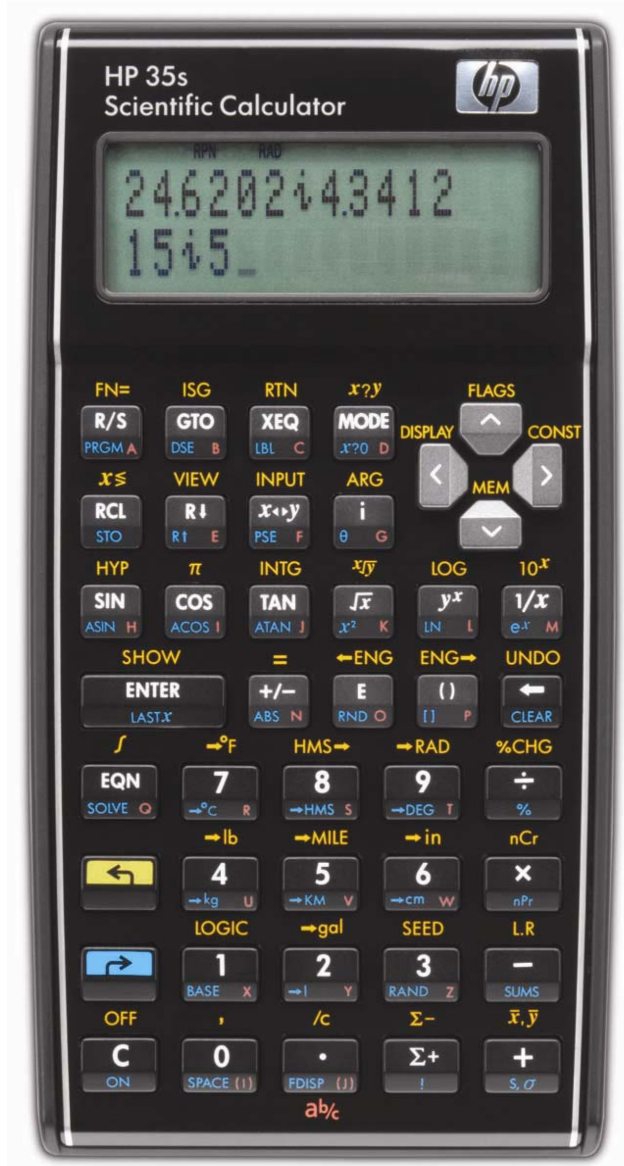
hp calculators

HP 35s Working with complex numbers – Part 2

Complex numbers

Practice working problems involving complex numbers



Complex numbers

Complex numbers occur in problems facing several disciplines, from quantum mechanics to working with magnetic fields. They are also useful in modeling the flow of a fluid around a pipe. They even show up in the solution of a differential equation that models the up and down movement of a car's shock absorber. They are also used to describe the inductance and capacitance of electrical circuits, for example, using the formula E = I x Z, where E is voltage, I is current, and Z is impedance. In many electricity and electronics areas, the "i" of an imaginary number is usually represented as "j" to avoid any confusion with the variable "I" which represents current in electronics formulas.

To distinguish complex numbers from real numbers, the HP 35s has a dedicated [i] key, which is pressed between the real and imaginary part of a complex number. Because the HP 35s holds an entire complex number in one stack register, the entire 4-level stack can hold 4 complex numbers at once.

In RPN mode, the HP 35s has two "complex number" modes available. The first is the standard xiy mode, where the real portion is input, the key pressed, and then the complex number portion is input. The second is by entering the complex number in "polar" format or a magnitude r, then the theta symbol, followed by an angle, or simply rΘa. These are selected using the [↰] [DISPLAY] menu choices 9 and 10 as shown in figure 1. To choose option 9 once [↰] [DISPLAY] has been pressed, press 9. To choose option 10, press the decimal point followed by a zero.

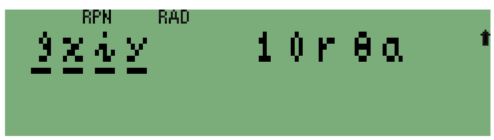


Figure 1

In algebraic mode, the HP 35s has three "complex number" modes available. The first two modes are the same as for RPN and are described in the preceding paragraph. The third mode which is only available in algebraic is the x+yi mode. It is selected using the [↰] [DISPLAY] menu choice 11, as shown in figure 2. To choose option 11 if you have already pressed [↰] [DISPLAY], press the decimal point followed by a one.

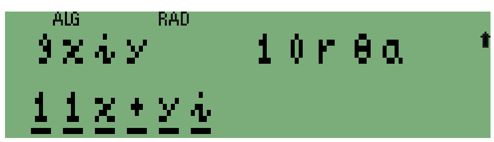


Figure 2

Note that changing the display mode changes any previously entered complex numbers to the new format. This means that to convert from polar to rectangular coordinates, for example, all that is needed is to change how a polar form complex number is displayed.

The HP 35s provides a new level of ease of use when dealing with complex numbers.

Practice working problems involving complex numbers

<u>Example 1:</u> Compute (2+3i) * [(7-6i) + (4+5i)]. Use the x+yi display mode in algebraic mode

<u>Solution:</u> Put the HP 35s into algebraic by pressing [MODE] [4]. Then press [↰] [DISPLAY] [.] [1]

[()] [2] [+] [3] [i] [>] [×] [()] [()] [7] [+] [6] [+/-] [i] [>] [+] [()] [4] [+] [5] [i] [ENTER]

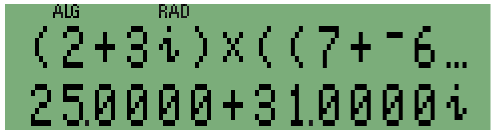


Figure 3

Answer: 25 + 31i. Figure 3 shows the display in algebraic mode.

Example 2: Extract the X and Y coordinates of the complex number 5Θ30. Use degrees mode.

Solution: Changing the display mode to [↰] [DISPLAY] [9] will convert the complex number to an X and Y form. However, to extract the X and Y values, it is necessary to leave the display in polar form using the [↱] [ABS] function to extract the magnitude and the [↰] [ARG] function to extract the angle. Once extracted, the X and Y coordinates can be computed for further use as follows:

X = r COS Θ
Y = r SIN Θ

In either RPN or algebraic mode:

[MODE] [1] (Sets degrees mode)
[↰] [DISPLAY] [·] [0]
[5] [↱] [θ] [3] [0] [ENTER]

In algebraic mode:

[↱] [ABS] [↱] [LAST x] [>] [×] [COS] [↰] [ARG] [↱] [LAST x] [ENTER]

Figure 4

[5] [↱] [θ] [3] [0] [ENTER] [↱] [ABS] [↱] [LAST x] [>] [×] [SIN] [↰] [ARG] [↱] [LAST x] [ENTER]

Figure 5

In RPN mode:

[↱] [ABS] [↱] [LAST x] [↰] [ARG] [COS] [×]

Figure 6

[x↔y] [↱] [ABS] [↱] [LAST x] [↰] [ARG] [SIN] [×]

Figure 7

Answer: The X coordinate is approximately 4.33 and the Y coordinate is 2.5. Figures 4 and 5 show the display in algebraic mode. Figures 6 and 7 show the display in RPN mode.

Example 3: Use the HP 35s to verify the triangle inequality for two complex numbers, which states that if z and w are any two complex numbers, then |z + w| ≤ |z| + |w|.

Use the complex numbers z = 3 + 1i and w = -1+2i

Solution: [MODE] [1] (Sets degrees mode)
[↰] [DISPLAY] [.] [0]

In RPN mode, compute |z + w| first.

[3] [i] [1] [ENTER] [1] [+/-] [i] [2] [+]

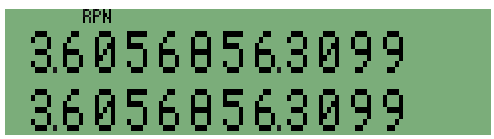


Figure 8

The magnitude of the resulting complex number will be approximately 3.6. It is computed by pressing:
[↱] [ABS]

Figure 9

In RPN mode, now compute |z| + |w|.

[3] [i] [1] [↱] [ABS]
[1] [+/-] [i] [2] [↱] [ABS]
[+]

Figure 10

Answer: The results verify the triangle inequality. The individual magnitudes of the two complex numbers added together is larger than the magnitude of the result from adding the complex numbers together.