

Formal Lab.

Biot-Savart Law



$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{r} \times \vec{r}}{|\vec{r}|^3}$$

pic 1



$$\vec{B} = \frac{\mu_0 I}{2\pi a} \hat{k}$$

pic 2



$$\begin{aligned} d\vec{B} \\ dB_z \\ \vec{B} \end{aligned}$$

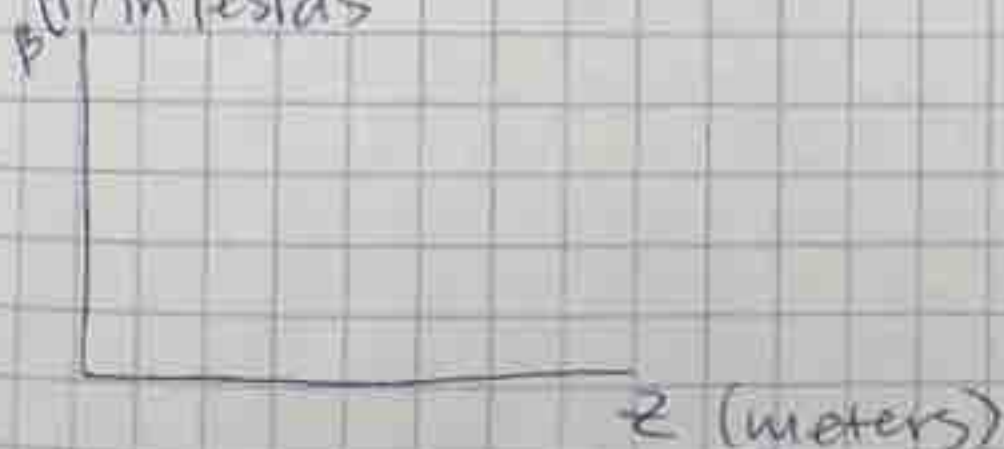
pic 3 include in the introduction part

$$a = 10.5 \text{ cm}$$

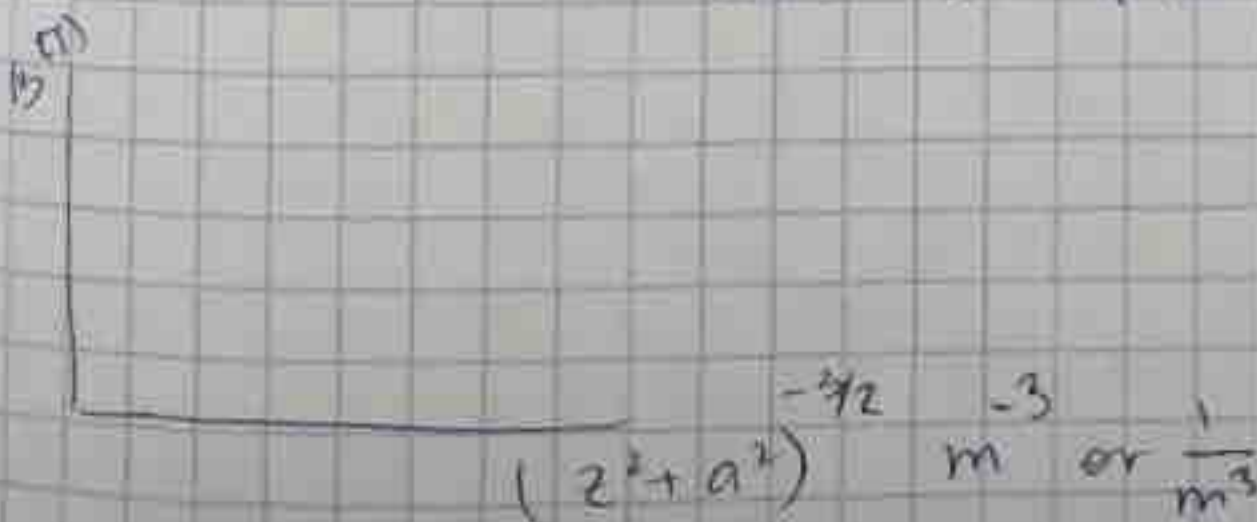
$$N = 200$$

Conclusion. plot B vs z

(1) Intestias



measure in cm, but when plot it, plot in meters



I will be measured =

$$I_{\text{theoretical}} = 0.65$$

$$N \mu_0 I a^2 / 2 = (200)(4\pi \times 10^{-7} \text{ N/A}^2)(0.65)(0.105 \text{ m})^2 / 2$$

$$B = \frac{\mu_0 I}{2a} \text{ theoretical from } I = 0.65 = 3.8896 \times 10^{-6} \times 200 = 7.78 \times 10^{-4} \text{ at } (67 \text{ cm})$$

$$\text{Measured: } 7.65 \times 10^{-4} \text{ at } 67 \text{ cm}$$

9.

0 cm distance
2 cm (at 65 cm from 67 cm)
4 cm (at 63 cm)
6 cm (61 cm)
8 cm (59 cm)
10 cm (57 cm)
12 cm (55 cm)
14 cm (53 cm)

Magnetic Field strength

$7.03 \times 10^{-4} \text{ T}$
$6.00 \times 10^{-4} \text{ T}$
$4.85 \times 10^{-4} \text{ T}$
$3.60 \times 10^{-4} \text{ T}$
$2.55 \times 10^{-4} \text{ T}$
$1.80 \times 10^{-4} \text{ T}$
$1.40 \times 10^{-4} \text{ T}$

Include 0 cm measurement as well.

10. 9.0 cm distance from the center = $1.18 \times 10^{-3} \text{ T} = 1.60 \times 10^{-3} \text{ T}$
- 12 cm (outside) = $7.6 \times 10^{-4} \text{ T}$

Things to be in lab notebook

- Title, Date, names of lab partners
- Calibration signal (square wave)
 - Sketch of the screen (drawn to scale, indicate the scale setup)
 - ↑
time/div
V/div
 - Peak-to-peak voltage (V) period (T), frequency (f)
 - with uncertainty
 - Compare to expected values (500mV, 1000Hz)
- Function Generator (Sine wave)
 - Sketch of the screen (similar to above)
 - V , T , f with uncertainties
 - compare f with function generator value
 - Answer question IV (g)
 - Do the same with 1kHz ←
 - Answer question IV (j)

Module M1: Magnetic Field of a Coil

Preparatory reading: Lea & Burke 903-6

In this experiment, you will make measurements of the magnetic field direction and strength near a coil of wire which carries a dc current.

Prelab questions: Answer the prelab questions on the summary sheet.

Procedure:

A. Magnetic Field on Coil Axis

1. Connect the one white terminal of the coil to the black terminal of the power supply. Connect the other white terminal of the coil to the "COM" (black) terminal of a multimeter. Connect the 20A terminal of the multimeter to the red or + terminal of the power supply. Set the multimeter scale to A dc and turn on the multimeter (but do not turn on the power supply yet).
2. Make sure the magnetic sensor is connected to the readout box and the two power supplies for the readout box are connected to it and plugged in to power outlets.
3. Connect a second multimeter to the readout box using a BNC-to-banana cable.
4. Select AXIAL by pressing the FIELD SELECTOR SWITCH on the top of the sensor box, and set the 10 X range using another switch on the sensor.
5. Place the Magnetic Field Sensor on the support rod so that the end of the field sensor probe is centered in the coil and is aligned with the coil axis.
6. Turn on the multimeter connected to the readout box and then zero the sensor output by pressing the TARE button on the top of the sensor. (See Fig. 1 below).

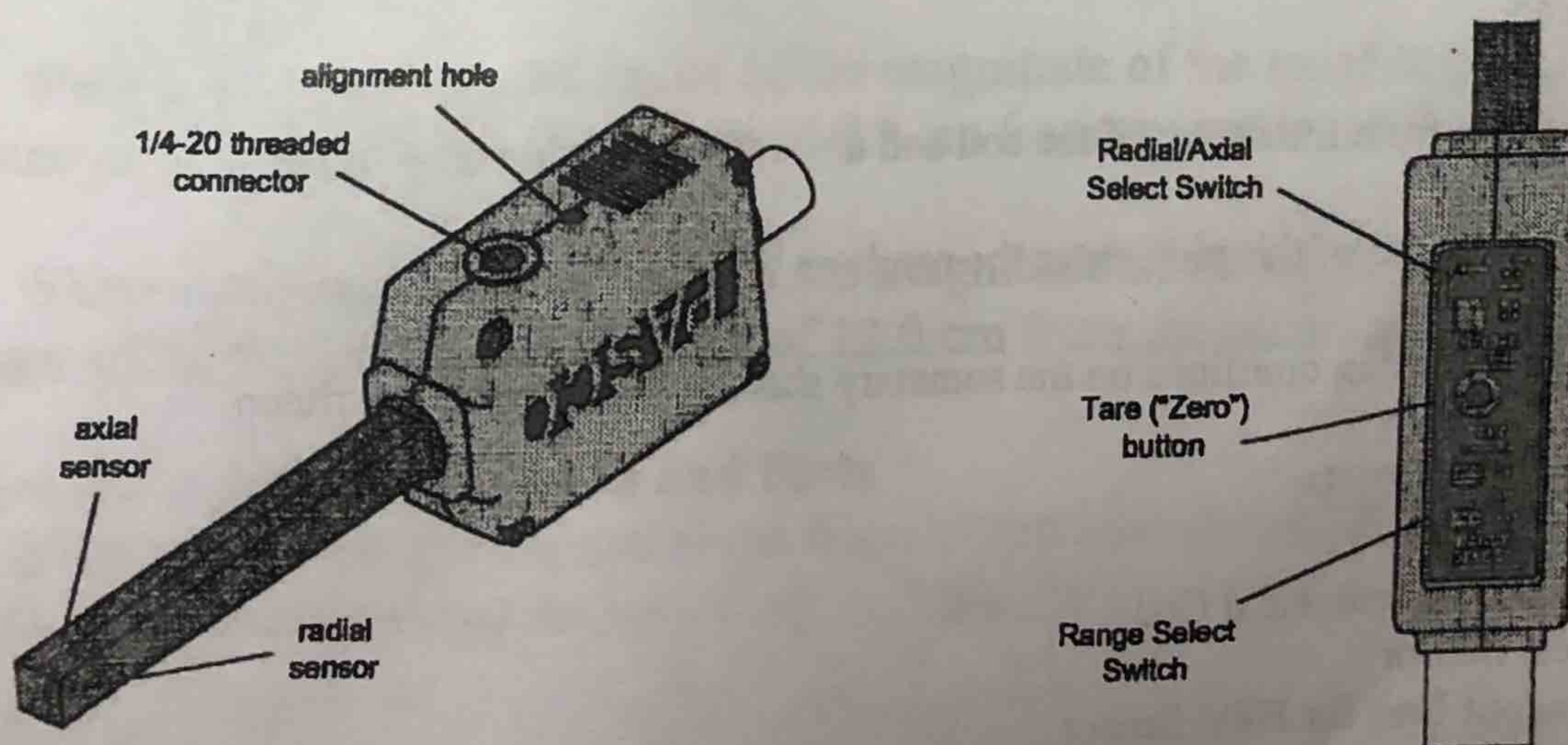


Fig. 1. Magnetic Field Sensor

7. Turn on the magnet power supply and adjust it to obtain a current of 0.65 A in the field coil (as read by the multimeter).
8. Measure and record in your lab notebook and on the summary sheet the axial magnetic field magnitude at the center of the coil. **The scale factor of the readout system is such that a reading of 1.0 V on the multimeter corresponds to a magnetic field magnitude of 1.0×10^{-3} Tesla.** Compare this result with your prediction.
9. Move the probe along the axis of the coil to obtain readings of the axial field at the following distances from the center of the coil: 2.0 cm, 4.0 cm, 6.0 cm, 8.0 cm, 10.0 cm, 12.0 cm, 14.0 cm.
10. Move the field sensor tip (white dot) so that it is in the plane of the coil but is at a radial distance of 9.0 cm from the center of the field coil (keep the probe pointing parallel to the coil axis). This will place the field sensor very close to the windings of the field coil. Measure and record the axial field magnitude.
11. Move the field sensor tip (white dot) so that it is in the plane of the coil but is at a radial distance of 12.0 cm from the center of the field coil (keep the probe pointing parallel to the coil axis). This will place the field sensor "outside" and very close to the windings of the field coil. Measure and record the axial field magnitude.
12. Turn off the power supply and multimeters.

B. Additional Analysis and Plotting

1. Make a plot of the axial field strength on the coil axis versus distance from the center of the coil.
2. Make a plot of the axial field strength on the coil axis (y-axis) versus (on the x-axis):

$$(z^2 + a^2)^{-3/2}$$

where z = distance from the center of the coil and a = radius of field coil = 0.105 m.

3. Determine the slope of this plot; enter the result on the summary sheet.
4. Answer the remaining questions on the summary sheet at the end of this writeup.

EQUIPMENT NEEDED:

Large-diameter Magnetic Field Coil
 Magnetic Field Sensor
 Interface/Readout Unit for Field Sensor
 Power Supply (0.65A minimum at 5V minimum)
 Multimeters (2)
 Connecting Wires
 Meter stick and sensor support stand