Magnetic Flux and Faraday's Law

Magnetic Flux

Magnetic flux is a measure of the number of magnetic field lines passing through an area, *A*. The equation for magnetic flux, Φ, is:

$$\Phi = BA\cos\theta$$

where B is the magnetic field and θ is the angle between the ***B*** vector and the area vector, ***A***.

The SI unit for magnetic flux is the weber (Wb).
1 Wb = 1 Tm^2

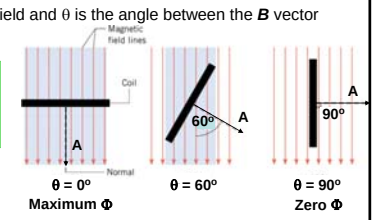
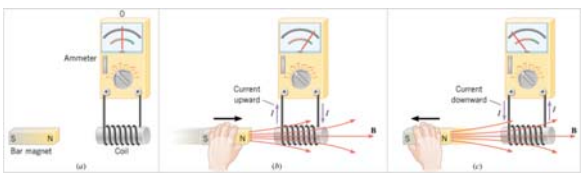


Figure. Illustration of how the magnetic flux through a coil varies with the angle θ.

Effect of Changing Magnetic Flux

Changing magnetic flux can induce an emf in a circuit, or if the circuit is complete, it can induce an electric current as illustrated below.



The directions of current flow seen in (b) and (c) can be deduced by Lenz's law, which we will discuss shortly.

Faraday's Law

Faraday's Law says that the emf induced in a coil of *N* turns is given by the rate of change of the magnetic flux in the coil:

Faraday's Law: $\varepsilon = -N\dfrac{\Delta\Phi}{\Delta t}$

Since Φ = *BA*cosθ, <u>the magnetic flux changes if any of *B*, *A* or θ changes</u>. Faraday's law has important applications in the generation and distribution of electricity.

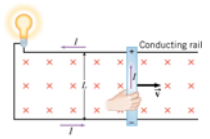
We call the voltage induced by a changing magnetic flux an <u>induced emf</u>. In other words, changing magnetic flux acts like a battery in a coil or loop, and a current flows when there's a complete circuit.

Faraday's Law (Cont'd)

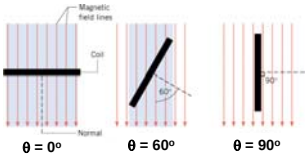
As pointed out above, the magnetic flux changes or an emf is induced if any of *B*, *A* or θ changes. Below are some examples:

Example where B changes:

Example where A changes:



Example where θ changes:



θ = 0° θ = 60° θ = 90°