wireless communication system
- Propagation models used as a suitable low-cost alternative for site measurements
- Propagation model: predict the average received signal strength

# FREE SPACE PROPAGATION MODEL

- The free space propagation model is used to predict received signal strength



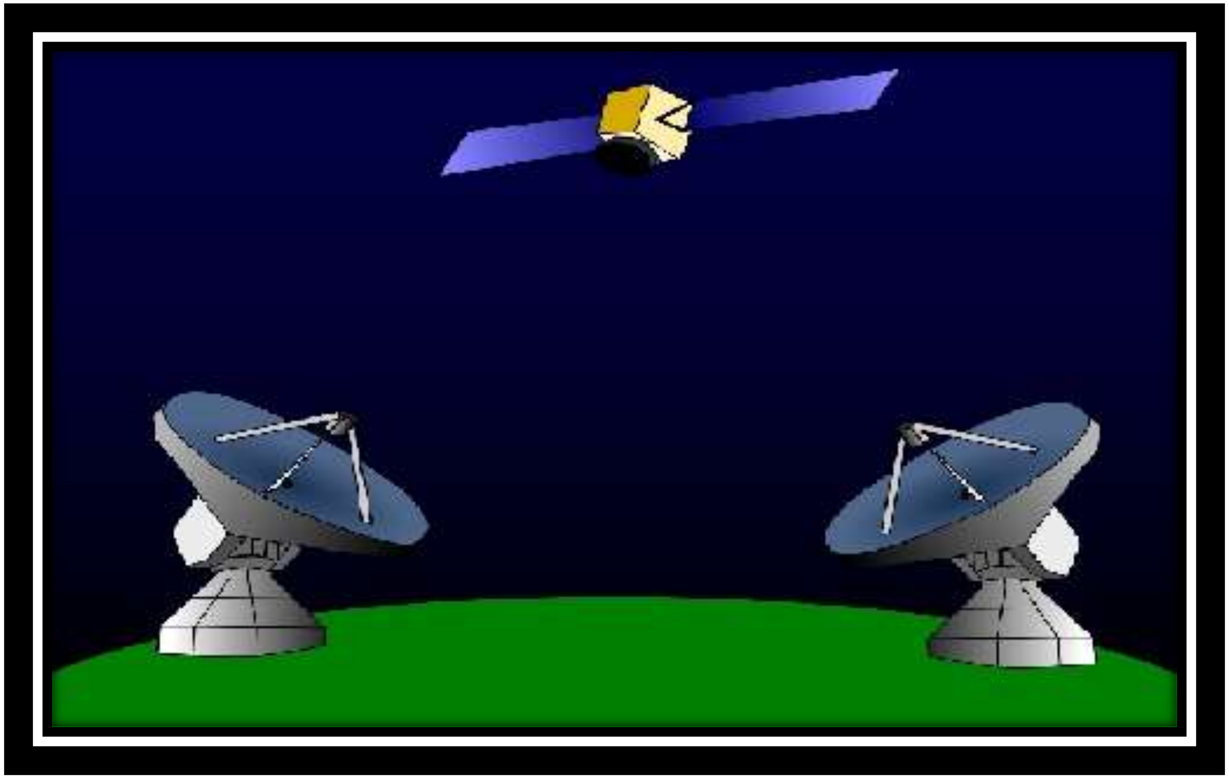

- The transmitter and receiver have a clear, unobstructed line of the sight path between them

- The free space model predicts that received power.

- Which decays as a function of the Transmitter-Receiver separation distance raised to some power (i.e. a power law function)

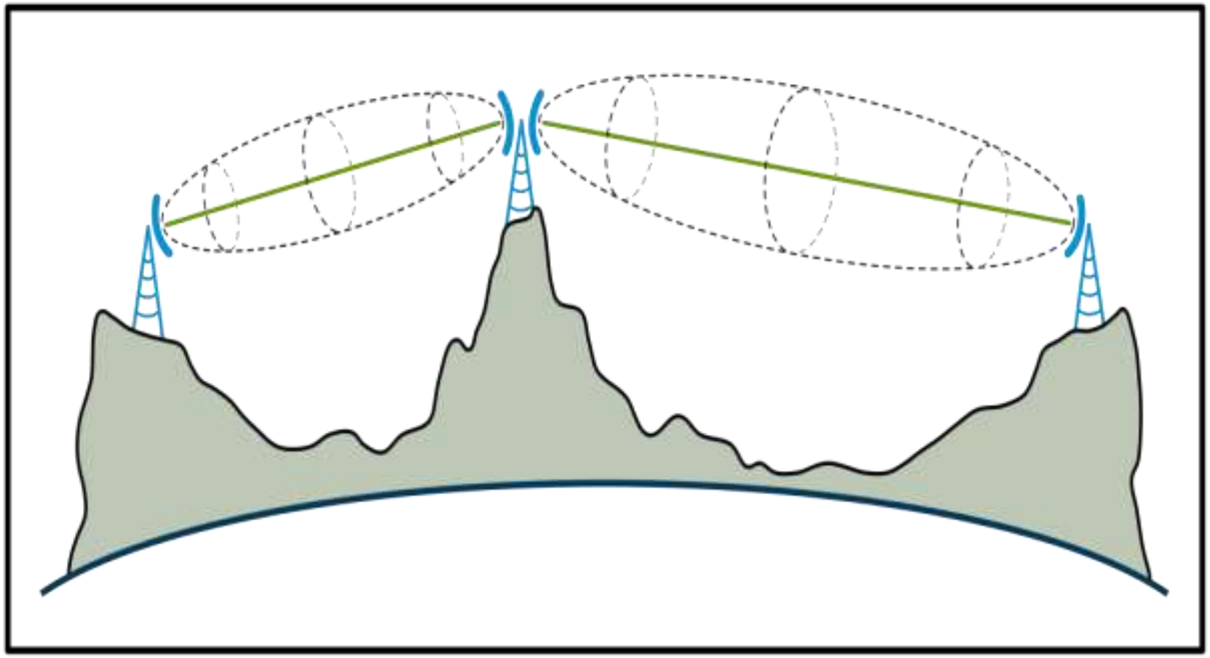
# EXAMPLES

Satellite communication systems



# EXAMPLES

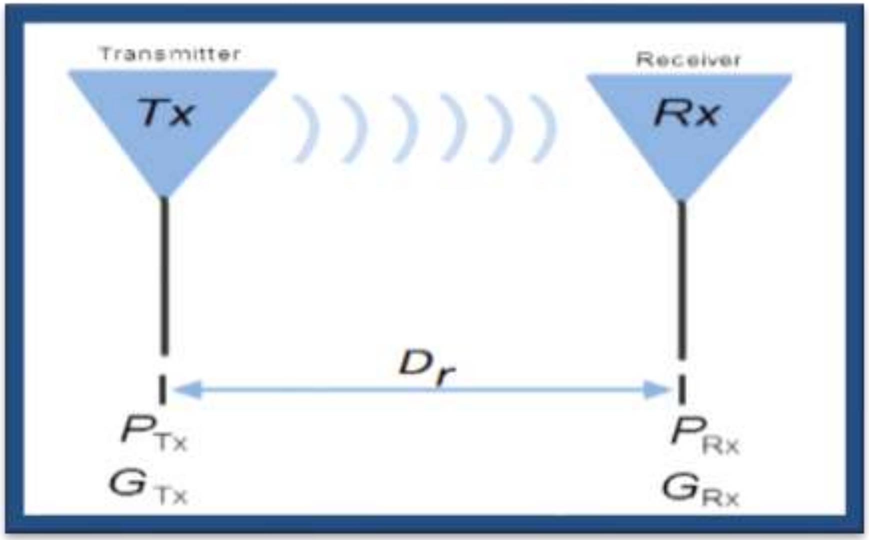
Microwave line of sight radio links



# FRIIS FREE SPACE EQUATION

- The free space power received by a receiver antenna which is separated from a radiating transmitter antenna by a distance d

- The Friis free space equation shows that the received power falls off as the square of the Transmitter-Receiver (T-R) separation distance.




- This implies that the received power decays at a rate of 20 dB/decade with distance.

# FRIIS FREE SPACE EQUATION

➢Given by the Friis free space equation

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

- Pt – transmitted power
- Pr (d) – received power which is a function of T–R separation
- Gtx – Transmitted antenna gain
- d – T-R separation distance in meters
- L – System loss factor not related to propagation (L≥1) if (L=1 there is no loss)
- λ- Wavelength in meters

# ACTIVITY

- Activity :  Think Pair Share


# FREE SPACE EQUATION

Effective aperture Ae is related to the Gain of the antenna

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

λ is related to the carrier frequency by

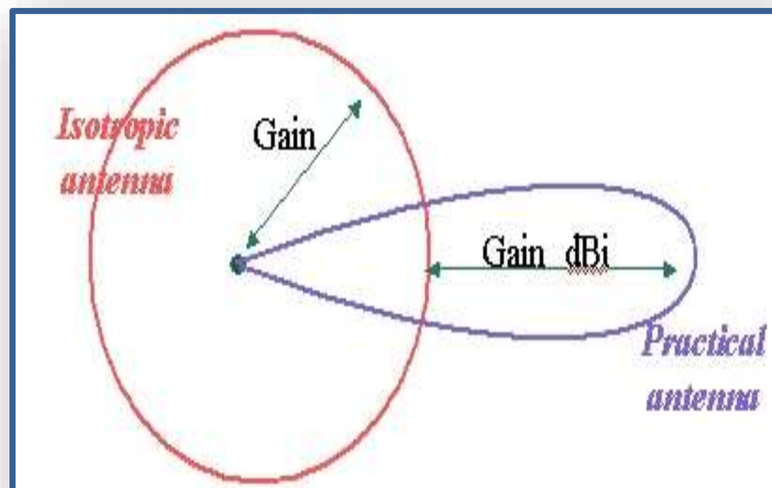
$$\lambda = \frac{c}{f} = \frac{2\pi c}{\omega_c}$$

# FREE SPACE EQUATION

- In Friis equation ,Gt and Gr is dimensionless quantities
- The isotropic radiation is an ideal antenna which radiates power with unit gain uniformly in all directions

ERP=EIRP - 2.15dB

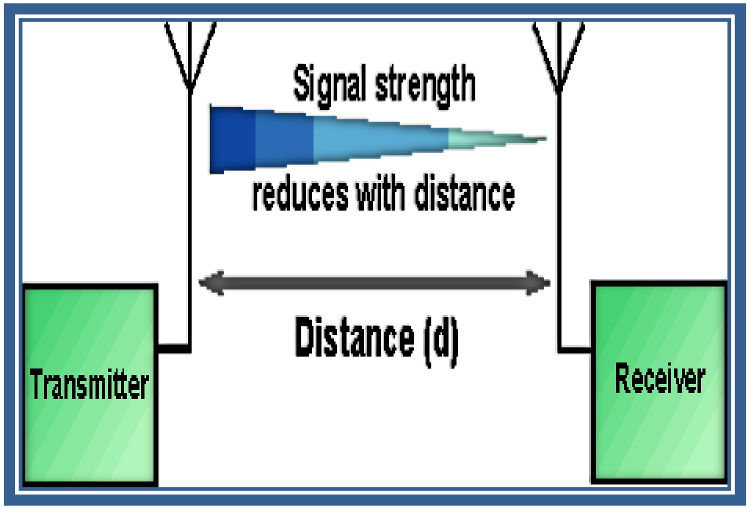
$$EIRP = P_t G_t$$




EIRP Calculations

# PATH LOSS

- ➢Path loss is the measured in dB
- ➢ Difference between the effective transmitted power and the received power
- ➢May or may not be included the effect of the antenna gains



# PATH LOSS

➢The path loss, which represents signal attenuation as a positive quantity measured in dB

➢It is defined as the difference (in dB) between the effective transmitted power and the received power

➢The path loss for the free space model when antenna gains are included is given by:

$$PL\ (dB) = 10 \log \frac{P_t}{P_r}$$

$$PL\ (\mathrm{dB}) = 10\log\frac{P_t}{P_r} = -10\log\left[\frac{\lambda^2}{(4\pi)^2 d^2}\right]$$

# PATH LOSS

$$\text{Path Loss} = -10 \log \left[ \frac{G_t G_r \lambda^2}{(4\pi)^2 d^2} \right]$$

➢It can be expanded to give an equation in terms of distance, d (km) and frequency of operation, f (MHz)

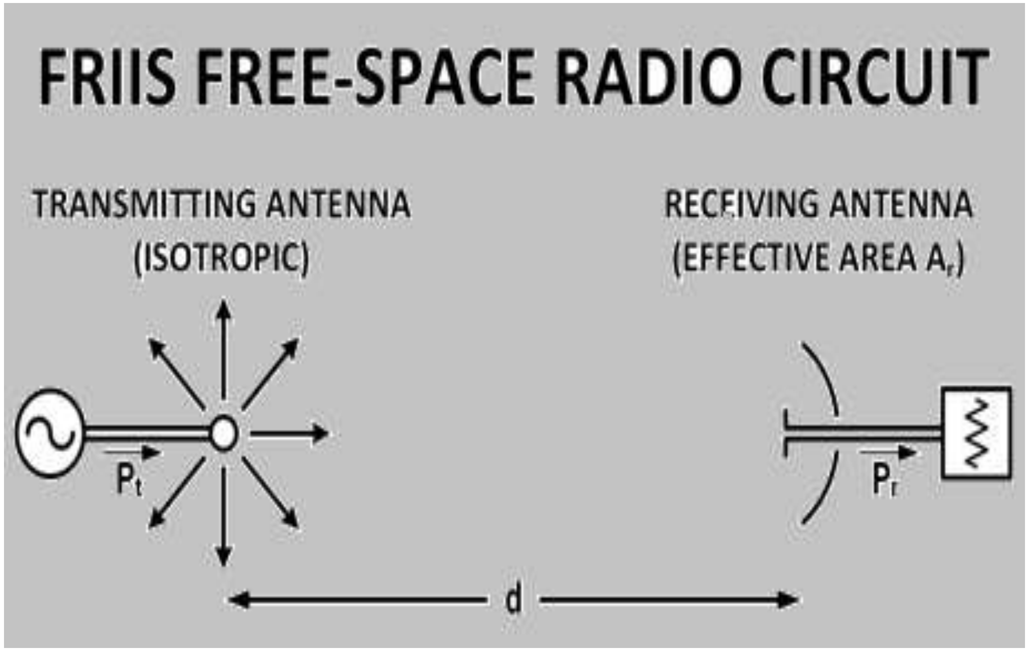
$$PL(dB) = -10 \log_{10}(G_t) - 10 \log_{10}(G_r) - 20 \log_{10}\left[\frac{(c \times 10^{-3})}{4\pi \times f \times 10^{6}}\right] - 20 \log_{10}(1/d)$$

where c is the speed of light

$$= -G_t(dB) - G_r(dB) + 32.44 + 20 \log_{10}(d/km) + 20 \log_{10}(f/MHz)$$

# PATH LOSS

➢The Friis free space model is only a valid prediction for Pr in the far– field of the transmitting antenna.

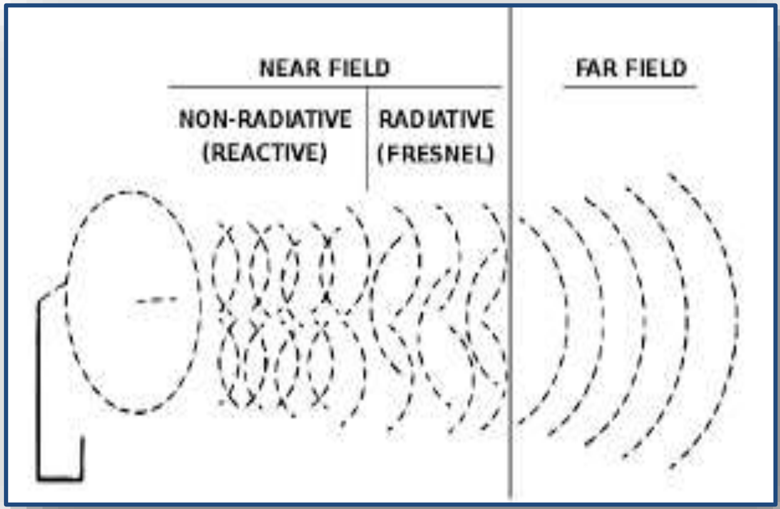


# FRAUNHOFER REGION

- The far – field of (or) fraunhofer region

- A transmitting antenna is defined as the region beyond the largest linear dimensions of transmitter antenna aperture and the carrier wave length.

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




D – Largest physical linear dimension of the antenna.

# CLOSE IN DISTANCE

- Does not hold for d=0
- Close - in distance $d_o$
- Received power at reference point

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

# RECEIVED POWER LEVEL

- Received power levels
- dBm or dBw units are used to express received power levels

$$P_r(d) = P_r(d_0)\left(\frac{d_0}{d}\right)^2 \qquad d \geq d_0 \geq d_f$$

# Assessment

- **Friis free space equation**

1. Is an expression for noise power
2. Is a function of transmitting and receiving antenna gain
3. Depends upon the distance between transmitting and receiving antenna


a. 1) and 2) are correct
b. All the three are correct
c. 1) and 3) are correct
d. 2) and 3) are correct.

- **The free space model of propagation refers to --------------------------**

- **According to Friis free space equation**

1. Received power falls with square of the distance between the transmitter and receiver
2. Increases with square of the distance between the transmitter and receiver
3. Received power increases with gains of transmitting and receiving antennas

a. 1) and 2) are correct
b. All the three are correct
c. 1) and 3) are correct
d. 2) and 3) are correct.