Physics Department
Electricity and Magnetism Laboratory

Lab Group			Students who hand in the report	Control Stamp
Session Date				
Deadline Date				

ELECTROMAGNETIC INDUCTION. FARADAY'S LAW.

Note:

- ***Include in the tables all units and uncertainties of the measurements.***

5.1. Electric current induced in a coil by a magnet.

A) Choose one of the poles of the magnet and move it towards the coil quickly until the magnet is fully inside the coil. What’s the direction of the line that represents the voltage in the screen of the oscilloscope?

Change to the other pole of the magnet and repeat the same. What’s now the direction of the line that represents the voltage in the screen of the oscilloscope?

Why does this happen?

B) Keeping the same pole as in the previous case, repeat part A) but moving the magnet slowly. What difference do you find?

C) Keeping the same pole as in the previous case, move the magnet quickly towards the coil until is fully inside of it, and then retreat it quickly until is fully outside. Indicate what happens to the line that represents the voltage in the screen of the oscilloscope.

Why does this happen?

D) Repeat part C) using another coil with higher or lower number of turns. Try to move the magnet at the same speed as in part C). What difference do you find?

5.2. Electric current induced in a coil by another coil.

- f_{gen} : frequency selected in the generator
- I_{rms} : current measured in the multimeter
- T_{osc} : period measured in the oscilloscope
- f_{osc} : frequency of the oscillation
- V_{pp} : peak to peak voltage measured in the oscilloscope
- ε_0 : amplitude of the oscillation

I_{rms} = ± ( )

REMARK: When the frequency of the signal is changed in the source, the intensity also varies. It is required to k*eep the intensity measured in the multimeter to a **constant value**.* In order to do that, change the amplitude in the source until you measure the same intensity you had before changing the frequency.

A) Indicate the expressions you have used to obtain f_{osc} and its uncertainty Δf_{osc}:

f_{osc} =

Δf_{osc} =

B) Indicate the expressions you have used to obtain ε_0 and its uncertainty $\Delta\varepsilon_0$:

ε_0 =

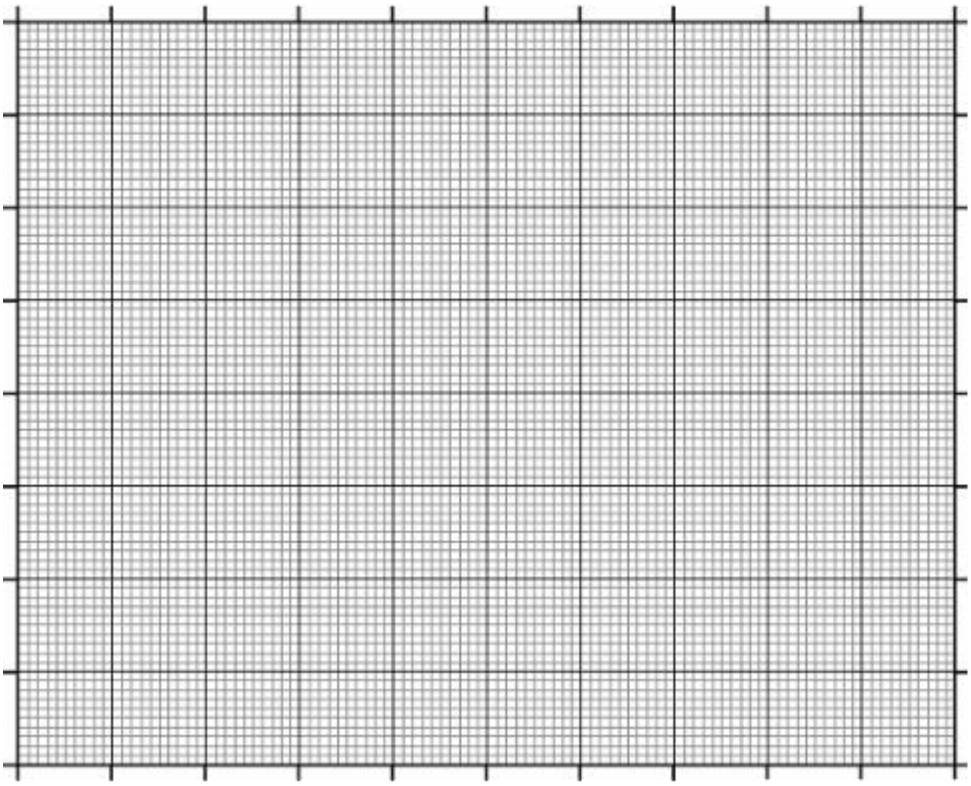
$\Delta\varepsilon_0$ =

f_{gen} ( )	t scale ± Δ t scale ( )	$T_{osc} \pm \Delta T_{osc}$ ( )	$f_{osc} \pm \Delta f_{osc}$ ( )	V scale ± Δ V scale ( )	$V_{pp} \pm \Delta V_{pp}$ ( )	$\varepsilon_0 \pm \Delta\varepsilon_0$ ( )

C) Using Faraday´s law and the fact that the magnetic field (B) inside a coil in which flows a current (I) is: $B = \mu_0 nI = \mu_0 nI_0 \cos\omega t$, *to* obtain the small coil induced emf to demonstrate it is a sinusoidal function with the same frequency that the generator.

D) Obtain the expression of the amplitude of the emf on the small coil as a function of frequency of the generator (ω)

E) Plot V_{pp} as a function of f_{gen} values depicted in the above table. Plot the straight line obtained in the linear least squares fitting calculated below.



- **Least squares fitting of $y = V_{pp}$ with respect to $x = f_{gen}$**

$$\sum x_i =$$
$$\sum y_i =$$
$$\sum x_i y_i =$$
$$\sum x_i^2 =$$
$$n =$$
$$\sigma =$$

- **Results of the linear least squares fitting:**

  - Slope:

m = Δm =

m = ± ( )

  - y-intercept:

b = Δb =

b = ± ( )

- **Discuss the meaning of the calculated parameters m and b (Hint: apply Farady's Law of induction):**

5.3. Measure the magnetic field inside a solenoid.

Solenoid data:

- number of turns of solenoid:

  $N =$

- length of the solenoid:

  $L = \qquad \pm \qquad (\quad)$

- number of turns per unit length:

  $n =$

  $\Delta n =$

  $n = \qquad \pm \qquad (\quad)$

- radius of the solenoid:

  $a =$

  $\Delta a =$

  $a = \qquad \pm \qquad (\quad)$

Probe data:

- number of turns of the small coil:

  $N_c =$

- radius of small coil:

  $R_c =$

  $\Delta R_c =$

  $R_c = \qquad \pm \qquad (\quad)$

- area of each turn of the small coil:

  $A_c =$

  $\Delta A_c =$

A_c = ± ( )

(a) Experimental measurement of the magnetic field (B_0) inside the solenoid.

- frequency selected in the generator:

  f = ± ( )

- angular frequency:

  ω =

  $\Delta\omega$ =

  ω = ± ( )

- solenoid current:

  I_{rms} = ± ( )

  I_0 =

  ΔI_0 =

  I_0 = ± ( )

- x: distance from the center of the solenoid to the small coil.
- V_{pp} : peak to peak voltage measured in the oscilloscope

- ε_0 : amplitude of the oscillations measured in the oscilloscope
- B_0 : amplitude of the magnetic field inside the solenoid

$$B_0 = \frac{\varepsilon_0}{N_c A_c \omega}$$

E) Indicate how you have obtained ε_0 and its uncertainty $\Delta\varepsilon_0$:

ε_0 =

$\Delta\varepsilon_0$ =

F) Indicate how you have experimentally obtained the magnetic field B_0 and its uncertainty ΔB_0:

B_0=

ΔB_0 =

(b) **Obtain the magnetic field (*B_0*) inside the solenoid from the theoretical expression [7]**

G) Get *B_0* at each point *x* of the solenoid using the theoretical expression:

$$B_0 = \frac{\mu_0 n I_0}{2}\left(\cos\beta_2 - \cos\beta_1\right)$$

$x \pm \Delta x$ ( )	$V_{pp} \pm \Delta V_{pp}$ ( )	$\varepsilon_0 \pm \Delta\varepsilon_0$ ( )	$B_0 \pm \Delta B_0$ ( )

Where:

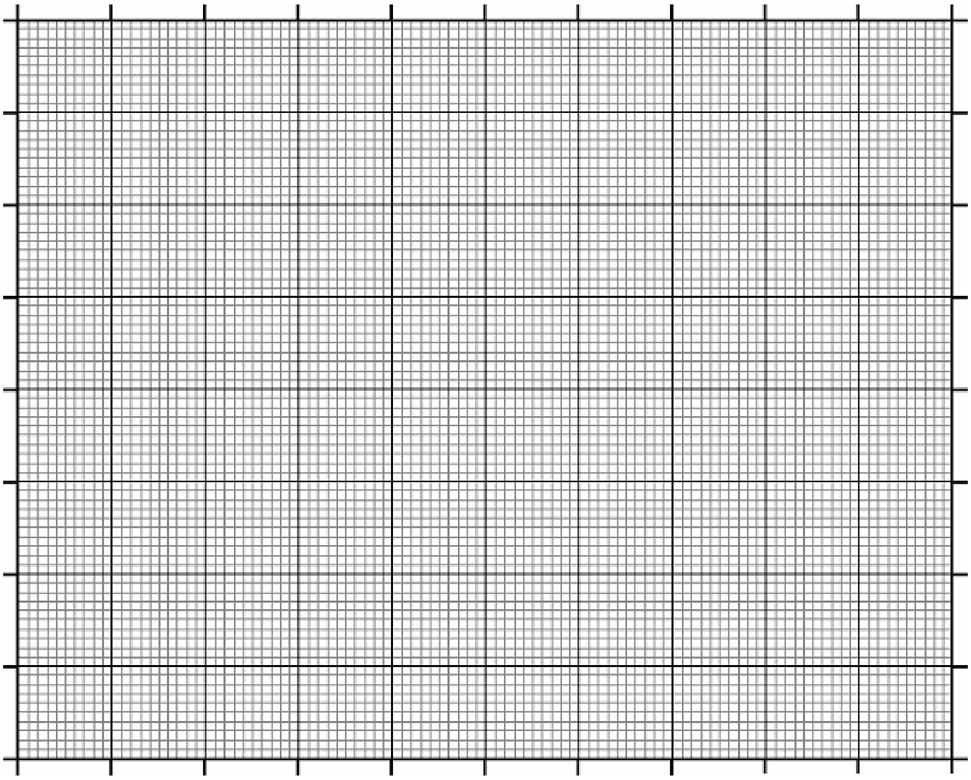
$$\cos\beta_1 = -\frac{\frac{L}{2} - x}{\sqrt{\left(\frac{L}{2} - x\right)^2 + a^2}}$$

$$\cos\beta_2 = +\frac{\frac{L}{2} + x}{\sqrt{\left(\frac{L}{2} + x\right)^2 + a^2}}$$

** the calculation of uncertainties is not necessary in this section

x **( )**	**Cos β_1**	**Cos β_2**	**B_0** **( )**

H) Plot theoretical and experimental values of B_0 as a function of x. Discuss the results.



<u>Discussion</u>: