Elec 4700 Assignment 2

Table of Contents

Finite Difference Method for Solving Laplace

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Section 1: Electrostatic Potential in a Rectangular Region

Using Laplace's equation by the finite difference method, an electrostatic potential problem was to be solved. The problem was modelled by an orthogonal resistor network in a region of W by L, choosen to be 90 by 60 for this problem. By using a mesh of resistors, boundary conditions and intrusions became easier to model.

Using the matrix form GV=F, the electrostatic potential in the rectangular region was solved using $del^2 * V = 0$.

Section 1a: $V = V_0 @ x = 0$ and $V = 0 @ x = L$

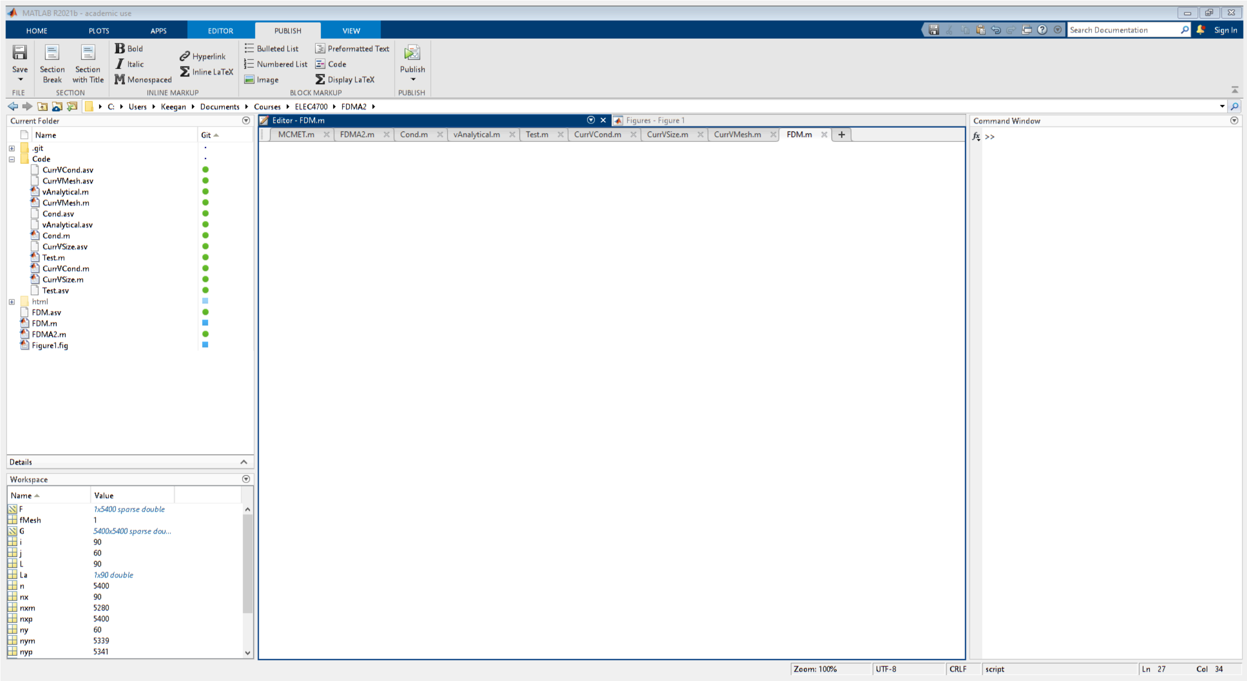
For this problem, the boundary conditions were set such that $V = V_0 = 1$ at the left region boundary, and $V = 0$ at the right region boundary. The y-axis boundary conditions were not set. This case was then solved, with the code and results shown below. Note that the region dimensions are taken to be unitless.

```
clear all;
close all;
clc;
set(0,'DefaultFigureWindowStyle','docked');

% Solving V=V0 @ x=0 and V=0 @ x=L in region LxW
% Implement funtion 'pbaspect' to fix Z aspect ratio

L = 90;
W = 2/3 * L;
V0 = 1;

fMesh = 1;                  % Mesh factor
nx = fMesh*L;
ny = fMesh*W;
G = sparse(nx*ny);
%V = sparse(nx,ny);
F = sparse(1,nx*ny);
```

```
La = linspace(0,L,nx);
Wa = linspace(0,W,ny);

for i = 1:nx                    %Iteration through length
    for j = 1:ny                %Iteration through width
        n = j + (i-1)*ny;

        if i == 1              % x=0 BCs
            G(n,:) = 0;
            G(n,n) = 1;
            F(n) = 1;
        elseif i == nx         % x=1 BCs
            G(n,:) = 0;
            G(n,n) = 1;
            F(n) = 0;           %F(n)=0 sets z at final width to 0

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

            G(n,n) = -(4);
            G(n,nxm) = 1;
            G(n,nxp) = 1;
            G(n,nym) = 1;
            G(n,nyp) = 1;
        end

    end
end
% figure(1)
% spy(G)

V = G\F';

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

figure(1)
surf(Vmap)
pbaspect([1 1 0.5])
view(90,270)
title('2D plot of Electrostatic Potential over a Rectangular Region')
xlabel('Region Width')    %Axis swapped due to view change, named correctly
ylabel('Region Length')
zlabel('Voltage (V)')
saveas(gcf,'Figure1')
```

Results

On the plot, the colourmap represents the voltage of the region. As expected, the voltage begins in the region at 1V and linearly decreses over the length to zero volts.



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