Friday Reading Assessment: Unit 5, Field Induction and Inductance

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1 Memory Bank

- $\epsilon = -N d\phi_m/dt$ ... Faraday's Law
- $N d\phi/dt = \oint \vec{E}\cdot d\vec{l}$ ... Induced E-field due to Faraday's law

2 Induced Electric Fields

1. Consider Fig. 1. Let the radius from the center of the solenoid to the outer edge be R. The turns per unit length is $n = N/L$, where N is the total number of tursn and L is the length. The current is I. Prove that the B-field inside the solenoid is
$$\vec{B} = \mu_0 n I \hat{x} \tag{1}$$
The direction $\hat{x}$ is whichever direction is appropriate given the direction of the current (RHR-2).

2. Imagine a single circular loop of wire with radius r inside the solenoid. If a uniform E-field $\vec{E}$ along this loop exists, show that
$$\oint \vec{E}\cdot d\vec{l} = 2\pi r E \tag{2}$$

3. Supose the current I started to shift: $I(t) = I_0 + bt$. (a) What would be the induced electric field along the loop inside the solenoid? Is it a constant? (b) What would have to change in order to make the E-field depend on time?

4. Suppose for a brief moment that $a = 100$ A/s, and that $n = 1000$ turns per meter. Let also the inner coil have $N = 100$ turns and a radius of $r = 1$ cm. What is the induced E-field value?

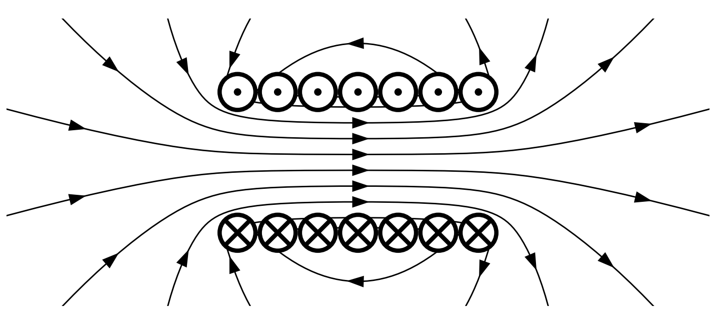

Figure 1: A cross-sectional view of a solenoid.