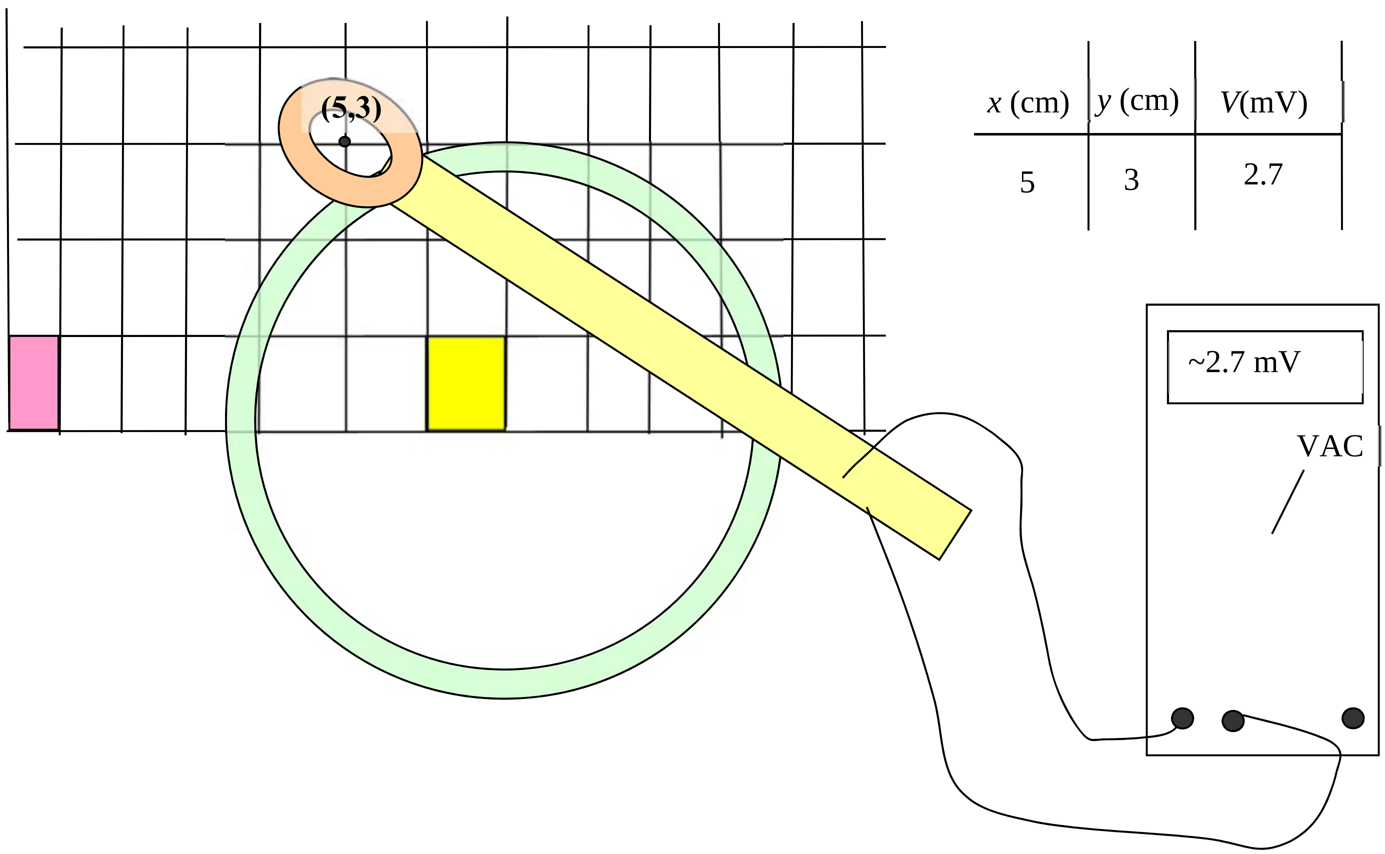
B-Fields

In this lab you will measure the relative *B*-field at various locations relative to the center of a toroid of wire (the big loop of wire). **Download the XL worksheet as specified by your instructor and print necessary parts.** Connect the 200 loop coil of wire in series with an AC power supply. Do not use the resistor in series with the 200-turn coil. Use the outer terminals on the big loop and set the driving voltage on the Pasco signal output to 5 VAC at a frequency of 20 kHz. Connect the 2000 turn detector coil to the DMM's leftmost inputs. Set the DMM to measure 200 mV AC. Measure the relative magnitude of the *B*-field by centering the hole of the probe coil over the position you wish to measure. **The hole of the detector coil and the hole of the big coil should both be facing the same direction.**

Part I: Plot the relative strength of the *B*-field versus position in the plane of the loop. Using the grid found in the XL worksheet named "grid" take values at every intersection on the grid (approx every 2 cm). Use team work and trade off to get it done quickly. See the image below for grid concept. Tabulate your data in the XL template provided by your instructor in the sheet named "part 1". After inputting the data make a "surface plot" in XL. Choose the option for a 2D surface plot ("contour plot").

The B-field measurement of coordinate (5, 3)

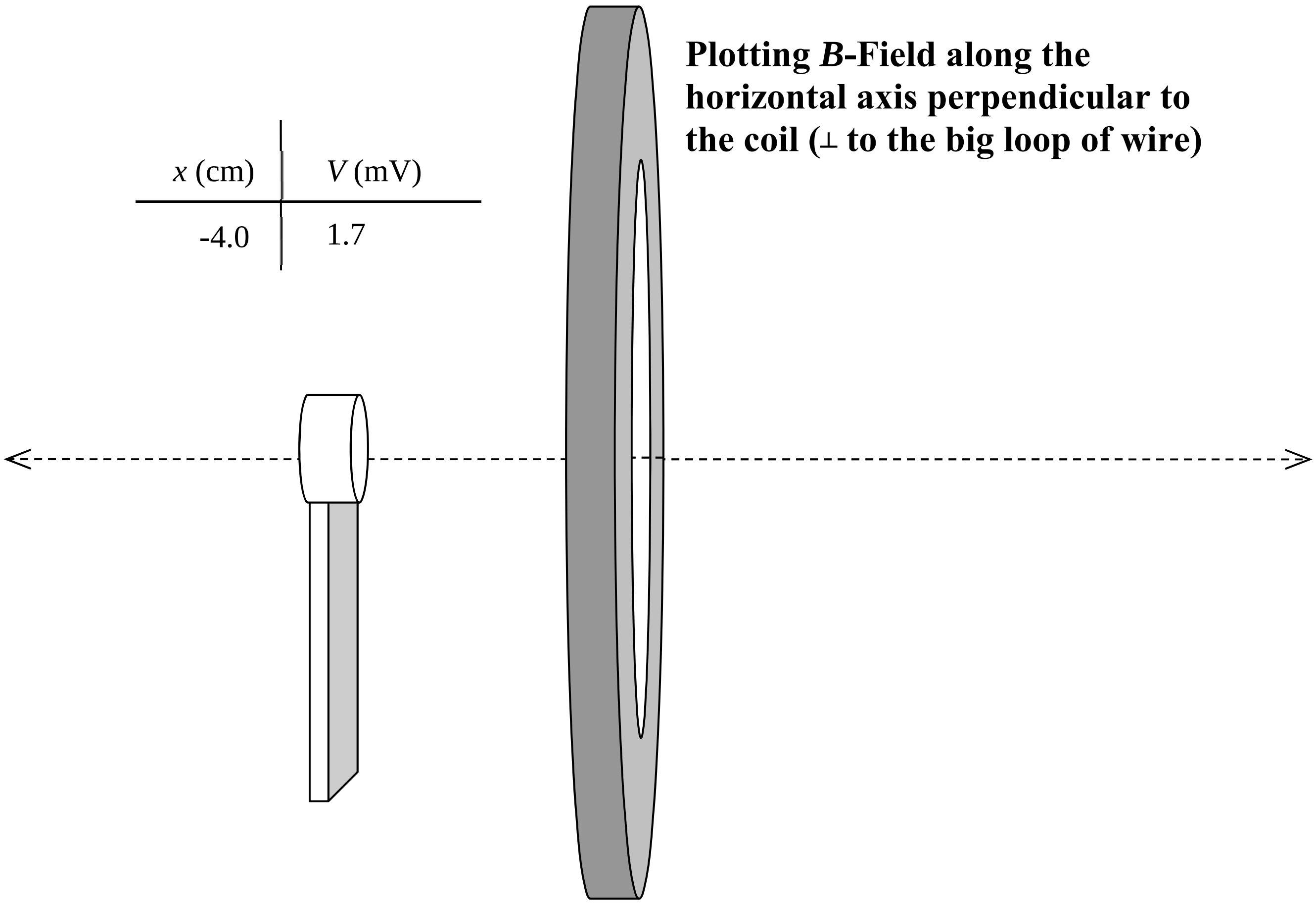


x (cm)	*y* (cm)	*V*(mV)
5	3	2.7

Part II: Plot the relative strength of the *B*-field versus horizontal position on axis. Take values of the *B*-field every cm for 15 cm on both sides of the loop and one value at the center of the loop. See the image on the next page for an idea about the experiment. When plotting this data, follow the instructions provided on the XL worksheet. *Calculus people only:* show experimental data as points only (no line) and the theory calculation as no points with a smooth line. Data points which are close to the smooth line are good agreement with the theory. Closeness of fit can be quantified by performing some sort of RMS value on each data point with the theory value. Hint: since you normalized the B-field to 1 at the center use that value to determine the current for your theoretical model.

Plotting *B*-Field along the horizontal axis perpendicular to the coil (⊥ to the big loop of wire)

x (cm)	*V* (mV)
-4.0	1.7



Conclusions:

1) What do you notice about the size of the *B*-field in **Part I** as you move radially away from the center?
2) Is the trend isotropic (the same in all directions) or anisotropic (not isotropic)?
3) Does the radial trend change as you move outside the loop?
4) Is there any region where the field is "flat"? Here flat means relatively constant. Where is the field most flat?
5) You are asked to do an experiment and exhibit a constant magnetic field on a large sample…for example your thumb. What place in the coil will all parts of the thumb feel approximately the same *B*-field?
6) Why do you think MRI magnets huge coils?
7) Is the *B*-field equal to zero outside the coil?
8) Which direction shows the *B*-field dropping faster: moving out from the center radially (part I) or on axis (part II)? Does this agree with theory? (Consider only the region of space within a few cm of the center.)
9) *Calculus people only:* MRI's typically use *B*-fields on the order of 1 Tesla (at the center of the MRI magnet coil) and have radii of about 0.5 m. Estimate the size of the *B*-field 2m from the center (hint: see text for formula). Compare this to the earth's magnetic field of size 0.5 Gauss. Note: 10^4G = 1T.
10) Should you walk into a MRI room (while someone is being scanned) with something magnetic or easily magnetized in your pocket? Which is more dangerous a small magnetizable object or a large one?