

Python Assignment:
Mandelbrot Sets



HOW TO TURN THIS IN!

To make it easy for everyone, you should be writing your code in the SAGE notebook, so you can take advantage of the mathematical functions SAGE has to offer. HOWEVER, to turn this in, you should copy your code and paste it into a text editor and save it as "Sage.py". On the online turn-in page, it will be looking for a file with that name.

HOMEWORK:

For this assignment, you should use SAGE in order to produce a graphical representation of the Mandelbrot Set. For more information about the Mandelbrot set, visit:

http://en.wikipedia.org/wiki/Mandelbrot_set

For this assignment, you will want to use SAGE's complex object in order to make your computations easier.

Definition:

A complex point is part of the Mandelbrot set if $Z_{20} < 2.0$. You can compute Z_{20} by following the following algorithm:

Let $Z_0 = 0$. Then, $Z_{n+1} = Z_n^2 + c$, where “ c ” is the complex number. (You can check the lecture slides for a more in depth look of how to solve this.

If $Z_{20} < 2.0$, then the point “ c ” is part of the Mandelbrot set and should be plotted.

To plot on the complex plane, remember the the “x-axis” is the real numbers and the “y-axis” is the imaginary numbers. So, if you had a complex number $1.2 + 1.2i$, You would plot it on a “normal” Cartesian coordinate plane at the point (1.2, 1.2). (See last slide in the lecture slides for another example.

Notes/Hints:

In Sage, remember you must concatenate “point objects” together in order to show them on one graph. You can use the “show()” method to show a graphical representation of the Mandelbrot set.

We want to limit ourselves to looking at the domain: $[-2,2]$ and the range: $[-2,2]$ on the complex plane. This means that we want to check every point in that box. In order to do this, we will want to look at the complex numbers at every .02 interval (starting at one corner (2, 2)):

$$(2 + 2i), (2 + 1.98i), (2 + 1.96i), (2 + 1.94i), (2 + 1.92i), \dots (2 + -2i)$$

Then, we want to check the points:

$$(1.98 + 2i), (1.98 + 1.98i), (1.98 + 1.96i) \dots (1.98 + -2i)$$

And so forth, until we get to $(-2 + -2i)$.

(Note, that there is a set number of points in a .02 interval from -2 to 2. i.e. You will be looking at 200 points going from left to right)

If we determine that a complex point “ c ” is part of the Mandelbrot set, (i.e. $Z_{20} < 2.0$ for that specific value “ c ”), then we want to plot that point. In order to plot that point, we will use the real number as it’s “x-value”, and the imaginary part as it’s “y-value”. In SAGE, we can use the .imag() and .real() method to find these values.

```
c = CC(2,3) # 2 + 3i
c.imag() # This is 3
```

```
c.real() # This is 2
```

Hopefully, when you have all the points, and graph it, you will get the picture shown above. Remember, this might take a while to process (about 30 seconds). Be patient!

By finishing this hw, you will receive one extra late day!