Subject Name: Wireless Communication

Subject Code: CSP311M

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Practical Number: 1

Aim: Path loss in Different Environment (ideal, urban, indoor) and their Receiver Antenna Power as increase in distance.

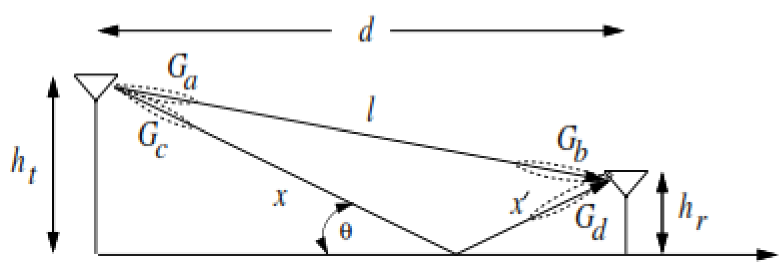
Brief Theory:

1. Free Space:

$$p_r = p_t * G_t * G_r * (\frac{\lambda}{4*\pi*d})$$

p_r: *Reciever Antenna Power*
p_t: *Transmited Antenna Power*
G_t: *Transmiter Antenna Gain*
G_r: *Reciever Antenna Gain*
$\lambda = \left(\frac{c}{f}\right)$: *Wavelenght* ($\therefore$ c: *Speed of light*, f: *frequency*)
d: *distance*

2. Two Ray:

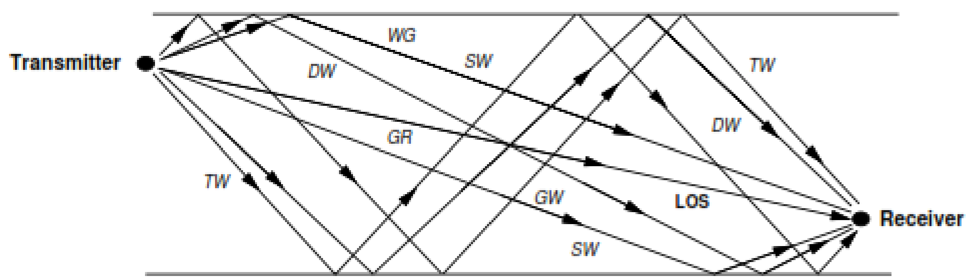


$$p_r = p_t * \left(\frac{\lambda}{4*\pi}\right)^2 * \left|\left(\frac{\sqrt{G_l}}{l} + \frac{R*\sqrt{G_r}*e^{(-1j*\Delta\phi)}}{x+x'}\right)\right|$$

p_r: *Receiver Antenna Power*
p_t: *Transmited Antenna Power*
$\lambda = \left(\frac{c}{f}\right)$: *Wavelenght* ($\therefore$ c: *Speed of light*, f: *frequency*)
d: *distance*

$G_l = \sqrt{G_a * G_b}$: $Antenna\ Gain\ of\ Direct\ sight\ path$
$G_r = \sqrt{G_c * G_d}$: $Antenna\ Gain\ of\ Reflected\ sight\ path$
$\Delta\boldsymbol{\phi}$: $Phase\ Diffrence$
$x + x'$: $Reflected\ Ray\ path\ (lenght)$
l: $Direct\ Line\ of\ sight\ path(Ray)(lenght)$
R: $Ground\ Reflection\ Coefficient$

3. Ten Ray:



$$p_r = p_t * \left(\frac{\lambda}{4*\pi}\right)^2 * \left|\left(\frac{\sqrt{G_l}}{l} + \frac{R_i * \sqrt{G_{r_i}} * e^{(-1j*\Delta\boldsymbol{\phi}_i)}}{x_i}\right)\right|$$

p_r: $Receiver\ Antenna\ Power$
p_t: $Transmited\ Antenna\ Power$
$\lambda = \left(\frac{c}{f}\right)$: $Wavelenght\ (\therefore\ c: Speed\ of\ light\ , f: frequency\ )$
d: $distance$
$G_l = \sqrt{G_a * G_b}$: $Antenna\ Gain\ of\ Direct\ sight\ path$
$G_{r_i} = \sqrt{G_{c_i} * G_{d_i}}$: $Antenna\ Gain\ of\ Reflected\ sight\ path$
$\Delta\boldsymbol{\phi_i}$: $Phase\ Diffrence$
x_i: $Reflected\ Ray\ path\ (lenght)$
l: $Direct\ Line\ of\ sight\ path(Ray)(lenght)$
R_i: $Ground\ Reflection\ Coefficients$

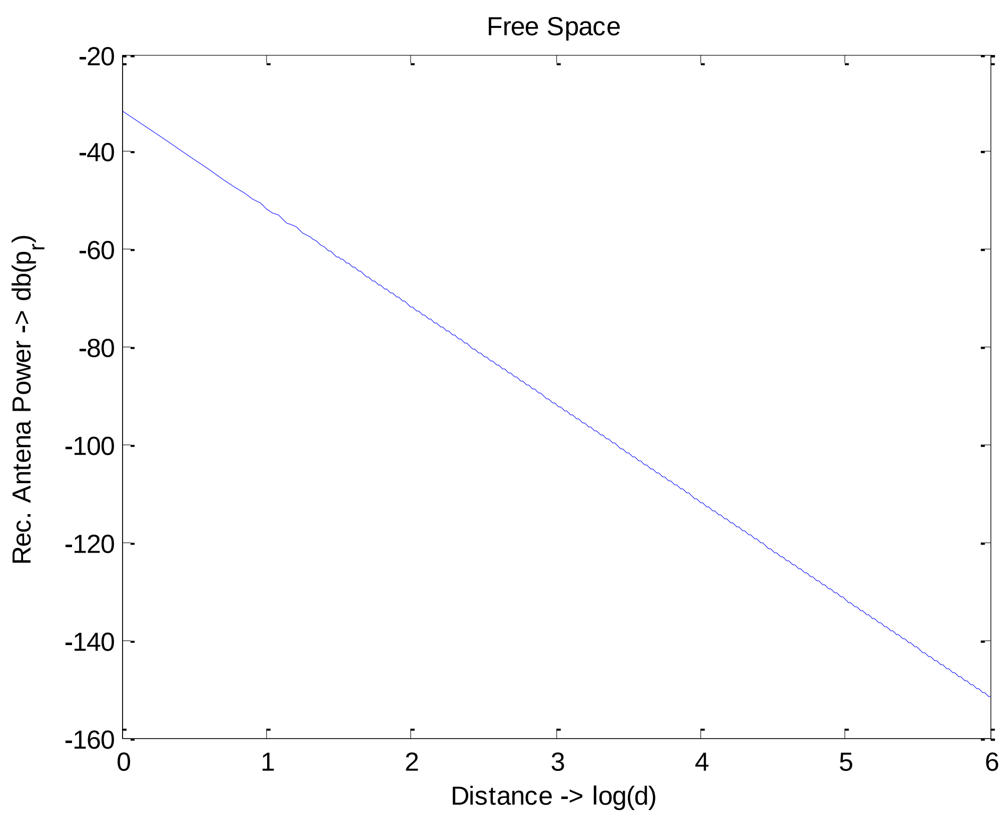
Matlab Code:

1. Free Space:

   Code:

```
d=1:1:10^6;% Distance
p_t=1;   %Trasmitting Antena Power
G_t=1;   %Trasmitting Antena Gain
G_r=1;   %Receiving Antena Gain
c=3*10^8;   %Speed of light
f=900*10^6;  %frequency
lamda=c/f;
p_r=p_t.*G_t.*G_r.*(lamda./(4.*pi.*d)); %Recevier Antena Power
plot(log10(d),db(p_r)); %plot
xlabel('Distance -> log(d)'); % X-Axis Label
ylabel('Rec. Antena Power -> db(p_r)'); % Y-Axis Label
title('Free Space'); %Title
```

   Simulation Results:



2. Two Ray:

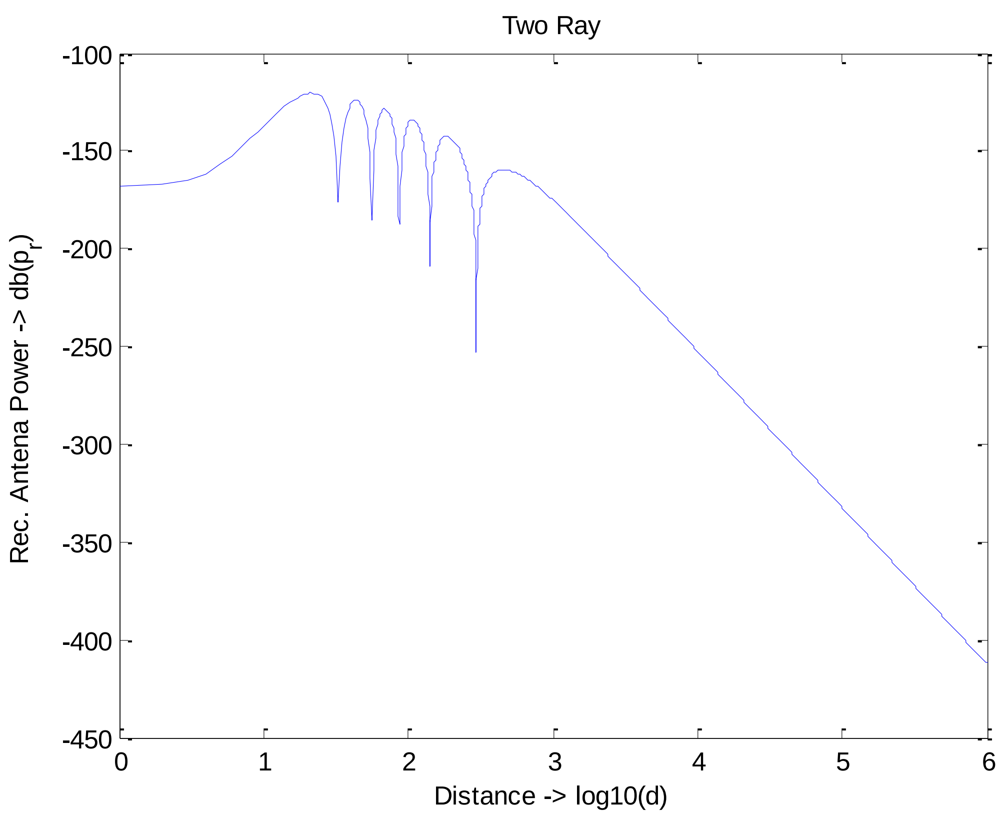
Code:

```
d=1:1:10^6;% Distance
p_t=1;    %Trasmitting Antena Power
G_t=1;    %Trasmitting Antena Gain
G_r=1;    %Receiving Antena Gain
c=3*10^8;    %Speed of light
f=900*10^6;   %frequency
lamda=c/f; %wavelenght
h_t = 50; %Height of Transmiting Antena
h_r = 3; %Height of Receiving Antena
R=-1;    %Reflaction co-efficient

xx_1=(sqrt((h_t+h_r)^2+d.^2));%Reflacted Ray Path(lenght)
l=(sqrt((h_t-h_r)^2+d.^2)); %Direct line of sight Ray path(lenght)
DeltaPhi=2.*pi.*(xx_1 - l); %the phase difference between the two received signal components
p_r=p_t*(lamda./(4.*pi)).^2.*abs(1./l + R.*exp(-1j.*DeltaPhi)./xx_1).^2; %Reciever Antena Power

plot(log10(d),db(p_r)); %plot
xlabel('Distance -> log10(d)'); %X-Axis Label
ylabel('Rec. Antena Power -> db(p_r)'); %Y-Axis Label
title('Two Ray'); %Title
```

Simulation Results:



3. Ten Ray:

Code:

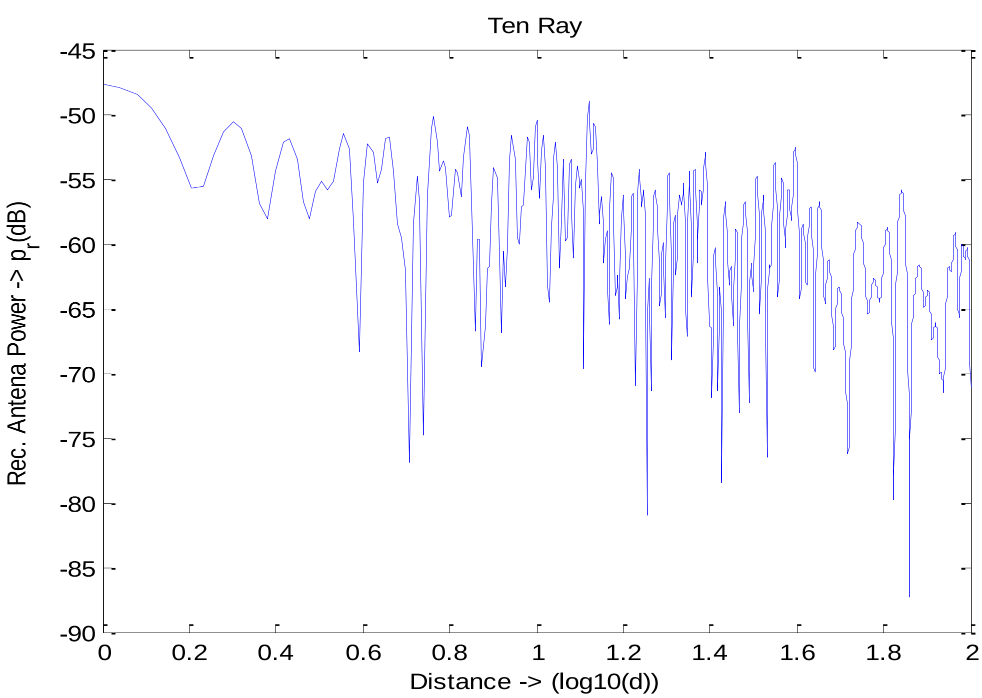
```
d = 1:0.1:100; % Distance
p_t=1;    %Trasmitting Antena Power
G_t=1;    %Trasmitting Antena Gain
G_r=1;    %Receiving Antena Gain
c=3*10^8;    %Speed of light
f=900*10^6;   %frequency
lamda=c/f;
h_t = 50; %Height of Transmiting Antena
h_r = 3; %Height of Receiving Antena
R=-1;    %Reflaction co-efficient
DeltaPhi=0; %Phase Diffrence
l=(sqrt((h_t-h_r)^2 + (d.^2)));    %Direct line of sight Ray path(lenght)
sum=0;

for i=1:9
t=0.1*i*d;
x=(sqrt((h_t).^2+(t.^2)));    %Reflacted Ray path(lenght)
x_1=(sqrt((h_r).^2+((d-t).^2)));    %Reflacted Ray path(lenght)
DeltaPhi=DeltaPhi+2.*pi.*((x+x_1)-l);  %Phase Different Between rays
sum = sum + R.*sqrt(G_r).*(exp(-1i.*(DeltaPhi))./(x+x_1));
end

p_r = p_t.*(c./(4.*pi*f)).^2.*(abs((sqrt(G_t)./l) + sum)).^2;     %Receiver Antena Power

plot(log10(d),10*log10(p_r)); %Plot
xlabel('Distance -> (log10(d))') %X-Axis Label
ylabel('Rec. Antena Power -> p_r(dB)') %Y-Axis Label
title('Ten Ray') %Title
```

Simulation Results:



Result interpretation:

1. As per Equation of the Free Space, Two Ray, Ten Ray Power of Receiving Antenna is Inversely Proportional to the Square of distance between Transmitting Antenna and Receiving Antenna and dependent on Reflection Co-efficient factor

2. As number of Rays increases the Signal Distortion Increases as we can observe from Two Ray and Ten Ray