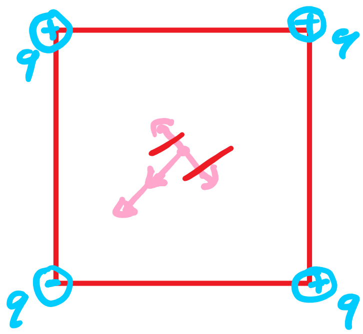
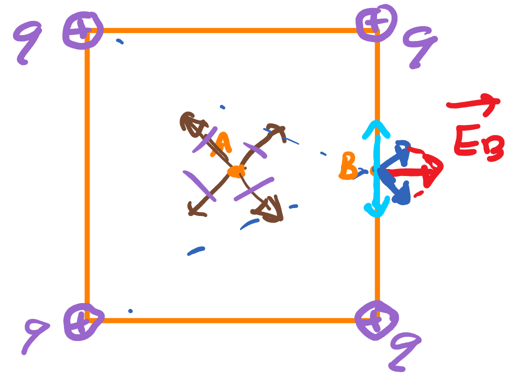
Lecture 7 (12-1)

Tuesday, March 9, 2021 11:39 AM

$\vec{E}_A = \text{zero}$

IF



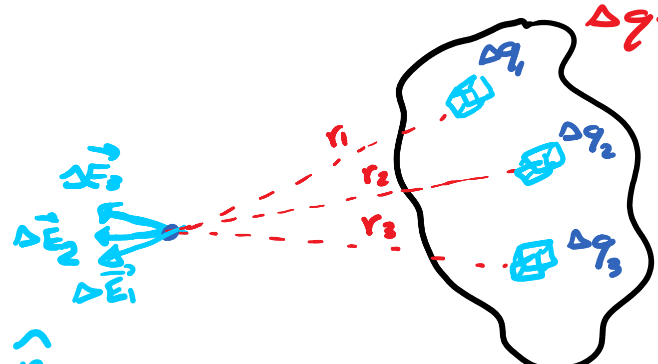


23.5 Electric Field of a Continuous Charge Distribution

Note that

$$\Delta\vec{E} = k_e \frac{\Delta q}{r^2}\hat{r}$$

Δq = element of charge



$$\Rightarrow \vec{E} \approx k_e \sum_i \frac{\Delta q_i}{r_i^2}\hat{r}_i$$

$$\Rightarrow \vec{E} = k_e \lim_{\Delta q \to 0} \sum_i \frac{\Delta q_i}{r_i^2}\hat{r}_i$$

$$\Rightarrow \boxed{\vec{E} = k_e \int \frac{dq}{r^2}\hat{r}}$$

$r \equiv$ distance from dq to the point at which you need to find $\vec{E}$ at.

• If Q is uniformly distributed throughout a volume $V \Rightarrow$ volume charge densisty is:

$$\rho = \frac{Q}{V} \quad (C/m^3)$$

• If Q is uniformly distributed over a surface A

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⇒ surface charge density is:

$$\sigma = \frac{\;}{A} \quad (C/m^2)$$

• If Q is uniformly distributed along a line L

⇒ linear charge density is:

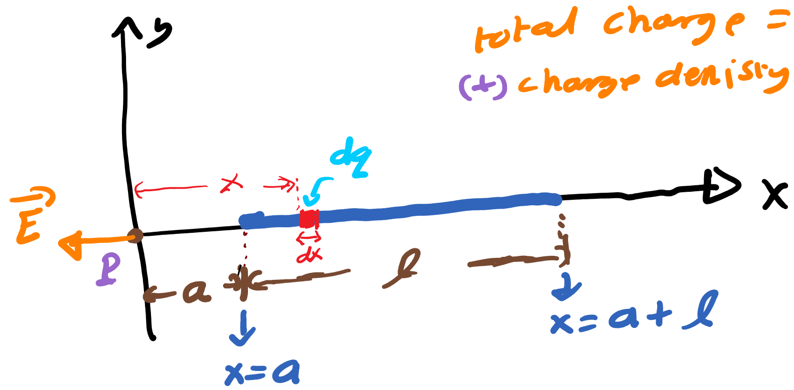
$$(C/m) \leftarrow \lambda = \frac{Q}{L}$$

For a small volume ⇒ $dq = \rho\, dV$
" " " area ⇒ $dq = \sigma\, dA$
" " " length ⇒ $dq = \lambda\, dl$

Ex 23.7:

$$\vec{E}_P = ?$$

total charge $= Q$
(+) charge density $= \lambda$



$\vec{E}$ to the left

Now $E = ?$

$$E = k_e \int \frac{dq}{r^2}$$

$$dq = \lambda\, dx \quad , \quad r = x$$

$$\Rightarrow E = k_e \int_a^{a+l} \frac{\lambda\, dx}{x^2} = k_e \lambda \int_a^{a+l} \frac{dx}{x^2}$$

$$= k_e \underbrace{\lambda}_{Q''} \left[-\frac{1}{x}\right]_a^{a+l} \Rightarrow \boxed{E = \frac{k_e Q}{a(l+a)}}$$

$\boxed{E = ?\ \text{if}\ a \gg l}$

⇒ $E = \frac{k_e Q}{a^2}$

point charge!!

$\frac{Q''}{\ell}$ a

point charge!!

$\lambda = \frac{Q}{L} \Leftarrow L, Q$

dq $d\ell$

$\lambda = \frac{dq}{d\ell}$

$\underbrace{\quad\quad}$ $dq = \lambda \, d\ell$

$\sigma = \frac{Q}{A} \Leftarrow Q, A$

$\sigma = \frac{dq}{dA}$

$\underbrace{\quad\quad}$ $dq = \sigma \, dA$

$\rho = \frac{Q}{V} \Leftarrow V, Q$

$\rho = \frac{dq}{dV}$

$\underbrace{\quad\quad}$ $dq = \rho \, dV$