Monday Reading Assessment: Unit 5, Field Induction and Inductance

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1 Memory Bank

- $M = \frac{N\phi}{I}$ ... Definition of mutual inductance.
- $\epsilon = -MdI/dt$ ... Relationship between induced voltage and inductance, and changing in current.
- $M_{21} = (N_2\phi_{21})/I_1$ ... Mutual inductance in solenoid 2 due to solenoid 1 with current 1.
- $P = i\epsilon$ ... Power is current times voltage.

2 Mutual Inductance

1. Consider Fig. 1, in which two solenoids are *ideally* coupled with an iron core. *Ideally* means that $\phi_{12} = \phi_{21}$, and this occurs because of the properties of iron atoms. Let solenoid P have N_1 turns, and AC voltage ϵ_1, while solenoid 2 has N_2 turns, and AC voltage ϵ_2. Show that
$$\frac{\epsilon_2}{\epsilon_1} = \frac{N_2}{N_1} \tag{1}$$

2. If the maximum voltage of $\epsilon_1(t)$ is 2 kV, with $N_1 = 1000$ turns, and we want the maximum of $\epsilon_2(t)$ to be 120 V, how many turns should we put in solenoid S?

3. Since energy has to be conserved, the power flowing into the transformer has to equal the power flowing out. Convince yourself that
$$i_P\epsilon_P = i_S\epsilon_S \tag{2}$$
If the current flowing into the transformer is 2.0 A, what current flows out?

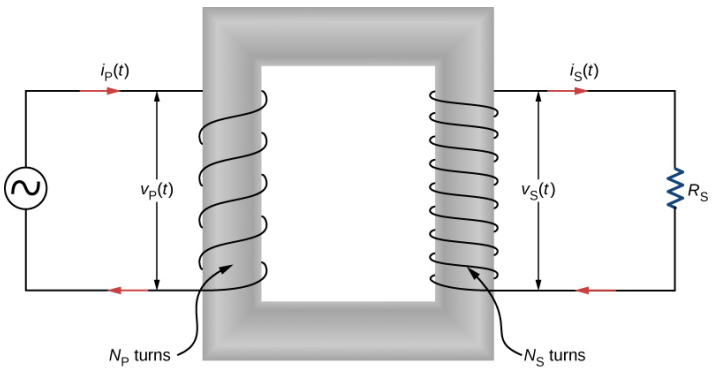

Figure 1: A cross-sectional view of a solenoid.