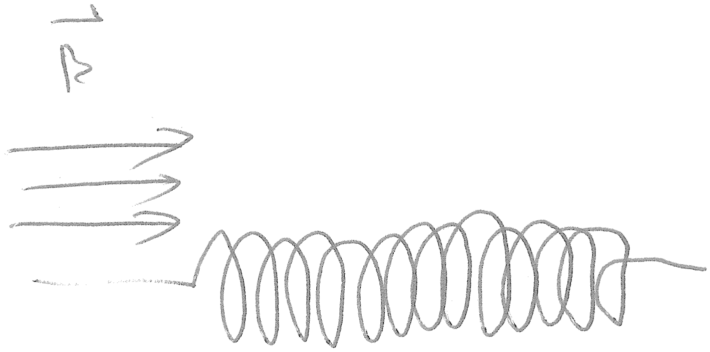
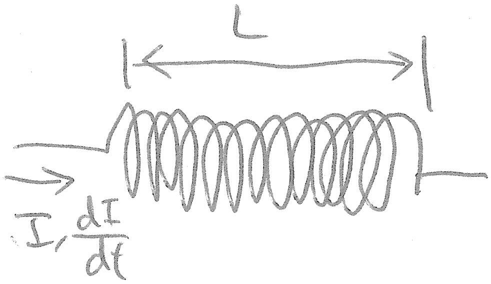


N COILS + CROSS SECTIONAL AREA A

FINITE $\frac{d\vec{B}}{dt}$ $\qquad \mathcal{E} = -N \frac{d\Phi_B}{dt}$

$$B = \mu_0 n I = \mu_0 \frac{N}{L} I$$



N COILS

$$\Phi_B = \mu_0 \frac{N}{L} I A$$

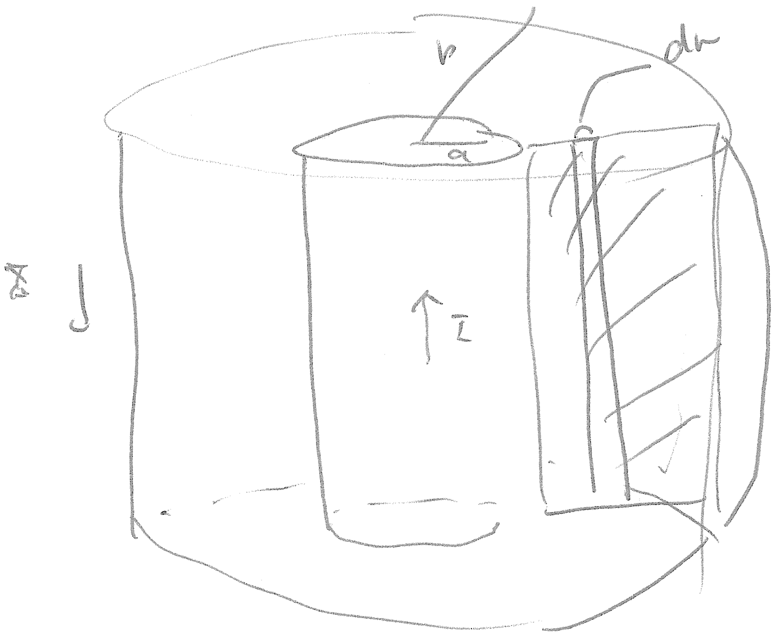
$$\mathcal{E} = -N \frac{d\Phi_B}{dt}$$ (IGNORES FRINGE FIELD)

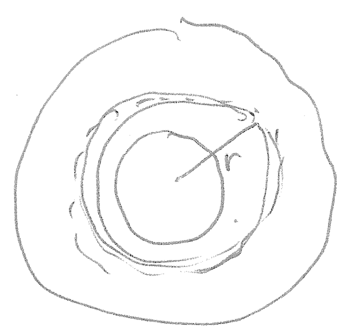
$$\mathcal{E} = -N \frac{d}{dt}\left[\mu_0 \frac{N}{L} I A\right]$$

$$\mathcal{E} = -\mu_0 \frac{N^2}{L} A \frac{dI}{dt}$$

$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -L\frac{dI}{dt} \qquad L_{SOLENOID} = \mu_0 \frac{N^2}{L} A$$

$$\frac{d\Phi_B}{dt} = L\frac{dI}{dt} \Rightarrow \underline{\Phi_B = LI}$$





$$\oint B \cdot ds = \mu_0 I$$

$$B \cdot 2\pi r = \mu_0 I$$

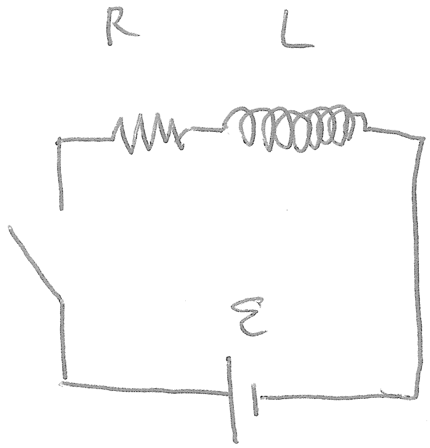
$$B = \frac{\mu_0 I}{2\pi r}$$

$$\Phi_B = \int B \cdot dA \qquad dA = dr\, l$$

$$= \int B \cdot l\, dr = \int_a^b \frac{\mu_0 I}{2\pi r}\, l\, dr$$

$$\Phi_B = \frac{\mu_0 I l}{2\pi} \ln(b/a) = LI$$

$$L = \frac{\mu_0 l}{2\pi} \ln(b/a)$$



$$\varepsilon - IR - L\frac{dI}{dt} = 0$$

$$\underbrace{\frac{\varepsilon}{R} - I}_{x} - \frac{L}{R}\frac{dI}{dt} = 0$$

$$\frac{dx}{dt} = -\frac{dI}{dt}$$

$$x + \frac{L}{R}\frac{dx}{dt} = 0$$

$$x = -\frac{L}{R}\frac{dx}{dt}$$

$$-\frac{R}{L}dt = \frac{dx}{x}$$

$x(t)$

$$\int_{x_0}^{x}\frac{dx}{x} = \int_0^t -\frac{R}{L}dt$$

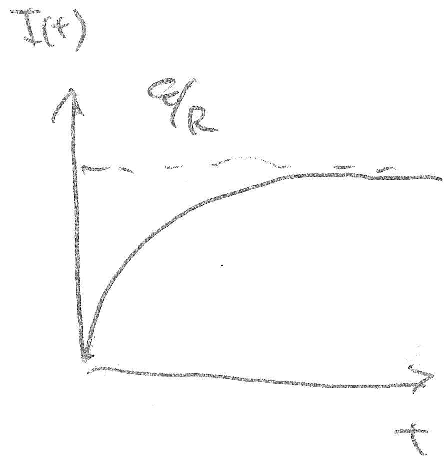
$$\ln\frac{x}{x_0} = -\frac{R}{L}t$$

$$x = x_0 e^{-R/L\, t}$$

$$x = \frac{\varepsilon}{R} - I$$

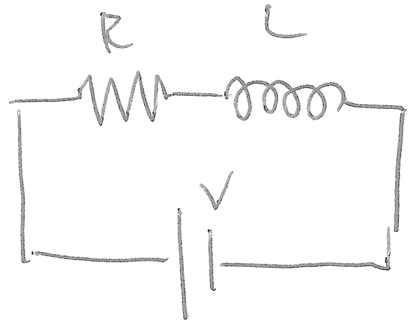
$\downarrow$

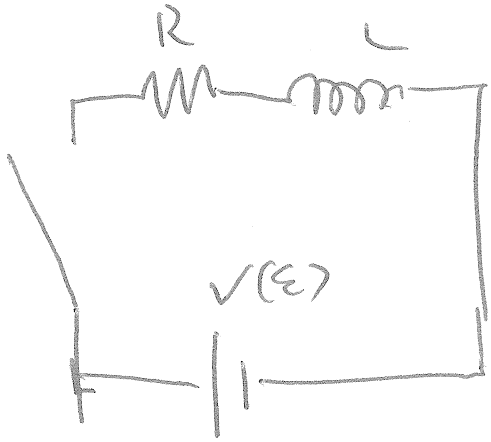
$$I = \frac{\varepsilon}{R}\left(1 - e^{-\frac{R}{L}t}\right)$$



AT $t=0$, INDUCTOR LOOKS LIKE $\infty\,\Omega$

AT $t=\infty$, INDUCTOR LOOKS LIKE $0\,\Omega$





$$\varepsilon - IR - L\frac{dI}{dt} = 0$$

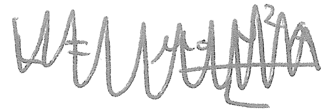
$$\varepsilon = IR + L\frac{dI}{dt}$$

$$\underbrace{I\varepsilon}_{\text{POWER PROVIDED BY BATTERY}} = \underbrace{I^2R + LI\frac{dI}{dt}}_{\text{POWER DISSIPATED}}$$

$LI\dfrac{dI}{dt} = \dfrac{dU}{dt}$: POWER IN INDUCTOR

$U = \frac{1}{2}LI^2$: ENERGY STORED IN INDUCTOR

FOR SOLENOID



l: LENGTH OF SOLENOID

N: NUMBER OF COILS

A: CROSS SECTIONAL AREA

$$L = \text{INDUCTANCE} = \frac{\mu_0 N^2 A}{l}$$

$$U = \frac{1}{2} L I^2 = \frac{1}{2} \frac{\mu_0 N^2 A}{l} \cdot I^2$$

$$B = \frac{\mu_0 N I}{l}$$

$$U = \frac{1}{2\mu_0} B^2 \cdot l \cdot A$$

$$\frac{U}{\underbrace{lA}_{\text{VOLUME}}} = \frac{1}{2\mu_0} B^2$$

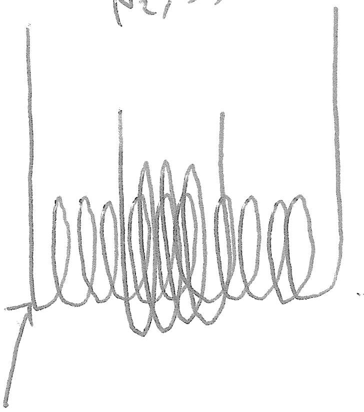
$$U = \frac{1}{2} C V^2$$

$$E = \frac{V}{d} \qquad C = \frac{\varepsilon_0 A}{d}$$

$$U = \frac{1}{2} \varepsilon_0 E^2 \cdot A \cdot d$$

$$\frac{U}{A \cdot d} = \frac{1}{2} \varepsilon_0 E^2$$

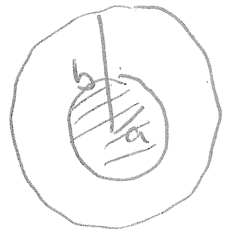
N_2, b, L_2, I_2



N_1, a, L_1, I_1

CASE 1, $\frac{dI_1}{dt}$ FINITE

WHAT IS $\mathcal{E}_2$?



$$\Phi_2 = \mu_0 \frac{N_1}{L_1} I_1 \pi a^2$$

$$\mathcal{E}_2 = -N_2 \frac{d\Phi_2}{dt} \quad \text{(FARADAY'S LAW)}$$

$$= -N_2 \frac{d}{dt}\left(\mu_0 \frac{N_1}{L_1} I_1 \pi a^2\right)$$

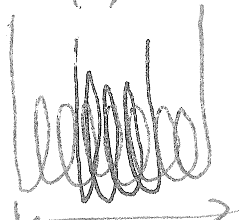
$$\mathcal{E}_2 = -N_2 \mu_0 \frac{N_1}{L_1} \pi a^2 \frac{dI_1}{dt}$$

$$= -\mu_0 \frac{N_2 N_1}{L_1} \pi a^2 \frac{dI_1}{dt}$$

CASE 2 ASSUMING NO FRINGE FIELD

$\frac{dI_2}{dt}$ = FINITE WHAT IS $\mathcal{E}_1$?

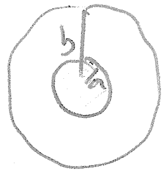
N_2, L_2



N_1, L_1

COILS IN MAGNETIC FIELD (IN COIL 1)

$$= \frac{N_1}{L_1} L_2$$



$$\Phi_1 = \mu_0 \frac{N_2}{L_2} I_2 \pi a^2$$

$$\mathcal{E}_1 = -\frac{N_1}{L_1} L_2 \frac{d\Phi_1}{dt}$$

$$\varepsilon_1 = -N_1 \frac{\cancel{L_2}}{L_1} \frac{\mu_0 N_2}{\cancel{L_2}} \pi a^2 \frac{dI_2}{dt}$$

$$\varepsilon_1 = -\mu_0 \frac{N_1 N_2}{L_1} \pi a^2 \frac{dI_2}{dt} \quad \text{.. CASE 2.}$$

BUT CASE 1 $\varepsilon_2 = -\underbrace{\mu_0 \frac{N_1 N_2}{L_1} \pi a^2}_{M} \frac{dI_1}{dt}$

$$\varepsilon_2 = -M \frac{dI_1}{dt} \quad \text{.. CASE 1}$$

$$\varepsilon_1 = -M \frac{dI_2}{dt} \quad \text{.. CASE 2}$$

M: MUTUAL INDUCTANCE