Chapter 7

Equation Calculations

Your graphic calculator can perform the following three types of calculations:

- Linear equations with two to six unknowns
- High-order equations (quadratic, cubic)
- Solve calculations

7

7-1 Before Beginning an Equation Calculation

Before beginning an equation calculation you have to first enter the correct mode, and you must also clear the equation memories of any data that might be left over from a previous calculation.

■ Entering an Equation Calculation Mode

In the Main Menu, select the **EQUA** icon to enter the Equation Mode.

```
Equation

Select Type
F1:Simultaneous
F2:Polynomial
F3:Solver
SIML POLY SOLV
```
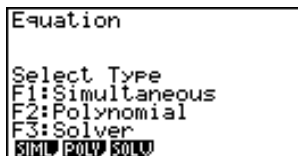
• {**SIML**} ... {linear equation with two to six unknowns}
• {**POLY**} ... {quadratic or cubic equation}
• {**SOLV**} ... {solve calculation}

■ Clearing Equation Memories

1. Enter the equation calculation mode (SIML or POLY) you want to use and perform the function key operation required for that mode.

• In the case of the SIML Mode (F1), use function keys F1 (2) through F5 (6) to specify the number of unknowns.

• In the case of the POLY Mode (F2), use function keys F1 (2) or F2 (3) to specify the degree of the polynomial.

• If your pressed F3 (SOLV), advance directly to step 2.

2. Press F2 (DEL).

3. Press F1 (YES) to delete the applicable equation memories, or F6 (NO) to abort the operation without deleting anything.

7-2 Linear Equations with Two to Six Unknowns

You can use the procedures described here to solve linear equations with unknowns that match the following formats:

Two unknowns
$$a_1x + b_1y = c_1$$
$$a_2x + b_2y = c_2$$

⋮

Six unknowns
$$a_1x + b_1y + c_1z + d_1t + e_1u + f_1v = g_1$$
$$a_2x + b_2y + c_2z + d_2t + e_2u + f_2v = g_2$$
$$a_3x + b_3y + c_3z + d_3t + e_3u + f_3v = g_3$$
$$a_4x + b_4y + c_4z + d_4t + e_4u + f_4v = g_4$$
$$a_5x + b_5y + c_5z + d_5t + e_5u + f_5v = g_5$$
$$a_6x + b_6y + c_6z + d_6t + e_6u + f_6v = g_6$$

• You can also solve linear equations with three, four, and five unknowns. In each case, the format is similar to those shown above.

■ Specifying the Number of Unknowns

While in the Equation Mode, press [F1] (SIML) and then specify the number of unknowns.

```
Simultaneous
No Data In Memory


Number Of Unknowns?
 2  3  4  5  6
```

• {**2**}/{**3**}/{**4**}/{**5**}/{**6**} ... linear equation with {2}/{3}/{4}/{5}/{6} unknowns

■ Solving Linear Equations with Three Unknowns

Example   To solve the following linear equations for x, y, and z:

$$4x + y - 2z = -1$$
$$x + 6y + 3z = 1$$
$$-5x + 4y + z = -7$$

1. While in the Linear Equation Mode (SIML), press F2 (3), because the linear equations being solved have three unknowns.

2. Input each coefficient.

   Coefficient input cells

   4 EXE 1 EXE (−) 2 EXE (−) 1 EXE
   1 EXE 6 EXE 3 EXE 1 EXE
   (−) 5 EXE 4 EXE 1 EXE (−) 7 EXE

   F1
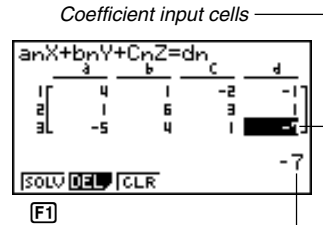
   Value being input into highlighted cell

   Each time you press EXE, the input value is registered in the highlighted cell. Each press of EXE inputs values in the following sequence:

   coefficient $a_1 \rightarrow$ coefficient $b_1 \rightarrow$ coefficient $c_1 \rightarrow$ coefficient $d_1 \rightarrow$
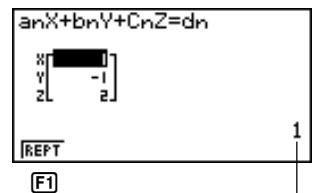 $$\vdots$$
   coefficient $a_n \rightarrow$ coefficient $b_n \rightarrow$ coefficient $c_n \rightarrow$ coefficient d_n (n = 2 to 6)

   • You can input fractions and value memory contents as coefficients.

3. After inputting the coefficients, solve the equations.

   F1 (SOLV)

   F1

   Highlighted solution cell value

- Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 10-digit mantissa and 2-digit exponent.
- This unit performs simultaneous linear equations by placing the coefficients inside of a matrix. Because of this, as the coefficient matrix approaches zero, precision in the inverse matrix is reduced and so precision in the results produced also deteriorates. For example, the solution for a linear equation with three unknowns would be calculated as shown below.

$$
\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}^{-1} \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix}
$$

- An error occurs whenever the unit is unable to solve the equations.
- Pressing $\boxed{\text{F1}}$ (REPT) returns to the initial display of the Linear Equation Mode.

> Depending on the coefficients that you use, it may take considerable time for the calculation result of simultaneous linear equations to appear on the display. Failure of a result to appear immediately does not mean that the unit is not functioning properly.

■ Changing Coefficients

You can change a coefficient either before or after you register it by pressing $\boxed{\text{EXE}}$.

●To change a coefficient before registering it with $\boxed{\text{EXE}}$

Press the $\boxed{\text{AC}}$ key to clear the current value and then input another one.

●To change a coefficient after registering it with $\boxed{\text{EXE}}$

Use the cursor keys to highlight the cell that contains the coefficient that you want to change. Next, input the value that you want to change to.

■ Clearing All the Coefficients

While in the Linear Equation Mode, press the $\boxed{\text{F3}}$ (CLR) function key. This operation clears all the coefficients to zero.

7-3 Quadratic and Cubic Equations

This calculator can also solve quadratic and cubic equations that match the following formats (when $a \neq 0$):

- **Quadratic:** $ax^2 + bx + c = 0$
- **Cubic:** $ax^3 + bx^2 + cx + d = 0$

■ Specifying the Degree of an Equation

While in the Equation Mode, press [F2] (POLY) and then specify the degree of the equation.

```
Polynomial
No Data In Memory




Degree?
 2   3
```

- {**2**}/{**3**} ... {quadratic}/{cubic} equation

■ Solving a Quadratic or Cubic Equation

Example   **To solve the following cubic equation:**
$$x^3 - 2x^2 - x + 2 = 0$$

1. Press [F2] (3) to enter the Cubic Equation Mode.

2. Input each coefficient.

      [1] [EXE] [(-)] [2] [EXE] [(-)] [1] [EXE] [2] [EXE]

- Each time you press [EXE], the input value is registered in the highlighted cell. Each press of [EXE] inputs values in the following sequence:

  coefficient a → coefficient b → coefficient c → coefficient d

  Input for coefficient d is required only for cubic equations.
- You can input fractions and value memory contents as coefficients.

3. After inputting the coefficients, press [F1] (SOLV) to solve the equations.
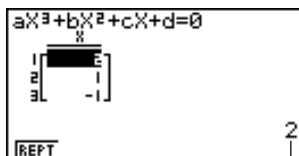
```
aX³+bX²+cX+d=0
       x
1┌       ┐
2│      1│
3└    -1┘
                  2
REPT
```

Highlighted solution cell value

- Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 10-digit mantissa and 2-digit exponent.
- An error occurs whenever the unit is unable to solve the equations.
- Pressing [F1] (REPT) returns to the initial display of the Cubic Equation Mode.

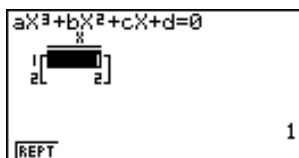## ■ Multiple root (1 or 2) solutions or imaginary number solutions

The following examples illustrate how multiple-root solutions and imaginary number solutions are handled.

●To solve a cubic equation that produces a multiple-value solution

Example   **To solve the following cubic equation:**

$$x^3 - 4x^2 + 5x - 2 = 0$$

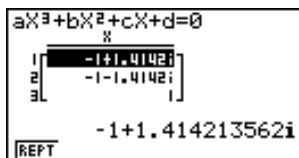[1] [EXE] [(−)] [4] [EXE] [5] [EXE] [(−)] [2] [EXE]
[F1] (SOLV)

●To solve a cubic equation that produces an imaginary number solution

Example   **To solve the following cubic equation:**

$$x^3 + x^2 + x - 3 = 0$$

[1] [EXE] [1] [EXE] [1] [EXE] [(−)] [3] [EXE]
[F1] (SOLV)

It may take considerable time for the calculation result of cubic equations to appear on the display. Failure of a result to appear immediately does not mean that the unit is not functioning properly.

■ Changing Coefficients

You can change a coefficient either before or after you register it by pressing EXE .

●To change a coefficient before registering it with EXE

Press the AC key to clear the current value and then input another one.

●To change a coefficient after registering it with EXE

Use the cursor keys to highlight the cell that contains the coefficient that you want
to change. Next, input the value that you want to change to.

■ Clearing All the Coefficients

While in the Quadratic or Cubic Equation Mode, press the F3 (CLR) function key.
This operation clears all the coefficients to zero.

7-4 Solve Calculations

You can determine the value of any variable you are using without having to solve the equation.

Input the equation, and a table of variables appears on the display. Use the table to assign values to variables and then execute the calculation to obtain a solution and display the value of the unknown variable.

• You cannot use the variable table in the Program Mode. When you want to use the Solve calculation function in the Program Mode, you have to use program commands to assign values to variables.

■ Entering the Solve Calculation Mode

While in the Equation Mode, press [F3] (SOLV). The Solve input screen appears.

Input the expression. You can input numbers, alpha-characters, and operation symbols. If you do not input an equals sign, the calculator assumes that the expression is to the left of the equals sign and there is a zero to the right. To specify a value other than zero to the right of the equals sign, you must input the equals sign and the value.

●**To perform solve calculations**

Example **To calculate initial velocity of an object thrown into the air and taking a time of 2 seconds to reach a height of 14 meters, when gravitational acceleration is 9.8 m/s²**

The following formula expresses the relationship between height H, initial velocity V, time T, and gravitational acceleration G of a free falling object.

$$H = VT - \frac{1}{2} GT^2$$

1. Press [F2] (DEL) [F1] (YES) to clear any previously input equations.

2. Input the equation.

   [ALPHA] [H] [SHIFT] [=] [ALPHA] [V] [ALPHA] [T] [−] [(] [1] [÷] [2] [)] [ALPHA] [G] [ALPHA] [T] [x²]
   [EXE]

3. Input the values.

[1] [4] [EXE] (H=14)
[0] [EXE] (V=0)
[2] [EXE] (T=2)
[9] [.] [8] [EXE] (G=9.8)

4. Press ⊙ to move the highlighting to V = 0.

5. Press [F6] (SOLV) to obtain the solution.

Equation ———
Solution ———

```
Eq:H=VT-(1÷2)GT²
    V=16.8
    Lft=14
    Rgt=14


REPT
```

• An error occurs if you input more than one equals sign.

• "Lft" and "Rgt" indicate the left and right sides that are calculated using the approximate value. The closer the difference between these two values is to zero, the greater the accuracy of the result.
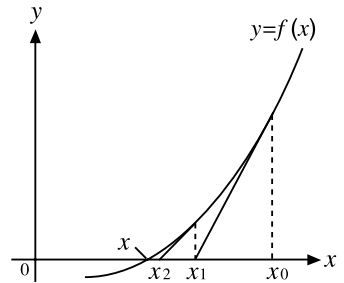
Solve Calculations

The solution of the function is approximated using Newton's method.

●Newton's method

This method is based on the assumption that $f(x)$ can be approximated by a linear expression within a very narrow range.

First, a starting value (predicted value) x_0 is given. Using this starting value as a base, approximate value x_1 is obtained, and then the left side and right side calculation results are compared. Next, approximate value x_1 is used as the initial value to calculate the next approximate value x_2. This procedure is repeated until the difference between the left side and right side calculated values is less than some minute value.

• Solutions obtained using Newton's method may include errors.

• To check results, plug them into the original expression and perform the calculation.

• Solve uses Newton's method to calculate approximations. The following can sometimes occur when this method is used.

—Solutions may be impossible to obtain for certain initial estimated values. Should this happen, try inputting another value that you assume to be in the vicinity of the solution and perform the calculation again.

—The calculator may be unable to obtain a solution, even though a solution exists.

• Due to certain characteristics of Newton's method, solutions for the following types of functions tend to be difficult to calculate.

—Periodic functions (i.e. $y = \sin x - a$)

—Functions whose graph produce sharp slopes (i.e. $y = e^x$, $y = {}^1/x$)

—Inverse proportion expressions and other discontinuous functions.

7-5   What to Do When an Error Occurs

●**Error during coefficient value input**

Press the AC key to clear the error and return to the value that was registered for the coefficient before you input the value that generated the error. Try inputting a new value again.

●**Error during calculation**

Press the AC key to clear the error and display coefficient a. Try inputting values for the coefficients again.