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P40C - SI
Prof. Sales

Monday Agenda (Possibly Tuesday as well depending on attendance)

1) Concept Summary / Map
   -> briefly touch on all that's been covered in class
2) Specific Q's
3) Charge Dist. WS 2a
4) Review WS
5) Comment Cards

We start w/ experimental observations

-> conductors v. insulators
  -> different ways to charge
  -> different behaviors

experimentally develop coulomb's law

$$\vec{F}_{1 \text{ on } 2} = \vec{F}_{2 \text{ on } 1} = \frac{k q_1 q_2}{|r^2|} \hat{r}$$

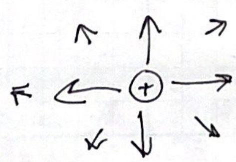
Then develop concept of a field

$$\vec{E}(\vec{r}) = \frac{kq}{r^2} \hat{r}$$

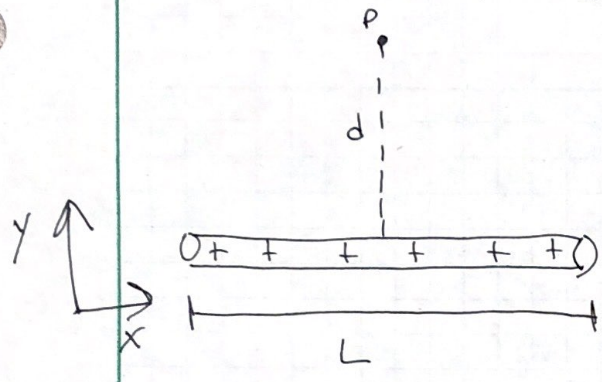
-> agent that exerts an electric force on a charged particle

-> charges interact via field

-> field created by source charges



A thin uniformly charged wire, total charge Q



Find $\vec{E}(p)$

We only know Coulomb's Law

$$\vec{E} = k\frac{q}{r^3}\vec{r}$$

How to solve?

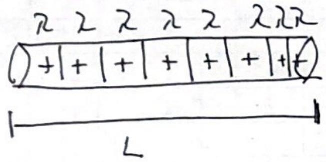
Assumption!

we assume wire is 1-d, then we cut it up into points

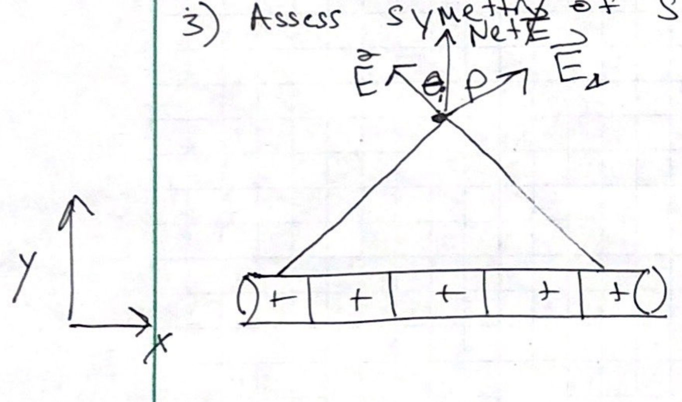
1) Wire is thin → a "line" of charge

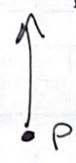
$\lambda = \frac{Q}{L}$ linear density

2) Break wire into small segments, "point" charges, then sum up $\vec{E}$ field contributions



3) Assess symmetry of system





$\vec{E}_{net} = |\vec{E}|\vec{e}_y$

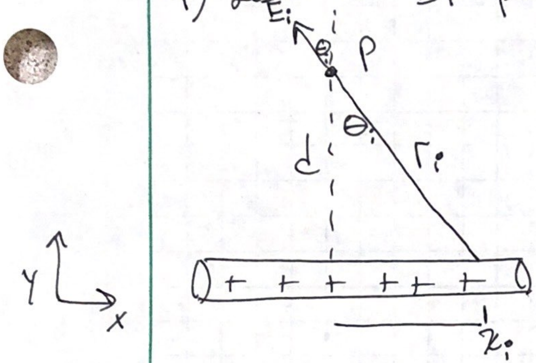
No field in $\vec{E}_x$, all gets cancelled

∴ each charge segment only contributes $|\vec{E}_i|\cos\theta$

$$\vec{E}_{total} = \sum_i |\vec{E}_i| \cos\theta$$

we only need to calculate $|\vec{E}|$ in $\hat{y}$. remember, we solve vector problems by components

4) Look at $\vec{E}_i$ produced by one "point"



$$\vec{E}_i = \frac{k\lambda}{r_i^2}\hat{r}_i$$

$$r_i^2 = d^2 + x_i^2$$

$$\left|\vec{E}_i\right|_y = \frac{k\lambda}{d^2+x_i^2}\cos\theta_i$$

5) Sum up all contributions

$$\left|\vec{E}\right|_y = \sum_{i=-L/2}^{L/2} \frac{k\lambda}{d^2+x_i^2}\cos\theta_i$$

$$\cos\theta_i = \frac{d}{r_i} \quad \& \quad r_i^2 = d^2 + x_i^2$$

$$\therefore \cos\theta_i = \frac{d}{(d^2+x_i)^{1/2}}$$

$$\left|\vec{E}\right|_y = k\lambda \sum_{i=-L/2}^{L/2} \frac{d}{(d^2+x_i)^{3/2}}$$

6) Summation $\rightarrow$ integral

"we take the limit" as $x_i \rightarrow 0$

$$\rightarrow \left|\vec{E}\right|_y = k\lambda \int_{-L/2}^{L/2} dx \frac{d}{(d^2+x_i)^{3/2}}$$

7) Mathematica!

$$\vec{E} = \frac{\lambda}{4\pi\epsilon}\int_{-L/2}^{L/2} dx \frac{d}{(d^2 + x_i^2)^{3/2}}\hat{y} = \frac{1}{4\pi\epsilon_0}\frac{Q}{d\left[(d^2 + (L/2)^2\right]^{3/2}}\hat{y}$$

$$\boxed{E_{rod} = \frac{1}{4\pi\epsilon_0}\frac{Q}{d\sqrt{d^2 + \left(\frac{L}{2}\right)^2}}}$$