***DETERMINATION OF MAGNETIC MOMENT***

**Preliminary**

1. Determine the weight of a ball bearing to 0.1g.
2. Use the set screw in plastic cap to hold rod so plastic/magnet combo is below top of scale. Determine the spring constant by adding the ball bearings one by one to magnet and determining how much the spring stretches. Use the tip of the arrow to measure position on scale. This data is used below to get k.
3. Adjust position of the plastic/magnet combo so it is in the middle of the coils.
4. Connect power supply in series with the coils so the current in same direction in both coils. Adjust power supply knobs as described below for constant current. Raise current to 2A. Which way does the arrow point? Lower current to zero and swap leads to power supply. Increase current to 2A. Which way does the arrow point? If the wiring is correct the spring will not stretch but the direction the arrow points will depend on direction of current. There is a torque on the magnet that depends on magnetic moment and B field strength and direction. Ideally the B field should be uniform around the point midway between the coils. This will be measured & calculated in a later step.
5. Switch power supply leads back. Change the wiring so the coils are in series but current flows in opposite direction in each coil. Lower the magnet to near bottom of tube. Raise the current to 2A. Use the rod to slowly raise the magnet and observe what happens. Think about what is happening. There is now a field gradient.

**Measuring Dipole Moment**

1. The formula F = magnetic moment X dB/dZ will be used to find magnetic moment of the magnet.
2. Adjust the rod to place the tip of the arrow at 0 on the scale.
3. Measure how much the spring stretches from its initial position (to nearest 0.5mm) as you change the current. Go from 0 to 1.25A in 0.25 A increments. Turn current back to zero. Switch leads at power supply to reverse current. Repeat procedure with force moving magnet up. Repeat in both directions using different currents between 0.2 and 1.6A.
4. If a magnetic field meter is available remove the plastic tube and measure the field between the coils in 5mm increments from bottom coil. First wire up as in step 4. Use 2 A. Return current to 0 when finished.
5. Replace the plastic tube.

**Analysis**

1. Plot graph (F=W=kx) and use slope to get k. Value of k should be close to 1N/m.
2. Use k and stretch to determine F in steps 6-8. The value of dB/dx = 0.037 x current. Plot a graph and get value of magnetic moment from slope for each data set from step 8. Include (0,0) as one of the points. Compute average value.

**Additional**

1. Use the formula below to calculate the field at various distances vertically (5mm increments from 0 to R). Use center of coil as x=0 in formula. Use # of turns = 168. R = 0.07m, and I = 2A. Add contribution from the two coils (x(top) + x(bottom = R). Plot B vs distance from midpoint between coils. Based on this and step 9 results, comment on how uniform the field is near the midpoint between the coils. Is the Earth’s magnetic field large enough to affect results (> 5% coil field)?
2. Take the derivative of the formula below to derive the formula for dB/dx . Plot dB/dx as function of distance from midpoint between coils. Derive the formula used for dB/dx in step 12. Use x=R/2.
3. This and #16 are optional extras for students interested in particle physics. Can Dr.Who reverse the polarity of the neutron flow or is this just SF nonsense? (<http://www.youtube.com/watch?v=yLD03bU5R5M>)
4. What is the value of the neutron electric dipole moment? Which two symmetries would be violated by a non-zero value for the electric dipole moment of a neutron?

Adjustment of Power Supply For Current Control

Adjust knobs 5&6 (fine & coarse voltage) clockwise to maximum position. Adjust knobs 3&4 (fine and coarse current) to minimum position. When ready to supply power press on/off switch. Adjust coarse current knob for desired current. Adjust fine current control as needed. The voltage should be ~15v for 3A.

Formula for B field is at <http://en.wikipedia.org/wiki/Helmholtz_coil>. Another source is <http://www.cabrillo.edu/~cfigueroa/4B/4Blabs/4Blab10_helmholtz_12.pdf>. Note: Even in the same source x or z is sometimes measured from center of coil and sometimes from midway between coils.