



Mandelbrot Magnitudes

Project Goal:

Students will use multiplication and addition of complex numbers to code an algorithm that determines if a point in the imaginary plane is a part of the famous Mandelbrot Set.

Standards:

[CCSS.MATH.CONTENT.HSN.CN.A.1](#)

Know there is a complex number i such that $i^2 = -1$, and every complex number has the form $a + bi$ with a and b real.

[CCSS.MATH.CONTENT.HSN.CN.A.2](#)

Use the relation $i^2 = -1$ and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers.

Student Guide

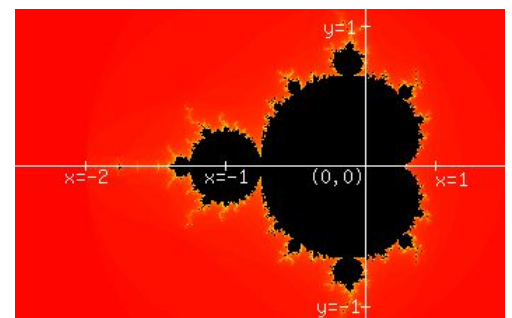
Teacher Guide: 2 Days

*Prerequisite: Students should have had exposure to complex numbers, graphed them in the complex plane, and understand basic arithmetic, especially multiplication.

Day 1:

10 Minutes:

Show the students a picture of the Mandelbrot set. Pick one of your favorites from a Google Search, or use the one pictured here with the the axis on it.



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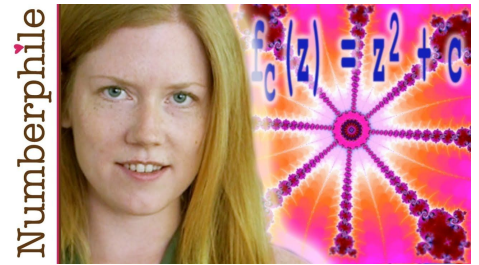


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20 Minutes:

Watch this [Numberphile video](#), please do to better understand the fundamentals of the set. Have students take notes!!



20 Minutes:

Students should spend a good chunk of time hand calculating some of the values shown in the video, and you can assign some from this grid as well and decide as a class which stay bounded...they make the set!

$c = -2+2i$	$c = -1+2i$	$c = 0+2i$	$c = 1+2i$	$c = 2+2i$
$c = -2+1i$	$c = -1+1i$	$c = 0+1i$	$c = 1+1i$	$c = 2+1i$
$c = -2+0i$	$c = -1+0i$	$c = 0+0i$	$c = 1+0i$	$c = 2+0i$
$c = -2+1i$	$c = -1+1i$	$c = 0+1i$	$c = 1+1i$	$c = 2+1i$
$c = -2+2i$	$c = -1+2i$	$c = 0+2i$	$c = 1+2i$	$c = 2+2i$
Coordinates	Birthday Labels	Labels		

50 minutes:

Complete Student Guide in Groups of 2. One student with the Guide opened, and the other on Scratch.

20 minutes:

Students verify accuracy of their program and program in their own personalized reactions to their if-else conditional.

For more fractal inspiration outside the Mandelbrot Set, consider taking a class period to watch this documentary from NOVA; [Fractals: Hunting the Hidden Dimension](#)

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Solutions:

Task 2 Step 2:

```
define Mandelbrot_equation a b
set new_a to a * a - b * b + a
set new_b to 2 * a * b + b
```

Task 3: Pythagorean Theorem :)

```
define iteration_test
repeat 25
  set magnitude to sqrt of new_a * new_a + new_b * new_b
  add magnitude to iteration
  Mandelbrot_equation new_a new_b
```





Task 4:

```
if <item 25 of iteration > < 2 > or <item 25 of iteration > = 2 then
  switch costume to black
  say "It's part of the BUG!" for 2 seconds
else
  switch costume to red
  say "It Blows Up! Not in the set :(" for 2 seconds
```

Final Code

```
when clicked
  delete all of iteration
  ask a? and wait
  set a to answer
  ask b? and wait
  set b to answer
  Mandelbrot_equation a b
  iteration_test

define iteration_test
  repeat 25
    set magnitude to sqrt of new_a * new_a + new_b * new_b
    add magnitude to iteration
    Mandelbrot_equation new_a new_b

define Mandelbrot_equation a b
  set new_a to a * a - b * b + a
  set new_b to 2 * a * b + b

if <item 25 of iteration > < 2 > or <item 25 of iteration > = 2 then
  switch costume to black
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else
  switch costume to red
  say "It Blows Up! Not in the set :(" for 2 seconds
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