Lenz's and Faraday's Laws

As you work through the steps in the lab procedure, record your experimental values and the results on this worksheet. Use the exact values you record for your data to make later calculations.

Faraday's Law Lab − Simulation and Tools

Open the Faraday's Law simulation to do this lab.

IA. The Magnetic Field at the Center of a Solenoid Carrying a Direct Current

1. Your current should be 6.00 A. Calculate the **theoretical** value for the magnetic field at the center of the solenoid.

Show your calculations here.

7. In the Graph Tool, the bottom graph displays the magnetic field measured by the probe at its tip. This should be constant in this case. Record this value below in both Gauss and Tesla units. Remember 1 Gauss $= 10^{-4}$ Tesla. Round the experimental values to the nearest gauss.

8. Calculate the percent error between the theoretical and experimental values for the magnetic field at the center of the solenoid.

IB. Variation of the Magnetic Field Along the Axis of the Solenoid

6. Complete the table.

Table 1: Magnetic Field at Five Positions Along the Solenoid Axis

$B_{\text{min(left)}}$ (G)	$B_{\text{sol(left)}}$ (G)	$B_{\text{sol(center)}}$ (G)	$B_{\text{sol(right)}}$ (G)	$B_{\text{min(right)}}$ (G)

7d. Take a **Screenshot** of your magnetic field graph and save it as "Faraday_Bmin_max.png". Upload it and/or print it out and attach it to your lab report to turn in. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

8. How would you describe the variation of B in the middle third of the length of the solenoid?

IIA. Initial Exploration of Induced Emf

1. Induced Emf Due to the Motion of a Coil Relative to a Field

3. Save your graph as "Faraday_5_points.png". Upload it and/or print it out and attach it to your lab report to turn in. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

5. Why is B changing when you jiggle the coil?

6. With steady jiggling, where along the solenoid axis is the greatest emf produced? Why?

7. As shown by your graph, the solenoid's field is at a maximum near its center and nearly zero far away from the solenoid. Why is the emf produced at both these places so small?

2. Induced Emf Due to a Change in Solenoid Field Due to a Change in Solenoid Current

16. What if you went backwards through the currents and made the jumps take longer? Describe what would be different about the return trip with the slower current changes.

18. Take a **Screenshot** of your voltage and emf graphs and save it as "Faraday_Emf_steps.png". Upload it and/or print it out and attach it to your lab report to turn in. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

IIB. Using the Function Generator to Vary the Field in the Solenoid

4. After turning on the function generator, you should already notice something different happening. What is it?

IIC. Induced Emf Due to a Sinusoidal Variation in the Magnetic Field − a Qualitative Investigation

6. What's the fundamental difference between the two pairs? (It's not the amplitude difference.)

7. Drag your Graph Tool to the middle of a voltage peak as shown in Figure 16.

   (a) Record t_1 and I_1 at that maximum current instant.

   (b) Record t_2 and I_2.

(c) Calculate $\Delta I = I_2 - I_1$.

8. Drag your Graph Tool a bit to the right to the steep part of the (V, t) graph where the graph crosses the time axis.

(a) Record t_3 and I_3.

(b) Record t_4 and I_4.

(c) Calculate $\Delta I = I_4 - I_3$.

9. Which of these 0.1-s intervals involved the **greater magnitude currents**?

- the first, near $V_{\max}$

- the second, near $V = 0$

10. Which of these 0.1-s intervals involved the **greater magnitude magnetic fields**?

- the first, near $V_{\max}$

- the second, near $V = 0$

11. Which of these 0.1-s intervals involved the **greater magnitude change in current**?

   - the first, near V_{max}

   - the second, near $V = 0$

12. Which of these 0.1-s intervals involved the **greater magnitude change in magnetic field**?

   - the first, near V_{max}

   - the second, near $V = 0$

13. Which of these 0.1-s intervals resulted in the **greater magnitude induced emf in the coil**?

   - the first, near V_{max}

   - the second, near $V = 0$

IID. Induced Emf Due to a Triangular Variation in the Magnetic Field - a Quantitative Investigation

7. Record that constant emf value as emf$_{\text{measured}}$.

8-10. Complete the table. Be sure to include the signs for the currents.

Table 2: Emf Measured by Pickup Coil and Calculated from Faraday's Law

	Time (s)	Current (A)	$B_{\text{(calculated)}}$ (T)
Point 1 - Start Constant Emf			
Point 2 - End Constant Emf			

Show your calculations below for the magnetic field.

11. Calculate the theoretical emf.

Show your calculations.

12. Calculate the percentage error between the theoretical and measured values for the emf.

If it's more than a few percent (5%), you probably need to retake your data or ask for help.

IIE. Maximizing the Emf

Decreasing Δt – The Effect of Frequency on Induced Emf

2-7. Complete the table.

Table 3

	emf$_{\text{measured}}$ (mV)	Period (s)	Frequency (Hz)
Frequency, f_1			
Frequency, f_2			

3. Show your calculations for T_1 and f_1.

7. Show your calculations for T_2 and f_2.

8. Calculate the ratio f_2/f_1.

9. How does the emf generated using the frequency f_2 compare to the emf generated using a frequency f_1?

11. What has changed in the f_2 section of the voltage, current graph as a result of doubling the frequency?

12. Explain why this should affect the induced emf, and specifically explain why the emf doubled when the frequency doubled. Remember that emf $= -NA\dfrac{\Delta B}{\Delta t}$ and $B = \mu_o nI$.

Effect of the Number of Turns, *N*, on the Pickup Coil on the Induced Emf

4. Record your original measured emf for Part IIE.

5. What do you predict for your new emf with $N = 128$ and $f = f_4$? Explain your reasoning.

7. Record your measured emf for f_4 and N = 128.

Hopefully you found that the emf was multiplied by a factor of approximately eight. If not, try again.