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% Assignment 2 Part 2 b). In this part of the assignment we are
% investigating mesh density. To do this we will start at a mesh size
 multiple
% of 10, and incrementally increase this size to observe the effect on
 the
% current density.

%nx will be incrementally increased using this loop. Note that
 meshsize
%replaces nx in this code.
for meshsize = 10:10:100

    %multiplying these values by the respective meshsize
    ny = (3/2)*meshsize;
    G = sparse(meshsize*ny);
    Op = zeros(1, meshsize*ny);


    Sigmatrix = zeros(ny, meshsize);       % The sigma matrix with nx
 set to meshsize
    Sig1 = 1;                              % sigma value given outside
 the box
    Sig2 = 10^-2;                          % sigma value given inside
 the box


    %bottleneck conditions with meshsize replacing nx
    box = [meshsize*2/5 meshsize*3/5 ny*2/5 ny*3/5];

   %Filling in G matrix
    for x = 1:meshsize

        for y = 1:ny

            n = y + (x-1)*ny;

            if x == 1
                G(n, :) = 0;
                G(n, n) = 1;
                Op(n) = 1;

            elseif x == meshsize
                G(n, :) = 0;
                G(n, n) = 1;
                Op(n) = 0;

            elseif y == 1

                if x > box(1) && x < box(2)
                    G(n, n) = -3;
                    G(n, n+1) = Sig2;
                    G(n, n+ny) = Sig2;
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                    G(n, n-ny) = Sig2;

                else

                    G(n, n) = -3;
                    G(n, n+1) = Sig1;
                    G(n, n+ny) = Sig1;
                    G(n, n-ny) = Sig1;

                end

            elseif y == ny

                if x > box(1) && x < box(2)

                    G(n, n) = -3;
                    G(n, n+1) = Sig2;
                    G(n, n+ny) = Sig2;
                    G(n, n-ny) = Sig2;

                else

                    G(n, n) = -3;
                    G(n, n+1) = Sig1;
                    G(n, n+ny) = Sig1;
                    G(n, n-ny) = Sig1;

                end

            else

                if x > box(1) && x < box(2) && (y < box(3)||y >
box(4))

                    G(n, n) = -4;
                    G(n, n+1) = Sig2;
                    G(n, n-1) = Sig2;
                    G(n, n+ny) = Sig2;
                    G(n, n-ny) = Sig2;

                else

                    G(n, n) = -4;
                    G(n, n+1) = Sig1;
                    G(n, n-1) = Sig1;
                    G(n, n+ny) = Sig1;
                    G(n, n-ny) = Sig1;

                end
            end
        end
    end

    %Just like in part a), except using different meshsizes
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    for Length = 1 : meshsize

        for Width = 1 : ny

            if Length >= box(1) && Length <= box(2)
                Sigmatrix(Width, Length) = Sig2;

            else

                Sigmatrix(Width, Length) = Sig1;

            end

            if Length >= box(1) && Length <= box(2) && Width >= box(3)
&& Width <= box(4)

                Sigmatrix(Width, Length) = Sig1;

            end
        end
    end


    Voltage = G\Op';


    sol = zeros(ny, meshsize, 1);

    for i = 1:meshsize

        for j = 1:ny

            n = j + (i-1)*ny;
            sol(j,i) = Voltage(n);

        end
    end

   %electric field found using gradient of voltage
    [elecx, elecy] = gradient(sol);

    %current desntiy is sigma times electric field
    J_x = Sigmatrix.*elecx;
    J_y = Sigmatrix.*elecy;
    J = sqrt(J_x.^2 + J_y.^2);

   %plotting current density vs mesh size
    figure(1)
    hold on

    if meshsize == 10

        Curr = sum(J, 1);
        Currtot = sum(Curr);
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        Currold = Currtot;
        plot([meshsize, meshsize], [Currold, Currtot])

    end
    if meshsize > 10

        Currold = Currtot;
        Curr = sum(J, 2);
        Currtot = sum(Curr);
        plot([meshsize-10, meshsize], [Currold, Currtot])
        xlabel("Meshsize")
        ylabel("Current Density")

    end

    title("The effect of Mesh Size on Current Density")

end

%the end%

%DISCUSSION%

%Analyzing the results of the plot, we see that meshsize and current
%density are proportional; an increase in meshsize leads to an
 increase in
%current density, which is to be expected.
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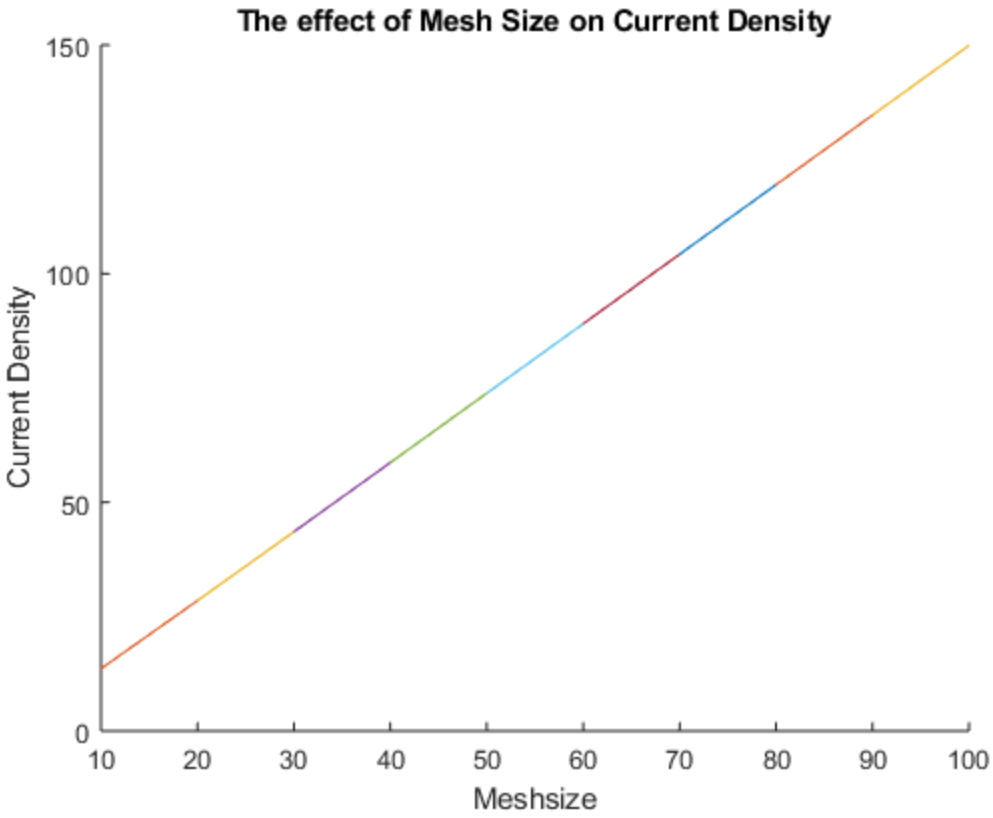

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