PROBLEM 2: SOUND AND THE DECIBEL SCALE

The intensity of sound is sometimes measured in watts per square meter. Humans can hear sounds that vary from approximately 10^{-12} to 100 watts per square meter. This range is extremely large; consequently we often use a different measure to assess the intensity of sound, the decibel. The decibel is one-tenth of a bel, a unit that was named after Alexander Graham Bell. Barely audible sounds are about 0 dB, city traffic or noisy kitchen sounds are around 90 or 100 dB, and a nearby jet may be about 140 dB.

The formula that relates the intensity of sound measured in watts per square meter (N) with the intensity measured in decibels (D) is $D = 10\log\left(\frac{N}{10^{-12}}\right)$.

A. Find the decibel equivalent for a conversation measured at $3.4 * 10^{-6}$ watts per square meter.

B. Find the intensity of sound measured in watts per square meter for a rock band whose music is measured at 128 dB.

ONE SOLUTION TO PROBLEM 2: SOUND AND THE DECIBEL SCALE

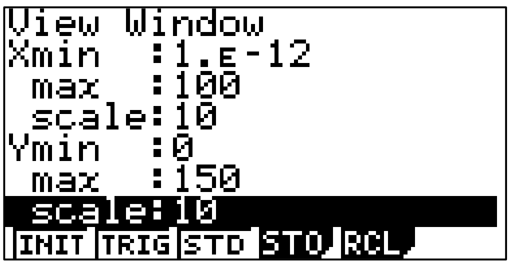
This problem can be investigated many ways. Here a graphic solution is suggested. We will let *x* represent the intensity of sound measured in watts per square meter and *y* be the intensity of sound measured in decibels. Our equation becomes

$$y = 10\log\left(\frac{x}{10^{-12}}\right) \quad .$$

From the MAIN MENU,

- Select "Graph."
- Either delete any functions that are there (by highlighting them, pressing [F2] for delete, and [F1] to confirm), or de-select them by highlighting them and pressing [F1] .
- With the cursor at Y1, make sure the type is "Y=." If not, press [F3] and [F1] .
- Type in the function so that it looks like the screen below left. Students should recall that 1 EXP –12 is the calculator's scientific notation form for $1 * 10^{-12}$. Alternately, we could simply use the carat key for the exponent and type in 10^{-12} without using scientific notation.

As usual, the next step is setting up a reasonable window. We could start by using the values presented in the problem. Press [SHIFT] [F3] for the viewing window screen. Type in the minimum and maximum *x* and *y* values as suggested in the problem. At this point, the scales are not critical, but we have chosen 10 for both axes. Your screen may look as shown below right.



x From the viewing window, press [EXIT] and [F6] to see the graph.

The problem asks us to find *y* when *x* is $3.4 * 10^{-6}$ and then to find *x* when *y* is 128. We can do this very easily with the calculator. For part A, while looking at the graph:

x Press [F5] to access the graph solver.

x Press [F6] for more and [F1] for *y*-calculate.

x At the X= prompt, type in 3.4 EXP –6. Press [EXE] and you will see the solution, which tells us that this conversation would be approximately 65 dB. See below left.

For part B, the commands are similar; however, on the second step, press [F2] for *x*-calculate instead of [F1]. Type in 128 and press [EXE], and you will see that the solution is approximately 6.3 watts per square meter. See below right.