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Beginning of Assignment 2

```
clear
close all
```

Part 2: Question B - Mesh Density

```
HigherMeshSize = 0;

if HigherMeshSize %If true try higher mesh size, otherwise use a default mesh size
    nx = 60;
    ny = 30;
else
    nx = 30;
    ny = 20;
end
%Higher mesh size produces similar result with smoother curves
```

Part 2: Question C - Narrowing of Bottle-Neck

```
%Box Sizes
BottleNeckType = 'DefaultBottleNeck';

switch(BottleNeckType)
    case 'NarrowBottleNeck'
        Lb = nx/10;
        Wb = ny/10;
    case 'WideBottleNeck'
        Lb = nx/10;
        Wb = ny/3;
    case 'DefaultBottleNeck'
        Lb = nx/10;
        Wb = ny/5;
end
%A narrow bottle neck creates higher current density between bottleneck
%compared to the wide bottle neck
```

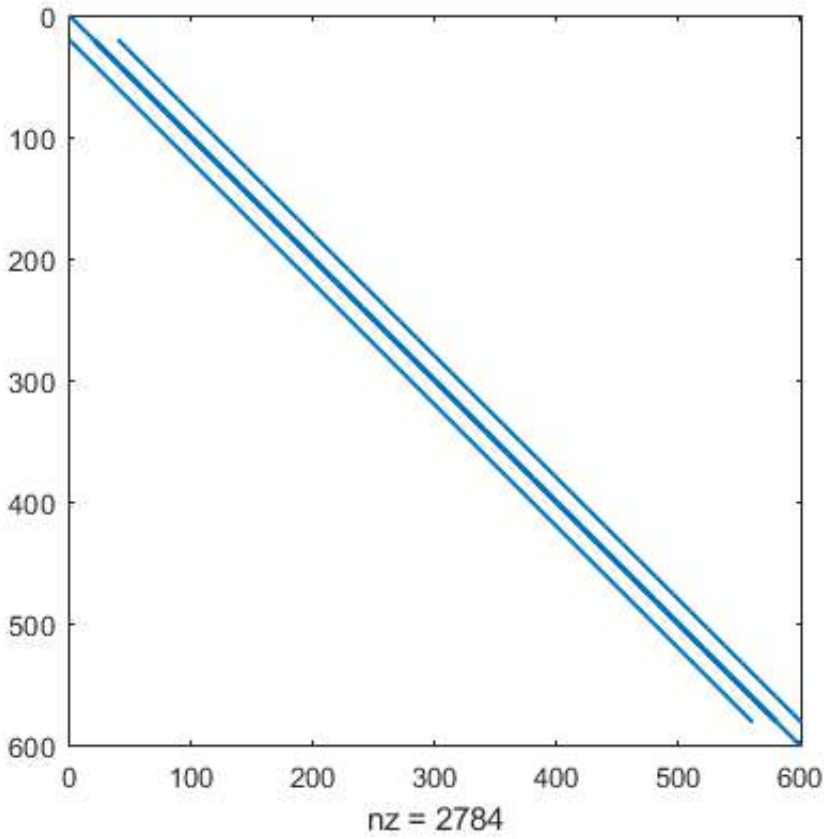
Part 2: Question D - Varying conduction of boxes

```
HigherResistivity = 0;

if HigherResistivity
    sigma = 1e-8;
else
    sigma = 1e-2;
end
%With higher resistivity in the boxes (ie boxes with low conductivity) the
%boundaries of the boxes are more defined and interfere less with the
%current density around the boxes
```

Numerical Solution for Current Flow

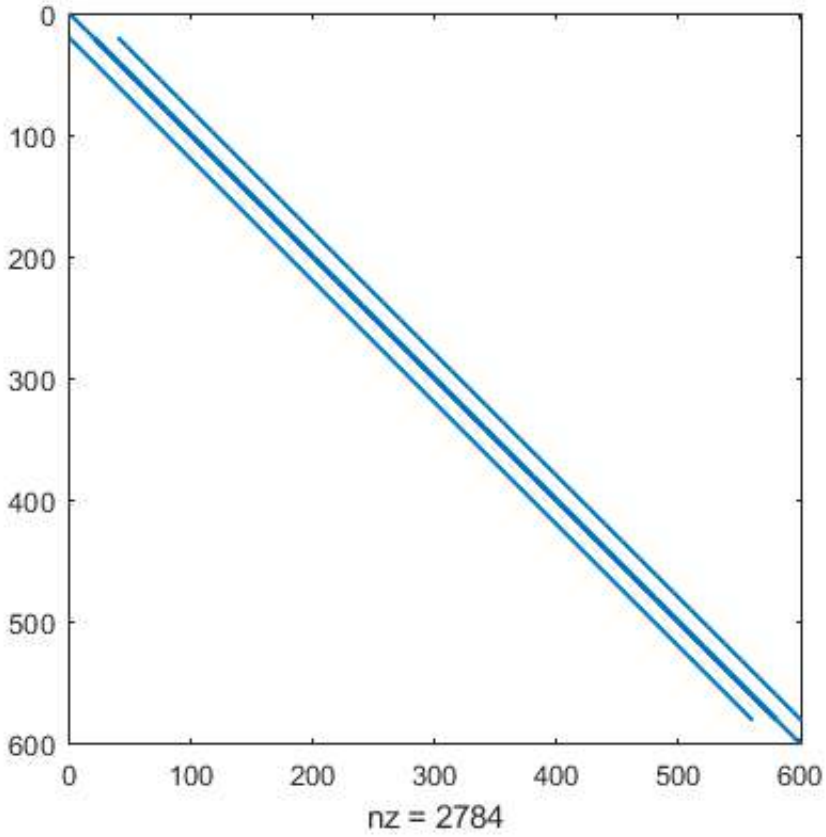
```
x = linspace(0,1,nx*ny);
G = zeros(nx*ny , nx*ny);
B = zeros(1,nx*ny);
cMap = zeros(nx, ny);%Conductivity Map
Part1QuestionA = 0;%Is 'one' only for Part 1 Question A
boundaryConditions = 1;%If rectangular region for Part 2: BC = 1, for Part 1: BC = 0

for i = 1:nx
    for j = 1:ny
        cMap(i, j) = 1;
        if boundaryConditions
            if i >= (nx/2 - Lb) && i <= (nx/2 + Lb) && (j >= (ny/2 + Wb) || j <= (ny/2 - Wb))
                cMap(i, j)= sigma;
            end
        end
    end
end

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

        if i == 1
            G(n, :) = 0;
            G(n, n) = 1;
            B(n) = 1;%Set boundary conditions 1
        elseif i == nx
            G(n, :) = 0;
            G(n, n) = 1;
            if ~Part1QuestionA
                B(n) = 1;%Set boundary conditions 2
            end
        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;
```

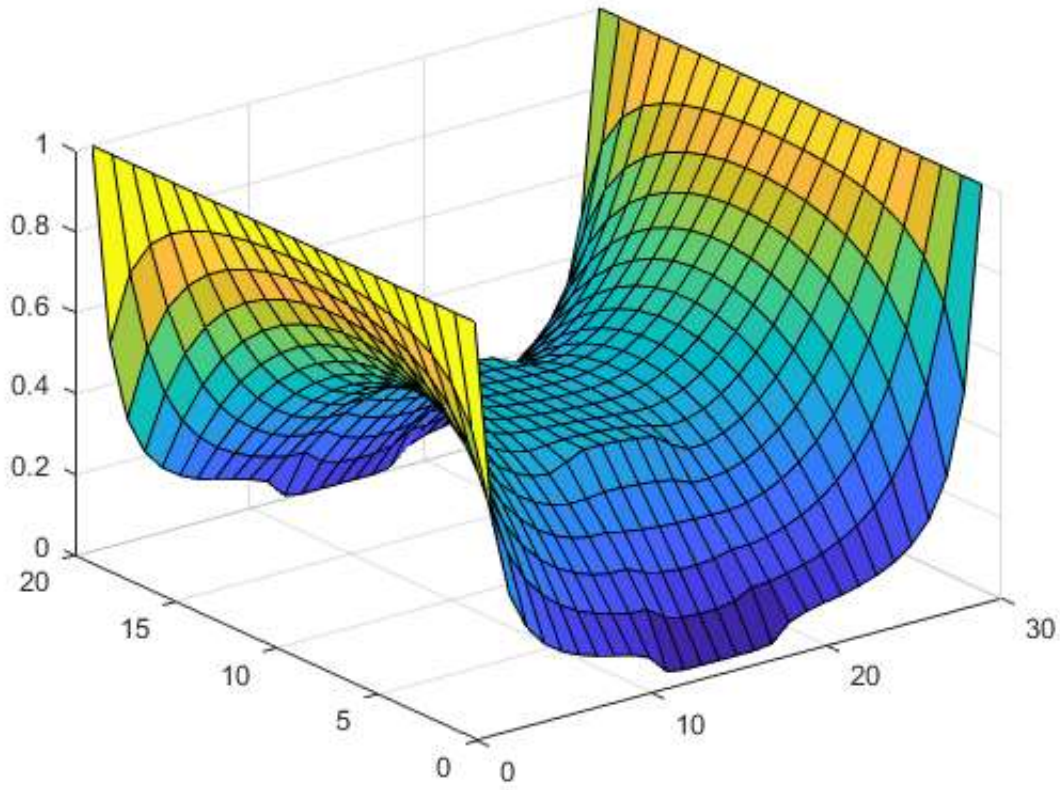
```
            ryp = (cMap(i, j) + cMap(i, j + 1)) / 2.0;

            G(n, n) = -4;
            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) = -4;
            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

figure;
spy(G)%Sparse G matrix result
```



Part 1: Numerical Voltage Plot

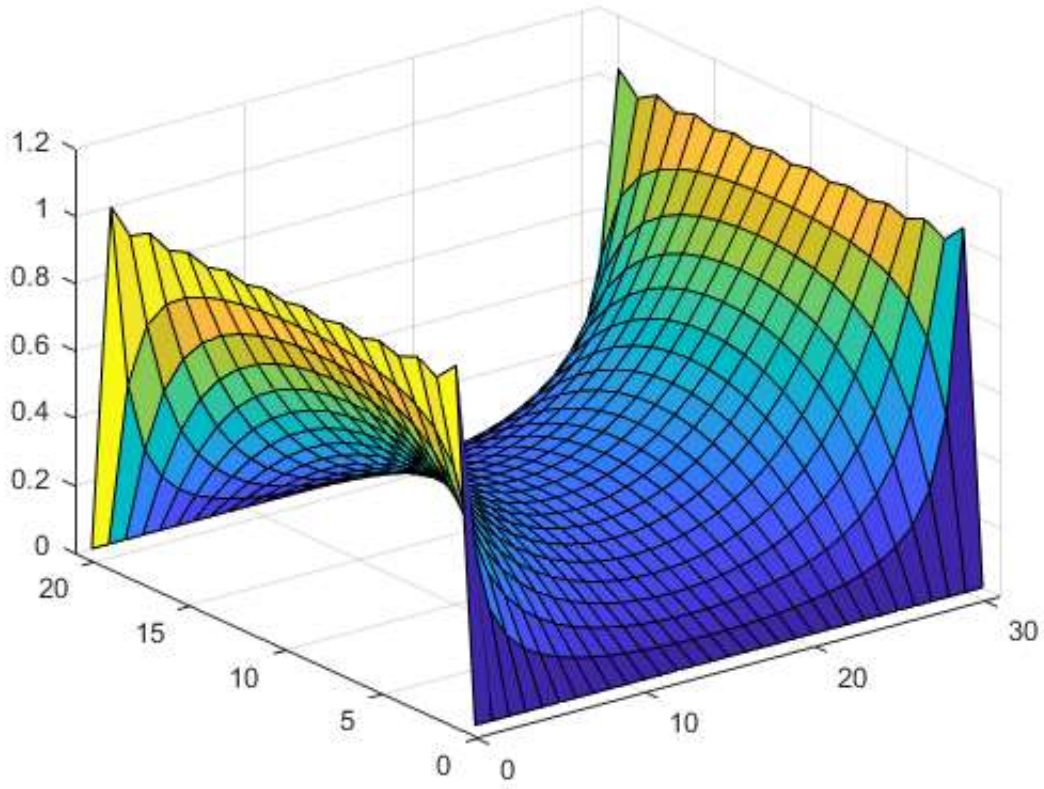
```
%For Part 1: Question A set Part1QuestionA to 1
%For Part 2: Question B and after set Part1QuestionA to 0
figure;
Vmap = zeros(nx,ny);
V = G\B';
for i = 1:nx
    for j = 1:ny
        n = j + (i - 1) * ny;

        Vmap(i, j) = V(n);
    end
end
surf(Vmap')
```





Part 1: Question B - Analytical Plot

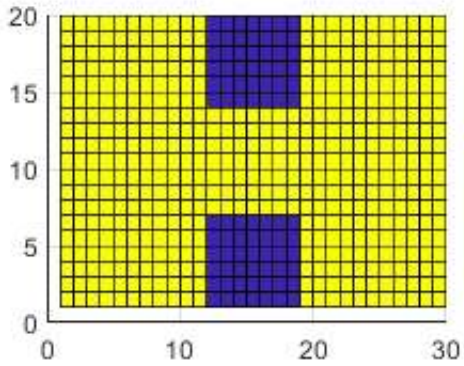
```
figure;
L = nx;
W = ny;
VanalyticalNew = zeros(L+1,W+1);
VanalyticalSum = zeros(L+1,W+1);
for n = 1:2:100
    for x = 1:(L+1)
        for y = 1:(W+1)
            p = x - L/2 - 1;%shift values over so centre of function is half the length
            q = y -1;
            VanalyticalNew(x,y) = 4/pi*(1/n)*(cosh((n*pi*p)/(W))/cosh((n*pi*(L)/2)/(W)))*sin(
(n*pi*q)/(W));
        end
    end
    VanalyticalSum = (VanalyticalSum + VanalyticalNew);
    surf(VanalyticalSum');
    %pause(0.5)
end
```

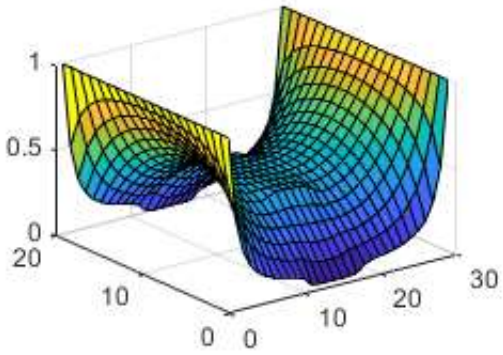


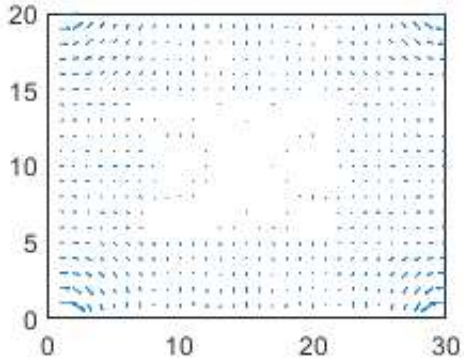
Part 2: Question A - Plots of Conductivity (cMap), Voltage (Vmap), Electric Field (Ex, Ey) and Current Density (Jx,Jy)

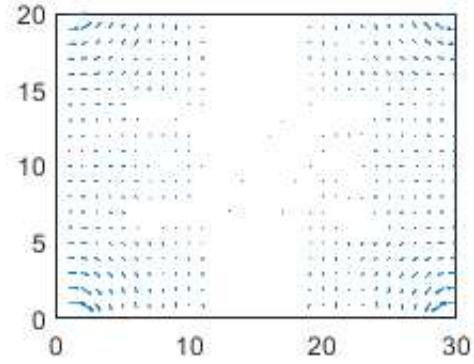
```
for i = 1:nx
    for j = 1:ny
        if i == 1
            Ex(i, j) = (Vmap(i + 1, j) - Vmap(i, j));
        elseif i == nx
            Ex(i, j) = (Vmap(i, j) - Vmap(i - 1, j));
```

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

Ex = -Ex;
Ey = -Ey;

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


figure;
subplot(2, 2, 1), surf(cMap');%Conductivity map
view(0, 90)

subplot(2, 2, 2), surf(Vmap');%Voltage Plot

subplot(2, 2, 3), quiver(Ex', Ey');%Electric Field Plot
axis([0 nx 0 ny]);

subplot(2, 2, 4), quiver(Jx', Jy');%Current Density Plot
axis([0 nx 0 ny]);
```









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