Magnetic Flux

1 Introduction

The definition of magnetic flux is

$$\Phi_B = \int ec{f B} \cdot d{f A}$$

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,

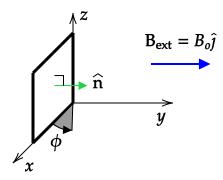
$$\Phi_B = BA\cos\phi$$

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{j} direction.



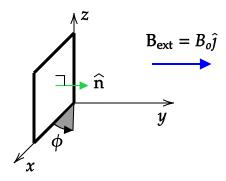
- 1. At what angles in the range of $\phi = [0, 360^\circ]$ is the magnetic flux zero?
- 2. Draw the loop, $\hat{\bf n}$, and $\vec{\bf B}_{\rm ext}$ as they would appear when viewed from above (on the positive z-axis) when $\phi=0^{\circ}$, $\phi=45^{\circ}$, $\phi=135^{\circ}$, and $\phi=180^{\circ}$.

- 3. When $\phi = 45^{\circ}$, is the magnetic flux positive or negative? What is its value in terms of a fraction of $B_o A$?
- 4. When $\phi=135^{\circ}$, 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 such that $\phi = \omega t$, where ω is a contant.



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 $d\Phi_B(t)/dt$ in terms of B_o , A, t, and ω ?