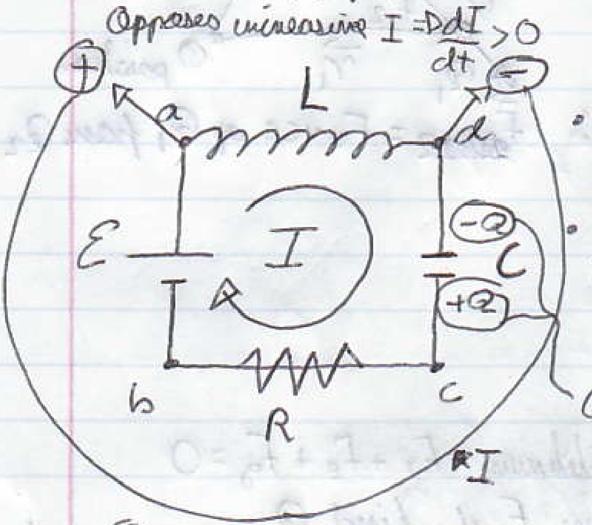
Review

Current flows "downhill" from higher to lower Voltage.

a ⁓⁓⁓ b $V_a < V_b$, so $V_{ab} = V_a - V_b = \underline{-IR}$



- Current flows from positive terminals to negative terminals.
- Positive terminals have higher voltage than negative terminals

Kirchoff's Loop Rule
$0 = V_{ab} + V_{bc} + V_{cd} + V_{da}$
$0 = \mathcal{E} - IR + \frac{Q}{C} - L\frac{dI}{dt}$

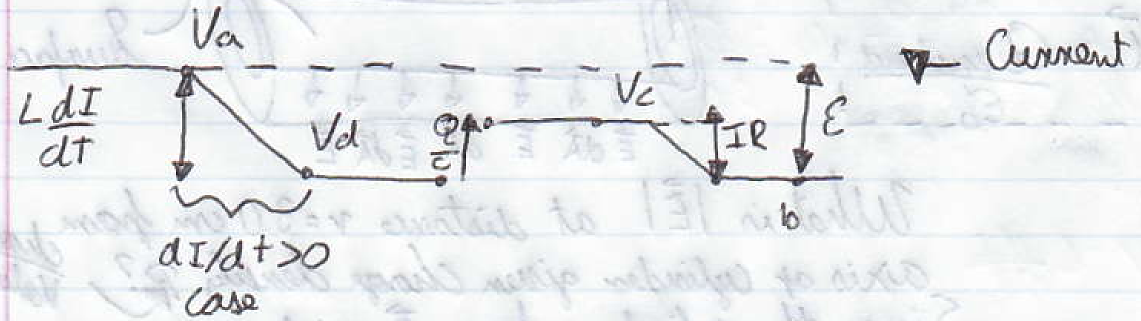
$\oplus V_a > V_b \ominus$ b $\xleftarrow{I}$ c
$V_b < V_c$
$\oplus V_c > V_d \ominus$

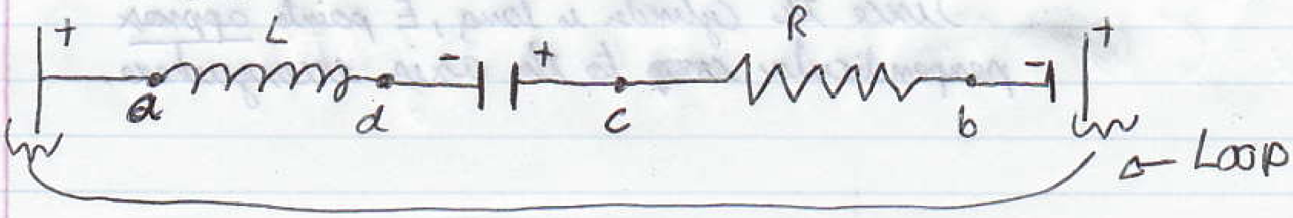
$V_a - V_b = \mathcal{E}$
$V_b - V_c = IR$
$V_c - V_d = \frac{Q}{C}$

Consider $\frac{dI}{dt} > 0$ & $I > 0$ case

Induced emf $= -L\frac{dI}{dt}$ opposes change in current

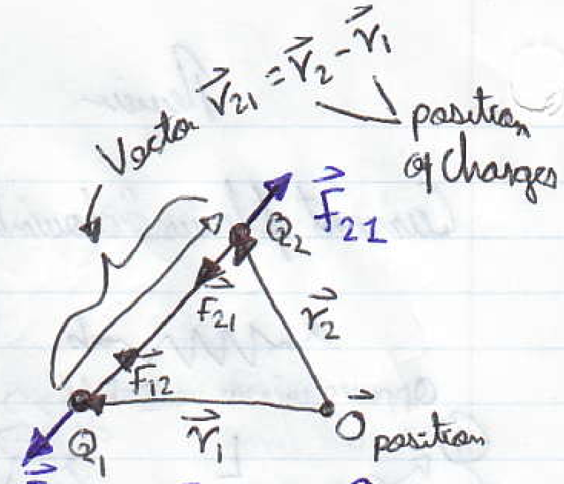
$V_d < V_a$ $V_d - V_a = -L\frac{dI}{dt}$





21 -) Coulomb's Law

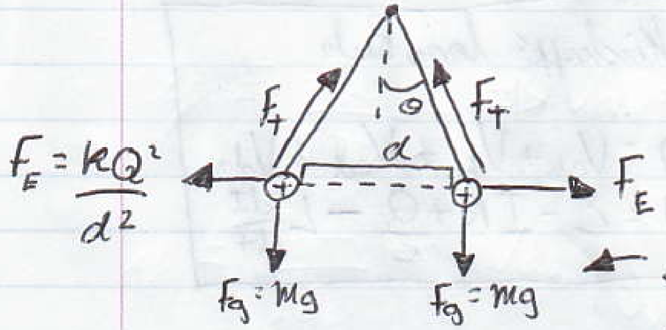
$$F = k\frac{Q_1 Q_2}{r^2} \Rightarrow F = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q_1 Q_2}{r^2}$$



$\vec{F}_{12}$ = Force of Q_1 from Q_2

case Q_1Q_2 negative: opposite charges attract

Blue: case $Q_1 Q_2 > 0$: like charges repel



In equilibrium $F_T + F_E + F_g = 0$

given F, d, find Q

← If both charges $= Q$ & both masses $= m$

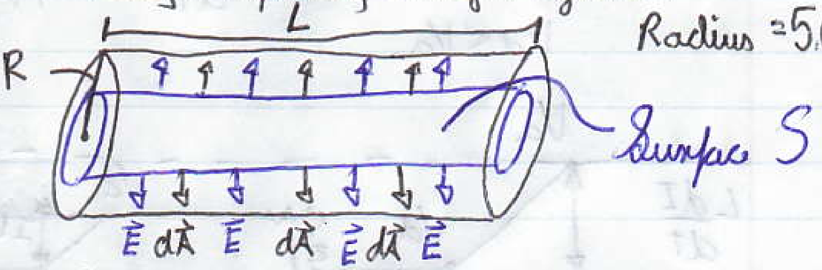
See Ch 21 #80 from HW.

22. Gauss' Law

Closed Surface S

$$\oint_S \vec{E}\cdot d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$$

Long Uniformly charged Cylinder



What is $|\vec{E}|$ at distance $r = 3.0$ cm from axis of cylinder given charge density ρ? charge/Volume

Since the cylinder is long, $\vec{E}$ points approx perpendicular ~~away~~ to the axis everywhere.

angle between $\vec{E}$ & $d\vec{A}$

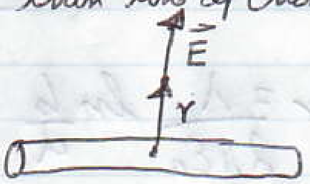
$$\vec{E}\cdot d\vec{A} = E\,dA\cos\theta = E\,dA\cos 0 = E\,dA$$

$$\frac{Q_{enc}}{\varepsilon_0} = \oint \vec{E}\cdot d\vec{A} = \int E\,dA = E\underset{\uparrow}{A} = 2\pi r L E$$

area of curved side $= 2\pi r L$

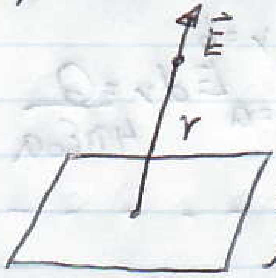
$$\frac{\text{Volume}\cdot\rho}{\varepsilon_0} = \frac{\pi r^2 L\rho}{\varepsilon_0} \Rightarrow \underbrace{E = \frac{r\rho}{2\varepsilon_0}}_{\text{Inside cylinder}}$$

* Outside long thin line of charge:



$E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$ where $\lambda = \dfrac{\text{charge}}{\text{length}}$

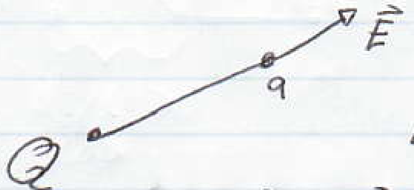
* Infinite Plate



$E = \dfrac{\sigma}{2\varepsilon_0}$ where $\sigma = \dfrac{\text{charge}}{\text{area}}$

large thin plate

* Point Charge



$$E = \frac{kQ}{r^2} = \frac{Q}{4\pi\varepsilon_0 r^2}$$

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

V = electric potential:

$$V_{ab} = V_a - V_b = -\int_b^a \vec{E}\cdot d\vec{l} = \int_a^b \vec{E}\cdot d\vec{l}$$

U = Potential energy:

$$U_{ab} = -W_b^a = \int_b^a \vec{F}\cdot d\vec{l} = \int_a^b \vec{F}\cdot d\vec{l}$$

$$U = qV$$

---

if $E = \dfrac{\lambda}{2\pi\varepsilon_0 r} \Rightarrow V_{ab} = \displaystyle\int_{r=a}^{r=b} E\,dr = \dfrac{\lambda}{2\pi\varepsilon_0}\ln\dfrac{b}{a}$

if $E = \dfrac{\sigma}{2\varepsilon_0} \Rightarrow V_{ab} = \displaystyle\int_{r=a}^{r=b} E\,dr = \dfrac{\sigma(b-a)}{2\varepsilon_0}$

if $E = \dfrac{Q}{4\pi\varepsilon_0 r^2} \Rightarrow V_{r,\infty} = \displaystyle\int_r^{\infty} E\,dr = \dfrac{Q}{4\pi\varepsilon_0 r}$ $\quad V_{ab} = \displaystyle\int_{r=a}^{r=b} E\,dr = \dfrac{Q}{4\pi\varepsilon_0 a} - \dfrac{Q}{4\pi\varepsilon_0 b}$

Capacitors $\quad C = \dfrac{Q}{V}$

$U = \displaystyle\int_0^Q V\,dq = \int_0^Q \dfrac{q}{C}\,dq = \dfrac{Q^2}{2C}$

Δ to Charge from 0 to Q

Inductors:

$$V = L\frac{dI}{dt}$$

$$U = \int_0^t V\,dq = \int_0^t L\frac{di}{dt}\,dq = \int_0^I L\,i\,di = \frac{1}{2}LI^2$$