Lecture 36 outline: 11/11/2020

- Friday class will be pre-recorded (will send link)
- Continue Chapter 7
- Chapter 6?
- Field of a solenoid
- What's J?

Impromptu Discussion of Magnetic Materials.

Everything we said in Ch. 4 about induced charges and polarization has a magnetic analog. Just as *dielectrics* polarize in such a way as to partially cancel an external electric field, *diamagnets* magnetize and partly cancel an external magnetic field.

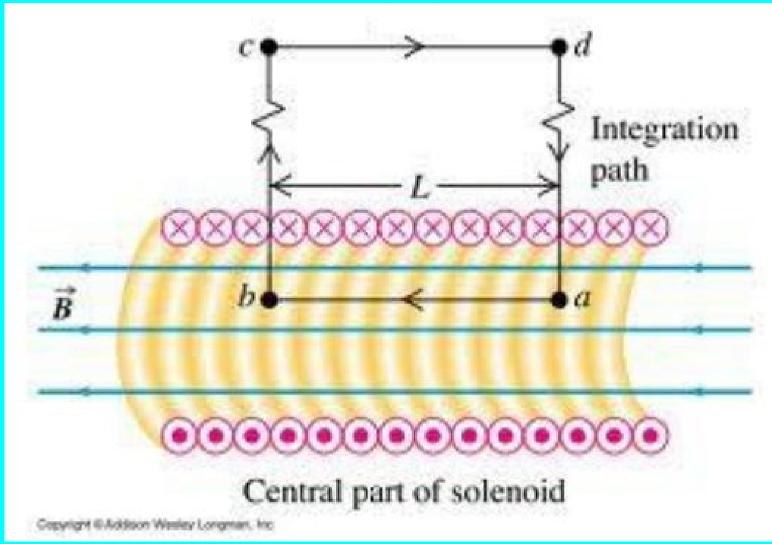
Some materials can be permanently polarized in the absence of an external electric field, we call them *electrets*. Some materials can be left magnetized with no external magnetic field … we call them *magnets*.

There are also *paramagnets*, these repond to an external magnetic field by intensifying it.

Finally there are *ferromagnets* which are extremely intense paramagnets. Iron is the paradigm for ferromagnets, though rare-earth magnets (e.g. NdFeB) are even stronger than iron magnets. Without ferrormagnetism, we might have electric motors and generators, but they would be much weaker and larger.

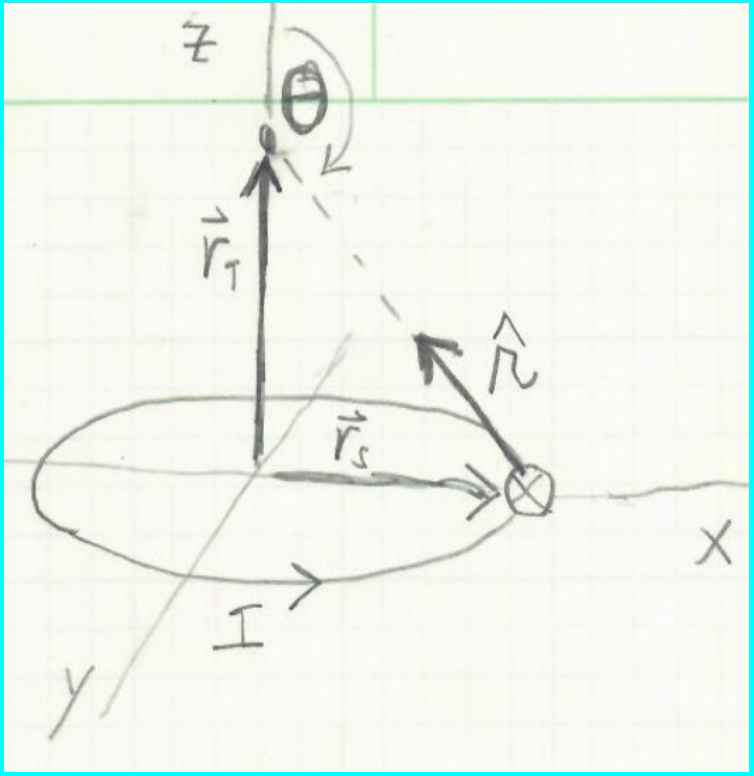
Solenoid $\vec{B} = \pm \mu_0 n I \hat{z}$

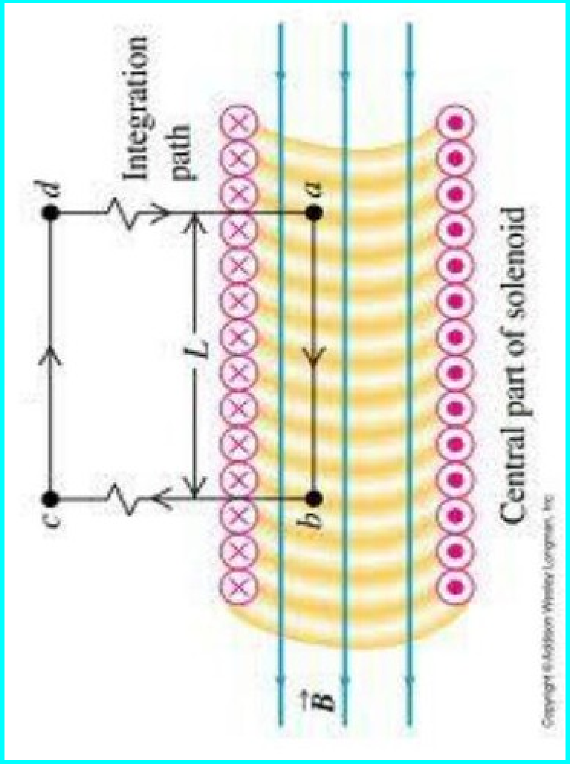
"Hush up and calculate"

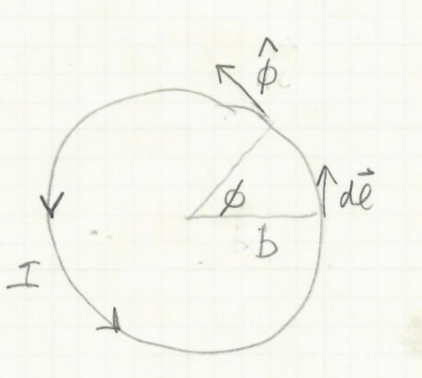


Biot Savart vs. Hitchhikers rule

$$\vec{B} = \frac{\mu_0}{4\pi} \int \frac{I\, d\vec{l} \times \hat{\mathscr{r}}}{\mathscr{r}^2}$$







Solenoid

No circumferential component (no current enclosed)

Radial component must be purely radial and independent of z (symettry + infinite coil)

No radial component (that would give a divergence)

Because Br=0, Bz is independent of r.

Bz=0 outside (Because B is zero at infinity)

Current

$$I \stackrel{\text{def}}{=} \frac{\Delta Q}{\Delta t} \qquad I = \lambda \vec{v}$$

$$I \stackrel{\text{def}}{=} \vec{J} \cdot \vec{A} \qquad \vec{J} = \rho \vec{v} = Nq \vec{v}$$

Current Density … what's J?

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