

# FRACTALS

- Primary characteristic  
Self-similar

1980 - Benoit Mandelbrot

1920's - Gaston Julia

Dynamical Systems - anything that moves or changes in time

\* weather prediction

\* stock market

\* chemical reactions

## Mandelbrot Set

$$f(x) = x^2 + c$$

$$f(x) = x^2 + (1+0i)$$

$$f(0) = 0^2 + 1+0i = 1$$

$$f(1) = 1^2 + 1+0i = 2$$

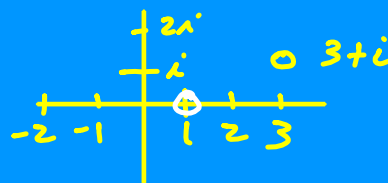
$$f(2) = 2^2 + 1 = 5$$

$$f(5) = 5^2 + 1 = 26$$

$$f(26) = 26^2 + 1 = \text{big}$$

$$f(\text{big}) = \text{big}^2 + 1 = \text{bigger}$$

iterates the function  
beginning at  $x_0 = 0$



Orbit = the list of #'s  
that result from  
iteration

1, 2, 5, 26

black = orbit  
does not go to  $\infty$

Color = does go to  $\infty$

red = fast

blue  
purple ) slow - many iterations

Mandelbrot Set--Choose coordinate for c-value. Always iterate beginning with 0. Change coordinate for c-value each time you want to color a different point.

Calculator:

1)  $x^2 + (1+i) \mid x = 0$

2)  $x^2 + (1+i) \mid x = \text{Ans}$

Mandelbrot Set--Choose coordinate for c-value. Always iterate beginning with 0. Change coordinate for c-value each time you want to color a different point.

Calculator:

1)  $x^2 + (1+i) \mid x = 0$

2)  $x^2 + (1+i) \mid x = \text{Ans}$

---

Julia Set--Choose a c-value from the Mandelbrot Set and leave it fixed. Iterate using a different seed (starting) value. The seed value is the coordinate you are trying to color.

Activity 5: Iterate the function  $f(x) = x^2 + (0 + 0i)$

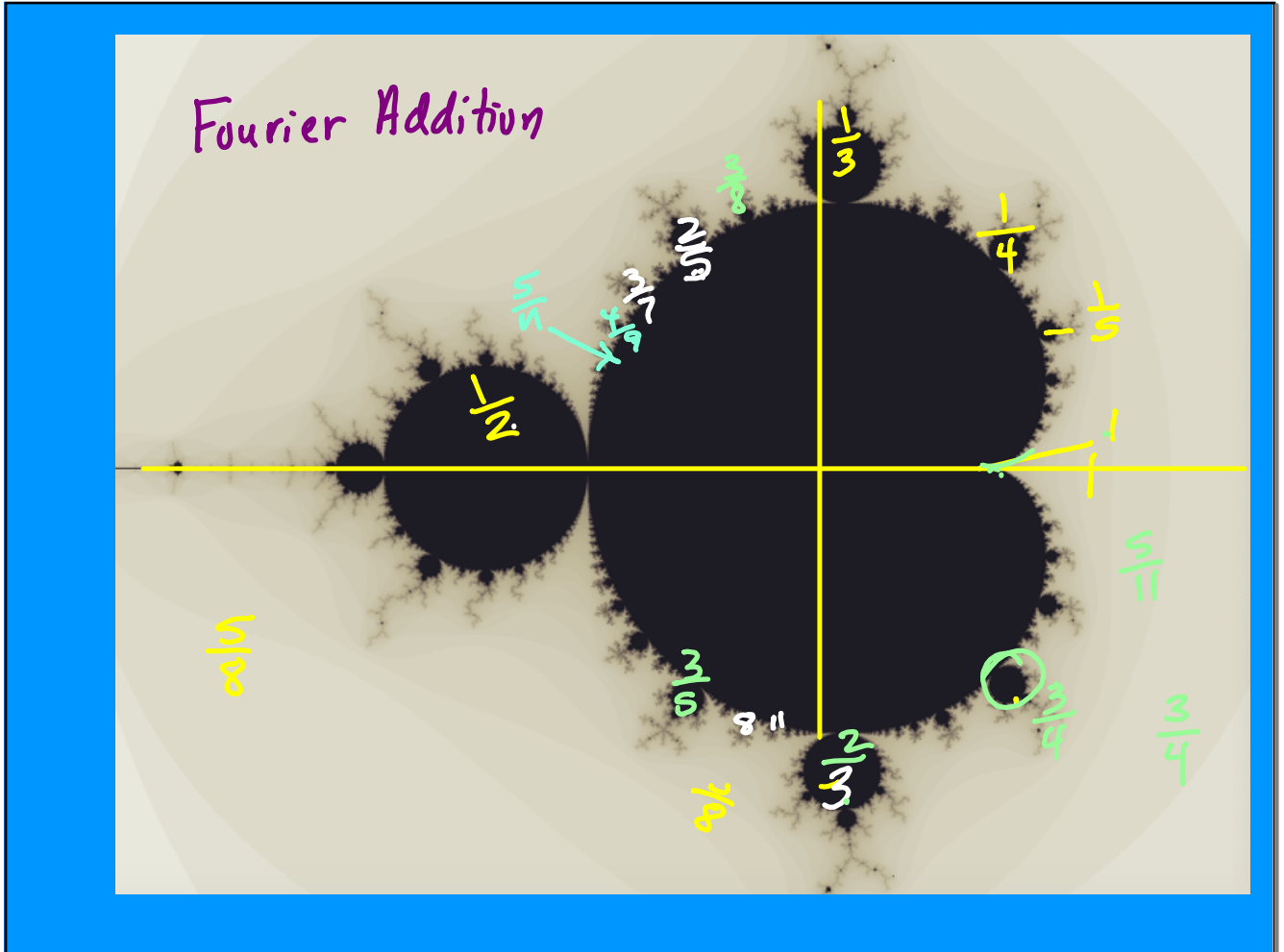
Problem #1:  $x_0 = 0.5$

Calculator:

1)  $x^2 + 0 \mid x = 0.5$

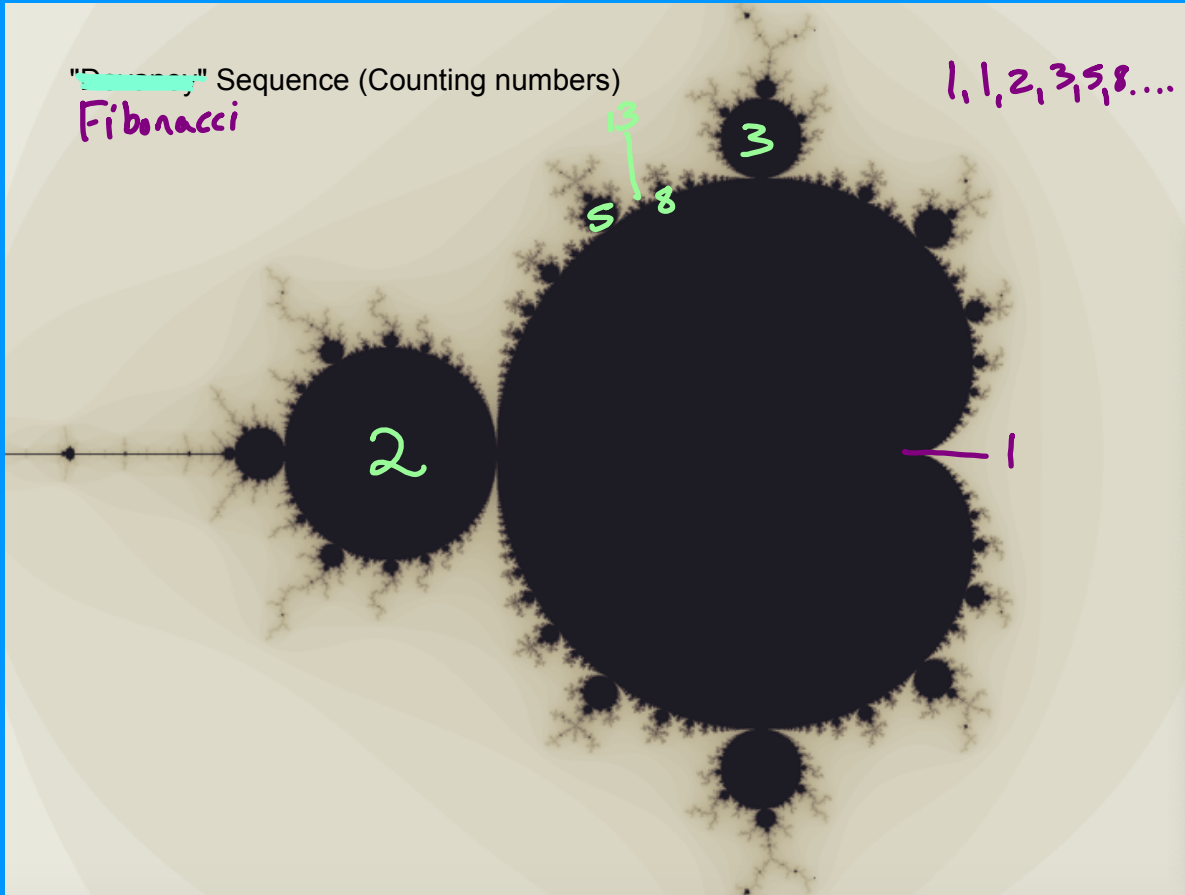
2)  $x^2 + 0 \mid x = \text{Ans}$

For each problem, start the iteration with the  $x_0$  value given.



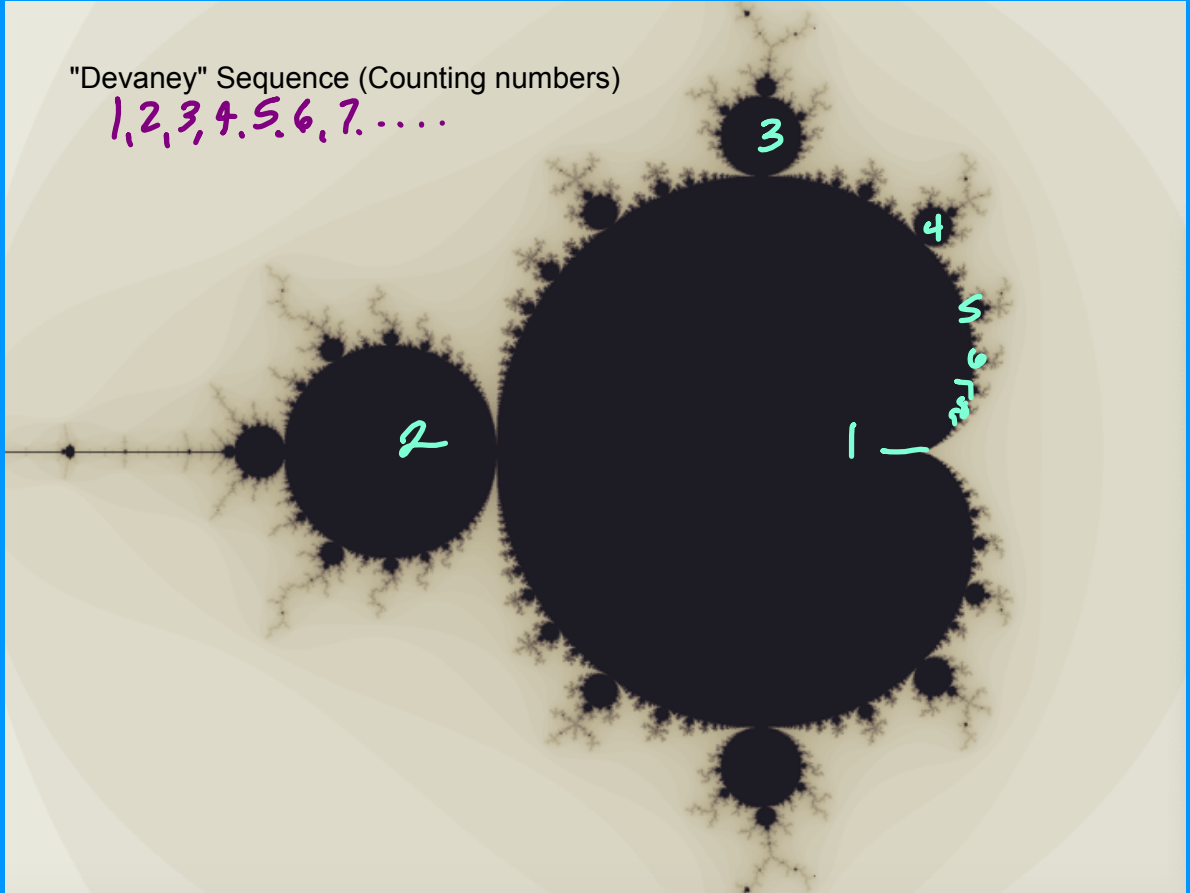
"Fibonacci" Sequence (Counting numbers)  
Fibonacci

1, 1, 2, 3, 5, 8, ...



"Devaney" Sequence (Counting numbers)

1, 2, 3, 4, 5, 6, 7, ...



## Julia Sets

Mandelbrot

$$f(x) = x^2 + c$$

$c =$  complex #  
coord.

$$x_0 = 0$$

Julia

$$f(x) = x^2 + c$$

$c =$  one complex # coord

$x_0 =$  iterate all possible seeds  
coordinates

Example:  $f(x) = x^2 + 0$

$$x = 1 + 0i$$

$$x = i$$

$$x = 2 + 3i$$

