Lecture 33

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1 Inductance

Example 1.1. Consider a falling magnet with north pointing downwards, about to fall through a coil. The applied $\vec{B}$ field points downwards and is increasing. The induced $\vec{B}$ field is pointing upwards, and it is also increasing. As the magnet passes the coil, the applied $\vec{B}$ field still points downwards, but it is decreasing. The induced $\vec{B}$ field points upwards, and is increasing.

Example 1.2. Considering a loop moving to the right with a constant speed. It is sandwiched by a pair of finitely large magnets, with the south pole on top. Then

$$V_{\text{emf}} = -N\frac{\partial \Phi}{\partial t} = -\frac{\partial \Phi}{\partial t} = -B\frac{\partial A}{\partial t}$$

Note that in Faraday's Law, as used above, Φ refers to total flux or net flux. We can also write

$$V_{\text{emf}} = -\frac{\partial \Phi_{\text{net}}}{\partial t} = -\frac{\partial}{\partial t}(\Phi_{\text{app}} + \Phi_{\text{ind}}) = Ri_{\text{ind}} + L\frac{di_{\text{ind}}}{dt} = V_R + V_L$$

which is just a RL circuit. This can be solved as a differential equation, or we can use the approximation

$$i_{\text{ind}} \approx \frac{V_{\text{emf}}}{R}$$

which holds if L or $\frac{di}{dt}$ is small.