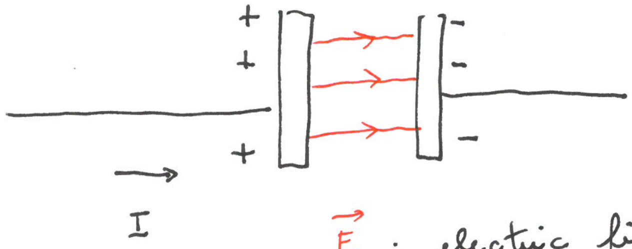
For capacitors:



$\vec{E}$: electric field constant between the plates

$$E = \frac{Q}{K \varepsilon_0 A}$$

* "Static" charges are deposited on the plates, a E field is created, and energy is stored in the capacitor.

* What happens if the charges move?

Electric currents, and moving charges generate a B field (in the space around them).

* One can verify experimentally that also the opposite happens

Induction (Faraday's law)

When the magnetic flux concatenated with a circuit varies with time $\longrightarrow$ an induced electro motive force is generated

↳ it's not a force it's a potential difference

S = surface which has the circuit as boundary

$$\Phi_{circuit}(\vec{B}) = \int_S \vec{B} \cdot \vec{n} \, dS$$

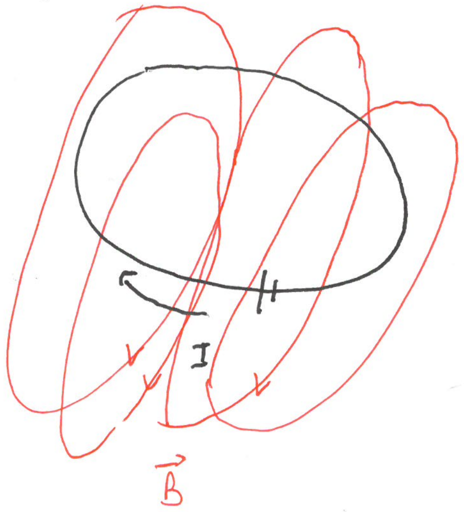
$\vec{n} \perp$ to the dS element of the surface

Magnetic field flux

$$\mathcal{E}_I(t) = \text{induced e.m.f.} = -\frac{d\,\Phi(\vec{B})}{dt}$$

Note that :

- when there is a current in a circuit, in the surrounding space there is a magnetic field which is generated by the current, and there is a magnetic flux concatenated with the circuit itself.



- if the current varies the $\vec{B}$ field concatenated with the circuits varies $\xrightarrow[\text{for Faraday's law}]{}$ this generates an induced e.m.f.

→ This phenomenon is called <u>auto-induction</u>

<u>Now</u> :

for 1st Laplace law, if you have a current I in the circuit the flux concatenated with the circuit is :

$$\Phi(\vec{B}) = L\, I$$

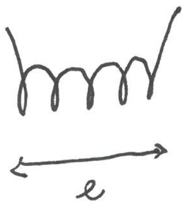
L → INDUCTANCE of the circuit (also auto-INDUCTANCE)

Similarly as with <u>capacitors</u> L is a constant that depends on
capacitance

the geometry of the circuit,

tells you " how many lines of the magnetic field you can pack into your circuit"

Let's have a look at the inductance for a solenoid



N - turns

$$B = \mu \frac{N}{\ell} \cdot I \xrightarrow[\text{total flux with N turns}]{} \mu \frac{N^2}{\ell} I \cdot S = \phi(\vec{B})$$

so $L = \mu \frac{N^2}{\ell} \cdot S$

$\mu \sim$ how easily the magnetic field passes through a material

If we put everything together :

$$\mathcal{E}_I = \text{induced e.m.f.} = - \frac{d\Phi(\vec{B})}{dt} = - L \frac{dI}{dt}$$

ELECTRO - MOTIVE - FORCE

* Now a current through an inductor will store energy in the form of magnetic field

$$\frac{dW}{dq} = V \quad ; \quad dW = V dq = V dt \cdot I = L \frac{dI}{\cancel{dt}} \cdot I \cdot \cancel{dt} = I L dI$$

$$W = \int_0^i L I dI = \frac{1}{2} L i^2$$

Sign : Lenz law : the sign of the induced e.m.f. $\mathcal{E}_I$ will compensate for the change in current which has induced it.