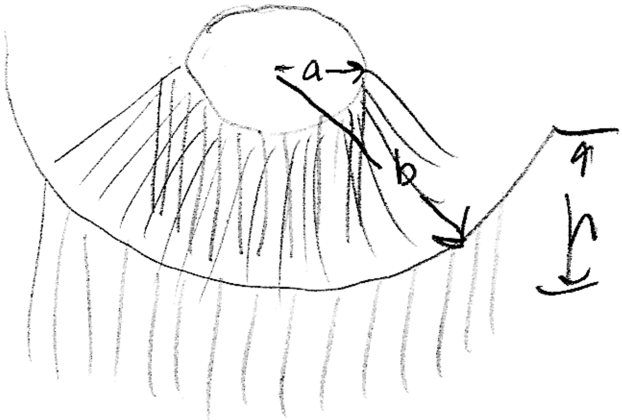
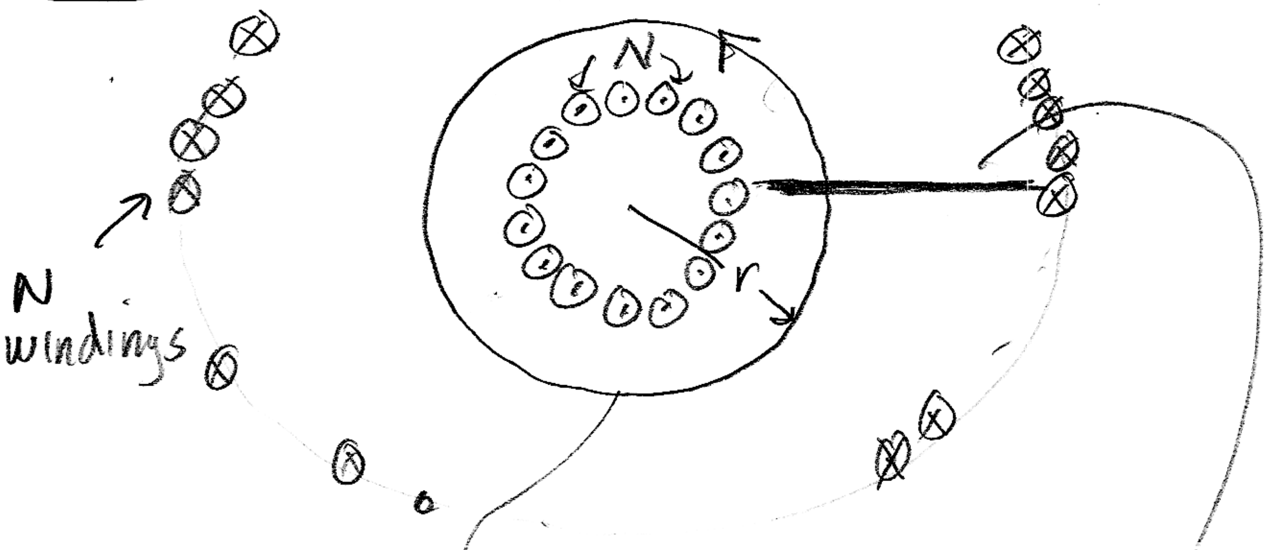


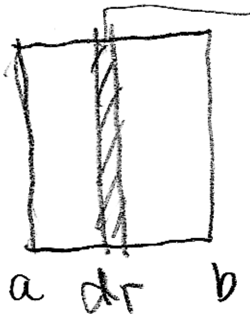
Cross sectional view:



$$2\pi r\cdot B = \frac{4\pi}{c}\cdot N\cdot I$$

$$B = \frac{2NI}{cr}$$

flux through this surface is



$$d\Phi_{B1} = \frac{2NI}{cr}\cdot h$$

$$\Phi_{B1} = \frac{2NIh}{c}\int_a^b \frac{dr}{r} = \frac{2NIh}{c}\ln\left(\frac{b}{a}\right)$$

There are N "loops" in the toroid.

$$\Phi_B = N\Phi_{B1} = \frac{2N^2 I h}{c} \ln\left(\frac{b}{a}\right)$$

$$\mathcal{E} = -\frac{1}{c}\frac{d\Phi_B}{dt} = -\frac{2N^2 h}{c^2} \cdot \ln\left(\frac{b}{a}\right)\frac{dI}{dt}$$

$$L = \frac{2N^2 h}{c^2} \ln\left(\frac{b}{a}\right) \quad \text{cgs}$$

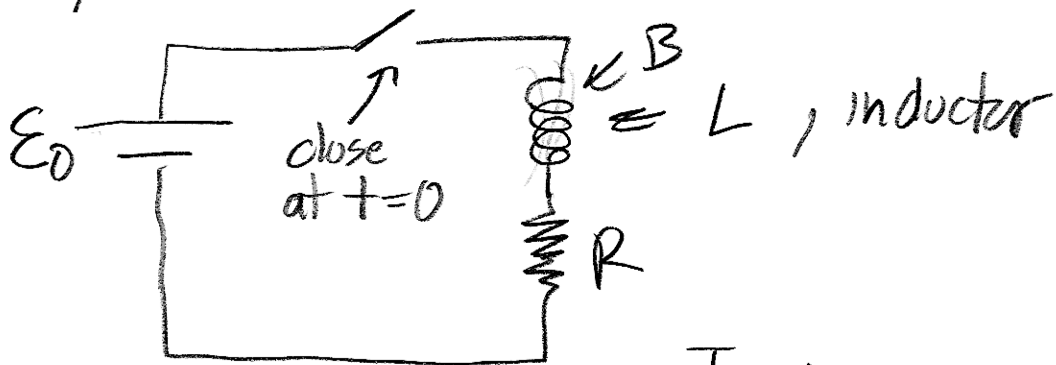
$$L(\text{henrys}) = \left(2\cdot 10^{-9}\right) N^2 h \ln\left(\frac{b}{a}\right)$$

$I \to$ amps
$h \to$ cm(!)

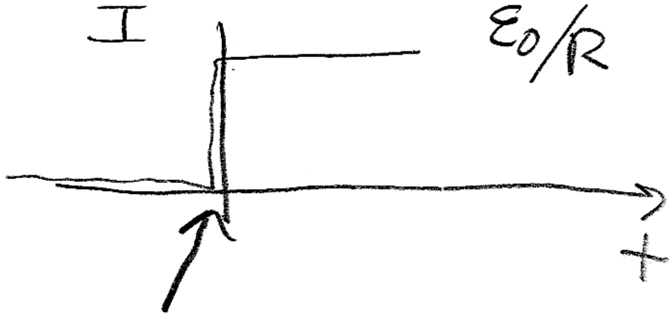
Turns out:
self inductance of a loop of wire.

is hard to compute!
(but not to measure).

Self inductance ... what inducters have!



No inductor ...

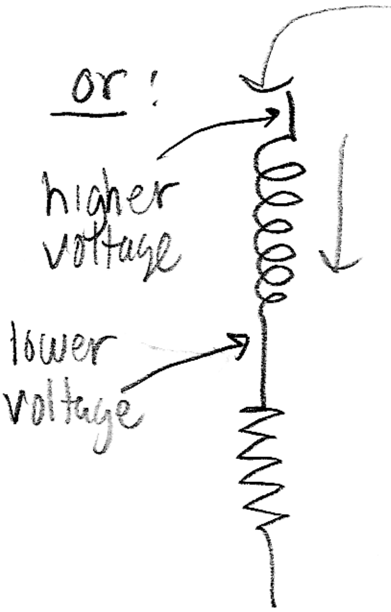


Inductor opposes the big change in current at t=0!

$$\mathcal{E}_0 - L\frac{dI}{dt} = RI$$

increase in I causes reduction in $\mathcal{E}$

or!



$\vec{E}$ field

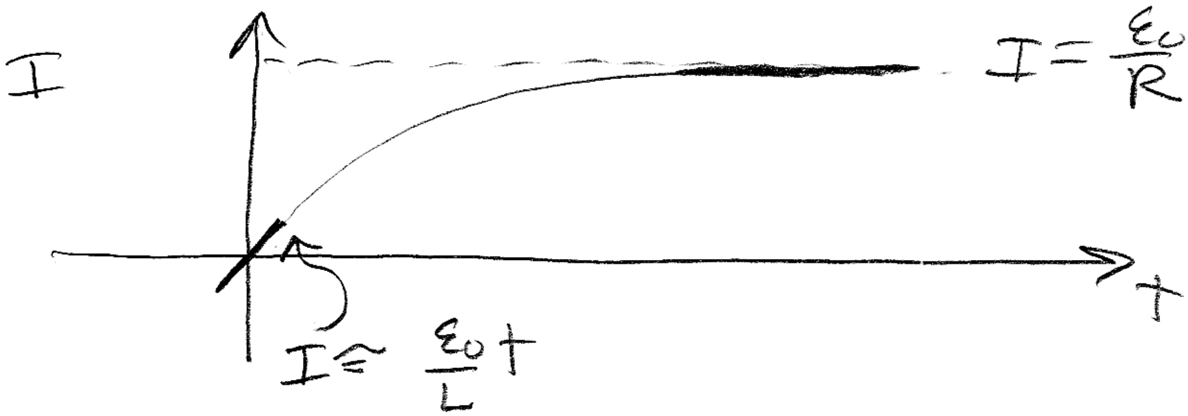
$\frac{dI}{dt}$ arrow is direction of increasing $\frac{dI}{dt}$

$$\mathcal{E}_0 = L\frac{dI}{dt} + RI$$

t a little greater than 0... $\frac{dI}{dt}$ dominates...

$$\frac{dI}{dt} = \frac{\mathcal{E}_0}{L}, \quad I \simeq \frac{\mathcal{E}_0}{L} t$$

$$t \to \infty \quad \ldots \quad I = \frac{\mathcal{E}_0}{R}$$



$$I = \frac{\mathcal{E}_0}{R}\left(1 - \underbrace{e^{-\left(\frac{R}{L}\right)t}}_{\text{vanishes as } t \to \infty}\right)$$

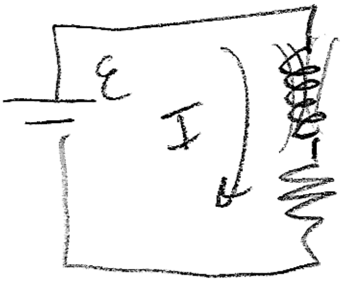
when $t \sim 0$

$$e^{-\left(\frac{R}{L}\right)t} \simeq 1 - \left(\frac{R}{L}\right)t + \ldots$$

$$I \simeq \frac{\mathcal{E}_0}{R}\left(1 - \left(1 - \left(\frac{R}{L}\right)t\right)\right) \simeq \frac{\mathcal{E}_0}{R} \cdot \frac{R}{L} t$$

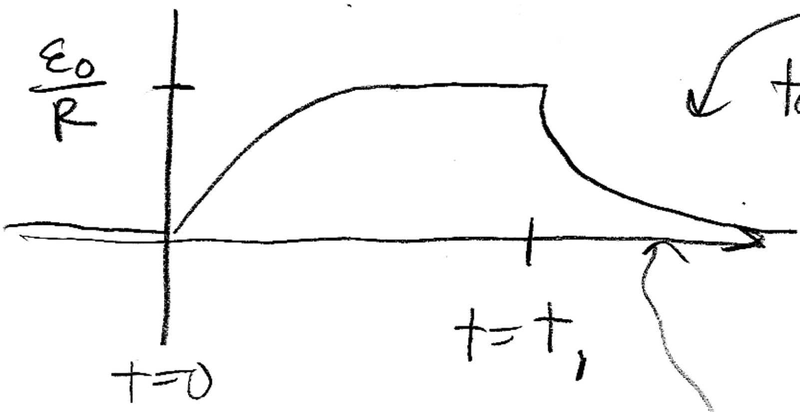
$$\simeq \frac{\mathcal{E}_0}{L} t$$

visualization is:



← takes a while to build up this energy

Suppose switch then opened



takes a while for the energy in the inductor to decay

$$I = \frac{\mathcal{E}_0}{R} e^{-\frac{R}{L}(t-t_1)}$$
$$= I_0 e^{-\frac{R}{L}(t-t_1)}$$

How much energy?

$$U = \int_{t_1}^{\infty} I^2 R \, dt = I_0^2 R \int_{t_1}^{\infty} e^{-\frac{2R}{L}(t-t_1)} dt$$

$\uparrow$ power

$x = \frac{2R}{L}(t-t_1)$

$$= I_0^2 R \int_0^{\infty} e^{-x} dx \times \frac{L}{2R}$$

$$\boxed{U = \frac{1}{2} L I_0^2}$$

can be thought of