VP240-1 Recitation class
Week #8

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Brief introduction

- The hardest part has already begun.

1 Short Review

1. General Idea
   - Electromagnetic induction: If the magnetic flux through a circuit changes, an emf and a current are induced in the circuit.
   - The central principle of electromagnetic induction is Faraday's law.
   - Electromagnetic induction tells us that a time-varying magnetic field can act as a source of electric field. We will also see how a time-varying electric field can act as a source of magnetic field. These remarkable results form part of a neat package of formulas, called Maxwell's equations.
2. Motional emf

   The common element in these experiments is changing magnetic flux through the coil connected to the galvanometer. In each case the flux changes either because the magnetic field changes with time or because the coil is moving through a nonuniform magnetic field. What's more, in each case the induced emf is proportional to the rate of change of magnetic flux through the coil. The direction of the induced emf depends on whether the flux is increasing or decreasing. If the flux is constant, there is no induced emf.

   $$\varepsilon = \oint_r (\bar{v} \times \bar{B}) \cdot d\bar{l} \tag{1}$$

   What does work hare? Pulling force. Note: Current in the direction to oppose the puling force (magnetic force out the for acts to left). This magnetic force causes the free charges in the rod to move, creating an excess of positive charge at the upper end a and negative charge at the lower end b. This in turn creates an electric field E within the rod, in the direction from a toward b (opposite to the magnetic force).

   But when we have stationary conductors in changing magnetic fields, Eq. (29.7) cannot be used; in this case, $\mathcal{E} = -d\Phi_B/dt$ is the only correct way to express Faraday's law.
3. flux rule for motional emf

   The flux through the surface bounded by Γ:$\Phi_B = \int_\Sigma \bar{B} \cdot d\bar{A} = BXh$

   Thus, the flux rule for motional emf is $\mathcal{E} = -\frac{d\Phi_B}{dt}$
4. current generators(slidewire, disk dynamo, alternator)

   Dicussed in class

5. Lenz's Rule

   The direction of any magnetic induction effect is such as to oppose the cause of the effect.

> **Info:**
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> - The "cause" may be changing flux through a stationary circuit due to a varying magnetic field, changing flux due to motion of the conductors that make up the circuit, or any combination. If the flux in a stationary circuit changes, as in Examples 29.1 and 29.2, the induced current sets up a magnetic field of its own. Within the area bounded by the circuit, this field is opposite to the original field if the original field is increasing but is in the same direction as the original field if the latter is decreasing. That is, the induced current opposes the change in flux through the circuit (not the flux itself).

6. More should be discussed in the later recitation class

2 Discussion

- Q29.5 You have just bought a voltage generator, but now you need an increased voltage output from it. What are the parameters you could change to increase the output?
- Q29.7 An airplane is in level flight over Antarctica, where the magnetic field of the earth is mostly directed upward away from the ground. As viewed by a passenger facing toward the front of the plane, is the left or the right wingtip at higher potential? Does your answer depend on the direction the plane is flying?
- Q29.10 A square conducting loop is in a region of uniform, constant magnetic field. Can the loop be rotated about an axis along one side and no emf be induced in the loop? Discuss, in terms of the orientation of the rotation axis relative to the magnetic-field direction.
- Q29.15 Is it possible to induce a current in a wire loop moving with constant velocity without rotation through a constant magnetic field? Explain.
- Q28.9 A current was sent through a helical coil spring. The spring contracted, as though it had been compressed. Why?
- Q29.17 Can one have a displacement current as well as a conduction current within a conductor? Explain.
- DC generator and magnitude and direction of an induced emf

3 Problems and exercises

Question 1

Exercises: 29.11, 29.19, 29.24, 29.35, 29.45

Question 2

Problems: 29.59, 29.65, 29.74, challenge problem 29.76 (time permitting)