

How to use this worksheet. Thirty questions, about 35 minutes. Reduce powers of i modulo 4 and powers of ω modulo 3 before anything else. For cube roots of unity, substituting $1 + \omega = -\omega^2$ at the first step turns a long expansion into two lines.

Formula sheet

$i^2 = -1$ | $i^3 = -i$ | $i^4 = 1$, powers repeat with period 4

$z = a + ib \Rightarrow \bar{z} = a - ib$ | $|z| = \sqrt{a^2 + b^2}$ | $z \times \bar{z} = |z|^2$ | $|z_1 z_2| = |z_1| |z_2|$

Polar form: $z = r(\cos\theta + i \sin\theta)$ | **Cube roots of unity:** $\omega^3 = 1$ and $1 + \omega + \omega^2 = 0$

Section A · Level 1 — Powers of i , conjugates and modulus

Ten questions. None should take more than twenty seconds.

1. The value of i^2 is:

(1) 1 (2) -1 (3) i (4) $-i$

2. The value of i^4 is:

(1) 1 (2) -1 (3) i (4) $-i$

3. The value of i^7 is:

(1) 1 (2) -1 (3) i (4) $-i$

4. The conjugate of the complex number $2 - 5i$ is:

(1) $-2 + 5i$ (2) $2 + 5i$ (3) $-2 - 5i$ (4) $5 - 2i$

5. The modulus of the complex number $3 + 4i$ is:

(1) 3 (2) 4 (3) 5 (4) 7

6. For any complex number z , the product $z \times \bar{z}$ equals:

(1) z^2 (2) $|z|^2$ (3) $2z$ (4) 0

7. In the polar form $z = r(\cos\theta + i \sin\theta)$, the quantity r is the:

(1) Argument (2) Modulus (3) Real part (4) Imaginary part

8. The three cube roots of unity satisfy:

(1) $1 + \omega + \omega^2 = 1$ (2) $1 + \omega + \omega^2 = 0$ (3) $\omega^2 = \omega$ (4) $\omega^3 = 0$

9. The complex number $0 + 0i$ is represented on the Argand plane by:

(1) A point on the real axis (2) The origin (3) A point on the imaginary axis (4) No point

10. A purely imaginary number has:

(1) Zero imaginary part (2) Zero real part (3) Equal real and imaginary parts (4) Modulus zero

Working space — Questions 1 to 10

Write the formula before you substitute.

Section B · Level 2 — Arithmetic, division and quadratic roots

Ten questions. Multiply by the conjugate whenever you divide.

11. The value of $(2 + 3i) + (4 - 5i)$ is:

(1) $6 + 2i$ (2) $6 - 2i$ (3) $-2 + 8i$ (4) $8 - 15i$

12. The value of $(2 + 3i)(2 - 3i)$ is:

(1) $4 - 9i$ (2) 13 (3) -5 (4) $4 + 9i$

13. The value of $(1 + i)^2$ is:

- (1) 2 (2) $2i$ (3) $1 + 2i$ (4) $-2i$

14. The value of $(1 + i)^4$ is:

- (1) 4 (2) -4 (3) $4i$ (4) $-4i$

15. The value of i^{10} is:

- (1) 1 (2) -1 (3) i (4) $-i$

16. Expressed in the form $a + ib$, the number $1 / (1 + i)$ is:

- (1) $\frac{1}{2} + \frac{1}{2}i$ (2) $\frac{1}{2} - \frac{1}{2}i$ (3) $1 - i$ (4) $-\frac{1}{2} + \frac{1}{2}i$

17. The value of $(1 + i) / (1 - i)$ is:

- (1) 1 (2) i (3) $-i$ (4) -1

18. The argument of the complex number $1 + i$ is:

- (1) $\pi/6$ (2) $\pi/4$ (3) $\pi/3$ (4) $\pi/2$

19. The roots of the equation $x^2 + 1 = 0$ are:

- (1) ± 1 (2) $\pm i$ (3) 0 and 1 (4) No roots

20. The roots of the equation $x^2 - 2x + 5 = 0$ are:

- (1) $1 \pm 2i$ (2) $2 \pm i$ (3) $-1 \pm 2i$ (4) $1 \pm 4i$

Working space — Questions 11 to 20 Write the formula before you substitute.

Section C · Level 3 — Polar form, cube roots of unity and loci

Seven questions. Reduce indices modulo 3 or 4 before computing.

21. For complex numbers z_1 and z_2 , the modulus $|z_1 z_2|$ equals:

- (1) $|z_1| + |z_2|$ (2) $|z_1| \times |z_2|$ (3) $|z_1| - |z_2|$ (4) $|z_1| / |z_2|$

22. The real part of $(3 + 4i) / i$ is:

- (1) 3 (2) 4 (3) -3 (4) -4

23. If ω is a complex cube root of unity, then ω^4 equals:

- (1) 1 (2) ω (3) ω^2 (4) 0

24. If ω is a complex cube root of unity, then $(1 + \omega)$ equals:

- (1) ω^2 (2) $-\omega^2$ (3) -1 (4) 0

25. The complex number -1 in polar form is:

- (1) $\cos \pi + i \sin \pi$ (2) $\cos(\pi/2) + i \sin(\pi/2)$ (3) $\cos 0 + i \sin 0$ (4) $2(\cos \pi + i \sin \pi)$

26. The conjugate of a purely real number is:

- (1) Its negative (2) Itself (3) Zero (4) Purely imaginary

27. On the Argand plane, $|z| = 3$ represents:

- (1) A straight line (2) A circle of radius 3 centred at the origin (3) A parabola (4) Two points

Working space — Questions 21 to 27 Write the formula before you substitute.

Section D · Previous year questions — Straight from the AAI ATC papers

Three questions from the 2023 papers, recovered by optical character recognition of the scanned answer sheets and independently re-solved with a computer algebra system.

28. If $(3i - 2)^2 + (5i + 6)^2 = a + ib$, what is the value of $a + b$? [PYQ 2023 · Morning]

(1) 54 (2) 48 (3) 102 (4) 144

29. What is the conjugate of the complex number $z = 3i + 7$? [PYQ 2023 · Morning]

(1) $\bar{z} = -3i - 7$ (2) $\bar{z} = -3i + 7$ (3) $\bar{z} = 3 + 7i$ (4) $\bar{z} = 3i - 7$

30. If ω is an imaginary cube root of unity, then $(1 + \omega - \omega^2)^5$ equals: [PYQ 2023 · Evening]

(1) -32 (2) 32 (3) 32ω (4) -32ω

Working space — Questions 28 to 30

Write the formula before you substitute.

Stuck on any of these? Bring them to a live class.

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