

# Chapter

# 8



## Graphing

A collection of versatile graphing tools plus a large  $127 \times 63$ -dot display makes it easy to draw a variety of function graphs quickly and easily. This calculator is capable of drawing the following types of graphs.

- Rectangular coordinate ( $Y =$ ) graphs
- Polar coordinate ( $r =$ ) graphs
- Parametric graphs
- $X =$  constant graphs
- Inequality graphs
- Integration graphs (in the RUN mode only)

A selection of graph commands also makes it possible to incorporate graphing into programs.

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## 8-1 Before Trying to Draw a Graph

### ■ Entering the Graph Mode

On the Main Menu, select the **GRAPH** icon and enter the GRAPH Mode. When you do, the Graph Function menu appears on the display. You can use this menu to store, edit, and recall functions and to draw their graphs.

Use  $\blacktriangle$  and  $\blacktriangledown$  to change selection.



- {SEL} ... {draw/non-draw status}
- {DEL} ... {function delete}
- {TYPE} ... {graph type menu}
- {COLR} ... {graph color}
- {GMEM} ... {graph memory save/recall}
- {DRAW} ... {graph draw}

## 8-2 View Window (V-Window) Settings

Use the View Window to specify the range of the  $x$ - and  $y$ -axes, and to set the spacing between the increments on each axis. You should always set the View Window parameters you want to use before drawing a graph.

1. Press **SHIFT** **F3** (V-Window) to display the View Window.

```
View Window
Xmin :-6.3
max :6.3
scale:1
Ymin :-3.1
max :3.1
scale:1
INIT TRIG STD STO RCL
```

- X min ..... Minimum  $x$ -axis value
- X max ..... Maximum  $x$ -axis value
- X scale ..... Spacing of  $x$ -axis increments
- Y min ..... Minimum  $y$ -axis value
- Y max ..... Maximum  $y$ -axis value
- Y scale ..... Spacing of  $y$ -axis increments



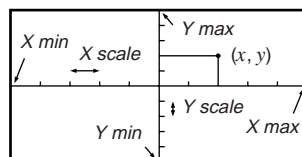
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- **{INIT}**/**{TRIG}**/**{STD}** ... View Window {initial settings}/{initial settings using specified angle unit}/{standardized settings}

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- **{STO}**/**{RCL}** ... View Window setting {store}/{recall}

The nearby illustration shows the meaning of each of these parameters.



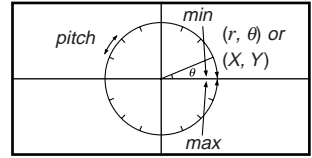
2. Input a value for a parameter and press **EXE**. The calculator automatically selects the next parameter for input.
  - You can also select a parameter using the **▼** and **▲** keys.
  - There are actually nine View Window parameters. The remaining three parameters appear on the display when you move the highlighting down past the Y scale parameter by inputting values and pressing **▼**.

```
View Window
T,θ
min :0
max :6.2831853
Pitch:0.06283185
INIT TRIG STD STO RCL
```

- T,  $\theta$  min ..... T,  $\theta$  minimum values
- T,  $\theta$  max ..... T,  $\theta$  maximum values
- T,  $\theta$  pitch ..... T,  $\theta$  pitch

## 8 - 2 View Window (V-Window) Settings

The nearby illustration shows the meaning of each of these parameters.



3. To exit the View Window, press **EXIT** or **SHIFT** **QUIT**.

- Pressing **EXE** without inputting any value also exits the View Window.



- The following is the input range for View Window parameters.  
–9.9999E+97 to 9.9999E+97
- You can input parameter values up to 14 digits long. Values greater than  $10^7$  or less than  $10^{-2}$ , are automatically converted to a 7-digit mantissa (including negative sign) plus a 2-digit exponent.
- The only keys that enabled while the View Window is on the display are: **0** to **9**, **.**, **EXP**, **(-)**, **(^)**, **(v)**, **(<)**, **(>)**, **+**, **=**, **✕**, **(÷)**, **( )**, **SHIFT** **(π)**, **EXIT**, **SHIFT** **QUIT**. You can use **(-)** or **=** to input negative values.
- The existing value remains unchanged if you input a value outside the allowable range or in the case of illegal input (negative sign only without a value).
- Inputting a View Window range so the min value is greater than the max value, causes the axis to be inverted.
- You can input expressions (such as  $2\pi$ ) as View Window parameters.
- When the View Window setting does not allow display of the axes, the scale for the  $y$ -axis is indicated on either the left or right edge of the display, while that for the  $x$ -axis is indicated on either the top or bottom edge.
- When View Window values are changed, the graph display is cleared and the newly set axes only are displayed.
- View Window settings may cause irregular scale spacing.
- Setting maximum and minimum values that create too wide of a View Window range can result in a graph made up of disconnected lines (because portions of the graph run off the screen), or in graphs that are inaccurate.
- The point of deflection sometimes exceeds the capabilities of the display with graphs that change drastically as they approach the point of deflection.
- Setting maximum and minimum values that create too narrow of a View Window range can result in an error.

## ■ Initializing and Standardizing the View Window

### ● To initialize the View Window

You can use either of the following two methods to initialize the View Window.

#### Normal initialization

Press  $\boxed{\text{SHIFT}} \boxed{\text{F3}}$  (V-Window)  $\boxed{\text{F1}}$  (INIT) to initialize the View Window to the following settings.

$$\begin{array}{ll} X_{\min} = -6.3 & Y_{\min} = -3.1 \\ X_{\max} = 6.3 & Y_{\max} = 3.1 \\ X_{\text{scale}} = 1 & Y_{\text{scale}} = 1 \end{array}$$

#### Trigonometric initialization

Press  $\boxed{\text{SHIFT}} \boxed{\text{F3}}$  (V-Window)  $\boxed{\text{F2}}$  (TRIG) to initialize the View Window to the following settings.

Deg Mode

$$\begin{array}{ll} X_{\min} = -540 & Y_{\min} = -1.6 \\ X_{\max} = 540 & Y_{\max} = 1.6 \\ X_{\text{scale}} = 90 & Y_{\text{scale}} = 0.5 \end{array}$$

Rad Mode

$$\begin{array}{l} X_{\min} = -9.4247779 \\ X_{\max} = 9.42477796 \\ X_{\text{scale}} = 1.57079632 \end{array}$$

Gra Mode

$$\begin{array}{l} X_{\min} = -600 \\ X_{\max} = 600 \\ X_{\text{scale}} = 100 \end{array}$$

- The settings for Y min, Y max, Y pitch, T/θ min, T/θ max, and T/θ pitch remain unchanged when you press  $\boxed{\text{F2}}$  (TRIG).

### ● To standardize the View Window

Press  $\boxed{\text{SHIFT}} \boxed{\text{F3}}$  (V-Window)  $\boxed{\text{F3}}$  (STD) to standardize the View Window to the following settings.

$$\begin{array}{ll} X_{\min} = -10 & Y_{\min} = -10 \\ X_{\max} = 10 & Y_{\max} = 10 \\ X_{\text{scale}} = 1 & Y_{\text{scale}} = 1 \end{array}$$

## ■ View Window Memory

You can store up to six sets of View Window settings in View Window memory for recall when you need them.

### ● To store View Window settings

Inputting View Window values and then pressing **[F4]** (STO) **[F1]** (V-W1) stores the View Window contents in View Window memory V-W1.

- There are six View Window memories numbered V-W1 to V-W6.
- Storing View Window settings in a memory area that already contains settings replaces the existing settings with the new ones.

### ● To recall View Window settings

Pressing **[F5]** (RCL) **[F1]** (V-W1) recalls the contents of View Window memory V-W1.

- Recalling View Window settings causes the settings currently on the display to be deleted.



- You can change View Window settings in a program using the following syntax.

View Window [X min value], [X max value], [X scale value],  
[Y min value], [Y max value], [Y scale value],  
[T,  $\theta$  min value], [T,  $\theta$  max value], [T,  $\theta$  pitch value]

## 8-3 Graph Function Operations

You can store up to 20 functions in memory. Functions in memory can be edited, recalled, and graphed.

### ■ Specifying the Graph Type

Before you can store a graph function in memory, you must first specify its graph type.

1. While the Graph Function Menu is on the display, press **F3** (TYPE) to display the graph type menu, which contains the following items.
  - $\{Y=\}/\{r=\}/\{\text{Parm}\}/\{X=c\}$  ... {rectangular coordinate}/ {polar coordinate}/ {parametric}/ {X=constant} graph
  - $\{Y>\}/\{Y<\}/\{Y\geq\}/\{Y\leq\}$  ...  $\{Y>f(x)\}/\{Y<f(x)\}/\{Y\geq f(x)\}/\{Y\leq f(x)\}$  inequality graph
2. Press the function key that corresponds to the graph type you want to specify.

### ■ Storing Graph Functions

#### ● To store a rectangular coordinate function ( $Y =$ )

**Example** To store the following expression in memory area Y1 :  
 $y = 2x^2 - 5$

**F3** (TYPE) **F1** ( $Y =$ ) (Specifies rectangular coordinate expression.)

**2** **[X,θ,T]** **[x<sup>2</sup>]** **[−]** **5** (Inputs expression.)

**EXE** (Stores expression.)

```
Graph Func :Y=
Y1 2x2-5
```

- You will not be able to store the expression in an area that already contains a parametric function. Select another area to store your expression or delete the existing parametric function first. This also applies when storing  $r =$  expressions,  $X =$  constant expressions, and inequalities.

#### ● To store a polar coordinate function ( $r =$ )

**Example** To store the following expression in memory area r2 :  
 $r = 5 \sin 3\theta$

**F3** (TYPE) **F2** ( $r =$ ) (Specifies polar coordinate expression.)

**5** **[sin]** **3** **[X,θ,T]** (Inputs expression.)

**EXE** (Stores expression.)

```
Graph Func :r=
r2 5sin 3θ
```

● **To store a parametric function**

Example To store the following functions in memory areas X<sub>t3</sub> and Y<sub>t3</sub> :

$$x = 3 \sin T$$

$$y = 3 \cos T$$

**F3**(TYPE) **F3**(Parm) (Specifies parametric expression.)

**3** **sin** **X.θT** **EXE** (Inputs and stores  $x$  expression.)

**3** **cos** **X.θT** **EXE** (Inputs and stores  $y$  expression.)

```
Graph Func :Param
Xt3 3sin T
Yt3 3cos T
```

- You will not be able to store the expression in an area that already contains a rectangular coordinate expression, polar coordinate expression, X = constant expression or inequality. Select another area to store your expression or delete the existing expression first.

● **To store an X = constant expression**

Example To store the following expression in memory area X<sub>4</sub> :

$$X = 3$$

**F3**(TYPE) **F4**(X = c) (Specifies X = constant expression.)

**3** (Inputs expression.)

**EXE** (Stores expression.)

```
Graph Func :X=const
X4 3
```

- Inputting X, Y, T,  $r$ , or  $\theta$  for the constant in the above procedures causes an error.

● **To store an inequality**

Example To store the following inequality in memory area Y<sub>5</sub> :

$$y > x^2 - 2x - 6$$

**F3**(TYPE) **F6**( $\triangleright$ ) **F1**(Y $\triangleright$ ) (Specifies an inequality.)

**X.θT** **x<sup>2</sup>** **=** **2** **X.θT** **=** **6** (Inputs expression.)

**EXE** (Stores expression.)

```
Graph Func :Y>
Y5 X^2-2X-6
```



## ■ Editing Functions in Memory

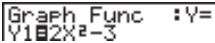
### ● To edit a function in memory

**Example** To change the expression in memory area Y1 from  $y = 2x^2 - 5$  to  $y = 2x^2 - 3$

▶ (Displays cursor.)

▶▶▶▶ 3 (Changes contents.)

▢ (Stores new graph function.)



### ● To delete a function

1. While the Graph Function Menu is on the display, press ▲ or ▼ to display the cursor and move the highlighting to the area that contains the function you want to delete.
2. Press F2 (DEL).
3. Press F1 (YES) to delete the function for F6 (NO) to abort the procedure without deleting anything.

Parametric functions come in pairs (Xt and Yt).

When editing a parametric function, clear the graph functions and re-input from the beginning.

## ■ Drawing a Graph

### ● To specify the graph color

The default color for graph drawing is blue, but you can change the color to orange or green if you want.

1. While the Graph Function Menu is on the display, press ▲ or ▼ to display the cursor and move the highlighting to the area that contains the function whose graph color you want to change.
2. Press F4 (COLR) to display a color menu, which contains the following items.
  - {Blue}/{Orng}/{Grn} ... {blue}/{orange}/{green}
3. Press the function key for the color you want to use.

● To specify the draw/non-draw status of a graph

Example To select the following functions for drawing :

$$Y1 = 2x^2 - 5 \quad r2 = 5 \sin 3\theta$$

Use the following View Window parameters.

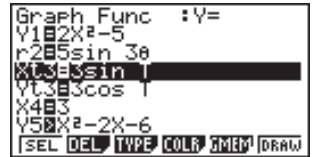
$$Xmin = -5 \quad Ymin = -5$$

$$Xmax = 5 \quad Ymax = 5$$

$$Xscale = 1 \quad Yscale = 1$$



(Select a memory area that contains a function for which you want to specify non-draw.)



**F1**

**F1**(SEL)

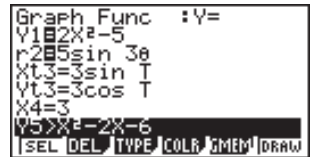
(Specify non-draw.)



Unhighlights

Two downward arrow icons **F1**(SEL)

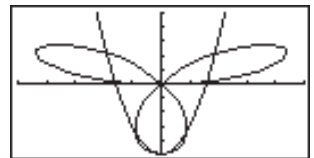
One downward arrow icon **F1**(SEL)



**F6**

**F6**(DRAW) or **EXE**

(Draws graphs.)



- Pressing **SHIFT** **F6** (G↔T) or **AC** returns to the Graph Function Menu.

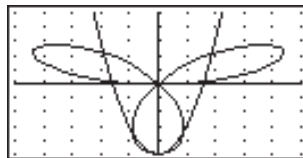


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- You can use the set up screen settings to alter the appearance of the graph screen as shown below.

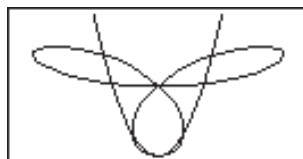
- Grid: On

This setting causes dots to appear at the grid intersects on the display.



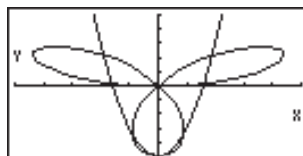
- Axes: Off

This setting clears the axis lines from the display.



- Label: On

This setting displays labels for the  $x$ - and  $y$ -axes.



- A polar coordinate ( $r =$ ) or parametric graph will appear coarse if the settings you make in the View Window cause the  $T, \theta$  pitch value to be too large, relative to the differential between the  $T, \theta$  min and  $T, \theta$  max settings. If the settings you make cause the  $T, \theta$  pitch value to be too small relative to the differential between the  $T, \theta$  min and  $T, \theta$  max settings, on the other hand, the graph will take a very long time to draw.
- Attempting to draw a graph for an expression in which  $X$  is input for an  $X =$  constant expression results in an error.

## 8-4 Graph Memory

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Graph memory lets you store up to six sets of graph function data and recall it later when you need it.

A single save operation saves the following data in graph memory.

- All graph functions in the currently displayed Graph Function Menu (up to 20)
- Graph types
- Graph colors
- Draw/non-draw status
- View Window settings (1 set)

### ●To store graph functions in graph memory

Pressing **[F5]** (GMEM) **[F1]** (STO) **[F1]** (GM1) stores the selected graph function into graph memory GM1.

- There are six graph memories numbered GM1 to GM6.
- Storing a function in a memory area that already contains a function replaces the existing function with the new one.
- If the data exceeds the calculator's remaining memory capacity, an error occurs.

### ●To recall a graph function

Pressing **[F5]** (GMEM) **[F2]** (RCL) **[F1]** (GM1) recalls the contents of graph memory GM1.

- Recalling data from graph memory causes any data currently on the Graph Function Menu to be deleted.

## 8-5 Drawing Graphs Manually

After you select the **RUN** icon in the Main Menu and enter the RUN Mode, you can draw graphs manually. First press **[SHIFT] [F4]** (Sketch) **[F5]** (GRPH) to recall the Graph Command Menu, and then input the graph function.

- $\{Y=\}/\{r=\}/\{\text{Parm}\}/\{X=c\}/\{G\}dx$  ... {rectangular coordinate}/ {polar coordinate}/ {parametric}/ {X = constant}/ {integration} graph
- $\{Y>\}/\{Y<\}/\{Y\geq\}/\{Y\leq\}$  ...  $\{Y>f(x)\}/\{Y<f(x)\}/\{Y\geq f(x)\}/\{Y\leq f(x)\}$  inequality graph

### ● To graph using rectangular coordinates (Y =) **[Sketch]-[GRPH]-[Y=]**

You can graph functions that can be expressed in the format  $y = f(x)$ .

**Example** To graph  $y = 2x^2 + 3x - 4$

Use the following View Window parameters.

$$\text{Xmin} = -5 \qquad \text{Ymin} = -10$$

$$\text{Xmax} = 5 \qquad \text{Ymax} = 10$$

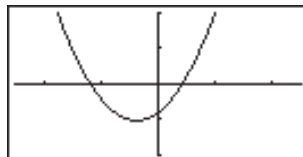
$$\text{Xscale} = 2 \qquad \text{Yscale} = 5$$

1. In the set up screen, specify "Y=" for Func Type and then press **[EXIT]**.
2. Input the rectangular coordinate (Y =) expression.

**[SHIFT] [F4]** (Sketch) **[F1]** (Cl) **[EXE]**

**[F5]** (GRPH) **[F1]** (Y =) **[2]** **[X,θ,T]** **[x<sup>2</sup>]** **[+]** **[3]** **[X,θ,T]** **[=]** **[4]**

3. Press **[EXE]** to draw the graph.



- You can draw graphs of the following built-in scientific functions.

• $\sin x$	• $\cos x$	• $\tan x$	• $\sin^{-1} x$	• $\cos^{-1} x$
• $\tan^{-1} x$	• $\sinh x$	• $\cosh x$	• $\tanh x$	• $\sinh^{-1} x$
• $\cosh^{-1} x$	• $\tanh^{-1} x$	• $\sqrt{x}$	• $x^2$	• $\log x$
• $\ln x$	• $10^x$	• $e^x$	• $x^{-1}$	• $\sqrt[3]{x}$

View Window settings are made automatically for built-in graphs.

● **To graph using polar coordinates ( $r =$ )**

[Sketch]-[GRPH]-[r=]

You can graph functions that can be expressed in the format  $r = f(\theta)$ .

**Example** To graph  $r = 2 \sin 3\theta$

Use the following View Window parameters.

**Xmin** = -3    **Ymin** = -2    **T,  $\theta$  min** = 0

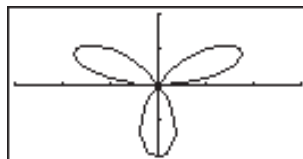
**Xmax** = 3    **Ymax** = 2    **T,  $\theta$  max** =  $\pi$

**Xscale** = 1    **Yscale** = 1    **T,  $\theta$  pitch** =  $\pi \div 36$

1. In the set up screen, specify “r=” for Func Type.
2. Specify “Rad” as the angle unit and then press [EXIT].
3. Input the polar coordinate expression ( $r =$ ).

[SHIFT] [F4] (Sketch) [F1] (Cls) [EXE]  
 [F5] (GRPH) [F2] ( $r =$ ) [2] [sin] [3] [X,  $\theta$ , T]

4. Press [EXE] to draw the graph.



- You can draw graphs of the following built-in scientific functions.

• $\sin \theta$	• $\cos \theta$	• $\tan \theta$	• $\sin^{-1} \theta$	• $\cos^{-1} \theta$
• $\tan^{-1} \theta$	• $\sinh \theta$	• $\cosh \theta$	• $\tanh \theta$	• $\sinh^{-1} \theta$
• $\cosh^{-1} \theta$	• $\tanh^{-1} \theta$	• $\sqrt{\theta}$	• $\theta^2$	• $\log \theta$
• $\ln \theta$	• $10^\theta$	• $e^\theta$	• $\theta^{-1}$	• ${}^3\sqrt{\theta}$

View Window settings are made automatically for built-in graphs.

●To graph parametric functions

[Sketch]-[GRPH]-[Parm]

You can graph parametric functions that can be expressed in the following format.

$$(X, Y) = (f(T), g(T))$$

Example

To graph the following parametric functions:

$$x = 7 \cos T - 2 \cos 3.5T \quad y = 7 \sin T - 2 \sin 3.5T$$

Use the following View Window parameters.

$$\mathbf{Xmin} = -20 \quad \mathbf{Ymin} = -12 \quad \mathbf{T, \theta min} = 0$$

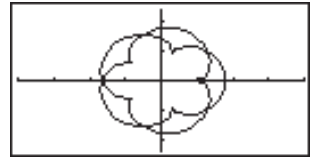
$$\mathbf{Xmax} = 20 \quad \mathbf{Ymax} = 12 \quad \mathbf{T, \theta max} = 4\pi$$

$$\mathbf{Xscale} = 5 \quad \mathbf{Yscale} = 5 \quad \mathbf{T, \theta pitch} = \pi \div 36$$

1. In the set up screen, specify “**Parm**” for Func Type.
2. Specify “**Rad**” (radians) as the angle unit and then press **[EXIT]**.
3. Input the parametric functions.

**[SHIFT]** **[F4]** (Sketch) **[F1]** (Cls) **[EXE]**  
**[F5]** (GRPH) **[F3]** (Parm)  
**[7]** **[cos]** **[X,θ,T]** **[=]** **[2]** **[cos]** **[3]** **[.]** **[5]** **[X,θ,T]** **[>]**  
**[7]** **[sin]** **[X,θ,T]** **[=]** **[2]** **[sin]** **[3]** **[.]** **[5]** **[X,θ,T]** **[>]**

4. Press **[EXE]** to draw the graph.



●To graph X = constant

[Sketch]-[GRPH]-[X=c]

You can graph functions that can be expressed in the format X = constant.

Example

To graph X = 3

Use the following View Window parameters.

$$\mathbf{Xmin} = -5 \quad \mathbf{Ymin} = -5$$

$$\mathbf{Xmax} = 5 \quad \mathbf{Ymax} = 5$$

$$\mathbf{Xscale} = 1 \quad \mathbf{Yscale} = 1$$

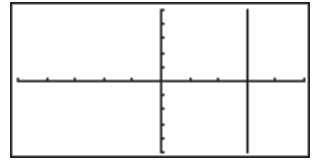
1. In the set up screen, specify “**X=c**” for Func Type and then press **[EXIT]**.

2. Input the expression.

**[SHIFT]** **[F4]** (Sketch) **[F1]** (Cls) **[EXE]**

**[F5]** (GRPH) **[F4]** (X = c) **[3]**

3. Press **[EXE]** to draw the graph.



**•To graph inequalities**

**[Sketch]-[GRPH]-[Y>]/[Y<]/[Y≥]/[Y≤]**

You can graph inequalities that can be expressed in the following four formats.

- $y > f(x)$     •  $y < f(x)$     •  $y \geq f(x)$     •  $y \leq f(x)$

**Example** To graph the inequality  $y > x^2 - 2x - 6$

Use the following View Window parameters.

<b>Xmin</b> = -6	<b>Ymin</b> = -10
<b>Xmax</b> = 6	<b>Ymax</b> = 10
<b>Xscale</b> = 1	<b>Yscale</b> = 5

1. In the set up screen, specify “Y>” for Func Type and then press **[EXIT]**.

2. Input the inequality.

**[SHIFT]** **[F4]** (Sketch) **[F1]** (Cls) **[EXE]**

**[F5]** (GRPH) **[F6]** (>) **[F1]** (Y>) **[X,θ,T]**  $x^2$  **[=]** **[2]** **[X,θ,T]** **[=]** **[6]**

3. Press **[EXE]** to draw the graph.





● **To draw an integration graph**

[Sketch]-[GRPH]-[G]dx

You can graph an integration calculation performed using the function  $y = f(x)$ .

**Example** To graph the following, with a tolerance of “tol” =  $1E-4$ :

$$\int_{-2}^1 (x + 2)(x - 1)(x - 3) dx$$

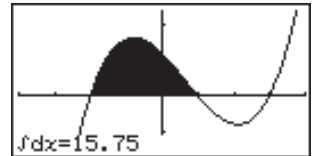
Use the following View Window parameters.

**Xmin** = -4                      **Ymin** = -8  
**Xmax** = 4                        **Ymax** = 12  
**Xscale** = 1                      **Yscale** = 5

1. In the set up screen, specify “Y=” for Func Type and then press **EXIT** .
2. Input the integration graph expression.

**SHIFT** **F4** (Sketch) **F1** (Cls) **EXE**  
**F5** (GRPH) **F5** (G)dx **C** **DEL** **+** **2** **)** **C** **DEL** **-** **1** **)**  
**C** **DEL** **-** **3** **)** **↵** **(-)** **2** **↵** **1** **↵** **1** **EXP** **(-)** **4**

3. Press **EXE** to draw the graph.



- Before drawing an integration graph, be sure to always press **SHIFT** **F4** (Sketch) **F1** (Cls) to clear the screen.
- You can also incorporate an integration graph command into programs.

## 8-6 Other Graphing Functions



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The functions described in this section tell you how to read the  $x$ - and  $y$ -coordinates at a given point, and how to zoom in and zoom out on a graph.

- These functions can be used with rectangular coordinate, polar coordinate, parametric,  $X = \text{constant}$ , and inequality graphs only.

### ■ Connect Type and Plot Type Graphs (Draw Type)

You can use the Draw Type setting of the set up screen to specify one of two graph types.

- Connect  
Points are plotted and connected by lines to create a curve.
- Plot  
Points are plotted without being connected.

### ■ Trace

With trace, you can move a flashing pointer along a graph with the cursor keys and obtain readouts of coordinates at each point. The following shows the different types of coordinate readouts produced by trace.

- Rectangular Coordinate Graph

```
X=-3.095238095  Y=5.8752834444
```

- Polar Coordinate Graph

```
r=1.7320508075  θ=0.34906585039
```

- Parametric Function Graph

```
T=0.78539816339  
X=6.7975065333  Y=4.1843806035
```

- $X = \text{Constant}$  Graph

```
X=3  Y=0
```

- Inequality Graph

```
X=-6.3  Y<38.69
```

### ● To use trace to read coordinates

#### Example

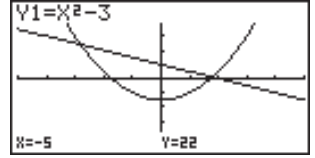
To determine the points of intersection for graphs produced by the following functions:

$$Y1 = x^2 - 3 \quad Y2 = -x + 2$$

Use the following View Window parameters.

$$\begin{array}{ll} X_{\min} = -5 & Y_{\min} = -10 \\ X_{\max} = 5 & Y_{\max} = 10 \\ X_{\text{scale}} = 1 & Y_{\text{scale}} = 2 \end{array}$$

1. After drawing the graphs, press **F1** (Trace) to make the pointer appear at the far left of the graph.

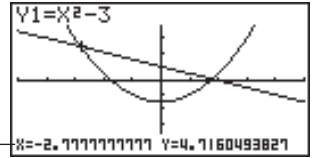


- The pointer may not be visible on the graph when you press **F1** (Trace).

2. Use **▶** to move the pointer to the first intersection.



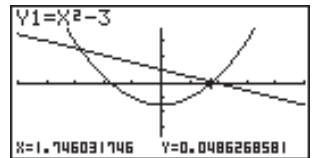
*x/y coordinate values* —



- Pressing **◀** and **▶** moves the pointer along the graph. Holding down either key moves the pointer at high speed.

3. Use **▲** and **▼** to move the pointer between the two graphs.

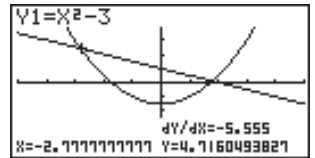
4. Use **▶** to move the pointer to the other intersection.



- To abort a trace operation, press **F1** (Trace).
- Do not press the **AC** key while performing a trace operation.

**•To display the derivative**

If the Derivative item in the set up screen is set to "On", the derivative appears on the display along with the coordinate values.



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- The following shows how the display of coordinates and the derivative changes according to the Graph Type setting.

• Rectangular Coordinate Graph

$\frac{dY}{dX} = -5.555$
$X = -2.1111111111$ $Y = 4.1160493821$

• Polar Coordinate Graph

$\frac{dY}{d\theta} = 4.2426$	$\frac{dY}{dX} = 0.6602$
$r = 1.4142135623$	$\theta = 0.26179938779$

• Parametric Function Graph

$\frac{dX}{dT} = 3$	$\frac{dY}{dT} = 0$
$T = 0$	$\frac{dY}{dX} = 0$

• X = Constant Graph

$X = 3$	$\frac{dY}{dX} = \text{ERROR}$
	$Y = 0$

• Inequality Graph

$\frac{dY}{dX} = -12.6$
$X = -6.3$ $Y < 38.69$

- The derivative is not displayed when you use trace with a built-in scientific function.

- Setting the Coord item in the set up screen to "Off" turns display of the coordinates for the current pointer location off.



• **Scrolling**

When the graph you are tracing runs off the display along either the  $x$ - or  $y$ -axis, pressing the  $\blacktriangleright$  or  $\blacktriangleleft$  cursor key causes the screen to scroll in the corresponding direction eight dots.

- You can scroll only rectangular coordinate and inequality graphs while tracing. You cannot scroll polar coordinate graphs, parametric function graphs, or  $X = \text{constant}$  graphs.
- The graph on the screen does not scroll when you are tracing while the Dual Screen Mode is set to "Graph" or "G to T".



- Trace can be used only immediately after a graph is drawn. It cannot be used after changing the settings of a graph.
- The  $x$ - and  $y$ -coordinate values at the bottom of the screen are displayed using a 12-digit mantissa or a 7-digit mantissa with a 2-digit exponent. The derivative is displayed using a 6-digit mantissa.
- You cannot incorporate trace into a program.
- You can use trace on a graph that was drawn as the result of an output command ( $\blacktriangle$ ), which is indicated by the "-Disp-" indicator on the screen.



■ **Scroll**

You can scroll a graph along its  $x$ - or  $y$ -axis. Each time you press  $\blacktriangle$ ,  $\blacktriangledown$ ,  $\blacktriangleleft$ , or  $\blacktriangleright$ , the graph scrolls 12 dots in the corresponding direction.

## ■ Graphing in a Specific Range

You can use the following syntax when inputting a graph to specify a start point and end point.

<function>  $\rightarrow$   $\text{[SHIFT] [L]}$  <start point>  $\rightarrow$  <end point>  $\text{[SHIFT] [J] [EXE]}$

**Example** To graph  $y = x^2 + 3x - 5$  within the range of  $-2 \leq x \leq 4$

Use the following View Window parameters.

**Xmin** = -3                      **Ymin** = -10

**Xmax** = 5                        **Ymax** = 30

**Xscale** = 1                      **Yscale** = 5

$\text{[F3]}$  (TYPE)  $\text{[F1]}$  (Y =)

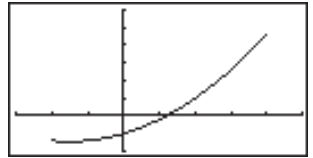
(Specifies graph type.)

$\text{[X,θ,T]}$   $\text{[x^2]}$   $\text{[+]}$   $\text{[3]}$   $\text{[X,θ,T]}$   $\text{[-]}$   $\text{[5]}$   $\rightarrow$

$\text{[SHIFT] [L] [-]}$   $\text{[2]}$   $\rightarrow$   $\text{[4]}$   $\text{[SHIFT] [J] [EXE]}$

(Stores expression.)

$\text{[F6]}$  (DRAW) or  $\text{[EXE]}$  (Draws graph.)



- You can specify a range for rectangular coordinate, polar coordinate, parametric, and inequality graphs.

## ■ Overwrite

Using the following syntax to input a graph causes multiple versions of the graph to be drawn using the specified values. All versions of the graph appear on the display at the same time.

<function with one variable>  $\rightarrow$   $\text{[SHIFT] [L]}$  <variable name>  $\text{[SHIFT] [=]}$   
 <value>  $\rightarrow$  <value>  $\rightarrow$  ... <value>  $\text{[SHIFT] [J] [EXE]}$

**Example** To graph  $y = Ax^2 - 3$ , substituting 3, 1, and -1 for the value of A

Use the following View Window parameters.

**Xmin** = -5                      **Ymin** = -10

**Xmax** = 5                        **Ymax** = 10

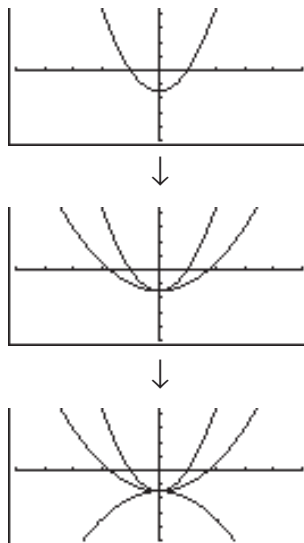
**Xscale** = 1                      **Yscale** = 2

$\text{[F3]}$  (TYPE)  $\text{[F1]}$  (Y =) (Specifies graph type.)

$\text{[ALPHA] [A]}$   $\text{[X,θ,T]}$   $\text{[x^2]}$   $\text{[-]}$   $\text{[3]}$   $\rightarrow$   $\text{[SHIFT] [L]}$   $\text{[ALPHA] [A]}$   $\text{[SHIFT] [=]}$

$\text{[3]}$   $\rightarrow$   $\text{[1]}$   $\rightarrow$   $\text{[-]}$   $\text{[1]}$   $\text{[SHIFT] [J] [EXE]}$  (Stores expression.)

**F6** (DRAW) (Draws graph.)



- The function that is input using the above syntax can have only one variable.
- You cannot use  $X$ ,  $Y$ ,  $r$ ,  $\theta$ , or  $T$  as the variable name.
- You cannot assign a variable to the variable in the function.
- When the set up screen's Simul Graph item is set to "On", the graphs for all the variables are drawn simultaneously.
- You can use overwrite with rectangular coordinate, polar coordinate, parametric, and inequality graphs.



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## ■ Zoom

The zoom feature lets you enlarge and reduce a graph on the display.

### ● Before using zoom

Immediately after drawing a graph, press **F2** (Zoom) to display the Zoom Menu.

- **{BOX}** ... {graph enlargement using box zoom}
- **{FACT}** ... {displays screen for specification of zoom factors}
- **{IN}/****{OUT}** ... {enlarges}/reduces graph using zoom factors
- **{AUTO}** ... {automatically sizes the graph so it fills the screen along the  $y$ -axis}
- **{ORIG}** ... {original size}
- **{SQR}** ... {adjusts ranges so  $x$ -range equals  $y$ -range}
- **{RND}** ... {rounds coordinates at current pointer location}
- **{INTG}** ... {converts View Window  $x$ -axis and  $y$ -axis values to integers}
- **{PRE}** ... {after a zoom operation, returns View Window parameters to previous settings}



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●To use box zoom

[Zoom]-[BOX]

With box zoom, you draw a box on the display to specify a portion of the graph, and then enlarge the contents of the box.

**Example** To use box zoom to enlarge a portion of the graph  $y = (x + 5)(x + 4)(x + 3)$

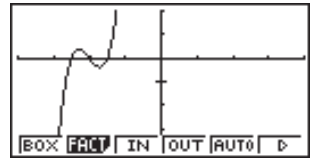
Use the following View Window parameters.

$$\text{Xmin} = -8 \qquad \text{Ymin} = -4$$

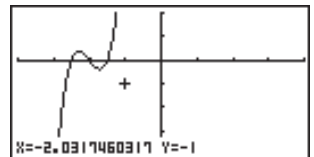
$$\text{Xmax} = 8 \qquad \text{Ymax} = 2$$

$$\text{Xscale} = 2 \qquad \text{Yscale} = 1$$

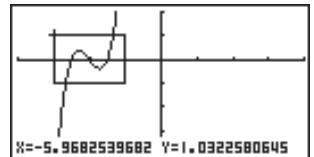
1. After graphing the function, press **F2** (Zoom).



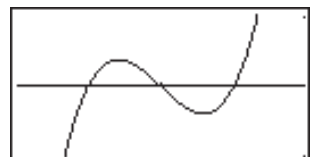
2. Press **F1** (BOX), and then use the cursor keys to move the pointer to the location of one of the corners of the box you want to draw on the screen. Press **EXE** to specify the location of the corner.



3. Use the cursor keys to move the pointer to the location of the corner that is diagonally across from the first corner.



4. Press **EXE** to specify the location of the second corner. When you do, the part of the graph inside the box is immediately enlarged so it fills the entire screen.





- To return to the original graph, press **F2** (Zoom) **F6** ( $\triangleright$ ) **F1** (ORIG).
- Nothing happens if you try to locate the second corner at the same location or directly above the first corner.
- You can use box zoom for any type of graph.

**•To use factor zoom**

**[Zoom]-[FACT]-[IN]/[OUT]**

With factor zoom, you can zoom in or zoom out on the display, with the current pointer location being at the center of the new display.

- Use the cursor keys to move the pointer around the display.

**Example** Graph the two functions below, and enlarge them five times in order to determine whether or not they are tangential.

$$Y1 = (x + 4)(x + 1)(x - 3) \quad Y2 = 3x + 22$$

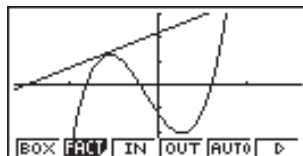
Use the following View Window parameters.

$$Xmin = -8 \quad Ymin = -30$$

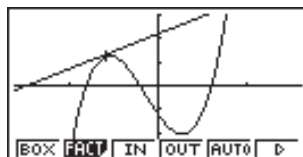
$$Xmax = 8 \quad Ymax = 30$$

$$Xscale = 5 \quad Yscale = 10$$

1. After graphing the functions, press **F2** (Zoom), and the pointer appears on the screen.



2. Use the cursor keys to move the pointer to the location that you want to be the center of the new display.



**F2**

3. Press **F2** (FACT) to display the factor specification screen, and input the factor for the  $x$ - and  $y$ -axes.

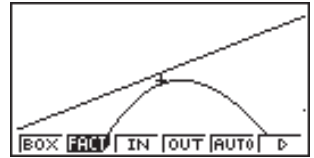
**F2**(FACT)

**5** **EXE** **5** **EXE**





4. Press **[EXIT]** to return to the graphs, and then press **[F3]** (IN) to enlarge them.



This enlarged screen makes it clear that the graphs of the two expressions are not tangential.

Note that the above procedure can also be used to reduce the size of a graph (zoom out). In step 4, press **[F4]** (OUT).

- The above procedure automatically converts the  $x$ -range and  $y$ -range View Window values to 1/5 of their original settings. Pressing **[F6]** ( $\triangleright$ ) **[F5]** (PRE) changes the values back to their original settings.
- You can repeat the factor zoom procedure more than once to further enlarge or reduce the graph.

#### ● To initialize the zoom factor

Press **[F2]** (Zoom) **[F2]** (FACT) **[F1]** (INIT) to initialize the zoom factor to the following settings.

Xfact = 2 Yfact = 2

- You can use the following syntax to incorporate a factor zoom operation into a program.

Factor <X factor>, <Y factor>

- You can specify only positive value up to 14 digits long for the zoom factors.
- You can use factor zoom for any type of graph.

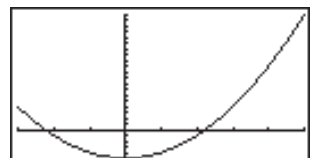
#### ■ Auto View Window Function

**[Zoom]-[AUTO]**

The auto View Window feature automatically adjusts  $y$ -range View Window values so that the graph fills the screen along the  $y$ -axis.

**Example** To graph  $y = x^2 - 5$  with  $X_{\min} = -3$  and  $X_{\max} = 5$ , and then use auto View Window to adjust the  $y$ -range values

1. After graphing the function, press **[F2]** (Zoom).
2. Press **[F5]** (AUTO).



**Graph Range Adjustment Function**

[Zoom]-[SQR]

This function makes the View Window  $x$ -range value the same as the  $y$ -range value. It is helpful when drawing circular graphs.

**Example** To graph  $r = 5\sin \theta$  and then adjust the graph.

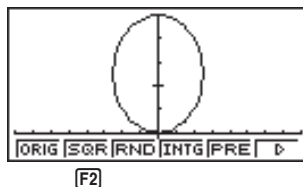
Use the following View Window parameters.

**Xmin** = -8                      **Ymin** = -1

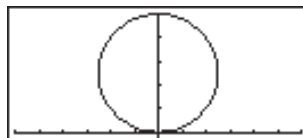
**Xmax** = 8                        **Ymax** = 5

**Xscale** = 1                      **Yscale** = 1

- After drawing the graph, press **F2** (Zoom) **F6** ( $\triangleright$ ).



- Press **F2** (SQR) to make the graph a circle.



**Coordinate Rounding Function**

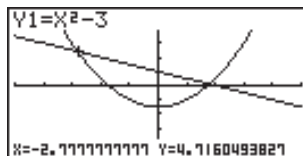
[Zoom]-[RND]-[Trace]

This feature rounds the coordinate values at the pointer location to the optimum number of significant digits. Rounding coordinates is useful when using trace and plot.

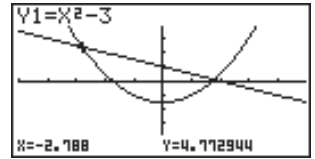
**Example** To round the coordinates at the points of intersection of the two graphs drawn on page 128

Use the same View Window parameters as in the example on page 128.

- After graphing the functions, press **F1** (Trace) and move the pointer to the first intersection.



2. Press **F2** (Zoom) **F6** ( $\triangleright$ ).
3. Press **F3** (RND) and then **F1** (Trace). Use  $\blacktriangleright$  to move the pointer to the other intersection. The rounded coordinate values for the pointer position appear on the screen.



## ■ Integer Function

[Zoom]-[INTG]

This function makes the dot width equal 1, converts axis values to integers, and redraws the graph.

If one  $x$ -axis dot is  $\Delta x$  and one  $y$ -axis dot is  $\Delta y$ :

$$\Delta x = \frac{X_{\max} - X_{\min}}{126}$$

$$\Delta y = \frac{Y_{\max} - Y_{\min}}{62}$$



## ■ Notes on the Auto View Window, Graph Range Adjustment, Coordinate Rounding, and Integer Functions

- These functions can be used with all graphs.
- These functions cannot be incorporated into programs.
- These functions can be used with a graph produced by a multi-statement connected by “:”, even if the multi-statement includes non-graph operations.
- When any of these functions is used in a statement that ends with a display result command {▲} to draw a graph, these functions affect the graph up to the display result command {▲} only. Any graphs drawn after the display result command {▲} are drawn according to normal graph overwrite rules.

## ■ Returning the View Window to Its Previous Settings

[Zoom]-[PRE]

The following operation returns View Window parameters to their original settings following a zoom operation.

**F6** (▷) **F5** (PRE)

- You can use PRE with a graph altered by any type of zoom operation.

## 8-7 Picture Memory

---

You can save up to six graphic image in picture memory for later recall. You can overdraw the graph on the screen with another graph stored in picture memory.

### ●To store a graph in picture memory

Pressing **OPTN** **F1**(PICT) **F1**(STO) **F1**(Pic1) stores the graph drawn on the display in picture memory Pic1.

- There are six picture memories numbered Pic1 to Pic6.
- Storing a graph in a memory area that already contains data replaces the existing data with the new data.

### ●To recall a stored graph

In the GRAPH Mode, pressing **OPTN** **F1**(PICT) **F2**(RCL) **F1**(Pic1) recalls the contents of picture memory Pic1.

- Dual Graph screens or any other type of graph that uses a split screen cannot be saved in picture memory.

## 8-8 Graph Background



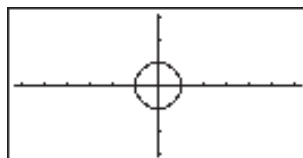
You can use the set up screen to specify the memory contents of any picture memory area (**Pict 1** through **Pict 6**) as the Background item. When you do, the contents of the corresponding memory area is used as the background of the graph screen.

- You can use a background in the RUN, STAT, GRAPH, DYNA, TABLE, RECUR, CONICS Modes.

**Example 1** With the circle graph  $X^2 + Y^2 = 1$  as the background, use Dynamic Graph to graph  $Y = X^2 + A$  as variable  $A$  changes value from  $-1$  to  $1$  in increments of  $1$ .

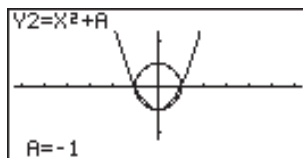
Recall the background graph.

$$(X^2 + Y^2 = 1)$$

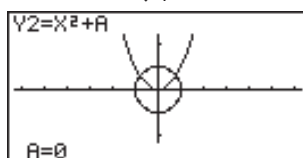


Draw the dynamic graph.

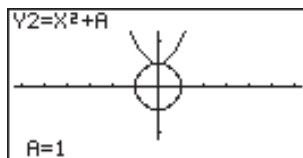
$$(Y = X^2 - 1)$$



$$(Y = X^2)$$



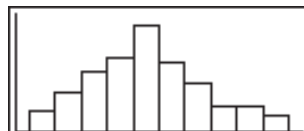
$$(Y = X^2 + 1)$$



- See “14. Implicit Function Graphs” for details on drawing a circle graph, and “13. Dynamic Graph” for details on using the Dynamic Graph feature.

**Example 2** With a statistical histogram as the background, graph a normal distribution

Recall the background graph.  
(Histogram)



Graph the normal distribution.



- See “18. Statistical Graphs and Calculations” for details on drawing a statistical graphs.