```
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% ELEC 4700 Assignment 2
% FINITE DIFFERENCE METHOD*
```
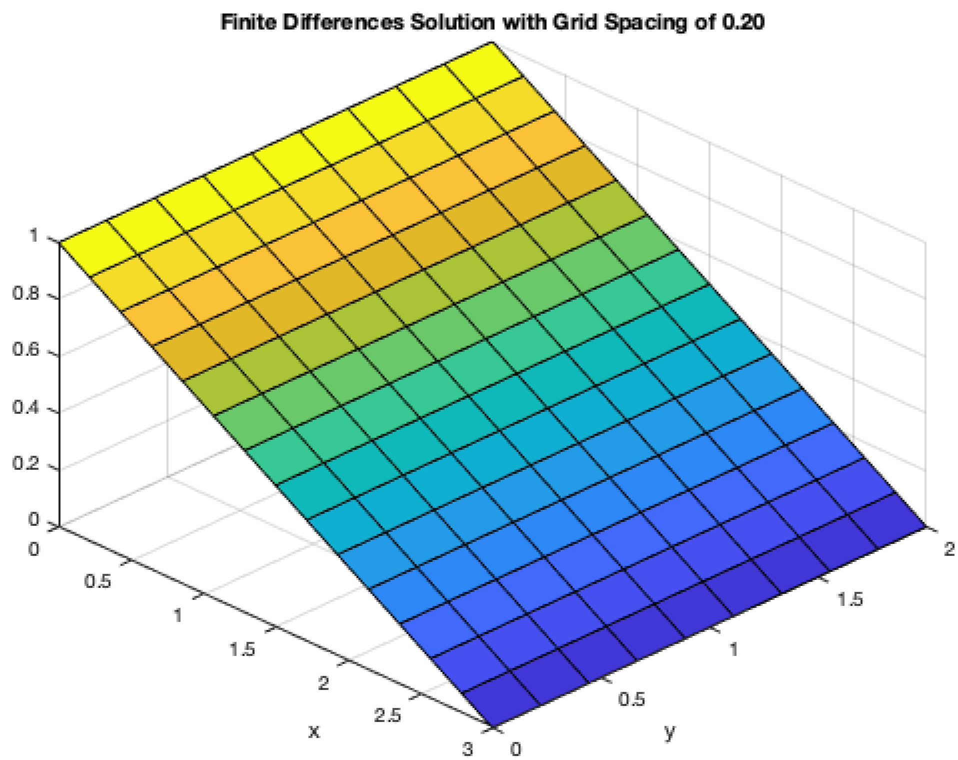
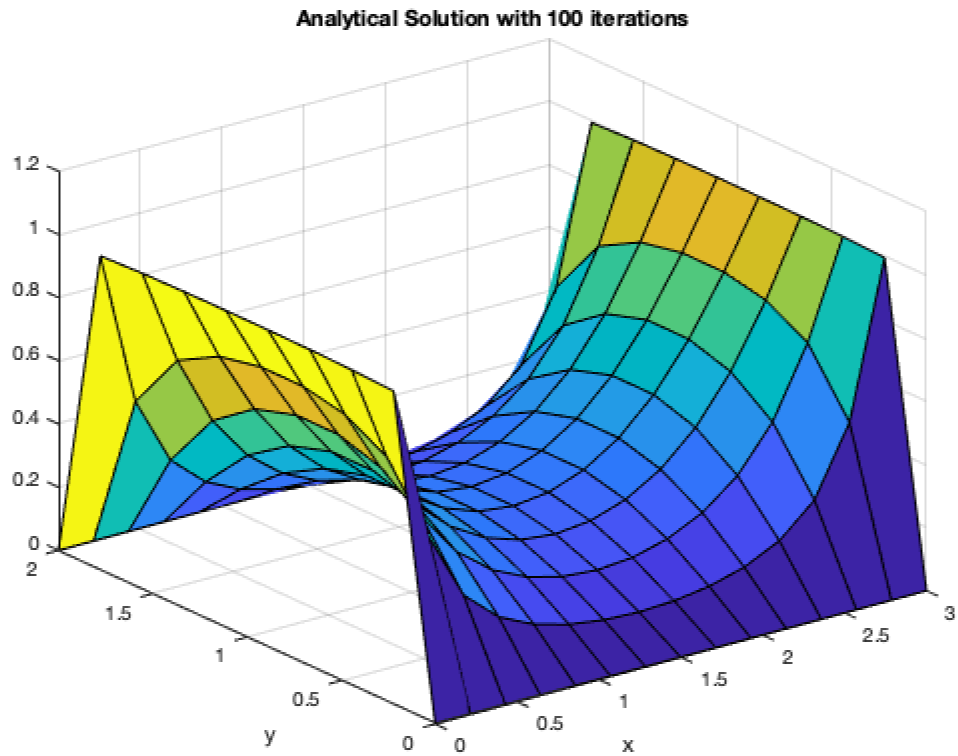

QUESTION 1

```
clear all
W = 2;
L = 3;
V0 = 1;

dx = 0.2; % x mesh spacing
dy = 0.2; % y mesh spacing
nx = L/dx; % Number of points along x
ny = W/dy; % Number of points along y


% Coefficients are calculated below.

c1 = -2*(1/dx^2 + 1/dy^2);
c2 = 1/(dx^2);
c3 = 1/(dy^2);


G = zeros(nx*ny,nx*ny);

for x=2:(nx-1)
    for y=2:(ny-1)
        i = coordinate(x,y,nx);
        G(i,i) = c1;
        G(i,coordinate(x-1,y,nx)) = c2;
        G(i,coordinate(x+1,y,nx)) = c2;
        G(i,coordinate(x,y-1,nx)) = c3;
        G(i,coordinate(x,y+1,nx)) = c3;
    end
end


% The F matrix is generated with boundary set to V0, where x = 0 and x
 = L.

F = zeros(nx*ny,1);

for y=1:ny
    i = coordinate(1,y,nx);
    G(i,i) = 1;

    F(i) = V0;

    i = coordinate(nx,y,nx);
```

```
    G(i,i) = 1;
end


% Setting up boundary conditions for analytical solution where V=0 at
 the
% corners.

for x=2:(nx-1)
    i = coordinate(x,1,nx);
    G(i,i) = 1;
    G(i,coordinate(x,2,nx)) = -1;

    i = coordinate(x,ny,nx);
    G(i,i) = 1;
    G(i,coordinate(x,ny-1,nx)) = -1;
end

% Solution from matrices

matsol = G\F;
matsol = reshape(matsol,[],ny)';

figure(1);
surf(linspace(0,L,nx),linspace(0,W,ny),matsol);
xlabel('x');
ylabel('y');
title(sprintf('Finite Differences Solution with Grid Spacing of %.2f',
 dx));
set(gca, 'View', [45 45])


% Analytical solution for comparison with Finite Difference solution.

anSol = zeros(ny, nx);
x1 = repmat(linspace(-L/2,L/2,nx),ny,1);
y1 = repmat(linspace(0,W,ny),nx,1)';
iter = 100;
avgError = zeros(iter,1);


for i=1:iter
    n = 2*i - 1;
    anSol = anSol + 1./n.*cosh(n.*pi.*x1./W) ...
        ./cosh(n.*pi.*(L./2)./W).*sin(n.*pi.*y1./W);

    avgError(i) = mean(mean(abs(anSol.*4.*V0./pi - matsol)));
end

anSol = anSol.*4.*V0./pi;

figure(2);
surf(linspace(0,L,nx),linspace(0,W,ny),anSol);
xlabel('x');
```

```
ylabel('y');
title(sprintf('Analytical Solution with %d iterations', iter));

%figure(3);
%plot(1:i,avgError);
%xlabel('Iteration');
%ylabel('Average Error (V)');
%title('Convergence of Analytical Solution');
%grid on;


%COMMENTS ON ADVANTAGES AND DISADVANTAGES OF NUMERICAL VS ANALYTICAL*
```





Analytical solution is easier to implement than numericcal although it is hard to find.

For complex problems, FD will be preferred as it is easier to find than the analytical solution.

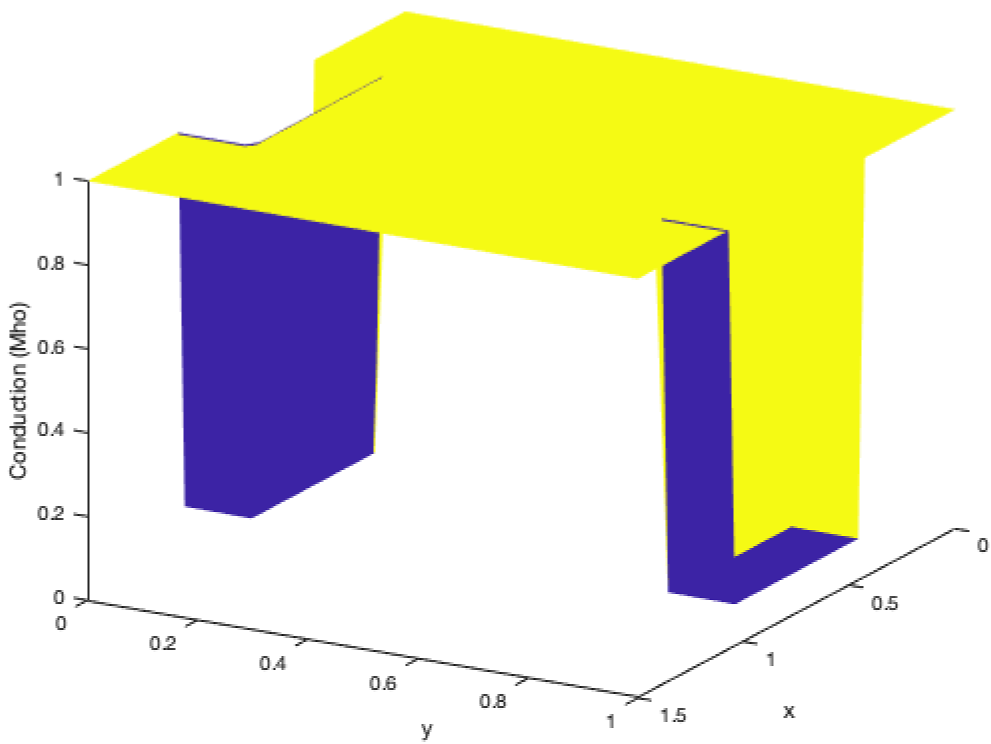
QUESTION 2

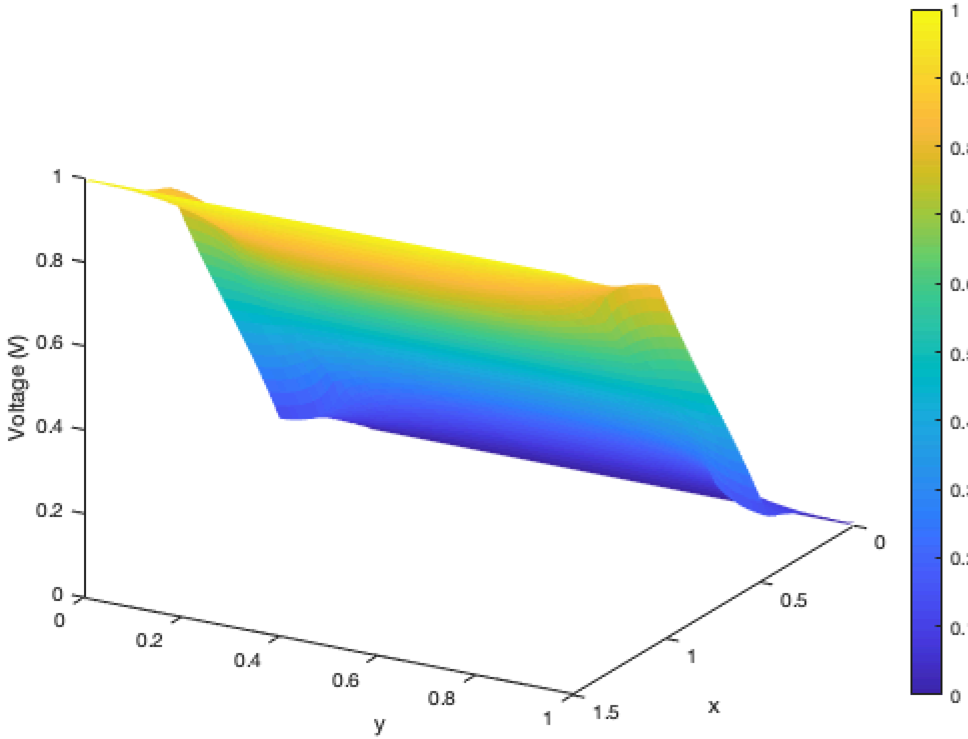
*PART A

```
nx = 75;
ny = 50;
Lb = 20;
Wb = 10;
V1 = 1;
figure(4);
hold on;
% Generating the map of conductivity of the area
sigma_out= 1;
sigma_in = 10e-2;
cMap = sigma_out*ones(nx, ny);
cMap(1:Wb,(1:Lb)+ny/2-Lb/2) = sigma_in;
cMap((1:Wb)+nx-Wb,(1:Lb)+ny/2-Lb/2) = sigma_in;
surf(linspace(0,1.5,ny), linspace(0,1,nx),
 cMap,'EdgeColor','none','LineStyle','none');
xlabel('x');
ylabel('y');
zlabel('Conduction (Mho)');
```

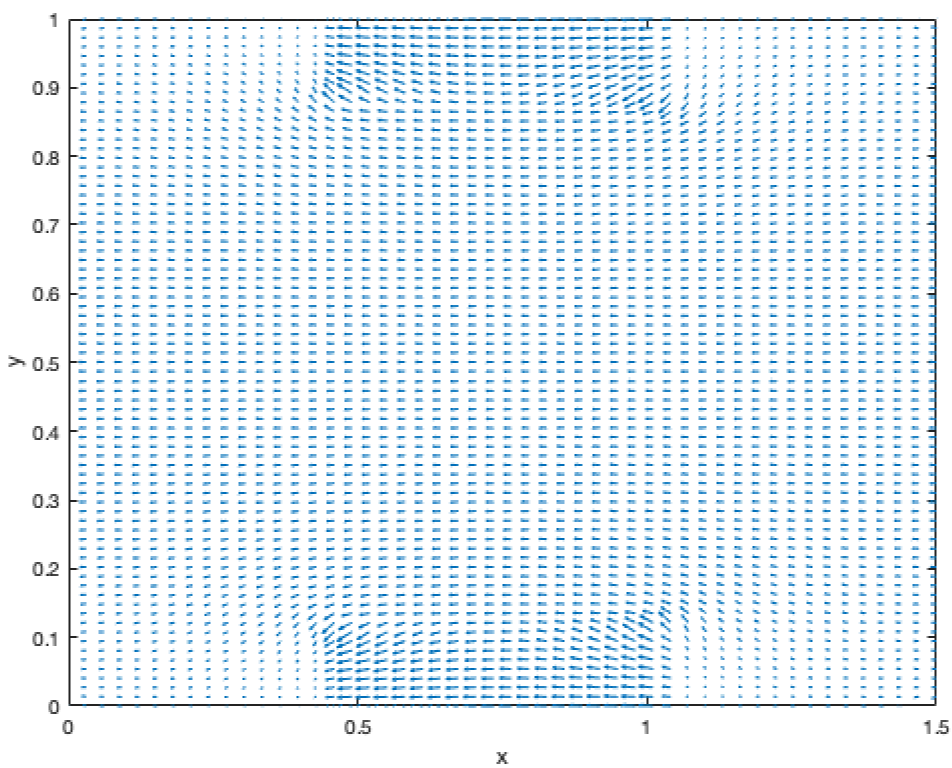
```
view([120 25])


% Numeric solution
V = numericSolution(nx, ny, cMap, Inf, Inf, 0, V1);
figure(5);
hold on;
surf(linspace(0,1.5,ny), linspace(0,1,nx),
 V,'EdgeColor','none','LineStyle','none');
xlabel('x');
ylabel('y');
zlabel('Voltage (V)');
view([120 25])
colorbar

% Electric field
[Ex, Ey] = gradient(V);
Ex = -Ex;
Ey = -Ey;
figure(6);
quiver(linspace(0,1.5,ny), linspace(0,1,nx), Ex, Ey);
ylim([0 1]);
xlim([0 1.5]);
xlabel('x');
ylabel('y');

% Current density
Jx = cMap.*Ex;
Jy = cMap.*Ey;
J = sqrt(Jx.^2 + Jy.^2);
figure(7);
hold on;
contourf(linspace(0,1.5,ny), linspace(0,1,nx),
 J,'EdgeColor','none','LineStyle','none');
quiver(linspace(0,1.5,ny), linspace(0,1,nx), Jx, Jy);
xlabel('x');
ylabel('y');
colorbar

%
% *PART B*
figure(8);
hold on;
range = 20:5:100;
I = [];
for x = range
    I = [I totalI(x, ny, V1, sigma_out, sigma_in, Wb, Lb)];
end
plot(range, I);
ylabel('Total Current (A)');
xlabel('Width mesh size');

%
% *PART C*
```

```
figure(9);
range = 0:1:50;
I = [];
for W = range
    I = [I totalI(nx, ny, V1, sigma_out, sigma_in, W, Lb)];
end
plot(range, I);
ylabel('Total Current (A)');
xlabel('Box width');

%
% *PART D*
figure(10);
hold on;
range = logspace(-5,0, 50);
I = [];
for sigma = range
    I = [I totalI(nx, ny, V1, sigma_out, sigma, Wb, Lb)];
end
plot(range, I);
ylabel('Total Current (A)');
xlabel('Box Conduction (Mho)');
```

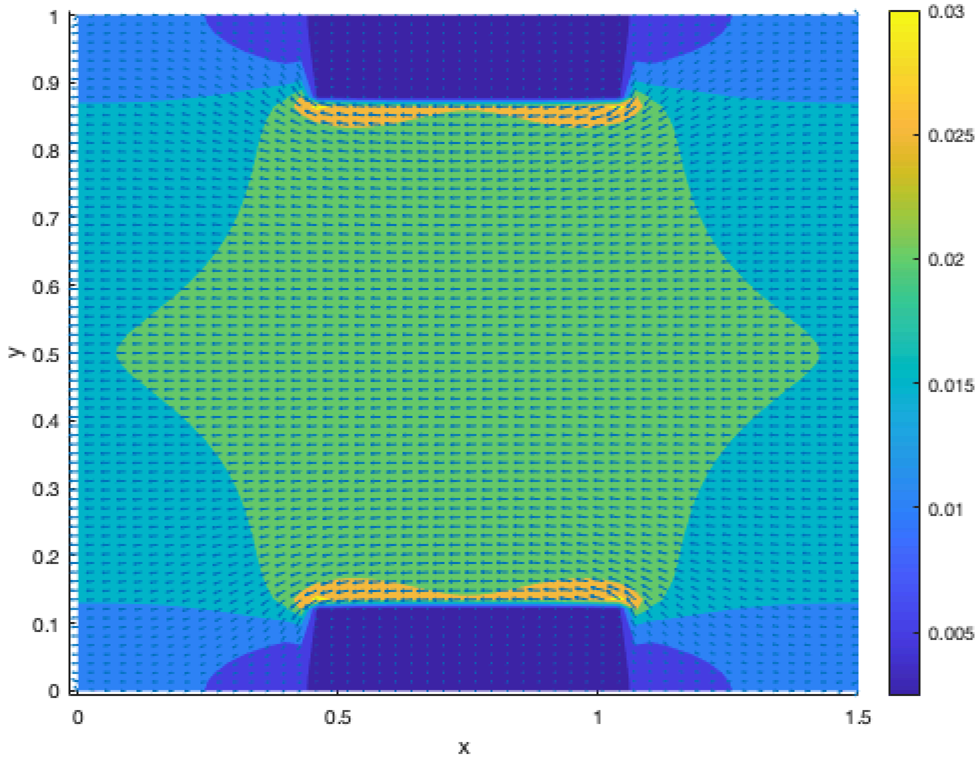




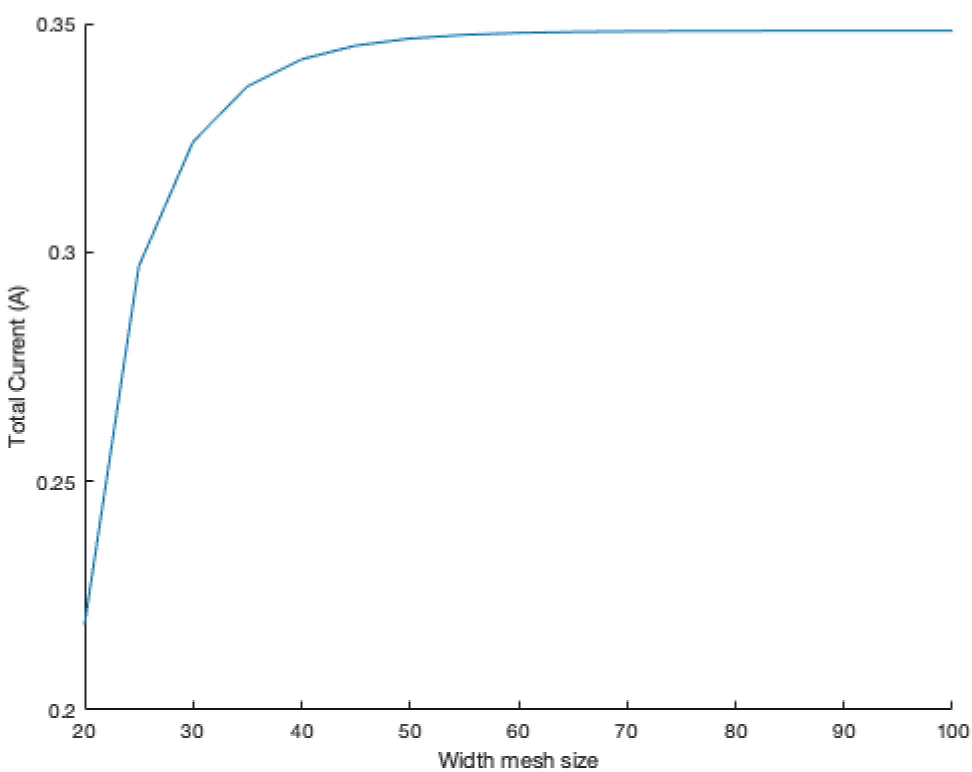
Voltage (V)
y
x



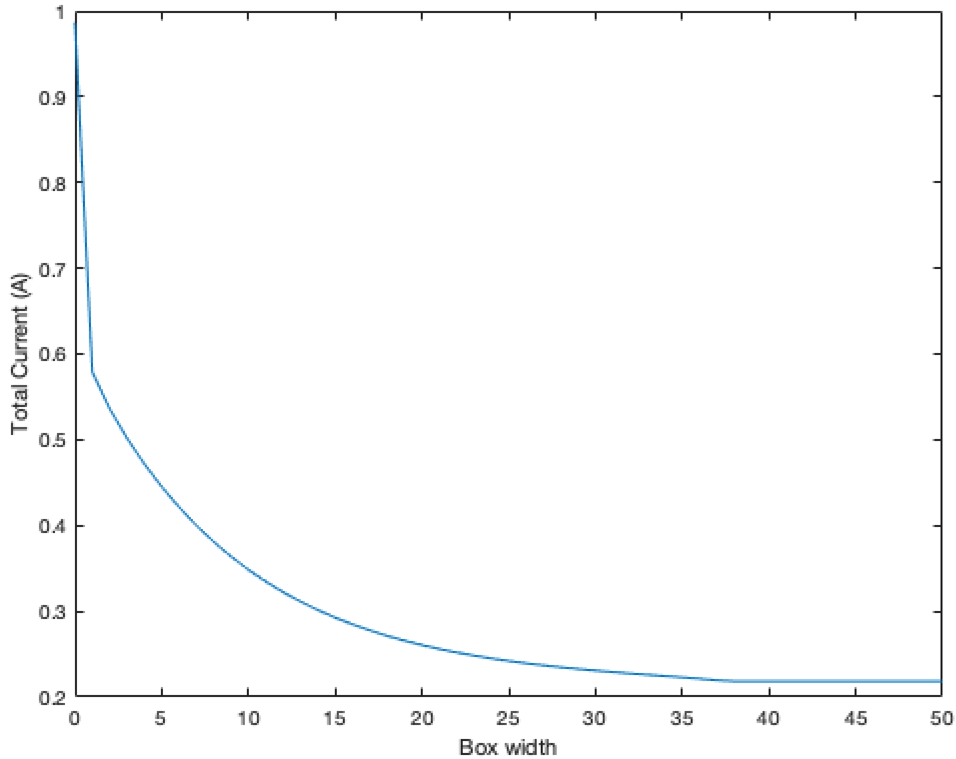
y
x

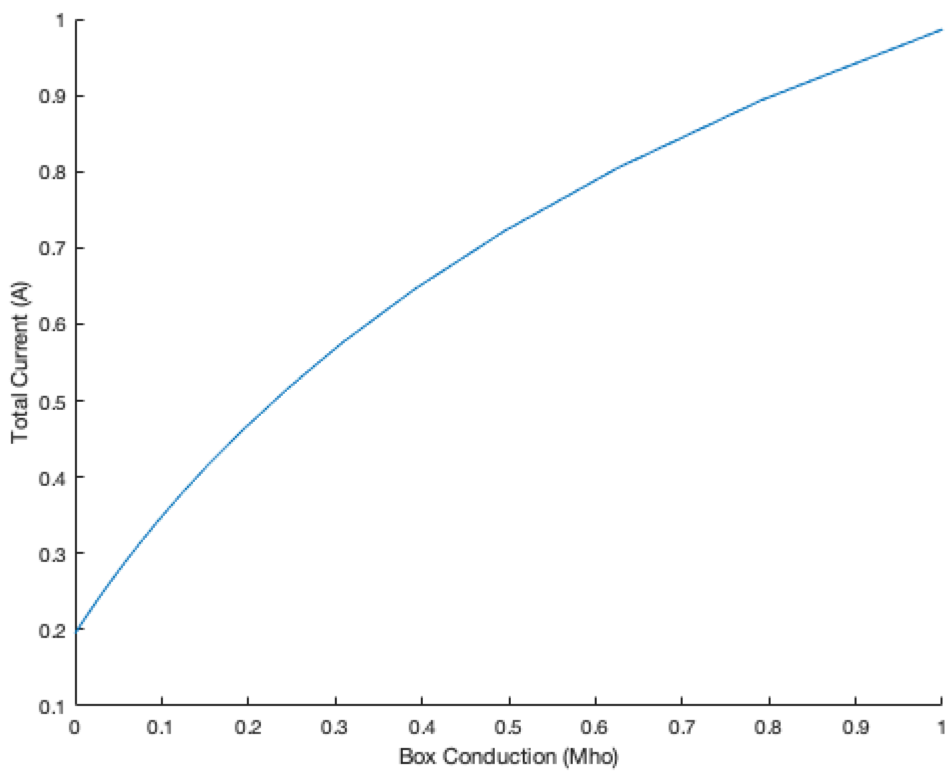


y
x
0
0.5
1
1.5
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.005
0.01
0.015
0.02
0.025
0.03



Total Current (A)
Width mesh size
0.2
0.25
0.3
0.35
20
30
40
50
60
70
80
90
100


Total Current (A)
Box width


Total Current (A)
Box Conduction (Mho)

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