PHYS 325: Computational Physics III

Winter 2023

Homework #1

Due: January 27, 2023

Please turn this homework in as a single PDF document using the course Learn site.

1. Write a program to calculate and plot the field lines and equipotential curves due a collection of `nq = 6` charges `q[i]`, with

```
q[0] = q[2] = q[4] = 1.e-6;
q[1] = q[3] = q[5] = -1.e-6;
```

Charges 0 through 4 lie on the vertices of a pentagon, with coordinates `xq` and `yq` given by

```
xq[i] = cos(2*i*math.pi/5);
yq[i] = sin(2*i*math.pi/5);
```

Charge 5 lies at the origin.

(a) Start by plotting the charges as points and drawing the field lines (take $n_\theta = 12$ starting points per charge), with steps $\delta s = \min(0.01, 10^3 \mathrm{V}/|\mathbf{E}|)$, as discussed in class. Use box limits of $-6 < (x, y) < 6$ to display the field lines, and stop computing lines that extend more than 9 units from the origin.

(b) An equipotential line may be defined by

$$\frac{dX}{ds} = \mp \frac{E_y}{|\mathbf{E}|}$$

$$\frac{dY}{ds} = \pm \frac{E_x}{|\mathbf{E}|} \, .$$

It will be sufficient to use the same step δs as in the field line computation. However, again as discussed in class, since the equipotential lines are closed loops, *you will have to take special care to ensure that the calculation terminates.* State clearly how you have addressed this issue in your program.

Draw the equipotentials (in *both* directions from the starting point if the line gets too far from the origin and doesn't return) through the points $\{(x, \pm 1), x = -4, -3, -2, \ldots, 4\}$.

Turn in your program (or programs if you choose to perform the two calculations separately), as well as plots of the field lines and equipotentials, with the locations of the charges clearly marked. If possible, draw both sets of curves on a single graph.

2. Repeat question 1, adding a seventh charge of 2×10^{-6} C at location $(2, 0)$. Qualitatively describe the effect of the extra charge on the shape of the field lines and equipotentials at large radii.