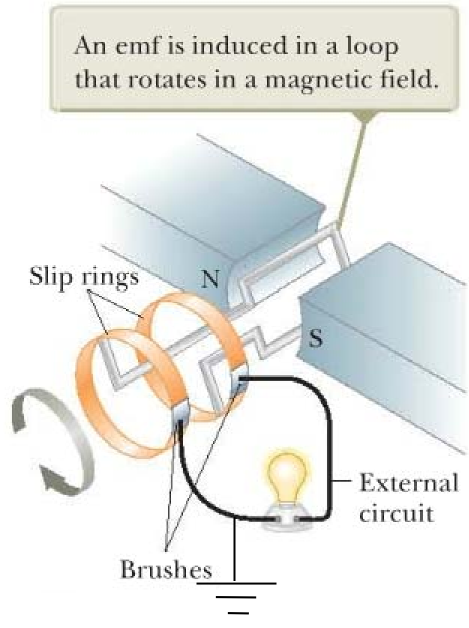
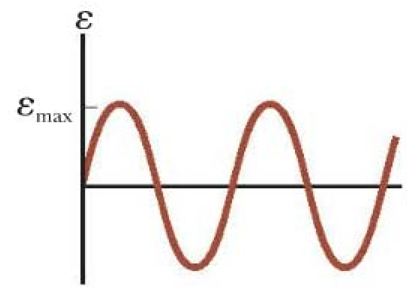
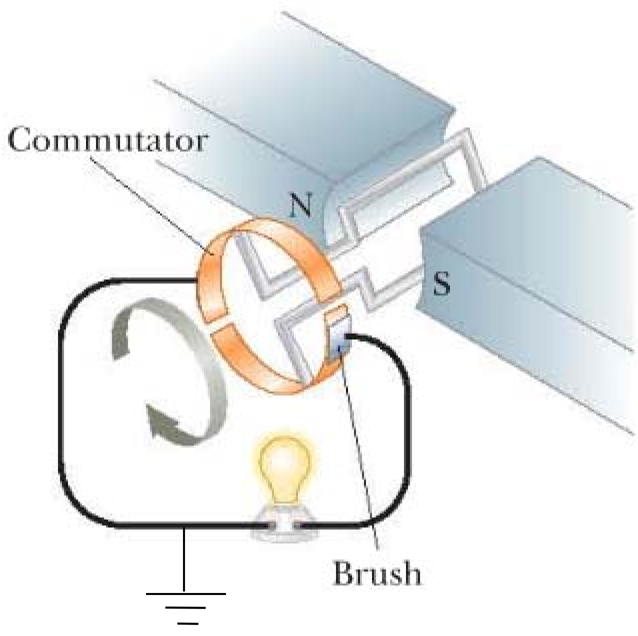
Class 34 Eddy current and Inductance

AC and DC Generators

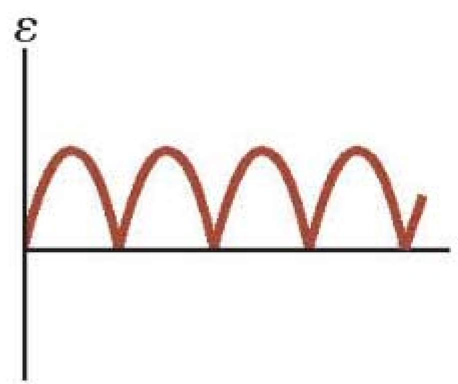


AC Generator

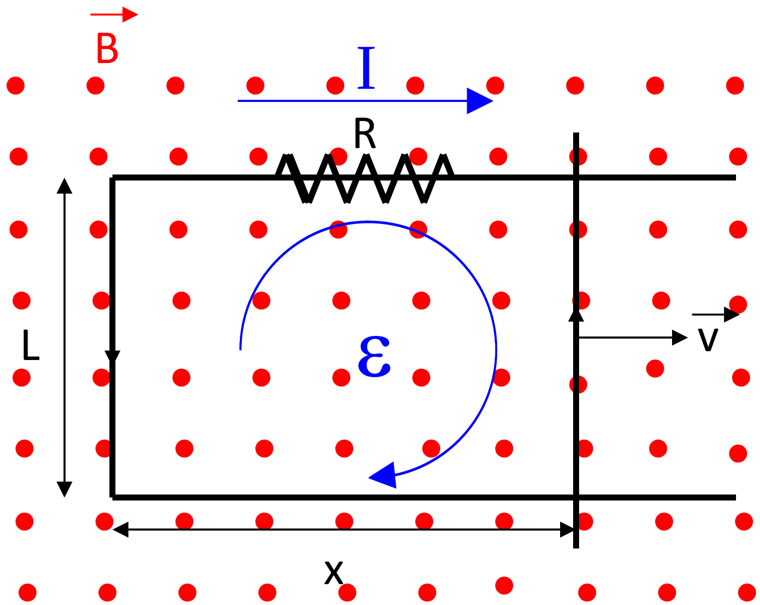




DC Generator



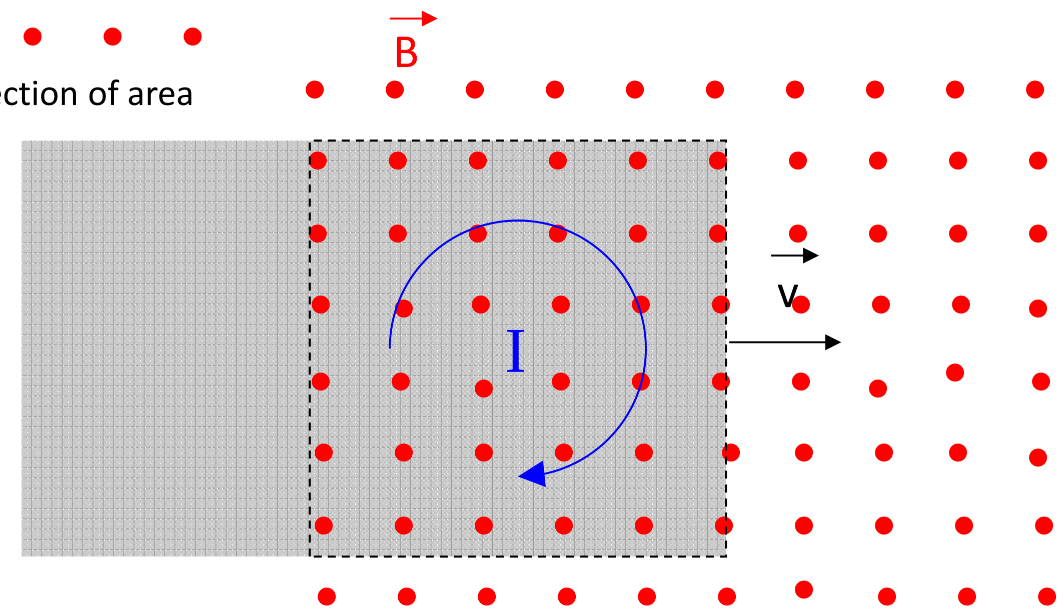
Eddy Current



Arrows on loop indicates positive direction of area vector.

When a conductor moves in an inhomogeneous magnetic field, the induced emf will produce current flow in the conductor, called Eddy current.

Lenz's Law: The Eddy current will in turn produce a magnetic force in opposite direction to the velocity, like friction.



Self Inductance

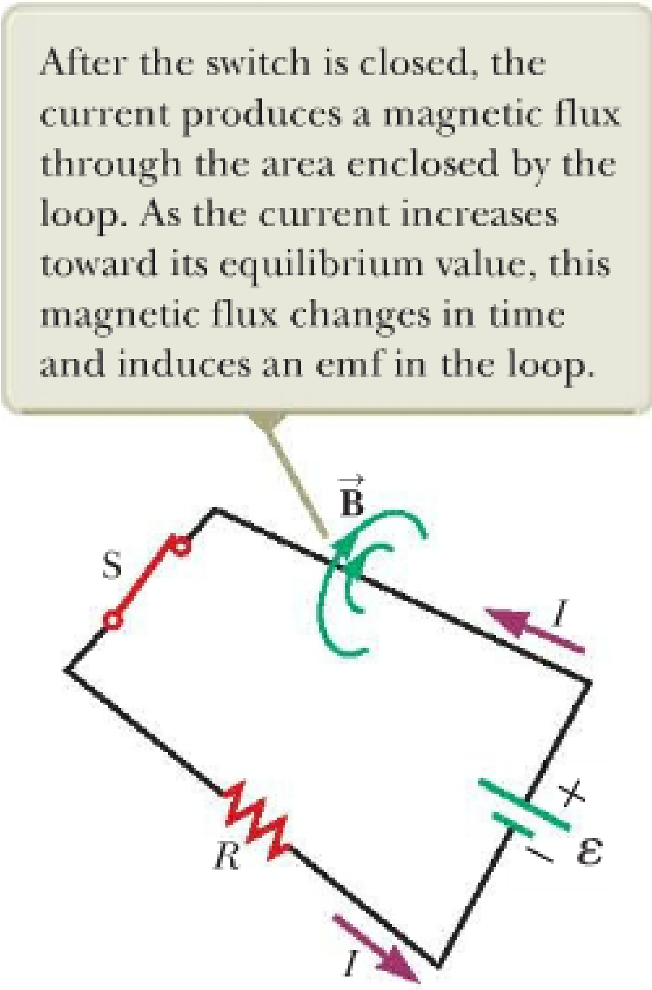


Figure 32.1 Self-induction in a simple circuit.

$$\text{Back emf} = \varepsilon_L = -\frac{d}{dt}\Phi_B$$

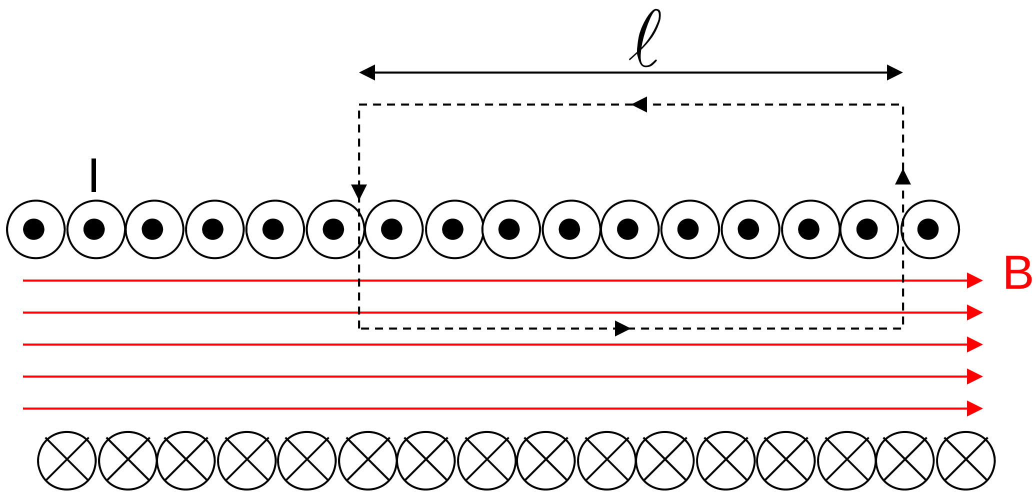
$$\Phi_B \propto B \propto I$$

$$\varepsilon_L \propto -\frac{d}{dt} I \quad \Rightarrow \quad \boxed{\varepsilon_L = -L\frac{dI}{dt}}$$

L is called the inductance.

SI unit of L : Henry (H)

Inductor



$$B = \mu_0 n\, I$$

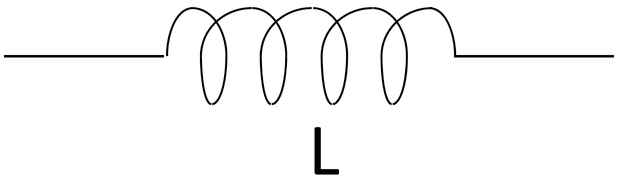
$$\Phi_B = NBA = N(\mu_0 n\, I)A = \mu_0 nNAI$$

$$\text{Back emf} = \varepsilon_L = -\frac{d}{dt}\mu_0 nNAI$$

$$= -\mu_0 nNA\frac{d}{dt}I$$

$$\therefore L = \mu_0 nNA \quad \text{or} \quad \mu_0\frac{N^2}{\ell}A$$

Inductor symbol:

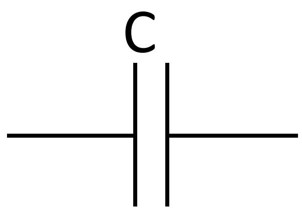


Capacitor and Inductor

Capacitor C	Inductor L
Charge Q	Current I
E field	B field
$V = \frac{Q}{C}$	$\varepsilon = -L \frac{dI}{dt}$
Parallel plate capacitor (uniform E field) $C = \frac{\varepsilon_0 A}{d}$ and $E = \frac{V}{d}$	Solenoid (uniform B field) $L = \mu_0 nNA$ and $B = \mu_0 nI$

From Class 11
(Slide 3)

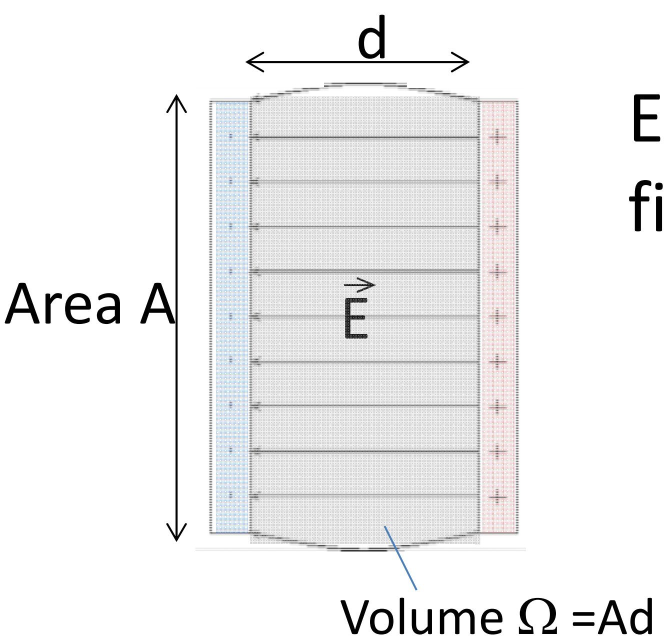
Energy Stored in a Capacitor



Energy stored in a charged capacitor:

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

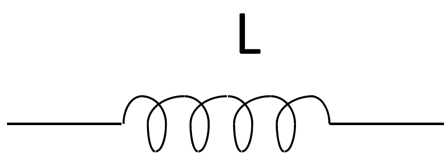
(Do not forget $C = \frac{Q}{V}$.)



Energy density stored in an electric field:

$$u_E = \frac{U}{\Omega} = \frac{1}{2} \varepsilon_0 E^2$$

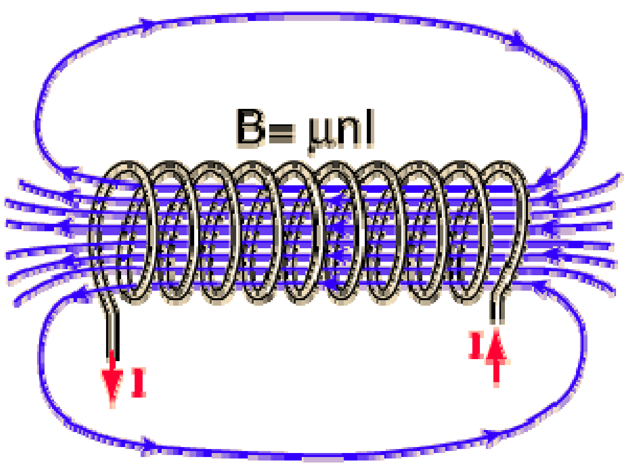
Energy Stored in an Inductor



Energy stored in an inductor:

$$U = \frac{1}{2} L I^2$$

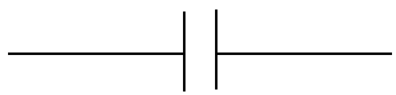
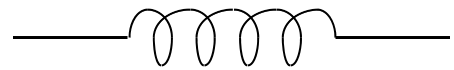
(Do not forget $\varepsilon = -L \frac{dI}{dt}$.)



Energy density stored in a magnetic field:

$$u_B = \frac{U_B}{\Omega} = \frac{1}{2\mu_0} B^2$$

Capacitor and Inductor

Capacitor C	Inductor L
	
Charge Q	Current I
E field	B field
$V = \frac{Q}{C}$	$\varepsilon = -L \frac{dI}{dt}$
Parallel plate capacitor (uniform E field) $C = \frac{\varepsilon_0 A}{d}$ and $E = \frac{V}{d}$	Solenoid (uniform B field) $L = \mu_0 nNA$ and $B = \mu_0 nI$
$U_E = \frac{1}{2} CV^2$ and $u_E = \frac{1}{2}\varepsilon_0 E^2$	$U_B = \frac{1}{2} LI^2$ and $u_B = \frac{1}{2\mu_0} B^2$