

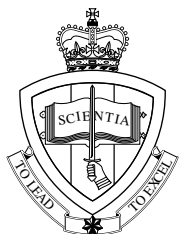
# Complex Numbers on a CFX-9850GB

Peter McIntyre

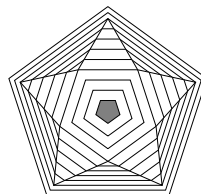
*These materials may be printed and copied for use by teachers and students for non-commercial educational purposes only.*

## Contents

<b>1</b>	<b>Setting Complex Mode</b>	<b>1</b>
<b>2</b>	<b>Basic Operations</b>	<b>1</b>
2.1	Addition and subtraction . . . . .	1
2.2	Multiplication and division . . . . .	1
2.3	Conjugation . . . . .	1
2.4	Real part . . . . .	1
2.5	Imaginary part . . . . .	1
2.6	Modulus . . . . .	1
<b>3</b>	<b>Polar Form</b>	<b>2</b>
3.1	Modulus and angle . . . . .	2
3.2	Conversion between forms . . . . .	2
<b>4</b>	<b>Powers and Roots</b>	<b>2</b>
4.1	Powers . . . . .	2
4.2	Roots . . . . .	2
4.3	The CMPXROOT program . . . . .	3
<b>5</b>	<b>Exercises</b>	<b>3</b>
<b>6</b>	<b>Answers to Exercises</b>	<b>4</b>



ADFA



CMA

## Contact for more help

Peter McIntyre

School of Physical, Environmental  
and Mathematical Sciences  
University College (UNSW)  
Australian Defence Force Academy  
Canberra ACT 2600

Email: p.mcintyre@adfa.edu.au  
Phone: (02) 6268 8896  
FAX: (02) 6268 8786

At [www.unsw.adfa.edu.au/pems/news/high\\_school/hsc\\_activities.html](http://www.unsw.adfa.edu.au/pems/news/high_school/hsc_activities.html)

- A variety of graphics-calculator activities for Years 9 and 10 — written as part of the CQTP Program for Sharp, Casio and TI calculators.
- *Using the CFX-9850GB* — an introduction to the basic operations, suitable for Years 8–12.
- *The Graphics Screen and Accuracy* — information to help you understand the graphical and numerical limitations of a graphics calculator.
- *Coordinate Geometry on a CFX-9850GB* — basic commands and a variety of problems, suitable for Years 9 and 10.
- *Population Modelling* — a variety of problems from simple exponential growth to Leslie matrices and difference equations, covering Years 7–12.
- *Sequences and Series on an CFX-9850GB* — basic commands and a variety of problems, suitable for Years 10–12.
- *Matrices on an CFX-9850GB* — suitable for Years 11 and 12.
- *Calculus on an CFX-9850GB* — suitable for Years 11 and 12.
- *Introduction to Complex Numbers* — complex numbers from the beginning, covering the basic operations, but set in the context of complex numbers as a mathematical structure.

The program CMPXROOT listed in these notes can be found at the above web site. You will need a PC-Link Kit FA-123 to copy the program from your computer to your calculator.

## 1 Setting Complex Mode

The CFX-9850GB is always in Complex mode — there is no need to select anything. The calculations are all done on the RUN screen ( $\boxed{\text{MENU}} \boxed{1}$ ).

To access the complex operations, press  $\boxed{\text{OPTN}} \boxed{\text{F3}}$  (CPLX).

We shall use  $z_1 = 1 + 2i$  and  $z_2 = 3 - i$  in our examples.  $i$  is  $\boxed{\text{F1}}$  in the CPLX menu.

Complex numbers can be stored in the same way as ordinary numbers. Store  $z_1$  in memory  $A$ :  $1 + 2i \rightarrow A$ ;  $z_2$  in memory  $B$ :  $3 - i \rightarrow B$ .

## 2 Basic Operations

### 2.1 Addition and subtraction

Just as you would expect.

$$1 + 2i + 3 - i = 4 + i \quad \text{or} \quad A + B = 4 + i$$

$$1 + 2i - (3 - i) = -2 + 3i \quad \text{or} \quad A - B = -2 + 3i$$

### 2.2 Multiplication and division

Again as you would expect. Implied multiplication works too.

$$(1 + 2i)(3 - i) = 5 + 5i \quad \text{or} \quad AB = 5 + 5i$$

$$(1 + 2i) \div (3 - i) = 0.1 + 0.7i \quad \text{or} \quad A \div B = 0.1 + 0.7i$$

### 2.3 Conjugation

Finding the complex conjugate.

$$\bar{z}_1 = \text{Conjg}(1 + 2i) = 1 - 2i \quad \text{Conjg is } \boxed{\text{F3}}; \text{ brackets are necessary unless the number is pure real or pure imaginary.}$$

### 2.4 Real part

$$\text{Re}(z_1) = \text{ReP}(1 + 2i) = 1 \quad \text{ReP is } \boxed{\text{F5}}; \text{ again brackets are necessary.}$$

### 2.5 Imaginary part

$$\text{Im}(z_1) = \text{ImP}(1 + 2i) = 2 \quad \text{ImP is } \boxed{\text{F6}}; \text{ again brackets are necessary.}$$

### 2.6 Modulus

Sometimes called length or absolute value.

$$|z_1| = \text{AbS}(1 + 2i) = \sqrt{1^2 + 2^2} = \sqrt{5} \approx 2.236 \quad \text{AbS is } \boxed{\text{F2}}; \text{ include brackets.}$$

## 3 Polar Form

The polar form  $(r, \theta)$  of a complex number can not be entered directly into the CFX-9850GB, but must first be converted to Cartesian form  $x + iy$ . See Section 3.2. The calculator will tell you the values for  $x$  and  $y$ , which you then have to enter manually as  $x + iy$ .

### 3.1 Modulus and angle

The CPLX operation  $AbS$ , used in Section 2.6, finds the modulus  $r$ , while  $Arg$  ( $\boxed{\text{F3}}$ ) finds the angle  $\theta$ , of a complex number given in Cartesian form. The angle is given in radians or degrees, depending on the angle setting in  $\boxed{\text{SETUP}}$ .

$\text{Arg}(z_1) = \text{Arg}(1 + 2i) \approx 63.435^\circ \approx 1.107$  radians.

### 3.2 Conversion between forms

To convert complex numbers from Cartesian or rectangular form to polar form and vice versa, use the conversions in the  $\boxed{\text{ANGL}}$  menu —  $\boxed{\text{OPTN}} \boxed{\text{F6}} \boxed{\text{F5}}$ . Press  $\boxed{\text{F6}}$  again to see  $Pol($  and  $Rec($ .

In *Radian* mode, converting  $1 + i$  to polar form:

$\text{Pol}(1, 1) \boxed{\text{EXE}}$  gives  $r \approx 1.414213562$  ( $\sqrt{2}$ ) and  $\theta \approx 0.7853981634$  ( $\pi/4$ ).

Converting  $(r, \theta) = (\sqrt{2}, \pi/4)$  to Cartesian or rectangular form:

$\text{Rec}(\sqrt{2}, \pi \div 4) \boxed{\text{EXE}}$  gives  $x = 1$  and  $y = 1$ , so the Cartesian form is  $1 + i$ .

## 4 Powers and Roots

### 4.1 Powers

Only the  $\boxed{x^2}$  and  $\boxed{x^{-1}}$  keys work. You can't use the  $\boxed{\wedge}$  key at all.

$$(1 + 2i)^2 = -3 + 4i.$$

$$(1 + 2i)^{-1} = 0.2 - 0.4i.$$

### 4.2 Roots

Only the square-root key  $\boxed{\sqrt{\quad}}$  works, and it only gives you one root of a complex number. To find all the roots,<sup>1</sup> you can use the program CMPXROOT.

---

<sup>1</sup>A complex number has  $n$   $n$ th roots ( $n$  a positive integer).

### 4.3 The CMPXROOT program

Download from [www.ma.adfa.edu.au/Events/WorkExperience/index.html](http://www.ma.adfa.edu.au/Events/WorkExperience/index.html)

Calculates the Cartesian form  $x + iy$  of each of the  $N$  Nth roots of the complex number  $A + iB$ .

**Use:** Run the program. Input values for  $A$ ,  $B$  and  $N$  (positive integer) when prompted. The program displays the roots in Mat A, with the real parts  $x$  in the first column and the imaginary parts  $y$  in the second column.

**Example:** The cube roots ( $N = 3$ ) of  $1 + 2i$  are  $1.220 + 0.472i$ ,  $-1.018 + 0.820i$  and  $-0.201 - 1.292i$ , all rounded to three decimal places.

## 5 Exercises

$$z_1 = 3 + 4i \quad z_2 = 2 + 3i \quad z_3 = \sqrt{2} \operatorname{cis}(\pi/4) \quad z_4 = \operatorname{cis}(\pi/2)$$

### Find

- |                              |  |
|------------------------------|--|
| 1. $z_1 + z_2$               | 11. $\operatorname{Im}(z_2)$                 |
| 2. $2z_1 + 3z_2$             | 12. $z_1^2$                                  |
| 3. $z_1 - z_2$               | 13. $z_1^4$                                  |
| 4. $4z_1 - 2z_2$             | 14. $\sqrt{z_1}$                             |
| 5. $z_1 z_2$                 | 15. $z_3 z_4$ in polar form                  |
| 6. $z_1/z_2$                 | 16. $z_3/z_4$ in polar form                  |
| 7. $\bar{z}_1$               | 17. $\sqrt{z_4}$ in polar and Cartesian form |
| 8. $z_1 \bar{z}_1$           | 18. $z_1$ in polar form                      |
| 9. $ z_1 ^2$                 | 19. $z_3$ in Cartesian form                  |
| 10. $\operatorname{Re}(z_1)$ | 20. $z_4$ in Cartesian form                  |

## 6 Answers to Exercises

1.  $5 + 7i$
2.  $12 + 17i$
3.  $1 + i$
4.  $8 + 10i$
5.  $-6 + 17i$
6.  $18/13 - i/13 \approx 1.3846 - 0.0769i$
7.  $3 - 4i$
8. 25
9. 25
10. 3
11. 3
12.  $-7 + 24i$
13.  $-527 - 336i$
14.  $2 + i$  and  $-2 - i$
15.  $(r, \theta) = (\sqrt{2}, 3\pi/4) \approx (1.4142, 2.3562)$
16.  $(r, \theta) = (\sqrt{2}, -\pi/4) \approx (1.4142, -0.7854)$
17.  $(r, \theta) = (1, \pi/4)$  and  $(1, 5\pi/4)$  or  $\pm(1 + i)/\sqrt{2}$
18.  $(5, 0.927295218)$
19.  $1 + i$
20.  $i$