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%%%%%%%%%%%% Harmonic Wave Equation in 2D FD and Modes %%%%%%%%%%%%
% By David, Patrobas, Andrew and Xiaochen
% Febuary 24th, 2019
% Assignment 2
% Patrobas Adewumi
global C;
C.q_0 = 1.60217653e-19;             % electron charge
C.hb = 1.054571596e-34;             % Dirac constant
C.h = C.hb * 2 * pi;                    % Planck constant
C.m_0 = 9.10938215e-31;             % electron mass
C.kb = 1.3806504e-23;               % Boltzmann constant
C.eps_0 = 8.854187817e-12;          % vacuum permittivity
C.mu_0 = 1.2566370614e-6;           % vacuum permeability
C.c = 299792458; % speed of light

% Define area of region
W = 20;    % width in y dir
L = W*3/2; % length in x dir

% Centre point of given region
mid_x = L/2;
mid_y = W/3;

% Setting up the matrices for evaluation
G = zeros(L*W,L*W);
B = zeros(L*W,1);

% Defining conductivity of the boxes (given area)
s1 = 1;
s2 = 0.01;

% Define resistive region size
res_L = L*1/4;
res_W = W*2/5;

Smap = ones(L,W);
for i = 1:1:L
    for j = 1:1:W
        n = j+(i-1)*W;
        nxm = j+(i-2)*W;
        nxp = j+i*W;
        nyp = j+1+ (i-1)*W;
        nym = j-1+ (i-1)*W;

        if(i == 1)
            G(n,:) = 0;
            G(n,n) = 1;
            B(n) = 1;
            Smap(i,j) = s1;
        elseif(i == L)
            G(n,:) = 0;
            G(n,n) = 1;
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                B(n) = 0;
                Smap(i,j) = s1;
            elseif(j == 1)
                G(n,:) = 0;
                if(i > mid_x - (res_L/2) && i < mid_x + (res_L/2))
                    G(n,nxm) = s2;
                    G(n,nxp) = s2;
                    G(n,nyp) = s2;
                    G(n,n) = -3*s2;
                    Smap(i,j) = s2;
                else
                    G(n,nxm) = s1;
                    G(n,nxp) = s1;
                    G(n,nyp) = s1;
                    G(n,n) = -3;
                    Smap(i,j) = s1;
                end
            elseif(j == W)
                G(n,:) = 0;
                if(i > mid_x - (res_L/2) && i < mid_x + (res_L/2))
                    G(n,nxm) = s2;
                    G(n,nxp) = s2;
                    G(n,nym) = s2;
                    G(n,n) = -3*s2;
                    Smap(i,j) = s2;
                else
                    G(n,nxm) = s1;
                    G(n,nxp) = s1;
                    G(n,nym) = s1;
                    G(n,n) = -3;
                    Smap(i,j) = s1;
                end
            else
                G(n,:) = 0;
                G(n,n) = -4;
                %  setting my X and Y Boundaries

                if((i > mid_x -(res_L/2) && i < mid_x + (res_L/2)) && ...
                        (j > mid_y + (res_W/2) || j < mid_y -(res_W/2)))
                   G(n,nxp) = s2;
                    G(n,nxm) = s2;
                    G(n,nyp) = s2;
                    G(n,nym) = s2;
                    Smap(i,j) = s2;
                else
                    G(n,nxp) = s1;
                    G(n,nxm) = s1;
                    G(n,nyp) = s1;
                    G(n,nym) = s1;
                    Smap(i,j) = s1;
                end
            end
        end
    end
```

```
V = G\B;
Vmap = zeros(L,W);
for i =1:1:L
    for j = 1:1:W
        n = j+(i-1)*W;
        Vmap(i,j) = V(n);
    end
end

[Ey,Ex] = gradient(Vmap);

E = gradient(Vmap);
J = Smap.*E;

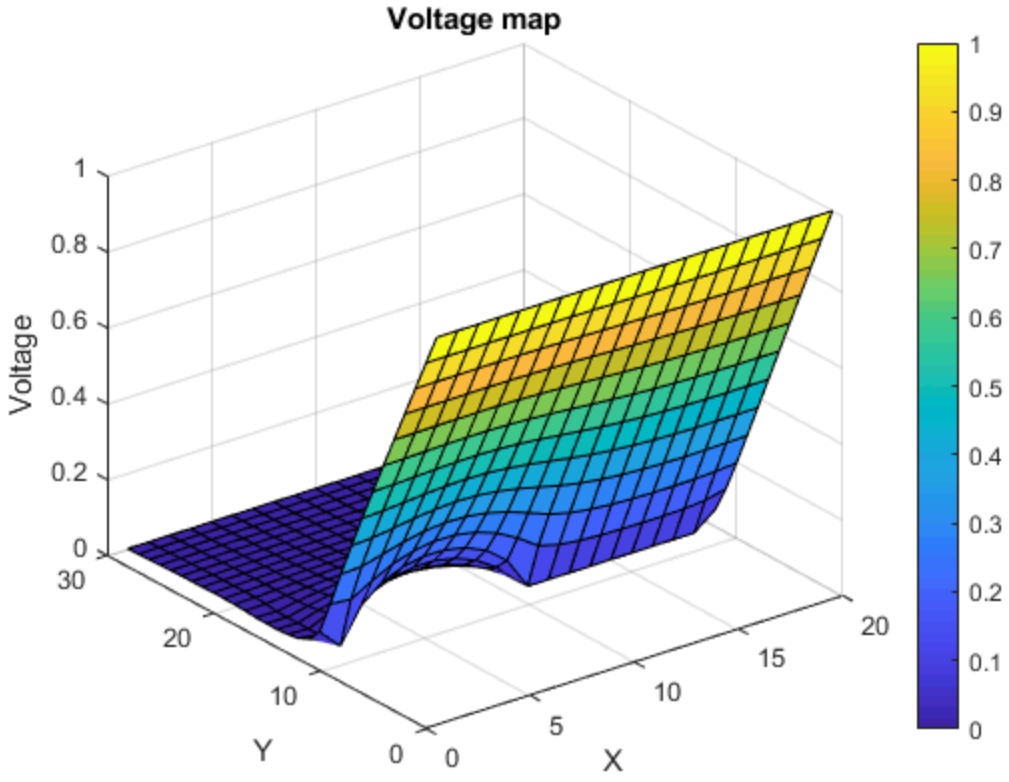
figure(5)
surf(Vmap)
colorbar
title('Voltage map')
xlabel('X')
ylabel('Y')
zlabel('Voltage')

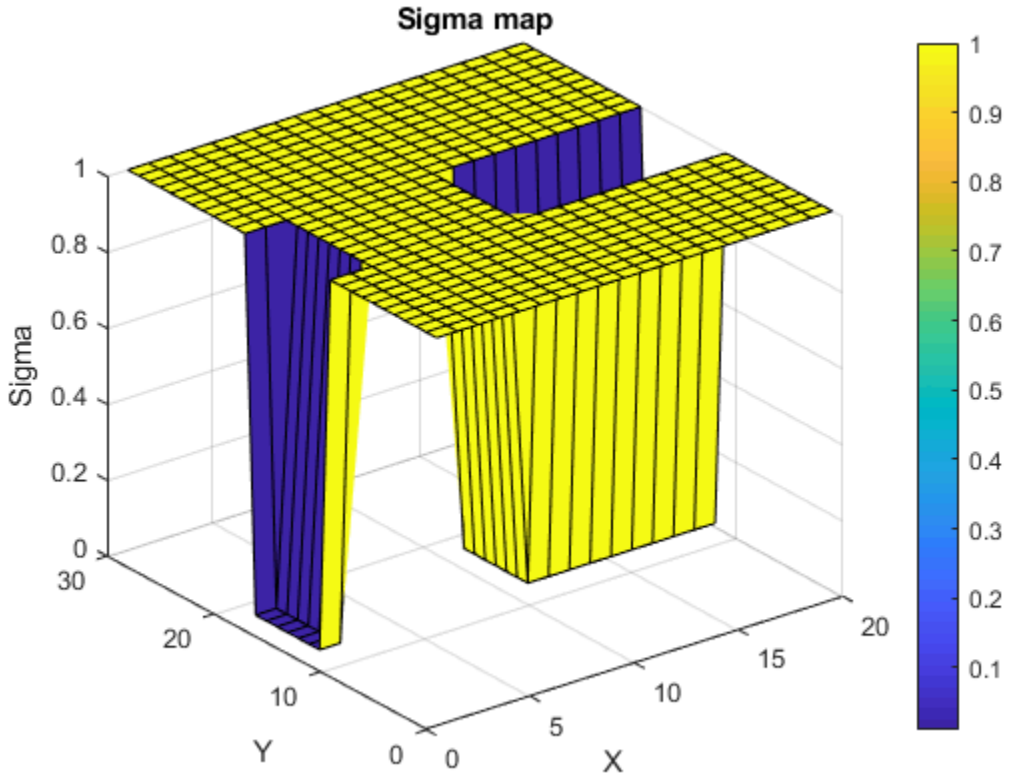
figure(6)
surf(Smap)
colorbar
title('Sigma map')
xlabel('X')
ylabel('Y')
zlabel('Sigma');

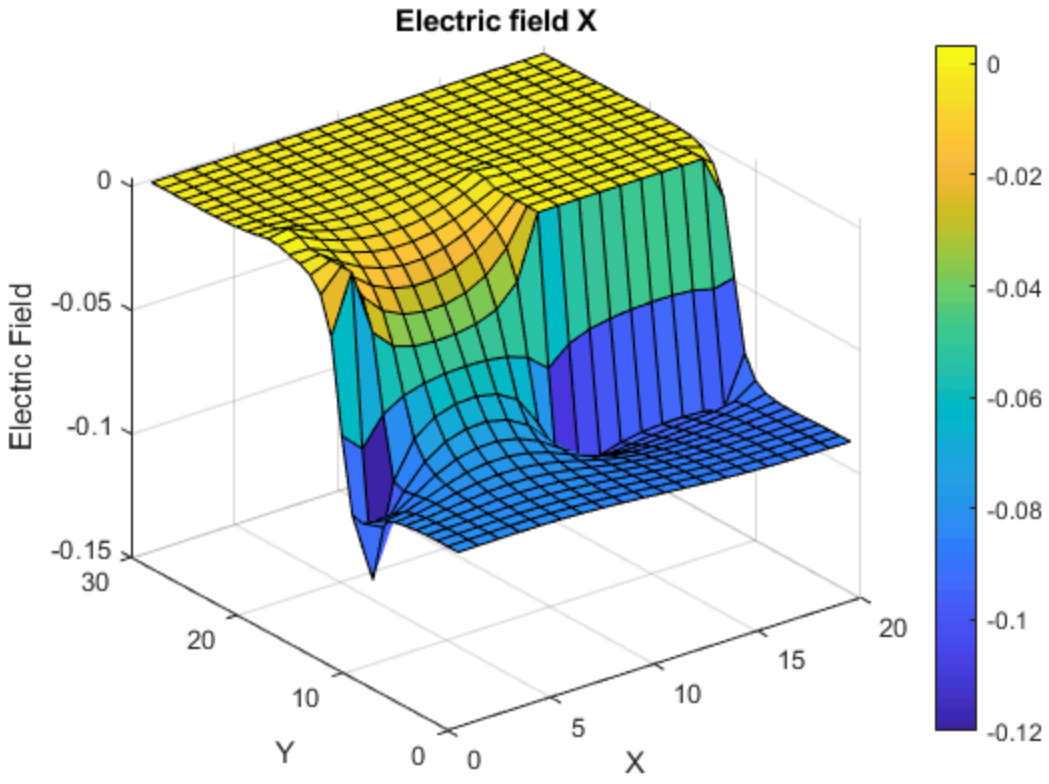
figure(7)
surf(Ex)
colorbar
title('Electric field X')
xlabel('X')
ylabel('Y')
zlabel('Electric Field');

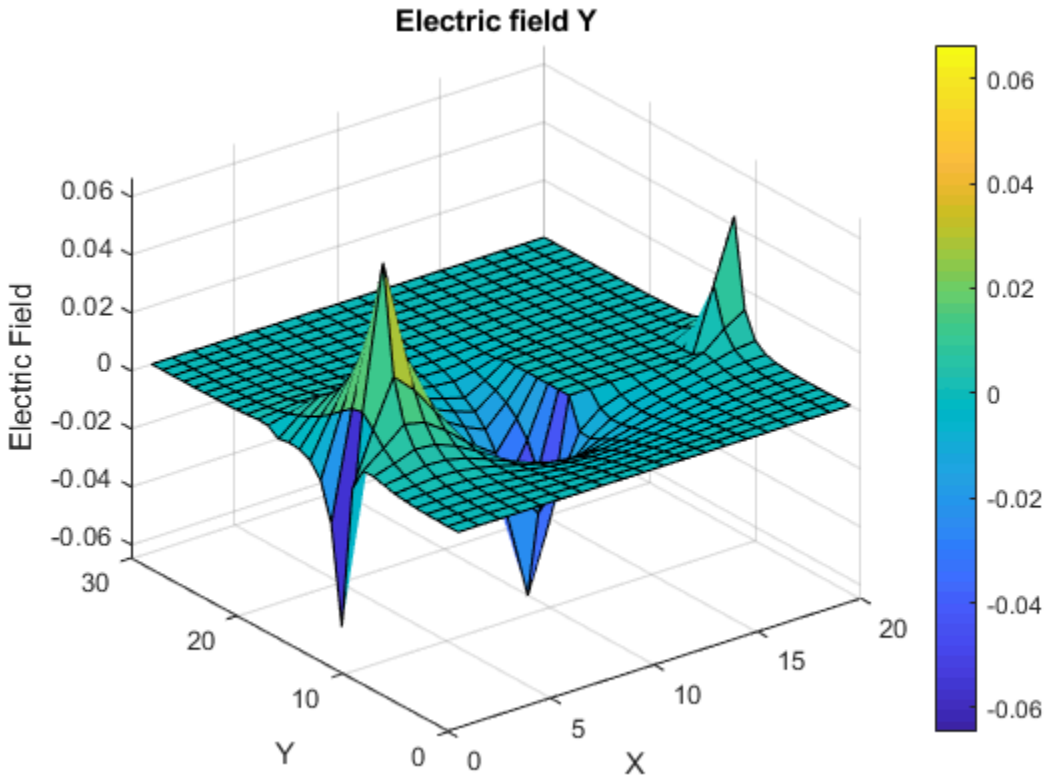
figure(8)
surf(Ey)
colorbar
title('Electric field Y')
xlabel('X')
ylabel('Y')
zlabel('Electric Field');

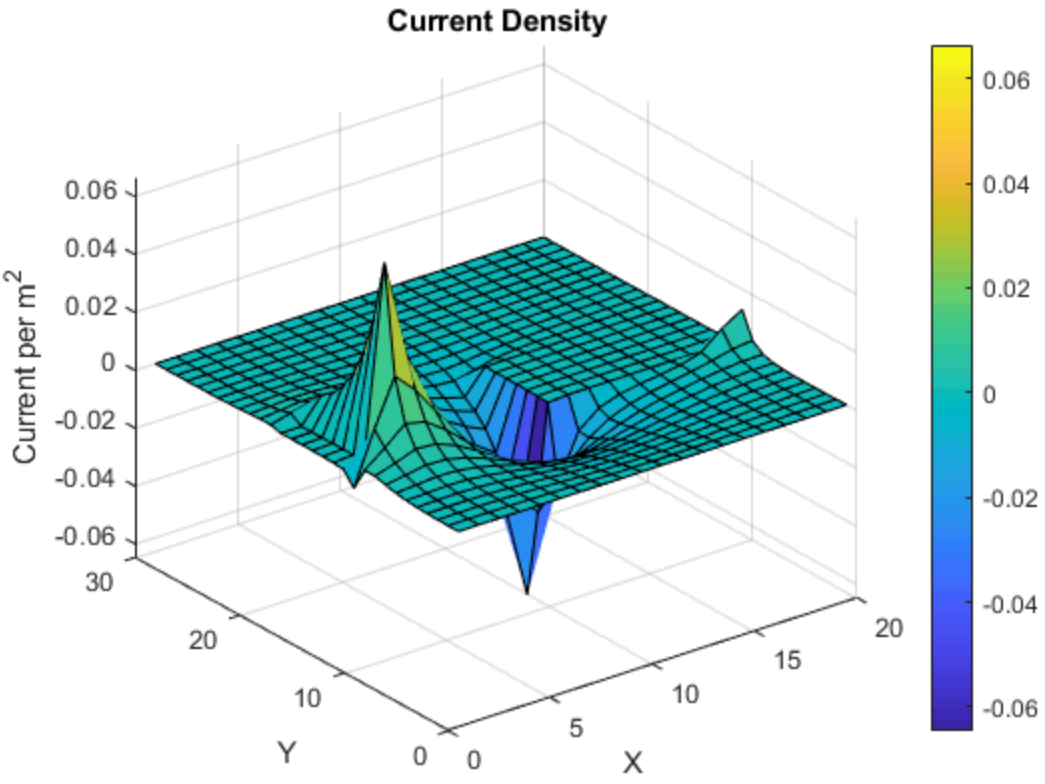
figure(9)
surf(J)
colorbar
title('Current Density')
xlabel('X')
ylabel('Y')
zlabel('Current per m^2');
```


Voltage map
Voltage
1
0.8
0.6
0.4
0.2
0
30
20
10
0
Y
0
5
10
15
20
X
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


Sigma map
Sigma
1
0.8
0.6
0.4
0.2
0
30
20
10
0
Y
0
5
10
15
20
X
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


Electric field X
Electric Field
0
-0.05
-0.1
-0.15
30
20
10
0
Y
0
5
10
15
20
X
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12


Electric field Y
Electric Field
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
30
20
10
0
Y
0
5
10
15
20
X
0.06
0.04
0.02
0
-0.02
-0.04
-0.06



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