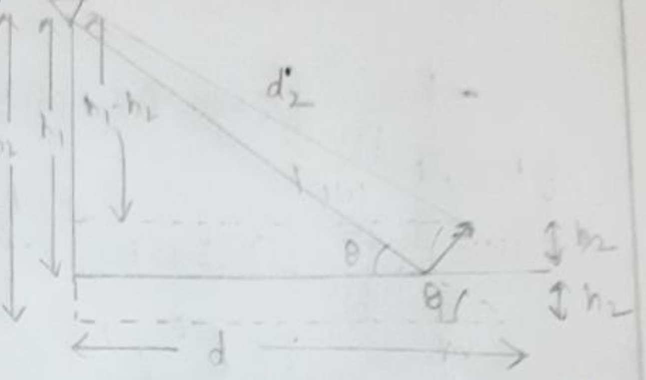
Unit - III

5) (a) Derive the expression for the received power in ground reflected model.

Ans:- For direct wave signal: e_0



For reflected wave signal

: $e_0 \, a_v \, e^{j\Delta\phi}$

$\Rightarrow e_0 + e_0 \, a_v \, e^{j\Delta\phi}$

In terms of power, the received power is, P_r = Directwave signal power $\times \left[1 + a_v e^{j\Delta\phi}\right]^2$

$$\Rightarrow P_r = \frac{P_0 \lambda^2}{(4\pi d)^2}\left[1 + a_v e^{j\Delta\phi}\right]^2 \quad \text{—(1)}$$

where a_v is the reflection coefficient

$\Delta\phi$ is the phase difference between direct & reflected path

P_0 is the transmitted power

d is the distance

λ is wavelength

In a mobile radio environment, $a_v = -1$ because of the small incident angle of groundwave caused by a relatively low cell site antenna height thus;

$$P_r = \frac{P_0 \lambda^2}{(4\pi d)^2}\left[1+(-1)(\cos\Delta\phi + j\sin\Delta\phi)\right]^2$$

$$= \frac{P_0 \lambda^2}{(4\pi d)^2}\left[1-\cos\Delta\phi - j\sin\Delta\phi\right]^2 \qquad \left[\because |a-jb|^2 = \left(\sqrt{a^2+b^2}\right)^2 = a^2+b^2\right]$$

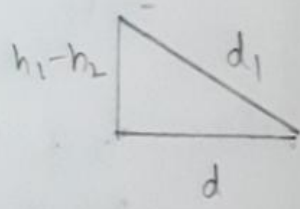
$$= \frac{P_0 \lambda^2}{(4\pi d)^2}\left[1+\cos^2\Delta\phi + \sin^2\Delta\phi - 2\cos\Delta\phi\right]$$

$$= \frac{P_0 \lambda^2}{(4\pi d)^2}\left[2-2\cos\Delta\phi\right] = \frac{P_0 \lambda^2 2}{(4\pi d^2)}(1-\cos\Delta\phi) = \frac{P_0 \lambda^2}{(4\pi d)^2}2\times\left(2\sin^2\frac{\Delta\phi}{2}\right)$$

$$\Rightarrow P_r = \frac{P_0 \lambda^2 4 \sin\frac{\Delta\phi}{2}}{(4\pi d)^2}, \text{ where } \Delta\phi = \beta\Delta d$$

and Δd is the difference between i.e $\Delta d = d_1 - d_2$

From the figure, $d_1 = \sqrt{(h_1+h_2)^2+d^2}$



$$d_2 = \sqrt{(h_1-h_2)^2+d^2}$$

$$\Rightarrow \Delta d = \sqrt{(h_1+h_2)^2-d^2} - \sqrt{(h_1-h_2)^2+d^2}$$

$$= d\left[\sqrt{\frac{(h_1+h_2)^2}{d^2}+1} - \sqrt{\left(\frac{h_1-h_2}{d}\right)^2+1}\right]$$

From Binomial Theory expansion,

$$= d\left[\left(1+\frac{1}{2}\left(\frac{h_1+h_2}{d}\right)^2+\dots\right)-\left(1+\frac{1}{2}\left(\frac{h_1-h_2}{d}\right)^2+\dots\right)\right]$$

$$= d\left[1+\frac{1}{2d^2}(h_1^2+h_2^2+2h_1h_2+\dots) - \left[1+\frac{1}{2d^2}(h_1^2+h_2^2-2h_1h_2+\dots)\right]\right]$$

$$= \frac{2h_1h_2}{d}$$

Here $\Delta\phi = \beta\Delta d = \frac{2\pi}{\lambda} \times \frac{2h_1h_2}{d} = \frac{4\pi h_1 h_2}{\lambda d}$

If $\Delta\phi < 0.6$ rad, then $\sin\frac{\Delta\phi}{2} \simeq \frac{\Delta\phi}{2}$, then the equation is,

$$P_r = \frac{P_0 \lambda^2 4}{(4\pi d)^2} \times \left(\frac{\frac{4\pi h_1 h_2}{\lambda d}}{2}\right)^2$$

$$\Rightarrow P_r = P_0\left(\frac{h_1h_2}{d^2}\right)^2$$

(b) Discuss the concept of frequency management concerned to the numbering of channels and grouping into the subsets, setup channels, paging and voice channels?

Ans:→ The function of frequency management is to divide the total number of available channels into subsets which can be assigned to each cell either in a fixed fashion or dynamically (i.e, in response to any channel among the available channels).

→ Frequency management refers to designating setup channels and voice channels, numbering the channels and grouping the voice channels into subsets.

Numbering the Radio channels:-

The total number of channels at present (January 1988) is 832. But most mobile units and systems are still operating on 666 channels. A channel consisting of two frequency channel bandwidths, one in the low band and one in high band. Two frequencies in channel 1 are 825.030 (Mobile Transmit) 870.030 MHz (Cell-site transmit). The two frequencies in channel 666 are 844.98 MHz (Mobile Transmit) and 898 MHz (Cell site transmit). The 666 channels are divided into two groups: block A system and block B system. Each market (i.e each city) has two systems for a duopoly market policy. Each block has 333 channels. The 42 set up channels are assigned as follows

Channels	313 - 333	Block A
Channels	334 - 354	Block B

The voice channels are assigned as follows

Channels	1-312 (312 Voice channels)	Block A
Channels	355-666 (312 Voice channels)	Block B

These 42 setup channels are assigned in the middle of all the assigned channels to facilitate scanning of those channels by frequency synthesizers.

Grouping into subsets

The number of voice channels for each system is 312. We can group these into any number of subsets. Since there are 21 setup channels for each system, it is logical to group the 312 channels into 21 subsets. Each subset then consists of 16 channels. In each set, the closest adjacent channel is 21 channels away. The 16 channels in each subset can be mounted on a frame and connected to a channel combiner. Wide separation between adjacent channels is required for meeting the requirement of minimum isolation. Each 16 channel subset is idealized for each 16-channel combiner. In a seven cell frequency-reuse cell system each cell contains three subsets, iA+iB+iC, where i is an integer from 1 to 7. The total number of voice channels in a cell is about 45. The minimum separation between three subsets is

7 channels. If six subsets are equipped in an omni-
-cell site, the minimum separation between two
adjacent channels can be only three ($\frac{21}{6} > 3$)
physical channel bandwidths.

Setup Channels

Setup channels are also called control channels are
the channels designated to setup calls. In a cellular
system, we are implementing frequency reuse concepts.
In this case, the setup channels are acting as
control channels. Theoretically, when cell size decreases
the use of set up channels should increase. Set up
channels can be classified by usage into two types
: access channels and paging channels.
An access channel is used for the mobile -
originating calls and paging channels for the
land originating calls. Setup channel is also
specified by two operations as a forward set-up
channel and a reverse setup channel.

5) (a) Discuss about point to point and area to area prediction model for cell coverage.

Ans:- Obtaining the mobile Point to Point model (Lee Model):-

The mobile point to point model is obtained in three steps:-

(a) Generating a standard condition
(b) Obtain an area to area prediction model
(c) A mobile point to point model using area to area prediction

The philosophy of developing this model is to try to separate two effects, i.e, one caused by natural terrain contour and other is human made structure, in the received signal strength.

Generating a standard condition

The advantage of using these standard values is to obtain directly predicted values in decibels above 1 mW expressed in dBm.

	Standard condition	Correction Factor
At Base station	Transmitted power, $P_t = 10W$ (40 dBm) then Antenna height, $h_i = 100ft$ (30m)	$\alpha_1 = 10\log\frac{P_t}{10}$

Standard Condition | Correction Factor

Antenna gain, $g_1 = 6dB/Pole$ | $\alpha_2 = 20\log\frac{h_1'}{h_1}$

$\alpha_3 = g_2' - 6$

At mobile unit: Antenna height, $h_2 = 10ft\,(3m)$ | $\alpha_4 = 10\log\frac{h_2'}{h_2}$

Antenna gain, $g_m = 6dB/dipole$ | $\alpha_5 = g_m'$

Obtain area to area prediction curves for human made structures

→ The area to area prediction curves are different in different areas. In this area to area prediction, all areas are considered to be flat. Even ~~through~~ though the data may be obtained from non flat areas, the area to area prediction is an average process.

→ An area to area prediction model can be represented by two parameters

(a) The 1mi intercept point

(b) The path loss slope

→ The 1mi intercept point is the power received at a distance of 1 mi from the transmitter.

→ Setup a transmitting antenna at the center of general area. As long as the building height is comparable to the others in the area, the antenna location is not critical.

→ Take 6 or 7 measured data points around the 1 mi intercept and around the 10 mi boundary based on high and low spots. Then compute the average of the 1 mi data points and the 10 mi data points. By connecting the two values, the path loss slope can be obtained.

→ If the terrain of the hilly area is generally sloped, then we have to convert the data points that were measured on the sloped terrain to a fictiously flat terrain in that area.

→ The conversion is based on the effective antenna height gain as

$$\Delta G = \text{Effective antenna height gain} = \log \frac{h_e}{h_1}$$

Where h_1 is the actual height

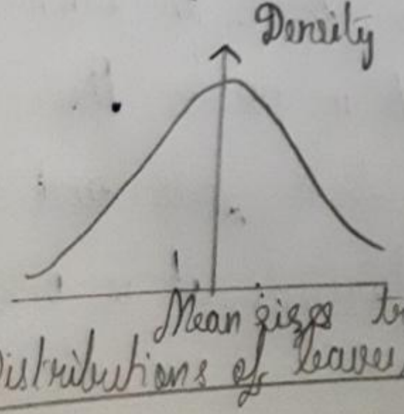
h_e is the effective antenna height at either 1 mi or 10 mi locations.

(b) Write short notes on foliage losses.

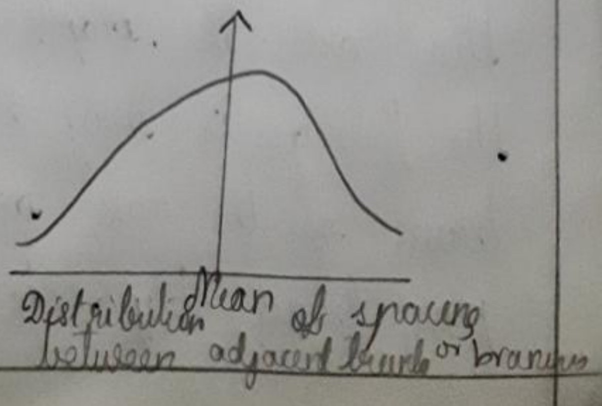
<u>Ans</u>:- Foliage loss is a very complicated topic that has many parameters and variations. The sizes of leaves, branches and trunks, the density and distribution of leaves, branches, and trunks, and the height of the trees relative to the antenna heights will all be considered. There are three levels; trunks, branches and leaves. In each level, there is a distribution of sizes of trunks, branches and leaves and also of the density and spacing between adjacent trunks, branches and leaves. The texture and thickness of the leaves also count.

Some trees, such as maple and oak, lose their leaves in winter, while others, such as pine, never do. For example, in Atlanta, Georgia, there are oak, maple and pine trees. In summer, the foliage is very heavy, but in winter the leaves of the oak and maple trees fall and the pine leaves stay. In these situations, it is very hard to predict the actual foliage loss. However, a rough estimate should be sufficient for the purpose of system design. In tropic zones, the sizes of tree leaves are so large and thick that the signal can hardly penetrate. In this case, the signal will propagate from the top of the tree and deflect to the mobile receiver.

Sometime, the foliage loss can be treated as a wire line loss, in decibels per foot or decibels per meter, when the foliage is uniformly heavy and the path lengths are short. When the path length is long and the foliage is non uniform, then decibels per octaves or decibels per decade are used. In general, foliage loss occurs with respect to the frequency to the fourth power.



Mean sizes trunks
Distributions of leaves, branches



Distribution Mean of spacing
between adjacent trunks or branches

Close in foliage at the transmitter site always heavily attenuates signal reception. Therefore, the cell site should be placed away from trees.