

COMPLEX NUMBER

Part I

Complex Numbers

A number $z = x + iy$ where $x, y \in \mathbb{R}$ and $i = \sqrt{-1}$; $x = \text{Real part or } \text{Re}(z)$; $y = \text{Imaginary part or } \text{Im}(z)$

Magnitude

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

$$|z| = |\bar{z}|$$

Argument

$$\text{amp}(z) = \arg(z) = \theta = \tan^{-1} \frac{y}{x}$$

General Argument: $2n\pi + \theta, n \in \mathbb{N}$

Principal Argument: $-\pi < \theta \leq \pi$

Least Positive Argument: $0 < \theta \leq 2\pi$

Complex Conjugate

If $z = x + iy$

then the conjugate of 'z' is

$$\bar{z} = x - iy$$

Representation

Polar Representation



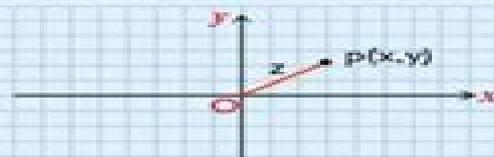
$$x = r \cos \theta, y = r \sin \theta$$

Exponential Form



$$z = r e^{i\theta} \text{ (where } e^{i\theta} = \cos \theta + i \sin \theta \text{)}$$

Vector Representation



$z = x + iy$ may be considered as a position vector of point P.

Properties of argument of a Complex Number

If z, z_1 and z_2 are complex numbers, then

- 1 $\arg(\text{any real positive number}) = 0$
- 2 $\arg(\text{any real negative number}) = \pi$
- 3 $\arg(z \cdot \bar{z}) = \pm \frac{\pi}{2}$
- 4 $\arg(z_1 \cdot z_2) = \arg(z_1) + \arg(z_2)$
- 5 $\arg(z_1 \cdot \bar{z}_2) = \arg(z_1) - \arg(z_2)$
- 6 $\arg(z_1 / z_2) = \arg(z_1) - \arg(z_2)$
- 7 $\arg(\bar{z}) = -\arg(z) = \arg(1/z)$
- 8 $\arg(-z) = \arg(z) \pm \pi$
- 9 $\arg(z^n) = n \arg(z)$
- 10 $\arg(z) + \arg(\bar{z}) = 0$
- 11 $|z_1 + z_2|^2 + |z_1 - z_2|^2 = 2[|z_1|^2 + |z_2|^2]$
- 12 $|z_1 - z_2| = |z_1 + z_2| \iff \arg(z_1) - \arg(z_2) = \frac{\pi}{2}$
- 13 $|z_1 + z_2| = |z_1| + |z_2| \iff \arg(z_1) = \arg(z_2)$
- 14 $|z_1 + z_2|^2 = |z_1|^2 + |z_2|^2 \iff \frac{z_1}{z_2} \text{ is purely imaginary.}$
- 15 $|z_1 - z_2|^2 \leq (|z_1| - |z_2|)^2 + (\arg(z_1) - \arg(z_2))^2$
- 16 $|z_1 + z_2|^2 \geq (|z_1| + |z_2|)^2 + (\arg(z_1) - \arg(z_2))^2$
- 17 $|z_1 + z_2|^2 = |z_1|^2 + |z_2|^2 + 2|z_1||z_2|\cos(\theta_1 - \theta_2)$,
where $\theta_1 = \arg(z_1)$ and $\theta_2 = \arg(z_2)$,
or $|z_1 + z_2|^2 = |z_1|^2 + |z_2|^2 + 2\text{Re}(z_1 \bar{z}_2)$
- 18 $|z_1 - z_2|^2 = |z_1|^2 + |z_2|^2 - 2|z_1||z_2|\cos(\theta_1 - \theta_2)$,
where $\theta_1 = \arg(z_1)$ and $\theta_2 = \arg(z_2)$,
or $|z_1 - z_2|^2 = |z_1|^2 + |z_2|^2 - 2\text{Re}(z_1 \bar{z}_2)$

Complex Numbers Unit Guide

Karin Nielsen-Saines



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