Introduction to Python: basic elements I (cont.)

In [4]:
```
import os
os.chdir("/home/gf/src/Python/Python-in-the-lab/Bk") # Insert here your dire
ctory. Windows should have "\" instead of "/"
os.path.abspath(".")
```

Out[4]:
```
'/home/gf/src/Python/Python-in-the-lab/Bk'
```

In [5]:
```
filename = "F64ac_0.02_T.dat"
```

Ok, I did lecture 1 so... Can we now open the file, please?

Method 1: hard rock

In [6]:
```
f = open(filename) # We need to be in the directory containing the file
data = f.readlines()
f.close() # MANDATORY, do not forget!
```

In [7]:
```
data[:10] # Let's printthe first 10 lines
```

Out[7]:
```
['5.01924E-006 0\n',
 '6.31885E-006 0\n',
 '7.95496E-006 0\n',
 '1.00147E-005 0\n',
 '1.26078E-005 0\n',
 '1.58722E-005 0\n',
 '1.9982E-005 0\n',
 '2.51558E-005 0\n',
 '3.16693E-005 0\n',
 '3.98693E-005 509496\n']
```

It looks like a list of two columns of numbers, with boaring elements like "\n". Not very efficient!

How can we get the numbers as two columns x and y?

In [8]:
```
col0, col1 = [], [] # Empty list
for row in data:
    c0, c1 = row.split() # Get rid of spaces, and return characters, etc...
    c0, c1 = float(c0), float(c1) # Att. c0,c1 = float(line.split()) does no
t work
    col0.append(c0)
    col1.append(c1)
# Ohhhh, what's wrong????
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-8-290e63ce2a10> in <module>
      1 col0, col1 = [], [] # Empty list
      2 for row in data:
----> 3     c0, c1 = row.split() # Get rid of spaces, and return characters,
etc...
      4     c0, c1 = float(c0), float(c1) # Att. c0,c1 = float(line.split())
does not work
      5     col0.append(c0)

ValueError: not enough values to unpack (expected 2, got 0)
```

In [10]:
```
row
# Eh?
```

Out[10]:
```
'\n'
```

In [11]:
```
data[-5:]
```

Out[11]:
```
['0.19982 0\n', '0.251558 0\n', '0.316693 0\n', '0.398693 0\n', '\n']
```

In [12]:
```
col0, col1 = [], [] # Empty list
for row in data[:-1]:
    c0, c1 = row.split() # Get rid of spaces, and return characters, etc...
    c0, c1 = float(c0), float(c1) # Att. c0,c1 = float(line.split()) does no
t work
    col0.append(c0)
    col1.append(c1)
# Cool...
```

In [13]:
```
type(col0[0]), col0[0]
```

Out[13]:
```
(float, 5.01924e-06)
```

Using the list comprehension

https://docs.python.org/3/tutorial/datastructures.html#list-comprehensions (https://docs.python.org/3/tutorial/datastructures.html#list-comprehensions)

In [15]:
```
# I make a loop of the rows first, splitting the two numbers
[row.split() for row in data[:-1]][:10]
```

Out[15]:
```
[['5.01924E-006', '0'],
 ['6.31885E-006', '0'],
 ['7.95496E-006', '0'],
 ['1.00147E-005', '0'],
 ['1.26078E-005', '0'],
 ['1.58722E-005', '0'],
 ['1.9982E-005', '0'],
 ['2.51558E-005', '0'],
 ['3.16693E-005', '0'],
 ['3.98693E-005', '509496']]
```

In [16]:
```
# Now I use the two numbers from the row.split()
q = [float(c) for row in data[:-1] for c in row.split()] # This is a long li
st
print(q[:10])
```

```
[5.01924e-06, 0.0, 6.31885e-06, 0.0, 7.95496e-06, 0.0, 1.00147e-05, 0.0, 1.26
078e-05, 0.0]
```

Ah, ah, we are close: wouldn't it be nice to make a two cols array just reshaping?

Welcome numpy and numpy array!

In [17]:
```
# Everything can be done in a single line
import numpy as np
d = np.array([float(c) for row in data[:-1] for c in row.split()]).reshape((
-1,2))
d[:10]
```

Out[17]:
```
array([[5.01924e-06, 0.00000e+00],
       [6.31885e-06, 0.00000e+00],
       [7.95496e-06, 0.00000e+00],
       [1.00147e-05, 0.00000e+00],
       [1.26078e-05, 0.00000e+00],
       [1.58722e-05, 0.00000e+00],
       [1.99820e-05, 0.00000e+00],
       [2.51558e-05, 0.00000e+00],
       [3.16693e-05, 0.00000e+00],
       [3.98693e-05, 5.09496e+05]])
```

Man, you are too fast, I did not understand.

In [18]:
```
# As a list cannot be reshaped, we do it using numpy array
q = [float(c) for row in data[:-1] for c in row.split()] # This is a long li
st
q = np.array(q)
# Now I can reshape using two columns. I do not know how many rows are prese
nt, so I put -1
q = q.reshape(-1,2)
q[:10]
```

Out[18]:
```
array([[5.01924e-06, 0.00000e+00],
       [6.31885e-06, 0.00000e+00],
       [7.95496e-06, 0.00000e+00],
       [1.00147e-05, 0.00000e+00],
       [1.26078e-05, 0.00000e+00],
       [1.58722e-05, 0.00000e+00],
       [1.99820e-05, 0.00000e+00],
       [2.51558e-05, 0.00000e+00],
       [3.16693e-05, 0.00000e+00],
       [3.98693e-05, 5.09496e+05]])
```

In [19]:
```
# In a single line
q = np.array([float(c) for row in data[:-1] for c in row.split()]).reshape(-
1,2)
q[:10]
```

Out[19]:
```
array([[5.01924e-06, 0.00000e+00],
       [6.31885e-06, 0.00000e+00],
       [7.95496e-06, 0.00000e+00],
       [1.00147e-05, 0.00000e+00],
       [1.26078e-05, 0.00000e+00],
       [1.58722e-05, 0.00000e+00],
       [1.99820e-05, 0.00000e+00],
       [2.51558e-05, 0.00000e+00],
       [3.16693e-05, 0.00000e+00],
       [3.98693e-05, 5.09496e+05]])
```

Clear now?

In [20]:
```
# Now I need to horizontally split the array in two
x, y = np.hsplit(q,2)
# or simply call the two columns
x, y = q[:,0], q[:,1]
```

Method 2: a little less hard rock

In [21]:
```
with open(filename) as f:
    data = f.readlines()
# NO NEED TO CLOSE THE FILE, IT IS AUTOMATIC
# data as above
q = np.array([float(c) for row in data[:-1] for c in row.split()]).reshape((
-1,2))
x, y = np.hsplit(q,2)
```

Method 3: the pythonic way

In [22]:
```
data = np.loadtxt(filename) # Exercise: explore the loadtxt help or check on
the numpy website
```

In [23]:
```
type(data)
```

Out[23]:
```
numpy.ndarray
```

In [24]:
```
data.shape
```

Out[24]:
```
(50, 2)
```

In [25]:
```
data.size
```

Out[25]:
```
100
```

In [26]:
```
data[:10] # it's a 2D array: where is the other axis???
```

Out[26]:
```
array([[5.01924e-06, 0.00000e+00],
       [6.31885e-06, 0.00000e+00],
       [7.95496e-06, 0.00000e+00],
       [1.00147e-05, 0.00000e+00],
       [1.26078e-05, 0.00000e+00],
       [1.58722e-05, 0.00000e+00],
       [1.99820e-05, 0.00000e+00],
       [2.51558e-05, 0.00000e+00],
       [3.16693e-05, 0.00000e+00],
       [3.98693e-05, 5.09496e+05]])
```

In [27]:
```
data[0,0] # sounds familiar?
```

Out[27]:
```
5.01924e-06
```

In [28]:
```
x, y = data[:,0], data[:,1] #or
x, y = np.hsplit(data,2)
```

Method 4: the real best pythonic way

In [29]:
```
# Isn't a better and faster way to do it? It's python!
x, y = np.loadtxt(filename, unpack=True) #Uauu, isn't it nice?
```

In the *hard rock* case we use many lines (it was an excuse to learn something else, of course). Here everything is in one line: this happens very often and is called refactoring: find the best, clearest and shortest code

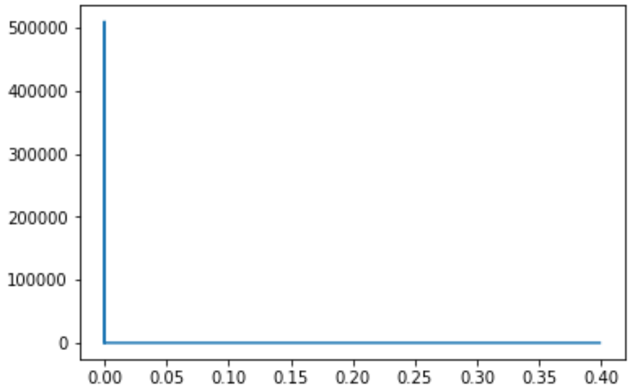
In [30]:
```
x,y = np.genfromtxt(filename, unpack=True) # This works too. Check the docum
entation
# https://docs.scipy.org/doc/numpy/user/basics.io.genfromtxt.html
```

Homework: explore the differences between loadtxt and genfromtxt

Ok, stop: plot, please!

In [31]:
```
import matplotlib.pyplot as plt
%matplotlib inline
plt.plot(x,y)
```

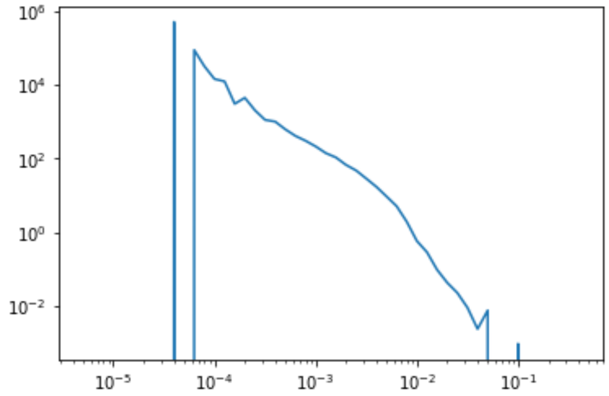
Out[31]: [<matplotlib.lines.Line2D at 0x7fd3ffb3bfd0>]



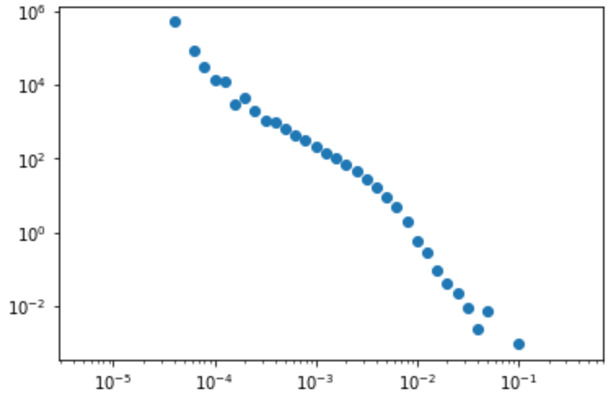
Oh, man! You are joking!

I try myself... let me think... a little more... ok, found

In [32]:
```
plt.loglog(x,y);
```



In [33]:
```
# I prefer dots, please
plt.loglog(x,y,'o'); # suppress the output ;
```



Problem n. 2

How can we plot all the files F64ac_someFreq_T.dat at different frequencies with a nice label etc etc???

In [34]:
```
# Let's find a pattern in the filename we are interested in
import glob
glob.glob("F64ac_*_T.dat")
```

Out[34]:
```
['F64ac_0.03_time_V_T.dat',
 'F64ac_0.02_ave_S_vs_T.dat',
 'F64ac_0.02_T.dat',
 'F64ac_0.03_T.dat',
 'F64ac_0.01_time_V_T.dat',
 'F64ac_0.03_ave_S_vs_T.dat',
 'F64ac_0.02_time_V_T.dat',
 'F64ac_0.01_T.dat',
 'F64ac_0.01_ave_S_vs_T.dat']
```

Oh, too many!

The "*" takes an arbitrary number of data One or two only?

In [35]:
```
glob.glob("F64ac_0.??_T.dat") # cool
```

Out[35]:
```
['F64ac_0.02_T.dat', 'F64ac_0.03_T.dat', 'F64ac_0.01_T.dat']
```

An unordered list, by the way

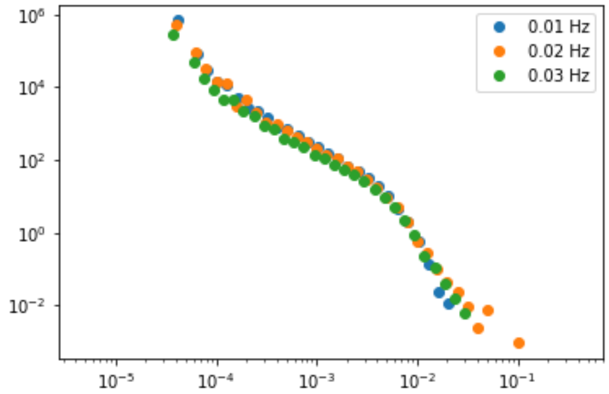
In [36]:
```
filenames = sorted(glob.glob("F64ac_0.0?_T.dat")) # nice
filenames
```

Out[36]:
```
['F64ac_0.01_T.dat', 'F64ac_0.02_T.dat', 'F64ac_0.03_T.dat']
```

Can I plot them all together?

In [37]:
```
# Sure
for filename in filenames:
    x, y = np.loadtxt(filename,unpack=True)
    # Let's extract the frequency value to make a legend
    material, freq, meas = filename.split("_")
    lb = "{0} Hz".format(freq)
    plt.loglog(x,y,'o',label=lb) # I use the same plot
plt.legend(numpoints=1)
```

Out[37]: <matplotlib.legend.Legend at 0x7f220ea94198>



Stop, man, I do not understand the logic!

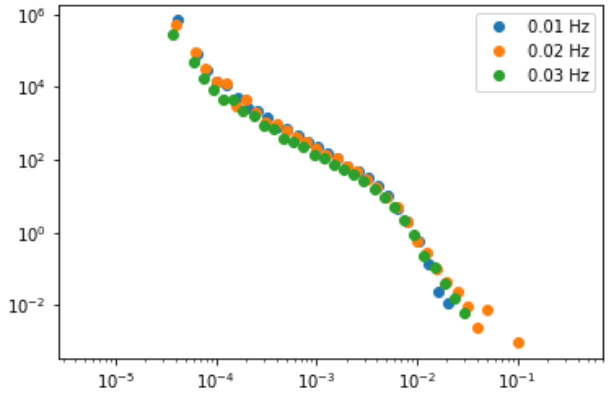
How does it know to put the new data in the same plot?

(teacher) Hem, it uses the same figure...

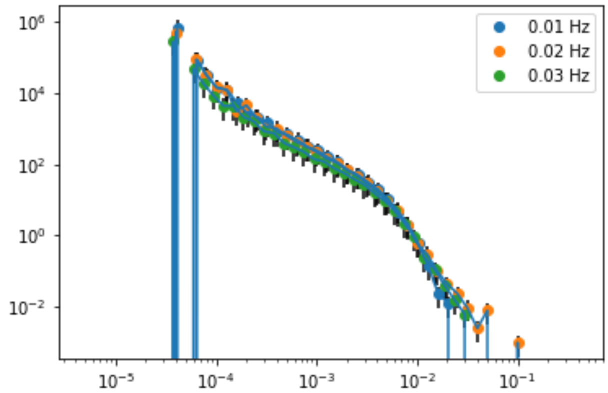
Oh, I see, but we did not tell him to make a figure, at least, explicity... Does it do something behind the curtain?

(teacher) Very good point! *Explicit is better than implicit!*

In [38]:
```
# Let's declare the figure, then add a (sub)plot
fig = plt.figure()
ax = fig.add_subplot(111) # 111 stands for: 1 row, 1 colums, fig n. 1
for filename in filenames:
    x, y = np.loadtxt(filename,unpack=True)
    # Let's extract the frequency value to make a legend
    material, freq, meas = filename.split("_")
    lb = "{0} Hz".format(freq)
    ax.loglog(x,y,'o',label=lb) # I use the same plot, explicitly
plt.legend(numpoints=1);
```



In [45]:
```
# My boss wants the error bars... :(
fig = plt.figure()
ax = fig.add_subplot(111)
for filename in filenames:
    x, y = np.loadtxt(filename,unpack=True)
    yerr = y * 0.6
    material, freq, meas = filename.split("_")
    lb = "{0} Hz".format(freq)
    ax.loglog(x,y,'o',label=lb)
    ax.errorbar(x,y,yerr,fmt="",ecolor='k')
plt.legend();
```



Oh, the autoscale does not work! Or does it? Better to check the data

In [46]:
```
y[:10]
```

Out[46]:
```
array([     0.,      0.,      0.,      0.,      0.,      0.,      0.,
            0.,      0., 281709.])
```

Oh, it is full of zero values. Can we get rid of them?

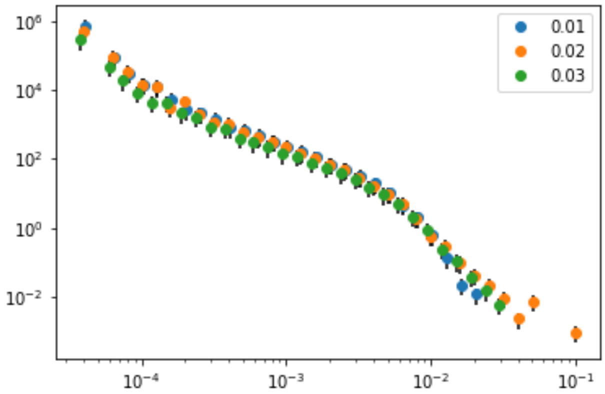
In [47]:
```
is_not_zero = y!=0 # Breath first
is_not_zero
```

Out[47]:
```
array([False, False, False, False, False, False, False, False, False,
        True, False,  True,  True,  True,  True,  True,  True,  True,
        True,  True,  True,  True,  True,  True,  True,  True,  True,
        True,  True,  True,  True,  True,  True,  True,  True,  True,
        True,  True,  True, False, False, False, False, False, False,
       False, False, False, False, False])
```

In [48]:
```
# Ok let me redefine x and y
x, y = x[is_not_zero], y[is_not_zero]
y
```

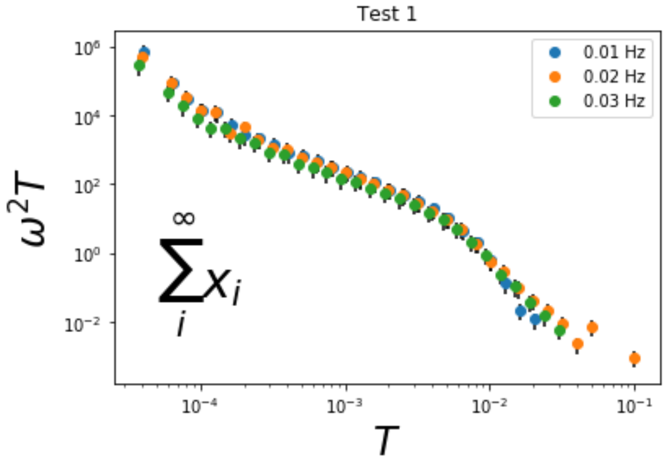
Out[48]:
```
array([2.81709e+05, 4.79296e+04, 1.81690e+04, 8.39005e+03, 4.32740e+03,
       4.32954e+03, 2.10176e+03, 1.58280e+03, 8.39195e+02, 7.36124e+02,
       3.91619e+02, 2.96808e+02, 2.19558e+02, 1.38495e+02, 1.17083e+02,
       7.62096e+01, 5.55879e+01, 3.80288e+01, 2.62899e+01, 1.52914e+01,
       9.44287e+00, 4.95448e+00, 2.13223e+00, 8.80718e-01, 2.38318e-01,
       1.09918e-01, 3.88048e-02, 1.54119e-02, 6.12104e-03])
```

In [49]:
```
fig = plt.figure()
ax = fig.add_subplot(111)
for filename in filenames:
    x, y = np.loadtxt(filename,unpack=True)
    is_not_zero = y!=0
    x, y = x[is_not_zero], y[is_not_zero]
    yerr = y * 0.5
    material, freq, meas = filename.split("_")
    lb = "{0} Hz".format(freq)
    ax.loglog(x,y,'o',label=freq)
    ax.errorbar(x,y,yerr,fmt="none",ecolor='k')
plt.legend();
```



In [50]:
```
# Ok, boss, hold on, let me finish....
fig = plt.figure()
ax = fig.add_subplot(111)
for filename in filenames:
    x, y = np.loadtxt(filename,unpack=True)
    is_not_zero = y!=0
    x, y = x[is_not_zero], y[is_not_zero]
    yerr = y * 0.5
    material, freq, meas = filename.split("_")
    lb = "{0} Hz".format(freq)
    ax.loglog(x,y,'o',label=lb)
    ax.errorbar(x,y,yerr,fmt="none",ecolor='k')
plt.legend()
plt.xlabel("$T$", size=24)
plt.ylabel("$\omega^2 T$", size=24)
plt.annotate("$\sum_i^\infty x_i$", (5e-5,.05), size=30)
plt.title("Test 1")
```

Out[50]: `Text(0.5, 1.0, 'Test 1')`

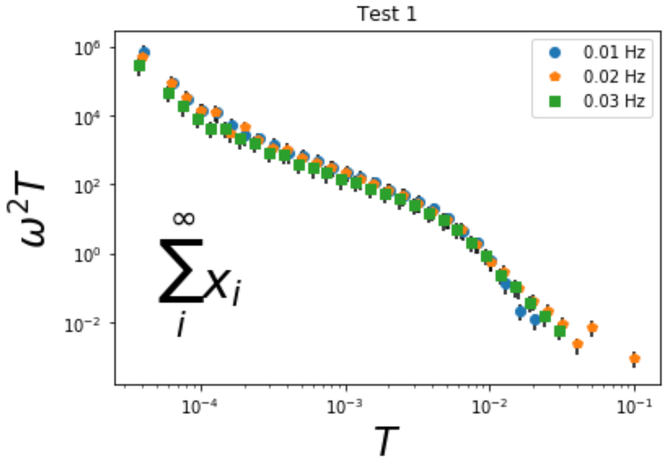


How can we add different markers?

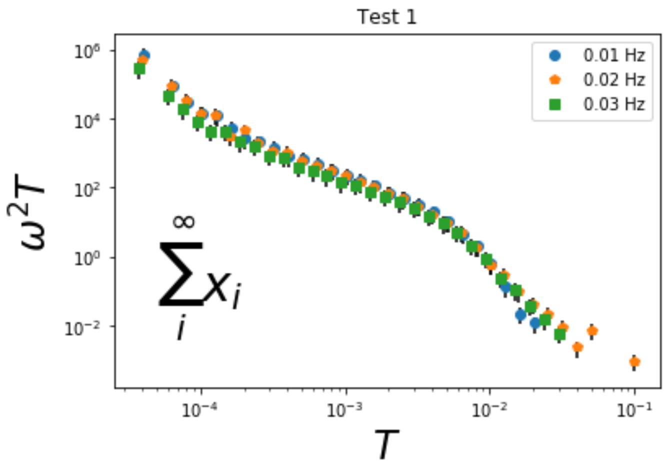
In [51]:
```
# Further points can be found here: http://matplotlib.org/api/markers_api.ht
ml
# Here: http://matplotlib.org/1.3.1/examples/pylab_examples/line_styles.html
# and here: http://matplotlib.org/examples/lines_bars_and_markers/marker_ref
erence.html
```

In [52]:
```
markers = ['o','p','s','<','>','8','v','d','D']*2
```

In [53]:
```
# Problem: how can we use this list of markers in our plot?
# There are different options
# This is not too bad. Let's use enumerate which gives us an index automatic
ally
fig = plt.figure()
ax = fig.add_subplot(111)
for i,filename in enumerate(filenames):
    x, y = np.loadtxt(filename,unpack=True)
    is_not_zero = y!=0
    x, y = x[is_not_zero], y[is_not_zero]
    yerr = y * 0.5
    material, freq, meas = filename.split("_")
    lb = "{0} Hz".format(freq)
    ax.loglog(x,y,markers[i],label=lb)
    ax.errorbar(x,y,yerr,fmt="none",ecolor='k')
plt.legend()
plt.xlabel("$T$", size=24)
plt.ylabel("$\omega^2 T$", size=24)
plt.annotate("$\sum_i^\infty x_i$", (5e-5,.05), size=30)
plt.title("Test 1");
```



In [54]:
```
# This is also nice, and it is MUCH safer. Why?
mks = markers[:len(filenames)]
fig = plt.figure()
ax = fig.add_subplot(111)
for filename,marker in zip(filenames,mks):
    x, y = np.loadtxt(filename,unpack=True)
    is_not_zero = y!=0
    x, y = x[is_not_zero], y[is_not_zero]
    yerr = y * 0.5
    material, freq, meas = filename.split("_")
    lb = "{0} Hz".format(freq)
    ax.loglog(x,y,marker,label=lb)
    ax.errorbar(x,y,yerr,fmt="none",ecolor='k')
plt.legend()
plt.xlabel("$T$", size=24)
plt.ylabel("$\omega^2 T$", size=24)
plt.annotate("$\sum_i^\infty x_i$", (5e-5,.05), size=30)
plt.title("Test 1");
```



In [51]:
```
# Zip is a nice tool to join to arrays, or list
zip(filenames, mks)
```

Out[51]:
```
<zip at 0x7f220ea32908>
```

In [52]:
```
for filename, marker in zip(filenames, mks):
    print(filename, marker)
```

```
F64ac_0.01_T.dat o
F64ac_0.02_T.dat p
F64ac_0.03_T.dat s
```

Satisfied?

Excercise

The three files F64ac_freq_sp.dat are the power spectra S of magnetic noise signals taken at three different frequencies f_H of an applied magnetic field .

I remember that the *amplitude* of the power spectra rescales, i.e. it is proportional, with the frequency f_H, but I do not remember if it is directly or inversely proportional.

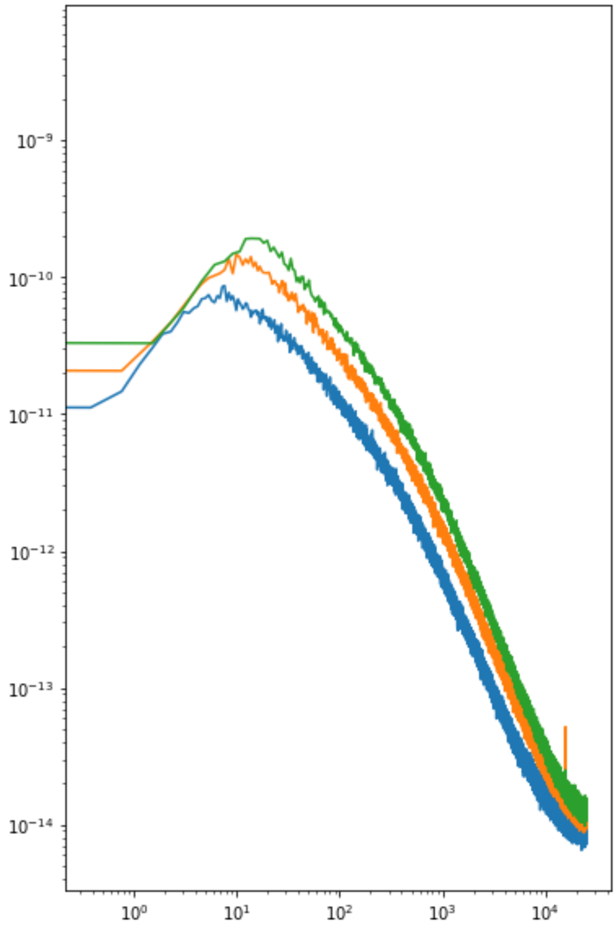
In other words, if S/f_H or Sf_H shows a good collapse of the data.

Would you please check it for me?

ps. Or are they already rescaled?

In [56]:
```
import glob
import numpy as np
import matplotlib.pylab as plt
%matplotlib inline
filenames = sorted(glob.glob("F64ac_0.0?_sp.dat"))
```

In [57]:
```
fig = plt.figure(figsize=(6,10))
ax = fig.add_subplot(111)
for filename in filenames:
    material, freq, something = filename.split("_")
    f, S = np.loadtxt(filename, unpack=True)
    f_H = float(freq)
    ax.loglog(f, S*f_H)
```



In [ ]: