Announcements

- Homework
  - Video HW3 due tonight!
  - Written HW6 will be due on Wednesday evening. Will be posted this afternoon
- Lab this week reinforces understanding dipoles and surrounding fields
- Test 1 is one week from this Friday
- I'm looking to get preliminary grade reports posted this week
- Nominate your peers for co-curricular honors and awards!
  - `http://www.willamette.edu/go/honorsandawards`
- Polling: `rembold-class.ddns.net`

Warm Up!

Suppose you have a 2 m long and very thin rod which you happen to know has 10 μC of charge spread across it. If you break the rod into chunks which are 1 cm in length, how much charge exists on each chunk?

A) 40 nC
B) 50 nC
C) 200 nC
D) 200 μC

Solution: 50 nC

Uniformly Charged Rod: Step 3

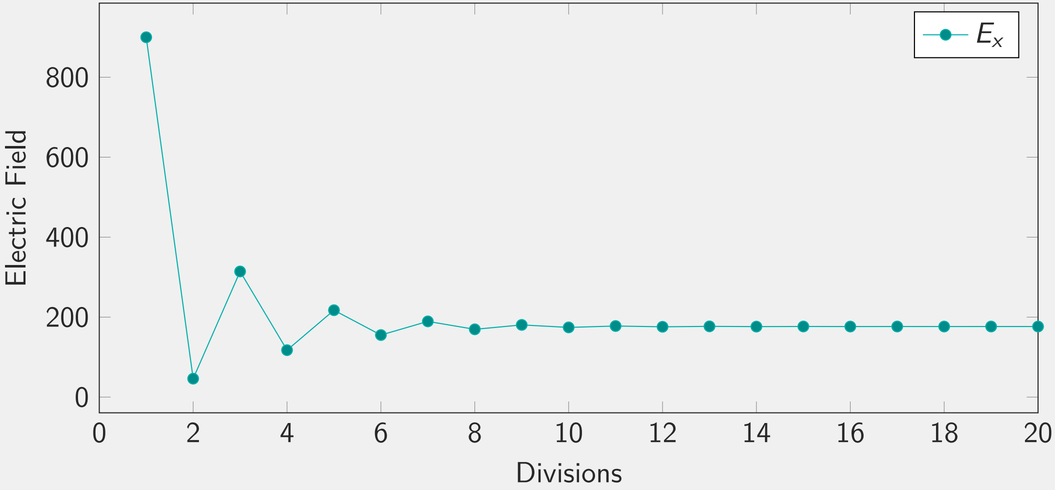
- Previously we'd found

$$\Delta E_x = \frac{1}{4\pi\epsilon_0}\frac{Q}{L}\frac{x}{(x^2+y^2)^{3/2}}\Delta y$$
$$\Delta E_y = \frac{1}{4\pi\epsilon_0}\frac{Q}{L}\frac{-y}{(x^2+y^2)^{3/2}}\Delta y$$

- Size of Δy determines precision
- Right shows the Efield results for:
  - 10 cm right of origin
  - 1 m long stick with 1 nC charge
  - Divided into 10 segments ($\Delta y = 0.1$ m)

y	ΔE_x	ΔE_y
−0.45	0.9188	4.13
−0.35	1.866	6.53
−0.25	4.6104	11.53
−0.15	15.3609	23.04
−0.05	64.3988	32.2
0.05	64.3988	−32.2
0.15	15.3609	−23.04
0.25	4.6104	−11.53
0.35	1.866	−6.53
0.45	0.9188	−4.13

Number of Divisions



Analytical Solutions

- Numeric solutions are great, but they don't give us much of an intuition for how the electric field behaves
- Would be nice to have an expression for the electric field
- Do this by letting Δy get infinitisimally small

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$$E_x = \frac{1}{4\pi\epsilon_0}\frac{Qx}{L}\int_{-L/2}^{L/2}\frac{1}{(x^2+y^2)^{3/2}}\,dy = \frac{1}{4\pi\epsilon_0}\left[\frac{Q}{x\sqrt{x^2+(L/2)^2}}\right]$$

$$E_y = \frac{1}{4\pi\epsilon_0}\frac{Q}{L}\int_{-L/2}^{L/2}\frac{-y}{(x^2+y^2)^{3/2}}\,dy = 0$$

Uniformly Charged Rod: Step 4

- There were a lot of steps involved in this, how can we check ourself?
  - Direction: The electric field does point away as it should, and it makes sense that the y-component is zero by symmetry
  - Units: Looking at the right fraction term, we see it still has units of C/m^2
  - Approximations:
    - If we get *really far away*, the line should look like a point. Does it?
    - If we make the line *really short*, then it should also look like a point. Does it?
- Get in the habit of doing these quick checks. The method is complicated enough that it is easy to make mistakes!

One More Approximation

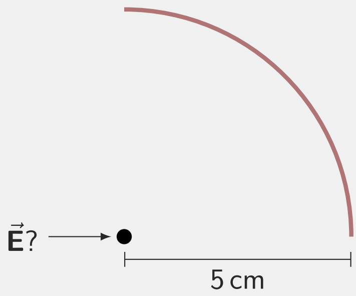
- Earlier approximations looked at $r \gg L$ and saw the expression for a point charge
- What if the rod is *really really long* (or r is *really really small*) so that $L \gg r$?

$$
\begin{aligned}
E_x &= \frac{1}{4\pi\epsilon_0}\left[\frac{Q}{r\sqrt{r^2 + (L/2)^2}}\right] \\
&= \frac{1}{4\pi\epsilon_0}\left[\frac{Q}{r\sqrt{(L/2)^2}}\right] \\
&= \frac{1}{4\pi\epsilon_0}\frac{2(Q/L)}{r}
\end{aligned}
$$

Your Turn

Determine the electric field at the origin. You should be able to do this both analytically with integration and computationally. The arc of wire has a total of 10 nC of charge on it and has a radius of 5 cm. Follow through each of our 4 steps.

- Break into chunks
- Determine the E-field due to one arbitrary chunk
- Add desired number of chunks or integrate
- Check yo'self



Solution: Worked out solutions can be viewed here