

complex numbers

$$ax^2 + bx + c$$

$$ax^2+bx+c=0$$



Input:

$$ax^2 + bx + c = 0$$

Solutions:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad (a \neq 0)$$

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Alternate form:

$$n = mx + x^3$$

$$x^3 + mx - n$$

Solutions:

$$x = \frac{\sqrt[3]{\sqrt{3} \sqrt{4m^3 + 27n^2} + 9n}}{\sqrt[3]{2} 3^{2/3}} - \frac{\sqrt[3]{\frac{2}{3}} m}{\sqrt[3]{\sqrt{3} \sqrt{4m^3 + 27n^2} + 9n}}$$

$$x = \frac{(1 + i\sqrt{3})m}{2^{2/3} \sqrt[3]{3} \sqrt[3]{\sqrt{3} \sqrt{4m^3 + 27n^2} + 9n}} - \frac{(1 - i\sqrt{3}) \sqrt[3]{\sqrt{3} \sqrt{4m^3 + 27n^2} + 9n}}{2 \sqrt[3]{2} 3^{2/3}}$$

$$x = \frac{(1 - i\sqrt{3})m}{2^{2/3} \sqrt[3]{3} \sqrt[3]{\sqrt{3} \sqrt{4m^3 + 27n^2} + 9n}} - \frac{(1 + i\sqrt{3}) \sqrt[3]{\sqrt{3} \sqrt{4m^3 + 27n^2} + 9n}}{2 \sqrt[3]{2} 3^{2/3}}$$

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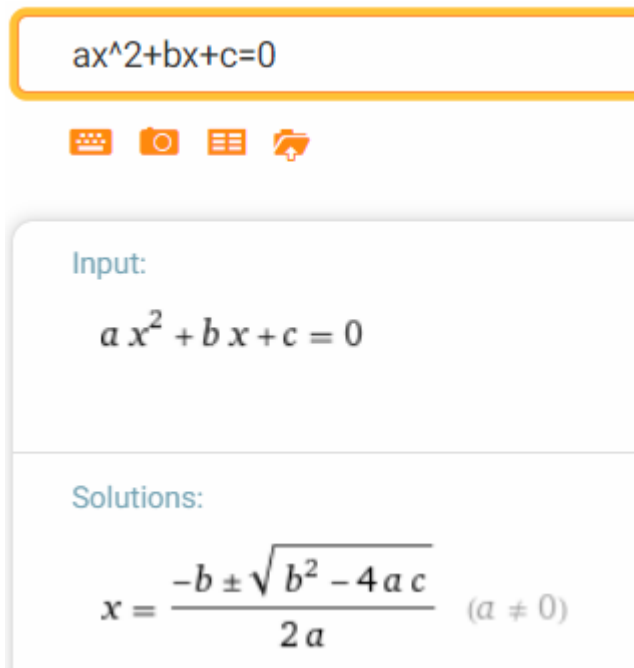
at least one real solution exists

$$x = \frac{(1 + i\sqrt{3})m}{2^{2/3} \sqrt[3]{3} \sqrt[3]{\sqrt{3} \sqrt{4m^3 + 27n^2} + 9n}} - \frac{(1 - i\sqrt{3}) \sqrt[3]{\sqrt{3} \sqrt{4m^3 + 27n^2} + 9n}}{2 \sqrt[3]{2} 3^{2/3}}$$

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complex numbers

$$ax^2 + bx + c$$



A screenshot of a digital math solver interface. At the top, the equation $ax^2+bx+c=0$ is entered into a search bar. Below the search bar are several icons: a keyboard, a camera, a list, and a share icon. Underneath, the text "Input:" is followed by the equation $ax^2 + bx + c = 0$. Below that, the text "Solutions:" is followed by the quadratic formula: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ with the condition $(a \neq 0)$.

$$x^3 + mx = n$$

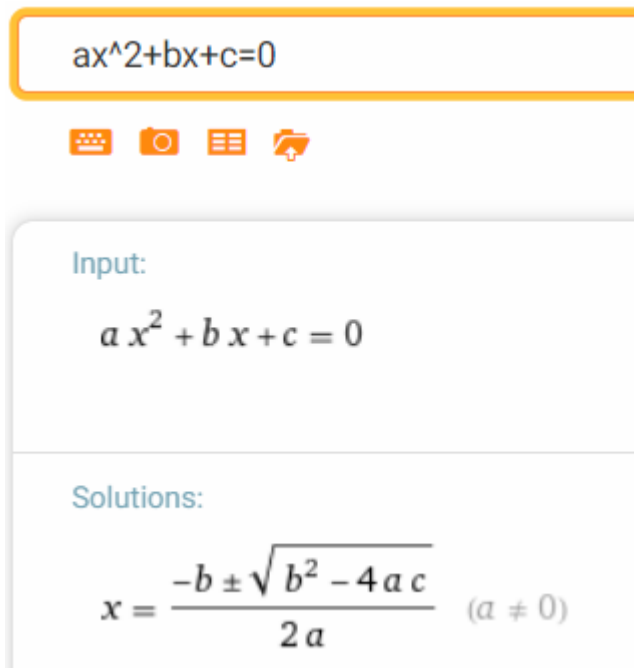
del Ferro's solution:

$$\sqrt[3]{\frac{n}{2} + \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}} + \sqrt[3]{\frac{n}{2} - \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}}$$

$$x^3 - 15x = 4$$

complex numbers

$$ax^2 + bx + c$$



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$$x^3 + mx = n$$

del Ferro's solution:

$$\sqrt[3]{\frac{n}{2} + \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}} + \sqrt[3]{\frac{n}{2} - \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}}$$

$$x^3 - 15x = 4$$

$$x = \sqrt[3]{2 + \sqrt{-121}} - \sqrt[3]{-2 + \sqrt{-121}}$$

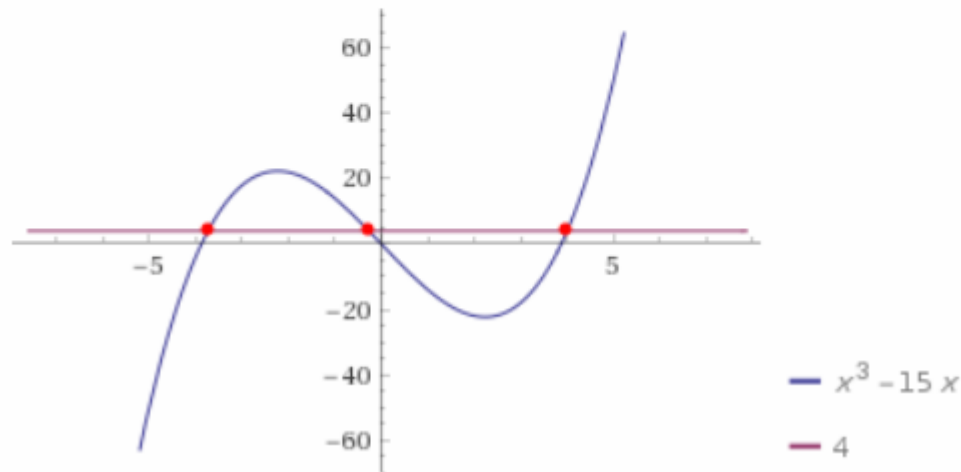
complex numbers

$$x^3 - 15x = 4$$

Input:

$$x^3 - 15x = 4$$

Plot:



$$x^3 + mx = n$$

del Ferro's solution:

$$\sqrt[3]{\frac{n}{2} + \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}} + \sqrt[3]{\frac{n}{2} - \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}}$$

$$x = \sqrt[3]{2 + \sqrt{-121}} - \sqrt[3]{-2 + \sqrt{-121}}$$

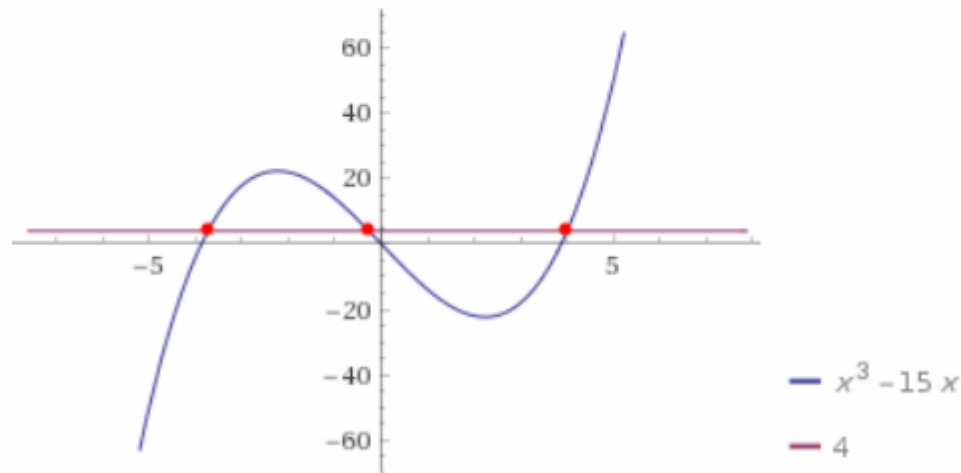
complex numbers

$$x^3 - 15x = 4$$

Input:

$$x^3 - 15x = 4$$

Plot:



$$x^3 + mx = n$$

del Ferro's solution:

$$\sqrt[3]{\frac{n}{2} + \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}} + \sqrt[3]{\frac{n}{2} - \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}}$$

$$x = \sqrt[3]{2 + \sqrt{-121}} - \sqrt[3]{-2 + \sqrt{-121}}$$

$$x = \sqrt[3]{(2 + \sqrt{-1})^3} - \sqrt[3]{(-2 + \sqrt{-1})^3}$$

complex numbers

$$x^3 - 15x = 4$$

Alternate forms:

$$x^3 = 15x + 4$$

$$x(x^2 - 15) = 4$$

$$x^3 - 15x - 4 = 0$$

Solutions:

$$x = 4$$

$$x = -2 - \sqrt{3}$$

$$x = \sqrt{3} - 2$$

$$x^3 + mx = n$$

del Ferro's solution:

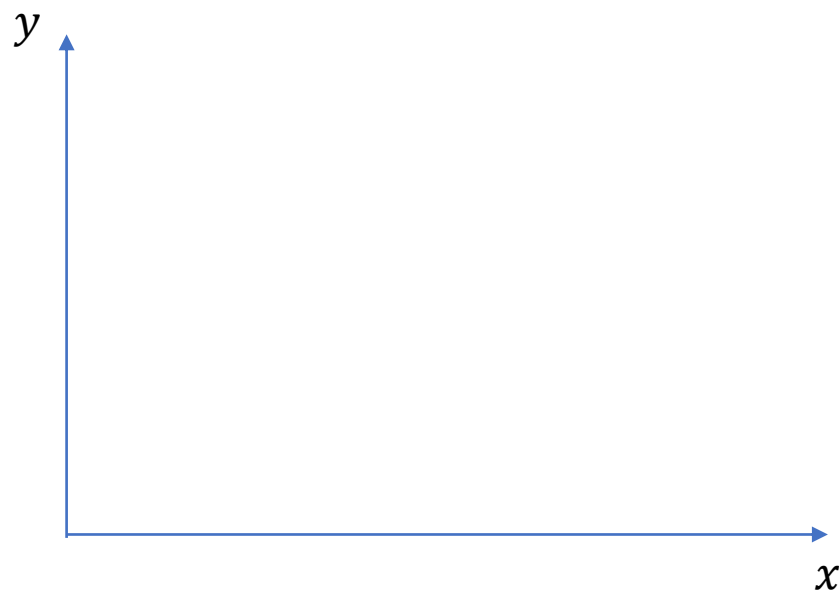
$$\sqrt[3]{\frac{n}{2} + \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}} + \sqrt[3]{\frac{n}{2} - \sqrt{\frac{n^2}{4} + \frac{m^3}{27}}}$$

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complex numbers

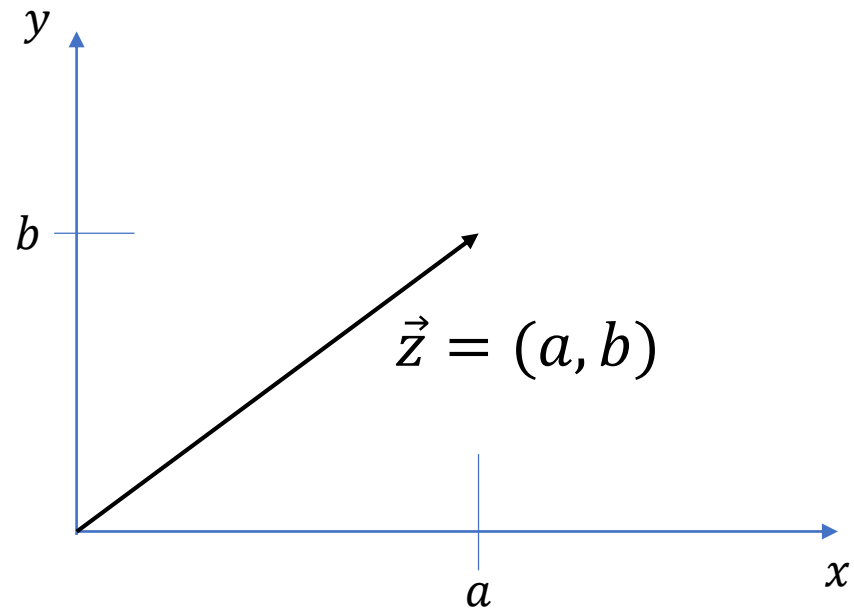
$$i = \sqrt{-1}$$



complex numbers

$$i = \sqrt{-1}$$

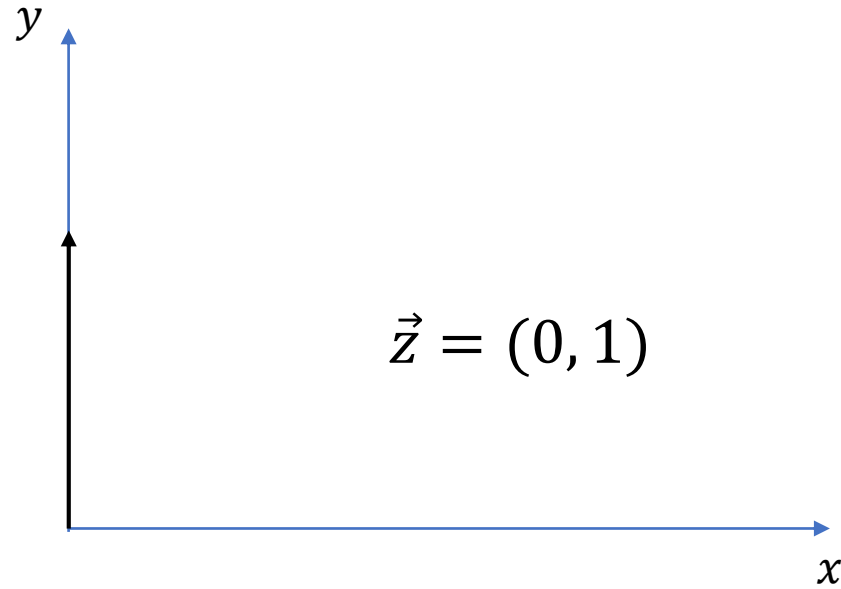
$$a + bi = z \quad a \in \mathbb{R}; b \in \mathbb{R}$$



complex numbers

$$i = \sqrt{-1}$$

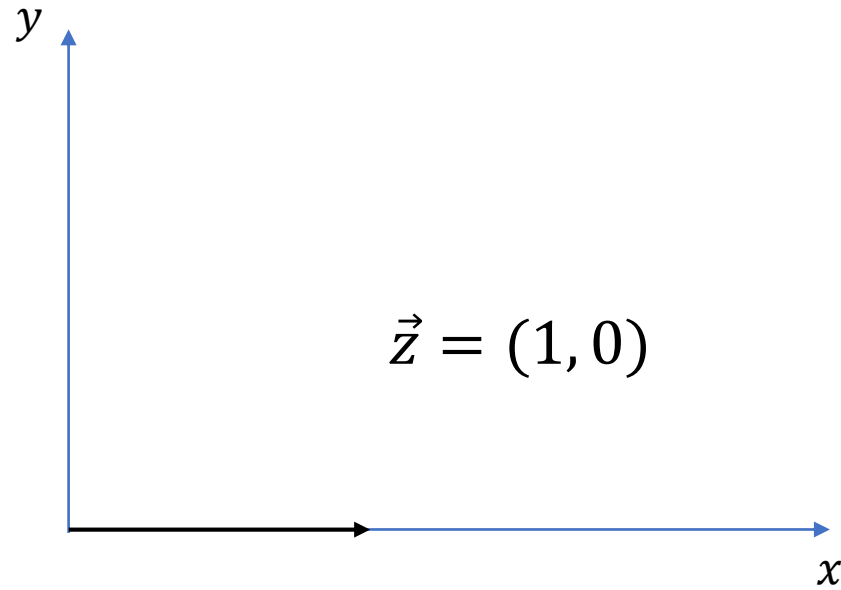
$$0 + 1i = z$$



complex numbers

$$i = \sqrt{-1}$$

$$1 + 0i = z$$

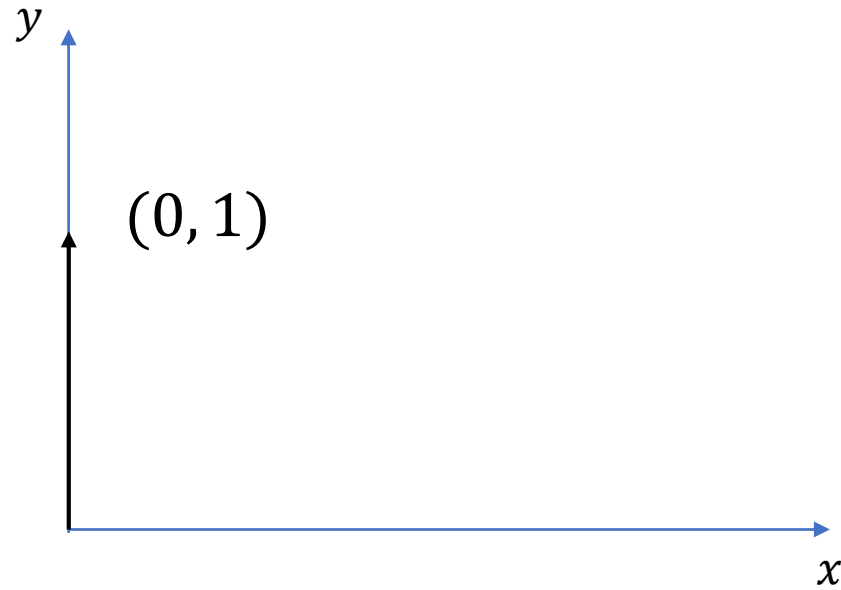


complex numbers

$$i = \sqrt{-1}$$

$$1 + 0i = z$$

$$0 + 1i = zi$$



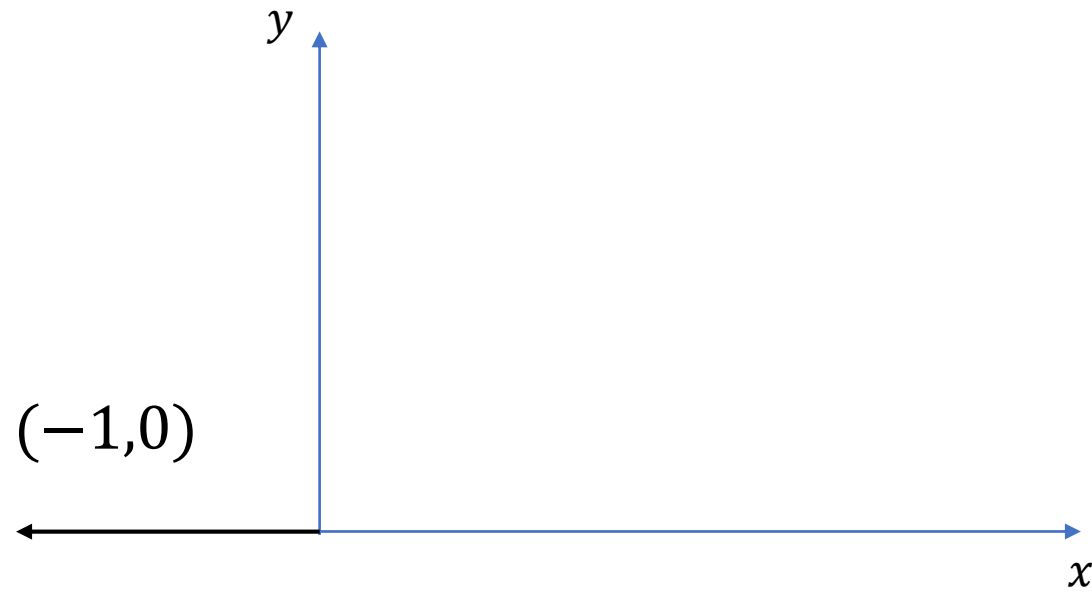
complex numbers

$$i = \sqrt{-1}$$

$$1 + 0i = z$$

$$0 + 1i = zi$$

$$-1 + 0i = zii$$



complex numbers

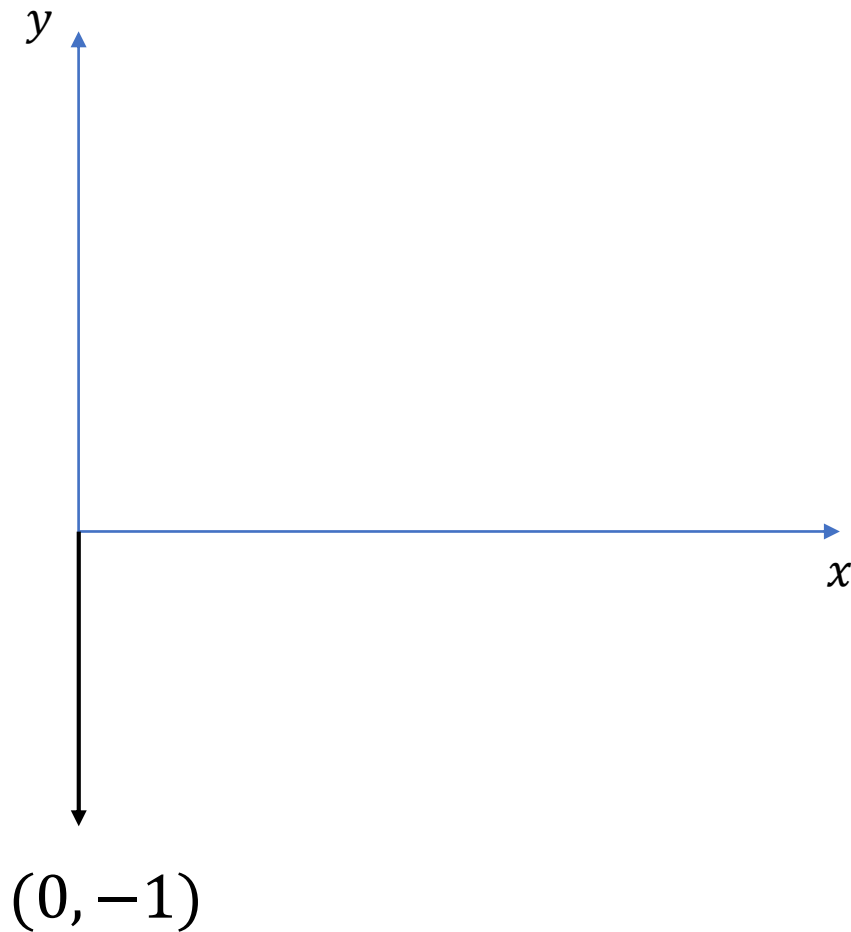
$$i = \sqrt{-1}$$

$$1 + 0i = z$$

$$0 + 1i = zi$$

$$-1 + 0i = zii$$

$$0 - 1i = ziii$$



complex numbers

$$i = \sqrt{-1}$$

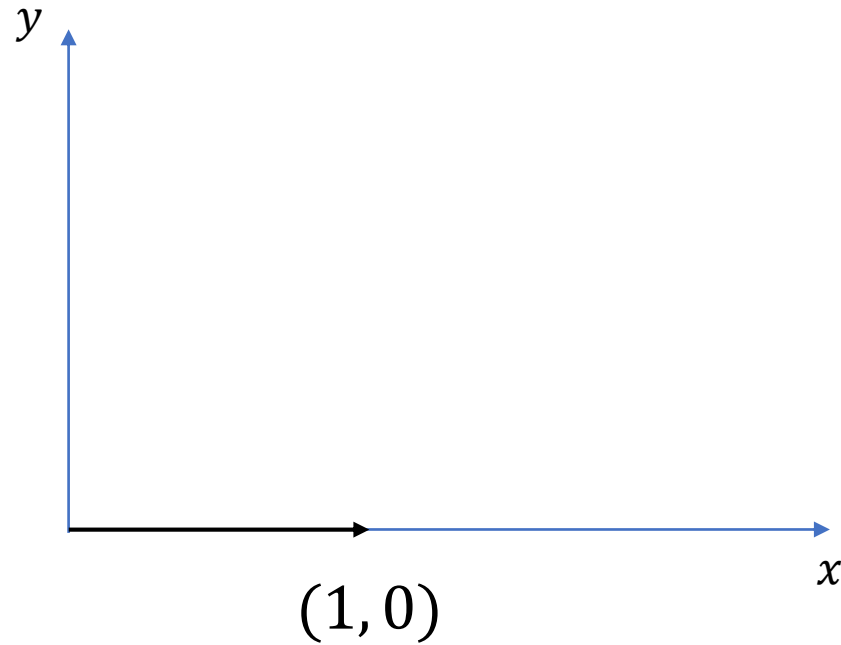
$$1 + 0i = z$$

$$0 + 1i = zi$$

$$-1 + 0i = zii$$

$$0 - 1i = ziii$$

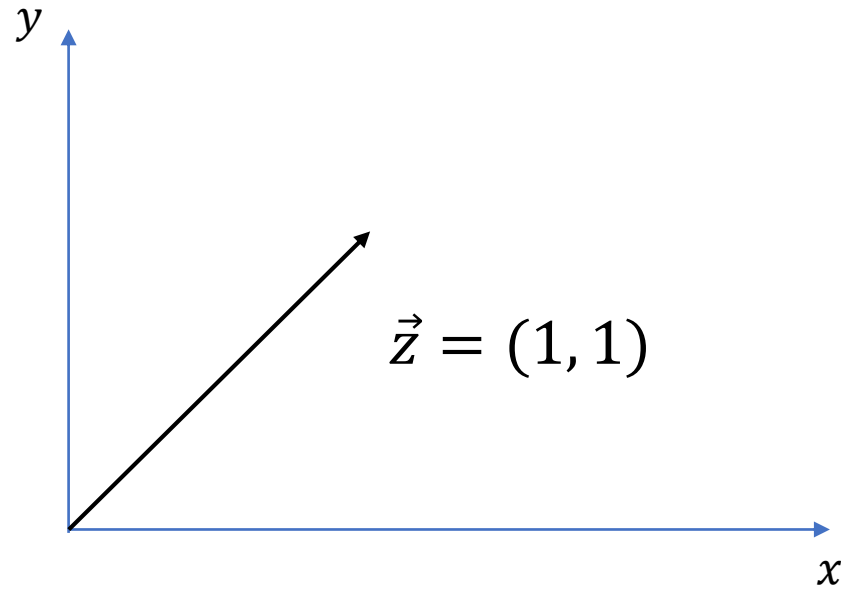
$$1 + 0i = ziiii$$



complex numbers

$$i = \sqrt{-1}$$

$$1 + 1i = z$$



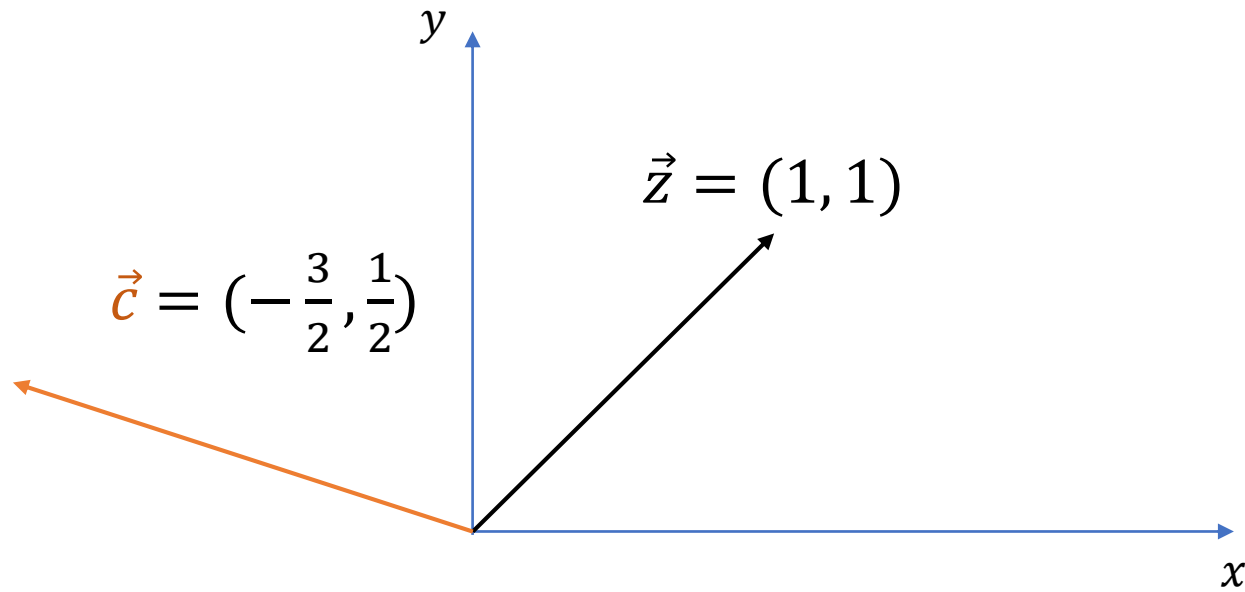
complex numbers

$$i = \sqrt{-1}$$

$$1 + i = z$$

$$-\frac{3}{2} + \frac{1}{2}i = c$$

$$zc = ?$$



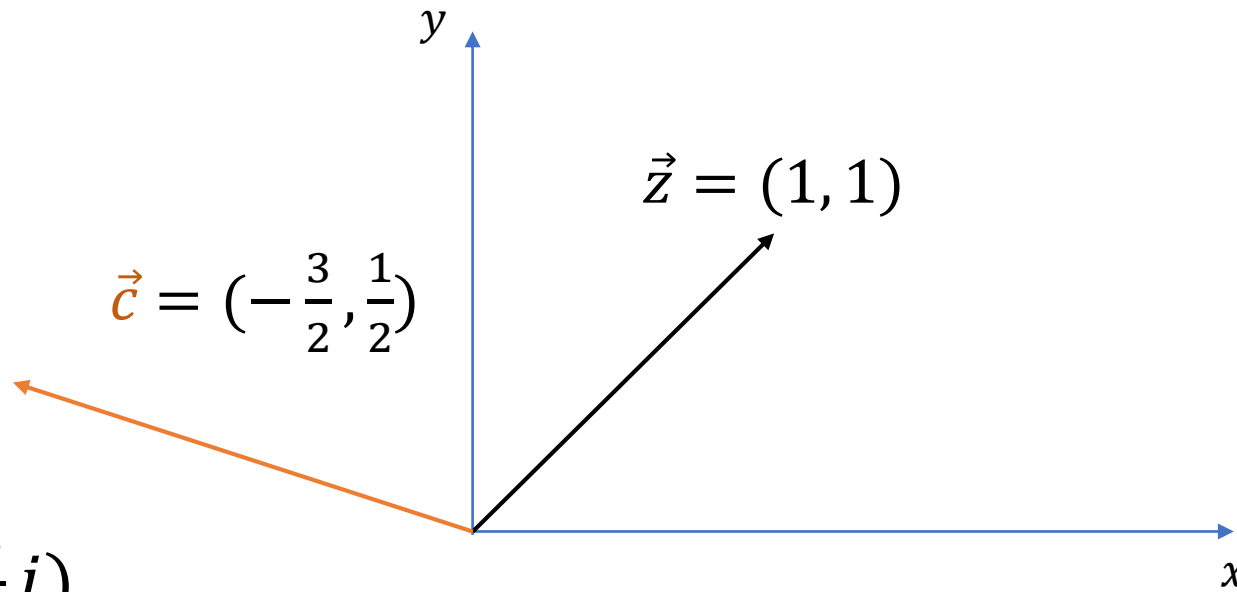
complex numbers

$$i = \sqrt{-1}$$

$$1 + i = z$$

$$-\frac{3}{2} + \frac{1}{2}i = c$$

$$zc = (1 + i)\left(-\frac{3}{2} + \frac{1}{2}i\right)$$



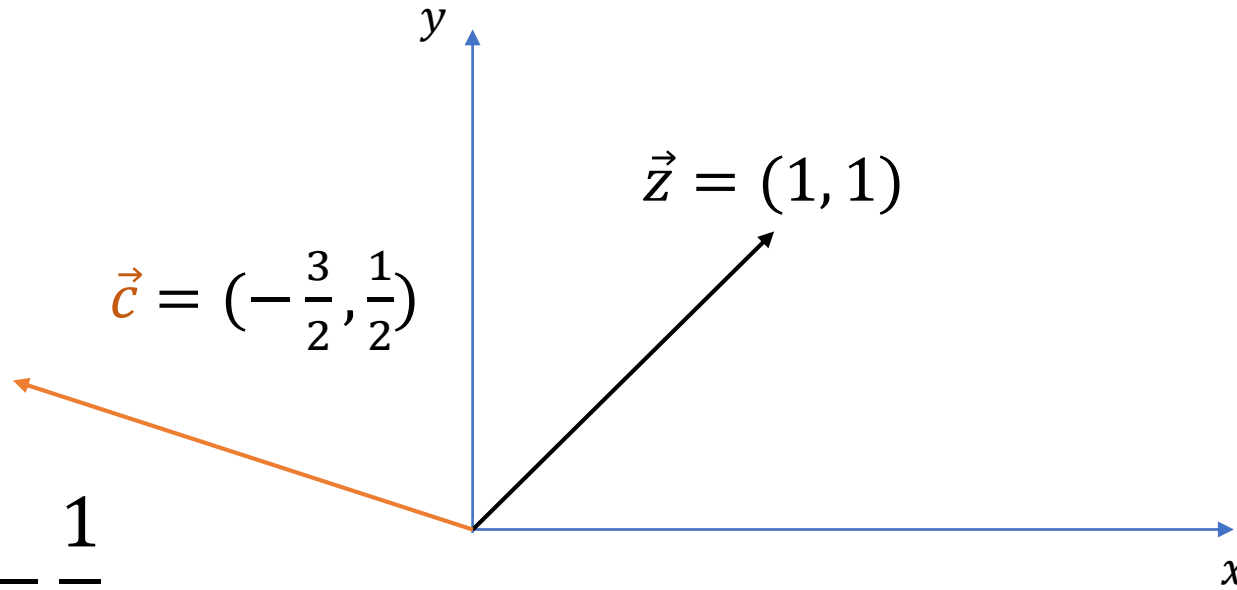
complex numbers

$$i = \sqrt{-1}$$

$$1 + i = z$$

$$-\frac{3}{2} + \frac{1}{2}i = c$$

$$zc = -\frac{3}{2} + \frac{1}{2}i - \frac{3}{2}i - \frac{1}{2}$$



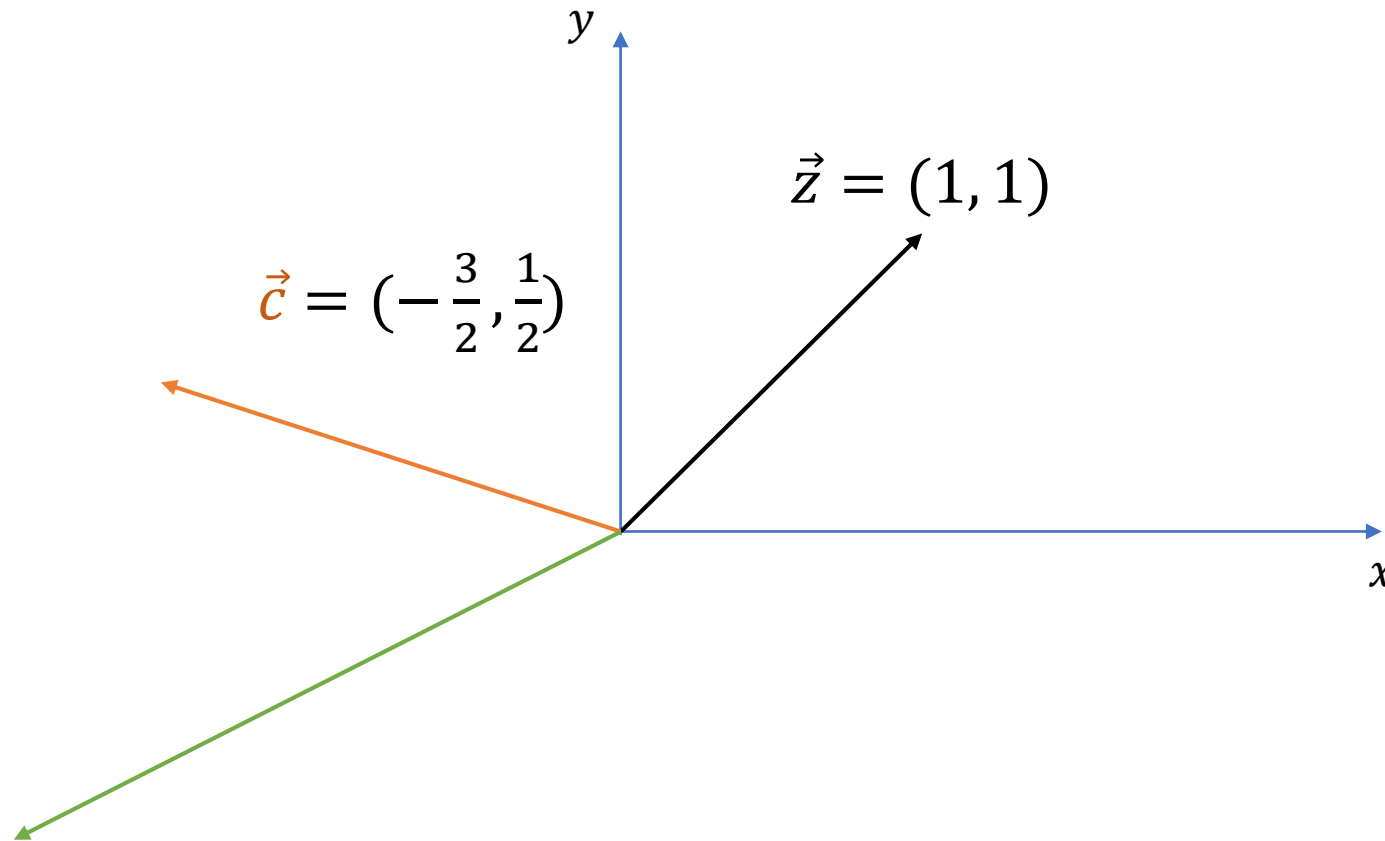
complex numbers

$$i = \sqrt{-1}$$

$$1 + i = z$$

$$-\frac{3}{2} + \frac{1}{2}i = c$$

$$zc = -\frac{4}{2} - \frac{2}{2}i$$



complex numbers

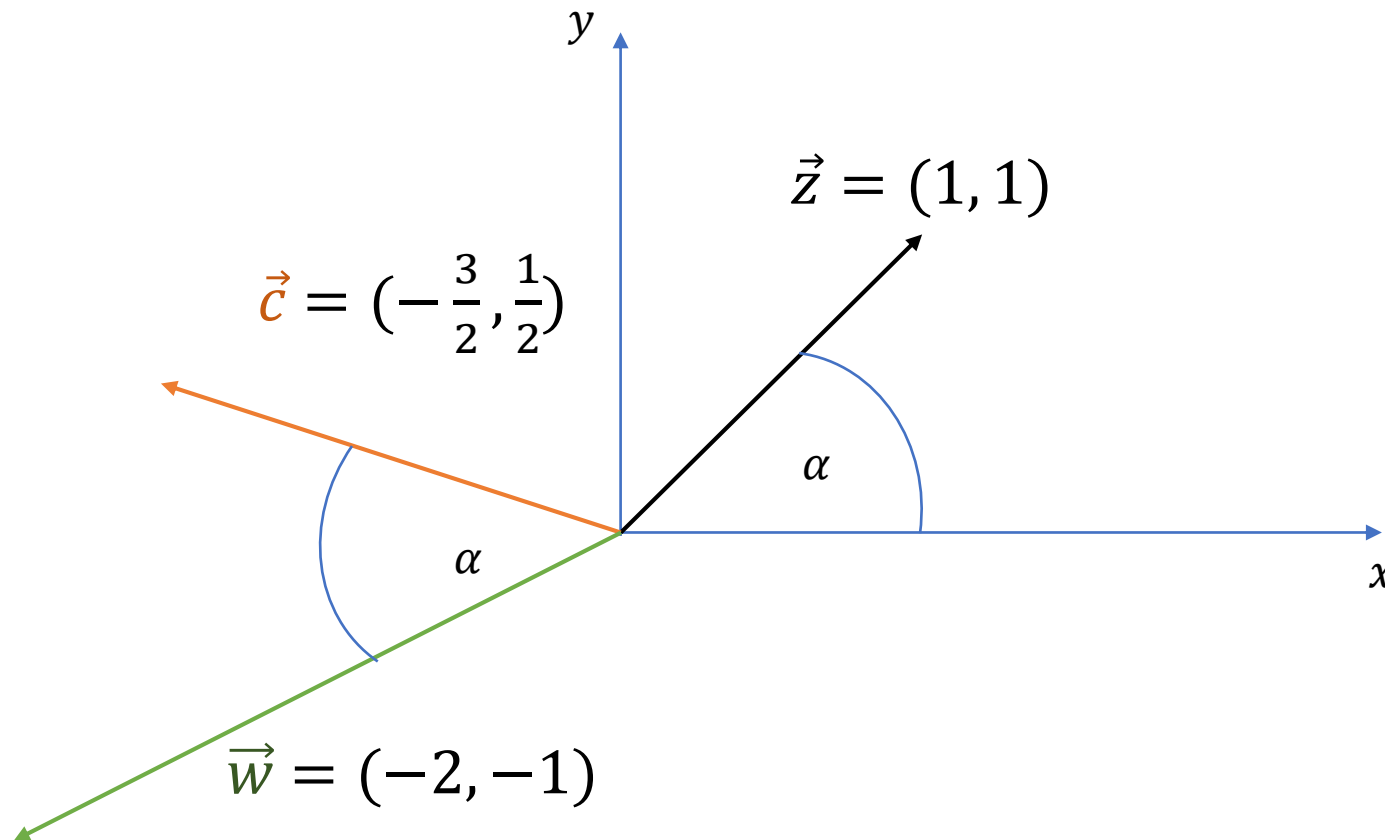
$$i = \sqrt{-1}$$

$$1 + i = z$$

$$-\frac{3}{2} + \frac{1}{2}i = c$$

$$zc = -2 - 1i$$

$$|\vec{w}| = |\vec{z}| |\vec{c}|$$



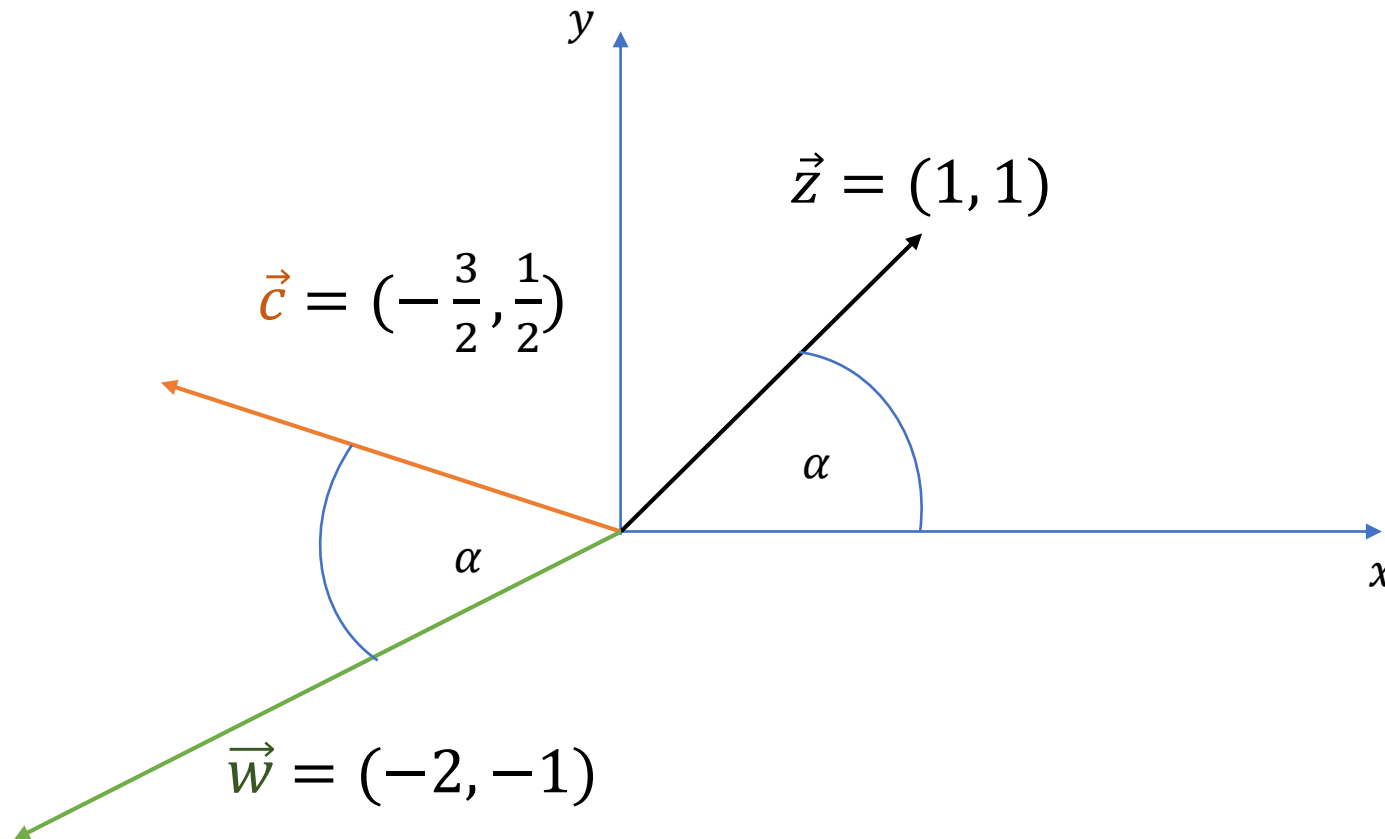
complex numbers

$$i = \sqrt{-1}$$

$$1 + i = z$$

$$-\frac{3}{2} + \frac{1}{2}i = c$$

$$zc = -2 - 1i$$



$$|\vec{w}| = |\vec{z}| |\vec{c}|$$

$$|\vec{z}| = \sqrt{2}$$

$$|\vec{c}| = \sqrt{\frac{9}{4} + \frac{1}{4}} = \frac{\sqrt{10}}{2}$$

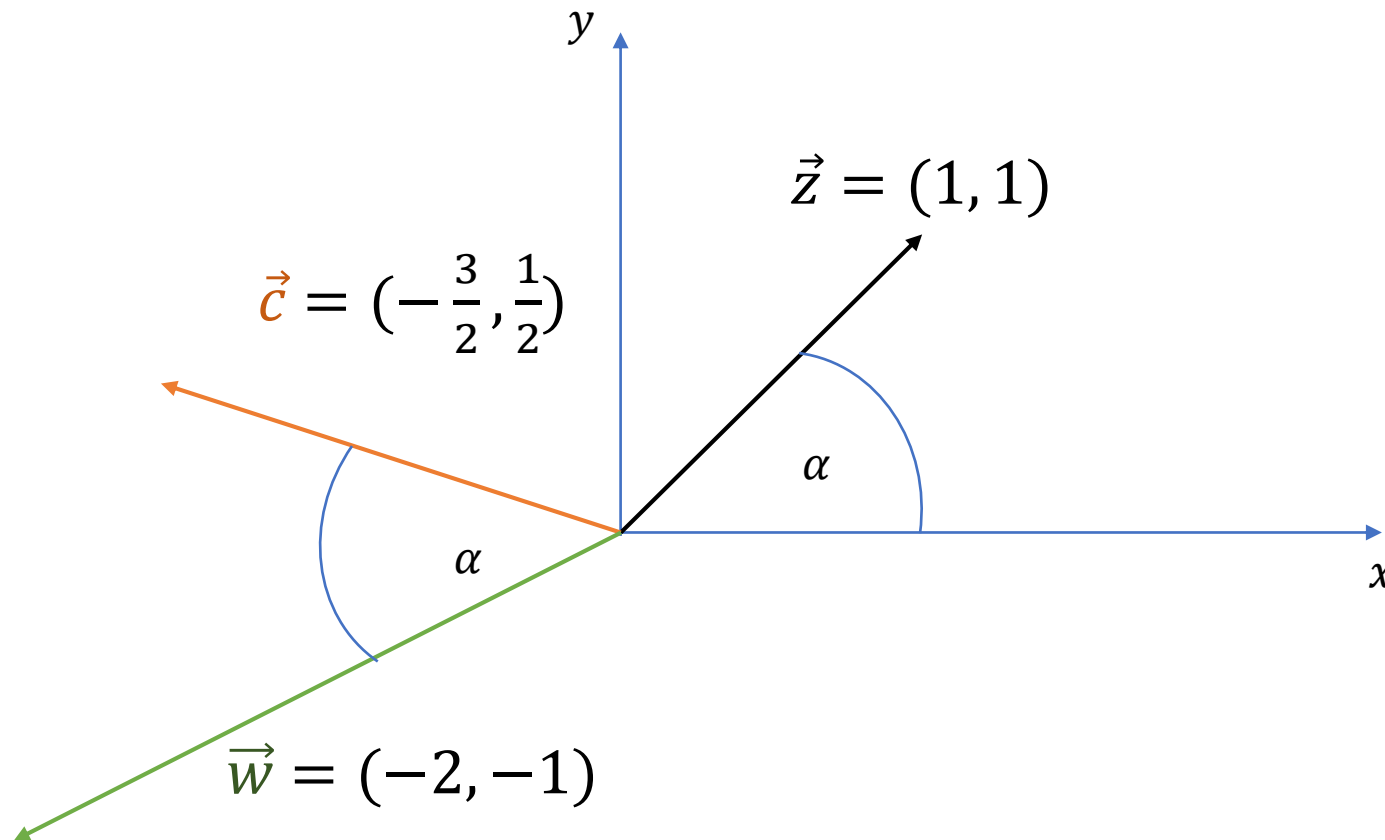
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$$|\vec{w}| = |\vec{z}| |\vec{c}|$$

$$|\vec{z}| = \sqrt{2}$$

$$|\vec{c}| = \frac{\sqrt{10}}{2} = \frac{\sqrt{5}}{2} \sqrt{2}$$

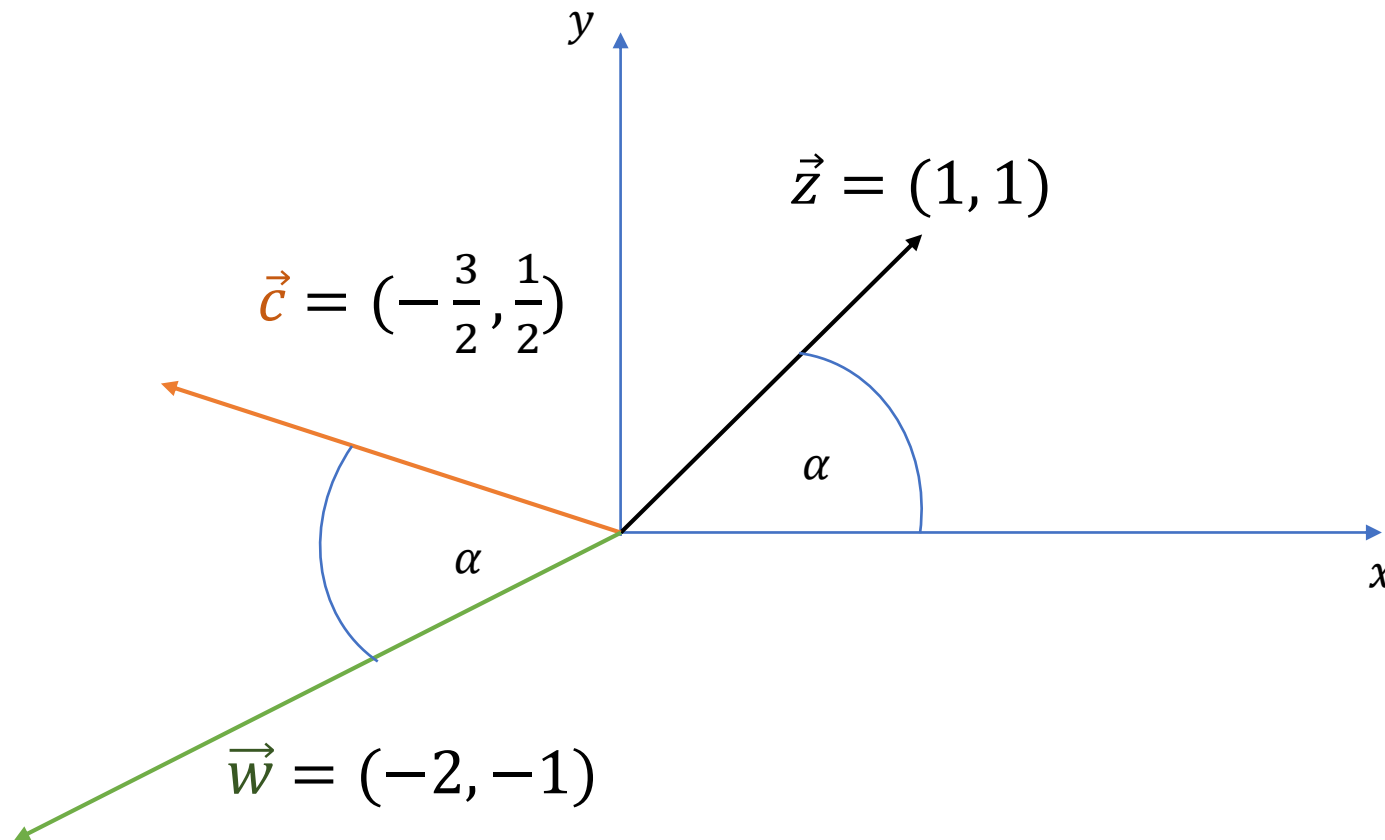
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$$|\vec{c}| = \frac{\sqrt{10}}{2} = \frac{\sqrt{5}}{2} \sqrt{2}$$

$$|\vec{z}| |\vec{c}| = \sqrt{5}$$

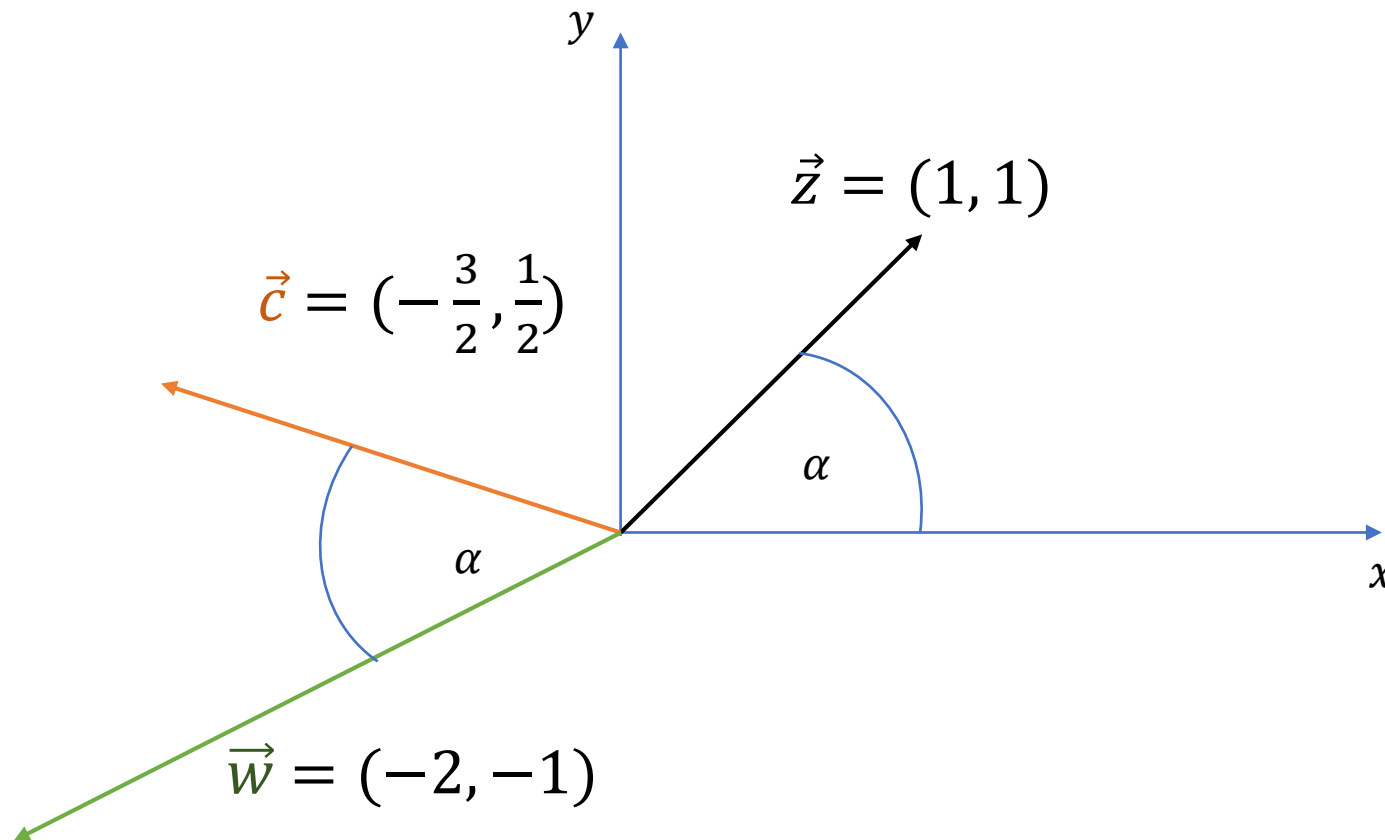
complex numbers

$$i = \sqrt{-1}$$

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$$|\vec{z}| |\vec{c}| = \sqrt{5}$$

$$|\vec{w}| = \sqrt{4 + 1}$$

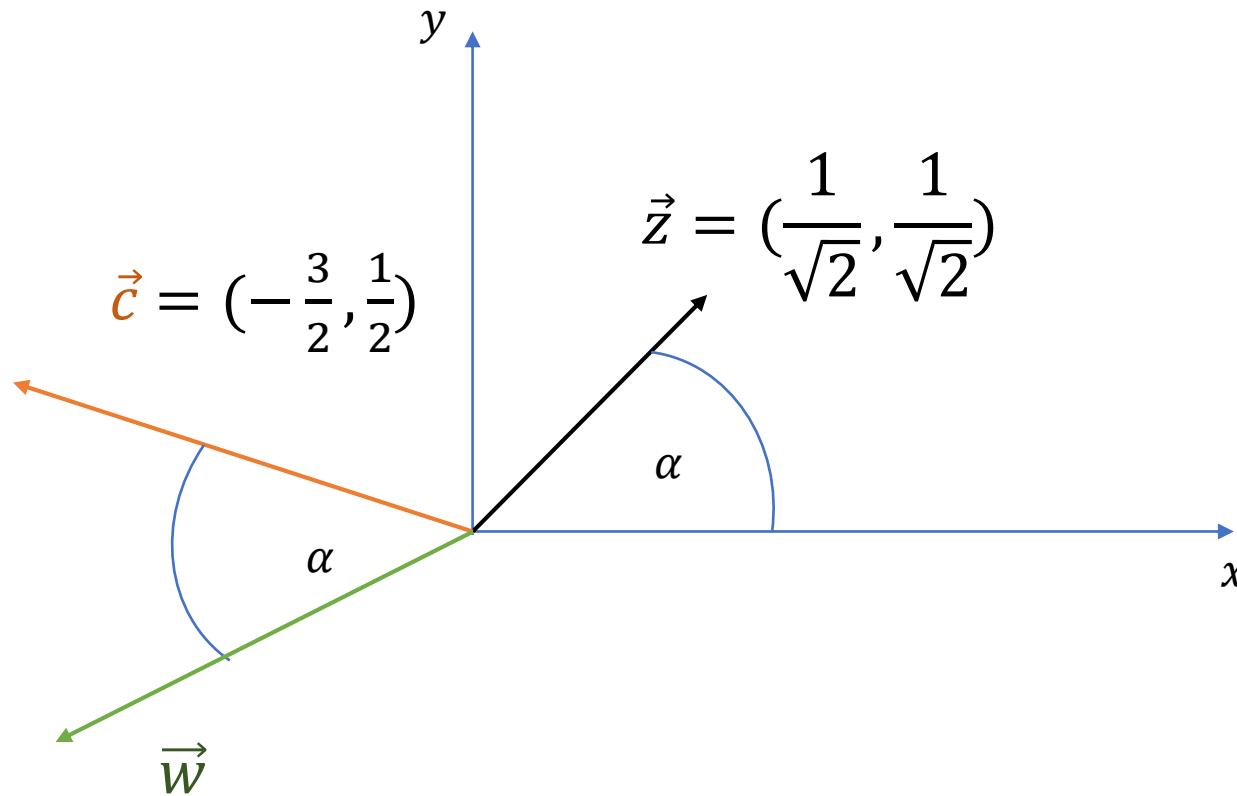
complex numbers

$$i = \sqrt{-1}$$

$$\frac{1}{\sqrt{2}} + \frac{i}{\sqrt{2}} = z$$

$$-\frac{3}{2} + \frac{i}{2} = c$$

$$zc = \frac{-4 - 2i}{2\sqrt{2}}$$



$$|\vec{w}| = |\vec{z}| |\vec{c}|$$

$$|\vec{z}| = 1$$

$$|\vec{c}| = \frac{\sqrt{10}}{2} = \frac{\sqrt{5}}{2} \sqrt{2}$$

$$|\vec{z}| |\vec{c}| = \frac{\sqrt{5}}{2} \sqrt{2}$$

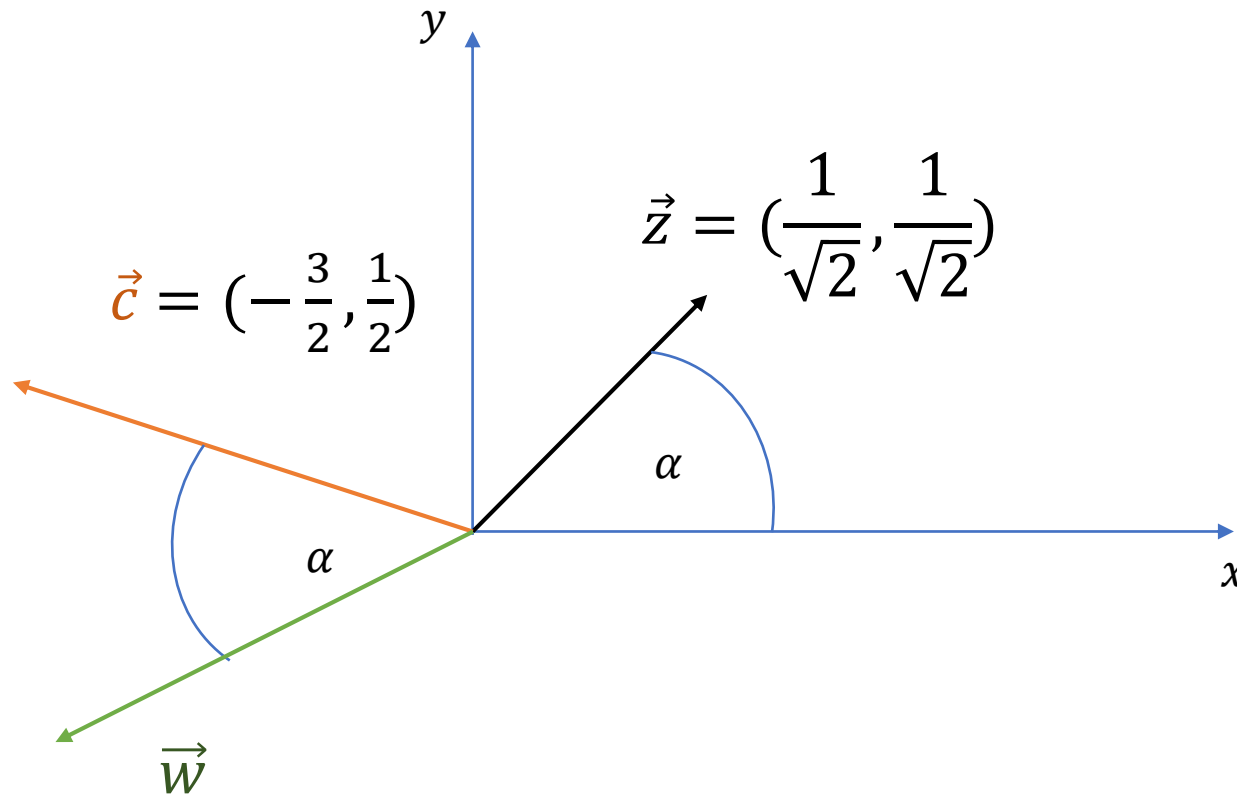
complex numbers

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$$zc = \frac{-2}{\sqrt{2}} - \frac{i}{\sqrt{2}}$$



$$|\vec{w}| = |\vec{z}| |\vec{c}|$$

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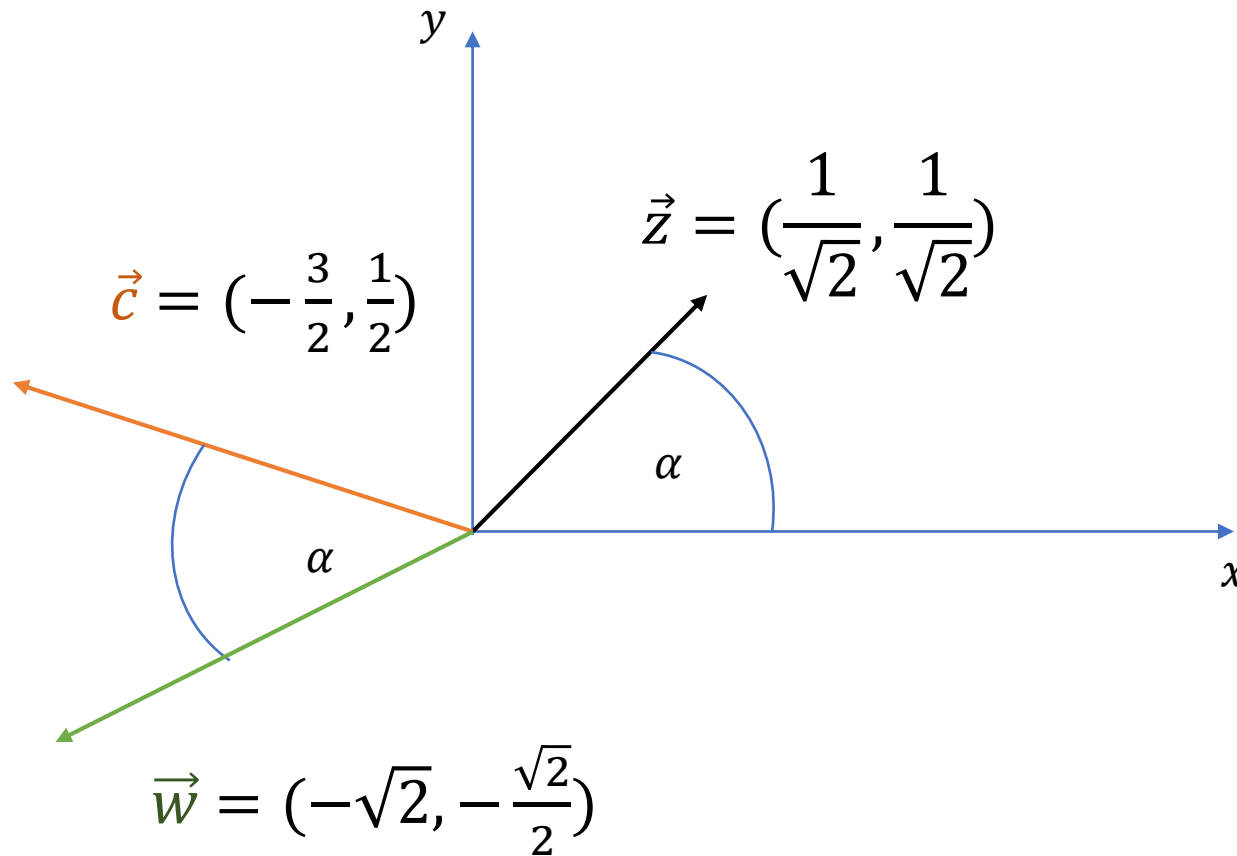
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$$|\vec{z}| |\vec{c}| = \frac{\sqrt{5}}{2} \sqrt{2}$$

$$|\vec{w}| = \sqrt{2 + \frac{2}{4}}$$

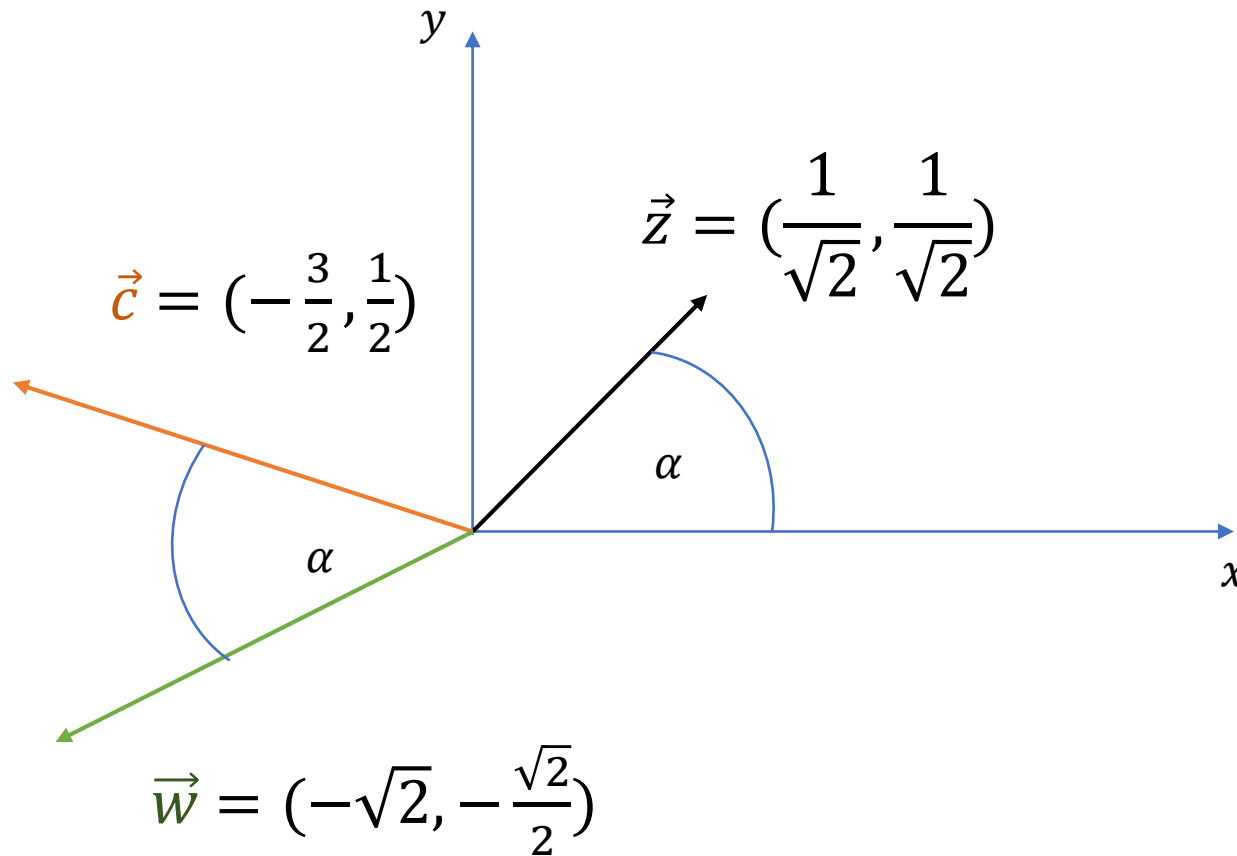
complex numbers

$$i = \sqrt{-1}$$

$$\frac{1}{\sqrt{2}} + \frac{i}{\sqrt{2}} = z$$

$$-\frac{3}{2} + \frac{i}{2} = c$$

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$$|\vec{w}| = |\vec{z}| |\vec{c}|$$

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$$|\vec{c}| = \frac{\sqrt{10}}{2} = \frac{\sqrt{5}}{2} \sqrt{2}$$

$$|\vec{z}| |\vec{c}| = \frac{\sqrt{5}}{2} \sqrt{2}$$

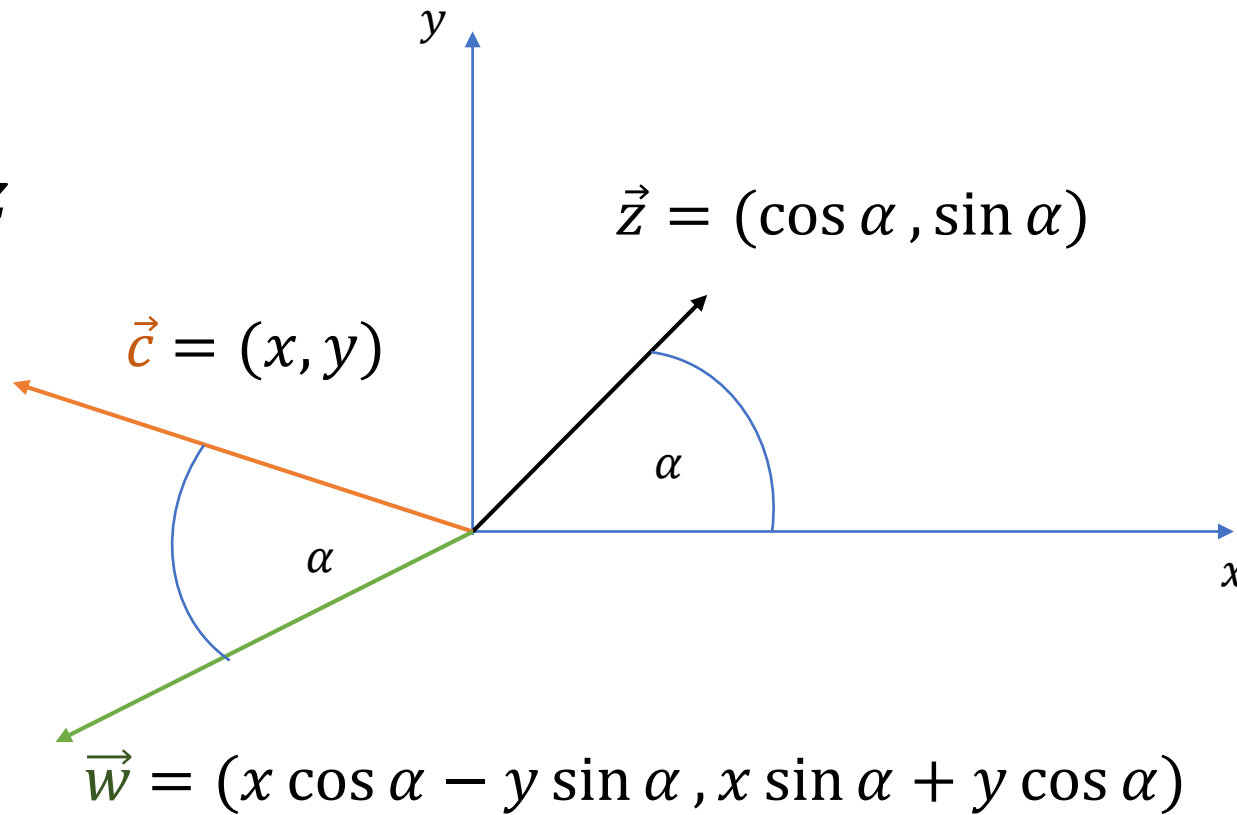
$$|\vec{w}| = \sqrt{\frac{10}{4}} = \frac{\sqrt{5}\sqrt{2}}{2}$$

complex numbers

$$i = \sqrt{-1}$$

$$\cos \alpha + i(\sin \alpha) = z$$

$$x + yi = c$$



$$|\vec{w}| = |\vec{z}| |\vec{c}|$$

$$|\vec{z}| = 1$$

$$|\vec{c}| = \sqrt{x^2 + y^2}$$

$$|\vec{z}| |\vec{c}| = \sqrt{x^2 + y^2}$$

$$|\vec{w}| = \sqrt{x^2 + y^2}$$

$$zc = x \cos \alpha - y \sin \alpha + (x \sin \alpha + y \cos \alpha)i$$

complex numbers

$$x^3 = 1$$

plot $x^3=1$ from -1 to 1



≡ Browse

Input interpretation:

plot

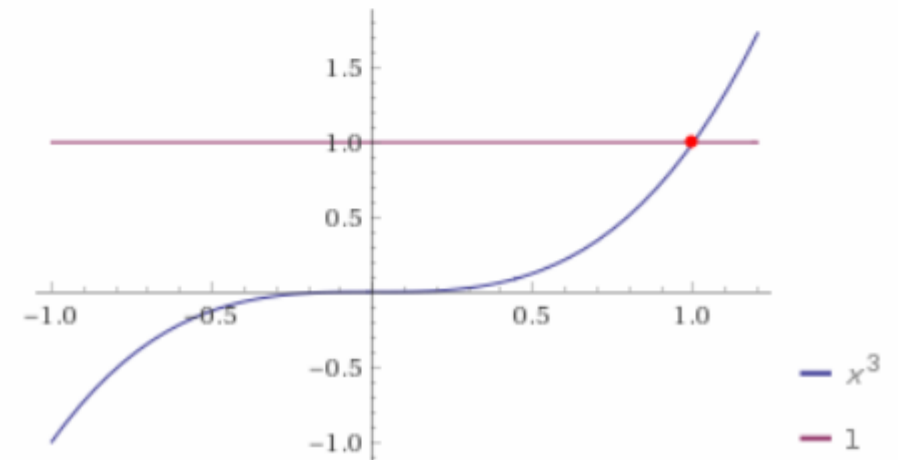
$x^3 = 1$

$x = -1$ to 1

Result:

(endpoints not on curve)

Plot:



complex numbers

$$x^3 = 1$$

$$x_1 = 1$$

plot $x^3=1$ from -1 to 1



Browse

Input interpretation:

plot

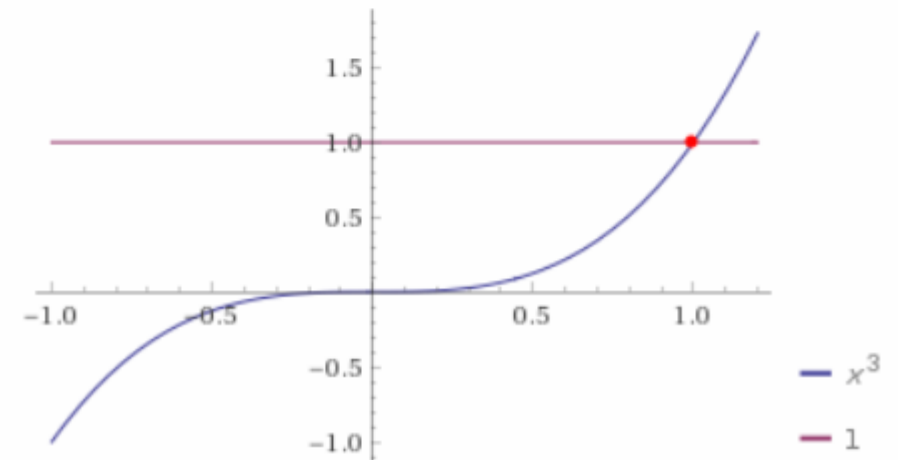
$x^3 = 1$

$x = -1$ to 1

Result:

(endpoints not on curve)

Plot:



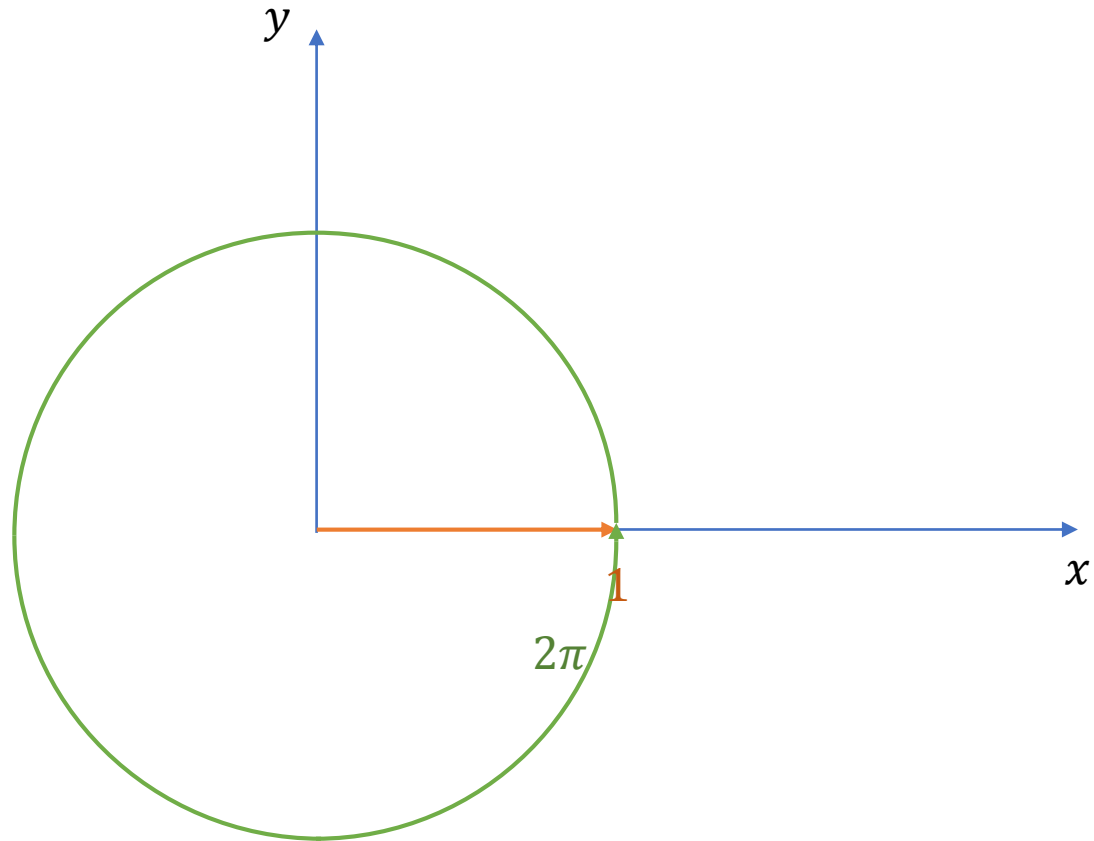
complex numbers

$$x^3 = 1$$

$$x_1 = 1$$

$$x_2 = ?$$

$$x_3 = ?$$



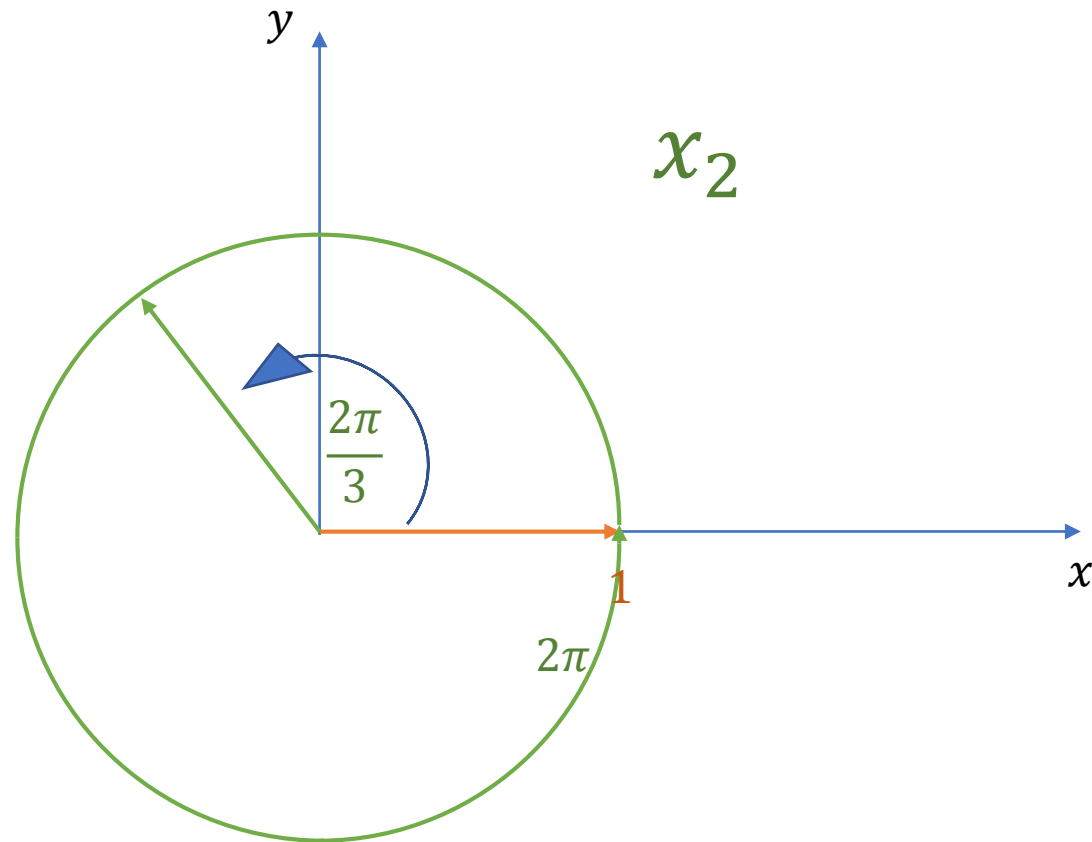
complex numbers

$$x^3 = 1$$

$$x_1 = 1$$

$$x_2 = \cos \frac{2\pi}{3} + i \sin \frac{2\pi}{3}$$

$$x_3 = ?$$



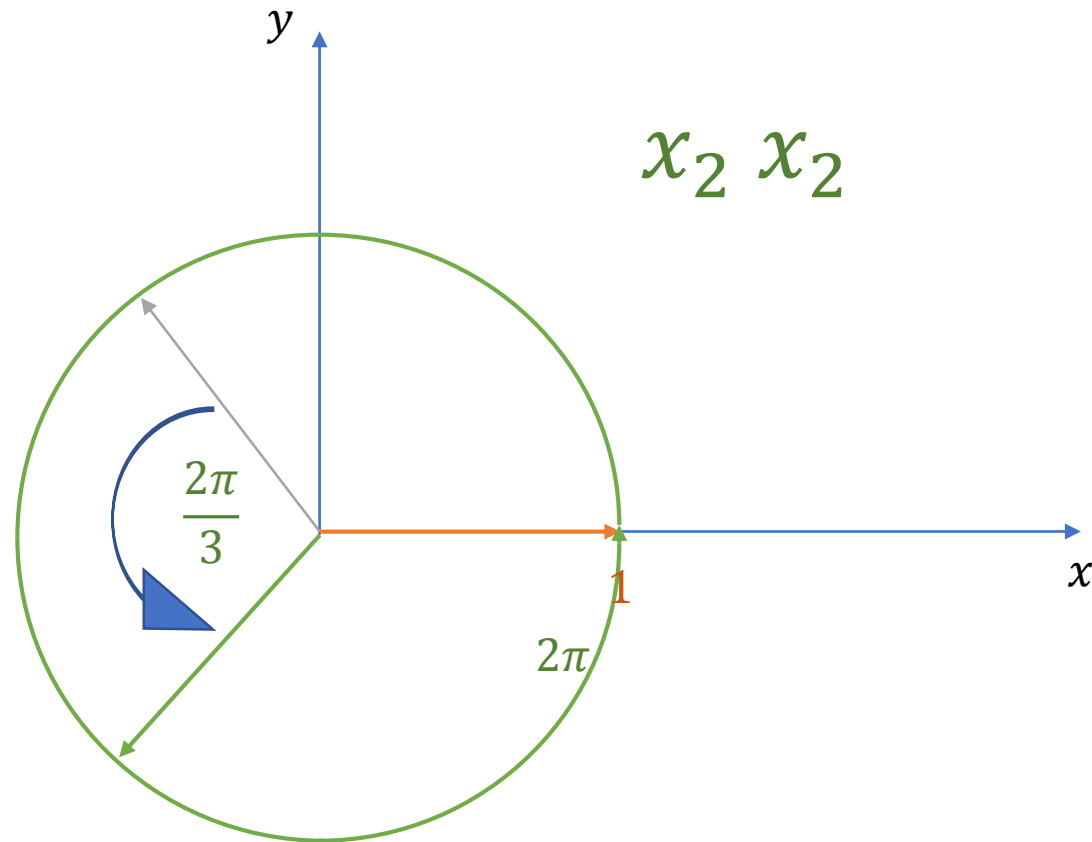
complex numbers

$$x^3 = 1$$

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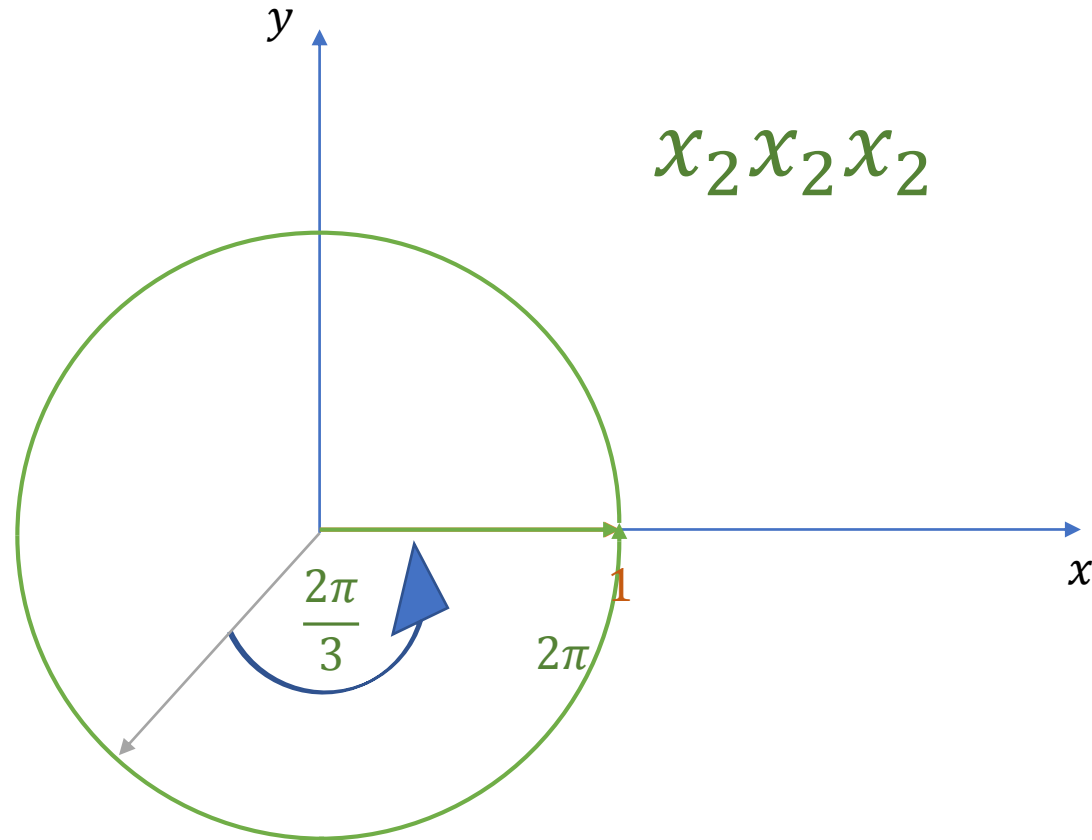
complex numbers

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$$x_3 = ?$$



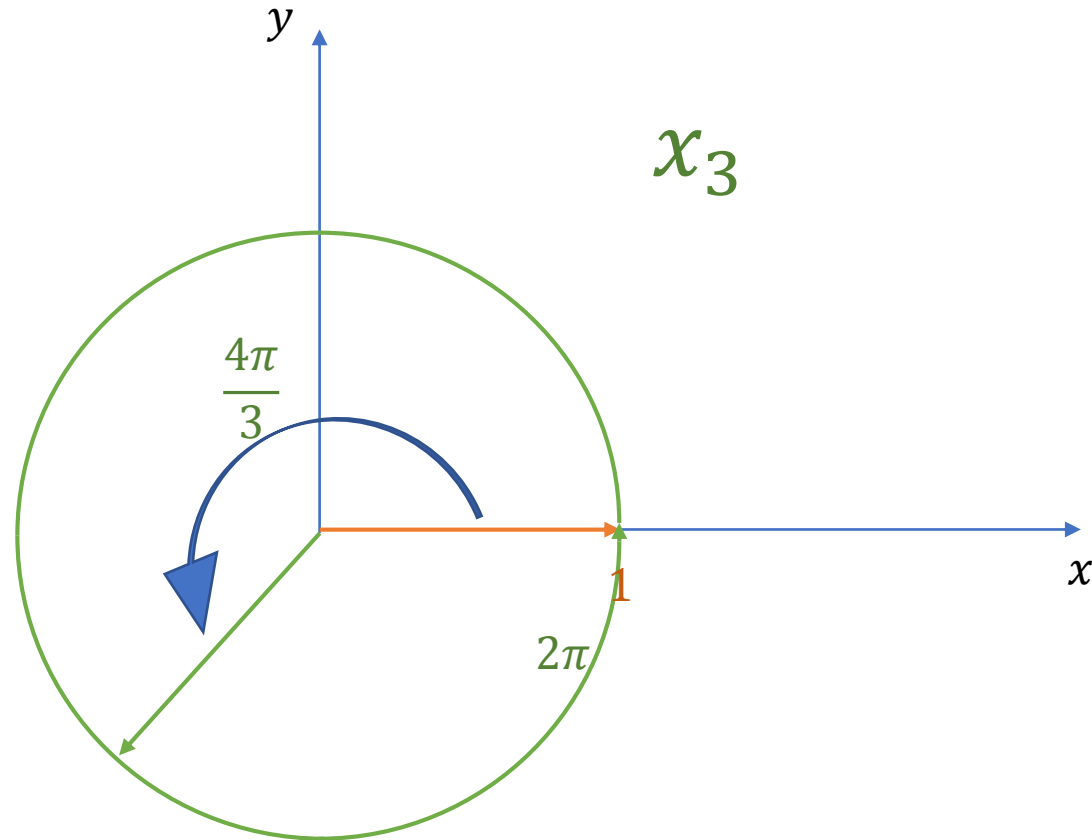
complex numbers

$$x^3 = 1$$

$$x_1 = 1$$

$$x_2 = \cos \frac{2\pi}{3} + i \sin \frac{2\pi}{3}$$

$$x_3 = \cos \frac{4\pi}{3} + i \sin \frac{4\pi}{3}$$



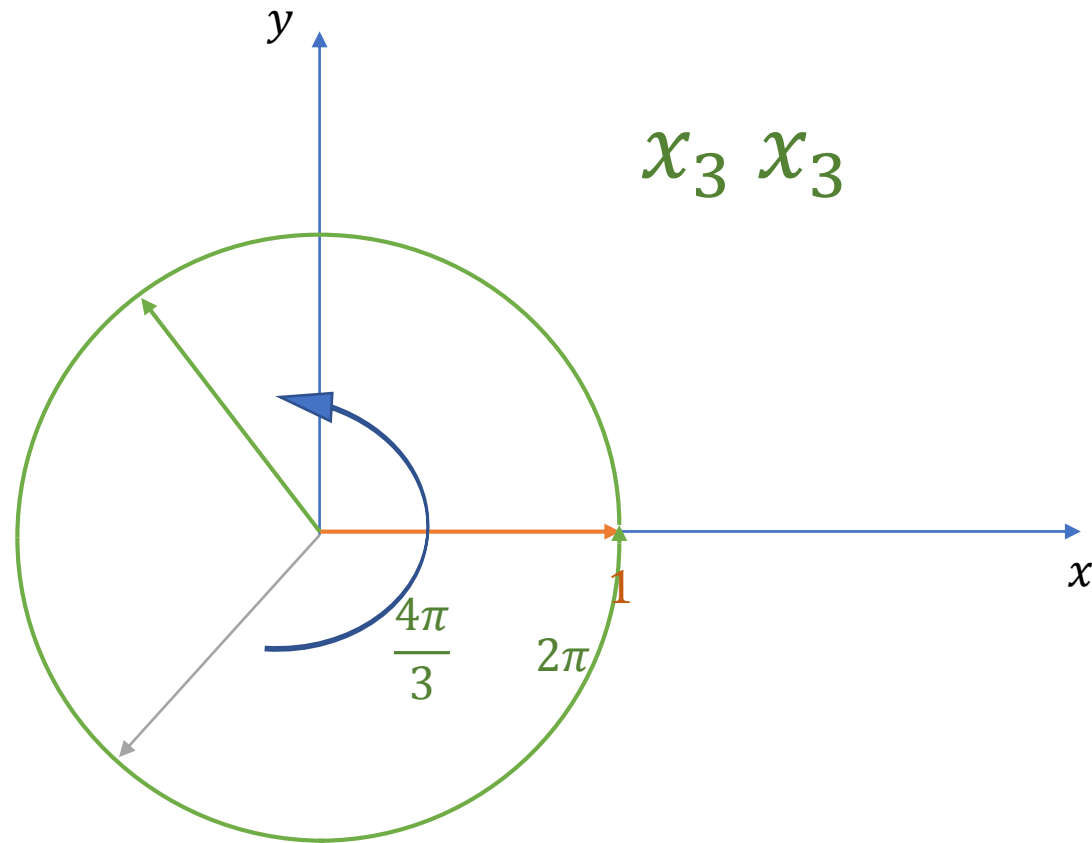
complex numbers

$$x^3 = 1$$

$$x_1 = 1$$

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$$x_3 = \cos \frac{4\pi}{3} + i \sin \frac{4\pi}{3}$$



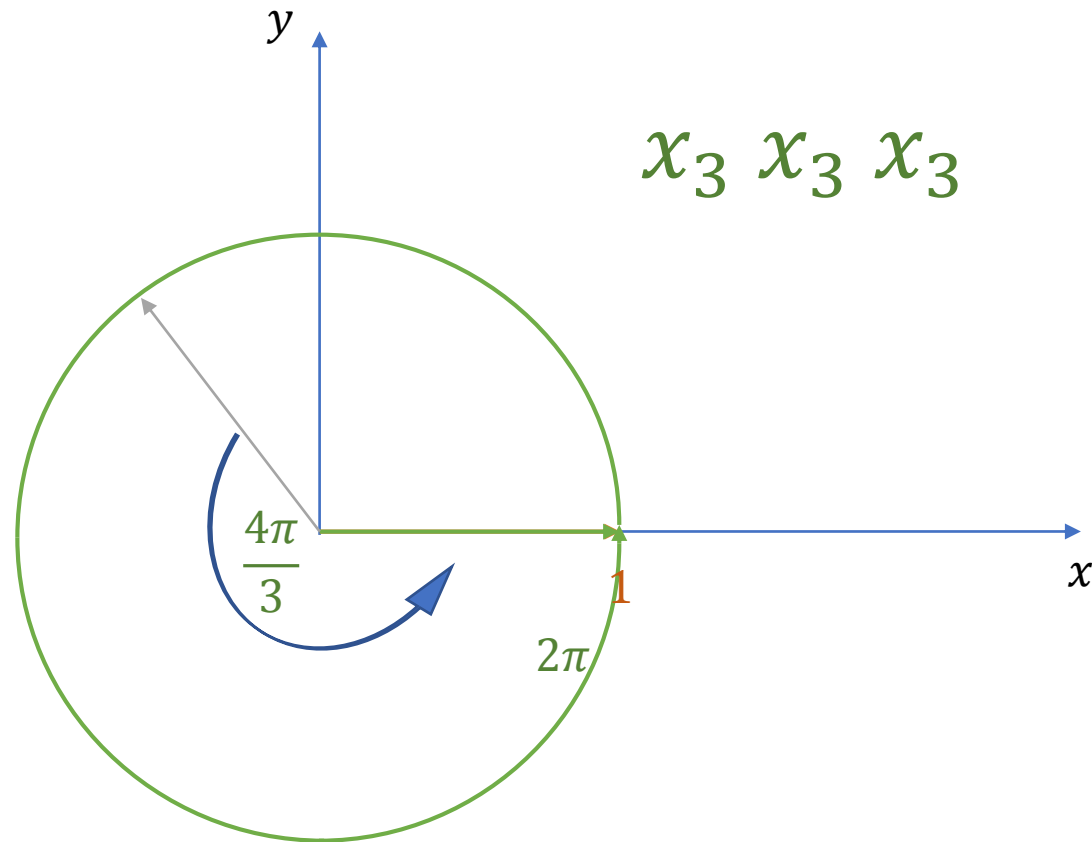
complex numbers

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$$x_1 = 1$$

$$x_2 = \cos \frac{2\pi}{3} + i \sin \frac{2\pi}{3}$$

$$x_3 = \cos \frac{4\pi}{3} + i \sin \frac{4\pi}{3}$$



quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$



quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$

$$ijk = -1$$

$$i^2jk = -i$$

$$-jk = -i$$

$$jk = i$$

quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$

$$ijk = -1$$

$$i^2jk = -i$$

$$-jk = -i$$

$$jk = i$$

$$j^2k = ji$$

$$-k = ji$$

quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$

$$ijk = -1$$

$$i^2jk = -i$$

$$-jk = -i$$

$$jk = i$$

$$j^2k = ji$$

$$-k = ji$$

$$-ki = ji^2$$

$$ki = j$$

quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$

$$ijk = -1$$

$$i^2jk = -i$$

$$-jk = -i$$

$$jk = i$$

$$j^2k = ji$$

$$-k = ji$$

$$-ki = ji^2$$

$$ki = j$$

$$kj = -i$$

$$ij = k$$

$$ik = -j$$

quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$

$$ijk = -1$$

$$i^2jk = -i$$

$$-jk = -i$$

$$jk = i$$

$$j^2k = ji$$

$$-k = ji$$

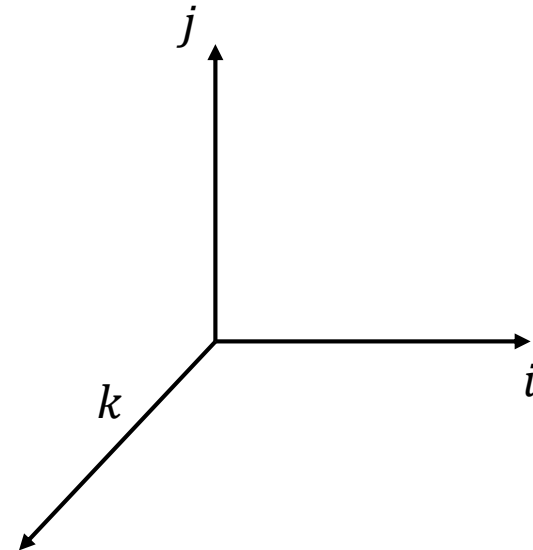
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quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$

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$$i^2jk = -i$$

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$$j^2k = ji$$

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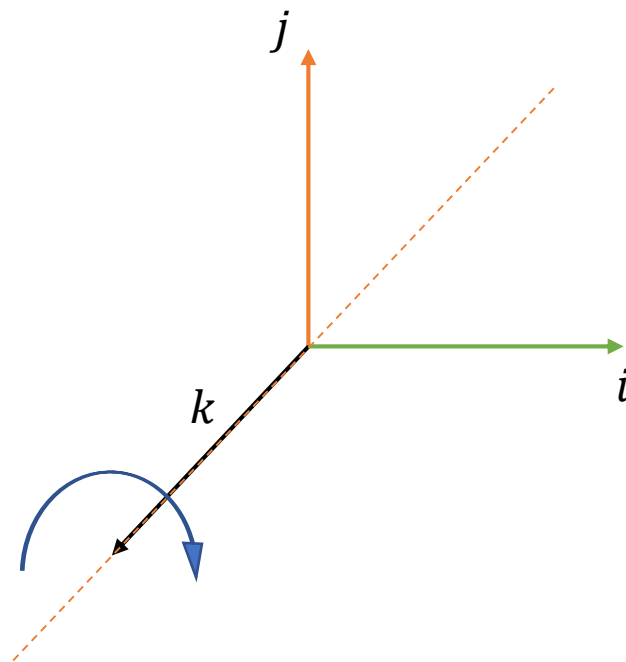
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quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$

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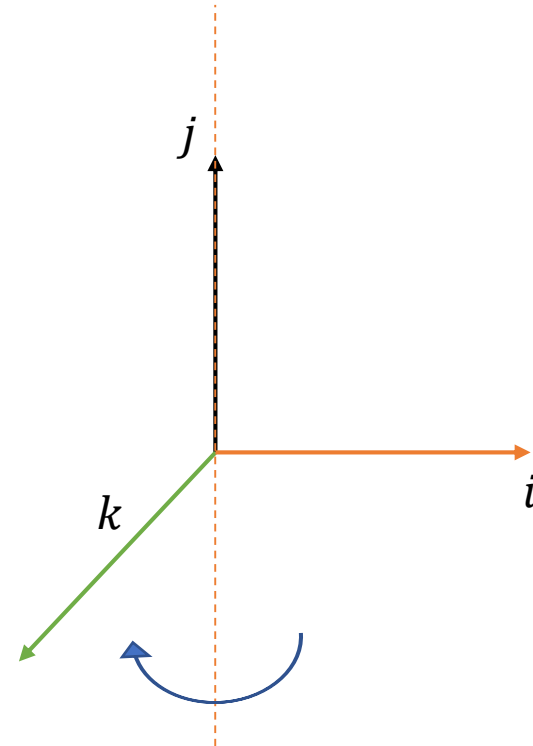
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quaternions

$$i^2 = j^2 = k^2 = ijk = -1$$

$$ijk = -1$$

$$i^2jk = -i$$

$$-jk = -i$$

$$jk = i$$

$$j^2k = ji$$

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$$-ki = ji^2$$

$$ki = j$$

$$kj = -i$$

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