

# Chapter 11

## Inductance and Magnetic Energy

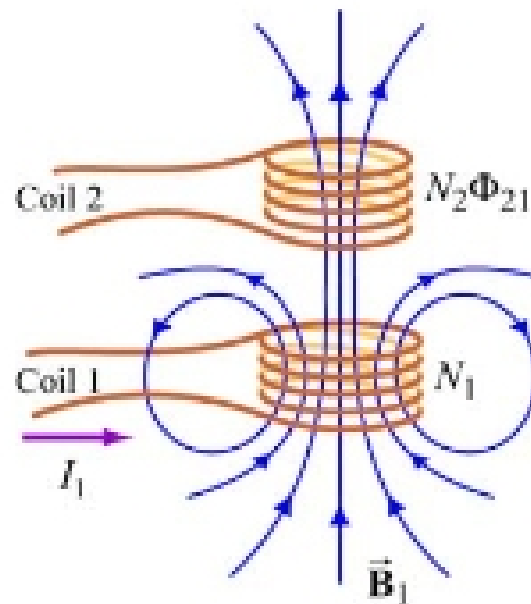
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# Inductance and Magnetic Energy

## 11.1 Mutual Inductance

Suppose two coils are placed near each other, as shown in Figure 11.1.1



**Figure 11.1.1** Changing current in coil 1 produces changing magnetic flux in coil 2.

The first coil has  $N_1$  turns and carries a current  $I_1$  which gives rise to a magnetic field  $\vec{B}_1$ . Since the two coils are close to each other, some of the magnetic field lines through coil 1 will also pass through coil 2. Let  $\Phi_{21}$  denote the magnetic flux through one turn of coil 2 due to  $I_1$ . Now, by varying  $I_1$  with time, there will be an induced emf associated with the changing magnetic flux in the second coil:

$$\varepsilon_{21} = -N_2 \frac{d\Phi_{21}}{dt} = -\frac{d}{dt} \iint_{\text{coil 2}} \vec{B}_1 \cdot d\vec{A}_2 \quad (11.1.1)$$

The time rate of change of magnetic flux  $\Phi_{21}$  in coil 2 is proportional to the time rate of change of the current in coil 1:

$$N_2 \frac{d\Phi_{21}}{dt} = M_{21} \frac{dI_1}{dt} \quad (11.1.2)$$

where the proportionality constant  $M_{21}$  is called the mutual inductance. It can also be written as

$$M_{21} = \frac{N_2 \Phi_{21}}{I_1} \quad (11.1.3)$$

The SI unit for inductance is the henry (H):