Lab 5: Lorentz Force

1 Assignment

At your lab station is an orange apparatus containing two magnets and two load cells. Your team has been tasked with measuring the strength and direction of the magnetic field between these magnets. The field should be determined via measuring the Lorentz force. The Lorentz force describes how a wire carrying a current (I) experiences a force ($\vec{F}_L$) in the presence of a magnetic field ($\vec{B}$). By measuring F_L and I, B can be determined.

2 Deliverables

For your lab report, 10% of the grade will be for following the guidelines in the lab report template. Another 10% will be allocated for the Abstract and Introduction of your report. The remaining percentage will be based on your inclusion of:

1. *[20%]* your load cell calibration curve (i.e., a plot showing load cell output voltage as a function of applied force) and your determined values for C_1 and C_2 (see sections 3.1 and 3.2)
2. *[20%]* a plot of Lorentz force (F_L) as a function of applied current (I)
3. *[20%]* your calculated value for the strength of the magnetic field ($|\vec{B}|$) found using the Lorentz force (see Section 3.3) and the uncertainty associated with this measurement. You must include a description of how you calculated the result from the measured force.
4. *[20%]* the orientation of the magnetic field (i.e., which end is north or south?) and an explanation of how you were able to determine this from the data

3 Technical Information

3.1 Load cell calibration

At the bottom of the orange apparatus are two load cells. Load cells are devices used to measure force. When connected to the DAQ, they produce a voltage that is proportional to the force applied to them. In order to measure force with the load cells, they will first need to be calibrated. By applying a known force and measuring the load cells' output voltages, you can determine a relationship between the two. For our purposes in this lab, you can assume that the load cells have a linear response:

$$V_{output} = C_1 F_{applied} + C_2 \tag{1}$$

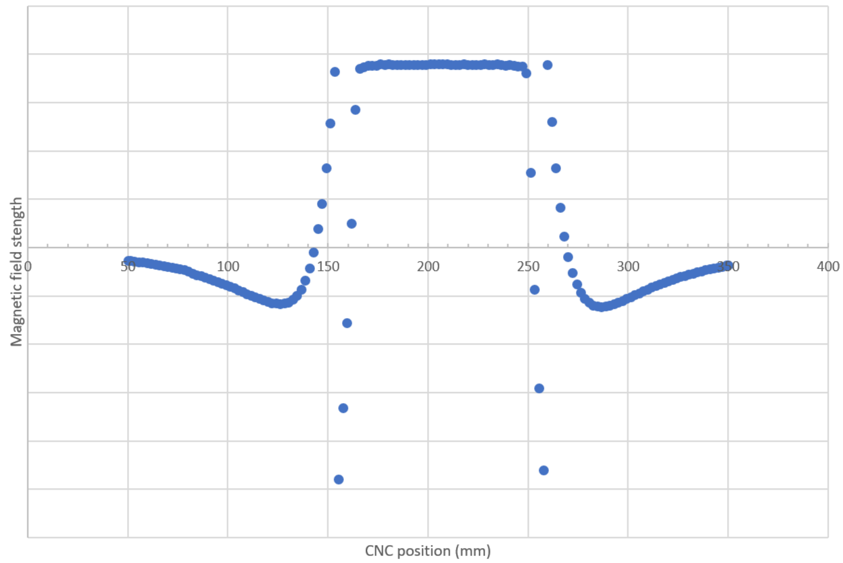
where C_1 and C_2 are some constants and V_{output} is the average voltage output by the two load cells. You will need to determine C_1 and C_2 for your load cells.

3.2 Reading from the load cells

To read from a load cell, you can simply read from the DAQ channel that the load cell is connected to. As you have seen in previous labs, you may either read directly from the `DAQ` class in an interactive Python session or you may use any of the data collection scripts in the `examples/daq` directory. For this lab, you may find the `daq_to_csv_with_input.py` to be particularly useful.

3.3 Magnetic field scan

The plot in the figure below shows a scan in a straight line down the center of the orange magnet apparatus with a Hall effect probe. Although the plot does not show units or scale for magnetic field strength, you may find it useful in performing your analysis.



4 Hazard Assessment

- This lab uses strong neodymium magnets. Use caution with ferromagnetic materials around these magnets, as they will attract strongly and can easily pinch fingers or break the magnets.
- Your team will be using a DC power supply in this lab.
  - Always ensure the channel is **off** when plugging into or unplugging from the supply
  - The current output from the supply should not be over **0.5 A** during this lab.
  - When not taking data, turn the power supply off.