Phys 219 -- Oct. 19, 2010

First load the required *Statistics* and *plots* packages

```
> with(Statistics) :
  with(plots) :
```

This Maple input enters a list of the calculated gain of from measurements made in the lab

```
> G := [100, 100, 97, 93, 75.5, 46.8, 27.5, 19.1, 13.4, 9.9];
```

$$G := [100, 100, 97, 93, 75.5, 46.8, 27.5, 19.1, 13.4, 9.9] \quad \textbf{(1)}$$

Enter the uncertainty in the gain. Have to use propagation of errors to find ΔG

```
> ΔG := [4, 4, 3, 5, 4, 3, 1, .7, .5, .4];
```

$$\Delta G := [4, 4, 3, 5, 4, 3, 1, 0.7, 0.5, 0.4] \quad \textbf{(2)}$$

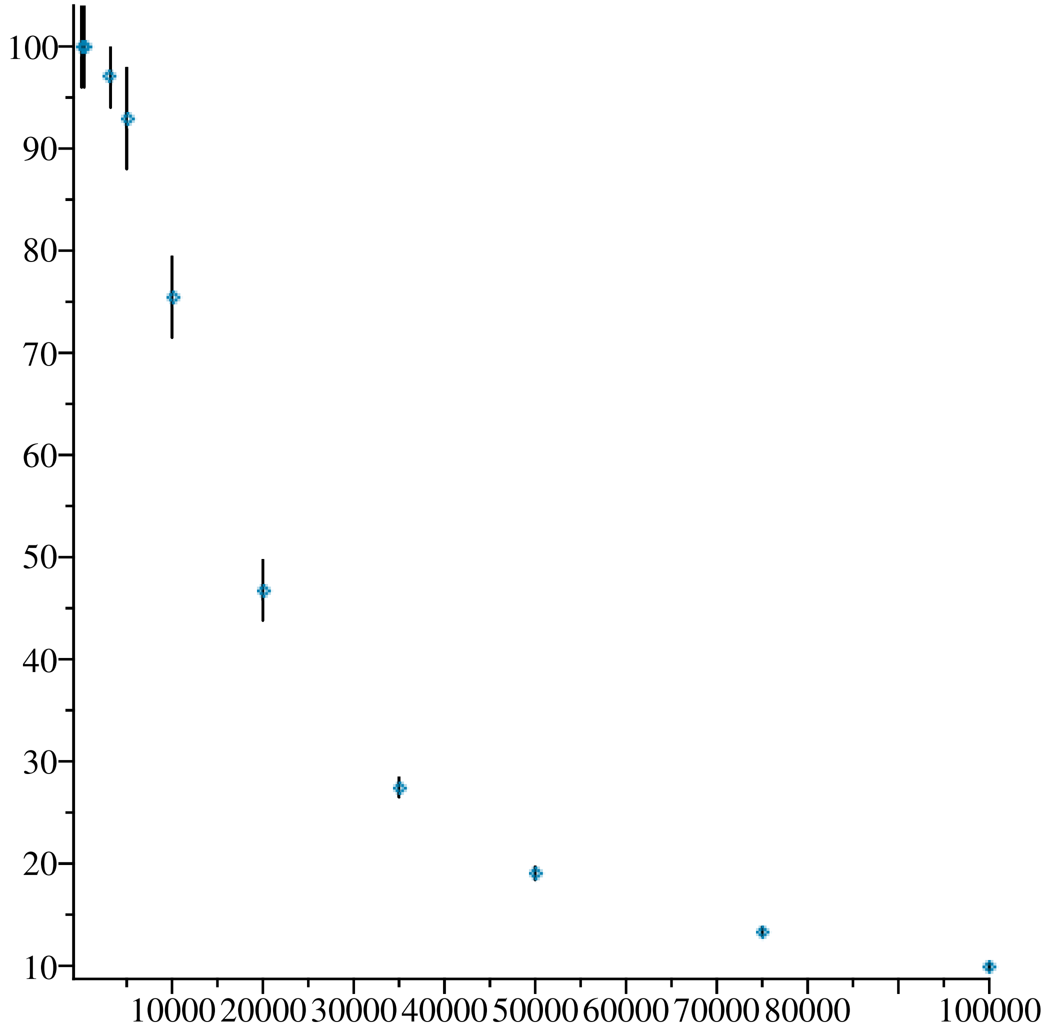
Enter the frequency of the generator in Hz. I'm assuming that the fractional error in the frequency is much less than that of the gain.

```
> f := [32.2, 322, 3220, 5006, 10000, 20000, 35000, 50000, 75000, 100000];
```

$$f := [32.2, 322, 3220, 5006, 10000, 20000, 35000, 50000, 75000, 100000] \quad \textbf{(3)}$$

Now plot *G* vs *f*.

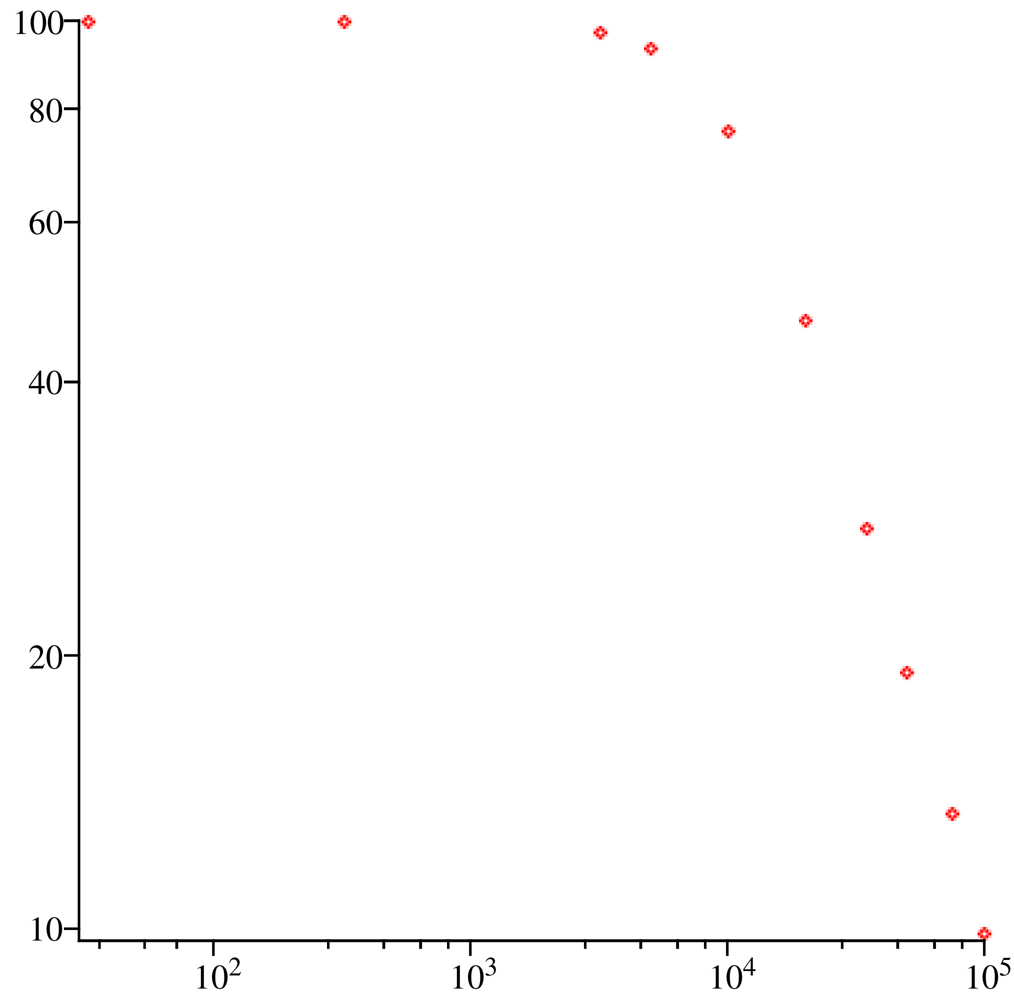
```
> ScatterPlot(f, G, yerrors = ΔG);
```



Really want a log-log plot. Use the *loglogplot* function of Maple. Set the option *style=point* to force Malpe to show the actual data points rather than a line.

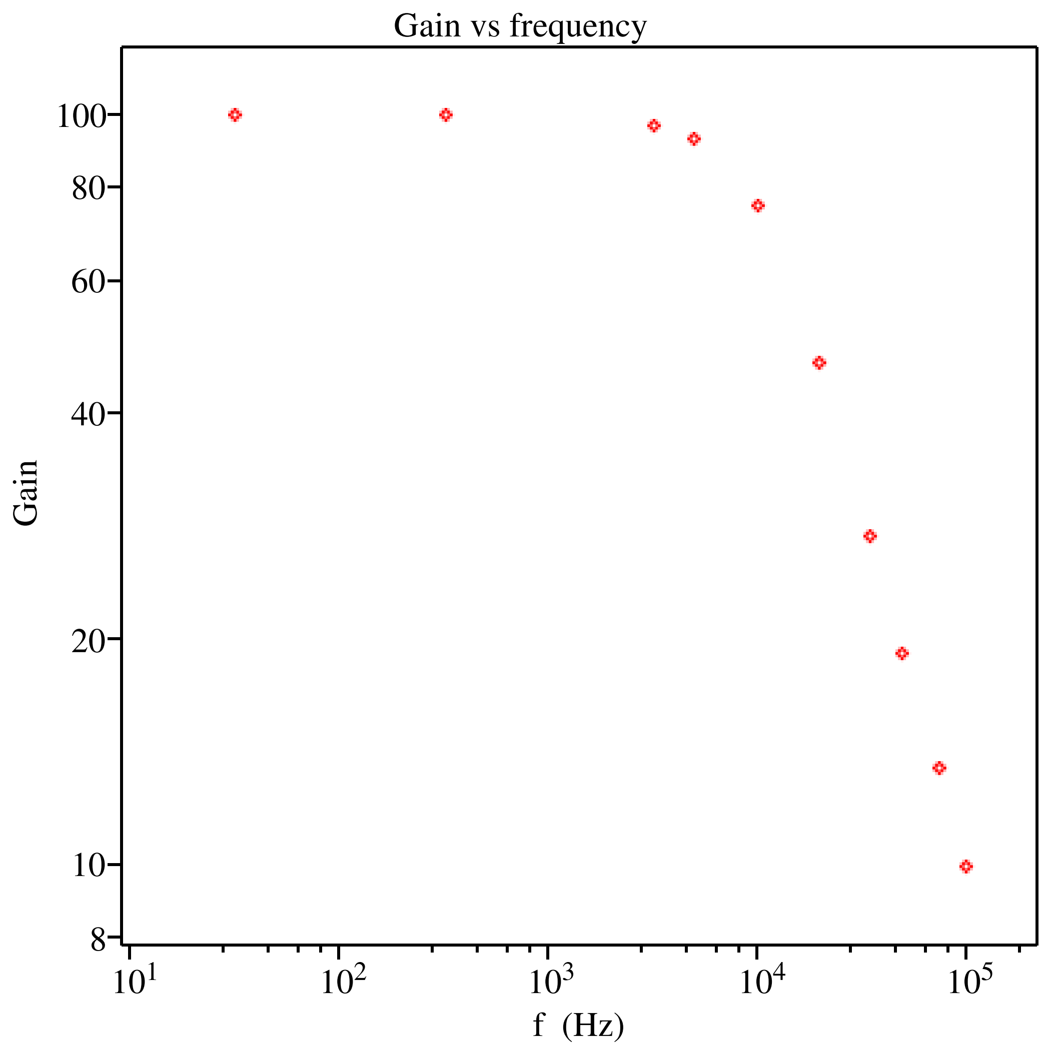
> $GainPlot := loglogplot(f, G, style = point);$
> $display(GainPlot);$

$$GainPlot := PLOT(...)$$



Use *display* to show Gain*Plot*. Use the same formating options in *display*.

> *display*({*GainPlot*}, *axes* = *boxed*, view = [10 .. 200000, 8 .. 120], title = "Gain vs frequency", labels = ["f (Hz)", "Gain"], *labeldirections* = ["horizontal", "vertical"]);



I haven't figured out how to put error bars in a *loglogplot*. One option is to calculate ln G and ln f and their errors and then do a linear-linear ScatterPlot.

I have figured out how to operate on a list. Consider the *seq* function

First note that $f[i]$ selects the ith element of the list f

```
> f[2];
```

$$322 \quad (4)$$

The *seq* function is very useful as it can be used to increment the value of i

```
> seq(i, i = 1 ..3);
```

$$1, 2, 3 \quad (5)$$

```
> [seq(i, i = 1 ..3)];
```

$$[1, 2, 3] \quad (6)$$

So, for example, to find the ln of all of the elements of f use:

```
> lnf := [seq(ln(f[i]), i = 1 ..nops(f))];
```

$lnf := [3.471966453, \ln(322), \ln(3220), \ln(5006), 4\ln(10), \ln(20000), \ln(35000),$ **(7)**

$\ln(50000), \ln(75000), 5\ln(10)]$

where *nops*(*f*) is function that returns the number of elements in *f* (don't ask me why *nops* and not something like *listlength*

In a similar way:

> $lnG := [seq(\ln(G[i]), i = 1..nops(G))];$

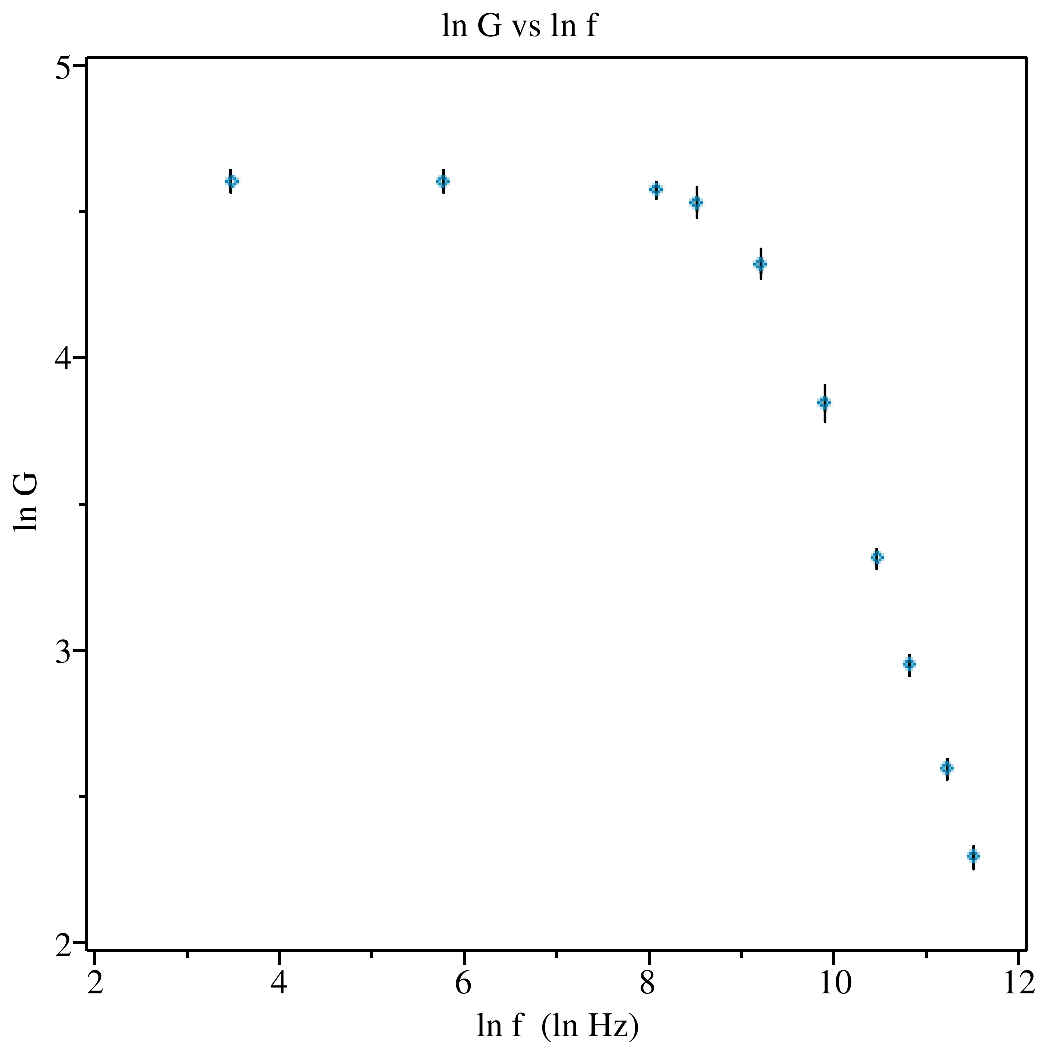
$$lnG := [2\ln(10), 2\ln(10), \ln(97), \ln(93), 4.324132656, 3.845883203, 3.314186005, 2.949688335, 2.595254707, 2.292534757] \quad (8)$$

The uncertainty in ln *G* can also be calculated (Δln*G*=Δ*G*/*G*)

> $\Delta lnG := \left[seq\left(\frac{\Delta G[i]}{G[i]}, i = 1..nops(G)\right)\right];$

$$\Delta lnG := \left[\frac{1}{25}, \frac{1}{25}, \frac{3}{97}, \frac{5}{93}, 0.05298013245, 0.06410256410, 0.03636363636, 0.03664921466, 0.03731343284, 0.04040404040\right] \quad (9)$$

> *ScatterPlot*(*lnf*, *lnG*, *yerrors* = *ΔlnG*, *axes* = *boxed*, view = [2 .. 12, 2 .. 5], title = "ln G vs ln f", labels = ["ln f (ln Hz)", "ln G"], *labeldirections* = ["horizontal", "vertical"]);



This last plot is ln G vs ln f whereas the second-to-last plot is G vs f on a log base 10 scale.

Of course, one could plot log G vs log f.
Note that, if:

$x=10^y$

then

$y=\log x$

Note also that

$\ln x = y \ln 10$

or, finally, that

$y=\ln x / \ln 10 = \log x$

Therefore,

$\Delta y = (\Delta x / x)(1/\ln 10)$

> $logf := [seq(\log10(f[i]), i = 1..nops(f))];$

$$logf := \left[1.507855872, \frac{\ln(322)}{\ln(10)}, \frac{\ln(3220)}{\ln(10)}, \frac{\ln(5006)}{\ln(10)}, 4, \frac{\ln(20000)}{\ln(10)}, \frac{\ln(35000)}{\ln(10)}, \frac{\ln(50000)}{\ln(10)}, \frac{\ln(75000)}{\ln(10)}, 5\right] \quad \textbf{(10)}$$

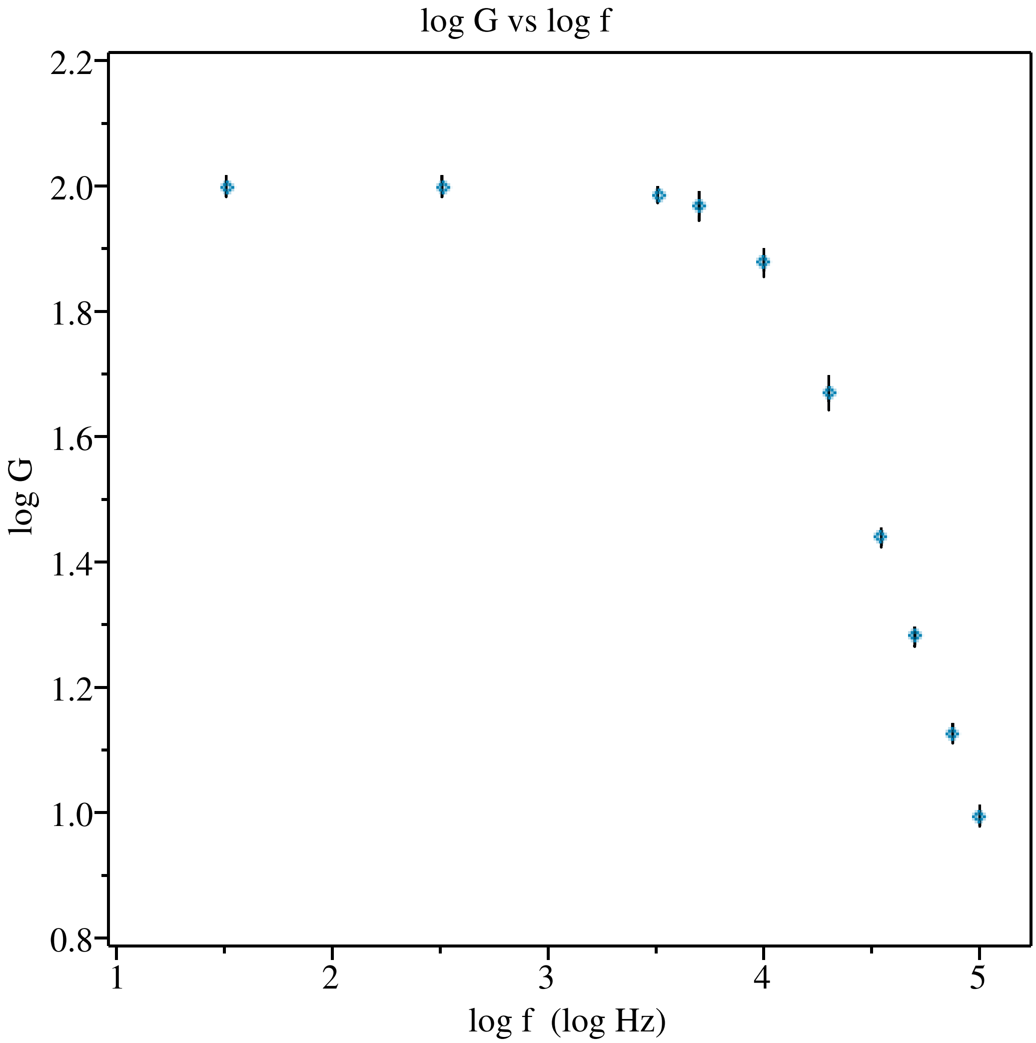
> $logG := [seq(\log10(G[i]), i = 1..nops(f))];$

$$logG := \left[2, 2, \frac{\ln(97)}{\ln(10)}, \frac{\ln(93)}{\ln(10)}, 1.877946952, 1.670245853, 1.439332694, 1.281033367, 1.127104798, 0.9956351946\right] \quad \textbf{(11)}$$

> $\Delta logG := \left[seq\left(\frac{\Delta G[i]}{G[i]} \cdot \frac{1}{\ln(10)}, i = 1..nops(G)\right)\right];$

$$\Delta logG := \left[\frac{1}{25\ln(10)}, \frac{1}{25\ln(10)}, \frac{3}{97\ln(10)}, \frac{5}{93\ln(10)}, \frac{0.05298013245}{\ln(10)}, \frac{0.06410256410}{\ln(10)}, \frac{0.03636363636}{\ln(10)}, \frac{0.03664921466}{\ln(10)}, \frac{0.03731343284}{\ln(10)}, \frac{0.04040404040}{\ln(10)}\right] \quad \textbf{(12)}$$

> *ScatterPlot*(*logf, logG, yerrors* = *ΔlogG, axes* = *boxed*, view = [1 .. 5.2, .8 .. 2.2], title = "log G vs log f", labels = ["log f (log Hz)", "log G"], *labeldirections* = ["horizontal", "vertical"]);



Notice that the slope of the high-frequency roll-off does not depend on whether we do a ln-ln plot or a log-log plot (as expected).

>