Magnetic Flux

1 Introduction

The definition of magnetic flux is

$$\Phi_B = \int \vec{\mathbf{B}} \cdot d\mathbf{A}$$

When the magnitude and direction of $\vec{\mathbf{B}}$ are the same at all points on the surface, the integral simplifies to

$$\Phi_B = \vec{\mathbf{B}} \cdot \mathbf{A}$$

or, equivalently,

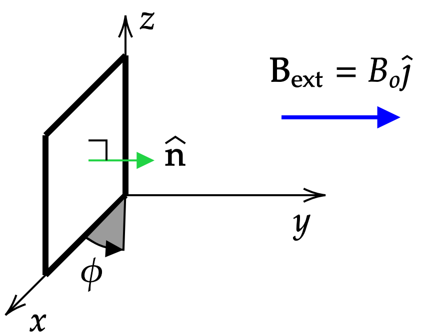
$$\Phi_B = BA\cos\phi$$

where ϕ is the angle between the $\vec{\mathbf{B}}$ and $\vec{\mathbf{A}}$ vectors.

Note that previously, electric flux was covered. The same techniques that apply to computing electric flux apply to magnetic flux. See the Electric Flux activity for additional discussion.

2 Computing Φ_B

In the following figure, a square loop of area A that can be rotated about the z axis is shown. Assume that the normal direction of the loop is as shown in the diagram. A uniform external magnetic field points in the $\hat{\jmath}$ direction.



1. At what angles in the range of $\phi = [0, 360°]$ is the magnetic flux zero?

2. Draw the loop, $\hat{\mathbf{n}}$, and $\vec{\mathbf{B}}_{\text{ext}}$ as they would appear when viewed from large z when $\phi = 0°$, $\phi = 45°$, $\phi = 135°$, and $\phi = 180°$.

3. When $\phi = 45°$, is the magnetic flux positive or negative? What is its value in terms of a fraction of B_oA?

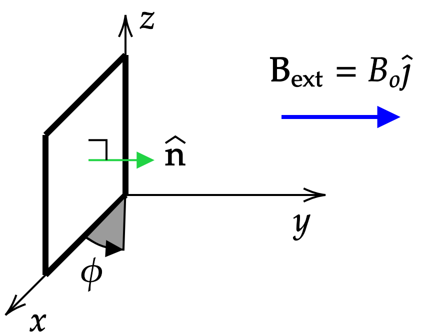
4. When $\phi = 135°$, is the magnetic flux positive or negative? What is its value in terms of a fraction of B_oA?

5. Sketch a plot of the magnetic flux, Φ_B, as a function of ϕ.

3 Computing $d\Phi_B/dt$

The time rate of change of magnetic flux through a closed loop is a quantity that will be used when Faraday's law is covered.

Suppose the loop in the previous problem rotates at a constant rate.



1. At what angles in the range $\phi = [0^\circ, 360^\circ]$ is $d\Phi_B/dt = 0$?

2. For what angle range is $d\Phi_B/dt$ increasing?

3. For what angle range is $d\Phi_B/dt$ decreasing?

4. What is the formula for $d\Phi_B/dt$?