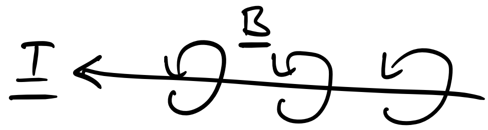
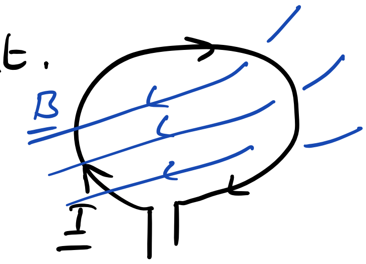


Inductors

Wires carrying currents generate magnetic fields. A current carrying loop generates magnetic flux through it.



The flux is proportional to current. We define inductance as the constant of proportionality:

$$\boxed{\Phi = LI}$$

Units: Henri - H - Wb/A

L depends on the size, shape, ... of the loop.

$$\mathcal{E} = -\frac{d\Phi}{dt} = -L\frac{dI}{dt}$$

This opposes a change in current! An inductor resists changes to current by producing a back emf.

It's normally pretty complicated but can work in some simple examples. Eg. the long thin solenoid. (woohoo)

$\Phi = BA$ for each turn $\Rightarrow \Phi = BAN$ for N turns.

$$L = \frac{\Phi}{I} = \frac{NA}{I}\cdot B = \frac{NA}{I}\cdot\frac{\mu_0 IN}{l} = \frac{\mu_0 AN^2}{l}$$

Energy Density of the Magnetic Field

An inductor carrying a current I stores energy. But where?

From BE, $U = \frac{1}{2}LI^2$. For a solenoid $L = \frac{\mu_0 A N^2}{L}$ & $I = \frac{BL}{\mu_0 N}$

$$U = \frac{1}{2}LI^2 = \frac{1}{2} \cdot \frac{\mu_0 A N^2}{L} \cdot \frac{B^2 L^2}{\mu_0^2 N^2} = \frac{B^2 A L}{\mu_0}$$

But AL is just the volume of the solenoid. As B is constant inside & 0 outside we can describe the energy density as

$$\frac{B^2}{2\mu_0}$$

This is a very vague proof but still true. An inductor stores energy in the field around it.