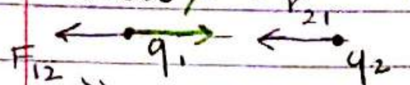
Midterm
7-9pm sharp!
need Blue Book
Review sesh: Sat&Sun
2-4pm Pimental
(different!)

Review ↗ F_{12}, q_1, q_2 opposite sign



↳ q_1, q_2 same sign

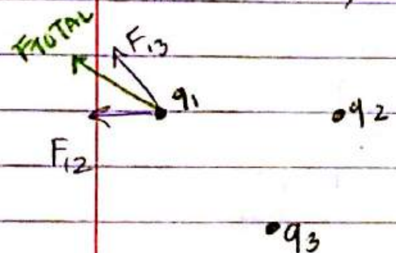
$$\vec{F}_{12} = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}\hat{r}_{21}$$

(1 = on, 2 = by)

★ direction of force dependent on charges

$1/4\pi\varepsilon_0 = k_c$

$F_{12} = -F_{21}$, by Newton's third law

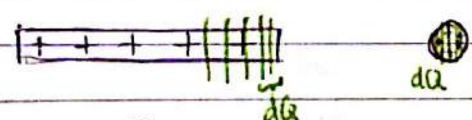


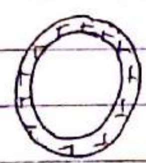
★ q_1, q_2, q_3 have same sign

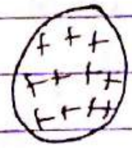
$$\sum_{i \neq j}^{n} \vec{F}_{ij} = F_{TOTAL}$$

BUT. what if we have TOO. MANY. CHARGES?!

continuous distribution of charge





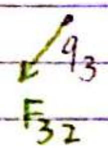


How do these charged objects interact? We must integrate.

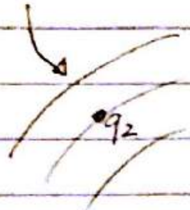
We are going to think in terms of electric field.

electric field

for force, we think of 2 objects.
what if we think about one object?



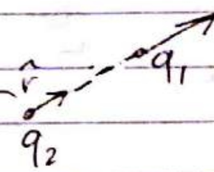
q_2 generates a "perturbation" → field
: $\vec{E}(\vec{r})$ ↑ how far away you are.



q_1 → Force due to $\vec{E}(\vec{r})$

$$F_{12} = \frac{k_c q_1 q_2}{r^2} \hat{r}_{21} \rightarrow \vec{F}_1 = q_1 \vec{E}(\vec{r})$$

$$\vec{E}_2(\vec{r}) = \frac{k_c q_2}{r^2} \hat{r}$$



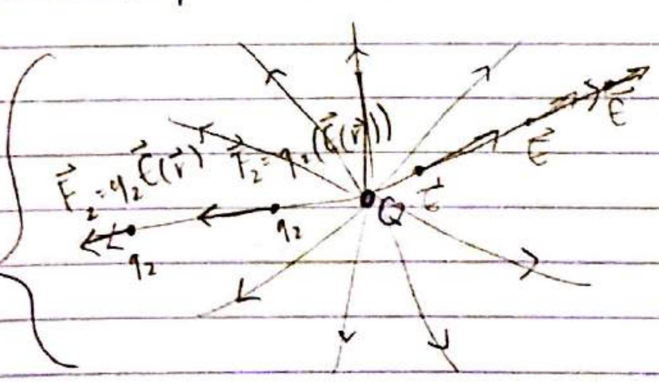
$$\vec{E} = \frac{\vec{F}}{q}$$

↳ more general.

Let's map the **E**-field (think level graph)

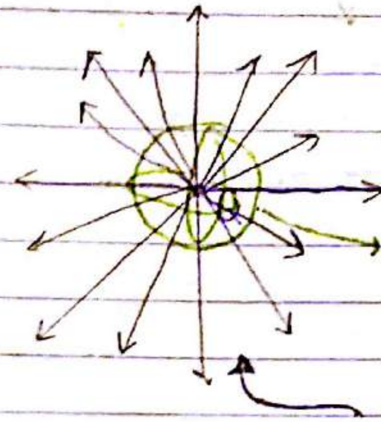
Gain
All info about F in any point

Lost
Magnitude info.



assume $Q > 0$

Let's get our information back. Look @ density of field line



use a sphere as surface (⊥ to surface)

density of field lines = $\frac{\text{mean \# lines crossing}}{\text{surface area}}$

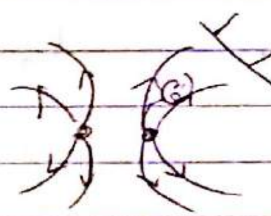
on the surface of sphere, $\vec{E}$ is constant.

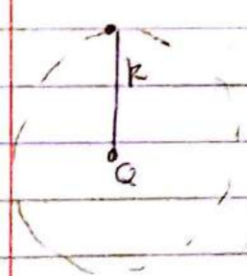
This is an equipotential line !!

Convention: if charge positive, field line points outward.
if charge negative, field line points inward.

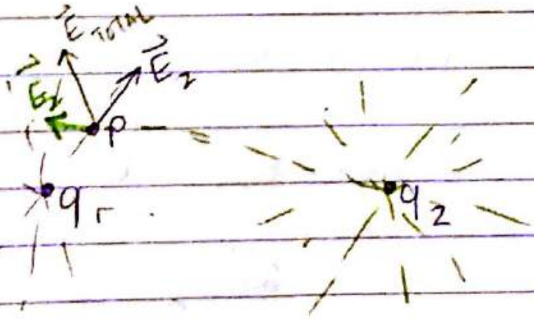
$$1 \text{ Coulomb} = \frac{1}{\varepsilon_0} \text{ lines}$$

$$q \text{ Coulombs} = \frac{q}{\varepsilon_0} \text{ lines}$$





$$\text{line density} = \frac{Q}{\varepsilon_0 4\pi R^2} \leftarrow \vec{E}\text{-Field !!}$$

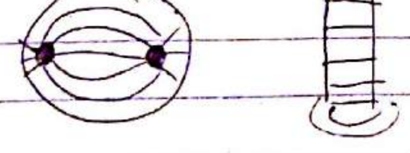


assume q_1, q_2 are same charge & positive

$$\vec{E}_{TOT,p} = \sum_{i=1}^{n} \vec{E}_{i,p}$$

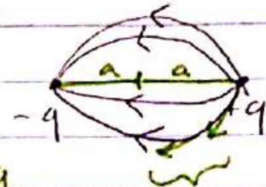
sum ALL the fields!

demo



Dipole

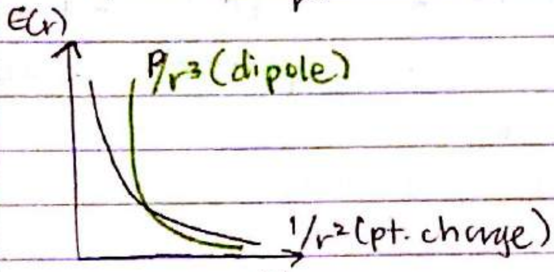
- 2 charges same
- distance = 2a
  - measured from -q to q



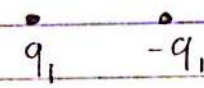
convention- positive to negative

$\vec{E}$ is tangent to field line

$\vec{E}_{dipole} \propto \frac{1}{r^3}$

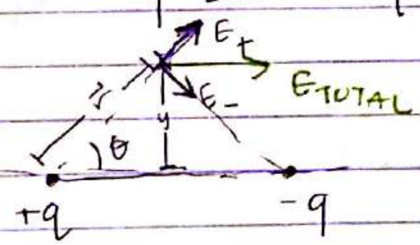


x ← it looks more like a 0 charge



Dipole Moment

$P = q \cdot 2a \rightarrow q \cdot \vec{r}$



$\vec{E}_{TOTAL} = \vec{E}_+ + \vec{E}_-$

$\vec{E}_{TOT\,y} = 0$

$\vec{E}_{TOT\,x} = \vec{E}_{+x} + \vec{E}_{-x}$

$= 2\vec{E}_{+x}$

$= 2\vec{E}\cos\theta$

$= 2\vec{E}\,\frac{a}{\vec{r}}$

$= 2\vec{E}\,\frac{a}{\sqrt{a^2+y^2}} = \frac{2K_c q}{(y^2+a^2)} \cdot \frac{a}{\sqrt{a^2+y^2}}$

$\frac{2K_c qa}{(y^2+a^2)^{3/2}}$ (qa = P)

if $y \gg a$, $= \boxed{\frac{K_c P}{y^3}}$