

CHAPTER 3 Calculator Notes for the TI-89, TI-92 Plus, and Voyage 200

Note 3A • Entering, Graphing, and Tracing Equations

Equations are entered into the Y= Editor screen for various purposes, including graphing. You can enter up to 99 equations, y_1 to y_{99} .

Entering Equations

Make sure you are in Function mode. Press $\boxed{\text{MODE}}$. In the first line, set Graph to FUNCTION. Then open the Y= Editor screen and enter an equation. The variable must be x using \boxed{X} . You can edit an equation by using the arrow keys and $\boxed{\Delta}$ [DEL] or $\boxed{2\text{nd}}$ [INS]. To remove an equation from the Y= Editor screen, highlight it and press $\boxed{\text{CLEAR}}$.

Before actually graphing, you'll need to determine which part of the Graph screen you want to view.

Setting the Window

Press $\boxed{\Delta}$ [WINDOW] and enter these values.

x_{min} = the minimum x -value you want displayed.

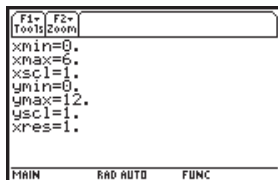
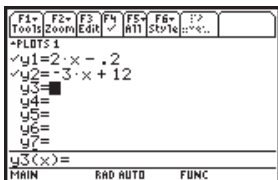
x_{max} = the maximum x -value you want displayed.

y_{min} = the minimum y -value you want displayed.

y_{max} = the maximum y -value you want displayed.

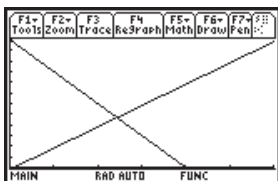
x_{scl} = and y_{scl} = the number of units between the tick marks on each axis. If there are too many tick marks, individual marks won't be distinguishable and the axes will appear too thick.

x_{res} = 1.



Graphing

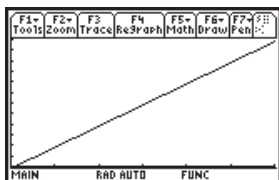
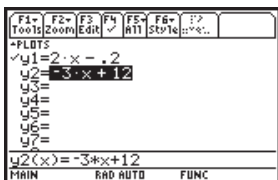
Go to the Graph screen. The graphs of the equations will appear one after another, in the order listed on the Y= Editor screen.



If the graph is not situated on the screen to your satisfaction, go back to the Window Editor screen and change the values. Experiment with various window settings until you're satisfied with the appearance of the graph.

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You can turn off the graph of an equation without clearing it from the Y= Editor screen by highlighting the equation and pressing $\boxed{F4}$ (\surd). When there is no check mark, the equation is turned off and will not graph.

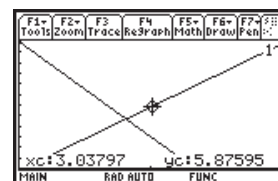


[0, 6, 1, 0, 12, 1]

Tracing

You can find approximate coordinates of points on the graph by tracing. From the Graph screen press $\boxed{F3}$ (Trace). A “spider” appears on the first graph. Use the left and right arrow keys to move it along the graph. The coordinates of the spider’s position appear at the bottom of the screen. You can move to the graphs of other equations by arrowing up or down.

Notation on the upper-right corner of the screen tells you which equation’s graph is being traced.



[0, 6, 1, 0, 12, 1]

Zooming

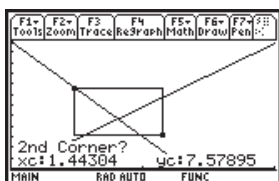
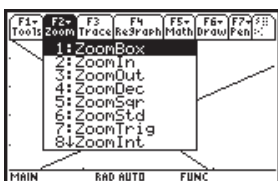
There are several ways to enlarge part of the graph. You can go back to the Window Editor screen and change the window settings, or you can choose one of the commands from the Zoom menu. On the Y= Editor screen or the Graph screen, press $\boxed{F2}$ (Zoom).

1:ZoomBox allows you to define your own enlargement. Select 1:ZoomBox to display a spider. Use the arrow keys to move the spider to the area you’d like to enlarge. (This spider isn’t restricted to the curve the way the trace spider is.) Press \boxed{ENTER} . Then draw a box by arrowing to the corner diagonally opposite from your current position. Press \boxed{ENTER} again. The interior of the box will enlarge and fill the screen.

2:ZoomIn enlarges the screen by a factor of 4. Selecting 2:ZoomIn will display a spider that you can position where you want the center of your new enlarged screen. Press \boxed{ENTER} to see the new screen.

3:ZoomOut does the opposite of ZoomIn. Select 3:ZoomOut, position the spider to the desired screen center, and press \boxed{ENTER} to see the new screen.

Zooming will automatically change the settings on the Window Editor screen.

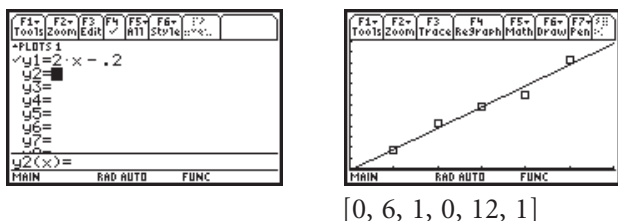


[0, 6, 1, 0, 12, 1]

(continued)

Graphing a Line and a Plot

You can graph a line over a plot by entering its equation into the Y= Editor screen and the plot as directed in **Note 1H**. If you trace, arrowing up or down causes the spider to jump to each plot and to each function in order.

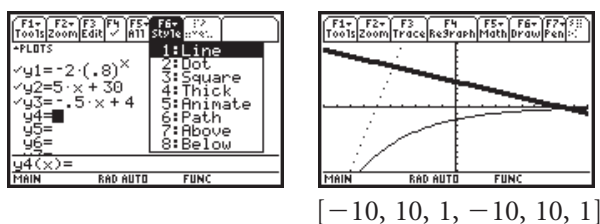


Setting the Graph Style

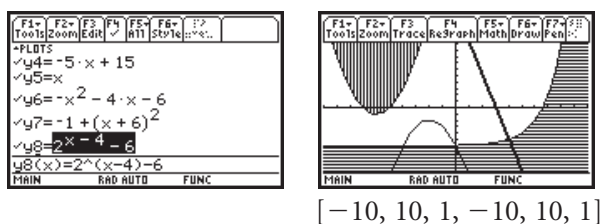
In order to distinguish between several displayed graphs or to achieve a special effect, it is sometimes helpful to use a graph style other than the usual thin, solid line.

Highlight the equation on the Y= Editor screen and press $\boxed{2nd}$ [F6] (Style). (On a TI-92 Plus or a Voyage 200, press $\boxed{F6}$.) Select the desired style. These examples show the possible styles.

- 1:Line graphs a curve using the usual thin, solid line. This is the default setting.
- 2:Dot graphs a curve using a series of disconnected points.
- 3:Square graphs a curve with a series of overlapping squares.



- 4:Thick graphs a curve using a thick, solid line.
- 5:Animate shows a moving circle that follows the curve but leaves no path (not shown on the screen below).
- 6:Path shows a moving circle that follows the curve and leaves a path.
- 7:Above shades the area above the curve.
- 8:Below shades the area below the curve.



To reset all of the graph styles to the default setting, 1:Line, on the Y= Editor screen, press $\boxed{F5}$ (All) 4:Reset Styles.

Note 3B • Function Tables

You can build a table of values for any function that is entered into the Y= Editor screen. Press \blacksquare [TblSet].

tblStart = the first x -value you wish to see in the table when first viewed.

Δ tbl = the difference between the x -values in the table. In the first screen below, Δ tbl=.1, so the difference between successive x -values is 0.1. Δ tbl can be negative.

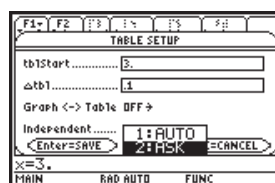
Graph \leftrightarrow Table should be set to OFF.

Independent set to AUTO means that the table will automatically start with the x -value equal to the tblStart value. If Independent is set to ASK, the table will be blank until you provide the x -values.

Press ENTER to save the settings, and press \blacksquare [TABLE] to display the table.



x	y1	y2	y3
3.	20.04	6.6	2.197
3.1	20.04	6.72	2.2554
3.2	19.88	6.84	2.3154
3.3	19.72	6.96	2.3769
3.4	19.56	7.08	2.4401



x	y1	y2	y3
4.	18.6	7.8	2.8561
7.	13.8	11.4	6.2749
47.	-50.2	59.4	2.27E5

If Independent is set to AUTO on the Table Setup screen, you can arrow up or down on the table to see more x -values. You can also arrow right to see values of other functions that are turned on (those marked with a \checkmark) in the Y= Editor screen. You can see only three columns of dependent variables at a time. (On a TI-92 Plus or Voyage 200, you can see five columns.)

When you are in a column of dependent variables, you can press F4 (Header) to display the equation at the bottom of the screen. The equation is highlighted. Press the right or left arrow keys to edit the equation. The changes will be reflected in the table when you press ENTER .

x	y1	y2	y3
4.	18.6	7.8	2.8561
7.	13.8	11.4	6.2749
47.	-50.2	59.4	2.27E5

y1(x) = -50.2

x	y1	y2	y3
4.	18.6	7.8	2.8561
7.	13.8	11.4	6.2749
47.	-50.2	59.4	2.27E5

y1(x) = 30 + 1.6 * x

x	y1	y2	y3
4.	36.4	7.8	2.8561
7.	41.2	11.4	6.2749
47.	105.2	59.4	2.27E5

y1(x) = 105.2

Note 3C • Balloon Blastoff

Press 2nd [VAR-LINK] and arrow down to see if the ranger program is on your calculator. If it is not on your calculator, you must download it before you can proceed. See Note 1F for help loading ranger.

With a link cable, connect the CBR to the calculator. Be sure to push in each plug firmly. From the Home screen type ranger() into the entry line and press ENTER . Press ENTER again to start the actual program and to go to the Main Menu.

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Select 1:Setup/Sample. Set Realtime to 1:No. Arrow down to Time (S). Select 2:Change Time and press **[ENTER]**, enter the number of seconds you want to follow the rocket (2 should be good), and press **[ENTER]**. Finally, set Begin On to 2:[TRIGGER] Button.

Now arrow up to Use this setup?, select Start Now, and press **[ENTER]**. Press **[ENTER]** again for more instructions. Disconnect the CBR if you wish.

Aim the CBR at the rocket. Right before the motion begins, start collecting data by pressing the trigger on the front of the CBR. If you think you didn't collect good data, get ready to restart the motion, again press the trigger, and repeat the movement.

Reconnect the CBR to the calculator and press **[ENTER]**. A graph of the data will be displayed. If you don't have good data, press **[ENTER]** and choose 5:Repeat Sample. You can now unplug the CBR again.

You can transmit the data to another calculator by connecting it to the CBR, starting the ranger program, choosing 5:Tools... from the Main Menu, and then selecting 1:Get CBR Data.

Clean-Up

When you are finished working with the graph, press **[ENTER]** and choose 7:Quit. If you exit the ranger program without choosing Quit, your calculator may be set to display three decimal places on the Mode screen. Press **[MODE]** and reset Display Digits to E:Float.

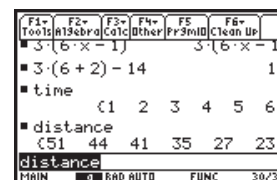
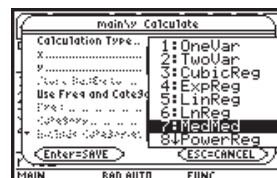
Note 3D • Median-Median Line

The calculator can find the equation of the median-median line for a set of data. You need two list variables or a data variable. (See Note 1G if you need help naming and storing data.) Go to a screen displaying a data variable in the Data/Matrix Editor, and press **[F5]** (Calc) 7:MedMed. (You can also find the equation in the Stats/List Editor by pressing **[F4]** (Calc) 3:Regressions 3:MedMed.)

You can enter the equation of the median-median line into the Y= Editor screen and graph it on the same screen as a scatter plot of the data.

Suppose that you have named and stored two lists of data, time = {1, 2, 3, 4, 5, 6} and distance = {51, 44, 41, 35, 27, 23}, and that you have set up Plot1 as a scatter plot to display points in the form (time, distance) in an appropriate window. (See Note 1H if you need help setting up a scatter plot.) To find the median-median line for the set of data and to graph it on the same screen as the scatter plot, follow these instructions:

- a. Press **[APPS]**, select Data/Matrix Editor, and open any data variable.
- b. Press **[F5]** (Calc) to display the Calculate screen.
- c. For Calculation Type select 7:MedMed.
- d. For x and y enter time and distance respectively.
- e. For Store RegEQ to select y1(x).



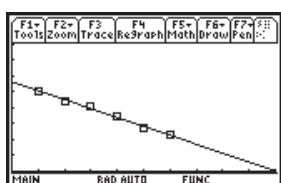
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- f. Press **[ENTER]**. The slope and y -intercept for the median-median line are displayed on a Stat Vars screen. Press **[ENTER]** again to return to the Stat Edit screen.



You can go to the Y= Editor screen to see if the equation of the median-median line is entered for y_1 , but it is not necessary.

- g. Open the Graph screen to display the scatter plot and the median-median line.

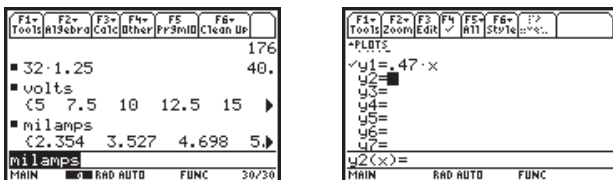


[0, 10, 1, 0, 80, 10]

Note 3E • Residuals and the Root Mean Square Error

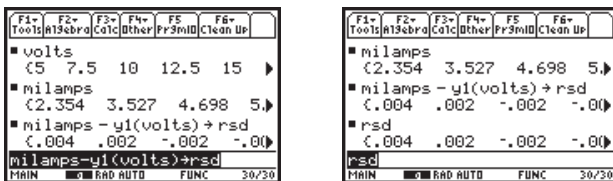
Once you have found a model for paired data, you can calculate the residuals and then the root mean square error.

For this example, assume that your data are stored in lists named volts and milamps and your equation is stored in y_1 .



Residuals

To create a new list named rsd of the residuals of your data and equation, on the Home screen enter $\text{milamps} - y_1(\text{volts}) \rightarrow \text{rsd}$. You can see the list by typing rsd into the entry line and pressing **[ENTER]**.



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Root Mean Square Error

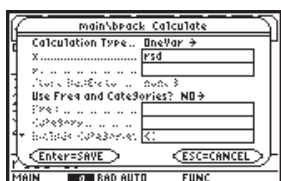
The root mean square error is defined as

$$s = \sqrt{\frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{n - 2}}$$

The numerator of the fraction is the sum of the squares of the residuals.
 The denominator is 2 less than the number of residuals.

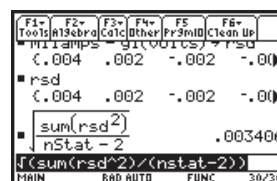
- First calculate the residuals and store them in a list called `rsd`.
- Press **[APPS]**, select Data/Matrix Editor, and open any data variable.
- Press **[F5]** (Calc). For Calculation Type, select 1:OneVar, and for `x` enter `rsd`. Press **[ENTER]** **[ENTER]**.

You will see the Stat Vars screen. The number of values in the residual list is now stored in a variable called `nstat`.



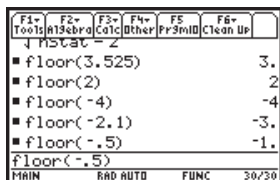
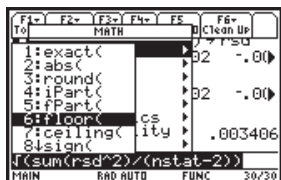
- Press **[ENTER]** to OK the Stat Vars calculations and to return to the Stat Edit screen, and then return to the Home screen.
- Now enter the formula **[2nd]** **[√]** **(sum(rsd^2)/(nstat-2))** **[ENTER]**. You can find the command `sum(` in the catalog, or type it; see **Note 1C** if you need help. The result is the root mean square error.

For large values of n , you can find a good approximation by dividing by $n - 1$ instead of $n - 2$. This is the sample standard deviation of the residuals, or the value of `Sx` when you get the Stat Vars screen.



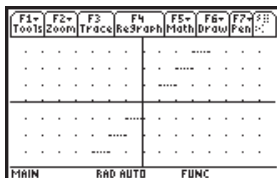
Note 3F • Greatest Integer Function

To find the greatest integer less than or equal to a value, press **[2nd]** **[MATH]** 1:Number 6:floor(, enter the value, and then close the parentheses. If the value is a positive decimal number, the function truncates everything after the decimal point; if the value is a negative decimal number, it does the same and then subtracts 1.



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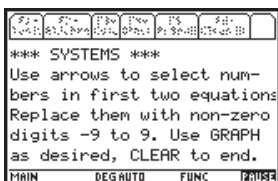
You can also use floor(as a function of x . When graphing this function, the calculator may show almost-vertical segments that shouldn't be there. You can eliminate them by changing the graph style to a dotted line. (See Note 3A for help setting the graph style.)



$[-7.9, 7.9, 1, -3.8, 3.8, 1]$

Note 3G • SYSTEMS Program

Run the program systems and press **ENTER**.

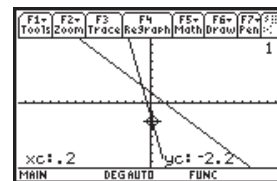
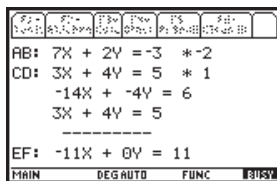
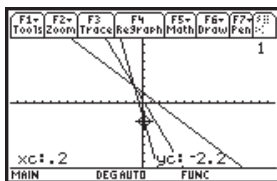


The top two lines of the screen show two equations of a system and a multiplier for each equation, initially set at 1. The third and fourth equations are the same as the first two, but each is multiplied by its multiplier. The fifth equation is the sum of the third and fourth.

Use the arrow keys to move to the multiplier you wish to change. Enter a new integer value between -9 and 9 . Once you've entered a new multiplier, the equations in the lower part of the screen will change accordingly.

Press **GRAPH** at any time to see the graph of the system; you should do this frequently. The Graph screen shows the graphs of the two equations, and the graph of their sum, the fifth equation. Use the up and down arrow keys to identify each equation on the graph. To return to the equation screen, press **ENTER**.

From the Equation screen, press **CLEAR** to exit the program.



Graphing Your Own System

You can use this program to write any system of equations with integer parameters between -9 and 9 . Instead of changing a multiplier, change the other parameters. When you change a coefficient or constant, only that corresponding number will change in the other affected equations. The new

(continued)

system is not equivalent to the original system and does not have the same solution. Press $\left[\frac{\blacktriangle}{\blacktriangledown}\right]$ [GRAPH] to see how the graphs of the equations and their intersection change.

Clean-Up

When you exit the program, you may want to go to the Y= Editor screen and clear the equations in y_1 , y_2 , and y_3 .

```

systems()
Prgm
  © initialize
  {7,2,-3,1,3,4,5,1,7,2,-3,3,4,5,0,8,16}→i ©coefficients
    and multipliers
  {0,0,0,0,12,12,12,12,24,24,24,36,36,36,60,60,60}→g
    ©first coordinates (rows) of coeffs and multipliers
  {24,54,84,114,24,54,84,114,24,54,84,24,54,84,24,54,84}→h
    ©second coordinates (cols) of coeffs and multipliers
  1→p © initial index of array of coefficients and
    multipliers
  -15.8→xmin:15.8→xmax
  -7.6→ymin:7.6→ymax
  1→xsc1:1→ysc1
  setMode("Graph","Function"):FnOff
  setMode("Angle","Degree"):ClrIO
  DelVar x

  © display instructions on I/O screen
  Disp "**** SYSTEMS ****"
  Disp "Use arrows to select num-"
  Disp "bers in first two equations."
  Disp "Replace them with non-zero"
  Disp "digits -9 to 9. Use GRAPH"
  Disp "as desired, CLEAR to end."
  Pause
  ClrIO

  1→n © initial value of negation flag
  Loop © main loop: display equations, get input,
    change equations accordingly

    ©display fixed variable names
    ClrIO
    Disp "AB:  X +  Y =  *"
    Disp "CD:  X +  Y =  *"

  For x,1,8 ©display coefficients and multipliers
    If i[x]≥0: Output g[x],h[x],i[x]
    If i[x]<0: Output g[x],h[x]-6,i[x]
  EndFor

```

(continued)

(PROGRAM: SYSTEMS continued)

```

For n,9,11  @multiply equations by multipliers
  (initially 1)
  i[n-8]*i[4]->i[n]
  i[n-4]*i[8]->i[n+3]
  i[n]+i[n+3]->i[n+6]
EndFor

@display multiplied equations and sum
Disp "      "&string(i[9])&"X + "&string(i[10])&"Y =
"&string(i[11])
Disp "      "&string(i[12])&"X + "&string(i[13])&"Y =
"&string(i[14])
Disp "      -----"
Disp "EF: "&string(i[15])&"X + "&string(i[16])&"Y =
"&string(i[17])

Loop @ get input character into k, to change
  coefficient or multiplier

  Loop @read input key until acceptable
    0->t
    Loop
      @flash character
      t+42->t
      If sin(t)<0 then
        If i[p]>=0: Output g[p],h[p],i[p]
        If i[p]<0: Output g[p],h[p]-6,i[p]
      EndIf
      If sin(t)>0
        Output g[p],h[p]-6,"  "

      getKey()->k
      If k≠0: Exit
    EndLoop

    If k=173 or k=263 or k>48 and k<58 or k=340
or k=337 or k=338 or k=344 or k=8462
      @ opposite, clear, digit, arrows, graph
    Exit
  EndLoop

```

(continued)

(PROGRAM: SYSTEMS continued)

```

If k=173 Then  @opposite (-)
  -1→n
  h[p]-6→h[p]  @shift to display opposite sign
  Output g[p],h[p],"-"
  h[p]+6→h[p]
  -i[p]→i[p]
  Exit
EndIf

If k>48 and k<58 Then  @ k is a non-0 digit;
convert to put value into v and then l[P]
  k-48→v
  Output g[p],h[p],v
  v*n→i[p]
  1→n
  If i[p]>=0: Output g[p],h[p],i[p]
  If i[p]<0: Output g[p],h[p]-6,i[p]
  340→k  @right arrow
  Exit
EndIf

If k=337:p-1→p  @ left arrow, previous one
If p<0:p+8→p
If k=340:p+1→p  @ right arrow; next coefficient
or multiplier
If k=338 or k=344:p+4→p  @ up or down arrow
If p>8:p-8→p  @ wrap to stay in original set of
equations

If k=8462 then @define and graph functions y1,
y2, and y3
  Define y1(x)=-i[1]/(i[2])x+i[3]/(i[2])
  Define y2(x)=-i[5]/(i[6])x+i[7]/(i[6])
  Define y3(x)=-i[15]/(i[16])x+i[17]/(i[16])
  PlotsOff
  Trace
  EndIf

If k=263 @clear
  Exit
EndLoop  @getting input
If k=263
  Exit
EndLoop  @main loop

DispHome

EndPrgm

```