Wednesday Reading Assessment: Unit 5, Field Induction and Inductance

Prof. Jordan C. Hanson

March 27, 2024

1 Memory Bank

- $\epsilon = -L\frac{\Delta I}{\Delta t}$ ... Faraday's law with induction, L. Think of this as the change in voltage across an inductor.
- Kirchoff's loop rule: the sum of all changes in voltage around a loop in a circuit must be zero.

2 RL Circuits

1. Consider the DC circuit in Fig. 1. There is a battery emf ϵ connected to a resistor R and and inductor L via switch 1. Switch 2 simply connects L and R. Suppose we observe the current through the circuit when switch 1 is closed to be

$$i(t) = \frac{\epsilon}{R}\left(1 - \exp(-t/\tau)\right) \tag{1}$$

(a) In terms of the variables given, what is the current at time $t = 0$, when switch 1 is closed? (b) In terms of the variables given, what is the current when t is much larger than τ? (This is like the situation in part (b) of Fig. 1).

2. After switching out the resistor and inductor independently, we determine that $\tau = L/R$. (a) What is τ when $R = 1$ kΩ, and $L = 0.2$ Henries? (The units should be seconds). (b) What will the time constant τ be if we double R and quadruple L?

3. Now we return to experimenting, to find out what happens when switch 2 is closed and switch 1 is opened. We do this after switch 1 has been closed for a long time, so that initially, $i \approx \epsilon/R$. The equation is observed to be

$$i(t) = \frac{\epsilon}{R}\exp(-t/\tau) \tag{2}$$

What time passes before the current is reduced to half of its original value?

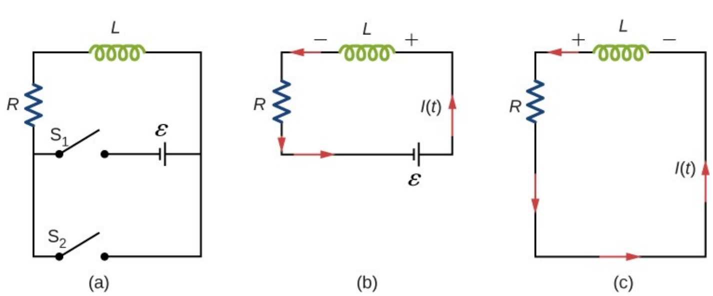

Figure 1: A circuit diagram of a DC emf with a resistor, inductor, and two switches.