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# 1 Questions

## 1.1 Question 1:

### 1.1.1 Introduction

The arrangement of seeds in a certain flower heads (such as sunflowers and daisies) adheres to a fixed mathematical pattern. The  $n^{th}$  seed is at position:

$$r = \sqrt{n}$$

With angular co-ordinate ( $\theta$ ) in radians, expressed by

$$\theta = \frac{\pi * d * n}{180}$$

where  $d$  is the constant angle of divergence (in degrees) between any two successive seeds.

The position of each seed can also be represented in Euclidean coordinates (x,y) by:

$$x = r * \cos(\theta)$$

$$y = r * \sin(\theta)$$

When plotting the positions of a large number of seeds (e.g. 20 000), the variable that determines the graph's shape is angle of divergence. This point is illustrated in figures 1,1; 1,2; 1,3; 1,4, where the constant angle of divergence ( $d$ ) is initialized to  $137.51^\circ$ ,  $137.45^\circ$ ,  $137.65^\circ$  and  $137.92^\circ$  respectively.

### 1.1.2 Results

*Refer to Appendix A for Matlab source code*

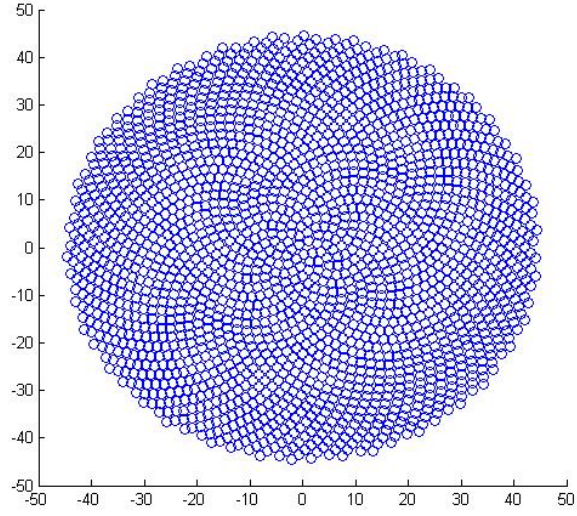


Figure 1: Perfect Sunflower Head ( $d = 137.51^\circ$ )

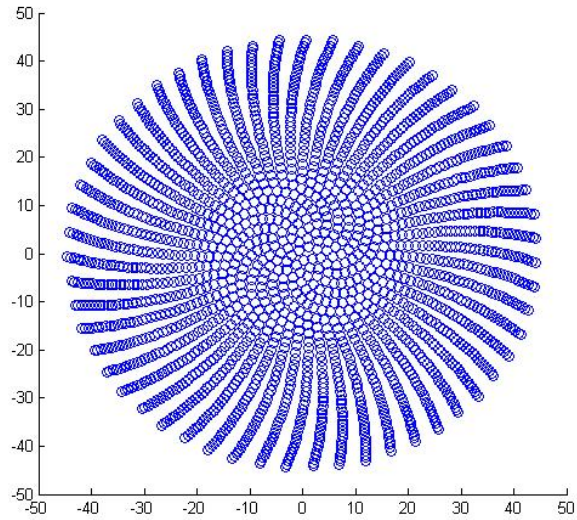


Figure 2: Spokes, from fairly far out ( $d = 137.45^\circ$ )

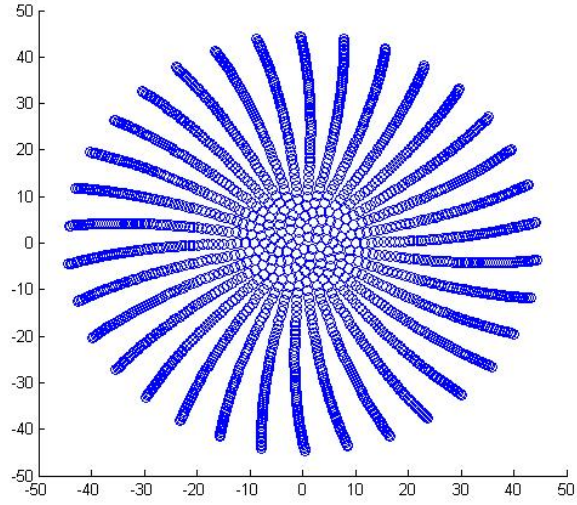


Figure 3: Spokes all the way ( $d = 137.65^\circ$ )

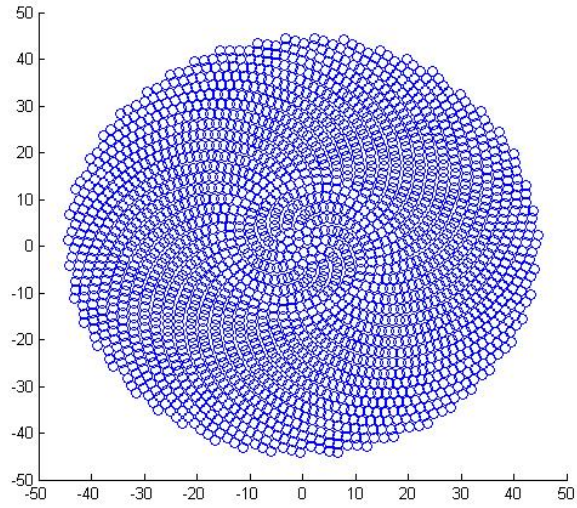


Figure 4: (Catherine wheels ( $d = 137.92^\circ$ ))

### 1.1.3 Conclusion

All 4 figures were generated by the same Matlab code, with the exception of the minute change to the angle of divergence. One would expect these results to be very similar. However, this small change to  $d$  produced considerably different graphs, proving that only an angle of divergence of exactly  $137.51^\circ$  would create the perfect sunflower.

## 1.2 Question 2:

### 1.2.1 Introduction

The following difference equations:

$$x_{k+1} = y_k(1 + \sin 0.7x_k) - 1.2|x_k|$$

$$y_{k+1} = 0.21 - x_k$$

draw a interesting fractal (when the initial x ( $x_k$ ) and initial y ( $y_k$ ) values equal zero)

### 1.2.2 Results

*Refer to Appendix B for Matlab source code*  
(Graph on the next page)

### 1.2.3 Conclusion

The programming aspect of this question was very straightforward. The previous x and y values of the difference equations had to be re-initialized in every iteration of the for-loop to the current x and y values, so that the previous value's could be used in the calculation of the co-ordinates in the following iteration. After a large number of repetitions of this procedure (e.g. 20 000), the stunning fractal in Figure 5 is generated.

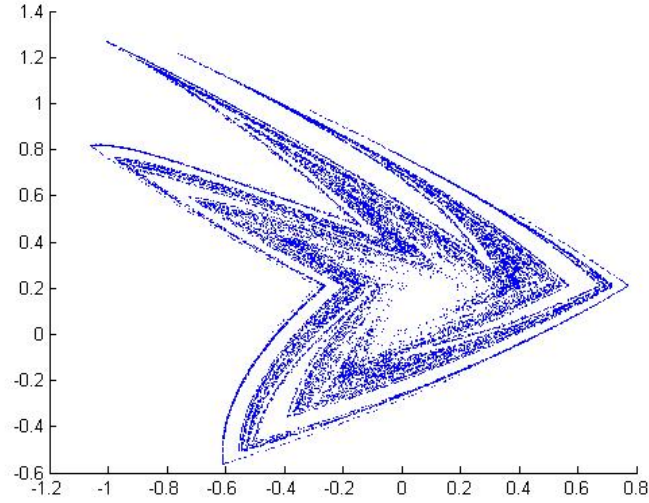


Figure 5: Fractal

### 1.3 Question 3:

#### 1.3.1 Introduction

In a series circuit, the equation

$$Q(t) = CV * (1 - e^{\frac{-t}{RC}})$$

represents the charge ( $Q$ ) as a function of time ( $T$ ) if  $Q = 0$  at  $T = 0$ . Given the initial values

$$Resistor(R) = 4, Capacitor(C) = 1, Battery(V) = 9$$

, the charge on the capacitor is monitored every  $(\frac{1}{10})^{th}$  of a second until  $T$  reaches, and also surpasses, 8 seconds.

#### 1.3.2 Results

*Refer to Sub-appendix C1 for Matlab source code*

*Refer to Sub-appendix C2 for Matlab source code*

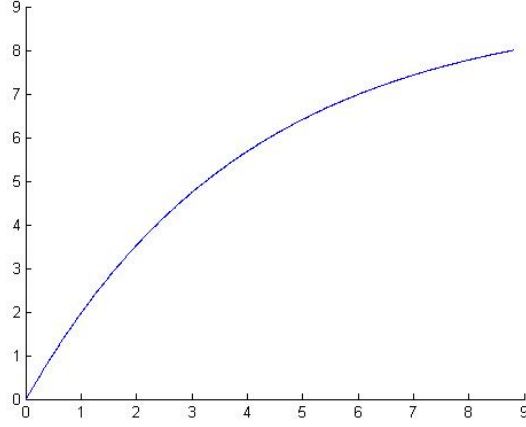


Figure 6: Time VS Charge

Displays the time and charge every 0.1 seconds:

*While charge is less than 8 units*

Time: 0	Charge: 0	Time: 1.000000e-01	Charge: 3.960227e-01
Time: 1.000000e-02	Charge: 2.002389e-01	Time: 2.000000e-01	
Charge: 0	Time: 1.100000e-01	Charge: 4.175057e-01	
Time: 2.000000e-02	Charge: 2.222108e-01	Time: 2.100000e-01	
Charge: 2.247190e-02	Time: 1.200000e-01	Charge: 4.389352e-01	
Time: 3.000000e-02	Charge: 2.441279e-01	Time: 2.200000e-01	
Charge: 4.488769e-02	Time: 1.300000e-01	Charge: 4.603111e-01	
Time: 4.000000e-02	Charge: 2.659902e-01	Time: 2.300000e-01	
Charge: 6.724751e-02	Time: 1.400000e-01	Charge: 4.816337e-01	
Time: 5.000000e-02	Charge: 2.877980e-01	Time: 2.400000e-01	
Charge: 8.955150e-02	Time: 1.500000e-01	Charge: 5.029030e-01	
Time: 6.000000e-02	Charge: 3.095513e-01	Time: 2.500000e-01	
Charge: 1.117998e-01	Time: 1.600000e-01	Charge: 5.241192e-01	
Time: 7.000000e-02	Charge: 3.312502e-01	Time: 2.600000e-01	
Charge: 1.339925e-01	Time: 1.700000e-01	Charge: 5.452824e-01	
Time: 8.000000e-02	Charge: 3.528950e-01	Time: 2.700000e-01	
Charge: 1.561299e-01	Time: 1.800000e-01	Charge: 5.663928e-01	
Time: 9.000000e-02	Charge: 3.744858e-01	Time: 2.800000e-01	
Charge: 1.782119e-01	Time: 1.900000e-01	Charge: 5.874505e-01	

Time: 2.900000e-01	Time: 4.800000e-01	Time: 6.700000e-01
Charge: 6.084556e-01	Charge: 9.977354e-01	Charge: 1.368957e+00
Time: 3.000000e-01	Time: 4.900000e-01	Time: 6.800000e-01
Charge: 6.294083e-01	Charge: 1.017716e+00	Charge: 1.388010e+00
Time: 3.100000e-01	Time: 5.000000e-01	Time: 6.900000e-01
Charge: 6.503086e-01	Charge: 1.037647e+00	Charge: 1.407017e+00
Time: 3.200000e-01	Time: 5.100000e-01	Time: 7.000000e-01
Charge: 6.711568e-01	Charge: 1.057528e+00	Charge: 1.425975e+00
Time: 3.300000e-01	Time: 5.200000e-01	Time: 7.100000e-01
Charge: 6.919529e-01	Charge: 1.077359e+00	Charge: 1.444887e+00
Time: 3.400000e-01	Time: 5.300000e-01	Time: 7.200000e-01
Charge: 7.126971e-01	Charge: 1.097141e+00	Charge: 1.463751e+00
Time: 3.500000e-01	Time: 5.400000e-01	Time: 7.300000e-01
Charge: 7.333894e-01	Charge: 1.116874e+00	Charge: 1.482568e+00
Time: 3.600000e-01	Time: 5.500000e-01	Time: 7.400000e-01
Charge: 7.540302e-01	Charge: 1.136557e+00	Charge: 1.501338e+00
Time: 3.700000e-01	Time: 5.600000e-01	Time: 7.500000e-01
Charge: 7.746193e-01	Charge: 1.156191e+00	Charge: 1.520061e+00
Time: 3.800000e-01	Time: 5.700000e-01	Time: 7.600000e-01
Charge: 7.951571e-01	Charge: 1.175776e+00	Charge: 1.538738e+00
Time: 3.900000e-01	Time: 5.800000e-01	Time: 7.700000e-01
Charge: 8.156436e-01	Charge: 1.195312e+00	Charge: 1.557368e+00
Time: 4.000000e-01	Time: 5.900000e-01	Time: 7.800000e-01
Charge: 8.360789e-01	Charge: 1.214799e+00	Charge: 1.575951e+00
Time: 4.100000e-01	Time: 6.000000e-01	Time: 7.900000e-01
Charge: 8.564632e-01	Charge: 1.234238e+00	Charge: 1.594488e+00
Time: 4.200000e-01	Time: 6.100000e-01	Time: 8.000000e-01
Charge: 8.767967e-01	Charge: 1.253628e+00	Charge: 1.612979e+00
Time: 4.300000e-01	Time: 6.200000e-01	Time: 8.100000e-01
Charge: 8.970793e-01	Charge: 1.272970e+00	Charge: 1.631423e+00
Time: 4.400000e-01	Time: 6.300000e-01	Time: 8.200000e-01
Charge: 9.173113e-01	Charge: 1.292263e+00	Charge: 1.649822e+00
Time: 4.500000e-01	Time: 6.400000e-01	Time: 8.300000e-01
Charge: 9.374928e-01	Charge: 1.311509e+00	Charge: 1.668174e+00
Time: 4.600000e-01	Time: 6.500000e-01	Time: 8.400000e-01
Charge: 9.576239e-01	Charge: 1.330706e+00	Charge: 1.686481e+00
Time: 4.700000e-01	Time: 6.600000e-01	Time: 8.500000e-01
Charge: 9.777047e-01	Charge: 1.349855e+00	Charge: 1.704742e+00



Time: 8.600000e-01	Time: 1.050000e+00	Time: 1.240000e+00
Charge: 1.722957e+00	Charge: 2.060536e+00	Charge: 2.382454e+00
Time: 8.700000e-01	Time: 1.060000e+00	Time: 1.250000e+00
Charge: 1.741127e+00	Charge: 2.077863e+00	Charge: 2.398977e+00
Time: 8.800000e-01	Time: 1.070000e+00	Time: 1.260000e+00
Charge: 1.759252e+00	Charge: 2.095146e+00	Charge: 2.415459e+00
Time: 8.900000e-01	Time: 1.080000e+00	Time: 1.270000e+00
Charge: 1.777331e+00	Charge: 2.112387e+00	Charge: 2.431900e+00
Time: 9.000000e-01	Time: 1.090000e+00	Time: 1.280000e+00
Charge: 1.795365e+00	Charge: 2.129585e+00	Charge: 2.448300e+00
Time: 9.100000e-01	Time: 1.100000e+00	Time: 1.290000e+00
Charge: 1.813354e+00	Charge: 2.146739e+00	Charge: 2.464659e+00
Time: 9.200000e-01	Time: 1.110000e+00	Time: 1.300000e+00
Charge: 1.831298e+00	Charge: 2.163851e+00	Charge: 2.480977e+00
Time: 9.300000e-01	Time: 1.120000e+00	Time: 1.310000e+00
Charge: 1.849198e+00	Charge: 2.180920e+00	Charge: 2.497254e+00
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Charge: 1.867052e+00	Charge: 2.197946e+00	Charge: 2.513490e+00
Time: 9.500000e-01	Time: 1.140000e+00	Time: 1.330000e+00
Charge: 1.884862e+00	Charge: 2.214930e+00	Charge: 2.529686e+00
Time: 9.600000e-01	Time: 1.150000e+00	Time: 1.340000e+00
Charge: 1.902628e+00	Charge: 2.231872e+00	Charge: 2.545842e+00
Time: 9.700000e-01	Time: 1.160000e+00	Time: 1.350000e+00
Charge: 1.920349e+00	Charge: 2.248771e+00	Charge: 2.561957e+00
Time: 9.800000e-01	Time: 1.170000e+00	Time: 1.360000e+00
Charge: 1.938026e+00	Charge: 2.265628e+00	Charge: 2.578032e+00
Time: 9.900000e-01	Time: 1.180000e+00	Time: 1.370000e+00
Charge: 1.955659e+00	Charge: 2.282443e+00	Charge: 2.594067e+00
Time: 1.000000e+00	Time: 1.190000e+00	Time: 1.380000e+00
Charge: 1.973248e+00	Charge: 2.299216e+00	Charge: 2.610062e+00
Time: 1.010000e+00	Time: 1.200000e+00	Time: 1.390000e+00
Charge: 1.990793e+00	Charge: 2.315947e+00	Charge: 2.626017e+00
Time: 1.020000e+00	Time: 1.210000e+00	Time: 1.400000e+00
Charge: 2.008294e+00	Charge: 2.332636e+00	Charge: 2.641932e+00
Time: 1.030000e+00	Time: 1.220000e+00	Time: 1.410000e+00
Charge: 2.025752e+00	Charge: 2.349284e+00	Charge: 2.657807e+00
Time: 1.040000e+00	Time: 1.230000e+00	Time: 1.420000e+00
Charge: 2.043165e+00	Charge: 2.365890e+00	Charge: 2.673643e+00

Time: 1.430000e+00	Time: 1.620000e+00	Time: 1.810000e+00
Charge: 2.689439e+00	Charge: 2.982183e+00	Charge: 3.261347e+00
Time: 1.440000e+00	Time: 1.630000e+00	Time: 1.820000e+00
Charge: 2.705196e+00	Charge: 2.997209e+00	Charge: 3.275675e+00
Time: 1.450000e+00	Time: 1.640000e+00	Time: 1.830000e+00
Charge: 2.720913e+00	Charge: 3.012197e+00	Charge: 3.289968e+00
Time: 1.460000e+00	Time: 1.650000e+00	Time: 1.840000e+00
Charge: 2.736591e+00	Charge: 3.027148e+00	Charge: 3.304226e+00
Time: 1.470000e+00	Time: 1.660000e+00	Time: 1.850000e+00
Charge: 2.752230e+00	Charge: 3.042061e+00	Charge: 3.318447e+00
Time: 1.480000e+00	Time: 1.670000e+00	Time: 1.860000e+00
Charge: 2.767830e+00	Charge: 3.056937e+00	Charge: 3.332633e+00
Time: 1.490000e+00	Time: 1.680000e+00	Time: 1.870000e+00
Charge: 2.783391e+00	Charge: 3.071777e+00	Charge: 3.346784e+00
Time: 1.500000e+00	Time: 1.690000e+00	Time: 1.880000e+00
Charge: 2.798913e+00	Charge: 3.086579e+00	Charge: 3.360899e+00
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Charge: 2.814396e+00	Charge: 3.101344e+00	Charge: 3.374980e+00
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Charge: 2.829841e+00	Charge: 3.116072e+00	Charge: 3.389025e+00
Time: 1.530000e+00	Time: 1.720000e+00	Time: 1.910000e+00
Charge: 2.845247e+00	Charge: 3.130763e+00	Charge: 3.403034e+00
Time: 1.540000e+00	Time: 1.730000e+00	Time: 1.920000e+00
Charge: 2.860615e+00	Charge: 3.145418e+00	Charge: 3.417009e+00
Time: 1.550000e+00	Time: 1.740000e+00	Time: 1.930000e+00
Charge: 2.875944e+00	Charge: 3.160036e+00	Charge: 3.430949e+00
Time: 1.560000e+00	Time: 1.750000e+00	Time: 1.940000e+00
Charge: 2.891235e+00	Charge: 3.174618e+00	Charge: 3.444855e+00
Time: 1.570000e+00	Time: 1.760000e+00	Time: 1.950000e+00
Charge: 2.906488e+00	Charge: 3.189163e+00	Charge: 3.458725e+00
Time: 1.580000e+00	Time: 1.770000e+00	Time: 1.960000e+00
Charge: 2.921703e+00	Charge: 3.203672e+00	Charge: 3.472561e+00
Time: 1.590000e+00	Time: 1.780000e+00	Time: 1.970000e+00
Charge: 2.936880e+00	Charge: 3.218145e+00	Charge: 3.486362e+00
Time: 1.600000e+00	Time: 1.790000e+00	Time: 1.980000e+00
Charge: 2.952019e+00	Charge: 3.232582e+00	Charge: 3.500129e+00
Time: 1.610000e+00	Time: 1.800000e+00	Time: 1.990000e+00
Charge: 2.967120e+00	Charge: 3.246982e+00	Charge: 3.513862e+00

Time: 2.000000e+00	Time: 2.190000e+00	Time: 2.380000e+00
Charge: 3.527560e+00	Charge: 3.781424e+00	Charge: 4.023511e+00
Time: 2.010000e+00	Time: 2.200000e+00	Time: 2.390000e+00
Charge: 3.541224e+00	Charge: 3.794454e+00	Charge: 4.035937e+00
Time: 2.020000e+00	Time: 2.210000e+00	Time: 2.400000e+00
Charge: 3.554854e+00	Charge: 3.807452e+00	Charge: 4.048332e+00
Time: 2.030000e+00	Time: 2.220000e+00	Time: 2.410000e+00
Charge: 3.568450e+00	Charge: 3.820417e+00	Charge: 4.060695e+00
Time: 2.040000e+00	Time: 2.230000e+00	Time: 2.420000e+00
Charge: 3.582012e+00	Charge: 3.833350e+00	Charge: 4.073028e+00
Time: 2.050000e+00	Time: 2.240000e+00	Time: 2.430000e+00
Charge: 3.595540e+00	Charge: 3.846250e+00	Charge: 4.085330e+00
Time: 2.060000e+00	Time: 2.250000e+00	Time: 2.440000e+00
Charge: 3.609034e+00	Charge: 3.859118e+00	Charge: 4.097601e+00
Time: 2.070000e+00	Time: 2.260000e+00	Time: 2.450000e+00
Charge: 3.622495e+00	Charge: 3.871955e+00	Charge: 4.109842e+00
Time: 2.080000e+00	Time: 2.270000e+00	Time: 2.460000e+00
Charge: 3.635922e+00	Charge: 3.884759e+00	Charge: 4.122052e+00
Time: 2.090000e+00	Time: 2.280000e+00	Time: 2.470000e+00
Charge: 3.649315e+00	Charge: 3.897531e+00	Charge: 4.134232e+00
Time: 2.100000e+00	Time: 2.290000e+00	Time: 2.480000e+00
Charge: 3.662675e+00	Charge: 3.910271e+00	Charge: 4.146381e+00
Time: 2.110000e+00	Time: 2.300000e+00	Time: 2.490000e+00
Charge: 3.676002e+00	Charge: 3.922979e+00	Charge: 4.158500e+00
Time: 2.120000e+00	Time: 2.310000e+00	Time: 2.500000e+00
Charge: 3.689295e+00	Charge: 3.935656e+00	Charge: 4.170589e+00
Time: 2.130000e+00	Time: 2.320000e+00	Time: 2.510000e+00
Charge: 3.702555e+00	Charge: 3.948301e+00	Charge: 4.182647e+00
Time: 2.140000e+00	Time: 2.330000e+00	Time: 2.520000e+00
Charge: 3.715782e+00	Charge: 3.960915e+00	Charge: 4.194675e+00
Time: 2.150000e+00	Time: 2.340000e+00	Time: 2.530000e+00
Charge: 3.728976e+00	Charge: 3.973497e+00	Charge: 4.206674e+00
Time: 2.160000e+00	Time: 2.350000e+00	Time: 2.540000e+00
Charge: 3.742137e+00	Charge: 3.986047e+00	Charge: 4.218642e+00
Time: 2.170000e+00	Time: 2.360000e+00	Time: 2.550000e+00
Charge: 3.755266e+00	Charge: 3.998566e+00	Charge: 4.230581e+00
Time: 2.180000e+00	Time: 2.370000e+00	Time: 2.560000e+00
Charge: 3.768361e+00	Charge: 4.011054e+00	Charge: 4.242489e+00

Time: 2.570000e+00	Time: 2.760000e+00	Time: 2.950000e+00
Charge: 4.254368e+00	Charge: 4.474516e+00	Charge: 4.684451e+00
Time: 2.580000e+00	Time: 2.770000e+00	Time: 2.960000e+00
Charge: 4.266217e+00	Charge: 4.485815e+00	Charge: 4.695226e+00
Time: 2.590000e+00	Time: 2.780000e+00	Time: 2.970000e+00
Charge: 4.278037e+00	Charge: 4.497087e+00	Charge: 4.705975e+00
Time: 2.600000e+00	Time: 2.790000e+00	Time: 2.980000e+00
Charge: 4.289827e+00	Charge: 4.508330e+00	Charge: 4.716696e+00
Time: 2.610000e+00	Time: 2.800000e+00	Time: 2.990000e+00
Charge: 4.301588e+00	Charge: 4.519545e+00	Charge: 4.727391e+00
Time: 2.620000e+00	Time: 2.810000e+00	Time: 3.000000e+00
Charge: 4.313319e+00	Charge: 4.530732e+00	Charge: 4.738059e+00
Time: 2.630000e+00	Time: 2.820000e+00	Time: 3.010000e+00
Charge: 4.325021e+00	Charge: 4.541891e+00	Charge: 4.748701e+00
Time: 2.640000e+00	Time: 2.830000e+00	Time: 3.020000e+00
Charge: 4.336694e+00	Charge: 4.553023e+00	Charge: 4.759316e+00
Time: 2.650000e+00	Time: 2.840000e+00	Time: 3.030000e+00
Charge: 4.348338e+00	Charge: 4.564126e+00	Charge: 4.769904e+00
Time: 2.660000e+00	Time: 2.850000e+00	Time: 3.040000e+00
Charge: 4.359953e+00	Charge: 4.575202e+00	Charge: 4.780466e+00
Time: 2.670000e+00	Time: 2.860000e+00	Time: 3.050000e+00
Charge: 4.371538e+00	Charge: 4.586250e+00	Charge: 4.791002e+00
Time: 2.680000e+00	Time: 2.870000e+00	Time: 3.060000e+00
Charge: 4.383095e+00	Charge: 4.597271e+00	Charge: 4.801512e+00
Time: 2.690000e+00	Time: 2.880000e+00	Time: 3.070000e+00
Charge: 4.394623e+00	Charge: 4.608264e+00	Charge: 4.811995e+00
Time: 2.700000e+00	Time: 2.890000e+00	Time: 3.080000e+00
Charge: 4.406122e+00	Charge: 4.619230e+00	Charge: 4.822452e+00
Time: 2.710000e+00	Time: 2.900000e+00	Time: 3.090000e+00
Charge: 4.417592e+00	Charge: 4.630168e+00	Charge: 4.832882e+00
Time: 2.720000e+00	Time: 2.910000e+00	Time: 3.100000e+00
Charge: 4.429034e+00	Charge: 4.641079e+00	Charge: 4.843287e+00
Time: 2.730000e+00	Time: 2.920000e+00	Time: 3.110000e+00
Charge: 4.440447e+00	Charge: 4.651963e+00	Charge: 4.853666e+00
Time: 2.740000e+00	Time: 2.930000e+00	Time: 3.120000e+00
Charge: 4.451832e+00	Charge: 4.662819e+00	Charge: 4.864019e+00
Time: 2.750000e+00	Time: 2.940000e+00	Time: 3.130000e+00
Charge: 4.463188e+00	Charge: 4.673648e+00	Charge: 4.874346e+00

Time: 3.140000e+00	Time: 3.330000e+00	Time: 3.520000e+00
Charge: 4.884647e+00	Charge: 5.075556e+00	Charge: 5.257610e+00
Time: 3.150000e+00	Time: 3.340000e+00	Time: 3.530000e+00
Charge: 4.894923e+00	Charge: 5.085355e+00	Charge: 5.266954e+00
Time: 3.160000e+00	Time: 3.350000e+00	Time: 3.540000e+00
Charge: 4.905173e+00	Charge: 5.095130e+00	Charge: 5.276275e+00
Time: 3.170000e+00	Time: 3.360000e+00	Time: 3.550000e+00
Charge: 4.915397e+00	Charge: 5.104880e+00	Charge: 5.285572e+00
Time: 3.180000e+00	Time: 3.370000e+00	Time: 3.560000e+00
Charge: 4.925596e+00	Charge: 5.114605e+00	Charge: 5.294847e+00
Time: 3.190000e+00	Time: 3.380000e+00	Time: 3.570000e+00
Charge: 4.935769e+00	Charge: 5.124307e+00	Charge: 5.304098e+00
Time: 3.200000e+00	Time: 3.390000e+00	Time: 3.580000e+00
Charge: 4.945917e+00	Charge: 5.133984e+00	Charge: 5.313326e+00
Time: 3.210000e+00	Time: 3.400000e+00	Time: 3.590000e+00
Charge: 4.956039e+00	Charge: 5.143637e+00	Charge: 5.322532e+00
Time: 3.220000e+00	Time: 3.410000e+00	Time: 3.600000e+00
Charge: 4.966137e+00	Charge: 5.153266e+00	Charge: 5.331714e+00
Time: 3.230000e+00	Time: 3.420000e+00	Time: 3.610000e+00
Charge: 4.976209e+00	Charge: 5.162870e+00	Charge: 5.340873e+00
Time: 3.240000e+00	Time: 3.430000e+00	Time: 3.620000e+00
Charge: 4.986256e+00	Charge: 5.172451e+00	Charge: 5.350009e+00
Time: 3.250000e+00	Time: 3.440000e+00	Time: 3.630000e+00
Charge: 4.996277e+00	Charge: 5.182008e+00	Charge: 5.359123e+00
Time: 3.260000e+00	Time: 3.450000e+00	Time: 3.640000e+00
Charge: 5.006274e+00	Charge: 5.191541e+00	Charge: 5.368214e+00
Time: 3.270000e+00	Time: 3.460000e+00	Time: 3.650000e+00
Charge: 5.016246e+00	Charge: 5.201051e+00	Charge: 5.377282e+00
Time: 3.280000e+00	Time: 3.470000e+00	Time: 3.660000e+00
Charge: 5.026193e+00	Charge: 5.210536e+00	Charge: 5.386327e+00
Time: 3.290000e+00	Time: 3.480000e+00	Time: 3.670000e+00
Charge: 5.036115e+00	Charge: 5.219998e+00	Charge: 5.395350e+00
Time: 3.300000e+00	Time: 3.490000e+00	Time: 3.680000e+00
Charge: 5.046012e+00	Charge: 5.229436e+00	Charge: 5.404351e+00
Time: 3.310000e+00	Time: 3.500000e+00	Time: 3.690000e+00
Charge: 5.055885e+00	Charge: 5.238851e+00	Charge: 5.413329e+00
Time: 3.320000e+00	Time: 3.510000e+00	Time: 3.700000e+00
Charge: 5.065733e+00	Charge: 5.248242e+00	Charge: 5.422284e+00

Time: 3.710000e+00	Time: 3.900000e+00	Time: 4.090000e+00
Charge: 5.431217e+00	Charge: 5.596771e+00	Charge: 5.754646e+00
Time: 3.720000e+00	Time: 3.910000e+00	Time: 4.100000e+00
Charge: 5.440128e+00	Charge: 5.605269e+00	Charge: 5.762749e+00
Time: 3.730000e+00	Time: 3.920000e+00	Time: 4.110000e+00
Charge: 5.449017e+00	Charge: 5.613745e+00	Charge: 5.770832e+00
Time: 3.740000e+00	Time: 3.930000e+00	Time: 4.120000e+00
Charge: 5.457883e+00	Charge: 5.622200e+00	Charge: 5.778895e+00
Time: 3.750000e+00	Time: 3.940000e+00	Time: 4.130000e+00
Charge: 5.466727e+00	Charge: 5.630634e+00	Charge: 5.786937e+00
Time: 3.760000e+00	Time: 3.950000e+00	Time: 4.140000e+00
Charge: 5.475549e+00	Charge: 5.639047e+00	Charge: 5.794960e+00
Time: 3.770000e+00	Time: 3.960000e+00	Time: 4.150000e+00
Charge: 5.484349e+00	Charge: 5.647439e+00	Charge: 5.802963e+00
Time: 3.780000e+00	Time: 3.970000e+00	Time: 4.160000e+00
Charge: 5.493128e+00	Charge: 5.655810e+00	Charge: 5.810945e+00
Time: 3.790000e+00	Time: 3.980000e+00	Time: 4.170000e+00
Charge: 5.501884e+00	Charge: 5.664160e+00	Charge: 5.818908e+00
Time: 3.800000e+00	Time: 3.990000e+00	Time: 4.180000e+00
Charge: 5.510618e+00	Charge: 5.672489e+00	Charge: 5.826851e+00
Time: 3.810000e+00	Time: 4.000000e+00	Time: 4.190000e+00
Charge: 5.519331e+00	Charge: 5.680797e+00	Charge: 5.834774e+00
Time: 3.820000e+00	Time: 4.010000e+00	Time: 4.200000e+00
Charge: 5.528022e+00	Charge: 5.689085e+00	Charge: 5.842677e+00
Time: 3.830000e+00	Time: 4.020000e+00	Time: 4.210000e+00
Charge: 5.536691e+00	Charge: 5.697352e+00	Charge: 5.850560e+00
Time: 3.840000e+00	Time: 4.030000e+00	Time: 4.220000e+00
Charge: 5.545338e+00	Charge: 5.705598e+00	Charge: 5.858424e+00
Time: 3.850000e+00	Time: 4.040000e+00	Time: 4.230000e+00
Charge: 5.553964e+00	Charge: 5.713824e+00	Charge: 5.866268e+00
Time: 3.860000e+00	Time: 4.050000e+00	Time: 4.240000e+00
Charge: 5.562568e+00	Charge: 5.722029e+00	Charge: 5.874093e+00
Time: 3.870000e+00	Time: 4.060000e+00	Time: 4.250000e+00
Charge: 5.571151e+00	Charge: 5.730214e+00	Charge: 5.881898e+00
Time: 3.880000e+00	Time: 4.070000e+00	Time: 4.260000e+00
Charge: 5.579713e+00	Charge: 5.738378e+00	Charge: 5.889683e+00
Time: 3.890000e+00	Time: 4.080000e+00	Time: 4.270000e+00
Charge: 5.588253e+00	Charge: 5.746522e+00	Charge: 5.897449e+00

Time: 4.280000e+00	Time: 4.470000e+00	Time: 4.660000e+00
Charge: 5.905196e+00	Charge: 6.048762e+00	Charge: 6.185669e+00
Time: 4.290000e+00	Time: 4.480000e+00	Time: 4.670000e+00
Charge: 5.912923e+00	Charge: 6.056131e+00	Charge: 6.192696e+00
Time: 4.300000e+00	Time: 4.490000e+00	Time: 4.680000e+00
Charge: 5.920631e+00	Charge: 6.063482e+00	Charge: 6.199706e+00
Time: 4.310000e+00	Time: 4.500000e+00	Time: 4.690000e+00
Charge: 5.928320e+00	Charge: 6.070814e+00	Charge: 6.206698e+00
Time: 4.320000e+00	Time: 4.510000e+00	Time: 4.700000e+00
Charge: 5.935990e+00	Charge: 6.078128e+00	Charge: 6.213672e+00
Time: 4.330000e+00	Time: 4.520000e+00	Time: 4.710000e+00
Charge: 5.943640e+00	Charge: 6.085423e+00	Charge: 6.220629e+00
Time: 4.340000e+00	Time: 4.530000e+00	Time: 4.720000e+00
Charge: 5.951272e+00	Charge: 6.092701e+00	Charge: 6.227569e+00
Time: 4.350000e+00	Time: 4.540000e+00	Time: 4.730000e+00
Charge: 5.958884e+00	Charge: 6.099960e+00	Charge: 6.234491e+00
Time: 4.360000e+00	Time: 4.550000e+00	Time: 4.740000e+00
Charge: 5.966477e+00	Charge: 6.107201e+00	Charge: 6.241396e+00
Time: 4.370000e+00	Time: 4.560000e+00	Time: 4.750000e+00
Charge: 5.974052e+00	Charge: 6.114424e+00	Charge: 6.248284e+00
Time: 4.380000e+00	Time: 4.570000e+00	Time: 4.760000e+00
Charge: 5.981607e+00	Charge: 6.121629e+00	Charge: 6.255155e+00
Time: 4.390000e+00	Time: 4.580000e+00	Time: 4.770000e+00
Charge: 5.989144e+00	Charge: 6.128816e+00	Charge: 6.262009e+00
Time: 4.400000e+00	Time: 4.590000e+00	Time: 4.780000e+00
Charge: 5.996661e+00	Charge: 6.135985e+00	Charge: 6.268845e+00
Time: 4.410000e+00	Time: 4.600000e+00	Time: 4.790000e+00
Charge: 6.004160e+00	Charge: 6.143136e+00	Charge: 6.275664e+00
Time: 4.420000e+00	Time: 4.610000e+00	Time: 4.800000e+00
Charge: 6.011640e+00	Charge: 6.150269e+00	Charge: 6.282467e+00
Time: 4.430000e+00	Time: 4.620000e+00	Time: 4.810000e+00
Charge: 6.019102e+00	Charge: 6.157385e+00	Charge: 6.289252e+00
Time: 4.440000e+00	Time: 4.630000e+00	Time: 4.820000e+00
Charge: 6.026545e+00	Charge: 6.164482e+00	Charge: 6.296020e+00
Time: 4.450000e+00	Time: 4.640000e+00	Time: 4.830000e+00
Charge: 6.033969e+00	Charge: 6.171562e+00	Charge: 6.302772e+00
Time: 4.460000e+00	Time: 4.650000e+00	Time: 4.840000e+00
Charge: 6.041375e+00	Charge: 6.178624e+00	Charge: 6.309507e+00

Time: 4.850000e+00	Time: 5.040000e+00	Time: 5.230000e+00
Charge: 6.316224e+00	Charge: 6.440724e+00	Charge: 6.559447e+00
Time: 4.860000e+00	Time: 5.050000e+00	Time: 5.240000e+00
Charge: 6.322926e+00	Charge: 6.447114e+00	Charge: 6.565541e+00
Time: 4.870000e+00	Time: 5.060000e+00	Time: 5.250000e+00
Charge: 6.329610e+00	Charge: 6.453488e+00	Charge: 6.571619e+00
Time: 4.880000e+00	Time: 5.070000e+00	Time: 5.260000e+00
Charge: 6.336278e+00	Charge: 6.459846e+00	Charge: 6.577683e+00
Time: 4.890000e+00	Time: 5.080000e+00	Time: 5.270000e+00
Charge: 6.342928e+00	Charge: 6.466189e+00	Charge: 6.583731e+00
Time: 4.900000e+00	Time: 5.090000e+00	Time: 5.280000e+00
Charge: 6.349563e+00	Charge: 6.472515e+00	Charge: 6.589764e+00
Time: 4.910000e+00	Time: 5.100000e+00	Time: 5.290000e+00
Charge: 6.356181e+00	Charge: 6.478826e+00	Charge: 6.595782e+00
Time: 4.920000e+00	Time: 5.110000e+00	Time: 5.300000e+00
Charge: 6.362782e+00	Charge: 6.485121e+00	Charge: 6.601785e+00
Time: 4.930000e+00	Time: 5.120000e+00	Time: 5.310000e+00
Charge: 6.369367e+00	Charge: 6.491401e+00	Charge: 6.607773e+00
Time: 4.940000e+00	Time: 5.130000e+00	Time: 5.320000e+00
Charge: 6.375935e+00	Charge: 6.497664e+00	Charge: 6.613746e+00
Time: 4.950000e+00	Time: 5.140000e+00	Time: 5.330000e+00
Charge: 6.382487e+00	Charge: 6.503912e+00	Charge: 6.619705e+00
Time: 4.960000e+00	Time: 5.150000e+00	Time: 5.340000e+00
Charge: 6.389023e+00	Charge: 6.510145e+00	Charge: 6.625648e+00
Time: 4.970000e+00	Time: 5.160000e+00	Time: 5.350000e+00
Charge: 6.395542e+00	Charge: 6.516362e+00	Charge: 6.631576e+00
Time: 4.980000e+00	Time: 5.170000e+00	Time: 5.360000e+00
Charge: 6.402045e+00	Charge: 6.522563e+00	Charge: 6.637490e+00
Time: 4.990000e+00	Time: 5.180000e+00	Time: 5.370000e+00
Charge: 6.408532e+00	Charge: 6.528749e+00	Charge: 6.643389e+00
Time: 5.000000e+00	Time: 5.190000e+00	Time: 5.380000e+00
Charge: 6.415002e+00	Charge: 6.534919e+00	Charge: 6.649273e+00
Time: 5.010000e+00	Time: 5.200000e+00	Time: 5.390000e+00
Charge: 6.421457e+00	Charge: 6.541074e+00	Charge: 6.655143e+00
Time: 5.020000e+00	Time: 5.210000e+00	Time: 5.400000e+00
Charge: 6.427895e+00	Charge: 6.547214e+00	Charge: 6.660997e+00
Time: 5.030000e+00	Time: 5.220000e+00	Time: 5.410000e+00
Charge: 6.434317e+00	Charge: 6.553338e+00	Charge: 6.666838e+00



Time: 5.420000e+00	Time: 5.610000e+00	Time: 5.800000e+00
Charge: 6.672663e+00	Charge: 6.780627e+00	Charge: 6.883583e+00
Time: 5.430000e+00	Time: 5.620000e+00	Time: 5.810000e+00
Charge: 6.678474e+00	Charge: 6.786169e+00	Charge: 6.888867e+00
Time: 5.440000e+00	Time: 5.630000e+00	Time: 5.820000e+00
Charge: 6.684271e+00	Charge: 6.791696e+00	Charge: 6.894139e+00
Time: 5.450000e+00	Time: 5.640000e+00	Time: 5.830000e+00
Charge: 6.690053e+00	Charge: 6.797210e+00	Charge: 6.899397e+00
Time: 5.460000e+00	Time: 5.650000e+00	Time: 5.840000e+00
Charge: 6.695821e+00	Charge: 6.802710e+00	Charge: 6.904642e+00
Time: 5.470000e+00	Time: 5.660000e+00	Time: 5.850000e+00
Charge: 6.701574e+00	Charge: 6.808197e+00	Charge: 6.909874e+00
Time: 5.480000e+00	Time: 5.670000e+00	Time: 5.860000e+00
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Time: 5.490000e+00	Time: 5.680000e+00	Time: 5.870000e+00
Charge: 6.713037e+00	Charge: 6.819128e+00	Charge: 6.920298e+00
Time: 5.500000e+00	Time: 5.690000e+00	Time: 5.880000e+00
Charge: 6.718748e+00	Charge: 6.824574e+00	Charge: 6.925491e+00
Time: 5.510000e+00	Time: 5.700000e+00	Time: 5.890000e+00
Charge: 6.724444e+00	Charge: 6.830006e+00	Charge: 6.930671e+00
Time: 5.520000e+00	Time: 5.710000e+00	Time: 5.900000e+00
Charge: 6.730125e+00	Charge: 6.835424e+00	Charge: 6.935837e+00
Time: 5.530000e+00	Time: 5.720000e+00	Time: 5.910000e+00
Charge: 6.735793e+00	Charge: 6.840829e+00	Charge: 6.940991e+00
Time: 5.540000e+00	Time: 5.730000e+00	Time: 5.920000e+00
Charge: 6.741446e+00	Charge: 6.846220e+00	Charge: 6.946133e+00
Time: 5.550000e+00	Time: 5.740000e+00	Time: 5.930000e+00
Charge: 6.747086e+00	Charge: 6.851597e+00	Charge: 6.951261e+00
Time: 5.560000e+00	Time: 5.750000e+00	Time: 5.940000e+00
Charge: 6.752711e+00	Charge: 6.856962e+00	Charge: 6.956376e+00
Time: 5.570000e+00	Time: 5.760000e+00	Time: 5.950000e+00
Charge: 6.758322e+00	Charge: 6.862313e+00	Charge: 6.961479e+00
Time: 5.580000e+00	Time: 5.770000e+00	Time: 5.960000e+00
Charge: 6.763919e+00	Charge: 6.867650e+00	Charge: 6.966569e+00
Time: 5.590000e+00	Time: 5.780000e+00	Time: 5.970000e+00
Charge: 6.769503e+00	Charge: 6.872974e+00	Charge: 6.971646e+00
Time: 5.600000e+00	Time: 5.790000e+00	Time: 5.980000e+00
Charge: 6.775072e+00	Charge: 6.878285e+00	Charge: 6.976711e+00

Time: 5.990000e+00	Time: 6.180000e+00	Time: 6.370000e+00
Charge: 6.981763e+00	Charge: 7.075388e+00	Charge: 7.164669e+00
Time: 6.000000e+00	Time: 6.190000e+00	Time: 6.380000e+00
Charge: 6.986802e+00	Charge: 7.080193e+00	Charge: 7.169252e+00
Time: 6.010000e+00	Time: 6.200000e+00	Time: 6.390000e+00
Charge: 6.991829e+00	Charge: 7.084987e+00	Charge: 7.173823e+00
Time: 6.020000e+00	Time: 6.210000e+00	Time: 6.400000e+00
Charge: 6.996843e+00	Charge: 7.089768e+00	Charge: 7.178383e+00
Time: 6.030000e+00	Time: 6.220000e+00	Time: 6.410000e+00
Charge: 7.001844e+00	Charge: 7.094538e+00	Charge: 7.182931e+00
Time: 6.040000e+00	Time: 6.230000e+00	Time: 6.420000e+00
Charge: 7.006834e+00	Charge: 7.099296e+00	Charge: 7.187468e+00
Time: 6.050000e+00	Time: 6.240000e+00	Time: 6.430000e+00
Charge: 7.011810e+00	Charge: 7.104041e+00	Charge: 7.191994e+00
Time: 6.060000e+00	Time: 6.250000e+00	Time: 6.440000e+00
Charge: 7.016774e+00	Charge: 7.108775e+00	Charge: 7.196508e+00
Time: 6.070000e+00	Time: 6.260000e+00	Time: 6.450000e+00
Charge: 7.021726e+00	Charge: 7.113498e+00	Charge: 7.201011e+00
Time: 6.080000e+00	Time: 6.270000e+00	Time: 6.460000e+00
Charge: 7.026666e+00	Charge: 7.118208e+00	Charge: 7.205503e+00
Time: 6.090000e+00	Time: 6.280000e+00	Time: 6.470000e+00
Charge: 7.031593e+00	Charge: 7.122906e+00	Charge: 7.209984e+00
Time: 6.100000e+00	Time: 6.290000e+00	Time: 6.480000e+00
Charge: 7.036508e+00	Charge: 7.127593e+00	Charge: 7.214453e+00
Time: 6.110000e+00	Time: 6.300000e+00	Time: 6.490000e+00
Charge: 7.041410e+00	Charge: 7.132269e+00	Charge: 7.218912e+00
Time: 6.120000e+00	Time: 6.310000e+00	Time: 6.500000e+00
Charge: 7.046301e+00	Charge: 7.136932e+00	Charge: 7.223359e+00
Time: 6.130000e+00	Time: 6.320000e+00	Time: 6.510000e+00
Charge: 7.051179e+00	Charge: 7.141584e+00	Charge: 7.227795e+00
Time: 6.140000e+00	Time: 6.330000e+00	Time: 6.520000e+00
Charge: 7.056045e+00	Charge: 7.146224e+00	Charge: 7.232220e+00
Time: 6.150000e+00	Time: 6.340000e+00	Time: 6.530000e+00
Charge: 7.060899e+00	Charge: 7.150853e+00	Charge: 7.236634e+00
Time: 6.160000e+00	Time: 6.350000e+00	Time: 6.540000e+00
Charge: 7.065740e+00	Charge: 7.155470e+00	Charge: 7.241037e+00
Time: 6.170000e+00	Time: 6.360000e+00	Time: 6.550000e+00
Charge: 7.070570e+00	Charge: 7.160075e+00	Charge: 7.245429e+00

Time: 6.560000e+00	Time: 6.750000e+00	Time: 6.940000e+00
Charge: 7.249810e+00	Charge: 7.331000e+00	Charge: 7.408424e+00
Time: 6.570000e+00	Time: 6.760000e+00	Time: 6.950000e+00
Charge: 7.254180e+00	Charge: 7.335167e+00	Charge: 7.412398e+00
Time: 6.580000e+00	Time: 6.770000e+00	Time: 6.960000e+00
Charge: 7.258539e+00	Charge: 7.339324e+00	Charge: 7.416362e+00
Time: 6.590000e+00	Time: 6.780000e+00	Time: 6.970000e+00
Charge: 7.262887e+00	Charge: 7.343471e+00	Charge: 7.420316e+00
Time: 6.600000e+00	Time: 6.790000e+00	Time: 6.980000e+00
Charge: 7.267224e+00	Charge: 7.347607e+00	Charge: 7.424261e+00
Time: 6.610000e+00	Time: 6.800000e+00	Time: 6.990000e+00
Charge: 7.271551e+00	Charge: 7.351733e+00	Charge: 7.428195e+00
Time: 6.620000e+00	Time: 6.810000e+00	Time: 7.000000e+00
Charge: 7.275867e+00	Charge: 7.355848e+00	Charge: 7.432120e+00
Time: 6.630000e+00	Time: 6.820000e+00	Time: 7.010000e+00
Charge: 7.280171e+00	Charge: 7.359954e+00	Charge: 7.436035e+00
Time: 6.640000e+00	Time: 6.830000e+00	Time: 7.020000e+00
Charge: 7.284466e+00	Charge: 7.364049e+00	Charge: 7.439940e+00
Time: 6.650000e+00	Time: 6.840000e+00	Time: 7.030000e+00
Charge: 7.288749e+00	Charge: 7.368133e+00	Charge: 7.443835e+00
Time: 6.660000e+00	Time: 6.850000e+00	Time: 7.040000e+00
Charge: 7.293022e+00	Charge: 7.372208e+00	Charge: 7.447720e+00
Time: 6.670000e+00	Time: 6.860000e+00	Time: 7.050000e+00
Charge: 7.297284e+00	Charge: 7.376272e+00	Charge: 7.451596e+00
Time: 6.680000e+00	Time: 6.870000e+00	Time: 7.060000e+00
Charge: 7.301536e+00	Charge: 7.380327e+00	Charge: 7.455462e+00
Time: 6.690000e+00	Time: 6.880000e+00	Time: 7.070000e+00
Charge: 7.305776e+00	Charge: 7.384371e+00	Charge: 7.459319e+00
Time: 6.700000e+00	Time: 6.890000e+00	Time: 7.080000e+00
Charge: 7.310007e+00	Charge: 7.388405e+00	Charge: 7.463166e+00
Time: 6.710000e+00	Time: 6.900000e+00	Time: 7.090000e+00
Charge: 7.314226e+00	Charge: 7.392429e+00	Charge: 7.467003e+00
Time: 6.720000e+00	Time: 6.910000e+00	Time: 7.100000e+00
Charge: 7.318436e+00	Charge: 7.396443e+00	Charge: 7.470831e+00
Time: 6.730000e+00	Time: 6.920000e+00	Time: 7.110000e+00
Charge: 7.322634e+00	Charge: 7.400446e+00	Charge: 7.474649e+00
Time: 6.740000e+00	Time: 6.930000e+00	Time: 7.120000e+00
Charge: 7.326822e+00	Charge: 7.404440e+00	Charge: 7.478458e+00

Time: 7.130000e+00	Time: 7.320000e+00	Time: 7.510000e+00
Charge: 7.482257e+00	Charge: 7.552664e+00	Charge: 7.619805e+00
Time: 7.140000e+00	Time: 7.330000e+00	Time: 7.520000e+00
Charge: 7.486046e+00	Charge: 7.556278e+00	Charge: 7.623251e+00
Time: 7.150000e+00	Time: 7.340000e+00	Time: 7.530000e+00
Charge: 7.489826e+00	Charge: 7.559883e+00	Charge: 7.626689e+00
Time: 7.160000e+00	Time: 7.350000e+00	Time: 7.540000e+00
Charge: 7.493597e+00	Charge: 7.563478e+00	Charge: 7.630118e+00
Time: 7.170000e+00	Time: 7.360000e+00	Time: 7.550000e+00
Charge: 7.497358e+00	Charge: 7.567065e+00	Charge: 7.633538e+00
Time: 7.180000e+00	Time: 7.370000e+00	Time: 7.560000e+00
Charge: 7.501110e+00	Charge: 7.570643e+00	Charge: 7.636950e+00
Time: 7.190000e+00	Time: 7.380000e+00	Time: 7.570000e+00
Charge: 7.504853e+00	Charge: 7.574212e+00	Charge: 7.640354e+00
Time: 7.200000e+00	Time: 7.390000e+00	Time: 7.580000e+00
Charge: 7.508586e+00	Charge: 7.577772e+00	Charge: 7.643749e+00
Time: 7.210000e+00	Time: 7.400000e+00	Time: 7.590000e+00
Charge: 7.512310e+00	Charge: 7.581323e+00	Charge: 7.647135e+00
Time: 7.220000e+00	Time: 7.410000e+00	Time: 7.600000e+00
Charge: 7.516025e+00	Charge: 7.584866e+00	Charge: 7.650513e+00
Time: 7.230000e+00	Time: 7.420000e+00	Time: 7.610000e+00
Charge: 7.519730e+00	Charge: 7.588399e+00	Charge: 7.653882e+00
Time: 7.240000e+00	Time: 7.430000e+00	Time: 7.620000e+00
Charge: 7.523426e+00	Charge: 7.591924e+00	Charge: 7.657244e+00
Time: 7.250000e+00	Time: 7.440000e+00	Time: 7.630000e+00
Charge: 7.527113e+00	Charge: 7.595439e+00	Charge: 7.660596e+00
Time: 7.260000e+00	Time: 7.450000e+00	Time: 7.640000e+00
Charge: 7.530790e+00	Charge: 7.598946e+00	Charge: 7.663941e+00
Time: 7.270000e+00	Time: 7.460000e+00	Time: 7.650000e+00
Charge: 7.534459e+00	Charge: 7.602445e+00	Charge: 7.667277e+00
Time: 7.280000e+00	Time: 7.470000e+00	Time: 7.660000e+00
Charge: 7.538118e+00	Charge: 7.605934e+00	Charge: 7.670604e+00
Time: 7.290000e+00	Time: 7.480000e+00	Time: 7.670000e+00
Charge: 7.541768e+00	Charge: 7.609415e+00	Charge: 7.673924e+00
Time: 7.300000e+00	Time: 7.490000e+00	Time: 7.680000e+00
Charge: 7.545409e+00	Charge: 7.612887e+00	Charge: 7.677235e+00
Time: 7.310000e+00	Time: 7.500000e+00	Time: 7.690000e+00
Charge: 7.549041e+00	Charge: 7.616350e+00	Charge: 7.680537e+00

Time: 7.700000e+00	Time: 7.890000e+00	Time: 8.080000e+00
Charge: 7.683832e+00	Charge: 7.744888e+00	Charge: 7.803112e+00
Time: 7.710000e+00	Time: 7.900000e+00	Time: 8.090000e+00
Charge: 7.687118e+00	Charge: 7.748022e+00	Charge: 7.806101e+00
Time: 7.720000e+00	Time: 7.910000e+00	Time: 8.100000e+00
Charge: 7.690396e+00	Charge: 7.751148e+00	Charge: 7.809082e+00
Time: 7.730000e+00	Time: 7.920000e+00	Time: 8.110000e+00
Charge: 7.693666e+00	Charge: 7.754266e+00	Charge: 7.812055e+00
Time: 7.740000e+00	Time: 7.930000e+00	Time: 8.120000e+00
Charge: 7.696928e+00	Charge: 7.757377e+00	Charge: 7.815022e+00
Time: 7.750000e+00	Time: 7.940000e+00	Time: 8.130000e+00
Charge: 7.700182e+00	Charge: 7.760480e+00	Charge: 7.817980e+00
Time: 7.760000e+00	Time: 7.950000e+00	Time: 8.140000e+00
Charge: 7.703427e+00	Charge: 7.763574e+00	Charge: 7.820932e+00
Time: 7.770000e+00	Time: 7.960000e+00	Time: 8.150000e+00
Charge: 7.706664e+00	Charge: 7.766662e+00	Charge: 7.823876e+00
Time: 7.780000e+00	Time: 7.970000e+00	Time: 8.160000e+00
Charge: 7.709894e+00	Charge: 7.769741e+00	Charge: 7.826812e+00
Time: 7.790000e+00	Time: 7.980000e+00	Time: 8.170000e+00
Charge: 7.713115e+00	Charge: 7.772813e+00	Charge: 7.829742e+00
Time: 7.800000e+00	Time: 7.990000e+00	Time: 8.180000e+00
Charge: 7.716328e+00	Charge: 7.775877e+00	Charge: 7.832664e+00
Time: 7.810000e+00	Time: 8.000000e+00	Time: 8.190000e+00
Charge: 7.719533e+00	Charge: 7.778934e+00	Charge: 7.835578e+00
Time: 7.820000e+00	Time: 8.010000e+00	Time: 8.200000e+00
Charge: 7.722731e+00	Charge: 7.781982e+00	Charge: 7.838486e+00
Time: 7.830000e+00	Time: 8.020000e+00	Time: 8.210000e+00
Charge: 7.725920e+00	Charge: 7.785024e+00	Charge: 7.841386e+00
Time: 7.840000e+00	Time: 8.030000e+00	Time: 8.220000e+00
Charge: 7.729101e+00	Charge: 7.788057e+00	Charge: 7.844279e+00
Time: 7.850000e+00	Time: 8.040000e+00	Time: 8.230000e+00
Charge: 7.732274e+00	Charge: 7.791083e+00	Charge: 7.847164e+00
Time: 7.860000e+00	Time: 8.050000e+00	Time: 8.240000e+00
Charge: 7.735440e+00	Charge: 7.794102e+00	Charge: 7.850043e+00
Time: 7.870000e+00	Time: 8.060000e+00	Time: 8.250000e+00
Charge: 7.738597e+00	Charge: 7.797113e+00	Charge: 7.852914e+00
Time: 7.880000e+00	Time: 8.070000e+00	Time: 8.260000e+00
Charge: 7.741747e+00	Charge: 7.800116e+00	Charge: 7.855778e+00

Time: 8.270000e+00	Time: 8.450000e+00	Time: 8.630000e+00
Charge: 7.858635e+00	Charge: 7.908858e+00	Charge: 7.956871e+00
Time: 8.280000e+00	Time: 8.460000e+00	Time: 8.640000e+00
Charge: 7.861485e+00	Charge: 7.911583e+00	Charge: 7.959476e+00
Time: 8.290000e+00	Time: 8.470000e+00	Time: 8.650000e+00
Charge: 7.864328e+00	Charge: 7.914300e+00	Charge: 7.962074e+00
Time: 8.300000e+00	Time: 8.480000e+00	Time: 8.660000e+00
Charge: 7.867164e+00	Charge: 7.917011e+00	Charge: 7.964665e+00
Time: 8.310000e+00	Time: 8.490000e+00	Time: 8.670000e+00
Charge: 7.869992e+00	Charge: 7.919715e+00	Charge: 7.967251e+00
Time: 8.320000e+00	Time: 8.500000e+00	Time: 8.680000e+00
Charge: 7.872814e+00	Charge: 7.922413e+00	Charge: 7.969829e+00
Time: 8.330000e+00	Time: 8.510000e+00	Time: 8.690000e+00
Charge: 7.875628e+00	Charge: 7.925103e+00	Charge: 7.972401e+00
Time: 8.340000e+00	Time: 8.520000e+00	Time: 8.700000e+00
Charge: 7.878436e+00	Charge: 7.927787e+00	Charge: 7.974967e+00
Time: 8.350000e+00	Time: 8.530000e+00	Time: 8.710000e+00
Charge: 7.881236e+00	Charge: 7.930464e+00	Charge: 7.977527e+00
Time: 8.360000e+00	Time: 8.540000e+00	Time: 8.720000e+00
Charge: 7.884029e+00	Charge: 7.933135e+00	Charge: 7.980080e+00
Time: 8.370000e+00	Time: 8.550000e+00	Time: 8.730000e+00
Charge: 7.886816e+00	Charge: 7.935799e+00	Charge: 7.982626e+00
Time: 8.380000e+00	Time: 8.560000e+00	Time: 8.740000e+00
Charge: 7.889595e+00	Charge: 7.938456e+00	Charge: 7.985166e+00
Time: 8.390000e+00	Time: 8.570000e+00	Time: 8.750000e+00
Charge: 7.892368e+00	Charge: 7.941106e+00	Charge: 7.987700e+00
Time: 8.400000e+00	Time: 8.580000e+00	Time: 8.760000e+00
Charge: 7.895133e+00	Charge: 7.943750e+00	Charge: 7.990228e+00
Time: 8.410000e+00	Time: 8.590000e+00	Time: 8.770000e+00
Charge: 7.897892e+00	Charge: 7.946388e+00	Charge: 7.992749e+00
Time: 8.420000e+00	Time: 8.600000e+00	Time: 8.780000e+00
Charge: 7.900644e+00	Charge: 7.949018e+00	Charge: 7.995264e+00
Time: 8.430000e+00	Time: 8.610000e+00	Time: 8.790000e+00
Charge: 7.903389e+00	Charge: 7.951643e+00	Charge: 7.997773e+00
Time: 8.440000e+00	Time: 8.620000e+00	
Charge: 7.906127e+00	Charge: 7.954260e+00	

*When charge first exceeds 8 units*

Time: 8.790000e+00

Charge: 8.000275e+00

### 1.3.3 Conclusion

The Time VS Charge Graph represents the fairly positive, directly proportional relationship between these two variables (that is, as time increases, charge increases,) where the charge on the capacitor initially increases rapidly, and gradually thereafter.

## 2 References

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## 3 Appendix A

```
% NOTE: 'd' is changed for each execution:  
% 137.51, 137.65, 137.92, and 137.45  
% to display the 4 figures
```

```

d = 137.51;
x = 0;
y = 0;

hold on;

for i = 1:2000
    theta = (pi*d*i)/180;
    r = sqrt(i);
    x = r.*cos(theta);
    y = r.*sin(theta);
    plot(x,y,'0');
end;

```

## 4 Appendix B

```

y = 0;
x = 0;

hold on;

for i = 1:20000

    previousX = x;
    previousY = y;
    x = previousY * (1+sin(0.7*previousX)) - 1.2 * abs(previousX);
    y = 0.21 - previousX;
    plot(x,y);

end;

```



## 5 Appendix C

Please Note: C1 displays time and charge until the charge first exceeds 8 units, whereas C2 displays time and charge only while charge is less than 8 units

### 5.1 Sub-appendix C1

```
T = 0; %Time
R = 4; %Resistor
C = 1; %Capacitor
V = 9; %Battery
Q = 0; %Charge

increment = 0.01;
b = false;

hold on;

while (b == false)

    Q = C*V*(1-exp(-T/(R*C)));
    display(sprintf('Time: %d\nCharge: %d\n', T,Q));

    T = T + increment;
    plot(T,Q);

    if (Q > 8)
        b = true;
    end;
end;
```

### 5.2 Sub-appendix C2

```
T = 0; %Time
R = 4; %Resistor
C = 1; %Capacitor
```

```

V = 9; %Battery
Q = 0; %Charge

increment = 0.01;

hold on;

while Q<8

    display(sprintf('Time: %d\nCharge: %d\n', T,Q));
    Q = C*V*(1-exp(-T/(R*C)));

    T = T + increment;
    plot(T,Q);

end;

```