🔷 Chapter: Complex Numbers and Quadratic Equations

🔹 1. Introduction

- Complex numbers help solve equations that have no real solutions.
- For example, the equation $x^2 + 1 = 0$ has no real solution, but in complex numbers, it does.

🔹 2. Complex Numbers

- A complex number is of the form:

z=a+ibz = a + ibz=a+ib

where:

- aaa is the real part
- bbb is the imaginary part
- i=−1i = \sqrt{-1}i=−1

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3. Algebra of Complex Numbers

- Addition/Subtraction: Add or subtract real and imaginary parts separately.

- Multiplication: Use distributive law and $i^2 = -1$

- Division: Multiply numerator and denominator by conjugate of the denominator.

- Conjugate: If $z = a + ib$, then $\bar{z} = a - ib$

- Modulus:

  $$|z| = \sqrt{a^2 + b^2}$$

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4. Argand Plane and Polar Form

- Complex numbers can be represented as points in a plane (Argand diagram).

- Polar form:

  $$z = r(\cos\theta + i\sin\theta)$$

  where:

  - $r = |z|$
  - $\theta = \arg(z)$

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5. Powers of i

- $i^1 = i$

- $i^2 = -1$
- $i^3 = -i$
- $i^4 = 1$, and this repeats every 4 powers.

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6. Quadratic Equations

- General form:

  $$ax^2 + bx + c = 0 \quad (a \ne 0)$$
- Discriminant (D):

  $$D = b^2 - 4ac$$

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7. Nature of Roots

- D>0D > 0D>0: Two real and distinct roots
- D=0D = 0D=0: Two real and equal roots
- D<0D < 0D<0: Two complex conjugate roots

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8. Solving Methods

- Factorization

- Quadratic formula:

  $$x = \frac{-b \pm \sqrt{D}}{2a}$$

- Completing the square

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9. Applications

- Used in engineering, physics, control systems, and signal processing.

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10. Exam Tips

- Memorize i powers up to i^4

- Practice converting between standard and polar forms
- Know how to determine nature of roots from discriminant
- Be comfortable with all 3 solution methods