

# Computer Graphics

## – WebGL2\* (Questions)

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# Possible Questions

What is the Mandelbrot set, how is it defined?

# Possible Questions

- The Mandelbrot set is the set of complex numbers  $c$ , for which

$$f_c(z) = z^2 + c$$

does not diverge, when we iterate with the sequence

$$f_c(0), f(f(0)), f(f(f(c))), \dots$$

# Possible Questions

Let  $z = 0.5 + 0.5i$ , is this complex number in the Mandelbrot set?

# Possible Questions

$$f_c(z) = z^2 + c$$

$$z \cdot z = (a^2 - b^2) + (2ab)i$$

Let  $z = 0.5 + 0.5i$ , is this point in the Mandelbrot set?

$$f_c(0) = 0^2 + \frac{1}{2} + \frac{1}{2}i = \frac{1}{2} + \frac{1}{2}i$$

$$f_c\left(\frac{1}{2} + \frac{1}{2}i\right) = \left(\frac{1}{2^2} - \frac{1}{2^2}\right) + \left(2 \cdot \frac{1}{2} \cdot \frac{1}{2}\right)i + \frac{1}{2} + \frac{1}{2}i = \frac{1}{2} + 1i$$

$$f_c\left(\frac{1}{2} + 1i\right) = \left(\frac{1}{2^2} - 1^2\right) + \left(2 \cdot \frac{1}{2} \cdot 1\right)i + \frac{1}{2} + \frac{1}{2}i = -\frac{1}{4} + \frac{3}{2}i$$

$$f_c\left(-\frac{1}{4} + \frac{3}{2}i\right) = \left(\frac{1}{4^2} - \frac{3^2}{2^2}\right) + \left(2 \cdot \frac{-1}{4} \cdot \frac{3}{2}\right)i + \frac{1}{2} + \frac{1}{2}i = -\frac{27}{16} - \frac{1}{4}i$$

$$|f_c^n(0)| \leq 2 \text{ for all } n$$

# Possible Questions

- Let's check:

$$f_c^4(0) = 3.2852 + 1.3438i$$

$$|f_c^4(0)| \approx \sqrt{3.2852^2 + 1.3438^2} \approx 3.5494$$

- Length exceeds 2 so it is not in the Mandelbrot set