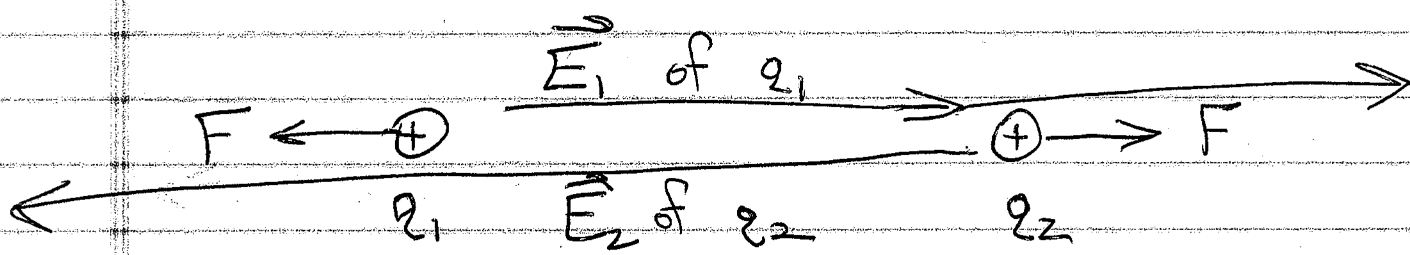
(1) Phys 2426 2017-09-07 Lec 2

<u>Charge</u> - Amount of electric "Stuff"
Can be ⊕ or ⊖.

<u>Coulomb Force</u> - Long-range, "central force", attractive or repulsive

Alternative to Coulomb Force: <u>Electric Field</u>



Old Process: $F = k q_1 q_2 / R^2$

New Process:

- q_1 makes E_1 $\quad E_1 = k q_1 / R^2$
- q_2 "Feels" E_1 $\quad F = q_2 E_1$

Compare to $F_g = m g$

Here, q_1 is the "source" and q_2 is the "test charge".
The Force is exerted on q_2.

Electric Field is force per charge
(i.e. per test charge)

$$\vec{F}_E = q_0 \vec{E} \quad \longrightarrow \quad \vec{E} = \frac{\vec{F}_E}{q_0}$$

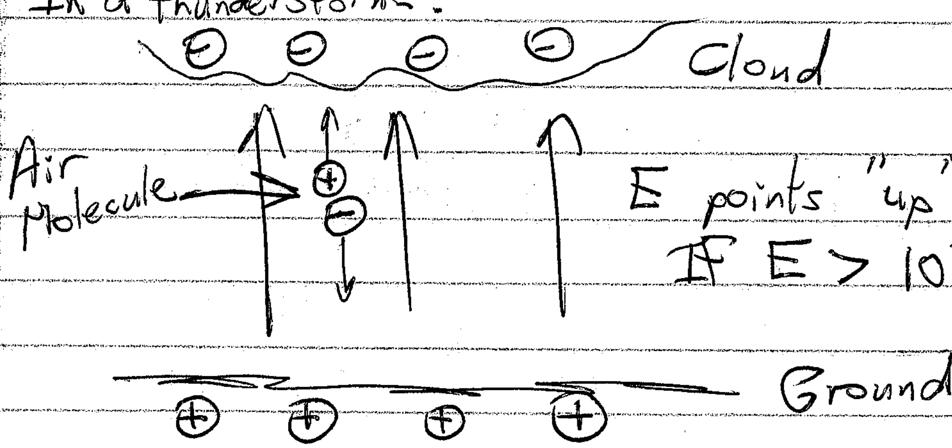
$\vec{E}$ is a vector.
- Points in same direction as $\vec{F}_E$ on a positive q_0.
- If q_0 is negative, $\vec{E}$ is opposite to $\vec{F}_E$

$\vec{E}$ is caused by source charges
- For ⊕ source, a ⊕ q_0 is pushed away.
  ∴ $\vec{E}$ points away from ⊕ source.

- For ⊕ source, a ⊖ q_0 is attracted.
  But $\vec{E}$ is opposite to $\vec{F}$ for ⊖ q_0, so
  $\vec{E}$ points away from ⊕ source.

Effect on materials: $\vec{E}$ distorts atom/molecule shapes.

In a thunderstorm:



E points "up"
If $E > 10^6$ N/C, Bang!

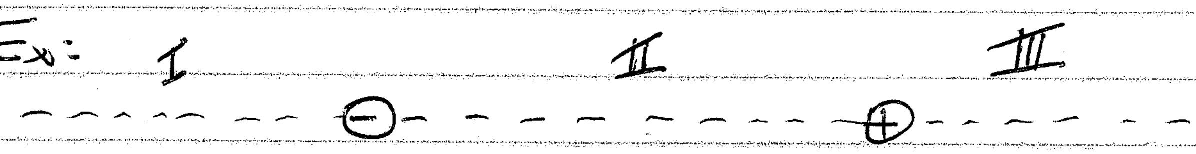
③

$\vec{E}$ of Charge distributions

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \dots$$

↑ ↑ $\vec{E}$ of each source.

Ex:



$q_1 = -5\ nC$ $\qquad$ $q_2 = +8\ nC$

Is $\vec{E}$ even zero?

At each point, $\vec{E} = \vec{E}_1 + \vec{E}_2$

For $E = 0$, E_1 & E_2 are equal & opposite,

- Our point must be along the connecting line.

X • In region II: E_1 is (Left) toward q_1
E_2 is (Left) away q_2

Plausible • In region I: E_1 is toward q_1 = (right)
E_2 is away q_2 = (left)

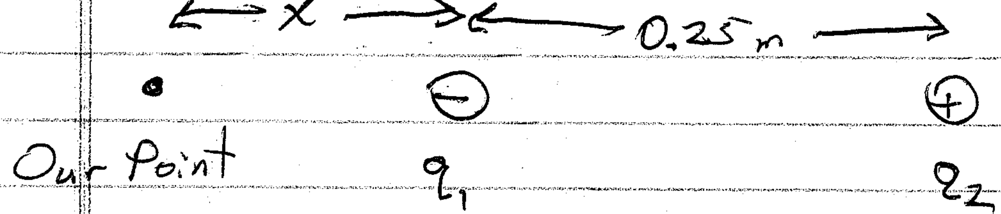
Plausible • In region III: ...

Want $E_1 = E_2$

$$\frac{kq_1}{r_1^2} = \frac{kq_2}{r_2^2}$$

(4)

Need one variable to solve for,



$r_1 = x$ $\qquad$ $r_2 = x + 0.25$

$$\frac{5}{x^2} = \frac{8}{(x+0.25)^2}$$

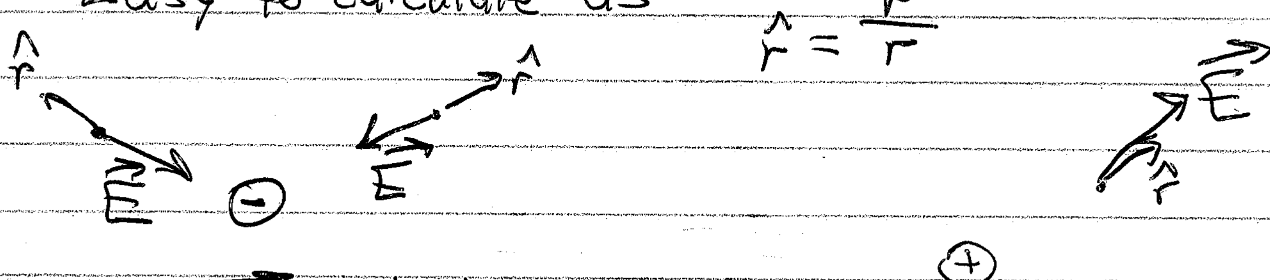
E of charge distributions

$Q = \int dq$ $\qquad$ $\vec{E} = \int d\vec{E}$

For a point charge: $\vec{E} = \frac{kq}{r^2}\hat{r}$ ← points away from source

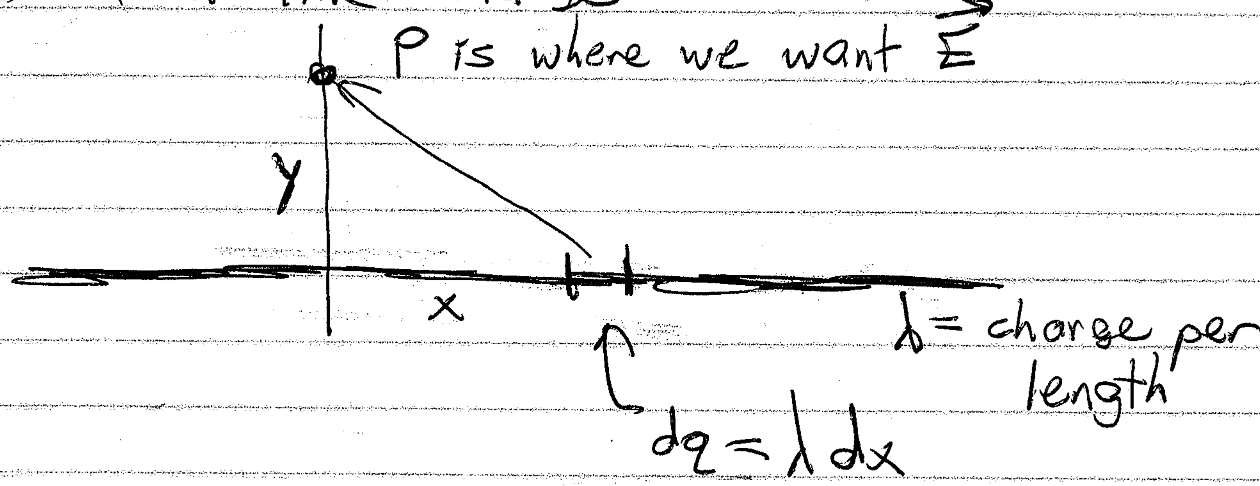
$\hat{r}$ is a unit vector
- magnitude is 1 w/ no units
- direction is specific to that unit vector.

Easy to calculate as $\hat{r} = \frac{\vec{r}}{r}$



$$d\vec{E} = \frac{k\,dq}{r^2}\hat{r}$$

E of a line charge



$\vec{r}$ = from (λdx) to P

$= (-x\hat{i} + y\hat{j})$

$r^2 = x^2 + y^2$

$$\hat{r} = \frac{-x\hat{i} + y\hat{j}}{\sqrt{x^2+y^2}}$$

$$E = \int \frac{k\lambda\, dx\,(-x\hat{i} + y\hat{j})}{(x^2+y^2)\sqrt{(x^2+y^2)}}$$

$$= \frac{2k\lambda}{y}\hat{j}$$