Physics 114 – January 21, 2010

- TA office hours

  Adam Sobolewski: Monday, 4-5 pm in the Physics and Astronomy library on B&L 3rd floor

  Arnab Kar: Tuesday, 4:15-5:15 pm in B&L 304

  Wei Lai: Wednesday, 1-2 pm in B&L 304

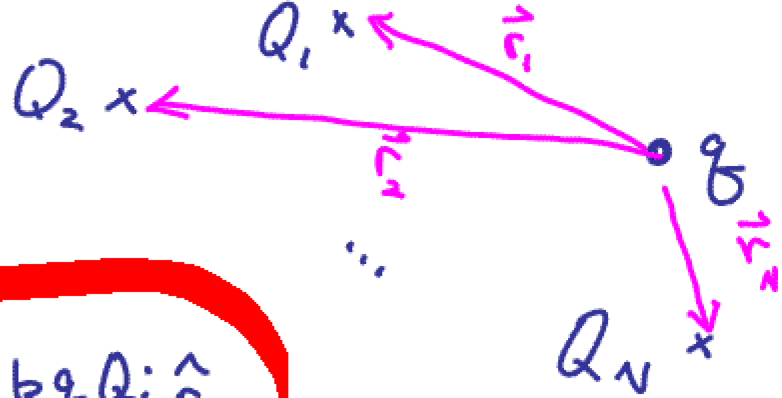
  Fred Moolekamp: Thursday, 9:30-10:30 am in B&L 373

- Solutions to Prob Set
- Solutions in library
- Other texts

Last Time

Coulomb's law

Force on q due to discrete charges

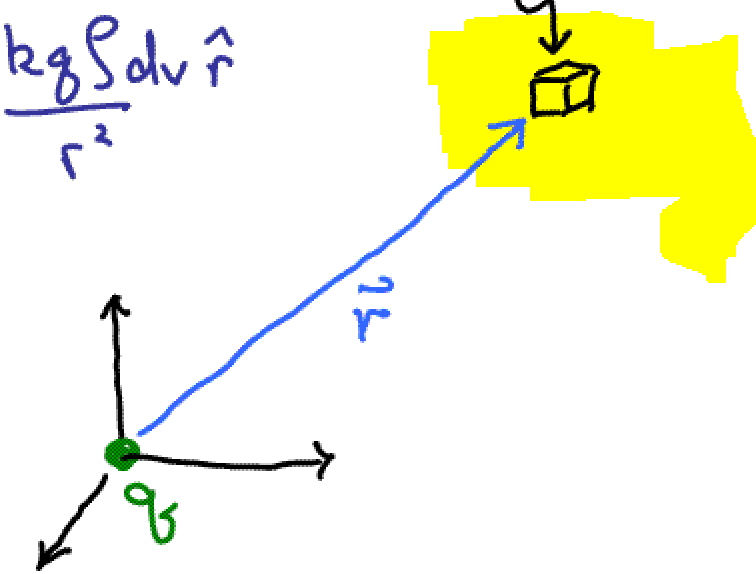


$$\vec F_q = \sum_i \vec F_i = \sum_i \frac{k q Q_i}{r_i^2}\hat r_i$$

Force on q due to continuous charge distribution $\rho(\vec r)$

$$dQ = \rho(\vec r)\,dv$$

$$d\vec F_q = \frac{kq}{r^2}\,dQ\,\hat r = \frac{kq\rho\,dv}{r^2}\,\hat r$$



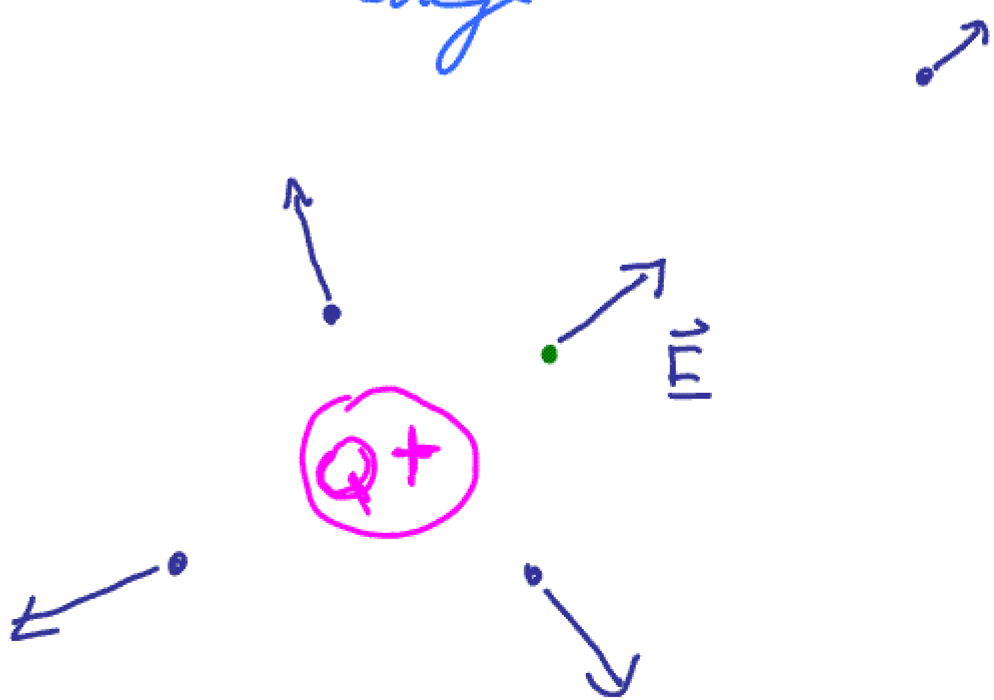
$$\vec F_q = \int_{\text{charge volume}} \frac{kq\rho\,dv}{r^2}\,\hat r$$

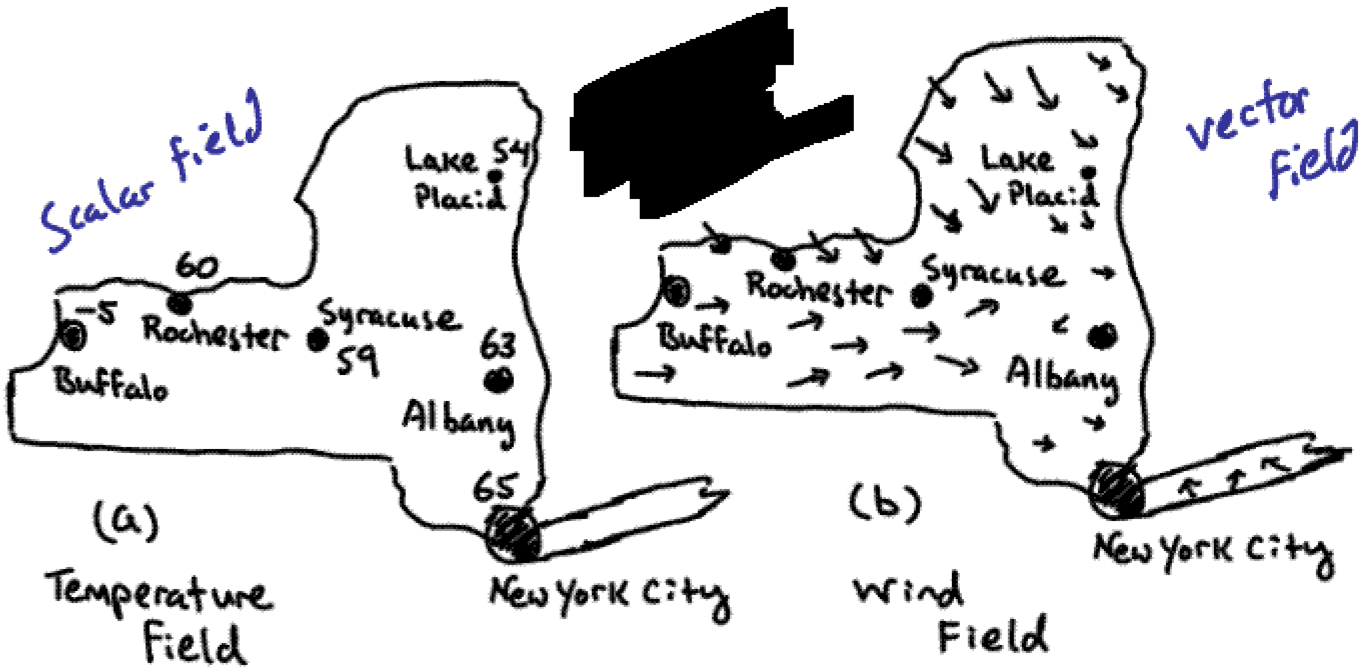
Electric Field

$$\vec{E} = \frac{\vec{F}_q}{q}$$

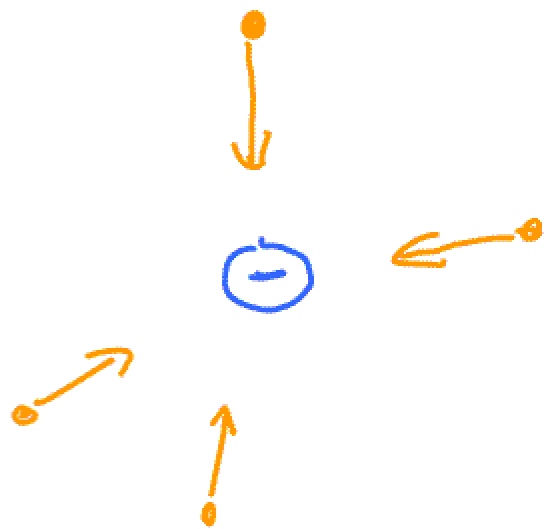
P

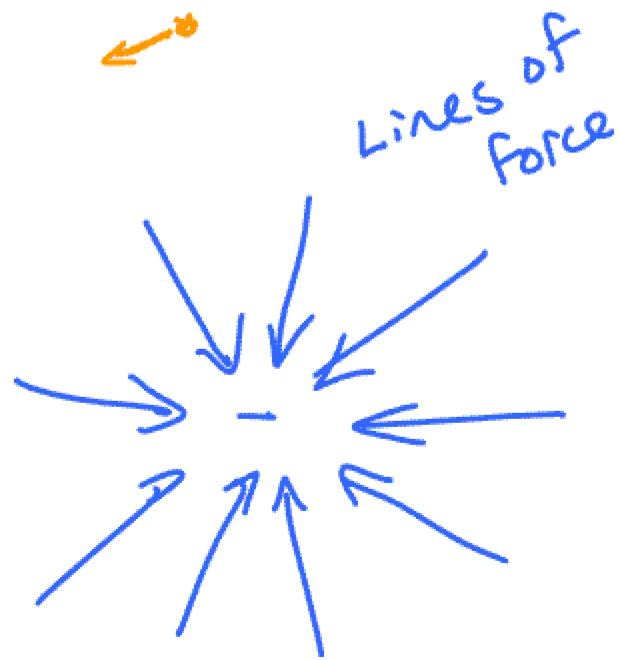
$q \equiv$ little test charge $= +1\,|e|$



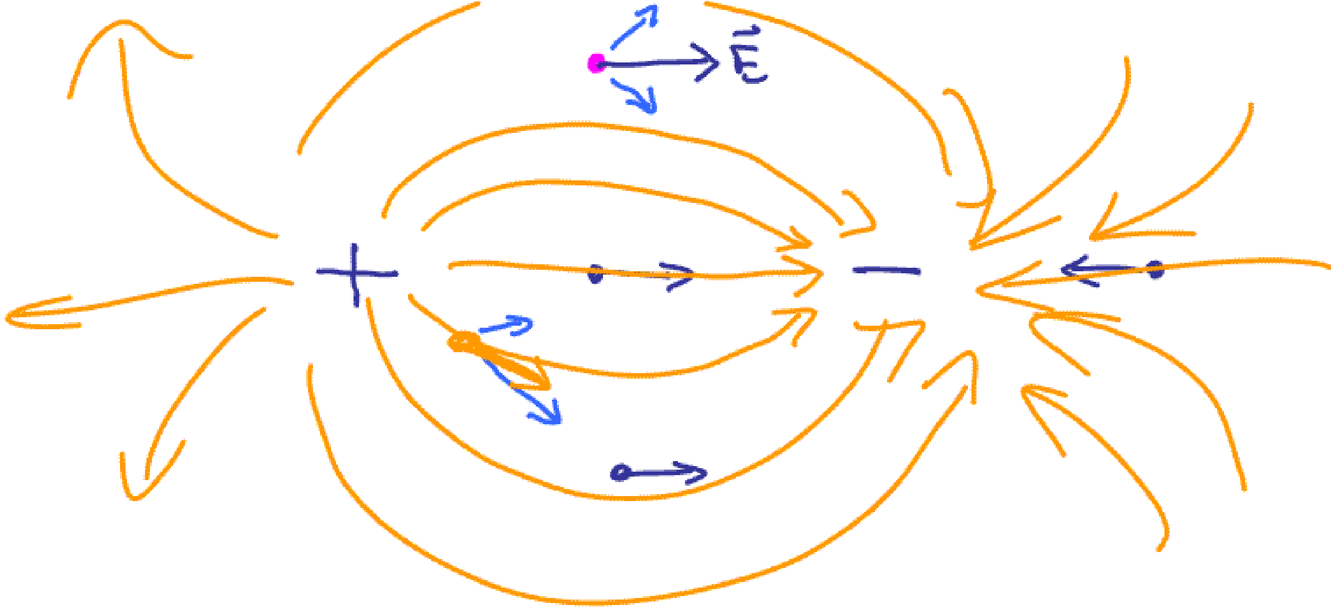


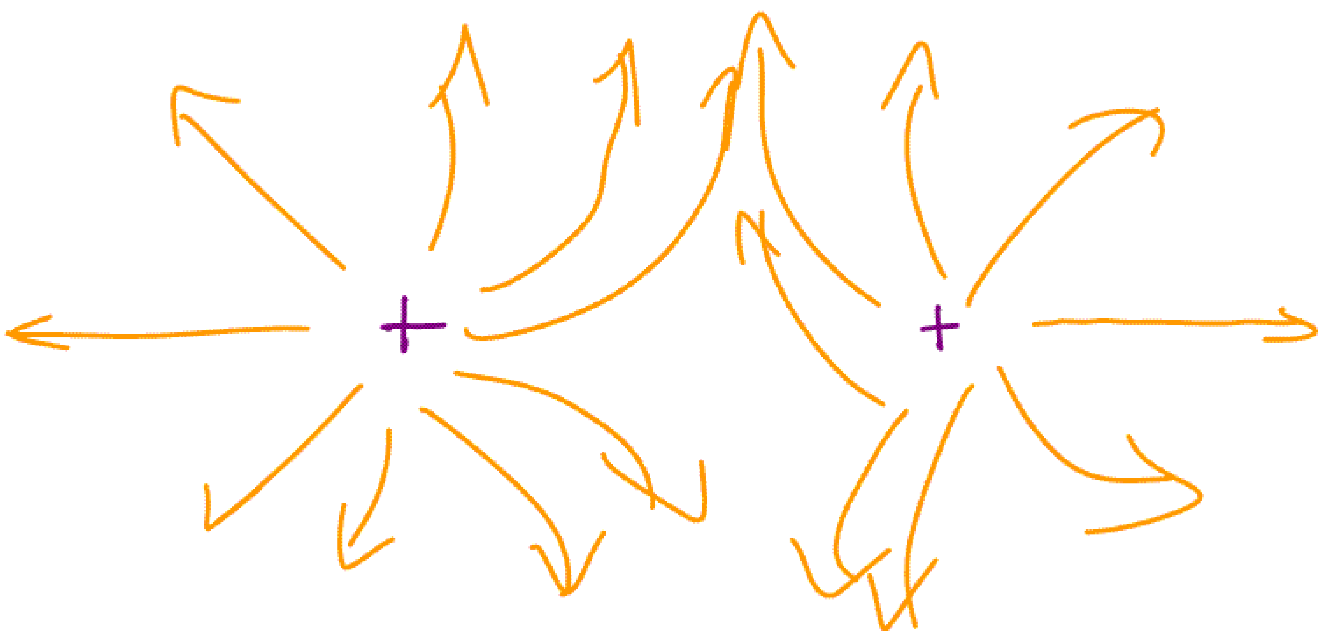
Scalar field
60
-5
Rochester
Syracuse
59
Lake Placid
54
63
Albany
Buffalo
65
(a)
Temperature Field
New York City
vector field
Lake Placid
Rochester
Syracuse
Buffalo
Albany
New York City
(b)
Wind Field





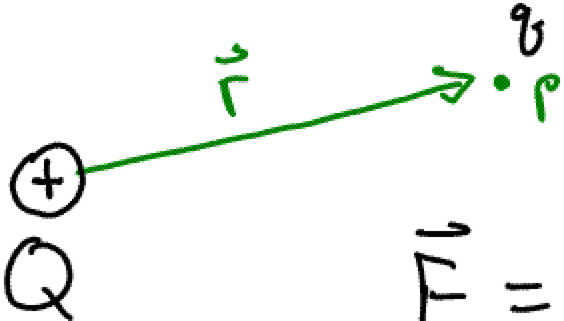
Map out electric field (and "lines of force") by mentally placing small + test charge in different positions and drawing arrows representing the force vectors on the test particle.


$\vec{E}$
+
−


+
+

Calculations of the electric field

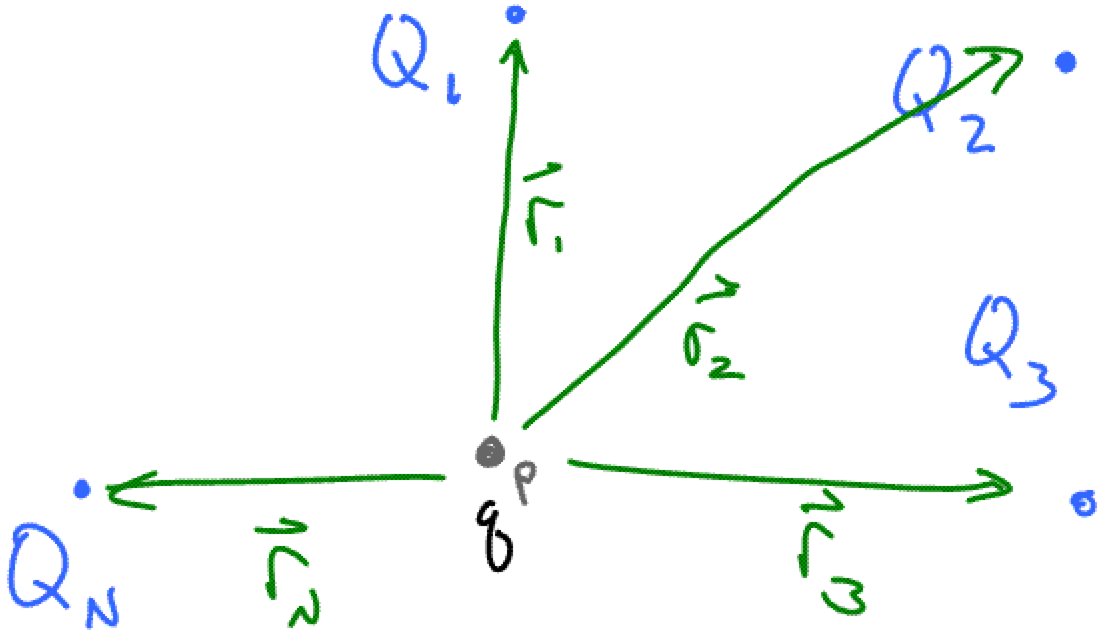
$\vec{E}$ of single point charge



$$\vec{F}_{P\,q} = \frac{k q Q\,\hat{r}}{r^2}$$

$$\vec{E} = \frac{\vec{F}_q}{q} = \frac{k Q\,\hat{r}}{r^2}$$

at P
due to Q



$$\vec{F}_{\substack{\text{on } q \\ \text{at } p}} = \frac{kQ_1 q}{r_1^2}\hat{r}_1 + \cdots \frac{kQ_N q}{r_N^2}\hat{r}_N$$

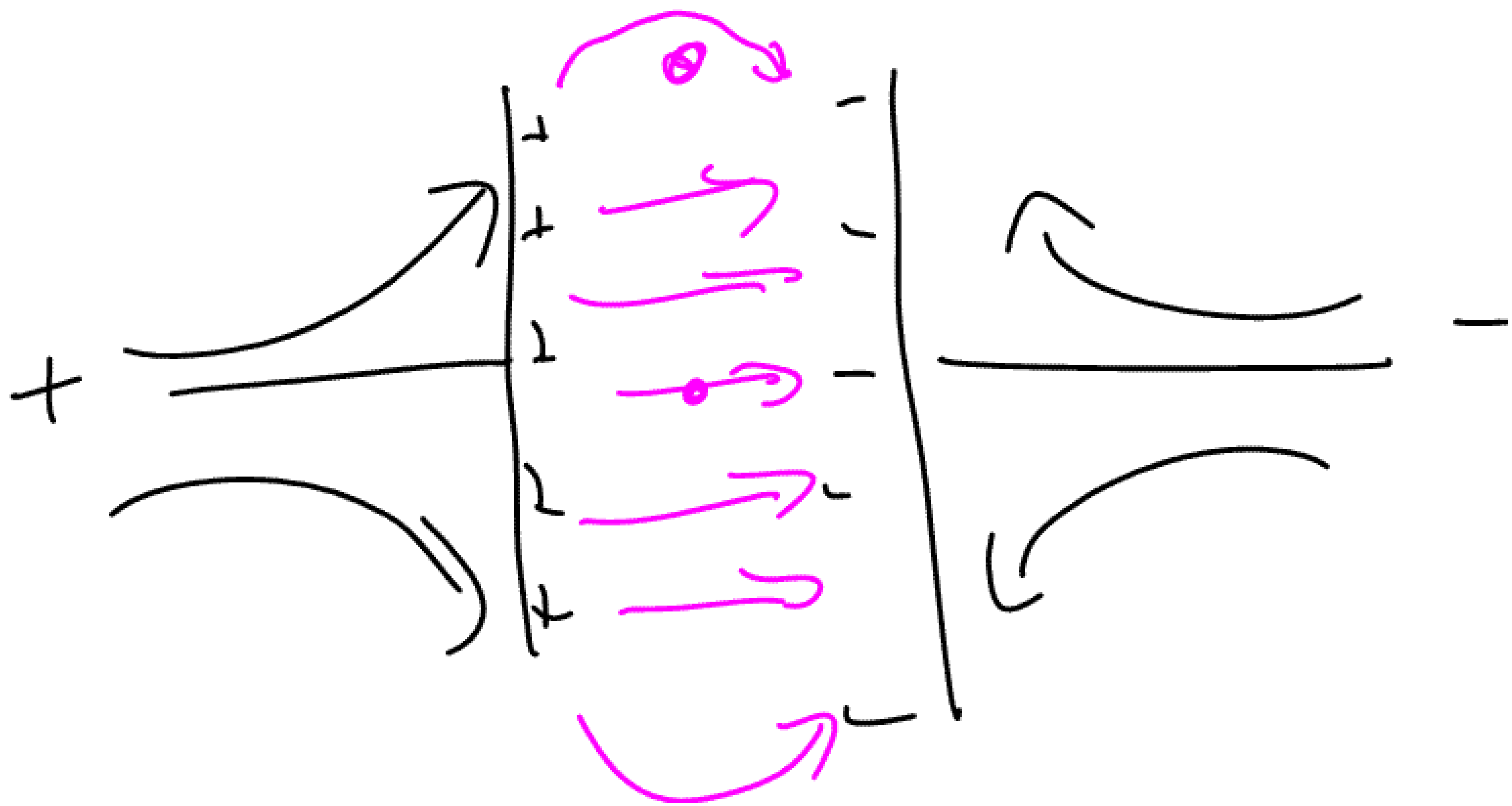
$$\vec{E}_{\substack{\text{at } p \\ \text{due to } Q_1 \cdots Q_N}} = \frac{kQ_1 \hat{r}_1}{r_1^2} + \cdots + \frac{kQ_N}{r_N^2}\hat{r}_N$$

What is $\vec{E}$ at P due to chg. distribution?

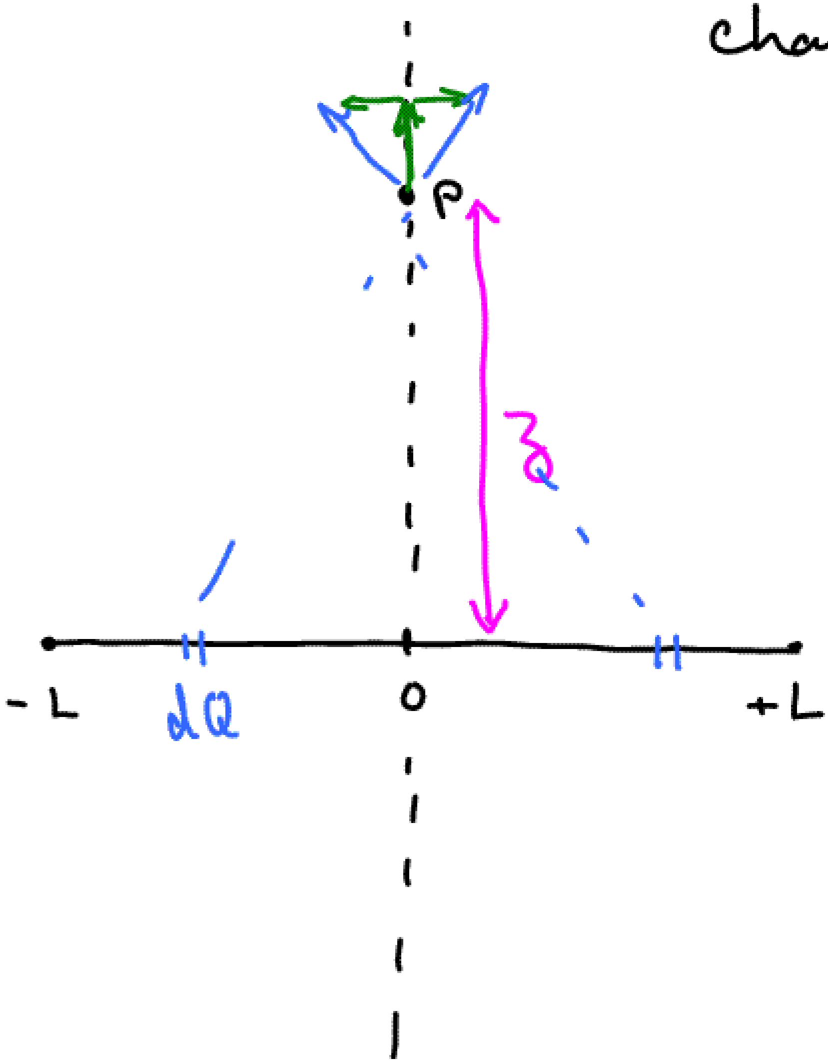
$$d\vec{F}_P = \frac{k q\, dQ}{r^2}\hat{r} = \frac{k q \rho(\vec{r})\,dv}{r^2}$$

$$d\vec{E}_P = \frac{k\, dQ}{r^2}\hat{r} = \frac{k \rho(\vec{r})\,dv}{r^2}\hat{r}$$

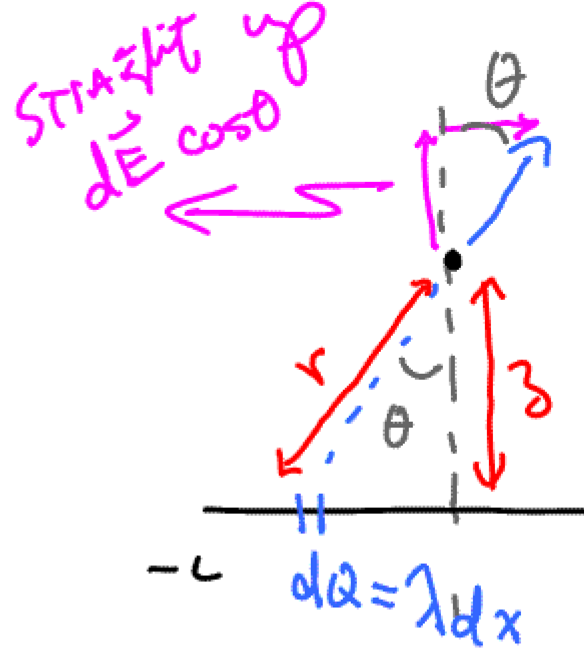
$$\vec{E}_P = \int_{\text{chg dist}} \frac{k \rho(\vec{r})\,dv}{r^2}\hat{r}$$



Find $\vec{E}$ at distance z above midpoint of a line segment of length $2L$ that carries a uniform charge $+\lambda$



$\vec{E}$ straight up by symmetry



$$d\vec{E} = \frac{k\,dQ\,\hat{r}}{r^2} = \frac{k\,\lambda\,dx\,\hat{r}}{r^2}$$

$$\cos\theta = z/r$$

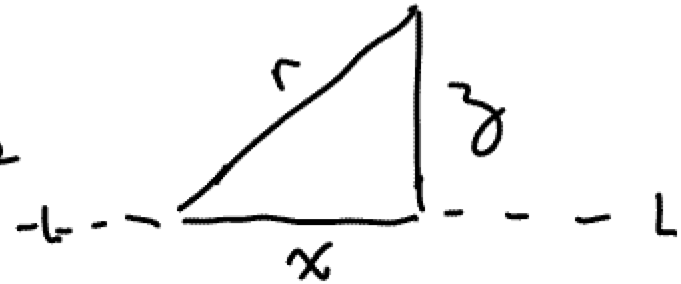
$$\vec{E} = \int_{-L}^{L} \frac{k\,\lambda\,dx\,\hat{r}}{r^2}$$

z/r

$$\vec{E} = \int_{-L}^{L} \frac{k\,\lambda\,dx\,\cos\theta}{r^2}\ \hat{up}$$

$$\vec{E} = \int_{-L}^{L} \frac{k\lambda\,dx}{r^3}\, z \;\widehat{up}$$

$$r = (x^2+z^2)^{1/2}$$



$$\vec{E} = \int_{-L}^{L} \frac{k\lambda z\,dx}{(x^2+z^2)^{3/2}}\;\widehat{up}$$

$$\vec{E} = k\lambda z\, 2\int_{0}^{L} \frac{dx}{(x^2+z^2)^{3/2}}\;\widehat{up}$$

$$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^{\boxed{2}}\sqrt{x^2+a^2}}$$

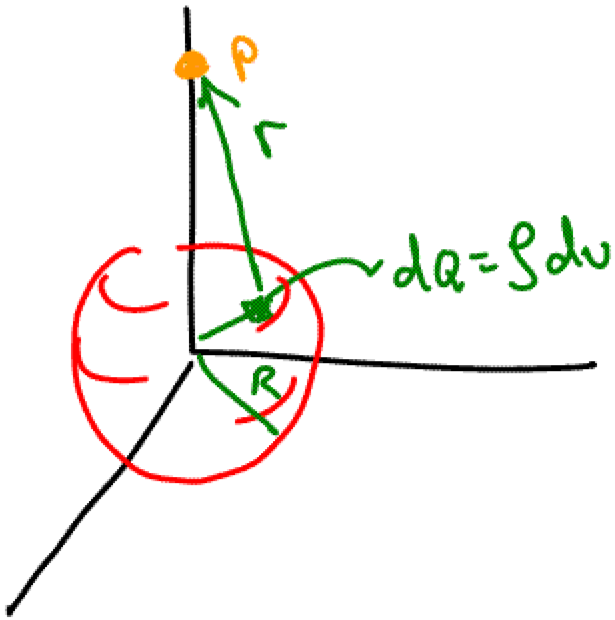
$$\vec{E} = \frac{2k\lambda L}{z(L^2+z^2)^{1/2}}\,\hat{z} \quad \hat{up}$$

$$F = \frac{k(coul)^2}{r^2}$$

$$k = \frac{N m^2}{coul^2}$$

$$E = \frac{N}{coul}$$

$$E = \frac{\frac{N\cancel{m^2}}{coul^{\cancel{2}}}\;\frac{\cancel{coul}\,\cancel{m}}{\cancel{m}}}{\cancel{m^2}} =$$



$$\rho = \frac{Q_{TOT}}{\frac{4}{3}\pi R^3}$$

$$\vec{E} = \int_{vol} \frac{k\, dQ\, \hat{r}}{r^2}$$

$$E = \int_0^R \int_0^\pi \int_0^{2\pi} \frac{k \rho r^2 \sin\theta \, d\theta \, d\phi \, dr}{r^2}$$

Holy Crap!!

Stay Tuned — Next week: Gauss' Law to the Rescue!