Electrostatics Project

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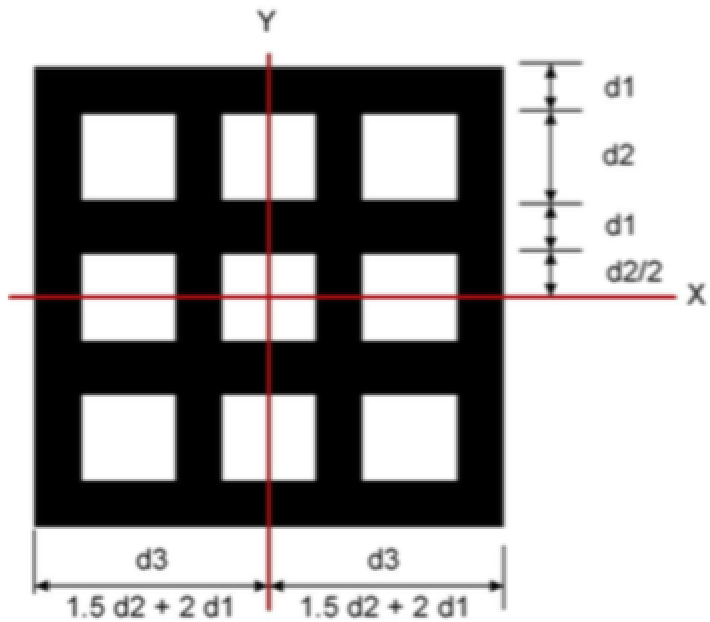

Summary

This electrostatics project uses Coulombs Law discrete summation to determine the electric field intensity of a metal plate at the observation points P(X,Y,Z) with the uniform square surface given and MATLAB. The electric field intensity was the greatest in the center of the surface despite having holes distributed along the surface. The out of range x,y,and z points are flagged to avoid calculation difficulty due to the fringing effect. The highest electric field intensities were when the point of observation was closer to the metal plate.

Introduction

The measurements of d1 and d2 were resulted by the month and date of your birthday which were then used to find the holes within the square surface which effects the electric field intensity. Splitting the surface into smaller uniform squares that were one by one centimeter, gathering the points at the center of each square, and distributing the points into our summation equation we were able to determine the electric field intensity at each point.

Discussion
Starting the project I began by breaking down the metal plate into smaller one by one cm squares that were distributed along the lines of the surface. To obtain the centers of each square, the top left square points would be (-34,34,0) and used the code in **Figure 1** to create all the x's and y's from -34 to 34 and concatenated them to generate all the points on the square. From here I opened my new matrix and found the places which were "holes" and removed them manually. For example, the center hole coordinates are when $-5 \leq x \leq 5$ and $-5 \leq y \leq 5$.

After creating the matrix for the points of the square, I created a code that loops through the observation points specified $-.7d3 \leq x \leq -.7d3$, $-.7d3 \leq y \leq .7d3$, $.1d3 \leq z \leq 10d3$ and subtracts them from each square point to find the magnitude for the R value. Then with each point observed and corresponding R value the final matrix has the value of electric field intensity associated. The code that creates this matrix can be found in **Figure 2**. I used centimeter squares as it was easiest since the plate and observation box were both measured in centimeters. If I scaled them down to millimeter and still observed the box in centimeters, the electric field intensity would be miniscule and hard to visualize. If I scaled the observation box down to millimeters as well, then my resulting electric field would end up visually the same, but scaled down a few magnitudes which is the delta S comparison.

Plotting this matrix with the points and corresponding E field, we used the scatter3 and the arguments used were concatenations of each column of the array. The plot found in **Figure 3** shows the yellow having the greatest value of electric field intensity and blue being the least. The electric field is a round phenomenon and if we removed the least move significant values of electric intensity the plot with then begin to start looking like less of a box and more round.

The next four figures are the electric field intensities at specific values of y and z to determine how the distance effects the electric field intensity. In **Figure 4** and **Figure 5**, we are demonstrating the electric field at the center on the plate, but at different heights. The lower z value will have a stronger electric field intensity located at the center because most of the intensity is from the center of the plate. In **Figure 6** and **Figure 7** we are comparing the electric field intensity when the observation points are no longer at the center of the plate along with at closer and further distances for z. It is less visually clear, but as the distance of z increases the less electric field intensity. Since the field is round, most of the effectiveness is around the center of each observations points.

The last plot was the fringe effect from the middle of the plate from x ranges that were greater than the size of the plate. We used the quiver3 plot command to plot this as this seemed to show direction of fields the best.Since the observation points were greater than the electrically charged plate, the fringe effect phenomenon starts to curve. The curve can be seen in **Figure 8**.

Appendix

```
matrix_append = [0 0 0];
for y = -34:1:34 % change for first center to last center
    for x = -34:1:34 % change for first center to last center
       new_row = [ x y 0];
        matrix_append = [matrix_append; new_row];
    end
end

square_coordinates= matrix_append;
```

Figure 1: Coordinates for Squares Code (X,Y,Z)

```
clc;
clear;
load('square_coordinates_with_holes.mat'); % center of all squares
D = .1; % C/cm^2;
dS = 1; % Surface Area /cm^2
e0 = 8.854e-10; % F/cm
E1 = (D * dS)/(4*pi*e0); % Coulomb's law
E_matrix = [0 0 0 0];

tic
for z= 3.45:1:345
    for y = -24.15:1:24.15
        for x = -24.15:1:24.15
observation_point_matrix = [x y z];
Radius = pdist2(square_coordinates, observation_point_matrix);% cm - cm
    E = E1./Radius.^2;
    E_total = sum(E);
    E_matrix = [position_with_E_matrix; x y z E_total];
        end
    end
end
toc
```

Figure 2: Coloumbs Law Summation

```
pointsize = 100;
scatter3(E_matrix(:,1), E_matrix(:,2), E_matrix(:,3), pointsize, E_matrix(:,4), 'filled')
xlabel('X Axis')
ylabel('Y Axis')
zlabel('Z Axis')
```

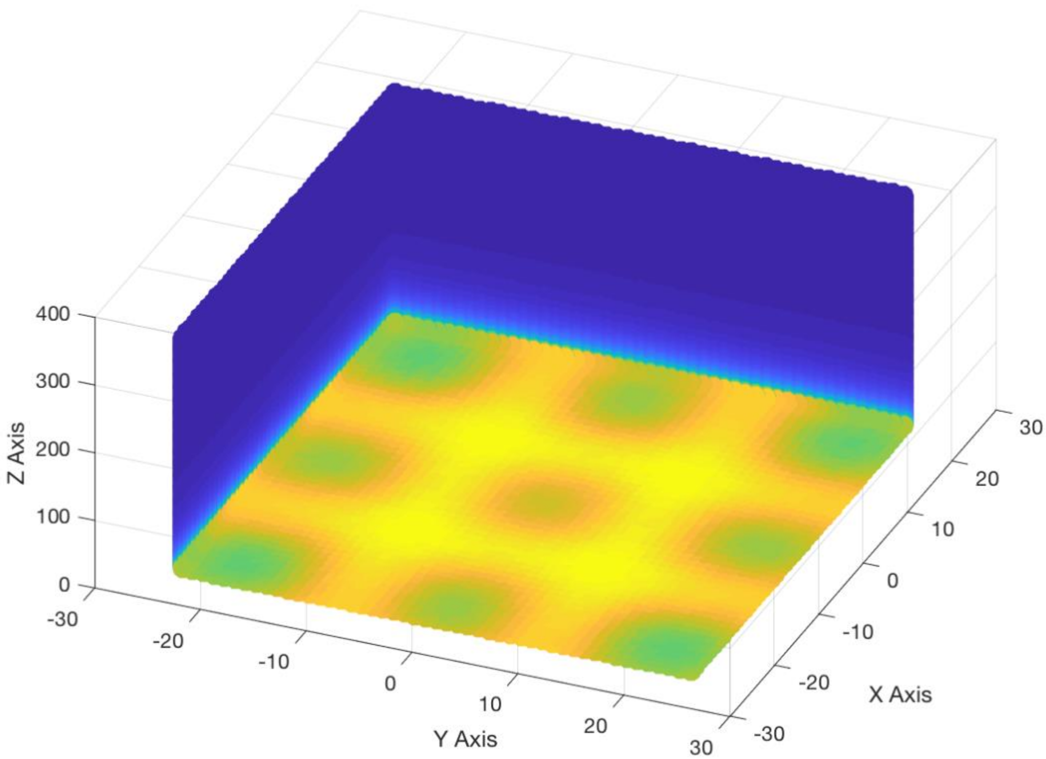

Figure 3: Plot of Electrical Field Intensity with MATLAB Code

```
z = 17.25;
y = 0;
for x = -24.15:1:24.15
observation_point_matrix = [x y z];
Radius = pdist2(square_coordinates, observation_point_matrix);% cm - cm
   E = E1./Radius.^2;
   E_total = sum(E);
   E_matrix = [E_matrix; x y z E_total];
end
```

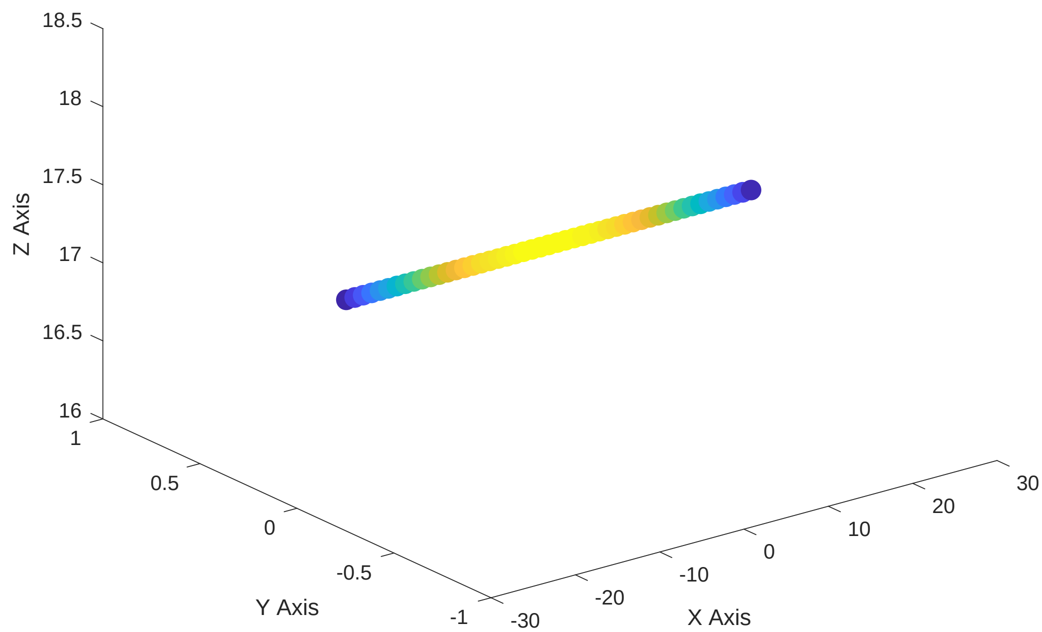

Figure 4: −0.7d3≤ x ≤ 0.7d3,y=0,andz=d3/2 with MATLAB Code

```
z = 276;
y = 0;
for x = -24.15:1:24.15
observation_point_matrix = [x y z];
Radius = pdist2(square_coordinates, observation_point_matrix);% cm - cm
   E = E1./Radius.^2;
   E_total = sum(E);
   E_matrix = [E_matrix; x y z E_total];
end
```

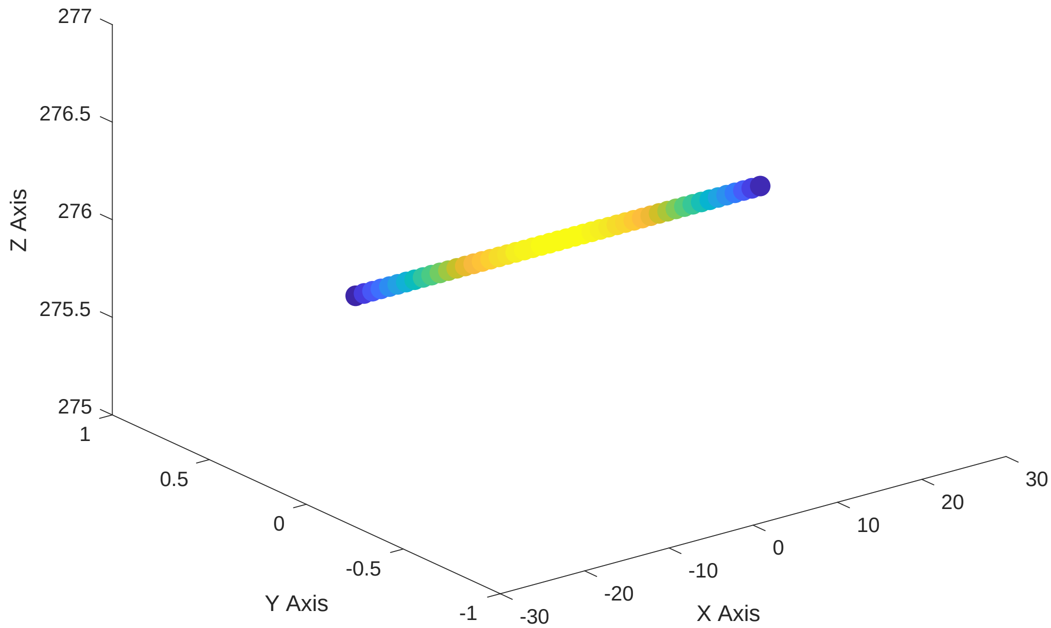

Figure 5:−0.7d3≤ x ≤ 0.7d3,y=0,andz=8d3 with MATLAB Code

```
z = 17.25;
y = 17.25;
for x = -24.15:1:24.15
observation_point_matrix = [x y z];
Radius = pdist2(square_coordinates, observation_point_matrix);% cm - cm
E = E1./Radius.^2;
E_total = sum(E);
E_matrix = [E_matrix; x y z E_total];
end
```

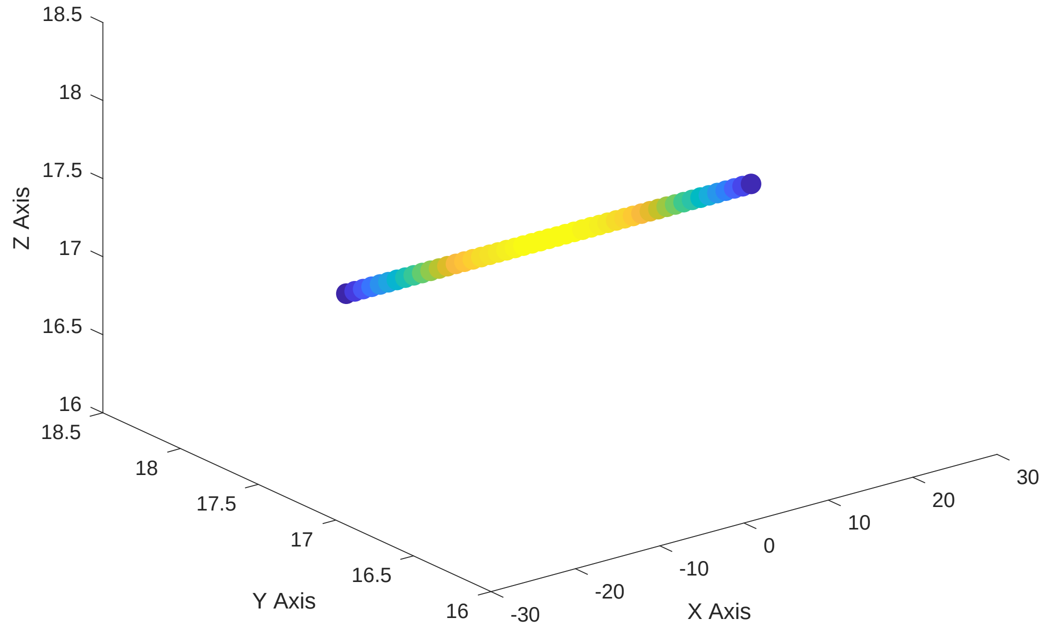

Figure 6:−0.7d3≤ x ≤ 0.7d3,y=d3/2andz=d3/2 with MATALAB Code

```
z = 276;
y = 17.25;
for x = -24.15:1:24.15
observation_point_matrix = [x y z];
Radius = pdist2(square_coordinates, observation_point_matrix);% cm - cm
E = E1./Radius.^2;
E_total = sum(E);
E_matrix = [E_matrix; x y z E_total];
end
```

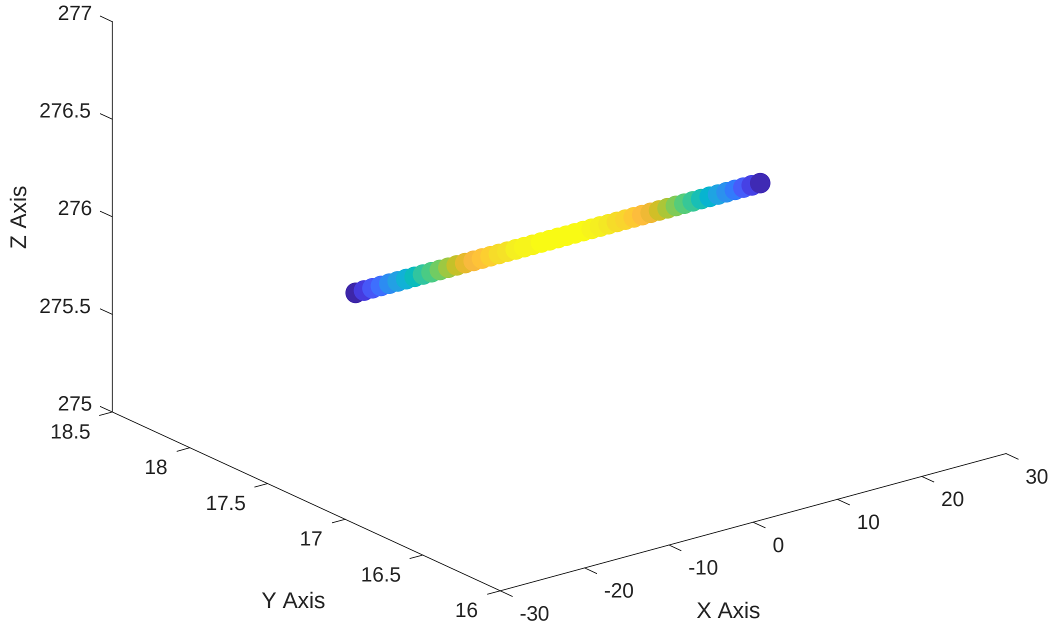

Figure 7:−0.7d3≤ x ≤ 0.7d3,y=d3/2,andz=8d3 with MATLAB Code

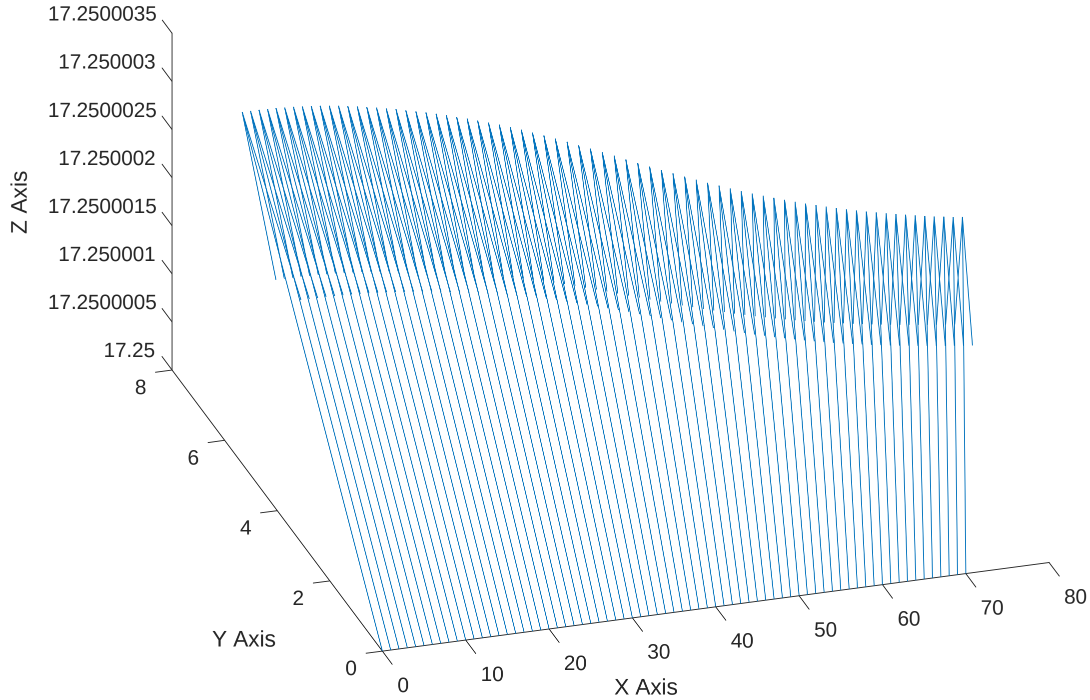

Figure 8: Fringe Effect

Conclusion

The outcome of this project did meet expectations as the visuals match with what I expected to see. Some of the graphs color maps were not as clear as I would like them to be as some of the plot figures look a bit similar. This project was effected greatly by the amount of time it took to run the code, so being efficient with my code was important in completing this project. I do think there are better ways to represent the fringing effect as I understood what the fringing effect was more than understood how to plot.