Experiment 5 B

Induction impulse of a falling magnet

Apparatus:

Forked light barrier, Glass Tube, Magnet, Coil, Connecting Wires.

Purpose of the experiment:

(i) Study the induced voltage impulses as a function of velocity of the falling magnet.

(ii) Calculate the magnetic flux of the magnet.

Basic Methodology: Drop a bar magnet across a coil and study the induced voltages.

I Theory

The magnetic flux across a loop is expressed as

$$\phi = \int \mathbf{B.da}, \tag{1}$$

where **B** is the magnetic field across the loop. If there is time variation of magnetic field and/or area of the loop there is induced voltage across the loop. The induced voltage $\mathcal{E}$ across a loop is given by

$$\mathcal{E} = -\frac{d\phi}{dt}. \tag{2}$$

Now the flux through the loop can be calculated by

$$\phi = \int \mathcal{E} dt. \tag{3}$$

II Procedure

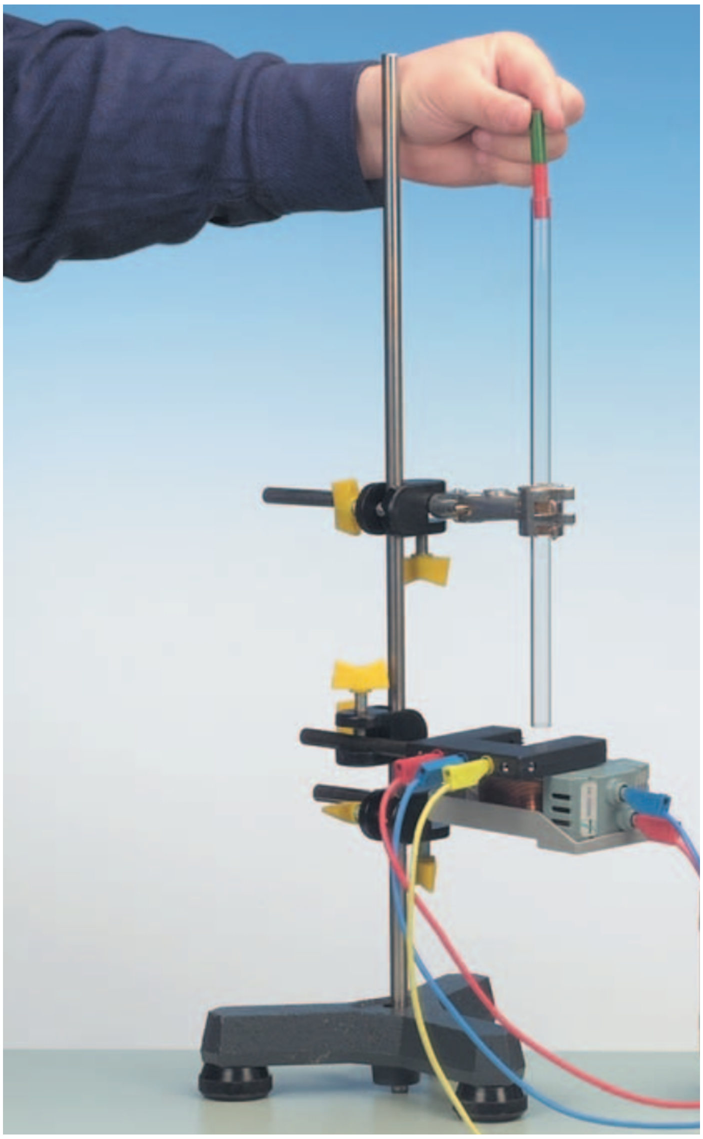

Figure 1: The experimental set-up

Figure 1 shows the experimental the set-up. Make sure that glass tube is in front of the infra-red light source of photo-gate, when magnet falls through the glass tube it should obstruct the light. The photo-gate is supplied 5 V for operation. The photo-gate output and the induced voltage across the coil both are read by the National Instruments Data Acquisition Card connected to the computer.

To collect and analyze the data, follow these steps:

1. Start the program "Photogate" from the desktop by double-clicking 

icon.

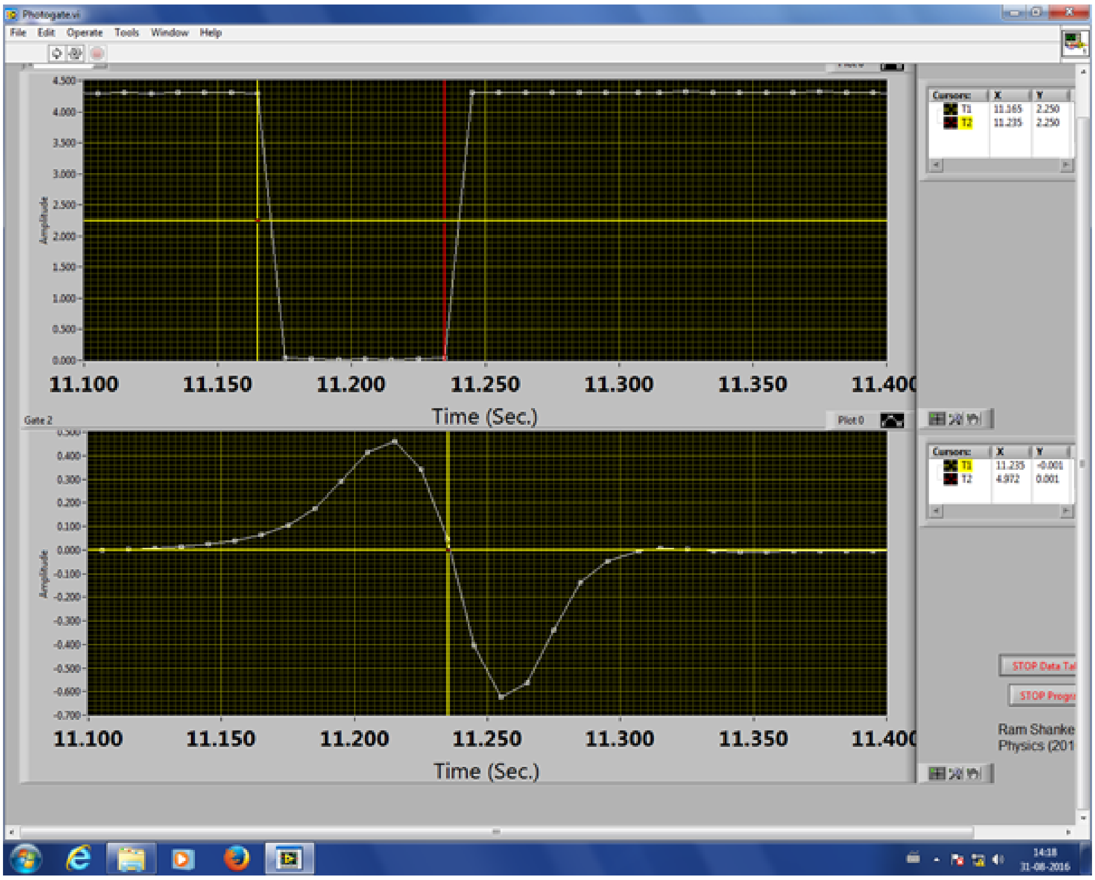

Figure 2: Screen-shot of Photogate LabView program which collects data for the experiment.

2. Run the program by pressing the arrow button . Top graph shows the output of the photo-gate with time. When there is no obstruction in front of the photo-gate the output would be nearly 4 volts but when there is obstruction the output would be nearly zero. If we know the length of the bar magnet and the time duration it took to pass through the photogate, we can estimate by which speed it passed through the photo gate.

3. The bottom graph shows the induced voltage across the coil as a function of time.

4. Drop the magnet through the glass tube, keep your hand at the other end of the glass tube and prevent the magnet from falling on table surface. If bar magnet falls on solid surface its magnetization will be reduced.

5. To stop the program, press “Stop Program” 

button. Now program will ask you to save data. Save the data on the desktop.

6. To analyze the data, start the QtiPlot program 

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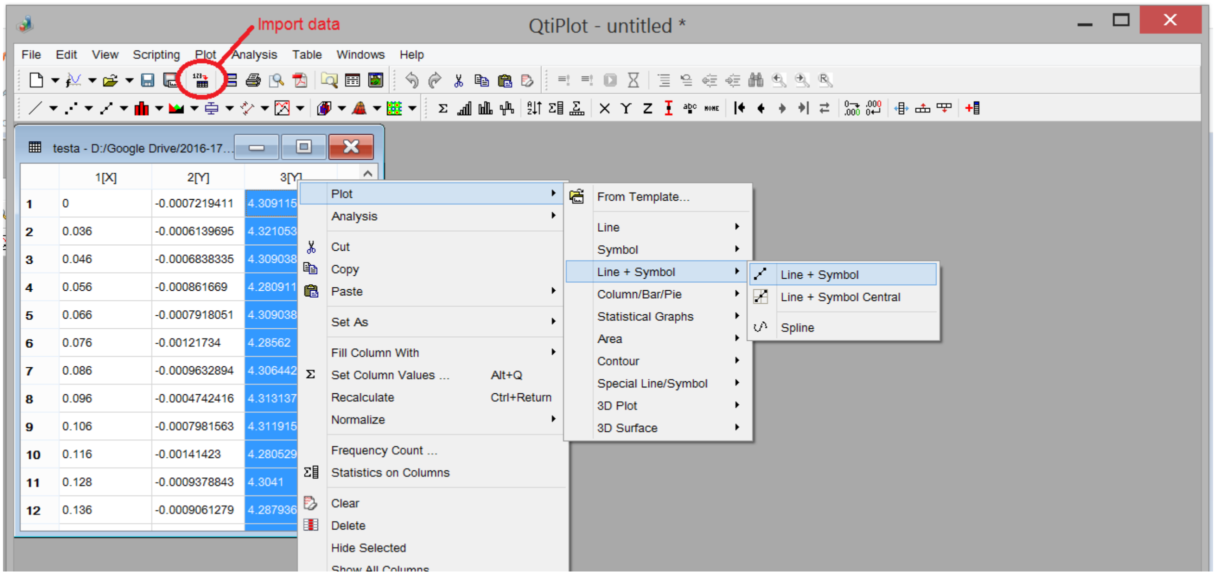

Figure 3: Screen-shot of QtiPlot program to analyze the data.

7. First import the data (Fig. 3, circled button). Column 1, 2, and 3 are time, voltage across the coil, and output of photogate data, respectively. Plot (a) Voltage across the coil vs. time and (b) Output of photo gate vs. time by right-clicking on the desired column as shown in Fig. 3.

8. Find out by which speed magnet crossed the photo-gate.

9. Observe the data for induced voltage when (i) the magnet is entering the loop and (ii) exiting the loop.

10. Calculate the magnetic flux when (i) the magnet is entering the loop and (ii) exiting the loop by numerical integration as shown in Fig. 4.

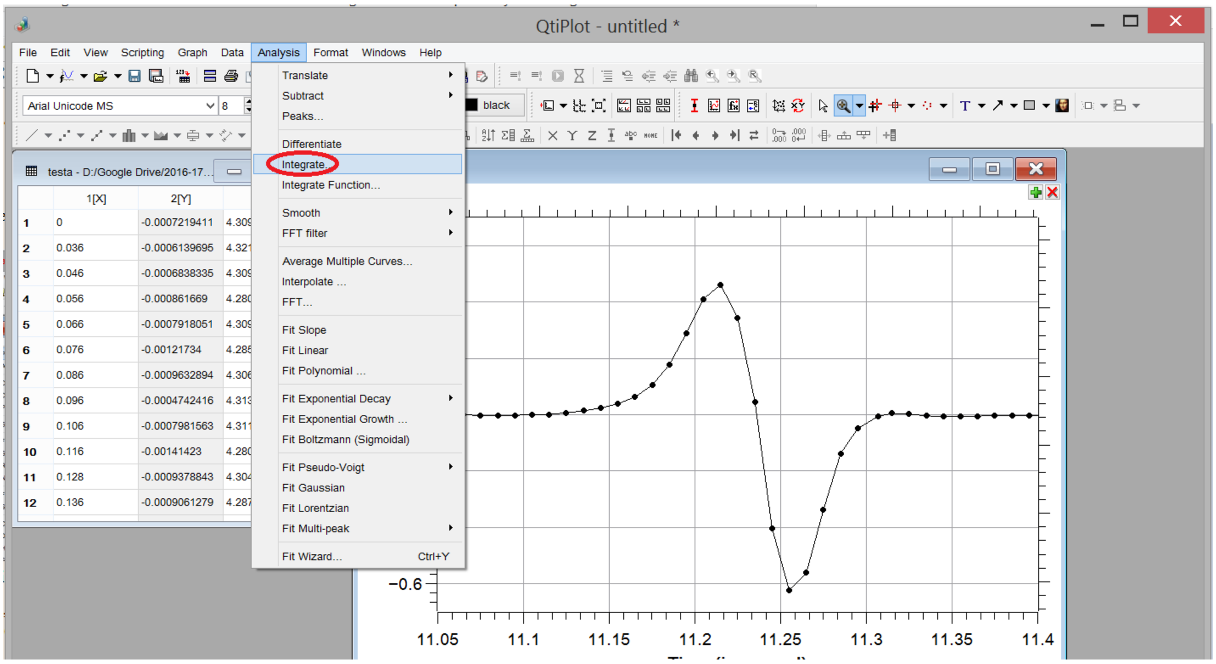

Figure 4: Screen-shot of QtiPlot program to estimate the flux through the coil.

11. Repeat the experiment for different speed of magnet (change the dropping height).

III Precaution

- Handle the magnet with care. Do not allow it to fall on the floor or table-top.

IV Exercises and Viva Questions

1. Why induced voltage across the loop is positive as well as negative?
2. Why the maximum induced voltage in positive and negative side is different?
3. Which parameters do decide the polarity of the induced voltage?