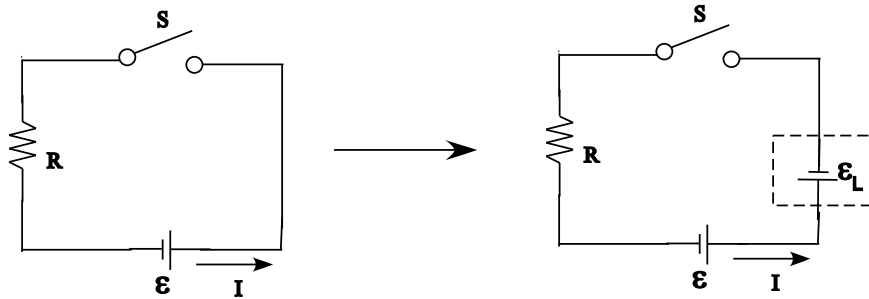


## SELF-INDUCTANCE

Consider the following circuit:



- A. When the switch is closed the current does not reach its max value of  $I = \epsilon/R$  instantaneously. Faraday's Law can be used to explain why this occurs.
- B. When the switch is closed the current increases and the magnetic flux through the circuit increases.
- C. This increase in flux induces an EMF such that it would cause an induced current that would oppose the increase in flux through the circuit.
- D. Such induced EMF would have to be opposite to  $\epsilon$ .
- E. The result is a gradual increase of the current rather than an instantaneous increase.
- F. This effect is called self-induction because the self-induced EMF arises from the circuit itself.

$$\epsilon_L = \text{self-induced EMF (back - emf)}$$

The flux through the loop is proportional to the current in the loop:

$$(1) \quad N\Phi_B = LI$$

Where the proportionality constant  $L$  is called the self-inductance.

$$\boxed{L = \frac{N\Phi_B}{I}} \text{ Self-Inductance}$$

Differentiating (1)  $N\Phi_B = LI$  gives:

$$N \frac{d\Phi_B}{dt} = L \frac{dI}{dt}$$
$$\boxed{\epsilon_L = -L \frac{dI}{dt}} \text{ self-induced EMF}$$

The negative sign is due to Lenz's Law which states that the induced EMF in a circuit opposes any change in the current in the circuit.

### Properties of Inductance

1. Since  $\frac{dI}{dt} = -\frac{\varepsilon_L}{L}$  ;
  - a) The larger  $L$  , the smaller  $\frac{dI}{dt}$  , and the more slowly the current increases.
  - b) The smaller  $L$  , the larger  $\frac{dI}{dt}$  , and the more faster the current increases.
  - c) Thus, inductance is a measure of the opposition to changes in current.
2. The purpose of an inductor is to oppose any variations in the current through a circuit.
3. Circuits element that have large self-inductances are called inductors. Ex. Solenoids



4. The current through an inductor cannot change instantaneously.
5. The SI unit of inductance is the Henry (H)  
 $1\text{H} = 1 \text{ V}\cdot\text{s}/\text{A}$