ASSIGNMENT TWO - ELEC 4700

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Joseph Kingsley A.Amiah

Question 1

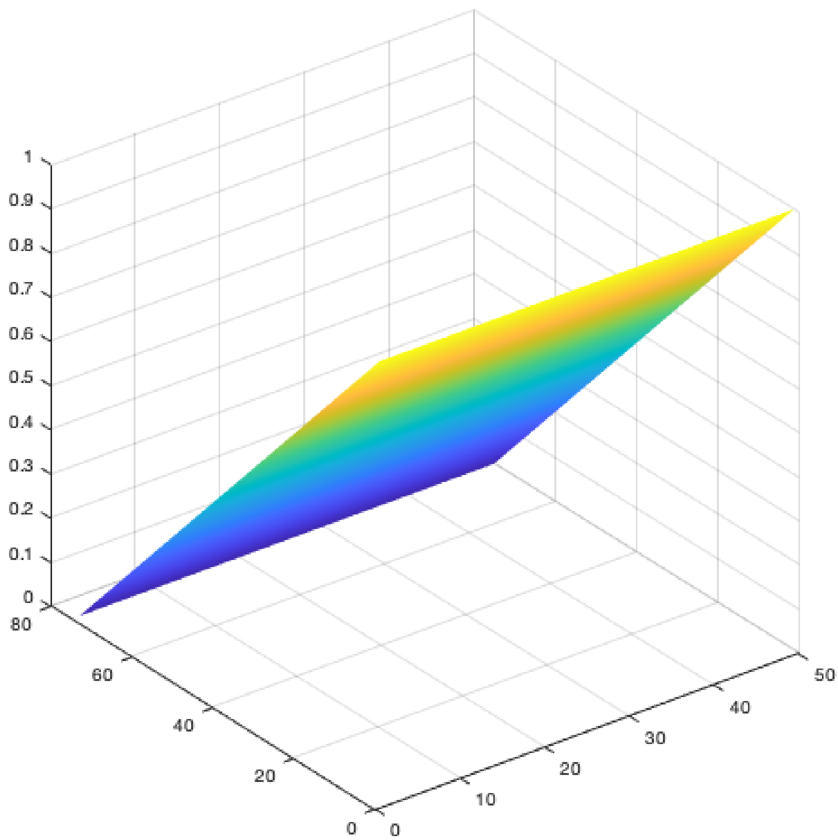
(a) Case where V = Vo at x = 0 and V = 0 at x = L;

The Code

```
clearvars
clearvars -GLOBAL
close all
%set(0,'DefaultFigureWindowStyle', 'docked')

global C
global CuCond
global nx ny

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
C.g = 9.80665;                      % metres (32.1740 ft) per s²

nx = 75;
ny = 50;

CuCond = 1.7e-8;

%Conductivity Map

cMap = zeros(nx,ny);

for i = 1:nx
    for j = 1: ny
        cMap(i,j) = CuCond;
    end
end

G = sparse(nx*ny, nx*ny);
F = zeros(1, nx*ny);

% G - Matrix Formulation

for i = 1:nx
```

```
    for j = 1:ny
        n = j + (i - 1) * ny;

        if i == 1
            G(n,:) = 0;
            G(n,n) = 1;
             F(n) = 1;

        elseif i == nx
             G(n,:) = 0;
             G(n,n) = 1;

        elseif j == 1
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nyp = (j+1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nyp) = ryp;

        elseif j == ny
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;

            G(n,n) = -(rxm + rxp + rym);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;

        else
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;
            nyp = (j+1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + rym + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;
            G(n, nyp) = ryp;
        end
    end
end

% Using Finite Difference

V = G\F';

for i = 1:nx
    for j = 1:ny
```

```
        n = j + (i-1) * ny;
        VG(i,j) = V(n);
    end
end

figure
set(surf(VG),'linestyle', 'none');
```

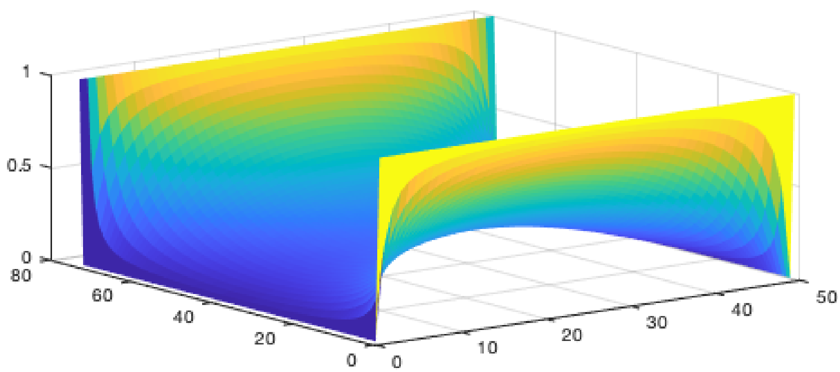


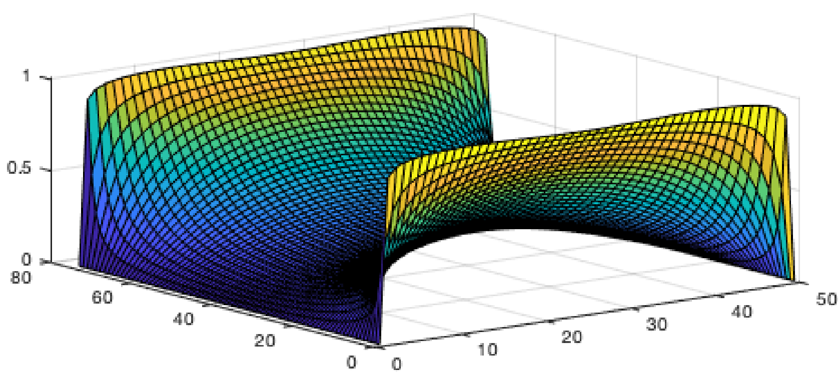
(b) Case where V = Vo at x = 0, x = L and V = 0 at y = 0, y = W;

```
clearvars
clearvars -GLOBAL
close all
%set(0,'DefaultFigureWindowStyle', 'docked')

nx = 75;
ny = 50;

CuCond = 1.7e-8;

%Conductivity map

cMap = zeros(nx,ny);

for i = 1:nx
    for j = 1: ny
        cMap(i,j) = CuCond;
    end
end
```

```
G = sparse(nx*ny, nx*ny);
F = zeros(1, nx*ny);

for i = 1:nx
    for j = 1:ny
        n = j + (i - 1) * ny;

        if i == 1
            G(n,:) = 0;
            G(n,n) = 1;
             F(n) = 1;

        elseif i == nx
             G(n,:) = 0;
             G(n,n) = 1;

             F(n) = 1;


        elseif j == 1
            G(n,:) = 0;
            G(n,n) = 1;
             F(n) = 0;
        elseif j == ny
            G(n,:) = 0;
            G(n,n) = 1;
             F(n) = 0;
        else
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;
            nyp = (j+1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + rym + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;
            G(n, nyp) = ryp;
        end
    end
end

% V using Finite Difference Method

V = G\F';

for i = 1:nx
    for j = 1:ny
        n = j + (i-1) * ny;
        VG(i,j) = V(n);
    end
end
figure
subplot(2,1,1);
set(surf(VG),'linestyle', 'none');

% V using the Analytical Series Method

N =101;

a = ny;
```

```
b = nx/2;
VpSig = zeros(nx,ny);

x = linspace(-b,b,nx);
y = linspace(0,a,ny);

VSig = zeros(nx,ny);
for k = 1:2:N
    for i = 1:nx
        for j = 1:ny
            VpSig(i,j) = ((4*1)/pi) * (1/k) * ((cosh((k*pi*x(i))/a))/(cosh((k*pi*b)/a))) * sin((k*pi*y(j))/a);
        end
    end
    VSig = (VSig + VpSig);
    subplot(2,1,2);

    surf(VSig)
    pause(0.1)
end
```





Both analytical and numerical show similar responses. Curved edges in the analytical plot show that the analytical simulation will need a lot itereations to get a precise answer. The multiple iterations may or may not allow the simulation to converge at a final solution.

Question 2

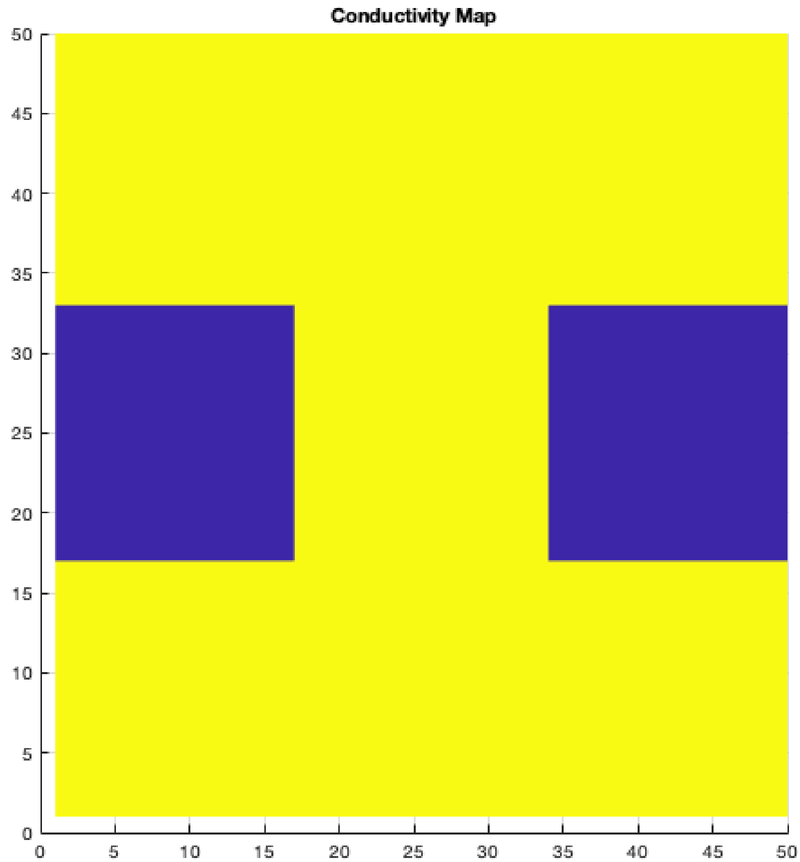
(a) Plots are shown below

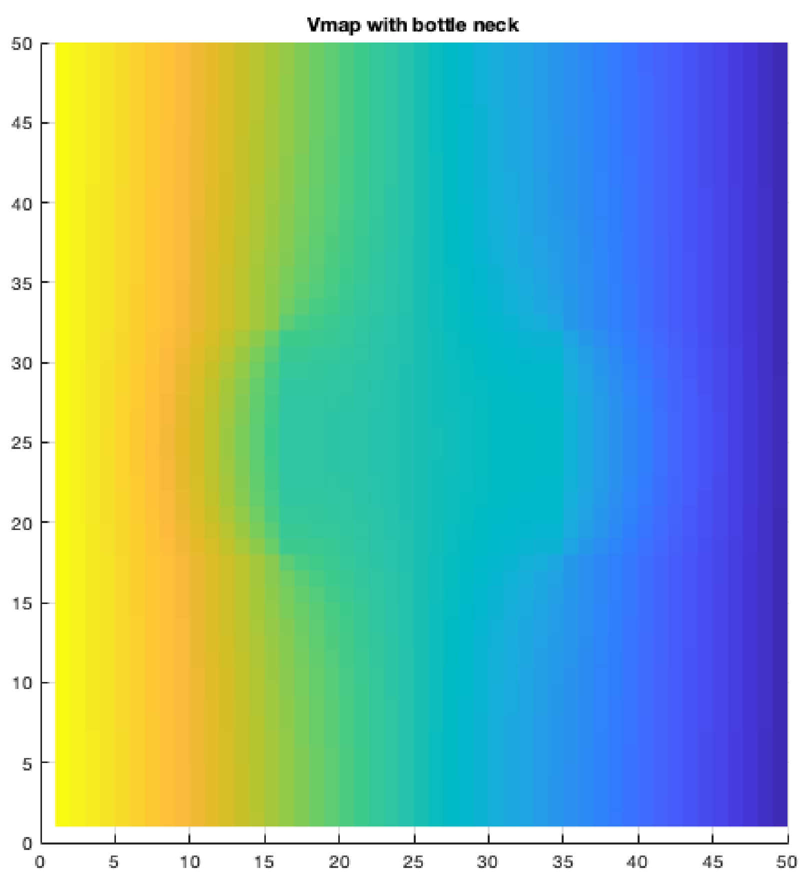
```
clearvars
clearvars -GLOBAL
```

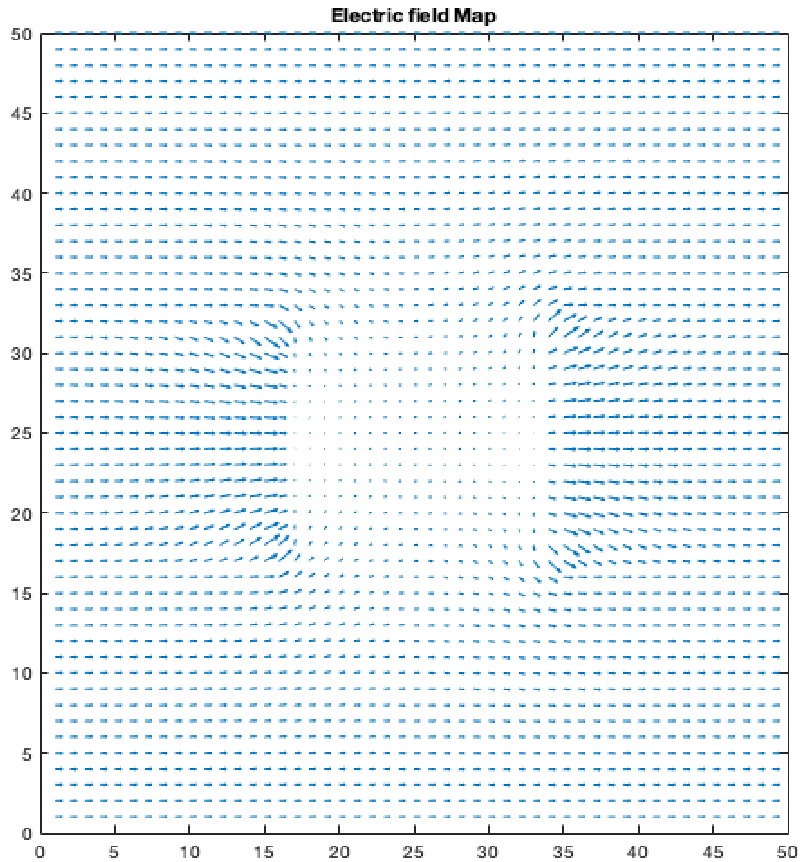
```
close all
set(0,'DefaultFigureWindowStyle', 'docked')

global C
global CuCond NoCond
global nx ny

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
C.g = 9.80665;                      % metres (32.1740 ft) per s²

nx = 50;
ny = 50;

Lb = floor(nx/3);
Wb = floor(ny/3);


CuCond = 100;
NoCond = 10e-9;

%Conductivity map

cMap = zeros(nx,ny);

for i = 1:nx
    for j = 1: ny
        cMap(i,j) = CuCond;
    end
end

for i = 1:nx
    for j = 1:ny
        if (i>=1 && i<=Wb && j>Lb && j<=(2*Lb))
            cMap(i,j) = NoCond;
        end

        if (i<=ny && i>=(ny-Wb) && j>Lb && j<=(2*Lb))
            cMap(i,j) = NoCond;
        end
    end
end

G = sparse(nx*ny, nx*ny);
F = zeros(1, nx*ny);

% V using Finite Difference Method
for i = 1:nx
    for j = 1:ny
        n = j + (i - 1) * ny;

        if i == 1
            G(n,:) = 0;
            G(n,n) = 1;
             F(n) = 1;

        elseif i == nx
             G(n,:) = 0;
             G(n,n) = 1;
```

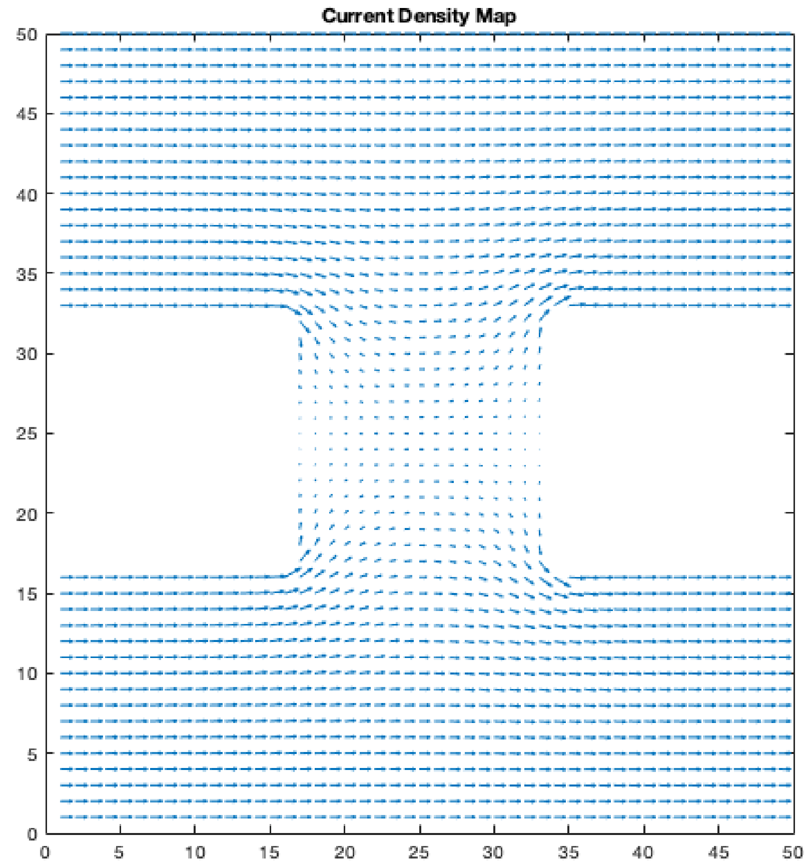
```
        elseif j == 1
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nyp = (j+1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nyp) = ryp;

        elseif j == ny
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;

            G(n,n) = -(rxm + rxp + rym);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;

        else
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;
            nyp = (j+1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + rym + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;
            G(n, nyp) = ryp;
        end
    end
end
V = G\F';

for i = 1:nx
    for j = 1:ny
        n = j + (i-1) * ny;
        VG(i,j) = V(n);
    end
end

% V using the Analytical Series Method

N =101;

a = ny;
b = nx/2;
VpSig = zeros(nx,ny);

for i = 1:nx
    for j = 1:ny
```

```
        if i == 1
            Ex(i, j) = (VG(i + 1, j) - VG(i, j));
        elseif i == nx
            Ex(i, j) = (VG(i, j) - VG(i - 1, j));
        else
            Ex(i, j) = (VG(i + 1, j) - VG(i - 1, j)) * 0.5;
        end
        if j == 1
            Ey(i, j) = (VG(i, j + 1) - VG(i, j));
        elseif j == ny
            Ey(i, j) = (VG(i, j) - VG(i, j - 1));
        else
            Ey(i, j) = (VG(i, j + 1) - VG(i, j - 1)) * 0.5;
        end
    end
end

Ex = -Ex;
Ey = -Ey;

Jx = cMap .* Ex;
Jy = cMap .* Ey;

figure

H = surf(cMap');
title('Conductivity Map')
set(H, 'linestyle', 'none');
view(0, 90)

figure
H = surf(VG');
title('Vmap with bottle neck')
set(H, 'linestyle', 'none');

view(0, 90)

figure
quiver(Ex', Ey');
title('Electric field Map')
axis([0 nx 0 ny]);

figure
quiver(Jx', Jy');
title('Current Density Map')
axis([0 nx 0 ny]);

C0 = sum(Jx(1, :));
Cnx = sum(Jx(nx, :));
Curr = (C0 + Cnx) * 0.5;
```


Conductivity Map
0
5
10
15
20
25
30
35
40
45
50


Vmap with bottle neck
0
5
10
15
20
25
30
35
40
45
50


Electric field Map
0
5
10
15
20
25
30
35
40
45
50



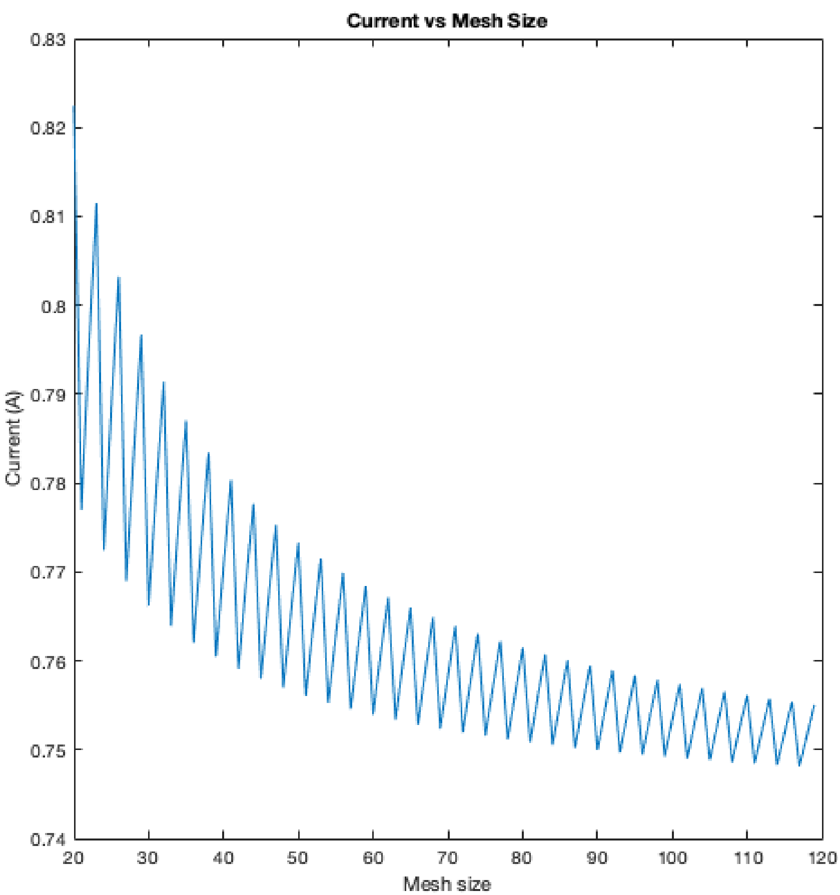
Graph of current vs mesh size

```
clearvars
clearvars -GLOBAL
close all
set(0,'DefaultFigureWindowStyle', 'docked')

global C
global CuCond NoCond
global nx ny

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
C.g = 9.80665;                      % metres (32.1740 ft) per s²

nx = 20;
ny = 20;
startSim = 20;
limitSim = 100;

Curr = zeros(1,limitSim);
Meshsizes = zeros(1,limitSim);
neckBT = zeros(1,limitSim);

for u = 1:limitSim
```

```
Meshsizes(u) = nx;

Lb = floor(nx/3);
Wb = floor(ny/3);


CuCond = 1;
NoCond = 10e-2;

%Conductivity map

cMap = zeros(nx,ny);

for i = 1:nx
    for j = 1: ny
        cMap(i,j) = CuCond;
    end
end

for i = 1:nx
    for j = 1:ny
        if (i>=1 && i<=Wb && j>Lb && j<=(2*Lb))
            cMap(i,j) = NoCond;
        end

        if (i<=ny && i>=(ny-Wb) && j>Lb && j<=(2*Lb))
            cMap(i,j) = NoCond;
        end
    end
end

G = sparse(nx*ny, nx*ny);
F = zeros(1, nx*ny);

for i = 1:nx
    for j = 1:ny
        n = j + (i - 1) * ny;

        if i == 1
            G(n,:) = 0;
            G(n,n) = 1;
            F(n) = 1;

        elseif i == nx
            G(n,:) = 0;
            G(n,n) = 1;

        elseif j == 1
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nyp = (j+1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nyp) = ryp;

        elseif j == ny
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;
```

```
            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;

            G(n,n) = -(rxm + rxp + rym);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;

        else
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;
            nyp = (j+1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + rym + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;
            G(n, nyp) = ryp;
        end
    end
end
V = G\F';

for i = 1:nx
    for j = 1:ny
        n = j + (i-1) * ny;
        VG(i,j) = V(n);
    end
end

for i = 1:nx
    for j = 1:ny
        if i == 1
            Ex(i, j) = (VG(i + 1, j) - VG(i, j));
        elseif i == nx
            Ex(i, j) = (VG(i, j) - VG(i - 1, j));
        else
            Ex(i, j) = (VG(i + 1, j) - VG(i - 1, j)) * 0.5;
        end
        if j == 1
            Ey(i, j) = (VG(i, j + 1) - VG(i, j));
        elseif j == ny
            Ey(i, j) = (VG(i, j) - VG(i, j - 1));
        else
            Ey(i, j) = (VG(i, j + 1) - VG(i, j - 1)) * 0.5;
        end
    end
end

Ex = -Ex;
Ey = -Ey;

Jx = cMap .* Ex;
Jy = cMap .* Ey;

C0 = sum(Jx(1, :));
Cnx = sum(Jx(nx, :));
```

```
    %Current
    Curr(u) = (C0 + Cnx) * 0.5;

    %Sizes
    nx = nx+1;
    ny = ny+1;
end

%Current vs Mesh Size
figure
plot(Meshsizes, Curr);
title('Current vs Mesh Size')
xlabel('Mesh size')
ylabel('Current (A)')
```



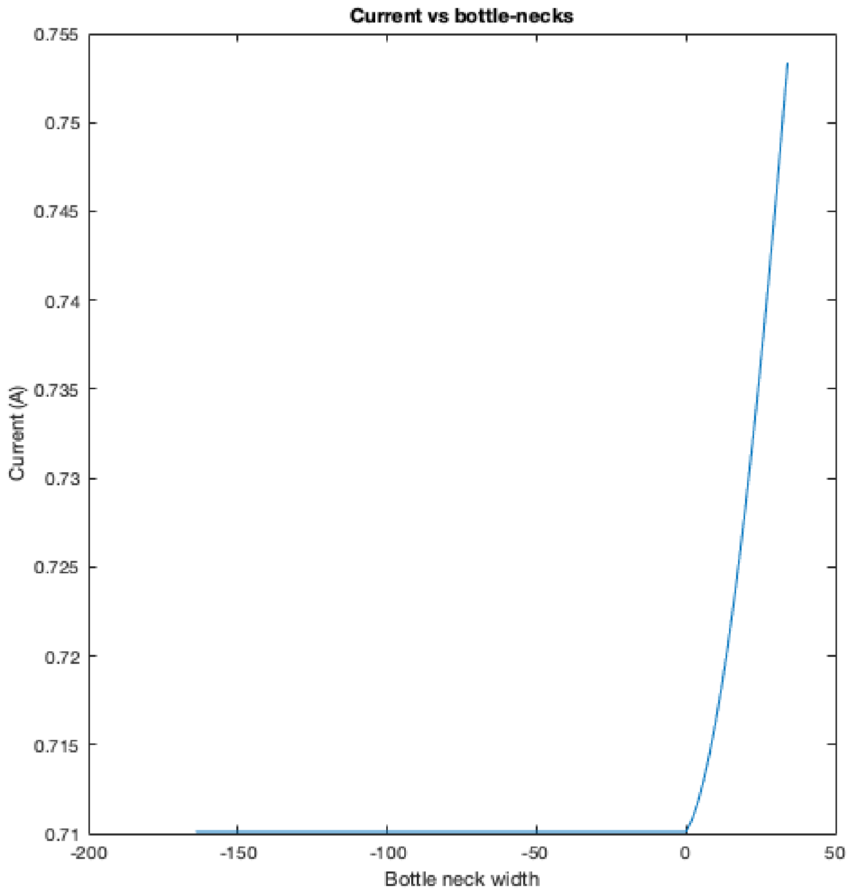
Current vs bottle Neck

```
clearvars
clearvars -GLOBAL
close all
set(0,'DefaultFigureWindowStyle', 'docked')

global C
global CuCond NoCond
global nx ny

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
C.g = 9.80665;                      % metres (32.1740 ft) per s²

nx = 100;
ny = 100;
startSim = 20;
limitSim = 100;

Curr = zeros(1,limitSim);
Necksizes = zeros(1,limitSim);

Lb = floor(nx/3);
Wb = floor(ny/3);

for u = 1:limitSim

    Necksizes(u) = Wb;

    CuCond = 1;
    NoCond = 10e-2;

    %Conductivity map

    cMap = zeros(nx,ny);

    for i = 1:nx
        for j = 1: ny
            cMap(i,j) = CuCond;
        end
    end

    for i = 1:nx
        for j = 1:ny
            if (i>=1 && i<=Wb && j>Lb && j<=(2*Lb))
                cMap(i,j) = NoCond;
            end

            if (i<=ny && i>=(ny-Wb) && j>Lb && j<=(2*Lb))
                cMap(i,j) = NoCond;
            end
        end
    end

    G = sparse(nx*ny, nx*ny);
    F = zeros(1, nx*ny);

    for i = 1:nx
        for j = 1:ny
            n = j + (i - 1) * ny;

            if i == 1
                G(n,:) = 0;
                G(n,n) = 1;
                F(n) = 1;

            elseif i == nx
                G(n,:) = 0;
                G(n,n) = 1;

            elseif j == 1
                nxm = j + (i-2) * ny;
                nxp = j + (i) * ny;
                nyp = (j+1) + (i-1) * ny;
```

```
            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nyp) = ryp;

        elseif j == ny
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;

            G(n,n) = -(rxm + rxp + rym);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;

        else
            nxm = j + (i-2) * ny;
            nxp = j + (i) * ny;
            nym = (j-1) + (i-1) * ny;
            nyp = (j+1) + (i-1) * ny;

            rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
            rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
            rym = (cMap(i,j) + cMap(i,j-1))/2.0;
            ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

            G(n,n) = -(rxm + rxp + rym + ryp);
            G(n,nxm) = rxm;
            G(n,nxp) = rxp;
            G(n, nym) = rym;
            G(n, nyp) = ryp;
        end
    end
end
V = G\F';

for i = 1:nx
    for j = 1:ny
        n = j + (i-1) * ny;
        VG(i,j) = V(n);
    end
end

for i = 1:nx
    for j = 1:ny
        if i == 1
            Ex(i, j) = (VG(i + 1, j) - VG(i, j));
        elseif i == nx
            Ex(i, j) = (VG(i, j) - VG(i - 1, j));
        else
            Ex(i, j) = (VG(i + 1, j) - VG(i - 1, j)) * 0.5;
        end
        if j == 1
            Ey(i, j) = (VG(i, j + 1) - VG(i, j));
        elseif j == ny
            Ey(i, j) = (VG(i, j) - VG(i, j - 1));
        else
```

```
                Ey(i, j) = (VG(i, j + 1) - VG(i, j - 1)) * 0.5;
            end
        end
    end

    Ex = -Ex;
    Ey = -Ey;

    Jx = cMap .* Ex;
    Jy = cMap .* Ey;

    C0 = sum(Jx(1, :));
    Cnx = sum(Jx(nx, :));

    %Current
    Curr(u) = (C0 + Cnx) * 0.5;

    %Bottle Neck
    Necksizes(u) = ny - (2*Wb);

    %Sizes
    Wb = Wb+1;
end

%Current vs Neck Size
figure
plot(Necksizes, Curr);
title('Current vs bottle-necks')
xlabel('Bottle neck width')
ylabel('Current (A)')
```



Negative botle neck sizes represent neck overlaps.

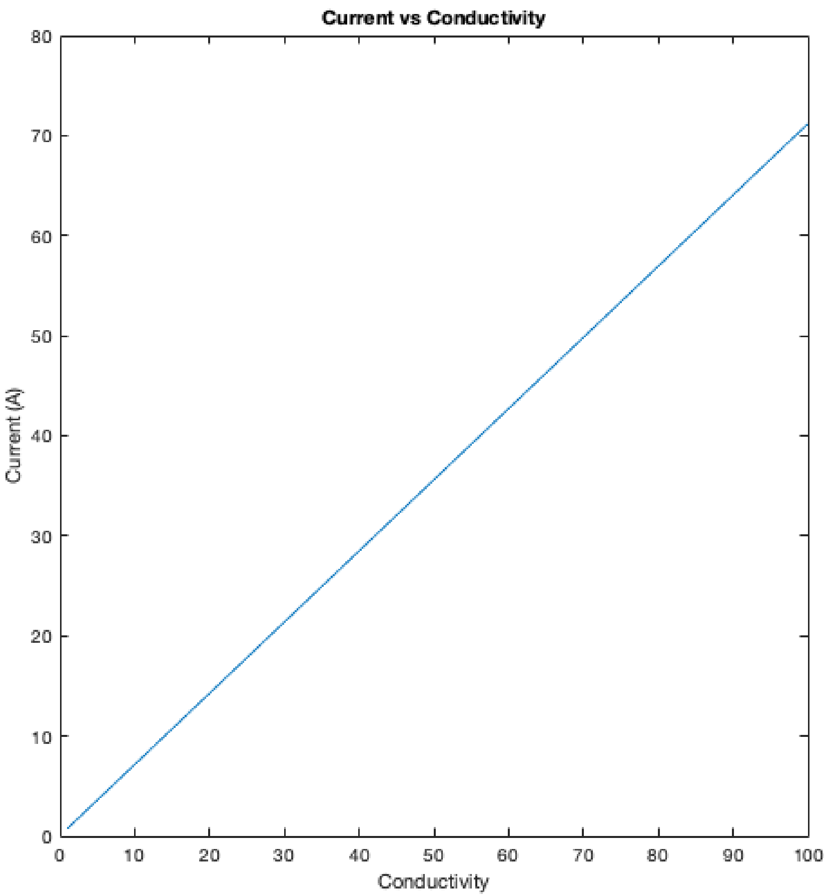
Current vs Conductivity

```
clearvars
clearvars -GLOBAL
close all
set(0,'DefaultFigureWindowStyle', 'docked')

global C
global CuCond NoCond
global nx ny

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
C.g = 9.80665;                      % metres (32.1740 ft) per s²

nx = 100;
ny = 100;
startSim = 20;
limitSim = 100;

Curr = zeros(1,limitSim);
CuCondVal = zeros(1,limitSim);
```

```
Lb = floor(nx/3);
Wb = floor(ny/3);

for i = 1:limitSim
    CuCondVal(i) = i;
end

for u = 1:limitSim

    CuCond = CuCondVal(u);
    NoCond = 10e-2;

    %Conductivity map

    cMap = zeros(nx,ny);

    for i = 1:nx
        for j = 1: ny
            cMap(i,j) = CuCond;
        end
    end

    for i = 1:nx
        for j = 1:ny
            if (i>=1 && i<=Wb && j>Lb && j<=(2*Lb))
                cMap(i,j) = NoCond;
            end

            if (i<=ny && i>=(ny-Wb) && j>Lb && j<=(2*Lb))
                cMap(i,j) = NoCond;
            end
        end
    end

    G = sparse(nx*ny, nx*ny);
    F = zeros(1, nx*ny);

    for i = 1:nx
        for j = 1:ny
            n = j + (i - 1) * ny;

            if i == 1
                G(n,:) = 0;
                G(n,n) = 1;
                F(n) = 1;

            elseif i == nx
                G(n,:) = 0;
                G(n,n) = 1;

            elseif j == 1
                nxm = j + (i-2) * ny;
                nxp = j + (i) * ny;
                nyp = (j+1) + (i-1) * ny;

                rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
                rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
                ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

                G(n,n) = -(rxm + rxp + ryp);
                G(n,nxm) = rxm;
                G(n,nxp) = rxp;
                G(n, nyp) = ryp;

            elseif j == ny
```

```
                nxm = j + (i-2) * ny;
                nxp = j + (i) * ny;
                nym = (j-1) + (i-1) * ny;

                rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
                rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
                rym = (cMap(i,j) + cMap(i,j-1))/2.0;

                G(n,n) = -(rxm + rxp + rym);
                G(n,nxm) = rxm;
                G(n,nxp) = rxp;
                G(n, nym) = rym;

            else
                nxm = j + (i-2) * ny;
                nxp = j + (i) * ny;
                nym = (j-1) + (i-1) * ny;
                nyp = (j+1) + (i-1) * ny;

                rxm = (cMap(i,j) + cMap(i-1,j))/2.0;
                rxp = (cMap(i,j) + cMap(i+1,j))/2.0;
                rym = (cMap(i,j) + cMap(i,j-1))/2.0;
                ryp = (cMap(i,j) + cMap(i,j+1))/2.0;

                G(n,n) = -(rxm + rxp + rym + ryp);
                G(n,nxm) = rxm;
                G(n,nxp) = rxp;
                G(n, nym) = rym;
                G(n, nyp) = ryp;
            end
        end
    end
    V = G\F';

    for i = 1:nx
        for j = 1:ny
            n = j + (i-1) * ny;
            VG(i,j) = V(n);
        end
    end

    for i = 1:nx
        for j = 1:ny
            if i == 1
                Ex(i, j) = (VG(i + 1, j) - VG(i, j));
            elseif i == nx
                Ex(i, j) = (VG(i, j) - VG(i - 1, j));
            else
                Ex(i, j) = (VG(i + 1, j) - VG(i - 1, j)) * 0.5;
            end
            if j == 1
                Ey(i, j) = (VG(i, j + 1) - VG(i, j));
            elseif j == ny
                Ey(i, j) = (VG(i, j) - VG(i, j - 1));
            else
                Ey(i, j) = (VG(i, j + 1) - VG(i, j - 1)) * 0.5;
            end
        end
    end

    Ex = -Ex;
    Ey = -Ey;

    Jx = cMap .* Ex;
    Jy = cMap .* Ey;
```

```
    C0 = sum(Jx(1, :));
    Cnx = sum(Jx(nx, :));

    %Current
    Curr(u) = (C0 + Cnx) * 0.5;

end

%Current vs Neck Size
figure
plot(CuCondVal, Curr);
title('Current vs Conductivity')
xlabel('Conductivity')
ylabel('Current (A)')
```



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