EE 331 - LECT. #32 APR. 13, 2020

## magnetostatics

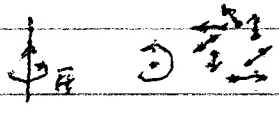
dc current here at $\bar{r}'$, effect over there at $\bar{r}$? → const magn field

how do we find magnetic field $\bar{H}$ [A/m]?

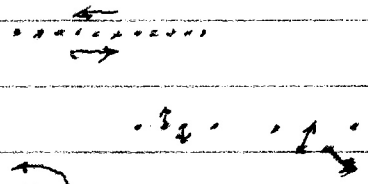
1. biot-savart law (analog of C's law)
2. ampere's law (analog of G's law) - exploit symmetry

biot-savart law - recall C's law: $\bar{E} = \frac{1}{4\pi\varepsilon}\int_L \frac{\rho_L(\bar{r}-\bar{r}')}{|\bar{r}-\bar{r}'|^3}dl'$ $\rho_s$, $\rho_v$ [C/m]

for line of current: $\bar{H} = \frac{1}{4\pi}\int_L \frac{I\bar{dl}'\times(\bar{r}-\bar{r}')}{|\bar{r}-\bar{r}'|^3}$ [A/m]




for sheet of current: $\bar{H} = \frac{1}{4\pi}\int_S \frac{\bar{K}\times(\bar{r}-\bar{r}')}{|\bar{r}-\bar{r}'|^3}ds'$ [A/m]

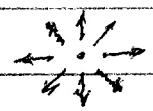


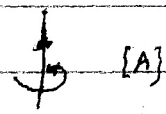
for volume of current: $\bar{H} = \frac{1}{4\pi}\int_V \frac{\bar{J}\times(\bar{r}-\bar{r}')}{|\bar{r}-\bar{r}'|^3}dv'$ [A/m]


### $\bar{E}$ vs $\bar{H}$

- $\bar{E}$ points away from charge
- $\bar{H}$ circles around (moving) charge

### building blocks of sources

Q:  [C]

I:  [A]

$\rho_L$ [C/m], $\rho_s$ [C/m²], $\rho_v$ [C/m³]  $\bar{K}$ [A/m], $\bar{J}$ [A/m²]

ampere's law - recall G's law: $\oint_S \bar{D} \cdot d\bar{s} = Q_{enc}$

$$\oint_L \bar{H} \cdot d\bar{l} = I_{enc}$$ amp's law

closed line integral (circulation) of $\bar{H}$ = dc current encircled by path

- can use g's law to find $\bar{E}$ for symmetric problems
- " " amp's law to find $\bar{H}$ " " "

next,

$$\oint_L \bar{H} \cdot d\bar{l} = \int_S (\nabla \times \bar{H}) \cdot d\bar{s} = I_{enc} = \int_S \bar{J} \cdot d\bar{s}$$

integrands of surf integrals must be the same. thus,

$$\nabla \times \bar{H} = \bar{J}$$ amp's law in point form (for statics)

$\bar{J}$: source

can find $\bar{J}$ from $\bar{H}$

example #27