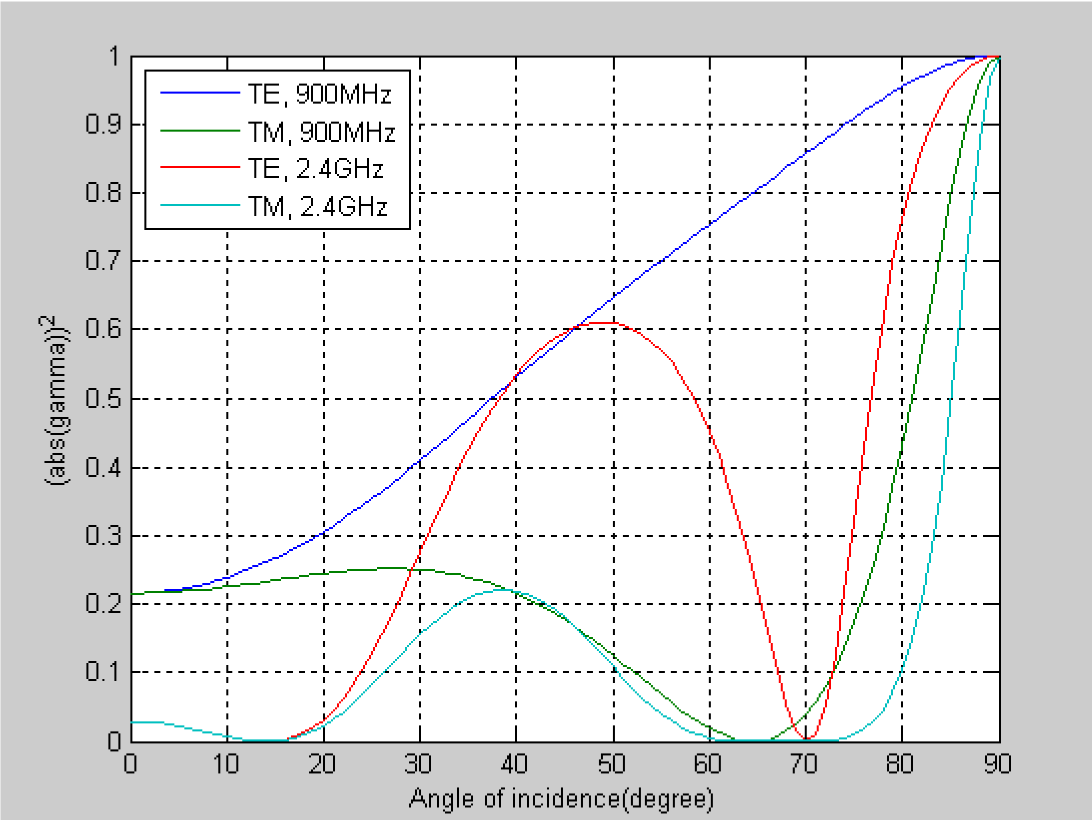
1. For a concrete brick wall

1) Source code

```
epsilon_0 = 1/(36*pi)*10^-9;      % permitivity
mu_0 = 4*pi*10^-7;               % permeability
eta = sqrt(mu_0/epsilon_0);        % wave impedence
c = 3*10^8;                     % wave velocity
epsilon_r = 4.4;                 % relative permitivity
f_1 = 9*10^8;                    %  900MHZ
f_2 = 2.4*10^9;                  % 2.4GHZ

theta = 0 : pi/2/90 : pi/2;       % angle of incidence

d = 0.3;                        %thickness of medium

k_a1 = 2*pi*f_1 / c;             % wave number of transmitted wave for f_1
k_a2 = 2*pi*f_2 / c;             % wave number of transmitted wave for f_2

k_w1 = k_a1 * sqrt(epsilon_r);    % wave number of reflected wave for f_1
k_w2 = k_a2 * sqrt(epsilon_r);    % using Snell's law

for i=1:91

   Kappa1 = sqrt(k_w1^2 -k_a1^2 * sin(theta(i))^2);
   Kappa2 = sqrt(k_w2^2 -k_a2^2 * sin(theta(i))^2);

   Zw_TE1 = 2*pi*f_1*mu_0 / Kappa1;
   Za_TE1 = eta / cos(theta(i));
   Zw_TE2 = 2*pi*f_2*mu_0 / Kappa2;
   Za_TE2 = eta / cos(theta(i));

   Zw_TM1 = Kappa1/(2*pi*f_1*epsilon_0*epsilon_r);
   Za_TM1 = eta*cos(theta(i));
   Zw_TM2 = Kappa2/(2*pi*f_2*epsilon_0*epsilon_r);
   Za_TM2 = eta*cos(theta(i));
```

```
    Z_TE1 = Zw_TE1 *(Za_TE1 * cos(Kappa1*d)+j*Zw_TE1 *sin(Kappa1*d)) /
(Zw_TE1*cos(Kappa1*d)+j*Za_TE1*sin(Kappa1*d));
    Z_TM1 = Zw_TM1 *(Za_TM1 * cos(Kappa1*d)+j*Zw_TM1 *sin(Kappa1*d)) /
(Zw_TM1*cos(Kappa1*d)+j*Za_TM1*sin(Kappa1*d));
    Z_TE2 = Zw_TE2 *(Za_TE2 * cos(Kappa2*d)+j*Zw_TE2 *sin(Kappa2*d)) /
(Zw_TE2*cos(Kappa2*d)+j*Za_TE2*sin(Kappa2*d));
    Z_TM2 = Zw_TM2 *(Za_TM2 * cos(Kappa2*d)+j*Zw_TM2 *sin(Kappa2*d)) /
(Zw_TM2*cos(Kappa2*d)+j*Za_TM2*sin(Kappa2*d));


    gamma_TE1 = (Z_TE1 - Za_TE1)/(Z_TE1 + Za_TE1); % reflection coeff.
    gamma_TM1 = (Z_TM1 - Za_TM1)/(Z_TM1 + Za_TM1);  % reflection coeff.
    gamma_TE2 = (Z_TE2 - Za_TE2)/(Z_TE2 + Za_TE2);
    gamma_TM2 = (Z_TM2 - Za_TM2)/(Z_TM2 + Za_TM2);


    y_TE1(i) = (abs(gamma_TE1))^2;
    y_TM1(i) = (abs(gamma_TM1))^2;
    y_TE2(i) = (abs(gamma_TE2))^2;
    y_TM2(i) = (abs(gamma_TM2))^2;
end
    phase = 180/pi * theta;

    plot(phase, y_TE1 , phase , y_TM1, phase, y_TE2 , phase , y_TM2);
    grid on
    hold on

xlabel('Angle of incidence(degree)');
ylabel('(abs(gamma))^2');
legend('TE, 900MHz', 'TM, 900MHz', 'TE, 2.4GHz', 'TM, 2.4GHz',2)
```

2) Result



2. For a glass window

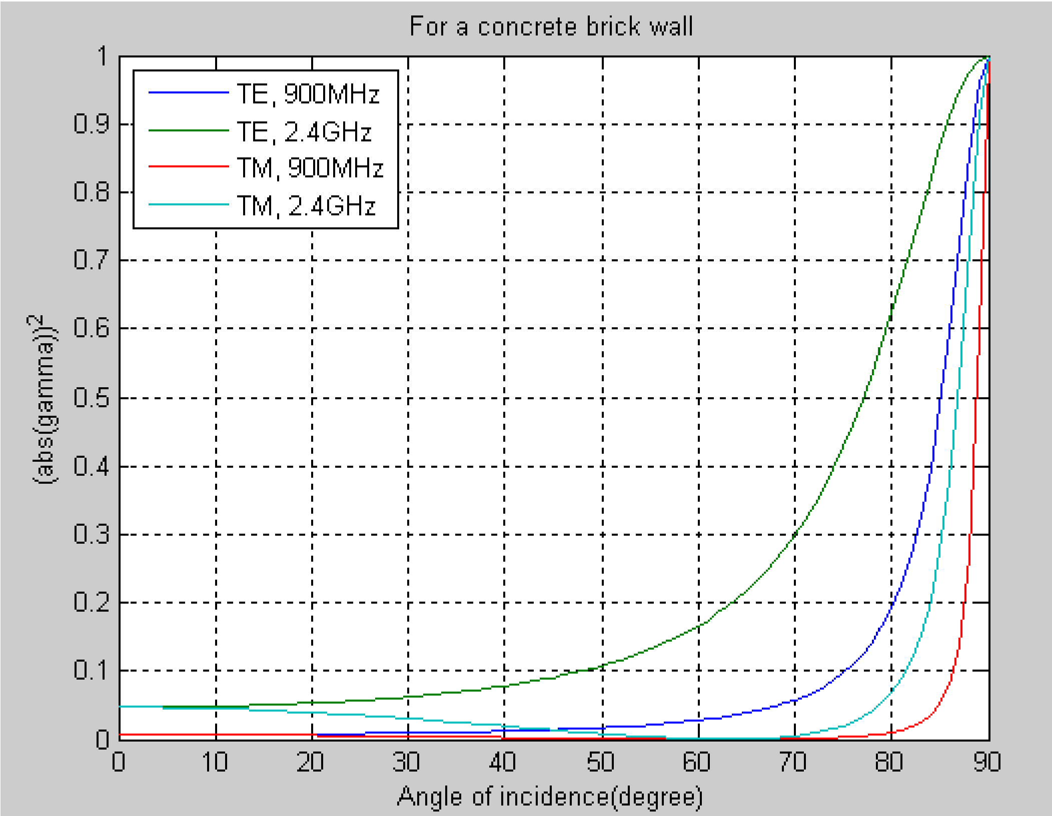
1) Source code

```
epsilon_0 = 1/(36*pi)*10^-9;        % permitivity
mu_0 = 4*pi*10^-7;                  % permeability
eta = sqrt(mu_0/epsilon_0);         % wave impedence
c = 3*10^8;                         % wave velocity
epsilon_r = 4;                      % relative permitivity
f_1 = 9*10^8;                       %  900MHZ
```

```
f_2 = 2.4*10^9;                  % 2.4GHZ

theta = 0 : pi/2/90 : pi/2;       % angle of incidence

d = 0.003;                        %thickness of medium

k_a1 = 2*pi*f_1 / c;             % wave number of transmitted wave for f_1
k_a2 = 2*pi*f_2 / c;             % wave number of transmitted wave for f_2

k_w1 = k_a1 * sqrt(epsilon_r);    % wave number of reflected wave for f_1
k_w2 = k_a2 * sqrt(epsilon_r);    % using Snell's law

for i=1:91

    Kappa1 = sqrt(k_w1^2 -k_a1^2 * sin(theta(i))^2);
    Kappa2 = sqrt(k_w2^2 -k_a2^2 * sin(theta(i))^2);

    Zw_TE1 = 2*pi*f_1*mu_0 / Kappa1;
    Za_TE1 = eta / cos(theta(i));
    Zw_TE2 = 2*pi*f_2*mu_0 / Kappa2;
    Za_TE2 = eta / cos(theta(i));

    Zw_TM1 = Kappa1/(2*pi*f_1*epsilon_0*epsilon_r);
    Za_TM1 = eta*cos(theta(i));
    Zw_TM2 = Kappa2/(2*pi*f_2*epsilon_0*epsilon_r);
    Za_TM2 = eta*cos(theta(i));

    Z_TE1 = Zw_TE1 *(Za_TE1 * cos(Kappa1*d)+j*Zw_TE1 *sin(Kappa1*d)) /
(Zw_TE1*cos(Kappa1*d)+j*Za_TE1*sin(Kappa1*d));
    Z_TM1 = Zw_TM1 *(Za_TM1 * cos(Kappa1*d)+j*Zw_TM1 *sin(Kappa1*d)) /
(Zw_TM1*cos(Kappa1*d)+j*Za_TM1*sin(Kappa1*d));
    Z_TE2 = Zw_TE2 *(Za_TE2 * cos(Kappa2*d)+j*Zw_TE2 *sin(Kappa2*d)) /
(Zw_TE2*cos(Kappa2*d)+j*Za_TE2*sin(Kappa2*d));
    Z_TM2 = Zw_TM2 *(Za_TM2 * cos(Kappa2*d)+j*Zw_TM2 *sin(Kappa2*d)) /
(Zw_TM2*cos(Kappa2*d)+j*Za_TM2*sin(Kappa2*d));
```

```
    gamma_TE1 = (Z_TE1 - Za_TE1)/(Z_TE1 + Za_TE1);% reflection coeff.
    gamma_TM1 = (Z_TM1 - Za_TM1)/(Z_TM1 + Za_TM1);% reflection coeff.
    gamma_TE2 = (Z_TE2 - Za_TE2)/(Z_TE2 + Za_TE2);
    gamma_TM2 = (Z_TM2 - Za_TM2)/(Z_TM2 + Za_TM2);

    y_TE1(i) = (abs(gamma_TE1))^2;
    y_TM1(i) = (abs(gamma_TM1))^2;
    y_TE2(i) = (abs(gamma_TE2))^2;
    y_TM2(i) = (abs(gamma_TM2))^2;
end

phase = 180/pi * theta;

plot(phase, y_TE1 , phase , y_TM1, phase, y_TE2 , phase , y_TM2);
grid on;
hold on;

xlabel('Angle of incidence(degree)');
ylabel('(abs(gamma))^2');
legend('TE, 900MHz', 'TM, 900MHz', 'TE, 2.4GHz', 'TM, 2.4GHz',2);
```

2) Result



For a concrete brick wall
TE, 900MHz
TE, 2.4GHz
TM, 900MHz
TM, 2.4GHz
(abs(gamma))2
Angle of incidence(degree)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
10
20
30
40
50
60
70
80
90