9.2: Magnetic Flux

Learning Objectives

By the end of this section, you will be able to:

- Calculate the flux of a uniform magnetic field through a loop of arbitrary orientation.
- Describe methods to produce a source voltage with a magnetic field or magnet and a loop of wire.

The method of inducing an source voltage used in most electric generators is shown in Figure $9.2.1$. A coil is rotated in a magnetic field, producing an alternating current source voltage, which depends on rotation rate and other factors that will be explored in later sections. Note that the generator is remarkably similar in construction to a motor (another symmetry).

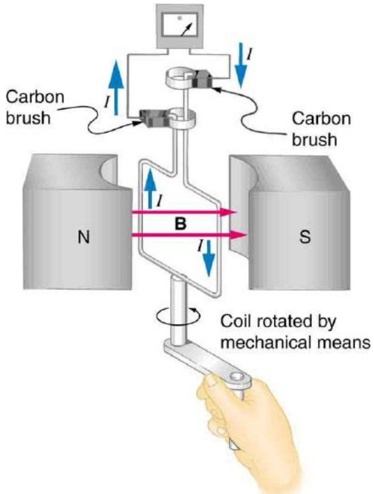

Figure $9.2.1$: Rotation of a coil in a magnetic field produces a source voltage. This is the basic construction of a generator, where work done to turn the coil is converted to electric energy. Note the generator is very similar in construction to a motor.

So we see that changing the magnitude or direction of a magnetic field produces a source voltage. Experiments revealed that there is a crucial quantity called the **magnetic flux**, Φ, given by

$$\Phi = BA\cos\theta, \tag{9.2.1}$$

where B is the magnetic field strength over an area A, at an angle θ with the perpendicular to the area as shown in Figure $9.2.2$.

Any change in magnetic flux Φ induces an source voltage. This process is defined to be **electromagnetic induction**. Units of magnetic flux Φ are $T \cdot m^2$. As seen in Figure $\boxed{\text{\PageIndex{2}}}$, $B\cos\theta = B_{\perp}$, which is the component of B perpendicular to the area A. Thus magnetic flux is $\Phi = B_{\perp}A$, the product of the area and the component of the magnetic field perpendicular to it.

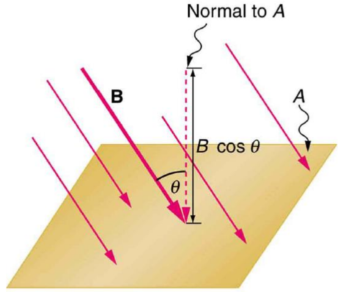

Figure $9.2.2$: Magnetic flux Φ is related to the magnetic field and the area over which it exists. The flux $\Phi = BA\cos\theta$ is related to induction; any change in Φ induces a source voltage.

All induction, including the examples given so far, arises from some change in magnetic flux Φ. For example, Faraday changed B and hence Φ when opening and closing the switch in his apparatus. This is also true for the bar magnet and coil. When rotating the coil of a generator, the angle θ and, hence, Φ is changed. Just how great a source voltage and what direction it takes depend on the change in Φ and how rapidly the change is made, as examined in the next section.
