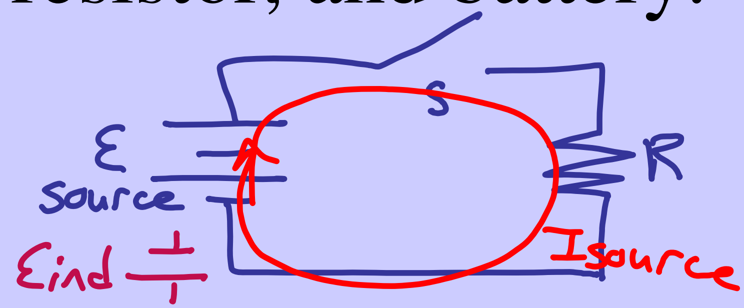
Self-Inductance

"Louis Pasteur's theory of germs is ridiculous fiction." Pierre Pachet, Professor of Physiology at Toulouse, 1872.

Self-Inductance

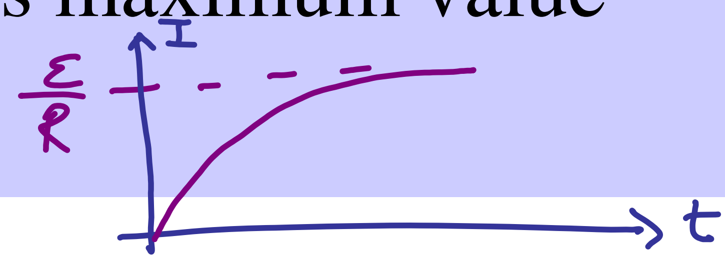
- We need to clearly distinguish between currents caused by a battery or other sources and currents induced by changing magnetic fields.
- We will use __Source__ *emf* for those associated with a physical source and __induced__ *emf* for those caused by changing magnetic fields.
- Draw a circuit with a switch, resistor, and battery.



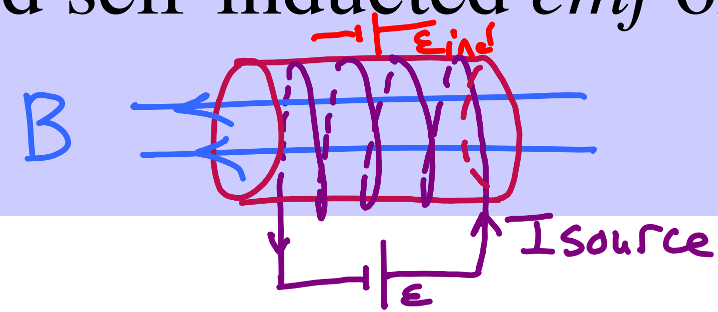
- The maximum current is

$$I_{MAX} = \frac{\mathcal{E}}{R}$$

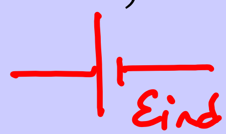
- The current does not reach its maximum value instantaneously.



- As the source current increases, what happens to the magnetic flux through the loop? increasing inward Φ_B into ↑, loop opposes the $d\Phi_B$ ⇒ $I_{induced}$ is ccw to create B-field outward
- This flux creates an induced *emf*. What is the direction of the induced *emf*? opposite
- Thus the direction of the induced *emf* is opposite the source *emf*. This results in a gradual rather than instantaneous increase in the source current.
- This is called self-inducted *emf* or back *emf*.



- Draw a coil wound around a cylindrical iron core.
- If the current increases, draw the polarity of the induced *emf*?
- If the current decreases, draw the polarity of the induced *emf*?



- Use Faraday's Law to derive an equation for the induced emf.
- The inductance, L, is equal to $L = \frac{N \Phi_B}{I}$
- The units of inductance are henrys, $H = \frac{V \cdot s}{A}$
- **Example:** Find the inductance of a uniformly wound solenoid having N turns and ℓ length. Assume that ℓ is much longer than the radius of the windings and that the core of the solenoid is air.

$$\mathcal{E}_L = -N\frac{d\Phi_B}{dt} = -L\frac{dI}{dt}$$

b/c $d\Phi_B \propto dB \propto dI$

$$-N\int\frac{d\Phi_B}{dt} = -L\int\frac{dI}{dt}$$

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

L - inductance (H)

$R = \frac{\mathcal{E}}{I}$ R is a measure of opposition to I.

$$L = \frac{-\mathcal{E}_L}{\left(\frac{dI}{dt}\right)}$$

L is a measure of opposition of dI

Example

L = ?

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

$\Phi_B = \mu_0 \frac{NA}{l} I$

$$L = \frac{N\left(\mu_0 \frac{NA}{l} I\right)}{I} = \frac{\mu_0 N^2 A}{l}$$