

## Building a directional magnetometer:

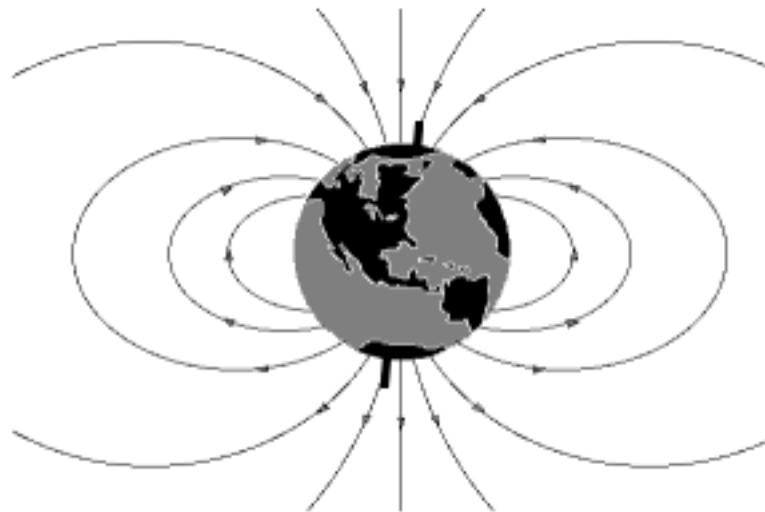
### A compass and magnetic field strength measuring device

#### Overview

We are going to be building a device that measures the strength and the direction of magnetic fields. This is both a *compass* (a device that measures where the magnetic fields are pointing) and a *magnetometer* (a device that measures how much magnetic field there is at a given location).

You will measure several sources of magnetic fields:

- The Earth
- Everyday magnets from home
- Magnets from inside electronic devices



*Earth's magnetic field*

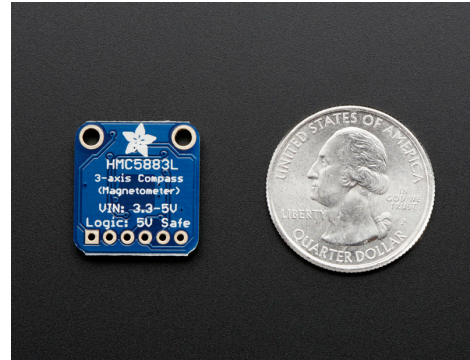
You will then collect these measurements and analyze them to obtain information about how the magnetic fields of these objects look (where they point), how they act, and how strong they are relative to one another.

## Components

Make sure you have each of these components before you start putting together your project!

### 1. Triple axis magnetometer

- Small square circuit board shown to the right next to a quarter

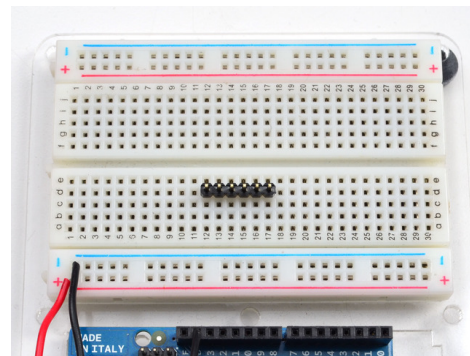


Magnetometer

### 2. Wiring board (aka

“breadboard”)

- Has many holes for connecting wires and different parts of the electronics



Wiring board (aka breadboard)

### 3. Arduino circuit board

#### 4. 6 wires

- 2 red
- 2 black
- 1 blue
- 1 green



Arduino circuit board

## Assembly Instructions

### *Information about the magnetometer electronics module*

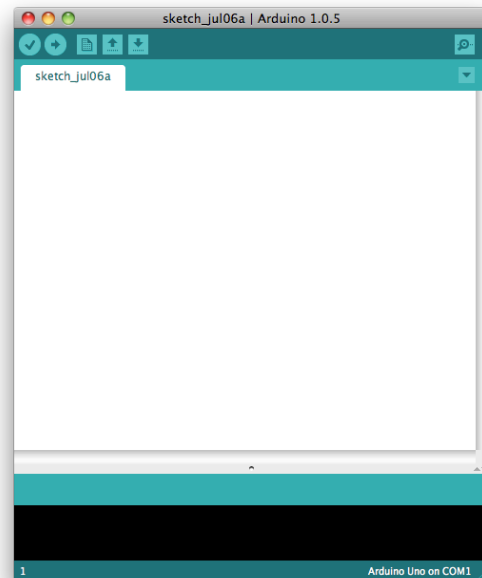
- **VIN** - this is the power in pin, give it +5VDC. It is reverse-polarity protected.
- **GND** - this is the common power and data ground pin
- **3vo** - This is the 3.3V output from the onboard regulator. This pin will provide 3.3V and a current level up to about 100mA in order to power other items.
- **SDA** and **SCL** - these are the I2C data and clock pins used to send and receive data from the module to your microcontroller.
- **RDY** - this is the 'data ready' pin output. If you want to stream data at high speed (higher than 100 times a second) you may want to listen to this pin for when data is ready to be read. Check the datasheet for more details about using the RDY pin, we don't use it because we don't read that fast!

### *Wiring and testing*

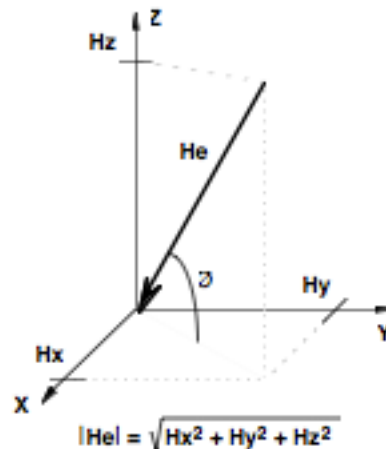
1. Connect **VIN** to the +5V pin on the Arduino.
2. Connect **GND** to the ground pin on the Arduino
3. Connect the **SDA** pin on the magnetometer to the I2C data **SDA** pin on your Arduino. This is also referred to as the **A4** pin.
4. Connect the **SCL** pin on the magnetometer to the I2C clock **SCL** pin on your Arduino. This is referred to as the **A5** pin.
5. Connect the USB cable and verify that the LED light on the Arduino is illuminated.

## Programming the Arduino Board to control the Magnetometer

1. Open the *Arduino program* on your laptop computer
  - a. Looks like the window to the right
2. Load the program by opening:
  - a. Navigate to **File > Examples > Adafruit\_HMC5883\_U > magsensor**
  - b. Select the Example named *magsensor*
3. Once you see the code in the Arduino program window, you need to “**Verify**” or **Compile** the code by clicking the *Check Button* on the top left part of the window.
4. Upload the code to the Arduino board by selecting the *Right Arrow Button* just next to the *Check Button*.
  - a. You should see a message at the bottom that this has succeeded
  - b. If you do not see this message, or you see an error message, please ask one of the TA’s for assistance
5. Begin the program by selecting the *Serial Monitor Button* on the top right side of the Arduino Program window.
  - a. This shows you the measurements of the magnitude and direction of the magnetic field



Arduino program



Magnitude and direction of the magnetic field measurement

## Experimental Procedure

For the two measurements below, you are going to use a different Example. Following the same instructions as above, load the example named “**HMC5883**” (instead of “**Adafruit\_HMC5883\_U**”). This program will report *only* the magnetic field strength (in units of Tesla [T]).

### *Comparisons of the Earth’s magnetic field and regular magnets*

Before making any measurements, write down your predictions for which will have the stronger magnetic fields. We will then compare your prediction with your measurements.

Compare the magnetic field strength of the Earth and the magnets available for testing.

How do the numbers read by the Arduino compare?

In addition, take measurements with the object at several different points around the magnetometer and try to see how the strength changes. Can you write down your observations?

Rank each object according to the average magnetic field, and include the error on your measurement.

Compare your measured rankings to your predictions.

### *Magnetic field strength versus distance*

If you have time, pick 1 of the objects you measured above and measure the magnetic field strength at several distances.

Use the meter sticks that are provided for you, lay them on the lab table, and again take 10 measurements of the field strength at each distance from the magnetometer. Record the distance from the magnetometer as well as the total strength.

Use the spreadsheet program to create a diagram showing the strength as a function of distance. This should look like a curve that starts out high and decreases quickly.

## Project Webpages

### *What to include on your webpage?*

- Your picture!
- Other pictures
  - Cartoons about physics and science
  - Photographs from the projects or lunches
  - Photographs from the Museum of Science and Industry
  - Photographs of the different magnets measured in the lab
- Short description of why you joined the Enrico Fermi Summer Interns Program this year
- Description of the project and the experiment
- Your results!
  - Try to explain what you showed and why your data look the way they do

### *How should the webpage look?*

However you want it to look! Make sure to include pictures and make it as clear as possible what you have done, why you did it, and what you liked about it!

Think about this page as telling the world about your experiment and your results. *Without doing that, how would anyone ever know what your experiment showed?!*