# Chapter 11

# Inductance and Magnetic Energy

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## 11.1 Mutual Inductance

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

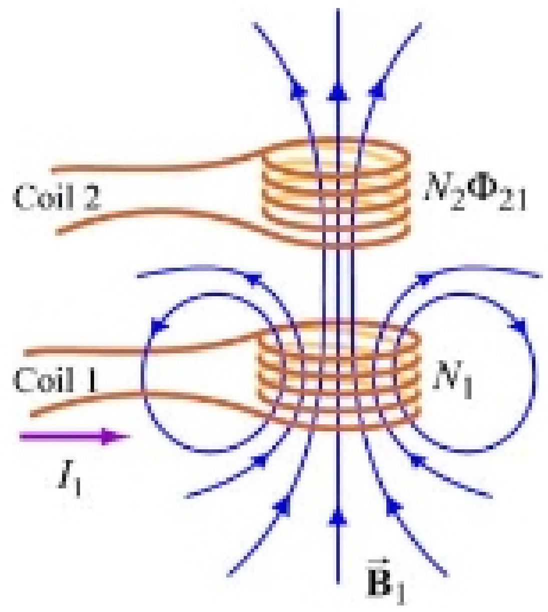


**Figure 11.1.1** Changing current in coil 1 produces changing magnetic flux in coil 2.

The first coil has $N_1$ turns and carries a current $I_1$ which gives rise to a magnetic field $\vec{\mathbf{B}}_1$. 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:

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

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:

$$N_2 \frac{d\Phi_{21}}{dt} = M_{21} \frac{dI_1}{dt} \tag{11.1.2}$$

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

$$M_{21} = \frac{N_2 \Phi_{21}}{I_1} \tag{11.1.3}$$

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