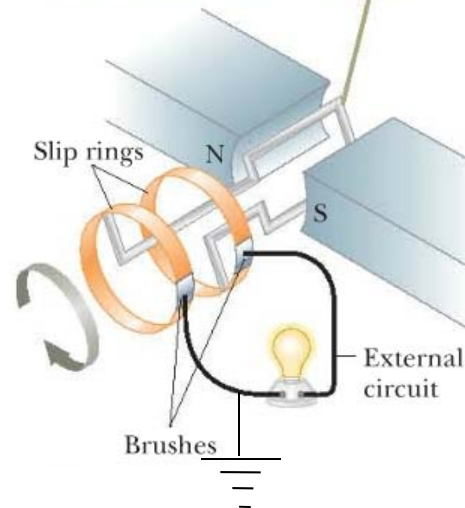


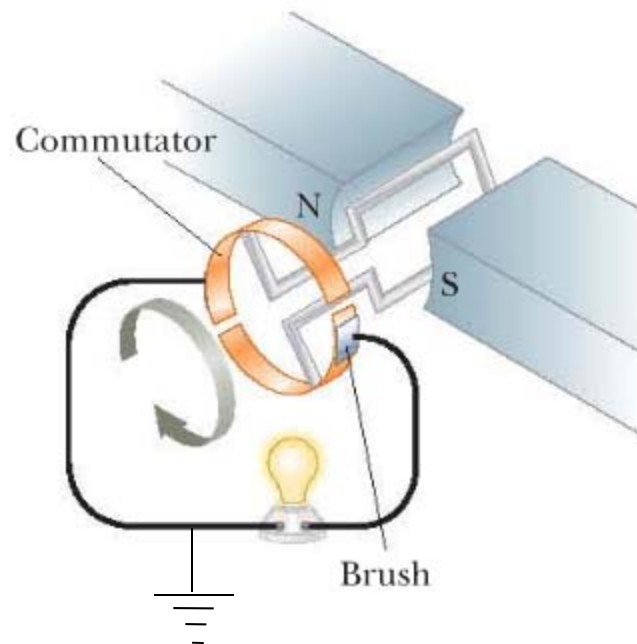
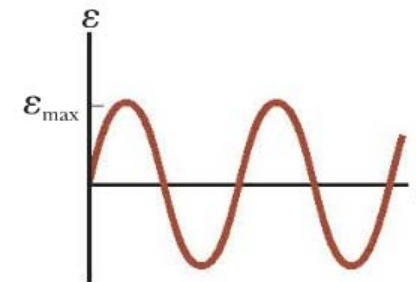
Class 34 Eddy current and Inductance

AC and DC Generators

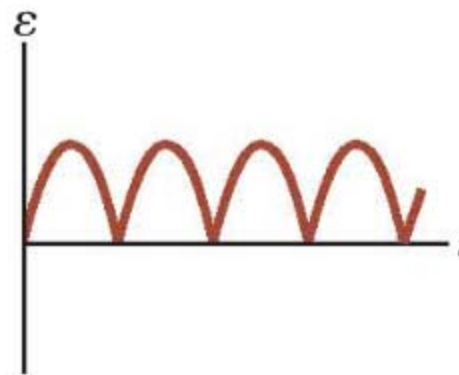
An emf is induced in a loop that rotates in a magnetic field.



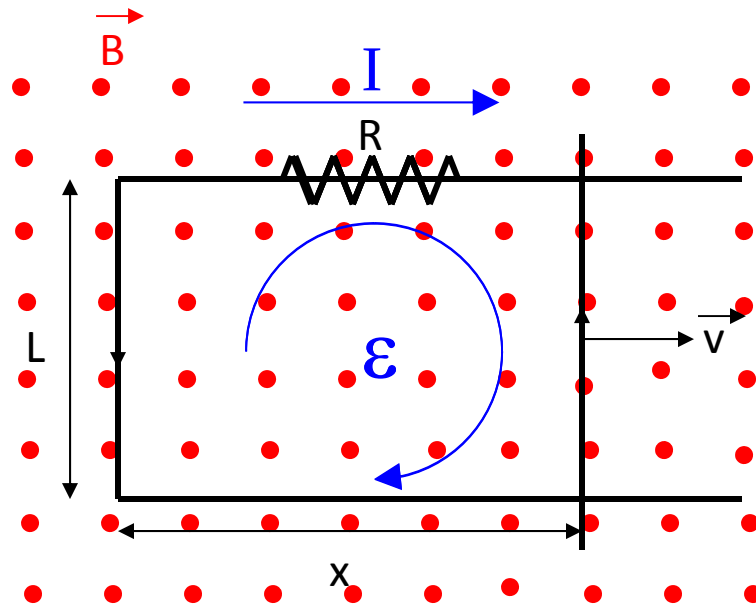
AC Generator



DC Generator



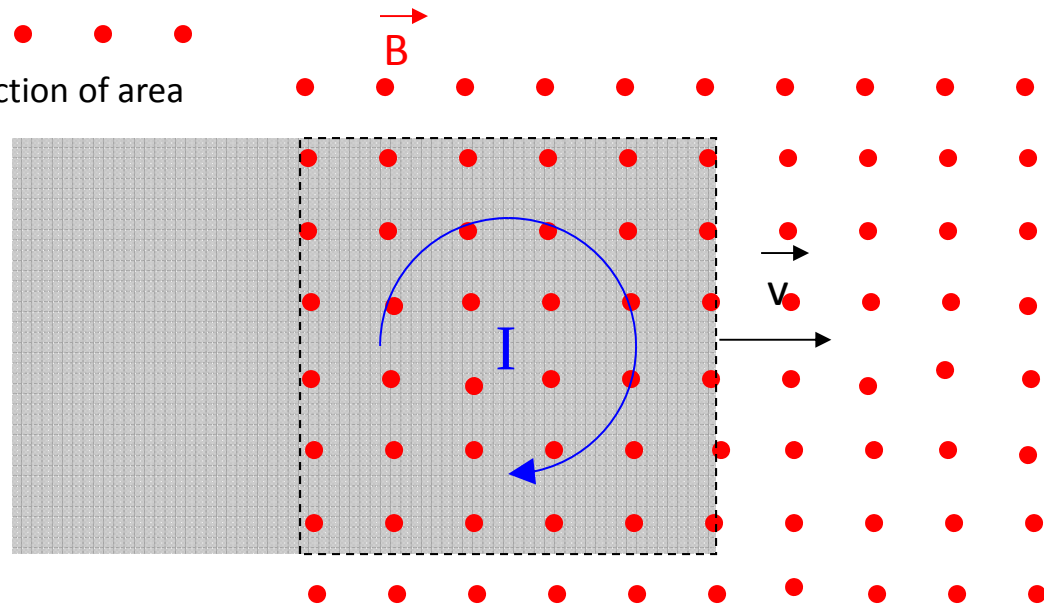
Eddy Current



Arrows on loop indicates positive direction of area vector.

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

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



Self Inductance

After the switch is closed, the current produces a magnetic flux through the area enclosed by the loop. As the current increases toward its equilibrium value, this magnetic flux changes in time and induces an emf in the loop.

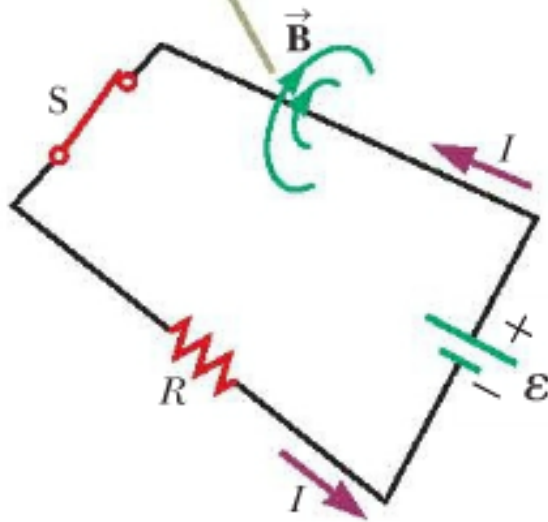


Figure 32.1 Self-induction in a simple circuit.

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

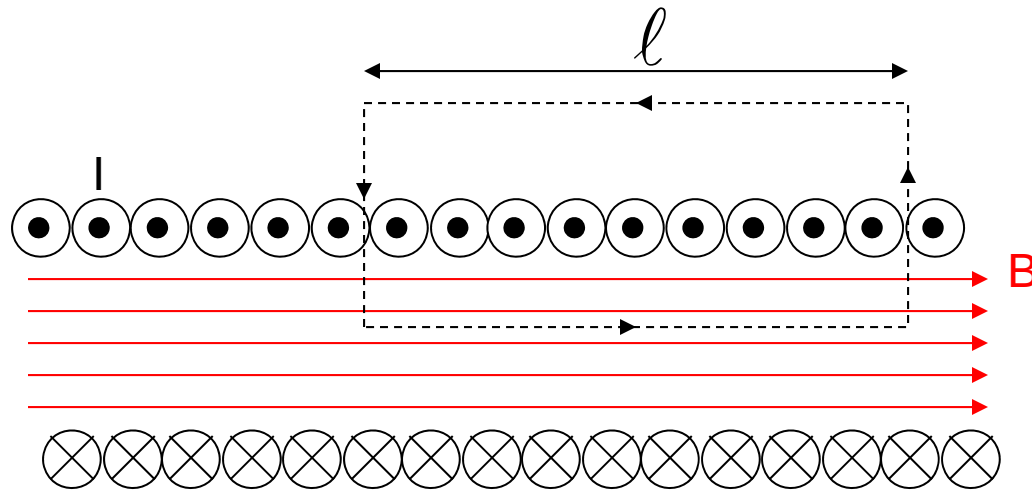
$$\Phi_B \propto B \propto I$$

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

L is called the inductance.

SI unit of L : Henry (H)

Inductor



$$B = \mu_0 n I$$

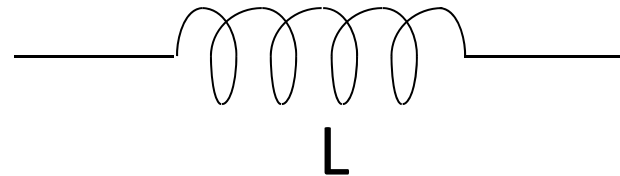
$$\Phi_B = NBA = N(\mu_0 n I)A = \mu_0 n N A I$$

$$\text{Back emf} = \varepsilon_L = - \frac{d}{dt} \mu_0 n N A I$$

$$= - \mu_0 n N A \frac{d}{dt} I$$

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

Inductor symbol:



Capacitor and Inductor

Capacitor C	Inductor L
Charge Q	Current I
E field	B field
$V = \frac{Q}{C}$	$\mathcal{E} = -L \frac{dI}{dt}$
Parallel plate capacitor (uniform E field) $C = \frac{\epsilon_0 A}{d}$ and $E = \frac{V}{d}$	Solenoid (uniform B field) $L = \mu_0 n N A$ and $B = \mu_0 n I$

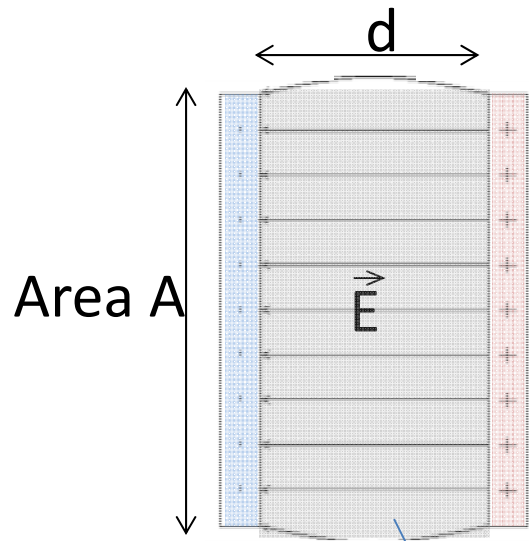
From Class 11
(Slide 3)

Energy Stored in a Capacitor

Energy stored in a charged capacitor:

$$U = \frac{1}{2} CV^2$$

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

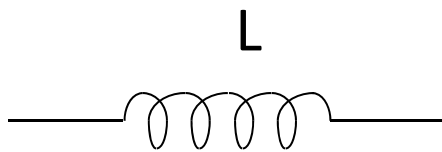


Volume $\Omega = Ad$

Energy density stored in an electric field:

$$u_E = \frac{U}{\Omega} = \frac{1}{2} \epsilon_0 E^2$$

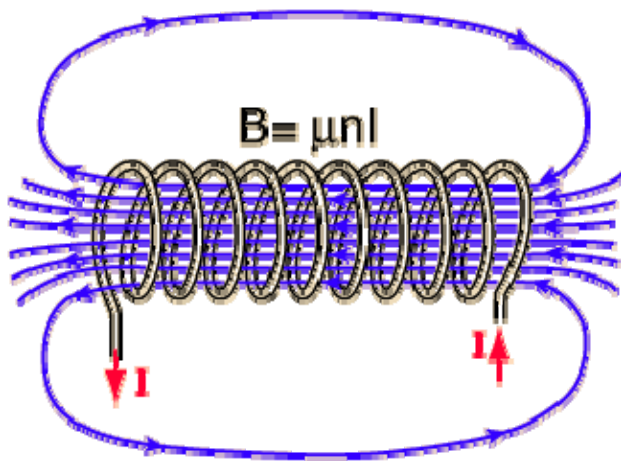
Energy Stored in an Inductor



Energy stored in an inductor:

$$U = \frac{1}{2} LI^2$$

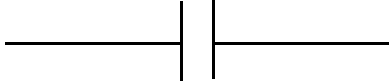
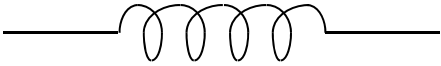
(Do not forget $\mathcal{E} = -L \frac{dI}{dt}$.)



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
$V = \frac{Q}{C}$	$\mathcal{E} = -L \frac{dI}{dt}$
Parallel plate capacitor (uniform E field) $C = \frac{\epsilon_0 A}{d} \text{ and } E = \frac{V}{d}$	Solenoid (uniform B field) $L = \mu_0 n N A \text{ and } B = \mu_0 n I$
$U_E = \frac{1}{2} C V^2 \text{ and } u_E = \frac{1}{2} \epsilon_0 E^2$	$U_B = \frac{1}{2} L I^2 \text{ and } u_B = \frac{1}{2 \mu_0} B^2$