Lab 2

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I	δI	R	δR	B	δB	r	δr
2.45	.05	113	1	3.3	.14	86	1.05
1.85	.05	93.76	2.2	2.5	.12	67	2.25
2.25	.05	107.5	.5	3.1	.14	80.7	0.55

In [34]:
```
import math
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
```

In [35]:
```
#multiplicationU
#multiplication with uncertainty propogation
#
#argument:
#   x: a factor to be multiplied
#xDel: the uncertainty in x
#   y: a factor to be multiplied
#yDel: the uncertainty in y
#
#returns:
#   p: the product of x and y
#pdel: the uncertainty in the product
def multiplicationU(x,xDel,y,yDel):
    p=x*y
    pDel=p*(float(xDel/math.fabs(x)+float(yDel/math.fabs(y))))
    return p,pDel
```

In [36]:
```
#subtractionU
#subtraction with uncertainty propogation
#
#arguments:
#   x: the minuend to subtract from
#xDel: the uncertainty in x
#   y: the subtrahend to be subtracted
#yDel: the uncertainty in y
#
#returns:
#   d: the difference in x and y
#dDel: the uncertainty in d
def subtractionU(x,xDel,y,yDel):
    d=x-y
    dDel=xDel+yDel
    return d, dDel
```

In [37]:

```
I=[2.45,1.85,2.25]
delI=0.05
R=[113.,93.76,107.5]
delR=[1.,2.2,0.5]
radius=53.65/2.
delRadius=0.05
B=[]
delB=[]
r=[]
delr=[]
for datum in I:
    b,db=multiplicationU(datum,.05,1.36,.03)
    B.append(b)
    delB.append(db)

for i in range(0,len(R)):
    lilr, delilr=subtractionU(R[i],delR[i],radius,delRadius)
    r.append(lilr)
    delr.append(delilr)

print"B"
print B
print 'delB'
print delB
print 'r'
print r
print 'delr'
print delr
```

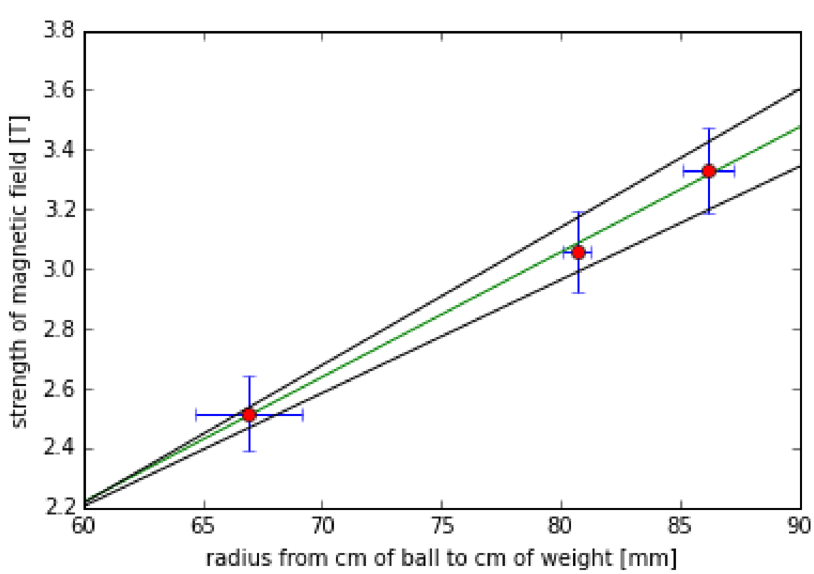
```
B
[3.3320000000000003, 2.5160000000000005, 3.06]
delB
[0.14150000000000001, 0.12350000000000003, 0.13549999999999998]
r
[86.175, 66.935, 80.675]
delr
[1.05, 2.25, 0.55]
```

In [38]:

```
r=np.array(r)
B=np.array(B)
delr=np.array(delr)
delB=np.array(delB)
model=np.polyfit(r,B,1)
maxmodel=np.polyfit(r+delr,B+delB,1)
minmodel=np.polyfit(r-delr,B-delB,1)
print model
print maxmodel
print minmodel
Slope=model[0]
delSlope=np.max(maxmodel[0]-model[0],model[0]-minmodel[0])
m=1.25
delm=.05
g=9.81
delg=.01
weight,delweight=multiplicationU(m,delm,g,delg)
Moment, delMoment=multiplicationU(weight,delweight,Slope,delSlope)
print Moment
print delMoment
line=np.linspace(60,90,100)
fit=np.array([model[1]+model[0]*i for i in line])
plt.errorbar(r,B,xerr=delr,yerr=delB,fmt='none')
plt.plot(line,fit,'g-')
plt.plot(line,np.array([maxmodel[1]+maxmodel[0]*i for i in line]),'k-')
plt.plot(line,np.array([minmodel[1]+minmodel[0]*i for i in line]),'k-')
plt.plot(r,B,'ro')
plt.xlabel('radius from cm of ball to cm of weight [mm]')
plt.ylabel('strength of magnetic field [T]')
```

```
[ 0.04186993 -0.29352064]
[ 0.04622325 -0.55858707]
[ 0.03795609 -0.07331088]
0.513430033713
0.0744431033893
```

Out[38]: <matplotlib.text.Text at 0xe6442e8>



I estimate that $\mu = 0.51 \pm 0.07 \frac{\mathrm{Nm}}{\mathrm{T}}$. This was calculated by plotting three points, and finding a linear regression to match them. The value $\frac{r}{b}$ was the estimated slope of the line, with uncertainty estimated by fitting a regeression to the maximum and minimum values resepectively. It was then multiplied by $g = 9.81 \pm 0.01 \frac{\mathrm{m}}{\mathrm{s}^2}$ with uncertainty to account for elevation, etc. All multiplication and division had propogation of errors built into the functions using the fractional or additive uncertainty that we discussed in class.

In [ ]:

In [ ]: