

# 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



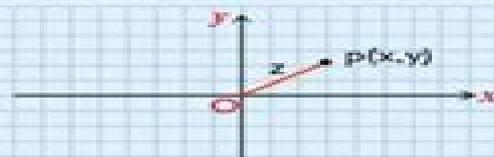
$$x = r \cos \theta, y = r \sin \theta$$

### 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  $\arg(z - \bar{z}) = \pm \frac{\pi}{2}$
- 4  $\arg(z_1 z_2) = \arg(z_1) + \arg(z_2)$
- 5  $\arg(z_1 \bar{z}_2) = \arg(z_1) - \arg(z_2)$
- 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

**Christian Drosten**



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*Complex Numbers Unit Guide* Stan Dolan, School Mathematics Project, 1992 The aim of 16 19 Mathematics has been to produce a course which while challenging is accessible and enjoyable to all students The course develops ability and confidence in mathematics and its applications together with an appreciation of how mathematical ideas help in the understanding of the world and society in which we live The unit guide contains an introduction to the unit stating the objectives advice on teaching and working through the unit commentaries on the discussion points and tasksheets in the student s text *The Companion Guide to the Mathematical Experience* Philip J. Davis, Reuben Hersh, Elena A.

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*Mathcad 3.1 User's Guide*, 1992 Allows user to work with formulas numbers text and graphs *High School Manual* University of Illinois (Urbana-Champaign campus), 1925

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