ECE221 – ELECTRIC AND MAGNETIC FIELDS

Hardware Lab
Wireless Power & Magnetic Coupling

1. Overview

In this lab, you will explore how magnetic fields enable wireless power transfer—a principle used in electric vehicle charging, wireless phone chargers, NFC, robotic systems, and more. You will build two coils, investigate how magnetic coupling works, and experiment with optimizing power transfer through distance, alignment, orientation, and core materials.

2. Learning Objectives

- Visualize magnetic coupling between two coils
- Measure how distance and alignment affect induced voltage
- Understand the concept of mutual inductance
- Explore efficiency factors in wireless power transfer
- Relate your observations to real Electric Vehicle wireless charging systems

3. Equipment

- Function generator (10–200 kHz range)
- Two air-core coils (≈ 10–30 turns of enamel wire)
- Ferrite core (optional)
- Oscilloscope
- Ruler or calipers
- Tape + markers for measurement points

4. Pre-Lab (Short)

- Watch the 3-minute video posted on Quercus: “How Wireless Power Works”
- Review Faraday’s Law and magnetic flux concepts:
- $V_{induced} = -N.\frac{d\Phi}{dt}$
- Bring a laptop (optional) if you want to graph your data during lab

5. Activity 1 — Build and Test Your Coils

1. Take two air-core coils provided at your station.
2. Connect Coil A (transmitter) to the function generator at 50 kHz.
3. Use the oscilloscope to observe the voltage waveform at Coil B (receiver).
4. Confirm you can detect induced voltage even at small spacing.

6. Activity 2 — Distance vs. Coupling

1. Set transmitter frequency to 50 kHz.
2. Start with coils touching, then gradually separate them in 1 cm increments.
3. Record induced voltage at each distance.
4. Plot $V_{induced}$ vs. distance.
5. Identify the approximate exponential decay trend.

7. Activity 3 — Orientation & Alignment

Experiment with misalignment:

- Rotate receiver coil by 15°, 30°, 60°, 90°
- Shift it sideways by 1–3 cm
- Observe changes in induced voltage

Goal: determine which alignment yields maximum coupling.

8. Activity 4 — Enhancing Power Transfer

Try at least two enhancements:

- Insert a ferrite core
- Increase number of turns
- Reduce coil spacing
- Record how each change affects induced voltage.

9. Engineering Connection (Short + Modern)

- EV wireless charging pads use resonant magnetic coupling
- NFC and keycards operate on identical principles at lower power levels
- Wireless phone chargers optimize alignment, coil shape, and ferrite backing

10. Deliverables

- A table of distance vs. induced voltage
- A plot of $V_{induced}$ vs. distance
- One paragraph on orientation effects
- One paragraph on improvement techniques tested
- Answer to the reflection question: "Why does alignment matter more than distance in some cases?"

12. Pre-Lab Quiz

Answer these questions before attending the lab:

1. What physical principle allows wireless energy transfer between coils?
2. How does distance affect magnetic coupling between two coils?
3. Define mutual inductance in your own words.
4. Why might adding a ferrite core improve power transfer efficiency?
5. Predict what will happen if the receiver coil is rotated by 90°.