<div style="border: 2px solid black; padding: 20px;">

Appendix E: Software

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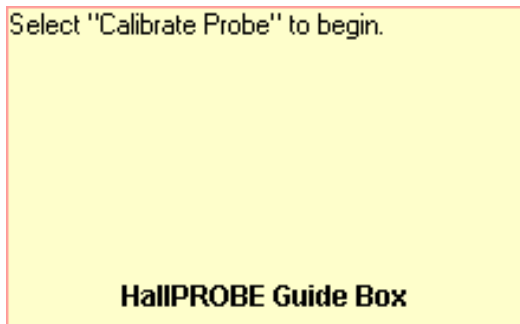## MEASURING CONSTANT MAGNETIC FIELD
(THE HALL PROBE APPLICATION)

Basics

Before you begin, you should ensure that you have read the relevant sections of *Appendix D* to familiarize yourself with the equipment.

The software package that works in tandem with your magnetic field sensor is written in LabVIEW™. It allows you to measure and record magnetic field strength as a function of a number of different variables.

After logging into the computer, execute the application by double clicking the "HallPROBE" icon on the desktop.

Before you start using the program, you should take a moment to identify several key elements. The two most important of these are the Command Panel, shown to the right, and the Guide Box, shown below.

Select "Calibrate Probe" to begin.

HallPROBE Guide Box

Command Panel options:
- Calibrate Probe
- Accept Prediction
- Acquire Data
- Erase Data Points
- Analyze Data
- Accept Fit
- Import Data
- Print Results on Close
- End Experiment / Abort
- Quit Program

The Guide Box will give you directions and tasks to perform. It will also tell you when to select a command in the Command Panel. After selecting a command, it will "gray out" and the next command will become available.

You can also print and/or quit from the Command Panel or abort your analysis and try again.
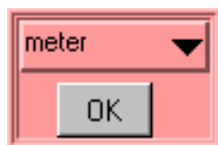
The primary data output you get is by printing your results, so be careful not to quit without printing or exporting your data.

Choosing your sensor range

The application detects the sensor setting when the program is first started. If you find that your initial setting is too big, or the magnetic field sensor is maxed out, you need to restart the software with the new setting.
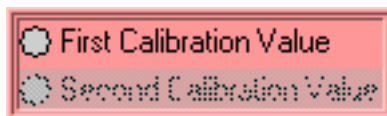
Calibration

After selecting the "Calibrate Probe" command, you will be asked to do *two* tasks. First, you will need to choose the quantity on the x-axis of your data graph. This is accomplished by moving the mouse cursor over to the word "meter" in the red-colored area (shown below) and then pressing the mouse button.

√ meter
cm
mm
micron
inch
foot
Hz
second
minute
hour
degree
radian
Volt
millivolt
amp
milliamp
turns

You should get a list of choices as shown to the right. By selecting any of these units, you will be making a choice about what you wish to measure. For example, if you choose to use "cm″ , you will make a graph of magnetic field strength as a function of distance (B vs. x). Selecting "degree" will make a plot of magnetic field strength as a function of angle (B vs. θ). Click "OK" when you are ready to proceed.
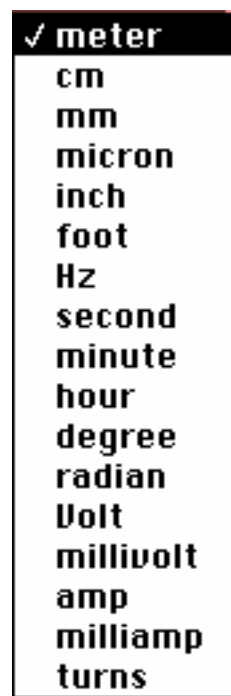
Secondly, you will need to eliminate the effect of the background magnetic fields. This process is called "zeroing the Hall probe" in the Guide Box. **Place the magnetic field sensor wand in the position you would like to take your measurement, but be sure that there are no magnets nearby.** Note that power supplies and computers generate magnetic fields, so it is a good idea to keep away from them! When you are ready, select the "First Calibration Value" as shown below. Now rotate the wand 180 degree around its long axis (similar to rolling a pencil) and select "Second Calibration Value." If you have trouble holding the want in one place you might have good luck rolling it across your lab table.

The calibration process is now complete.

Predictions

This type of analysis relies on your graphical skills to interpret the data, so you should be familiar with both Appendix C: *Graphing*, and Appendix B: *Uncertainties*.

The first task is to enter your prediction of the mathematical function you expect to represent your data. Making a prediction before taking data is the best way to determine if anything is going wrong (remember Murphy's Law).

It's also a good way to make sure you have learned something, but only if you stop to think about the discrepancies or similarities between your prediction and the results.

In order to enter your graphical prediction, you first need to decide on your coordinate axes and scale (units) for your measurements. Record these in your lab journal.

Next, you will need to select the generic equation, u(x), which describes the graph you expect for the data. Clicking the equation currently showing in the box will bring up a list of equations to choose from; see the diagrams to the right.

After selecting your generic equation, you next need to enter your best approximation for the parameters A, B, C, and/or D. These values should come directly from your prediction equation you did for class. As you enter these values, you should see the red line in the "Plot" box changing.

Once you are satisfied that the equation you selected and the values of the constants are correct, select the *Prediction* button in the Fit Equation command box. Your prediction equation will then show up on the graph on the computer screen. If you do not see the curve representing your prediction, change the scale of the graph axes or use the *AutoScale* feature (see Finding Data below). If you wish to change your prediction, simply repeat the above procedure. When you are satisfied, select the *Accept Prediction* option from the Command Panel. Once you have done this you cannot change your prediction except by starting over.

Exploration

After you have entered your prediction, you can explore the limitations of your magnetic field sensor before you take data. The value of the magnetic field strength is displayed directly under the Guide Box. When you are ready to take data, select *Acquire Data* from the Command Panel.

Data Acquisition

Collecting data requires that you enter the x-axis data each time the computer reads in a value for the magnetic field strength. You enter this data using the panel shown to the right. For every x-axis data value you enter, the analysis program will record the magnetic field strength in gauss on the y-axis of the "Plot". Press "OK" to collect the next data point. Each data point should appear on the graph on the

computer screen as you take it. If it doesn't, adjust the scales of your graph axes or use the *AutoScale* feature (see Finding Data below). If you are satisfied with your data, choose *Analyze Data* from the Command Panel.
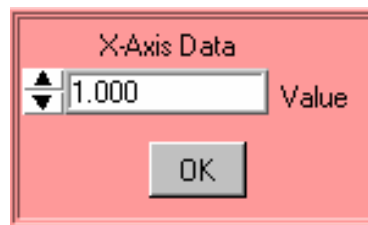
Finding Data on the Graph

You can find your data on the graph by adjusting the scales of your X-axis and Y-axis plots. This scaling is accomplished by entering the appropriate values into the "Y-Axis Max." and "Y-Axis Min." fields (as shown to the right) as well as adjusting the "X-Axis Max." and "X-Axis Min." fields (also shown to the right). If you cannot locate your data, you can select both "AutoScale Y-axis" and "AutoScale X-Axis" to let the program find the data for you. You can then adjust your axis scales to give you a convenient graph for analysis. Be careful, the AutoScale option will often set the scales in such a way that small fluctuations in the data are magnified into huge fluctuations.
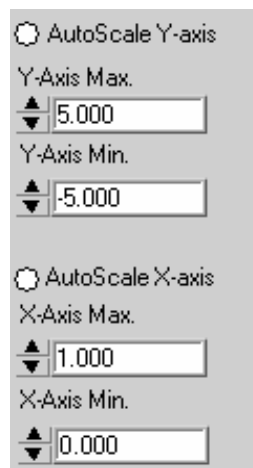
Data Fits

Deciding which equation best fits your data is the most important part of using this analysis program. While the actual mechanics of choosing the equation and parameters is similar to what you did for your predictions, fitting data is somewhat more complicated.

By looking at the behavior of the data on the graph, determine the best possible function to describe this data. After you have decided on the appropriate equation, you need to determine the constants of this equation so that it best fits the data. Although this can be done by trial and error, it is much more efficient to think of how the behavior of the equation you have chosen depends on each parameter. Calculus can be a great help here. *This can be a time-consuming task, so be patient.*
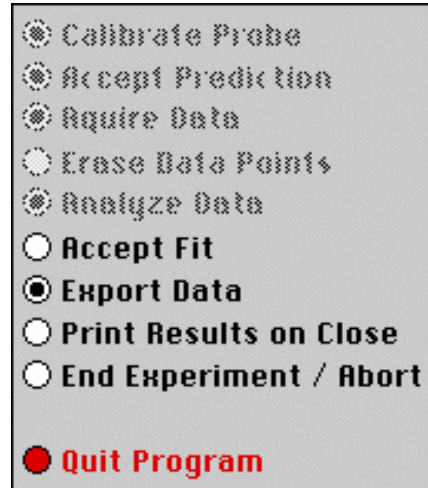
Now you need to estimate the uncertainty in your fit by deciding the range of other lines that *could* also fit your data. This method of estimating your uncertainty is described in Appendix D. Slightly changing the values for each constant in turn will allow you to do this quickly.

After you have computed your uncertainties, return to your best-fit line and use it as your fit by selecting *Accept Fit* in the Command Panel.

Importing / Exporting Data

After you have selected *Analyze Data*, it is possible to save your data to the computer's hard drive. This feature can come in handy if you need to analyze your data at a later date or if you want to re-analyze your data after you have printed it out.

To save your data, simply select *Export Data* (as shown to the right) and follow the instructions in the windows. Your file will be saved to your section's lab folder. To retrieve this file, restart *HallPROBE* from the desktop and select *Import Data.*

⦿ Calibrate Probe
⦿ Accept Prediction
⦿ Aquire Data
○ Erase Data Points
⦿ Analyze Data
○ Accept Fit
● Export Data
○ Print Results on Close
○ End Experiment / Abort

● Quit Program

Last Words

These directions are not meant to be exhaustive. You will discover more features as you analyze more data. Be sure to record these features in your lab journal.

FLUX SIMULATOR

A computer movie called <u>FluxSimulator</u> shows the magnetic flux through a rectangular coil of wire (called a frame in the program). The frame is rotated in a uniform magnetic field changing the magnetic flux passing through it. The screen of this simulation is shown below. The magnetic flux is visualized by a "magic eye" that is always perpendicular to the cross-sectional area of the frame (as shown below). The amount of flux "seen" is indicated by the use of color intensity as the frame rotates. Blue indicates positive flux while red indicates negative flux.
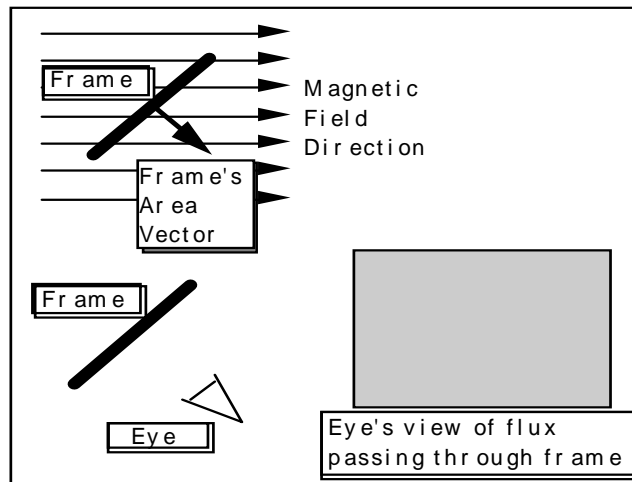
Picture of <u>FluxSimulator</u> Screen

Use the control bar with the slider, as shown below, to control the rotation of the frame.
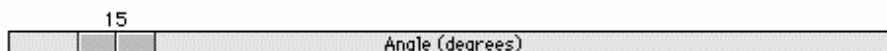
Slider

As you rotate the frame, observe both the angle the frame's area vector makes with the magnetic field and the color seen by the eye.

MEASURING TIME-VARYING VOLTAGES
(FaradayPROBE)

The Display:

This software package, written in LabVIEW™, allows you to measure and record potential differences as a function of time. Since the application to measure time-varying voltage is a slight modification of the application to measure magnetic field, you are already familiar with how to use much of it. These instructions assume a working familiarity with the HallPROBE application.

The basic difference between the FaradayPROBE and the HallPROBE applications is an additional display. The potential difference versus period display is described in these paragraphs. The display itself is shown below.
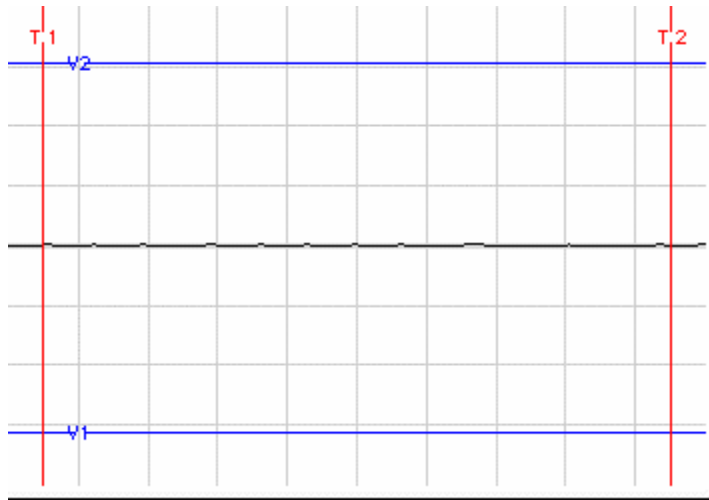
The vertical axis is a measure of the potential difference (voltage) between the two clips. The horizontal axis measures time. You should also notice that the display has a grid on it. The scale of each axis is shown at the bottom of the display. As you might suspect, it is possible to change the grid size of each axis. To change the scale of an axis simply click on the highest or lowest number on that axis and type in a new value. The axis will automatically adjust to create even increments over the newly defined range.

NOTE: Be patient! It takes up to 5 seconds for the display to register a signal.

Measurements:

The FaradayPROBE has two modes for acquiring data. The continuous mode acquires data constantly and updates at specified time intervals. There also exists a one shot mode in which

one time interval worth of data will be measured after which the program will pause. Talk to your TA for specifics on which mode might work best in the lab problems you are solving.

Voltage and Time cursors
The red and blue lines that are on the display are movable simply by putting your mouse pointer on one of the lines. When the mouse pointer changes shape, hold the mouse button down and drag the lines to mark a voltage or time as shown below. The lines mark the voltage and time boundaries of the data that will be considered for analysis.

If you are unable to see the lines, it is possible that you changed the axes scale and "zoomed in" too far. Try changing the axes to "zoom out" again, and determine if you can locate the blue and red lines. Move the lines to within the values of the new scale, and they should remain visible on the screen when you zoom in.
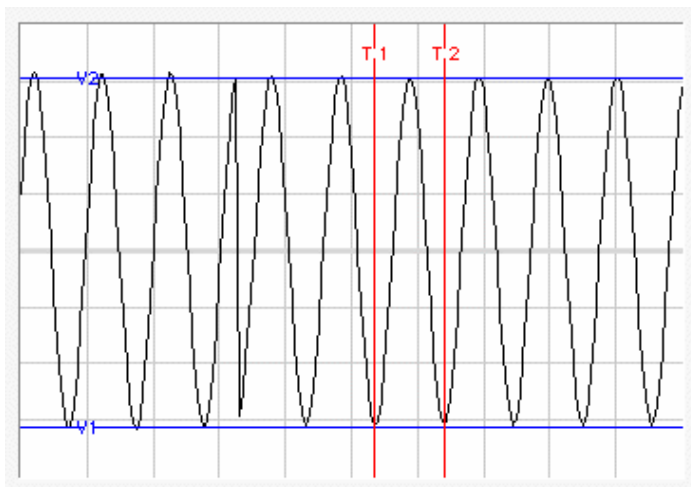
MEASURING RADIATION
(Geiger Counter with LoggerPro software)

The software used with the Geiger Counter to measure radiation is called LoggerPro, and a link to it should be located on the desktop.

Depending on which lab you are doing you may wish to measure radiation counts vs. time, radiation counts vs. distance, or radiation counts vs. shielding thickness. Software modules exist for each of these situations. To open the appropriate software module:
- start running LoggerPro 3.4.1
- go to the File menu and choose Open
- from the list of folders select Probes & Sensors
- from the next list of folders select Radiation Monitor
- choose the appropriate module from the list of modules; the list should include counts vs. time, counts vs. distance, and counts vs. shielding

There may be a box that you have to click "ok" in after selecting your module.

You can collect data using the collect button on screen. Depending on what module you've chosen there may be information about how the module works and the default sample time on screen.