Jupyter Notebook Supplement for Lab 06

This Jupyter Notebook is to be completed as part of your report for Lab 05. Use text cells to answer questions and code sections to input, fit, and plot data.

In [27]:
```
# Load the standard set of libraries for basic numerical computing.
import numpy as np
%matplotlib notebook
import matplotlib
import matplotlib.pyplot as plt
```

Module 28B

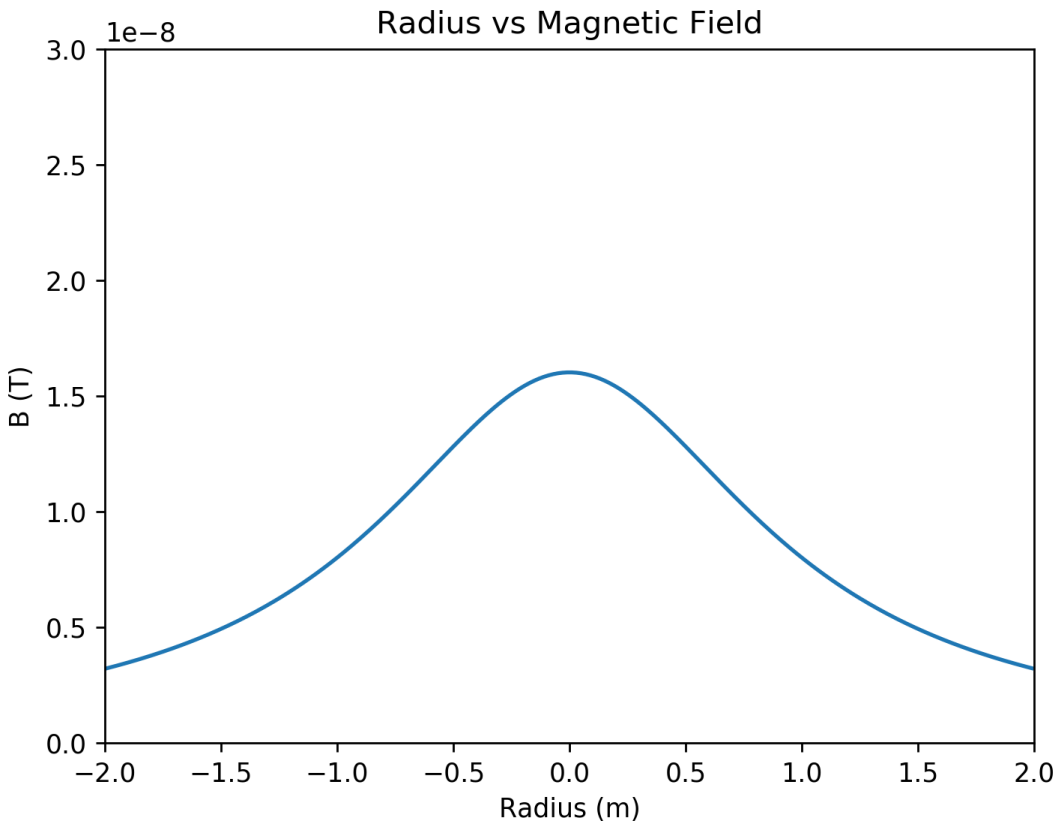
The magnetic field on the axis a distance x from the center of a coil of N turns, radius a, and carrying current I is:

$$B = \frac{N\mu_0 I a^2}{2(x^2 + a^2)^{3/2}}$$

The cell below will plot the magnetic field for a single coil as a function of distance along the axis from the center of the coil. EDIT to insert your experimental parameters and label the plot where indicated within the cell.

In [28]:
```
a=1 # INSERT YOUR MEASURED COIL RADIUS HERE
x=np.arange(-2*a,2*a,0.01*a)  # Steps for the calculation. from twice the radi
us on either side of the coil in steps of 0.01a.
N=15  # INSERT THE NUMBER OF TURNS IN YOUR COIL HERE.
I=0.0017     # This is a placeholder for current which you can calculate from
 applied voltage and series resistance in the coil circuit.
mu0=4*3.1416E-7   # Value for the permeability of free space.
B0=N*mu0*I*a**2/(2*(x**2+a**2)**(3/2)) # Calculate the magnetic field in Tesla
from expreimental parameters.
print ("Field at the center of the coil=",B0[200],"T")
plt.figure()
plt.plot(x,B0)
plt.axis([-2*a,2*a,0,.3E-7])   # Adjust axis parameters as desired.
plt.title("Radius vs Magnetic Field")   # Add appropriate title and axis label
s.
plt.xlabel("Radius (m)")
plt.ylabel("B (T)")
plt.show()
```

```
('Field at the center of the coil=', 1.6022159999999998e-08, 'T')
```



Answer the question below by editing this cell.

QUESTION 1: Discuss what the numbers on the x-axis in the plot above mean. (In what units are they measured? Where are they measured from?)

The x-axis represents the radius from the center of the loop at x = 0 m.

QUESTION 2: Discuss what the numbers on the y-axis in the plot above mean. (In what units are they measured? Where are they measured from?)

The y-axis represents the calculated magnetic field in Tesla's from the persepctive of the center of the loop.

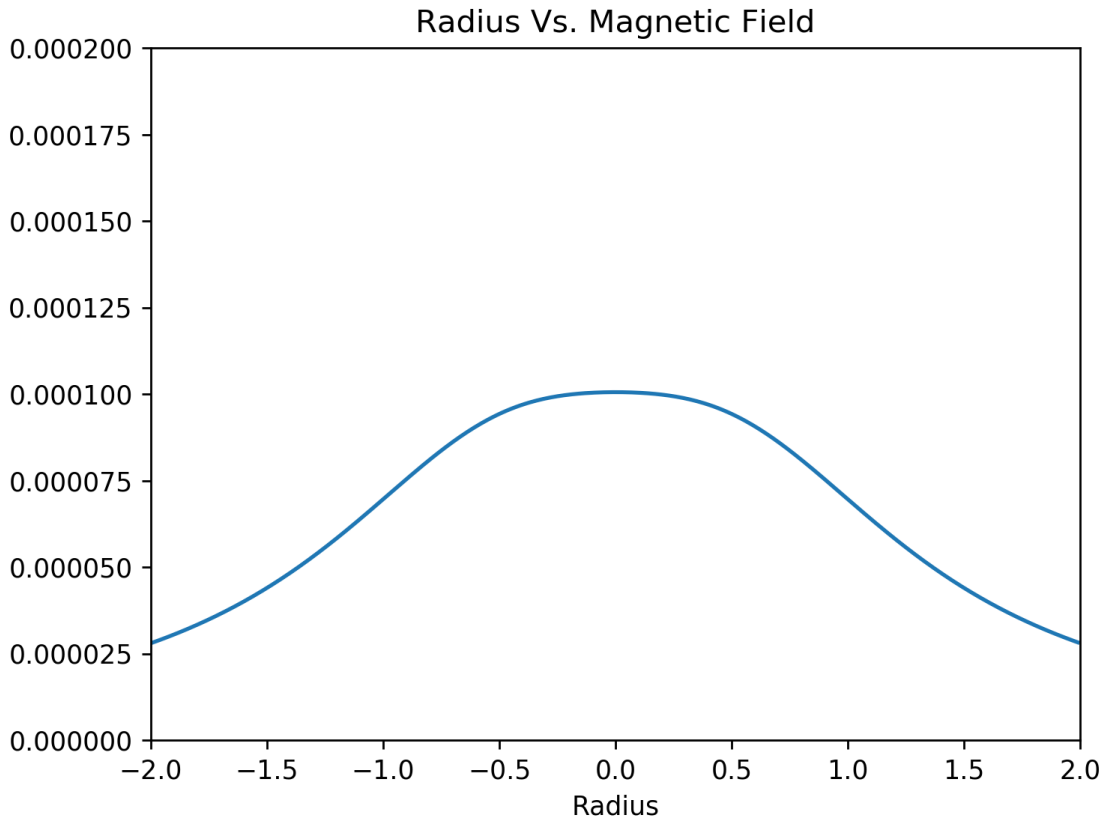
28D Supplement - Helmholtz Coils

Edit the cell below to explore the dependence of the field on position between the coils of a Helmhotz coil system. You will be asked in the cell after the plot to determine the range in x over which the field varies by less than 2% from its maximum. You can change the axes in the plot to observe the variation in more detail.

In [29]:
```
# Calculation of the field as a function of position for two coils a distance
 d apart.
ah=.15
xh=np.arange(-2*ah,2*ah,0.01*ah)  # Steps for the calculation. from twice the
 radius on either side of the coil in steps of 0.01a.
Nh=100  # INSERT THE NUMBER OF TURNS IN YOUR COIL HERE.
Ih=1     # This section is to see how the field varies with position, so we wi
ll allow the current to just be 1.

d=ah  # INPUT DISTANCE BETWEEN COILS IN THE SAME UNITS as a.
B1=Nh*mu0*Ih*ah**2/(2*((xh-d/2)**2+ah**2)**(3/2))
B2=Nh*mu0*Ih*ah**2/(2*((xh+d/2)**2+ah**2)**(3/2))
BT=B1+B2
B = [i for i in BT]
print ("Field at the center of the coils=",BT[200],"T")
print ("center to middle variation:", (BT[200]-BT[150])/BT[150])
if d == ah:
    for i in B:
        if B[200] > i >= .98*B[200]:
            print("2% variation from:", xh[B.index(i)], i)
            break
plt.figure()
plt.plot(x,BT)
plt.axis([-2*a,2*a,0,2E-4])   # Adjust axis parameters as desired to answer th
e question.
plt.title("Radius Vs. Magnetic Field")   # Add appropriate title and axis labe
ls.
plt.xlabel("Radius")
plt.ylabel("Magnetic Field")
plt.show()
```

```
('Field at the center of the coils=', 0.00010053119999999999, 'T')
('center to middle variation:', 0.06666666666666615)
('2% variation from:', -0.046499999999999764, 9.858253303552865e-05)
```



EDIT THIS CELL TO ANSWER THE QUESTIONS.

Carry out the calculation above for d= 0.5a, 1.0a, and 1.5a.

QUESTION 3: Describe the shape of the field as a function of x for each case. (One bump, two bumps, three bumps? Constant across the middle, or dipped?)

for d = .5a: Te distribution is approximately Gaussian

for d = 1a: The distribution is roughly Gaussian, flattened at the top more than .5a.

for d = 1.5a The distribution is bi-modal, as each coil now begins to exhibit its own maximum.

QUESTION 4: For d=1a, over what range in x is the variation in field smaller than 2%?

For x in range -0.0465 to +.0465 there is smaller than 2% variation from the maximum, the code to calculate this is in the above module.

QUESTION 5: What is the percent variation in magnitude of the field from the center between the coils to the center of one coil?

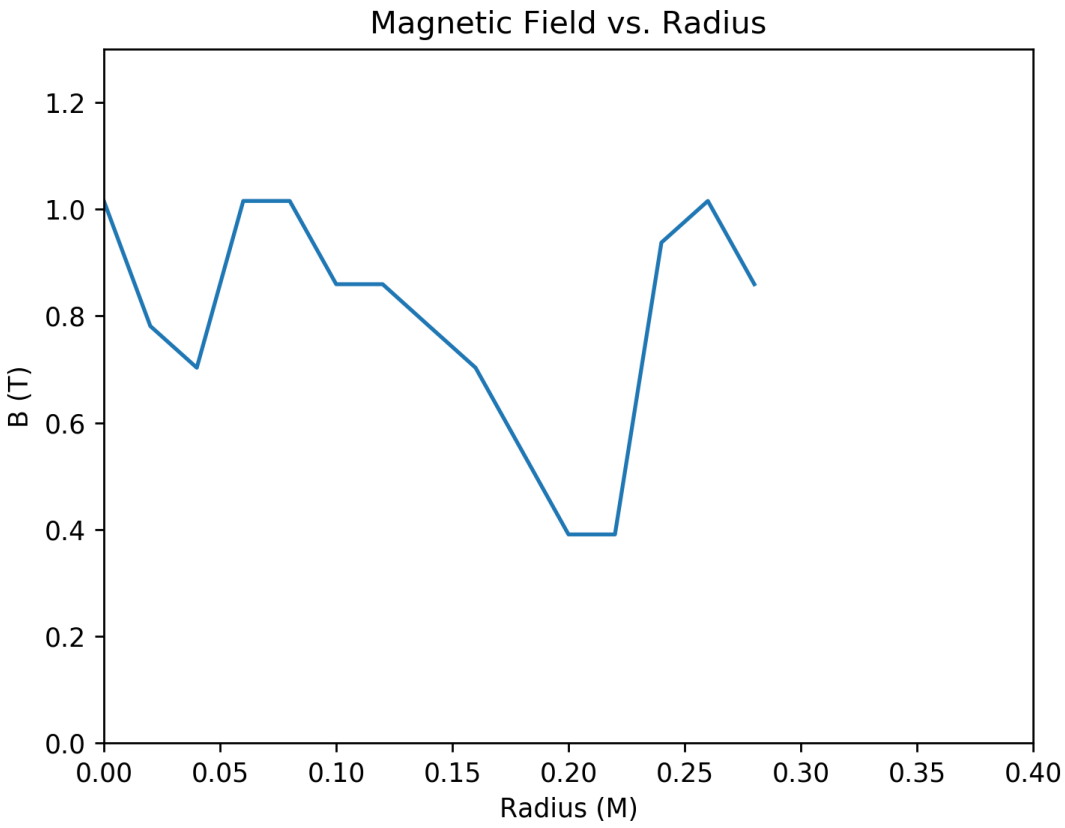
for d=1a, the percent variation is approximately 6.67%, the code to calculate this is in the above module,

Now let's plot your data.

This time prepare your data in an Excel Spreadsheet that you will store as a .csv file. Column "0" is the position and column "1" is your measured signal.

In [30]:
```
# Ive written some code to read data from a .csv table.  You can still write o
ut the data as two 1D arrays if you like.
#position=[1,2,3,4,5]
#field=[8,9,8,9,8]
#The following line reads data from a PHYS1250Data05.csv.csv data file that is
stored at the path location shown.
data05=np.genfromtxt("Book1.csv",delimiter=",")
#print (data05)  # Note that I just made up data here.
position=data05[:,0]
field=data05[:,1]
print(type(position))
plt.figure()
plt.plot(position,field)
plt.axis([0,.4,0,1.3])   # Adjust axis parameters as desired.
plt.title("Magnetic Field vs. Radius")   # Add appropriate title and axis labe
ls.
plt.xlabel("Radius (M)")
plt.ylabel("B (T)")
plt.show()
```

```
<type 'numpy.ndarray'>
```



EDIT THIS CELL TO ANSWER THE QUESTION.

QUESTION 6: What is the percentage variation in the measured field from the center between the two coils to the center of one coil? Is this consistent with the theoretical calculation above?

The percentage variation from the center between two coils at x = 0cm to the center of one coil at x = 8cm is exactly 0. This is onconsistant with the calculation above, which predicts a 6.67% drop in magnitude.

In [ ]: