Lecture 35

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1 Motional Electromotive Force

Consider a sliding bar along an open loop in the presence of magentic fields. We can see this as a changing magnetic flux, where

$$V_{\text{emf}} = -\frac{\partial \Phi}{\partial t} = -B_0 \frac{dS}{dt}$$

Now $S(t) = lu_0 t$, so $V_{\text{emf}} = -B_0 l u_0$

Alternatively, this can be seen as electrons move with the bar, in the presence of a field, which produces a force on the electrons. This produces a current. Then

$$\begin{aligned}
V_{\text{emf}} &= -\frac{\partial \Phi}{\partial t} \\
&= \oint_C \frac{\vec{F} \cdot d\vec{l}}{q} \\
&= \oint_C \vec{u} \times \vec{B} \cdot d\vec{l} \\
&= \int_0^{-l} u_0 \hat{a}_y \times B_0 \hat{a}_z \cdot dx \hat{a}_x \\
&= -u_0 B_0 l
\end{aligned}$$

Example 1.1. Consider a short-circuited loop with fixed area S which lies in the xy-plane with a resistance R. It moves through a static magnetic field $B_0 y \hat{a}_z$. It is moved with a constant velocity $u_0 \hat{a}_y$. Find the induced emf and

current in the loop.
Now
$$V = -\frac{\partial \Phi}{\partial t} = -\frac{\partial \Phi}{\partial y}\frac{dy}{dt} = -B_0 S u_0$$
and current is $\frac{B_0 S u_0}{R}$ in the clockwise direction.

2 AC Generator

With a constant $\vec{B}$ field and a rotating loop, a current is produced.

$$\begin{aligned} V_{\text{emf}} &= -\frac{\partial \Phi}{\partial t} \\ &= -\frac{\partial}{\partial t}\iint \vec{B} \cdot d\vec{S} \\ &= -\frac{\partial}{\partial t} B_0 S \cos(\omega t) \\ &= B_0 S \omega \sin \omega t \end{aligned}$$