WW01-02 Outline

- Electrostatics
  - Coulumb's Law
  - Gauss's Law

Interested Readers:

- Textbook 1.2
- Textbook 1.3, 1.4

1

Maxwell's Equations

Fundamental postulates:

$$\oint_c \vec{E} \cdot d\vec{l} = -\frac{\partial}{\partial t} \iint_s \vec{B} \cdot d\vec{s} - k$$ Faraday's law

$$\oint_c \vec{H} \cdot d\vec{l} = \frac{\partial}{\partial t} \iint_s \vec{D} \cdot d\vec{s} + I$$ Ampère's law

$$\oiint_s \vec{D} \cdot d\vec{s} = Q$$ Gauss's law

$$\oiint_s \vec{B} \cdot d\vec{s} = Q_m$$ Gauss's law-magnetic

$\boxed{\text{Maxwell's equations in integral form}}$

Basic quantities:

$\vec{E}$: V/m $\vec{H}$: A/m

$\vec{D}$: C/m^2 $\vec{B}$: webers/m^2

k : V I : A

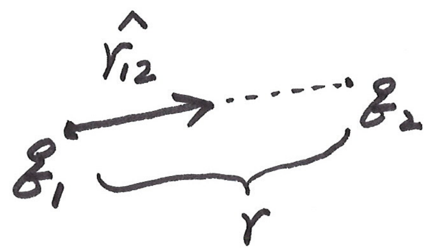
Q : coulumbs Q_m : webers

Chapter I

Electrostatics

Coulomb's law

$$\vec{f}_{1\to 2} = \frac{q_1 q_2}{4\pi\varepsilon r^2}\,\hat{r}_{12}$$



$\vec{f}$ (Force) : Newton

q (Charge): Coulombs

ε (permittivity): farads/meter

r (distance between q_1 and q_2): m

$\hat{r}_{12}$: Unit vector pointing ~~away~~ from ~~the~~ charge 1 to charge 2

$$\hat{r}_{12} = \frac{\vec{r}_2 - \vec{r}_1}{|\vec{r}_2 - \vec{r}_1|}, \quad r = |\vec{r}_2 - \vec{r}_1|$$

$$\therefore \vec{f}_{12} = \frac{q_1 q_2 (\vec{r}_2 - \vec{r}_1)}{4\pi\varepsilon |\vec{r}_2 - \vec{r}_1|^3}$$

($\vec{r}_1$, $\vec{r}_2$ are position vectors)

Electric Field $\vec{E}$

$$\vec{E} = \frac{\vec{F}}{\Delta q} \qquad (V/m)$$

$\vec{E}$ from a point charge q at origin

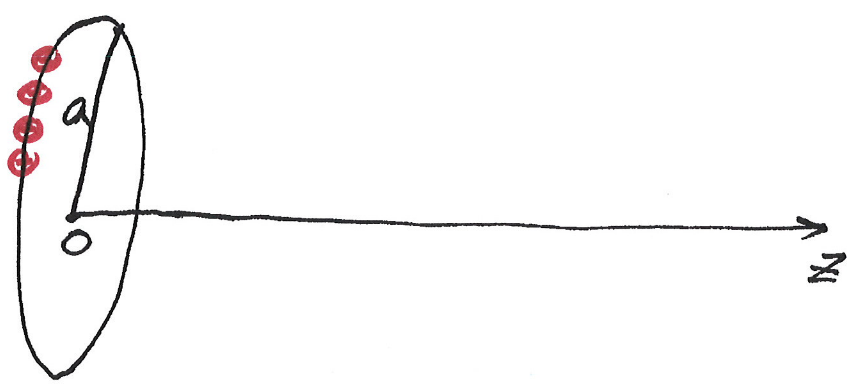
$$\vec{E} = \frac{q}{4\pi\varepsilon r^2}\hat{r}$$

$\vec{E}(\vec{r})$ from a point charge q at $\vec{r}'$

$$\vec{E}(\vec{r}) = \frac{q(\vec{r}-\vec{r}')}{4\pi\varepsilon|\vec{r}-\vec{r}'|^3}$$

Example

Field of a ring of charge of density ρ_l c/m



Question: What is $\vec{E}$ along z axis?

Remark: If you know $\vec{E}$ due to a point charge, you know $\vec{E}$ due to any charge distribution
$\because$ any charge distribution can be decomposed into point charges

Gauss's Law

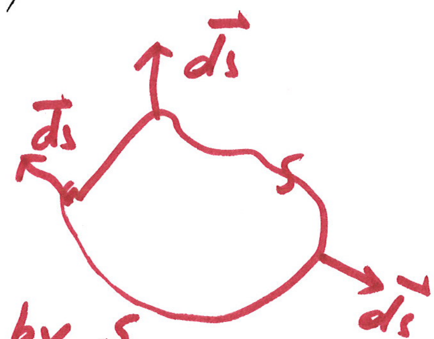
$$\oiint_S \vec{D} \cdot d\vec{s} = Q$$

$\vec{D}$: Electric flux density C/m^2

$\vec{D} = \varepsilon \vec{E}$

$d\vec{s}$: normal to S

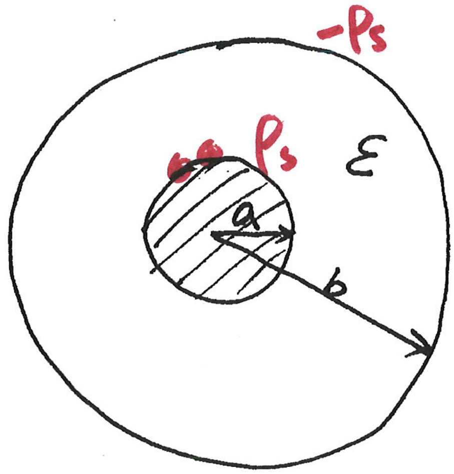
pointing outward



Q: Total charge enclosed by S.

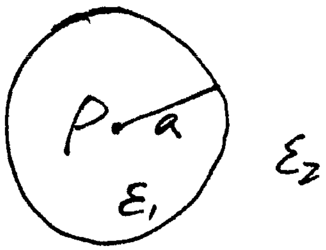
Example

Field Between Coaxial Cylinders of unit length



Question: What is $\vec{E}$?

<u>Example</u>: Fields of a sphere of uniform charge density



Question: What is $\vec{E}$?