

About this homework: *We meet in the computer lab, Gulick 208, on Monday, April 7. You will use programs to work with the Chaos Game and the Mandelbrot set, and the assignment is based on those programs. You will turn in written answers to some of the exercises, plus printouts of at least four images. The programs that you will use were demonstrated in class on April 4. This assignment is due on Friday, April 11. Note that the third test is coming up on Monday, April 14.*

How to run the programs. The configuration of the computers in Gulick 208 makes it a little difficult to run the two programs that you need for this lab. There are two ways to do it.

The first way is to open a file browser window, for example by selecting “Computer” from the right side of the Start menu. Then double-click the “I” drive (NetCommon), followed by a double-click on “Software Install kits,” then on “Public,” then on “Math-110.” You will find the programs in that folder. To run the Chaos Game program, double-click the batch file named *ChaosGame* or *ChaosGame.bat*. (You might also see a jar file named *ChaosGame*; if you double-click that file, you will get an error message. Run the “batch file.”) To run the Mandelbrot program, double-click the batch file named *xMandelbrot* or *xMandelbrot.bat*.

The second way to run the program is to type a complicated command into a DOS window. The commands that you need are on the course web site, and you can copy-and-paste them from there. To open a DOS window, go to the Start menu, type *cmd* in the search box, and press return, then copy and paste the command from the web page.

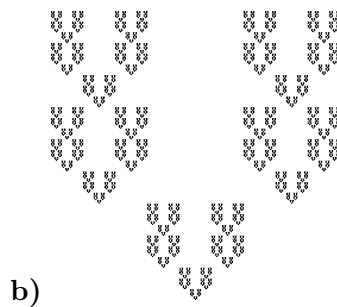
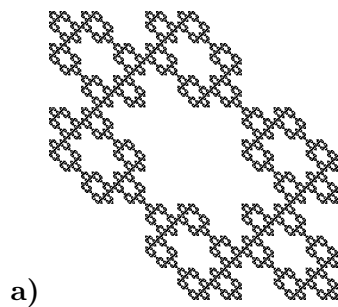
You can run the programs on your own computer, as long as your computer has Java support. There are links on the course web page for downloading the programs.

The Chaos Game. For the first six exercises, you will use the *ChaosGame* program. Run the program as described above. Remember that you can click a map to select it. Once a map is in the window, you can drag the map to move it around, you can drag various points along the border to change its shape, and you can drag the arrow at the end of the central handle to rotate it. Click outside the selected map to deselect it and to see the image at full resolution.

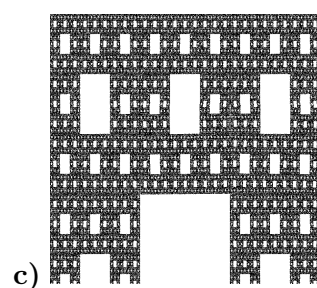
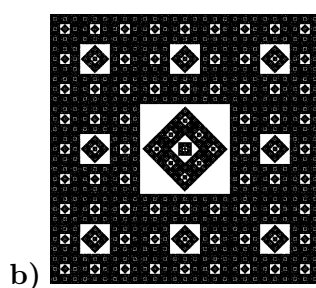
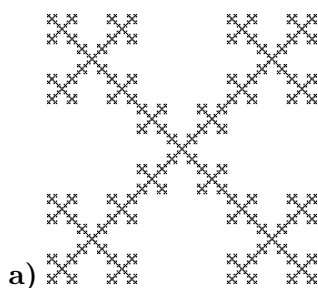
Exercise 1. Select “Sierpinski Triangle” from the “Examples” menu. Use the “Add Map” menu to add a 1/5 Size Map. Drag the new map into the middle of the largest white rectangle in the Sierpinski triangle. Remember that you can click outside the map to see the actual fractal. For this exercise, *write a few sentences discussing what happens to the picture as a whole.*

Exercise 2. Continuing from Exercise 1, try moving the smaller map around, rotating it, and changing its size. Do **not** modify any of the three original maps! Make the prettiest or most interesting picture that you can in this way. Save a copy of the image, using the “Print PNG Image” command from the “File” menu. Print out a copy of the image to turn in. (Note for printing images: Consider opening the image in a Web browser and printing it from there.)

Exercise 3. Select “Sierpinski Carpet” from the “Examples” menu. The following two pictures can be created by simply **deleting** maps from this example. For each image, just state which maps you removed in order to get the image. [The images are on the next page.]



Exercise 4. Figure out how to create each of the following three pictures. In each case, you should start with a fresh copy of the “Sierpinski Carpet” example, and make the picture by adding and/or deleting and/or transforming maps. The third picture is a little harder than the other two; there is a link on the course web page to a colored version of the third picture that will help you to see where the individual maps are. For each of the three parts, just *describe in words exactly what you did to make the picture*.



Exercise 5. The grasping monster shown at the right was made using two $2/3$ -size maps. The maps were rotated and moved but were not otherwise transformed. Make the same picture, or at least something very similar. There is a link to a colored version of the image on the course web site that could help you figure out how to rotate the two maps with respect to each other. *Save a copy of your image using the “Save PNG Image Including Maps” command, and print out the image to turn in.*



Exercise 6. Make one more pretty or interesting picture using the ChaosGame program. Save an image, and make a printout to turn in.

Exercise 7. For this final exercise, you should run the *xMandelbrot* program and spend some time exploring it. Write a short paragraph with your thoughts and impressions of the Mandelbrot set. In addition, save a copy of the nicest image that you can make with the program, and print out a copy of the image to turn in.

Some guidelines for using the program: Remember that the interesting part is the boundary between the black area and the colored area. Click-and-drag to make a box around a part of the image, and that part will be blown up to fill the window. Remembered that colored areas are not part of the Mandelbrot set. Black areas *might* be in the set, but might become colored if you increase the iteration count in the “MaxIterations” menu. As you zoom into the set, you will need to increase the iteration count to see a correct image.

The “Show Palette Editor” command in the “Control” menu opens a window where you can control the colors in the image. The most important control in that window is the palette length. If the colors in the image are too uniform, try decreasing the palette length. If the colors change too rapidly, giving a random-looking staticy picture, try increasing the palette length. You can type in a value for the palette length, or you can adjust it by dragging the red tab near the bottom of the window. The palette editor also allows you to change the set of colors that is used.