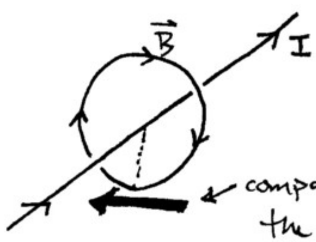
Physics 106b-2011 Class 18 Wednesday 3-2-11 Summary

Ch. 30 Sources of $\vec{B}$

Oersted's expt ⇒ The current-carrying wire produces a $\vec{B}$, which exerts the force on the compass needle.

By symmetry, this $\vec{B}$ must go in a circle around the wire:



← compass needle directly underneath the wire

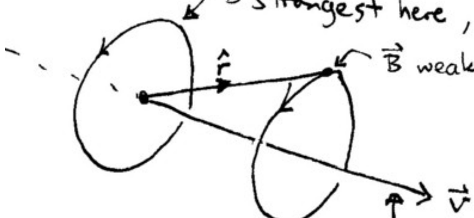
** Right-hand rule for the production of $\vec{B}$: thumb ⟷ I, curled fingers ⟷ $\vec{B}$ **

Many experiments ⇒

$$\vec{B}_{\text{produced by point charge}} = \frac{\mu_0}{4\pi} q \frac{\vec{v}\times\hat{r}}{r^2}$$

$\hat{r}$: unit vector from q to the point at which $\vec{B}$ is measured

$\mu_0 = 4\pi_{-7}$ Tm/A "permeability of free space"



$\vec{B}$ strongest here, because of $\frac{1}{r^2}$ dependence

$\vec{B}$ weaker here because:

1) r is greater ⇒ $\frac{1}{r^2}$ smaller
2) $\hat{r}$ is closer to being // to $\vec{v}$ ⇒ $\vec{v}\times\hat{r}$ is smaller

$\vec{B} = 0$ along line of movement, since $\vec{v}\times\hat{r} = 0$

Usually, we care more about the $\vec{B}$ produced by a current-carrying wire

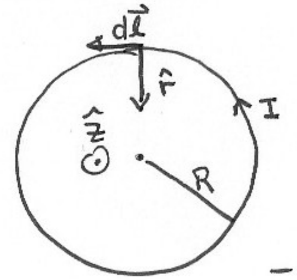
$\vec{B}_{\text{due to point charge}}$ ⟶

* $$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\, d\vec{\ell}\times\hat{r}}{r^2}$$ * Biot-Savart Law

$\vec{B}$ due to the segment $d\vec{\ell}$ of a current-carrying wire

Using the Biot-Savart Law

example: a circular current-carrying wire: What is $\vec{B}$ at center?



$$\vec{B} = \int_{\text{loop}} d\vec{B} = \int_{\text{loop}} \frac{\mu_0 I}{4\pi} \frac{1}{r^2} d\vec{\ell}\times\hat{r}$$

$d\vec{\ell}$ always ⊥ to $\hat{r}$ ⇒ $d\vec{\ell}\times\hat{r} = d\ell\,\hat{z}$

$$\rightarrow \vec{B}_{\text{at center}} = \hat{z}\,\frac{\mu_0 I}{2R}$$