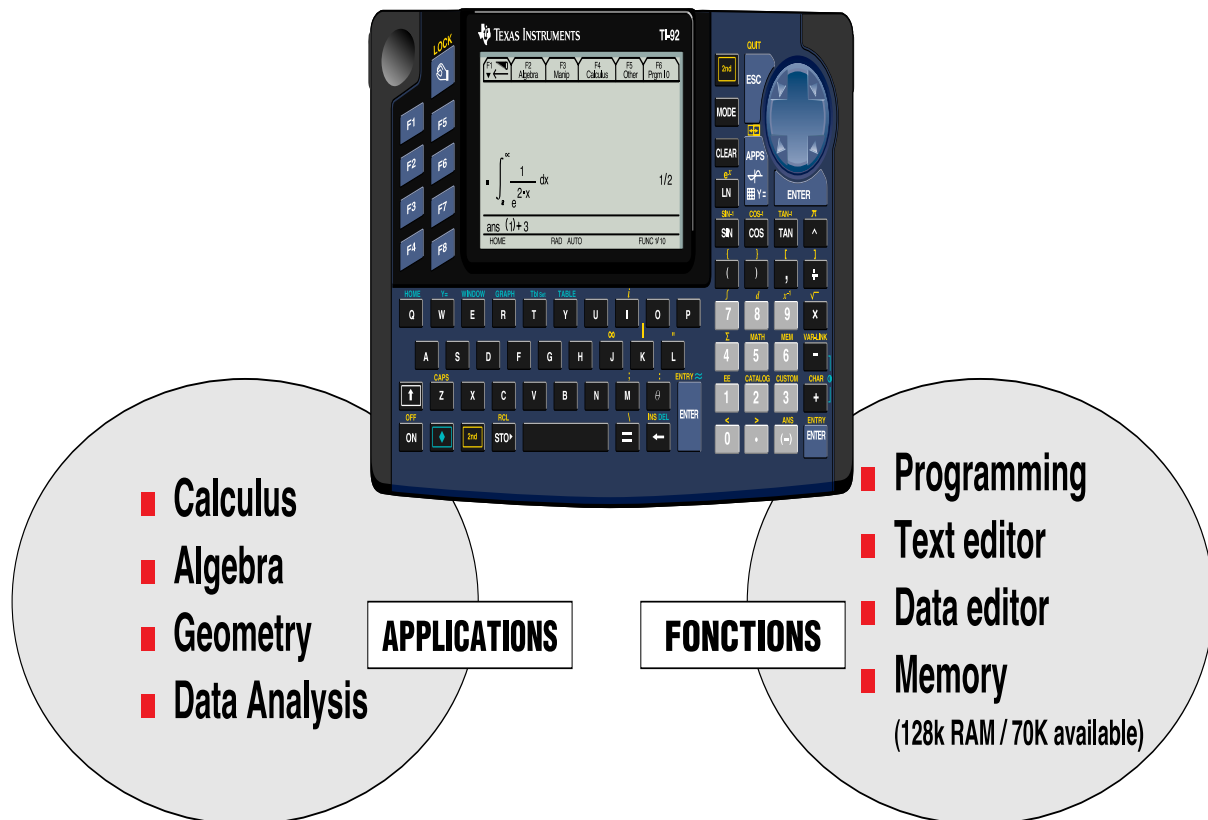


INTRODUCING THE TI-92 (OVERVIEW)

by B KUTZLER

(0) What is the TI-92?



TI-92 = The power of a computer lab with the independence of a calculator.

The TI-92 is Texas Instruments' new calculator that combines established calculator features like numeric computing, plotting and programming with latest technology in computational algebra and interactive computational geometry.

The TI-92 is very robust, weighs only 600 grams and measures 20 cm x 12 cm (that is 3/4 of an A5 sheet). Its ergonomics is comparable to that of a GameBoy™ and it is as simple and intuitive to use. It is a powerful assistant for dealing with mathematics and science in virtually any environment: in an office, in a lecture hall, in a classroom, at home, in a car, on a train, on a school bus, ...

The TI-92's two most prominent modules are computer algebra and interactive geometry. The computer algebra module was developed jointly by TI and the developers of DERIVE™, who are with Soft Warehouse, Inc. in

Honolulu, USA. The interactive geometry module was developed jointly by TI and the developers of CABRI GEOMETRE II™, who are with the University of Joseph Fourier in Grenoble, France.

In this document we will demonstrate:

- symbolic manipulation (computer algebra)
- 2D and 3D graphing
- the interactive geometry module
- the date/matrix editor, the programming editor and the text editor.

The various options of linking the TI-92 with other devices will be described at the end of this document.

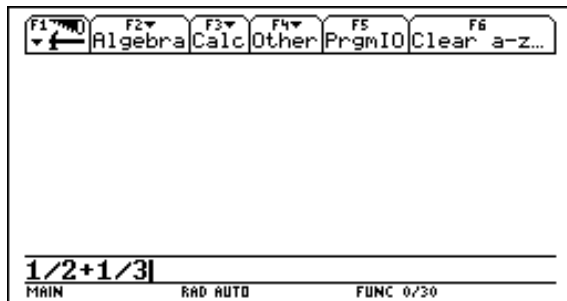
Computational power never has been so mobile before!

(1) Demonstrating symbolic manipulation in the Home screen

We start with a simple operation on two rational numbers:

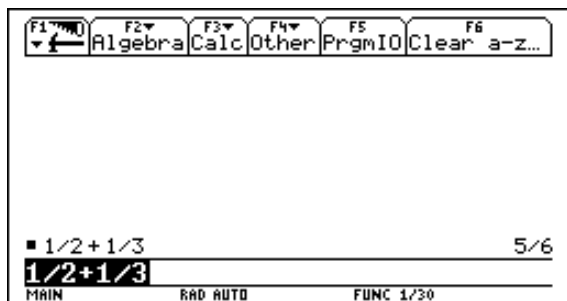
- o $1 \div 2 + 1 \div 3$

As one types this, the characters appear in the line editor at the bottom of the screen:



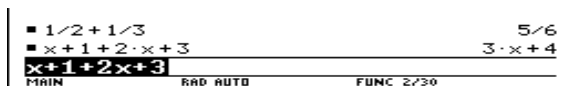
The input will be processed (i.e. the calculation will be performed) after one presses

- o (ENTER)



The first *history pair* is now displayed in the *history area* (that is the space between the menu bar at the top of the screen and the line editor). A history pair consists of the *entry* (left) and the *answer* (right). A copy of the entry remains in the line editor for possible further processing. The answer is a rational number - and not a floating point approximation as it would have appeared on most scientific calculators. Now a first example for symbolic simplification:

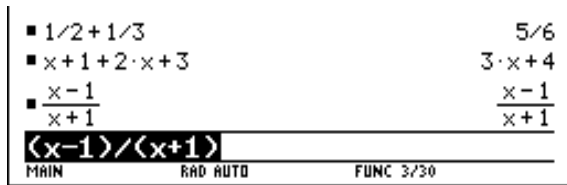
- o $1+x+2x+3$ (ENTER)



Another history pair was added to the history area.

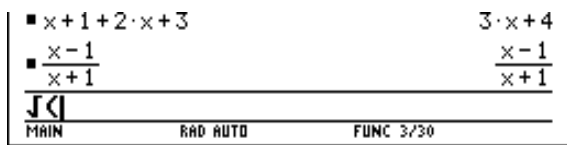
The next example shows how the TI-92 uses two-dimensional format for displaying expressions.

- o $(x-1) \div (x+1)$ (ENTER)



In the sequel we use the expression $\frac{x-1}{x+1}$ from the history area to generate the new expression $\sqrt{\frac{x-1}{x+1}}$. Pressing the square root key inserts a square root symbol *and* an opening paranthesis into the line editor:

- o [$\sqrt{\quad}$]

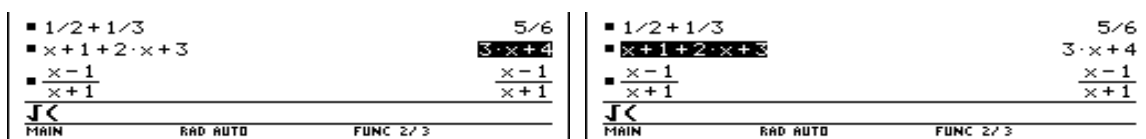


Now we need to copy the last answer into the line editor. To be able to do so, we highlight the said expression. With the up and down cursors (top and bottom edges of the blue cursor pad) one can move the highlighting into and within the history area. Repeated applications of the up cursor moves the highlighting from the line editor to the last answer - to the last entry - to the first but last answer - to the first but last entry - ...

- o \uparrow

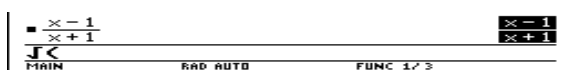


- o \uparrow



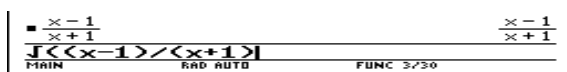
To continue with the above example, the highlighting is moved to the last answer:

- o $\downarrow\downarrow\downarrow$



The highlighted expression will be copied into the line editor by pressing

- o (ENTER)



It remains to type the closing paranthesis and conclude the input:

- o) (ENTER)



The above examples demonstrated some simple algebra. The next example shows how the TI-92 can do calculus. We start with computing a simple derivative. The differential operator can be entered, for example, by using the [d] key. (Again, this key inserts the differential operator *and* an opening paranthesis.)

- o [d] x^2+a (*) x+b, x) (ENTER)

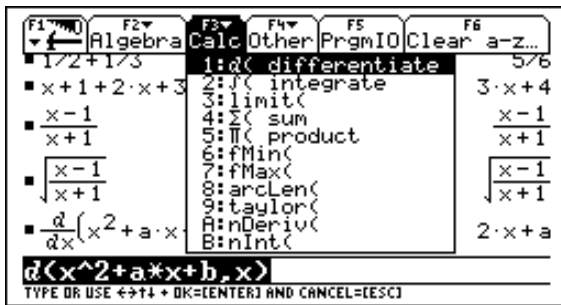


Another method for entering the differential operator is through the menu bar:



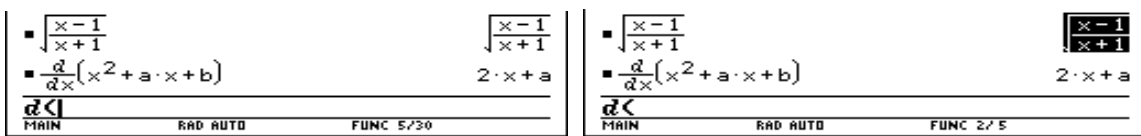
The CALC menu seems appropriate for calculus operations. It is evoked with the (F3) function key.

- o (F3): CALC



Apparently, this menu offers many more functions than are available on the keyboard. (ENTER) copies the highlighted operator (which happens to be the differential operator) into the line editor and closes the pull down menu (left picture). To prepare for copying the first but last answer into the line editor, we select this expression by pressing the up cursor three times (right picture):

- o (ENTER)



(ENTER) copies the expression into the line editor, thus making it the first argument for the differential operator (left picture). A comma, the differentiation variable 'x' as its second argument and a closing paranthesis conclude the input of this example (right picture).

- o (ENTER)

, x) (ENTER)



The computation of this rather non-trivial derivative goes far beyond what any handheld calculator could do so far. But there is much more to come ...

To evaluate this expression at the point $x = 2$ one can simply edit the last entry. The right cursor (right edge of the cursor pad) deactivates the highlighting in the line editor and sets the cursor to the right end of the expression. It can then be edited like in any of the widely used editors and word processors.

- o →

The TI-92 offers a very powerful operator, which is called the "With" operator and which is denoted by the symbol '|'. In combination with a simple equation like $x = 2$ it performs a local substitution.

- o [|] $x=2$

(ENTER)



Since computations are performed exact by default, the last answer includes $\sqrt{3}$. If the result shall be given as a floating point approximation instead, one needs to conclude the input with [≈] (= [♦]-(ENTER)) rather than (ENTER).

- o [≈]



Determining the antiderivative (the indefinite integral) of an expression is as simple:

- o [√] 1-x^2) (ENTER) ... to enter the expression $\sqrt{1-x^2}$
- [∫] ... to enter the integral operator (and an opening parenthesis)
- ↑ (ENTER) ... to highlight and copy the last answer, i.e. the square root expression
- , x) (ENTER) ... to enter the integration variable as the second argument

$$\int \sqrt{1-x^2} dx = \frac{\sin^{-1}(x)}{2} + \frac{x \cdot \sqrt{1-x^2}}{2}$$

The expression $\sqrt{1-x^2}$ describes the upper half of a unit circle around the origin. Therefore, the corresponding *definite* integral between -1 and 1 should give half the area of a unit circle:

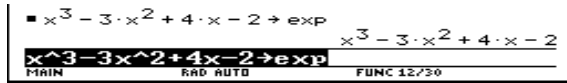
- o → ... to allow editing of the expression
- ← ... to move the cursor one character to the left

- o , («-»)1, 1 ... use the unary minus here! (ENTER)



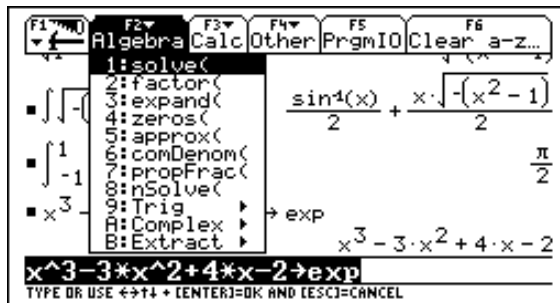
The TI-92 "knows" about numbers like π and uses them as appropriate. But now back to some "simple" algebra. For easier reference, the following polynomial will be stored as EXP:

- o $x^3 - 3x^2 + 4x - 2$ (STO) exp (ENTER)



Now we want to solve the corresponding polynomial equation. The ALGEBRA menu contains the function SOLVE (among many other functions for performing algebraic operations):

- o (F2): ALGEBRA (ENTER) ... to copy the SOLVE function



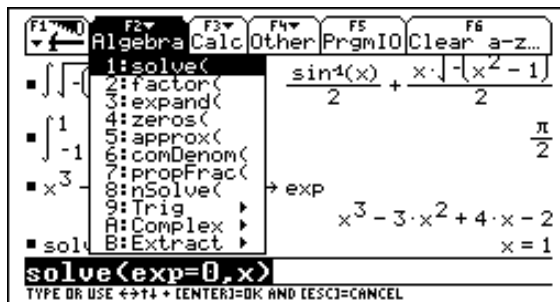
SOLVE takes two arguments: The equation and the variable with respect to which the equation shall be solved.

- o $exp=0, x$) (ENTER)



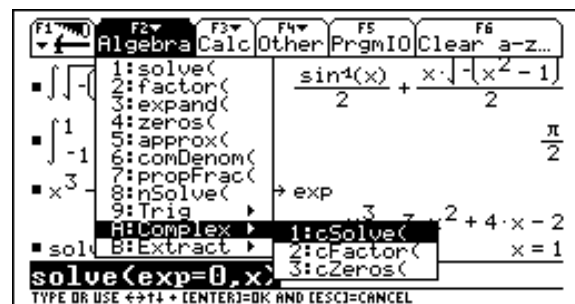
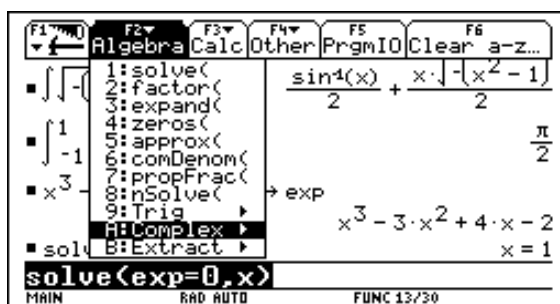
Apparently, the SOLVE function computes real solutions only - which is what many teachers wish to have anyway. However, one can as easily compute the solutions over the complex numbers. For this case the ALGEBRA menu offers the submenu COMPLEX.

- o (F2): ALGEBRA



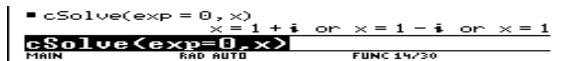
COMPLEX is evoked by pressing the down cursor often enough (left picture) and then pressing (ENTER) (right picture) - or simply by pressing (B), i.e. the character preceding the word 'COMPLEX'.

- o ↓ ... (ENTER)



The function CSOLVE is used for computing complex solutions of an equation.

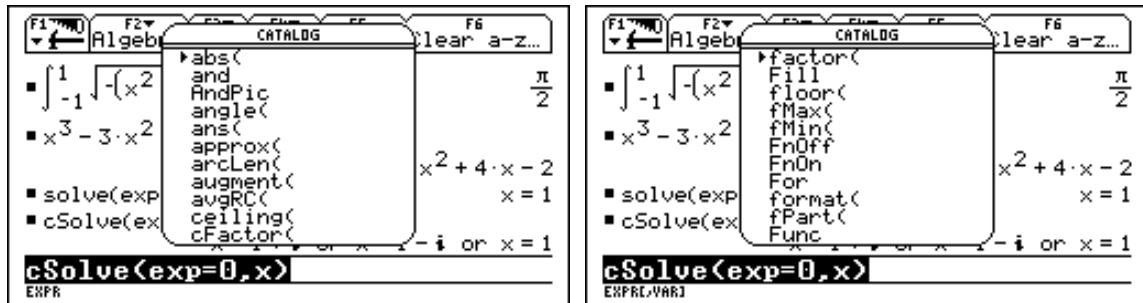
- o (ENTER) ... to copy the CSOLVE function into the line editor
exp=0, x) (ENTER)



Please note how the TI-92 produces this mathematically sound answer: It separates the various solutions of the equation with the logical operator OR.

Another source for finding functions is the catalog, in which all functions and commands are listed in alphabetical order (left picture). For faster search within the catalog, press the letter key of the command's first letter in order to move to the respective section, e.g. (F) when looking for factorization (right picture).

- o [CATALOG] (F)

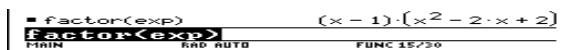


A very useful feature of the catalog is the "on-line help" below the line editor. It describes the type and order of the arguments of the selected function:



This display means: The FACTOR function takes one or two arguments. The first argument is an expression and is compulsory. The second argument is a variable and is optional (as is denoted by the square brackets).

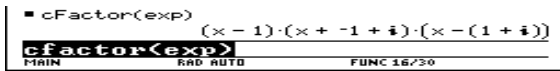
- o (ENTER) ... to copy the FACTOR function into the line editor
exp) (ENTER) ... to enter the argument



Factorization using FACTOR is done over the real numbers. A factorization over the complex numbers is performed by CFACOR. This function can be copied from the ALGEBRA-COMPLEX submenu, or copied from the catalog, or simply typed in. Since a copy of the last entry still is in the line editor, we just need to insert the letter 'C' in front of the command name 'FACTOR'.

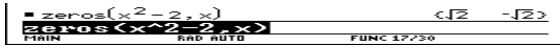
- o ← ... to allow editing of the expression c ... to insert the letter 'c'

- o (ENTER)



Another method for entering a function name is typing it. For example, the function ZEROS computes the set of zeros of a given expression with respect to a given variable.

- o zeros(x²-2,x) (ENTER)



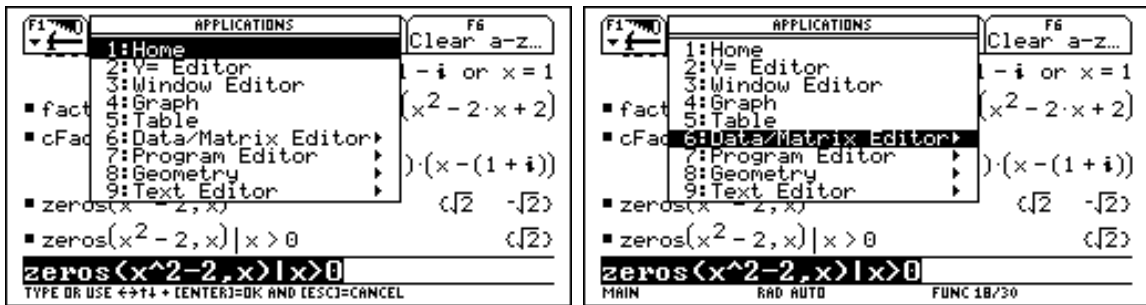
This function produces the "same" answer as SOLVE but apparently displays them in a different format. To restrict the search for zeros to the positive numbers, we use the "With" operator:

- o → ... to allow editing of the expression [|] x>0 (ENTER)

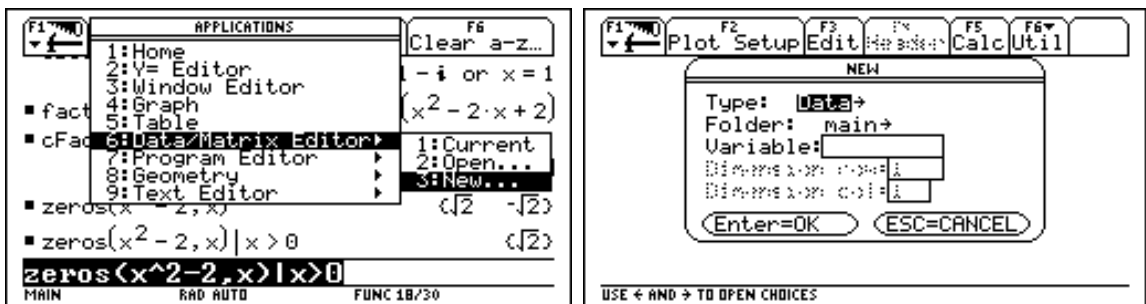


The next example shows how to work with matrices. There are several ways to enter a matrix. Very convenient is using the built-in matrix editor. This editor can be accessed through the applications menu, which is evoked by the key

- o (APPS) ↓ ... ↓ ... to select the matrix editor

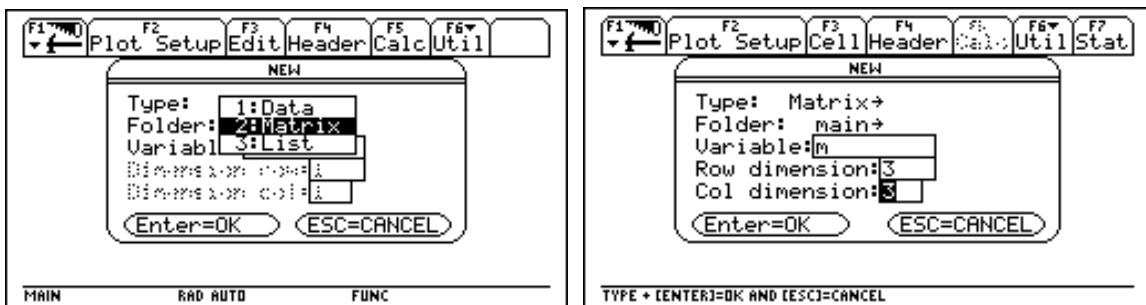


- o (ENTER) ↓ ↓ ... to choose the NEW option (ENTER) ... to start the matrix editor



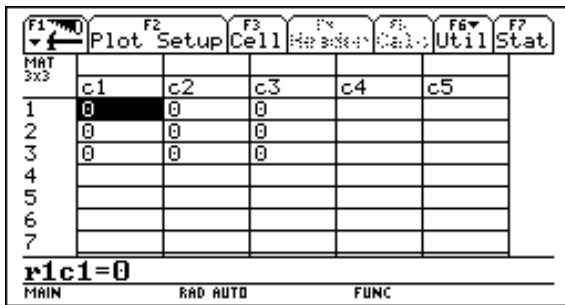
To use the editor for entering a matrix, one must change the type to MATRIX. The right arrow left of the blinking entry DATA indicates that a selection menu can be opened by pressing the right cursor. We open this menu and highlight the entry MATRIX (left picture). We then use the down cursor to select the other fields for entering the matrix name and the row and column dimensions (right picture).

- o → ↓ ... to choose the matrix editor (ENTER) ↓ ↓ m ↓ 3 ↓ 3 (ENTER)

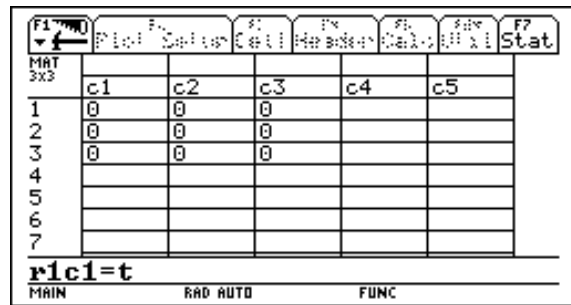


(ENTER) concludes this definition and opens a table in which all 9 elements of the 3 by 3 matrix are filled with zeros. The element in the first row and first column is highlighted and also is displayed in the line editor (left picture). (ENTER) moves control to the line editor and we overwrite the zero with the variable 't' (right picture).

- o (ENTER)



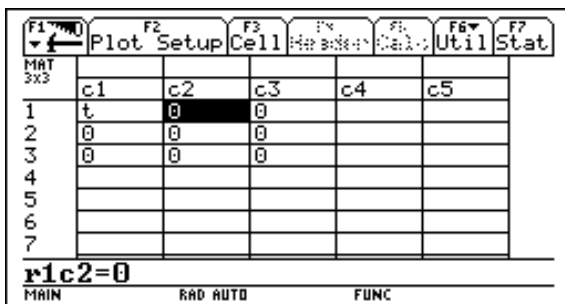
- t



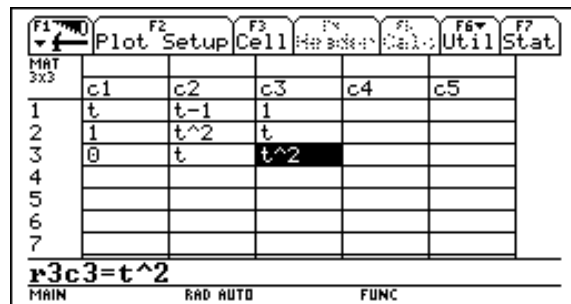
(ENTER) copies the contents of the line editor into the table and moves the highlighting to the next element (left picture). We repeat this process for all the other elements of $\begin{pmatrix} t-1 & 1 \\ t^2 & t \\ t & t^2 \end{pmatrix}$, thus entering the matrix row by row.

row.

- o (ENTER)



- t-1 (ENTER) 1 (ENTER) ...



Switching back to the Home screen can be done with the hot key [\blacklozenge]-[HOME]. The matrix M now is available from within the Home screen:

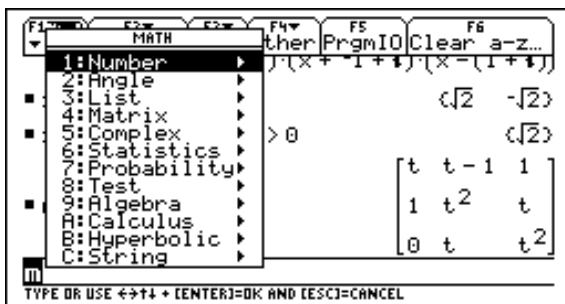
- o [HOME] ... to switch to the Home screen
- m (ENTER) ... to enter the matrix M



For computing the determinant of this matrix, one needs a respective function. There is no such key on the keyboard, nor seems any of the menus appropriate. One could use the catalog, but there is another source for finding functions: the [MATH]-menu, in which submenus are offered for 12 different application areas (left picture). We select the MATRIX submenu and find the determinant function therein (right picture).

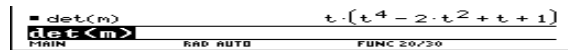
- o [MATH]

- (4): MATRIX ↓



- o (ENTER) ... to copy the DET function

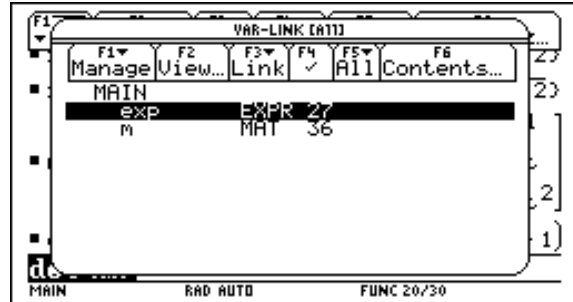
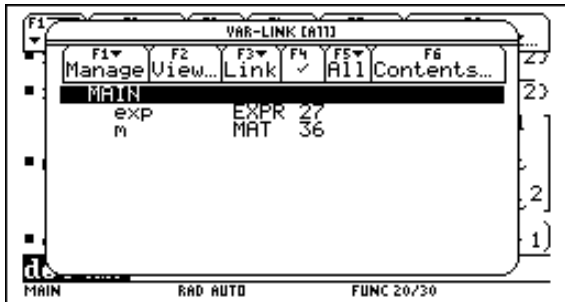
- m) (ENTER)



Often it is convenient to have access to the list of all assigned variables (and functions) and to delete, view, or otherwise process them easily. The TI-92 provides such a key.

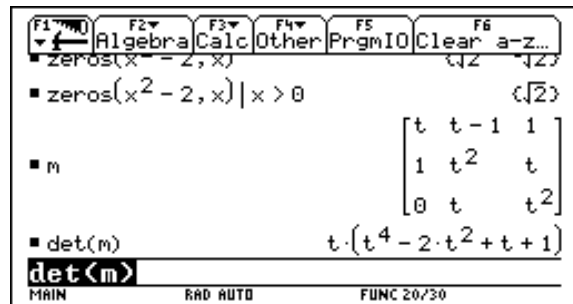
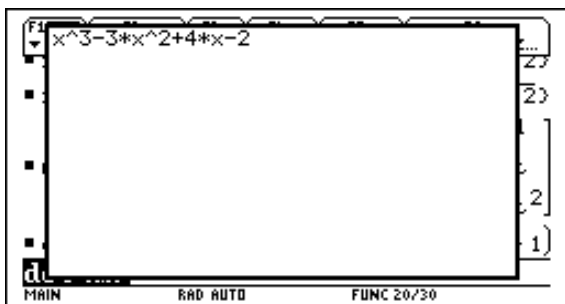
- o [VAR-LINK]

↓ ... to select the variable EXP



- o (F6): CONTENTS

(ESC) (ESC) ... to exit from the variable list



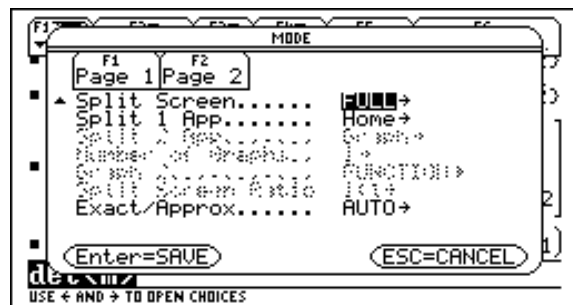
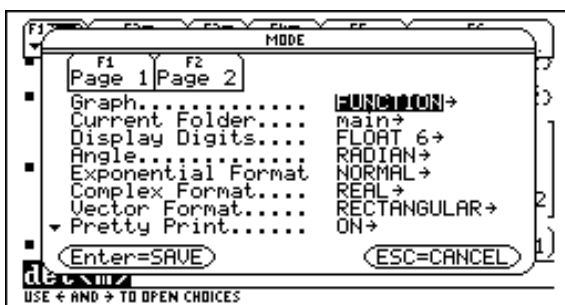
Symbolic manipulations are done by applying functions or commands. On the TI-92 there are several ways to enter a function or a command: some are available via a key or a combination of keys. More functions are available from pull down menus. Still more are available through the [MATH] menu and a list of all available functions and commands is provided by the [CATALOG].

(2) Demonstrating 2D and 3D plotting

Another major feature of the TI-92 is plotting of graphs. A plot window can use either the complete screen or only a part of it, so that a user can view graphs and another application at the same time. Below we change the SPLIT SCREEN entry in the MODE menu so that the Home screen and the plot window will be visible simultaneously.

- o (MODE)

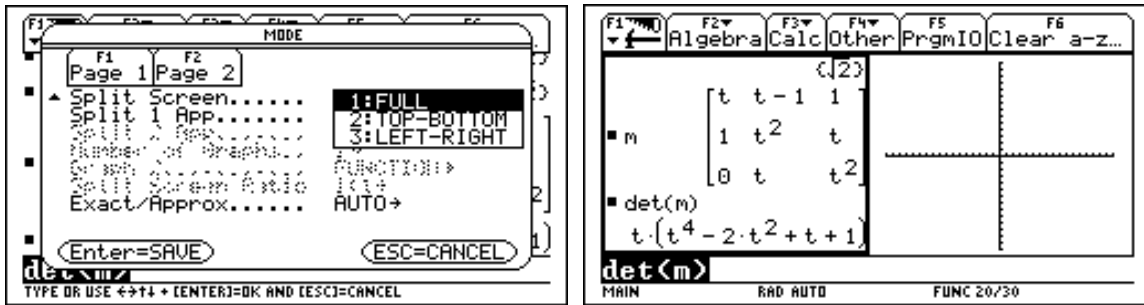
(F2): PAGE 2



The right arrow following FULL indicates that by pressing the right cursor a selection menu appears.

- o →

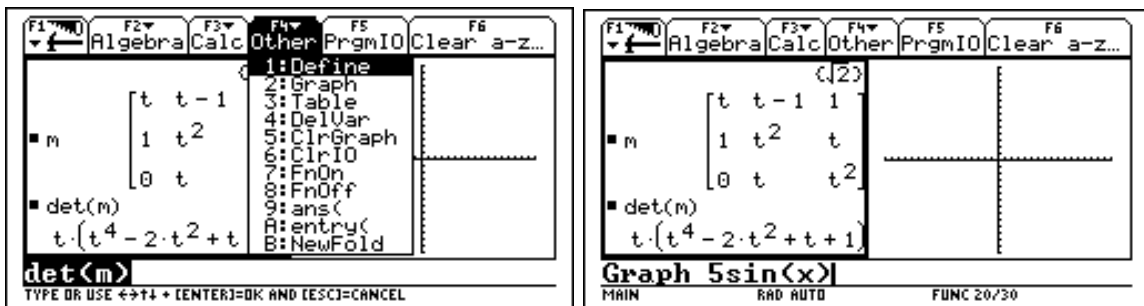
(3): LEFT-RIGHT (ENTER)



There are two applications visible now. The left one is the Home screen which still contains all the history pairs that we have entered so far, the right one is a plot window. The left one is active, as is indicated by the bold window frame.

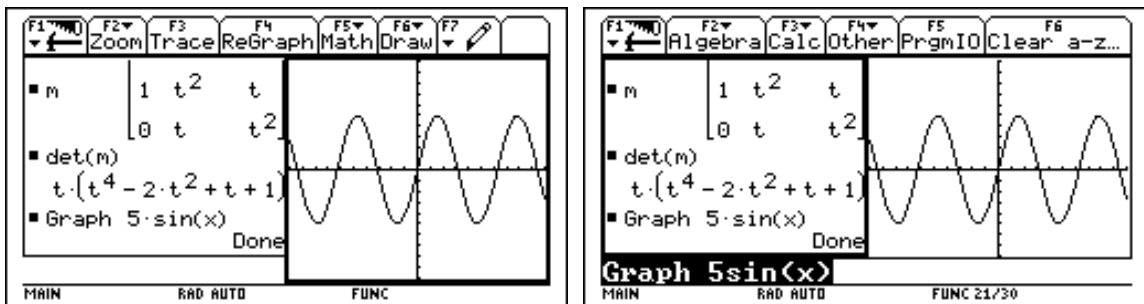
We want to plot the graph of $5\sin(x)$. A suitable command is found in the (F4): OTHER menu (left picture). To enter the sine function one can type the function name or simply press the (SIN) key which, like many other function keys, inserts the function name *and* an opening paranthesis into the line editor.

- o (F4): OTHER (2): GRAPH $5\sin(x)$



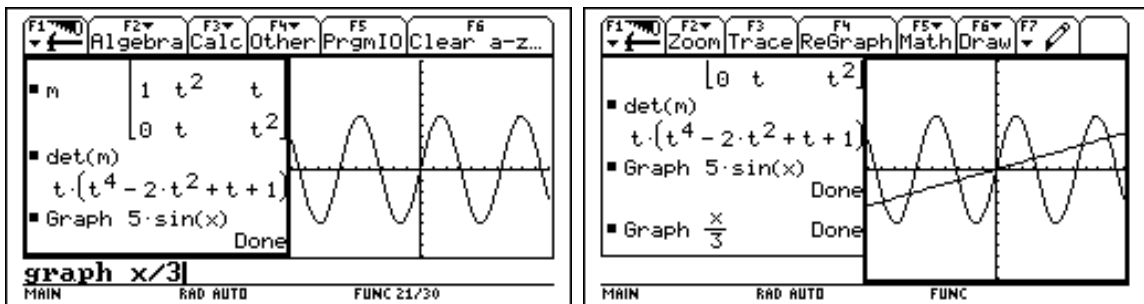
Pressing (ENTER) starts the plotting of the function and finally the plot window becomes the active window (left picture). We use the flip-window key to make the algebra window the active one again (right picture).

- o (ENTER) [α/\mathbb{E}] (= (2nd) (APPS))

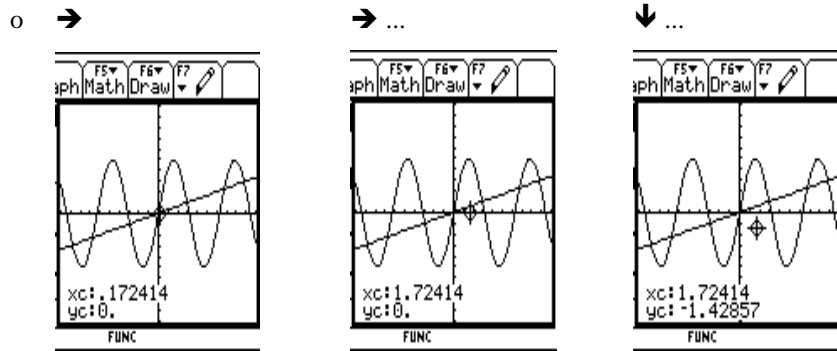


Now we superimpose the graph of $x/3$.

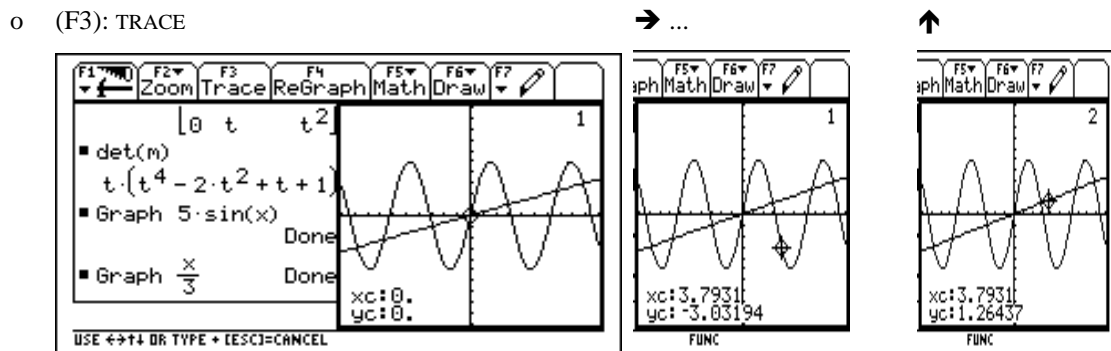
- o graph $x/3$ (ENTER)



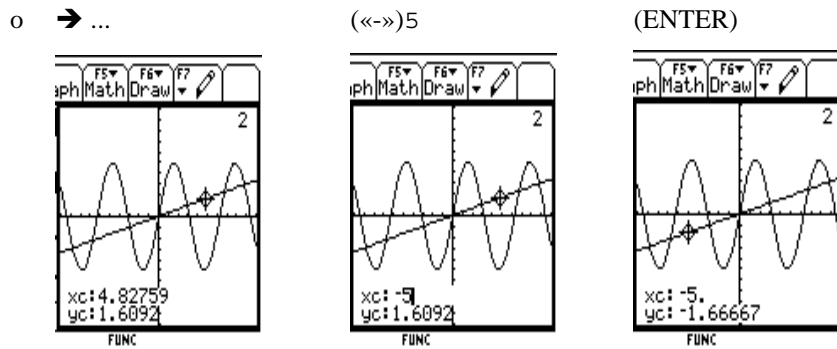
Pressing any edge of the cursor pad switches on the graphics cursor and the display of the cursor's coordinates. The cursor can be moved in 8 different directions (corresponding to and controlled with the 8 edges of the cursor pad).



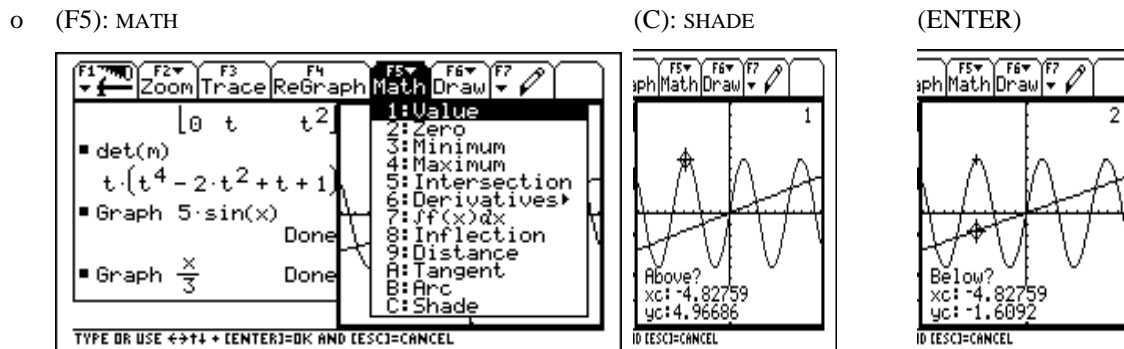
The trace mode (which is switched on with the (F3) function key) is very convenient for inspecting curves. → and ← move the trace cursor along a curve, ↑ and ↓ select other curves. The number of the traced curve is displayed in the plot window's upper right corner.



For repositioning the trace cursor at a certain position on the curve, one can move the trace cursor all the way using → or ← (1st picture), or simply enter the desired x-coordinate (2nd and 3rd picture) and press (ENTER).



The (F5): MATH menu offers many commands for processing the plots further. We are going to choose the SHADE command, which requires four arguments. When used interactively as here, the TI-92 requests all four arguments separately by displaying respective questions in the plot window. In the following we shade the area above the sine function and below the straight line between $x = -8$ and $x = 8$.



The ABOVE and BELOW curves can be selected with ↑ or ↓ and (ENTER). For specifying the LOWER and UPPER bounds one can use one of two methods: Either use → or ← to move the cursor to the desired lower and upper

bound, respectively, and then select the value with (ENTER), or simply type the lower and upper bound values and press (ENTER). We use the second method and enter -8 and 8, respectively.

- o (ENTER) (<<->) 8 (ENTER) 8
-

- o (ENTER)
-

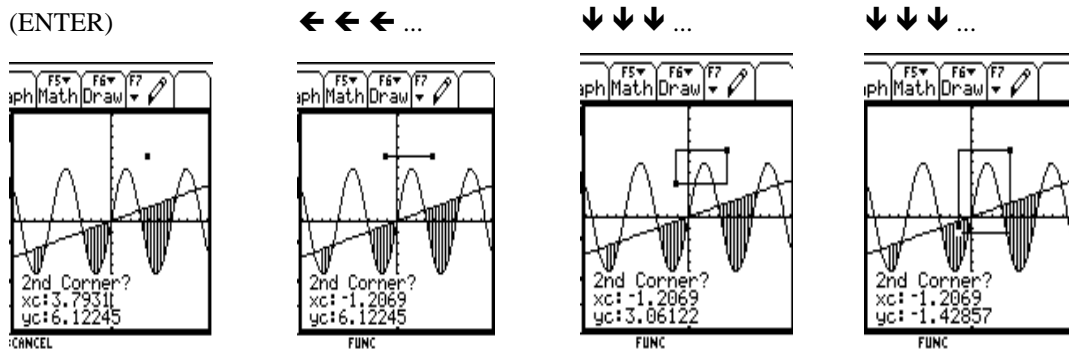
As can be see in this manuscript, there are means to send TI-92 generated graphs and screen dumps to a PC or a Macintosh, where they can be imported into text documents and/or be printed.

The (F2): ZOOM menu offers many options for changing the plot window's parameters like scale factors, position of the origin, etc. In the sequel we are going to use a zoom box to enlarge a particular part of the plot. The zoom box is defined by selecting two opposite corners. First one needs to move the cursor to the position where the zoom box's upper right corner shall be.

- o (F2): ZOOM (ENTER) ↑ ... ← ...
-

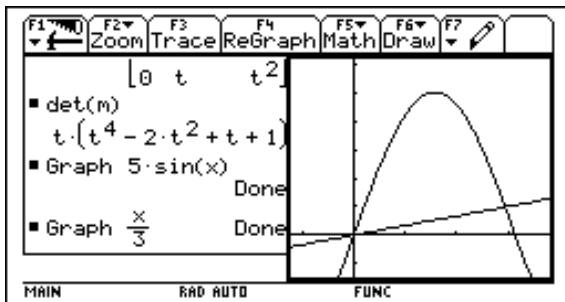
(ENTER) selects the current cursor position as the box's first corner. While moving the cursor to the second position, the zoom box is updated dynamically.

- o (ENTER)



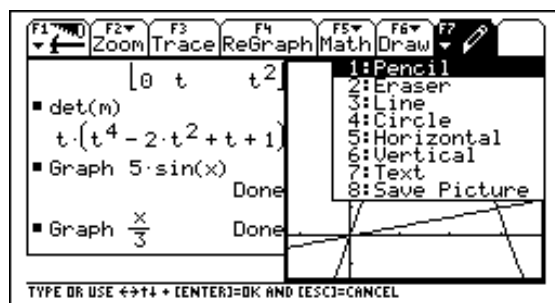
Pressing (ENTER) starts the application of the ZOOM command and the graph is plotted again according to the new plot window parameters.

- o (ENTER)

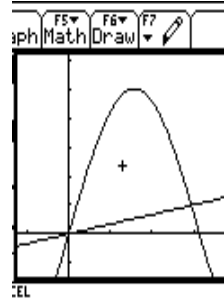


The (F7) menu offers tools like a pencil, an eraser, etc. The TEXT command allows to enter some text.

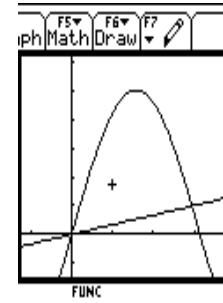
- o (F7)



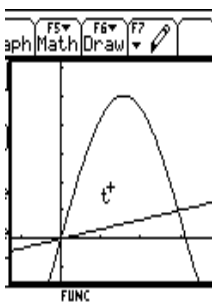
- (7): TEXT



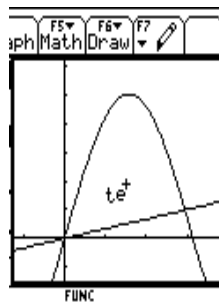
- ↑ ... ← ...



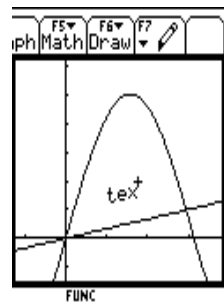
- o t ↑



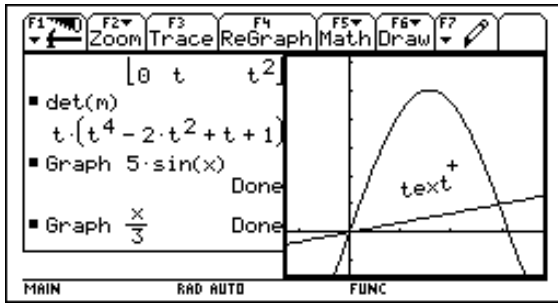
- e ↑



- x ↑

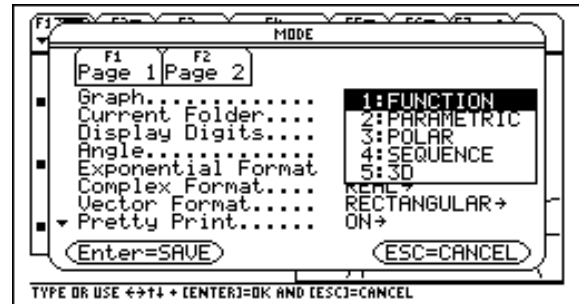
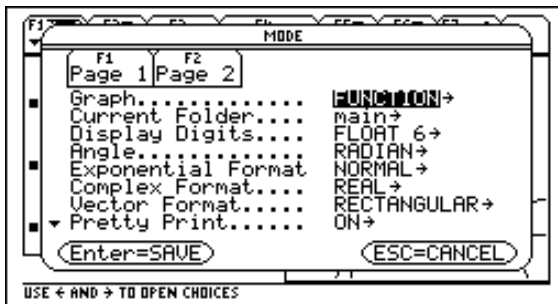


- o t ↑↑↑↑↑

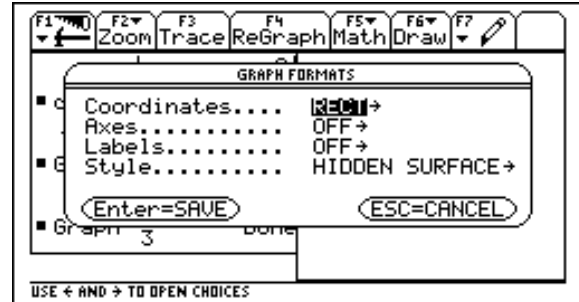
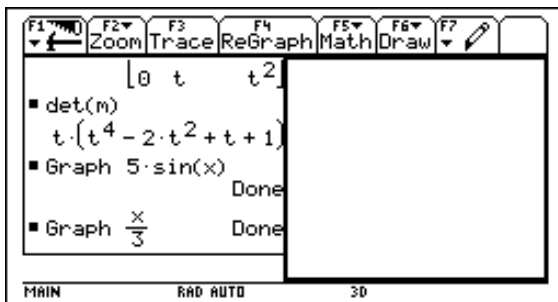


The TI-92 can plot 3D graphs also. To prepare for a 3D plot, one has to change the MODE accordingly. We also open the FORMAT menu (evoked with the [◆](F) hot key) to switch on the display of the axes.

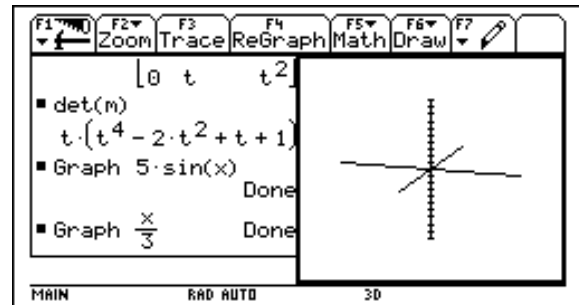
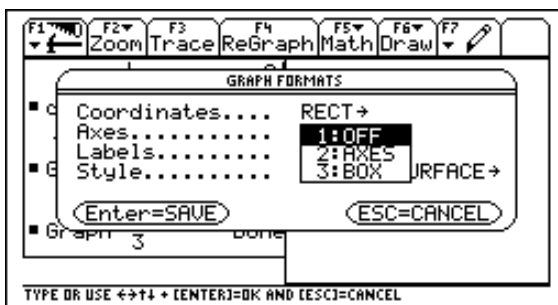
- o (MODE) → ... to display the selection menu



- o (5): 3D (ENTER) [◆](F) ... to display the FORMAT menu

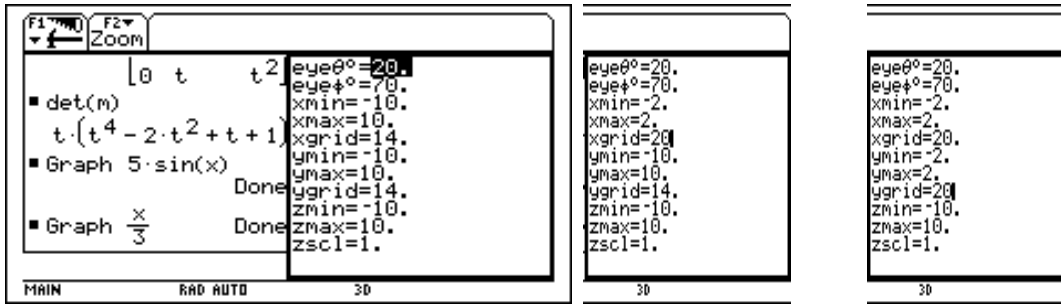


- o ↓ → ... to display the AXES selection menu (2): AXES (ENTER)

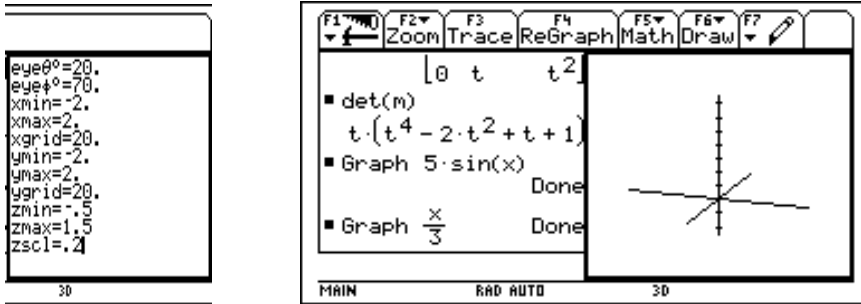


The look of a 3D plot very much depends on a good choice of the plot window parameters. It takes some exercise as well as mathematical insight to learn how to choose suitable parameters for a given function. With the [WINDOW] (= [◆](E)) hot key one can open the window for setting the window parameters (plot intervals, scale factors, etc.). As a preparation for the following example, we leave the eye angles (i.e. the upper two parameters) unchanged but update all the other values:

- o [WINDOW] ↓ ↓ -2 ↓ 2 ↓ 20 ↓ -2 ↓ 2 ↓ 20

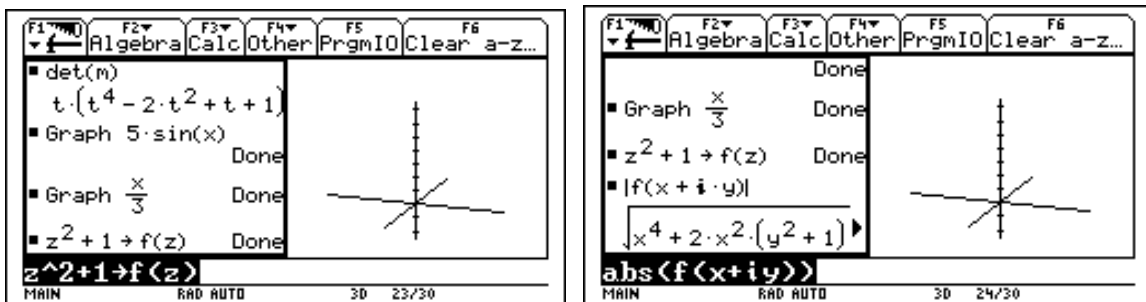


- o \downarrow .5 \downarrow 1.5 \downarrow .2 [GRAPH] ... hot key for returning to the plot window

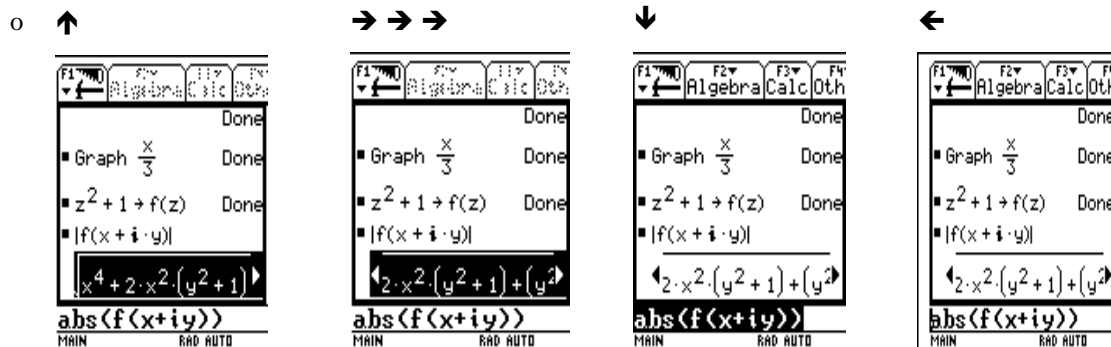


Now the function that shall be plotted has to be entered. In a first step, we define a function $f(z) = z^2 + 1$ in the Home screen. In a second step we compute the absolute value of f applied to a generic complex number (i.e. $|f(x + i \cdot y)|$). We use the TI-92's key for the imaginary unit i .

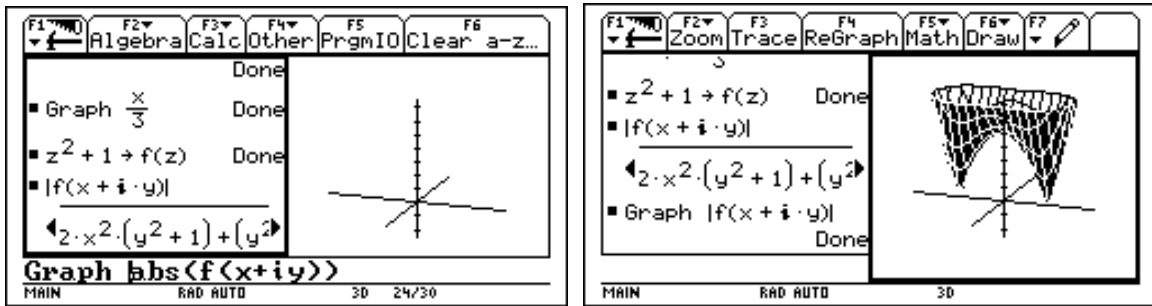
- o [$\langle \rangle$] ... to make the Home window the active one
- $z^2 + 1$ (STO) $f(z)$ (ENTER) $\text{abs}(f(x + [i] y))$ (ENTER)



The answer is larger than the window and, therefore, appears cut off. To see the rest of the expression, we highlight it (1st picture) and then use the right cursor for side scrolling (2nd picture). We proceed with graphing the expression by inserting the GRAPH command before the expression (3rd and 4th picture).



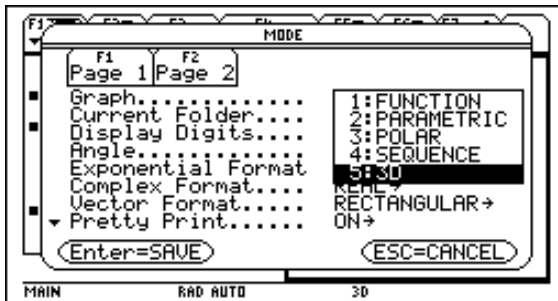
- o (F4): OTHER (2): GRAPH (ENTER)



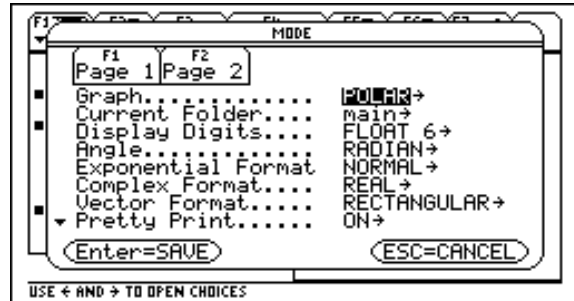
As a third application of plotting we show how to save the pictures of three circles and how to combine them into an animated "film". Since the equation of a circle is particularly simple in polar coordinate mode (and since we want to demonstrate that the TI-92 also can be used in polar coordinates mode), we start this example by switching to POLAR mode. And we switch back to full screen mode.

- o (MODE)

➔ ... to open the GRAPH selection menu



(3): POLAR

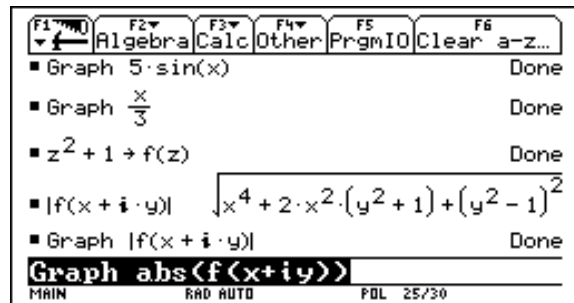


- o (F2): PAGE2

➔ ... to open the SPLIT SCREEN selection menu

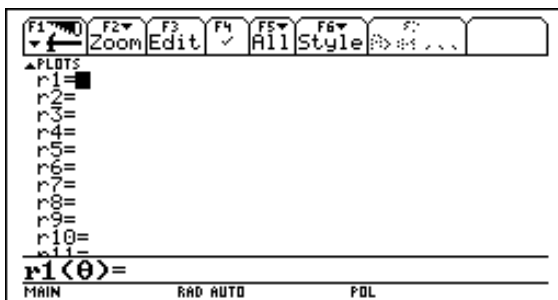


(1): FULL (ENTER)

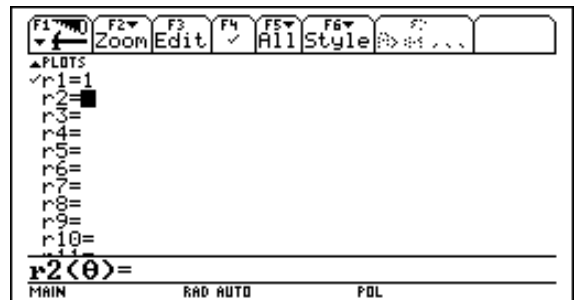


An alternative to applying the Home screen GRAPH command is entering the expression in the [Y=] expression editor. In the sequel we use the hot keys [◆]-[Y=] and [◆]-[GRAPH] to flip between the expression editor (next two pictures) and the plot window (below picture).

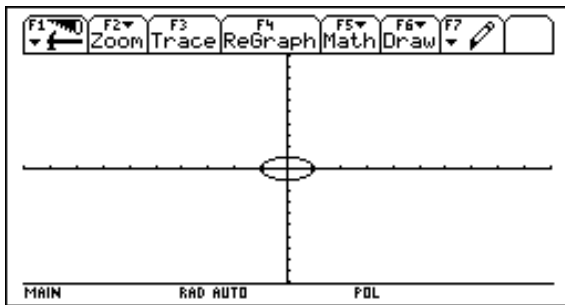
- o [Y=]



1 (ENTER)

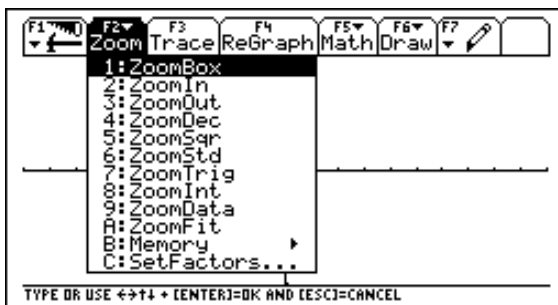


- o [GRAPH]

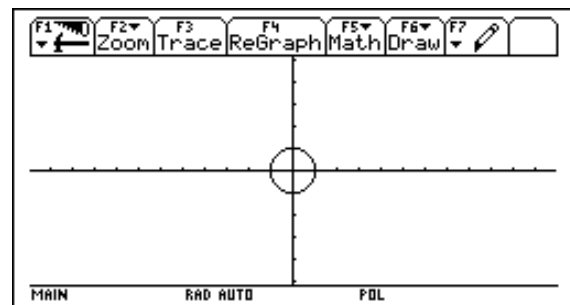


The default choice for the scale factors is such that the same number of units are displayed in both directions. The ZDECIMAL command from the ZOOM menu changes the scale factor for y such that the units have the same length in both directions. Only then does a circle appear as a circle.

- o (F2): ZOOM



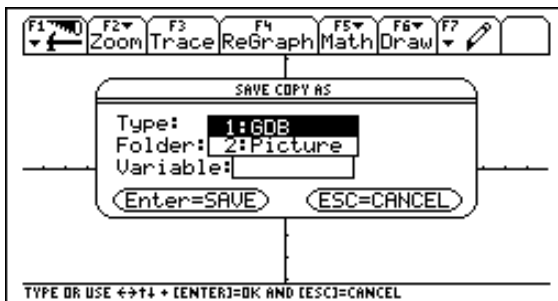
- (4): ZOOMDEZ



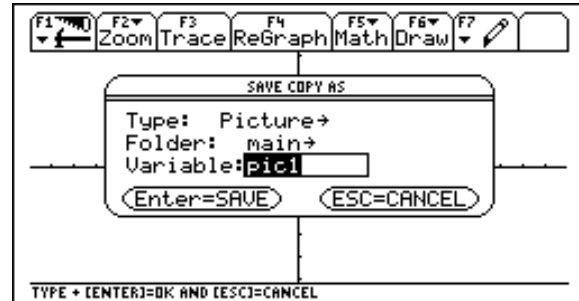
The (F1) menu offers the SAVE AS command for saving the picture in a variable. We store it as PIC1.

- o (F1)

- (2): SAVE COPY AS →

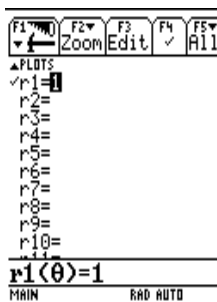


- (2): PICTURE ↓↓ pic1 (ENTER)



We flip to the expression editor (1st picture), then update the circle to a circle with radius 2 (2nd picture), and then update the plot window accordingly (3rd picture).

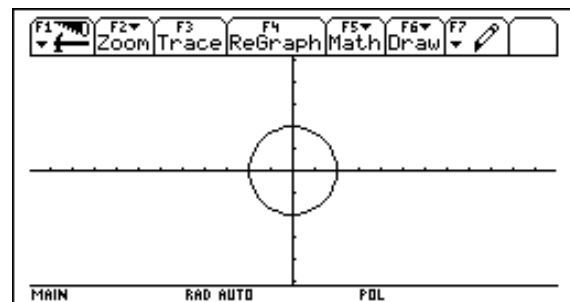
- o (ENTER) [Y=] ↑



- 2 (ENTER)

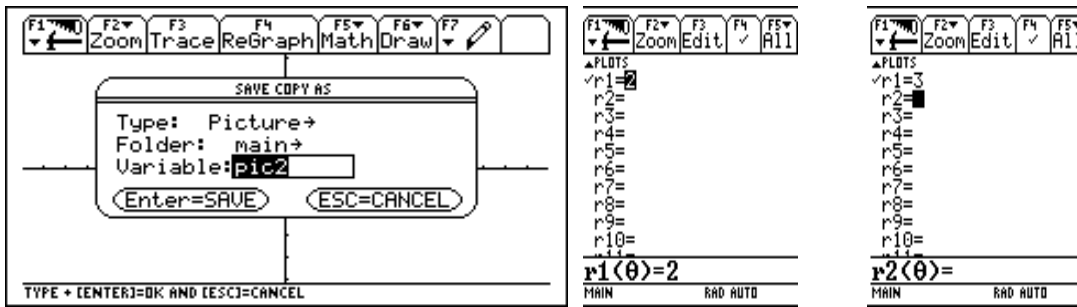


- [GRAPH]



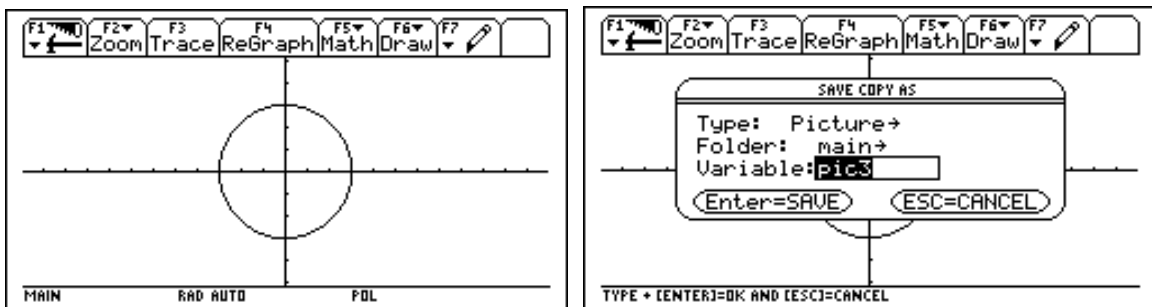
[♦](S) is the hot key for the SAVE AS command. We store the picture of the second circle as PIC2 (1st picture). Then we update the circle to a circle with radius 3 (2nd and 3rd picture).

- o [\blacklozenge](S) \rightarrow (2): PICTURE $\downarrow\downarrow$ pic2 (ENTER) (ENTER) [$\gamma=$] \uparrow (ENTER) 3 (ENTER)



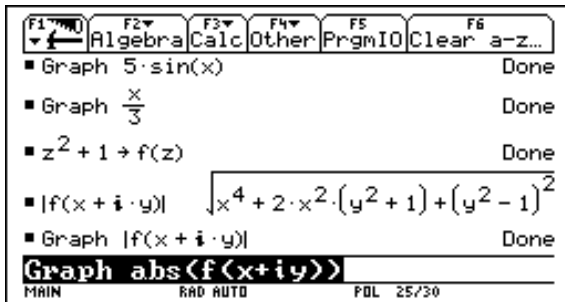
Again we update the plot window (left picture) and store the circle with radius 3 as PIC3 (right picture).

- o [GRAPH] [\blacklozenge](S) \rightarrow (2): PICTURE $\downarrow\downarrow$ pic3 (ENTER)



Finally we return to the Home screen where we enter the CYCLEPIC command. This command combines the three pictures PIC1, PIC2, PIC3 into an animated "film".

- o (ENTER) [HOME]



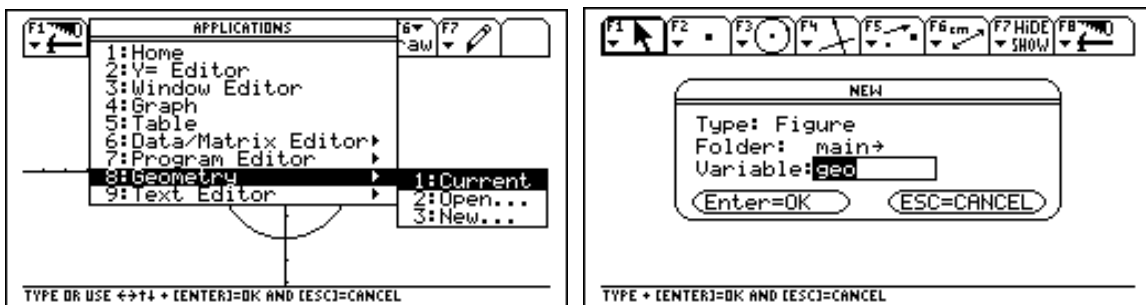
- o cyclepic "pic", 3, .2, 10 (ENTER)

The animation cannot be shown here.

(3) Demonstrating interactive geometry

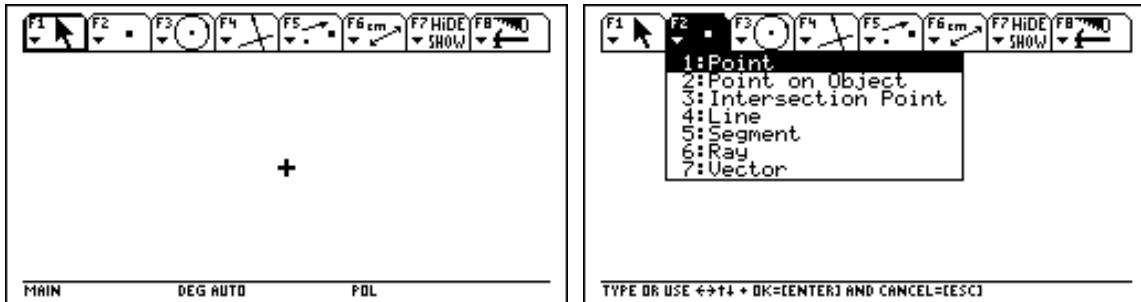
The TI-92's geometry module provides easy to use tools for performing geometric constructions. It is started via the APPLICATIONS menu. Opening a NEW figure and naming it GEO is done as follows:

- o (APPS) (8):GEOMETRY (3):NEW \downarrow geo (ENTER)



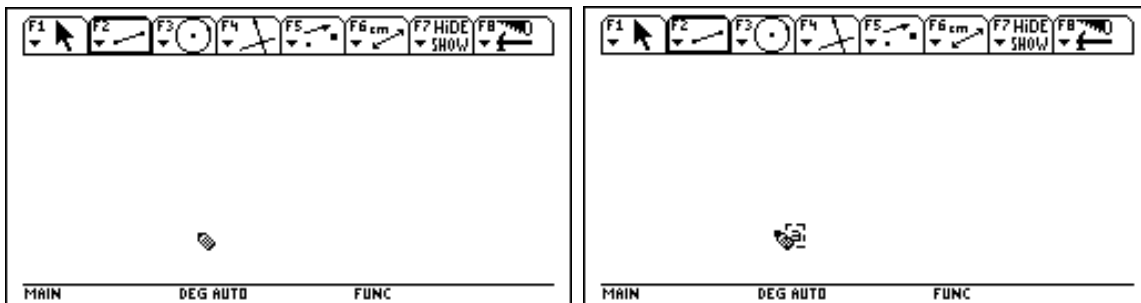
An empty geometry screen with the cursor in the center appears (left picture). The next example shall consist of two segments. The corresponding tool can be found in the (F2) menu (right picture).

- o (ENTER)
- (F2)



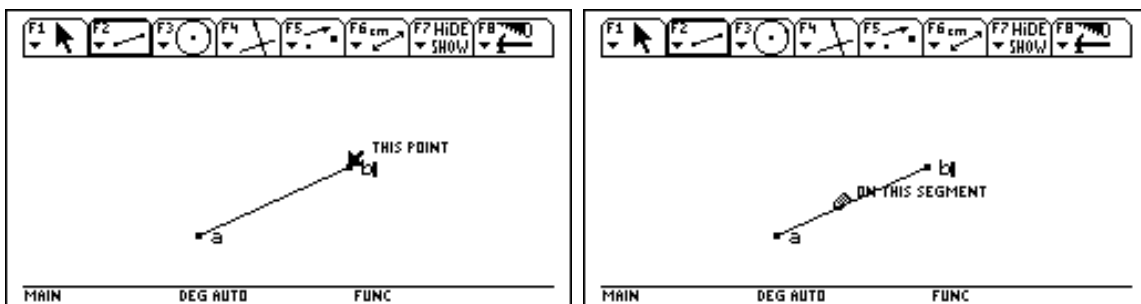
After starting the SEGMENT tool we move the geometry cursor to the position where one end of the first segment shall lie (left picture). Pressing (ENTER) defines the point. We assign the name A to the point simply by entering the name 'A' (right picture).

- o (5):SEGMENT ← .. ↙ .. ↓
- (ENTER) a



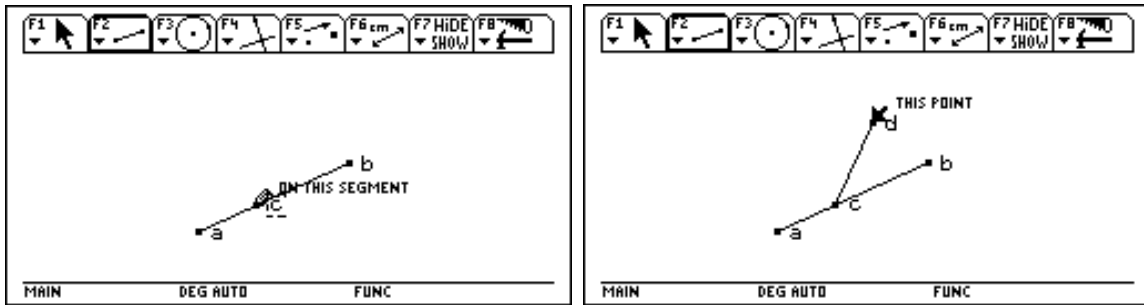
We move the cursor to the position where the other end of the segment shall be. The point is defined and named B (left picture). Now the second segment. The TI-92 still is in "SEGMENT mode", as can be seen by the bold frame of the (F2) menu and the symbol shown therein. One end of the second segment shall lie *on* the first segment, so we move the cursor to where the new point shall be. The message ON THIS SEGMENT indicates that the point will be put *on* the segment - should we press (ENTER) now (right picture). The TI-92 provides such kind of information all the time, allowing a very convenient 3 pixel tolerance.

- o → ... ↗ ... (ENTER) b
- ← ... ↙ ...



We define a point, name it C, and then choose point D as the second segment's other end.

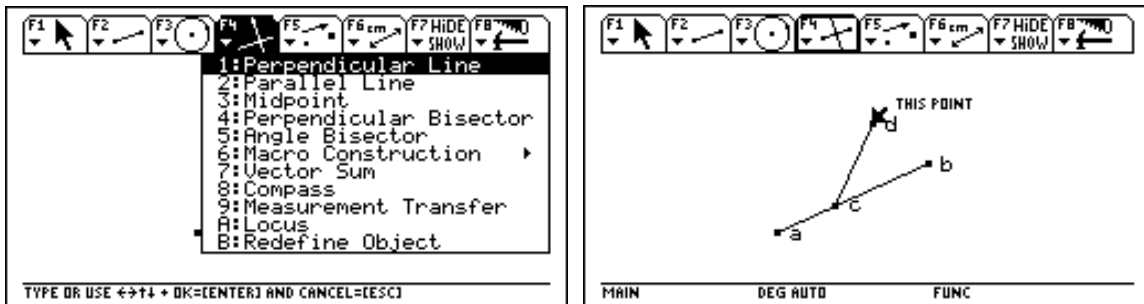
- o (ENTER) c
- ↑ ... ↗ ... (ENTER) d



The perpendicular bisector of the segment CD shall be constructed. The appropriate tool is contained in the (F4) menu (left picture). After activating the PERPENDICULAR BISECTOR tool one has to select the segment to which it shall be applied.

o (F4)

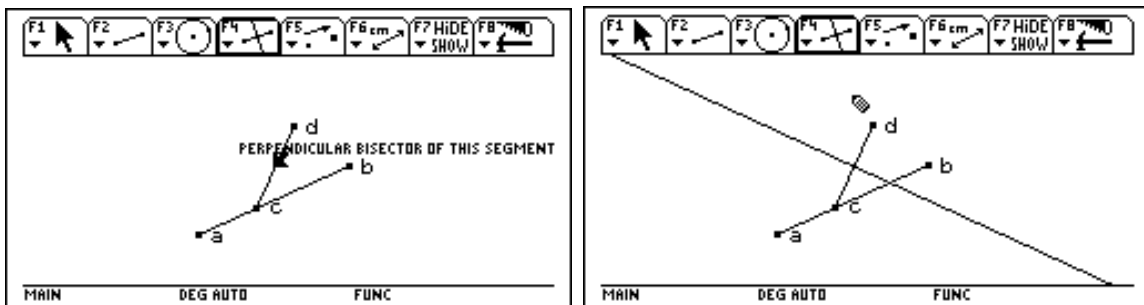
(4):PERPENDICULAR BISECTOR



We move the cursor towards the segment until the message PERPENDICULAR BISECTOR OF THIS SEGMENT appears (left picture) and press (ENTER). This starts the construction (right picture):

o ↙ ... ↘

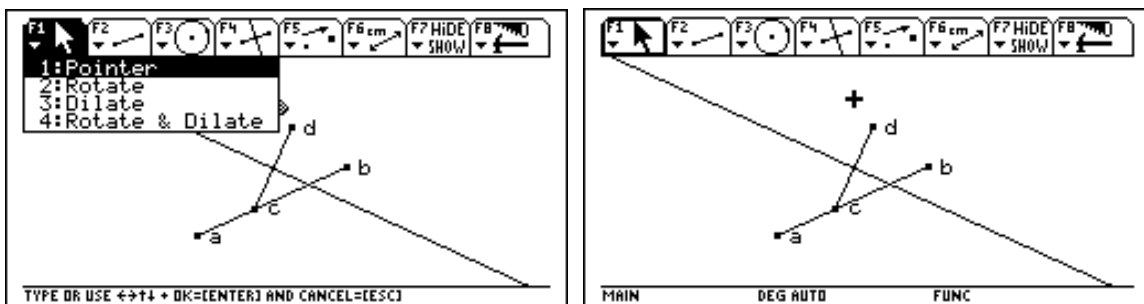
(ENTER) ↑ ... ↑



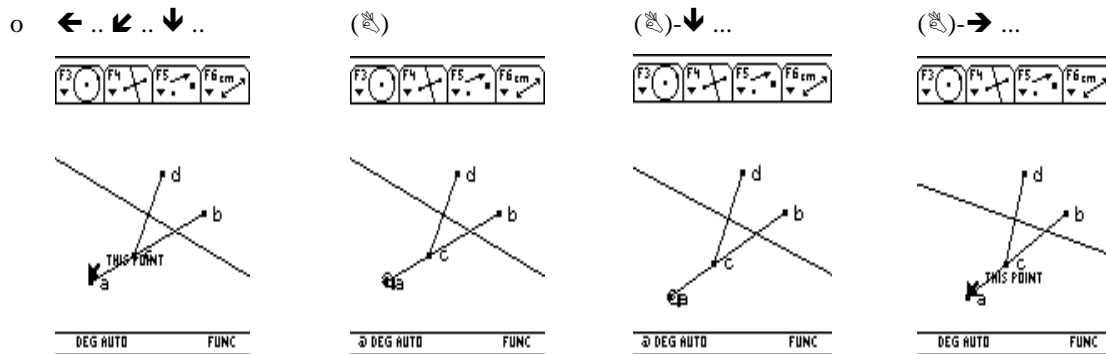
Every geometric configuration consists of independent and dependent objects. In the above example, the points A, B, and D are independent, because they were chosen with no constraints. Point C is semi-dependent, because it needs to fulfill one constraint (it has to lie on segment AB) but still has one degree of freedom (it can be anywhere on AB). The perpendicular bisector is dependent, because it was obtained as the result of a deterministic construction. As will be demonstrated below, independent objects can be moved in any direction using the POINTER tool. When independent objects are moved, all dependent objects will be updated automatically, such that all geometric properties that were enforced during the construction (like incidence, perpendicularity, parallelity, etc.) remain valid. To move objects one has to start the POINTER tool:

o (F1)

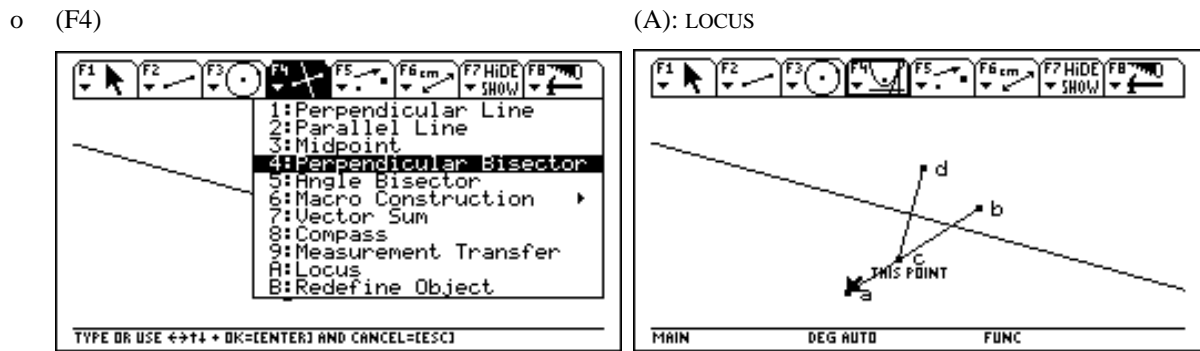
(1):POINTER



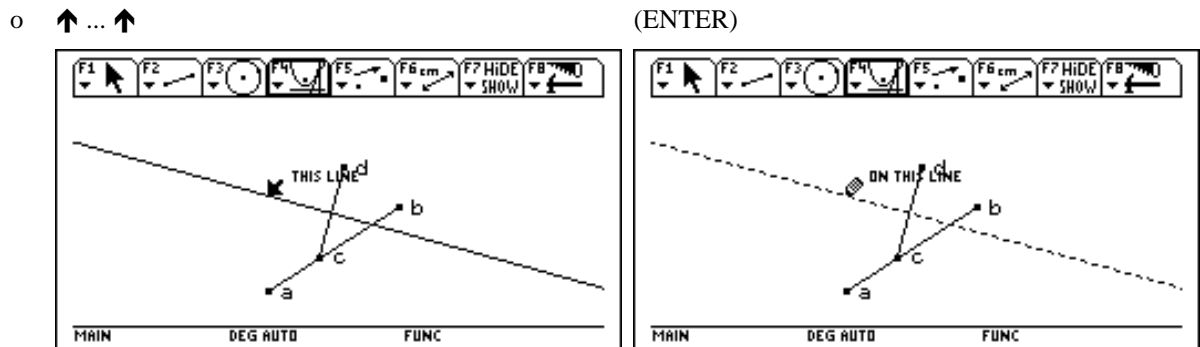
Before one can move, say, point A, one has to move the cursor to it (first picture). We press the "hand" key (H) and hold it down (second picture). As long as this key is pressed, the geometry cursor has the shape of a hand. With the "hand" key pressed, we move the geometry cursor and with it point A. As the point moves, the whole configuration changes accordingly (third and fourth picture).



The LOCUS tool is used to create a set of objects defined by the movement of a point along a path. This tool can be activated through the (F4) menu.

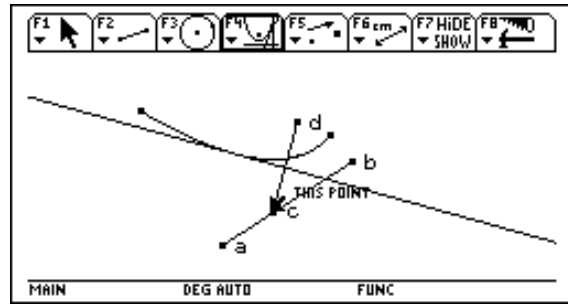
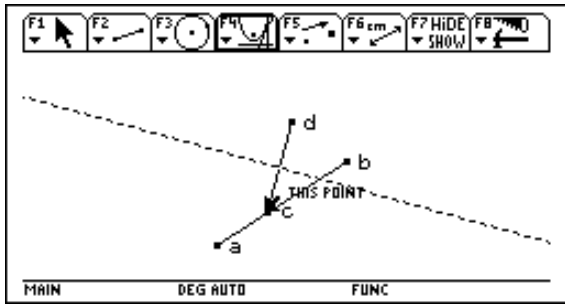


What is the set of perpendicular bisectors defined by moving point C along AB? The LOCUS tool will provide an answer. The perpendicular bisector has to be selected as this tool's first argument:



The selected line appears as a marquee (dotted) outline. Now we move the geometry cursor to the point that shall be moved (left picture). Pressing (ENTER) selects this point as the second argument for the LOCUS tool, and the calculation starts. After a few seconds a part of a parabola appears (right picture). It is due to a preset parameter that the envelope of the set of all perpendicular bisectors is displayed - rather than the set itself. (However, this parameter can be updated by the user so that the set is displayed.)

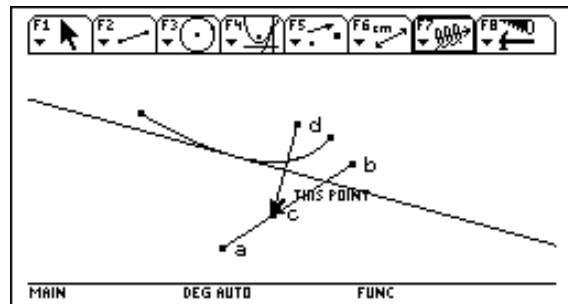
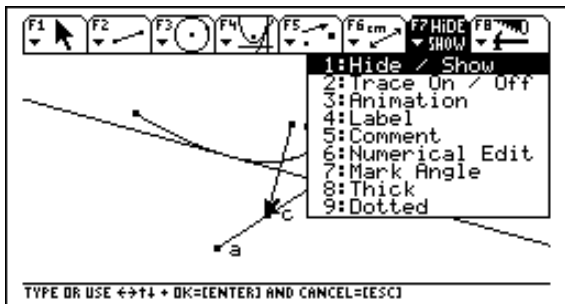




A very spectacular tool is ANIMATION. With this tool one can very well visualize why the above envelope takes the form of a parabola. In the following we animate the movement of the point along the segment.

o (F7)

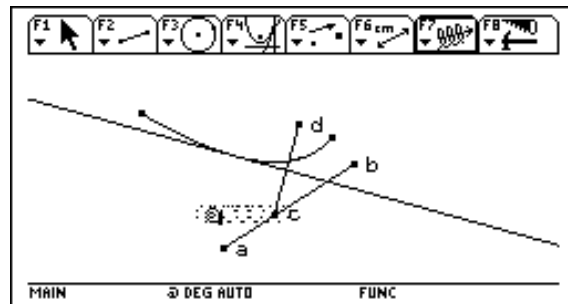
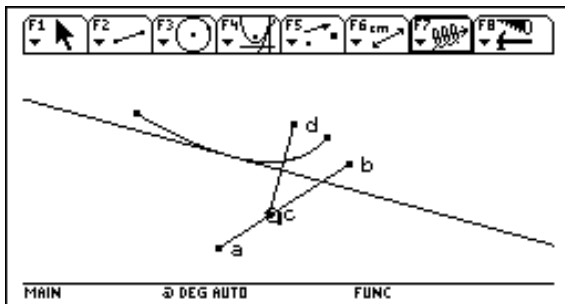
(3): ANIMATION



We hold down the "hand" key (left picture) and as we move the hand cursor to the left, a spring appears that connects the point with the hand (right picture).

o (F7)

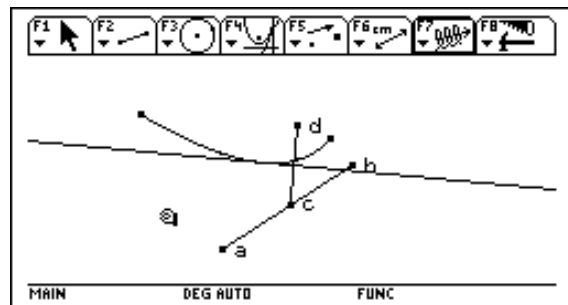
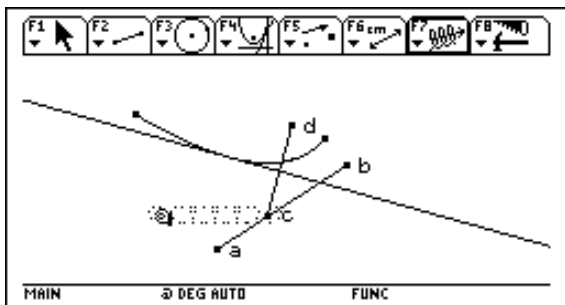
(F7)-←←← ...

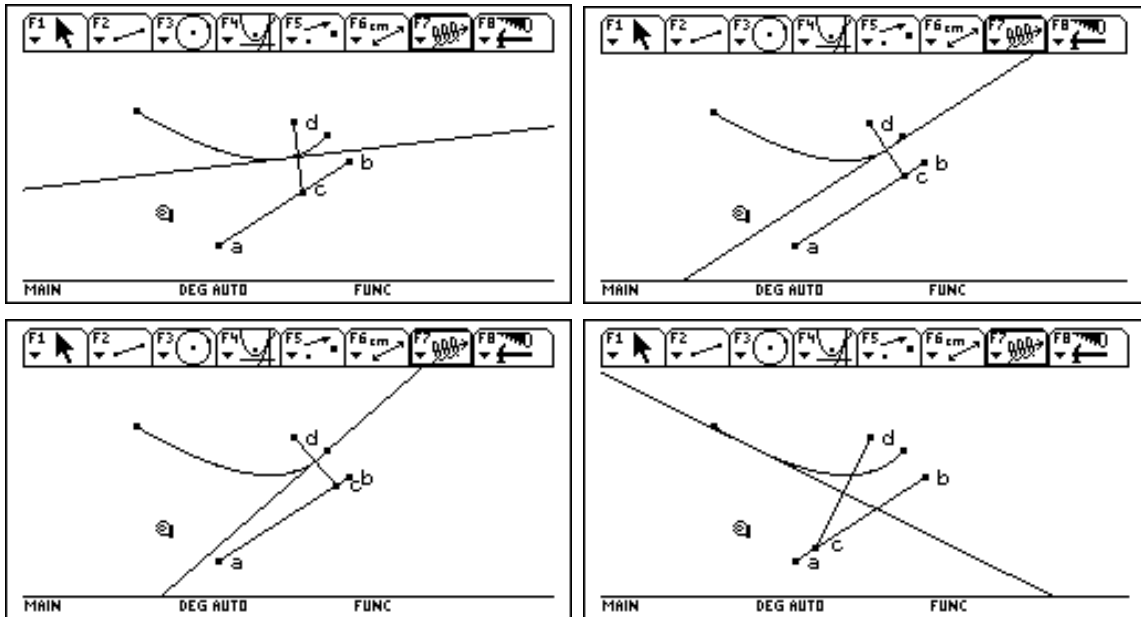


The farther the spring is extended, the faster the animation will be. When releasing the hand, the spring returns and point C begins to move between A and B. Press (ENTER) to stop the animation at any time.

o (F7)-←←← ...

release the hand

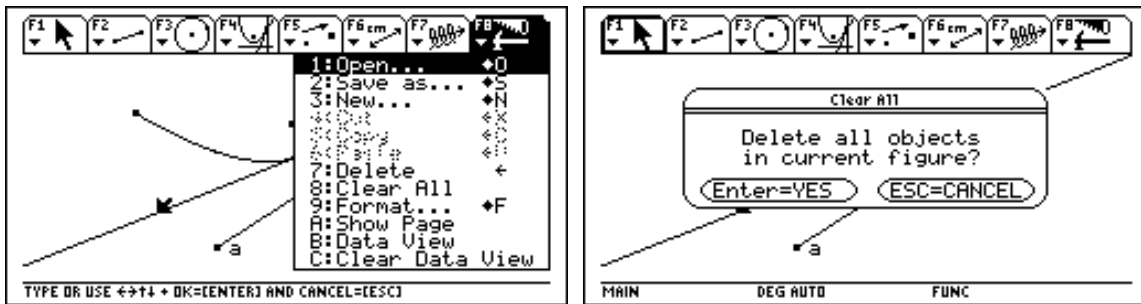




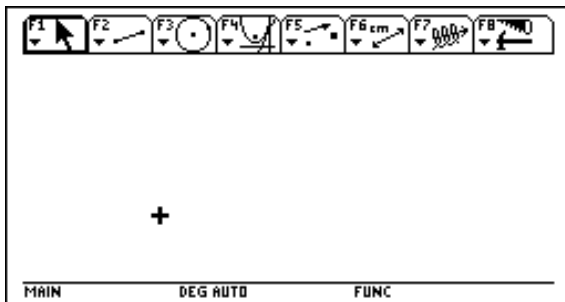
- o (ENTER) ... to stop the animation

Before continuing with another example, we abandon this configuration using the CLEAR ALL command.

- o (F8) (8): CLEAR ALL

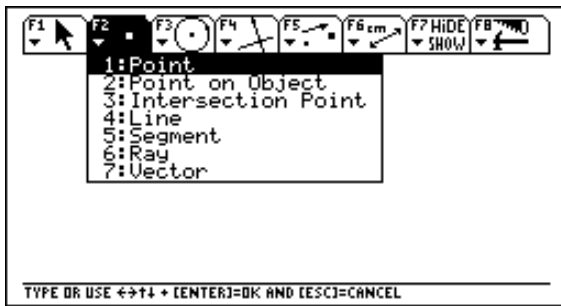


- o (ENTER)

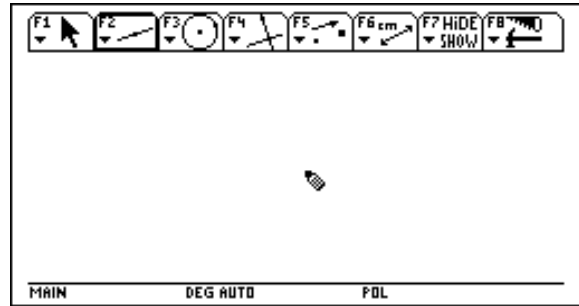


We are going to see how to display equations or coordinates and how to send numerical data samples to a data file. Two lines and their intersection point will serve as an example. The LINE tool determines a line by a point and a direction. Select the point first (right picture).

o (F2)

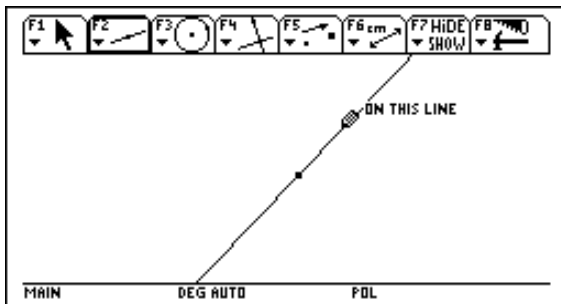


(4): LINE ↑ ... ↗ ... (ENTER)

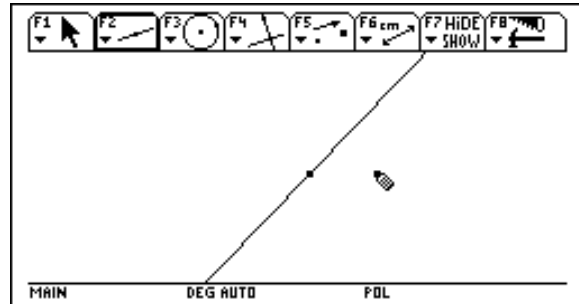


After the point was chosen, we select the direction (left picture). Then the process is repeated for the second line: choose a point (right picture),

o ↗ ↗ ↗ ... (ENTER)

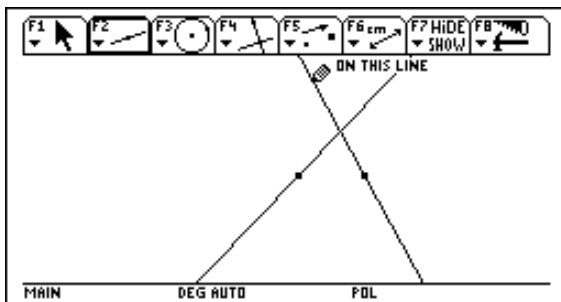


↓ ↓ ↓ ... (ENTER)



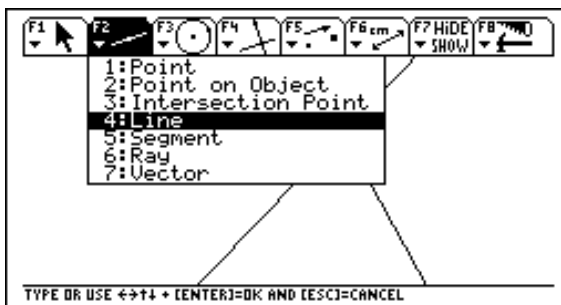
and a direction:

o ↑ .. ↖ .. (ENTER)

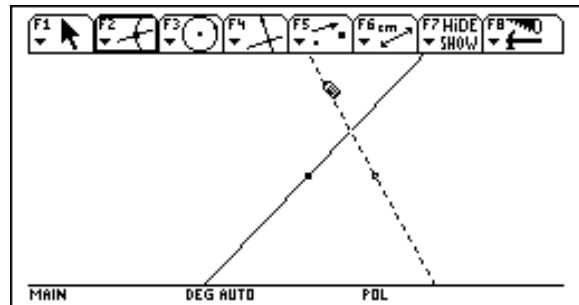


The INTERSECTION POINT tool from the (F2) menu is used for constructing and introducing the intersection point of two suitable objects (left picture). Once the tool is activated, one has to select the two objects. Since the cursor already points at one of the lines, the selection of the first line is done simply by pressing (ENTER) (right picture).

o (F2)



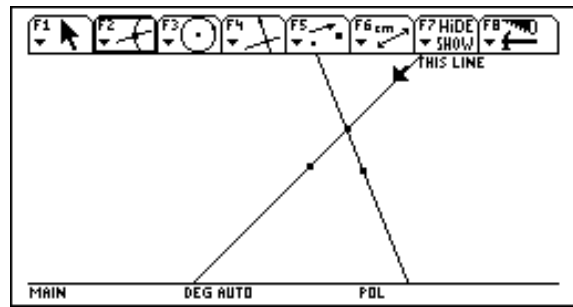
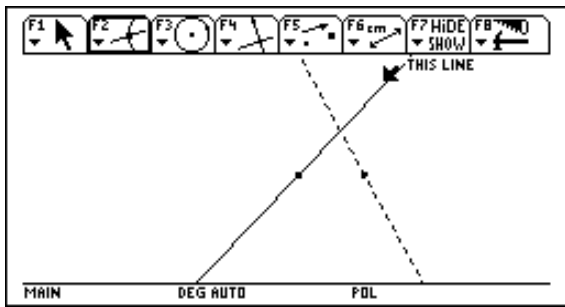
(3): INTERSECTION POINT (ENTER)



We move the cursor to the second line (left picture). Then we select this line with (ENTER) and observe the intersection point appearing (right picture).

o → ... →

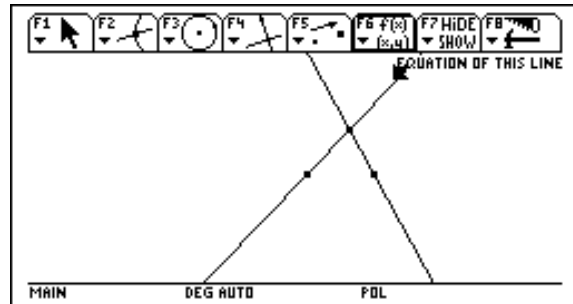
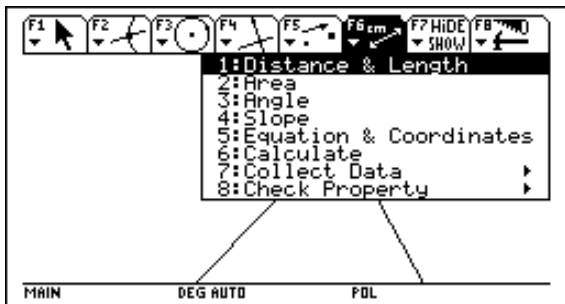
(ENTER)



The display of the coordinates of the intersection point is done with the EQUATION & COORDINATES tool from the (F6) menu.

o (F6)

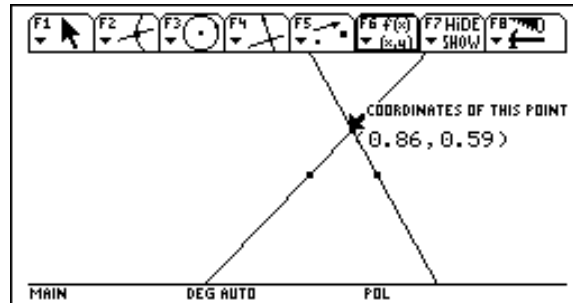
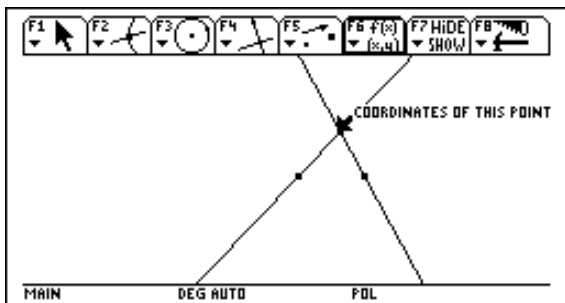
(5): EQUATION & COORDINATES



Currently, the cursor points at a line. Therefore, the TI-92 would give the line's equation - should the (ENTER) key be pressed now (observe the text 'EQUATION OF THIS LINE' above the pointer). To obtain the coordinates of the intersection point, one has to move the cursor to that point (left picture) and then press (ENTER) (right picture).

o ↩ ... ↪

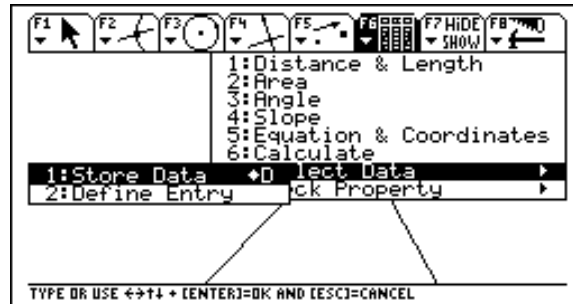
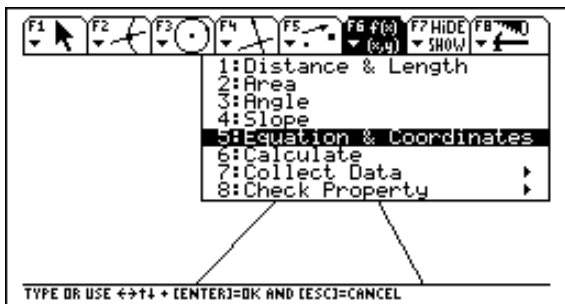
(ENTER)



We are now going to move one of the lines and will observe, how the coordinates change accordingly. To send sample coordinates to a data file, one has to start the COLLECT DATA tool first:

o (F6)

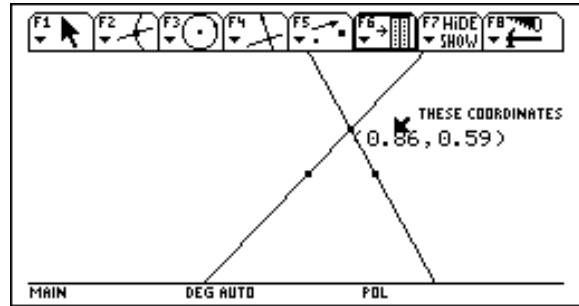
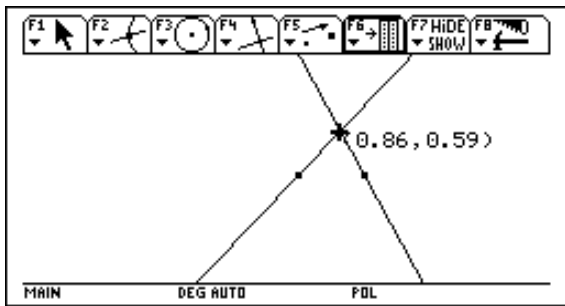
(7): COLLECT DATA



One has to define the entries that shall be stored (left picture). Move the cursor to the first data field (right picture),

- o (2): DEFINE ENTRY

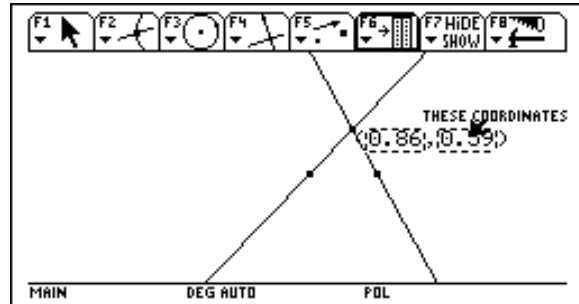
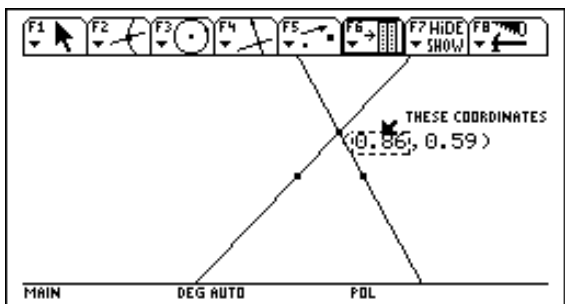
↑ ... ↗ ... → ...



and use (ENTER) to select this entry (left picture). Then move the cursor to the y-coordinate and select this one as well.

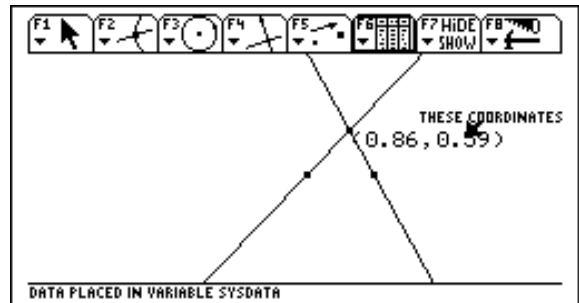
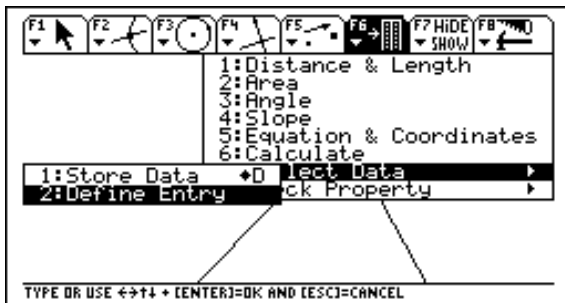
- o (ENTER)

→ ... (ENTER)



To send the first pair of coordinates, one has to apply the STORE DATA command from the COLLECT DATA tool.

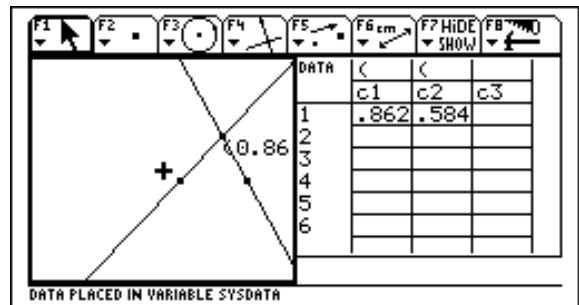
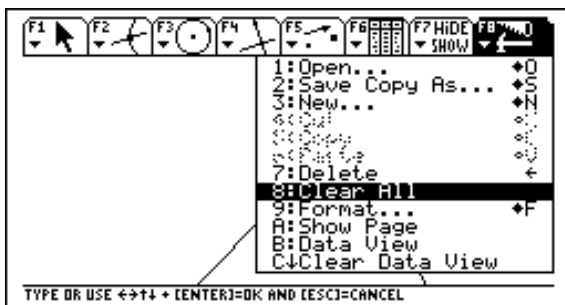
- o (F6) (7): COLLECT DATA (1): STORE DATA



Switching to DATA VIEW mode allows to see the geometry and the data file at the same time.

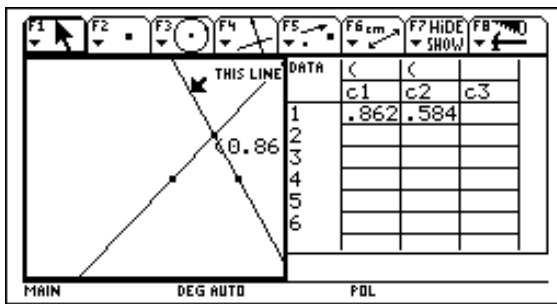
- o (F8)

(B): DATA VIEW

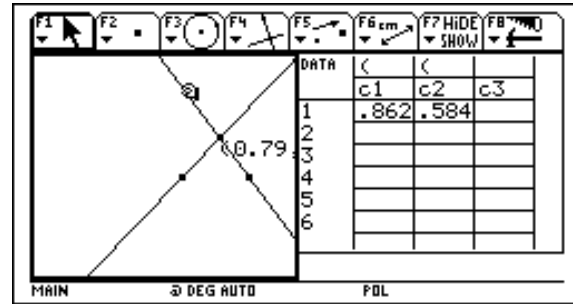


Moving one line to the left is done with the help of the "hand" key.

o ↑ ...

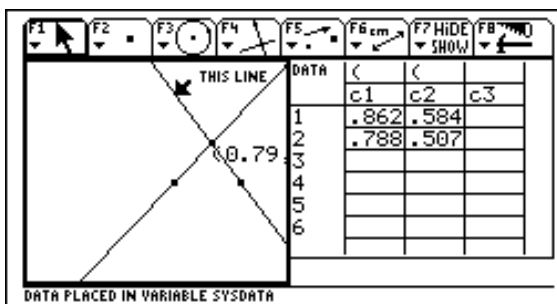


(←)-← ...

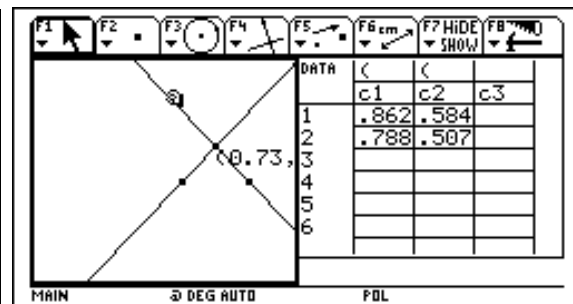


The hot key [◆](D) is a shortcut for sending the sample coordinates to the data file (i.e. it is a shortcut for pressing the three keys (F6) (A): COLLECT DATA (1): STORE DATA). We use it (left picture) and then move the line farther to the left (right picture).

o [◆](D)

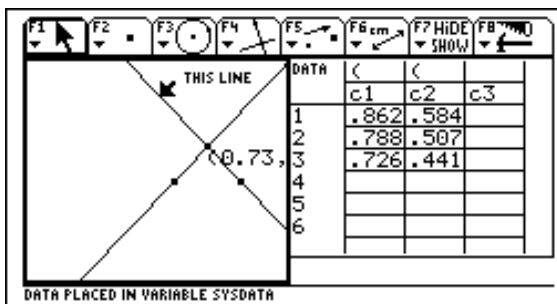


(←)-← ...

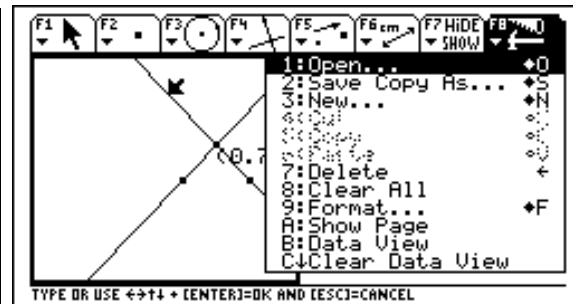


We send a third pair of sample coordinates (left picture) and then close the DATA VIEW mode. By the way: The collected data can be used - and processed - in other TI-92 applications.

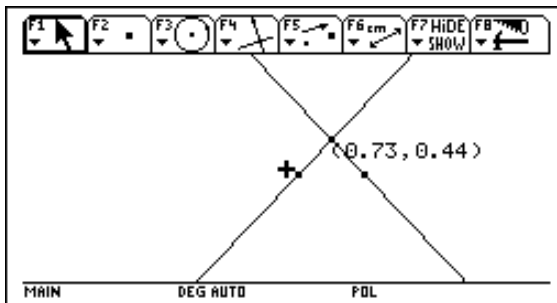
o [◆](D)



(F8)



o (C): CLEAR DATA VIEW

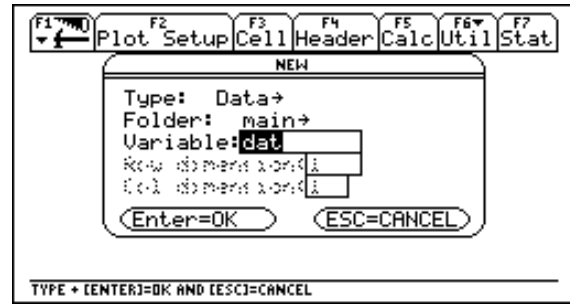
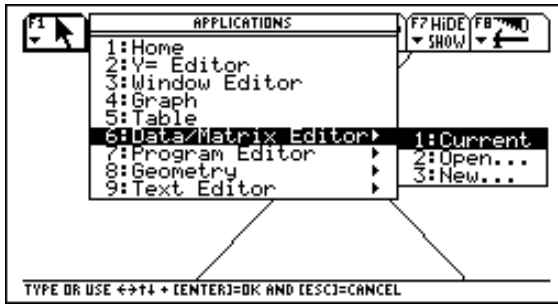


(4) A glimpse at the various editors

The data/matrix editor was used before both for entering a matrix and for collecting sample coordinates from an interactive geometry application. In the sequel more of its features are demonstrated. The editor is started and a new data file named DAT is opened.

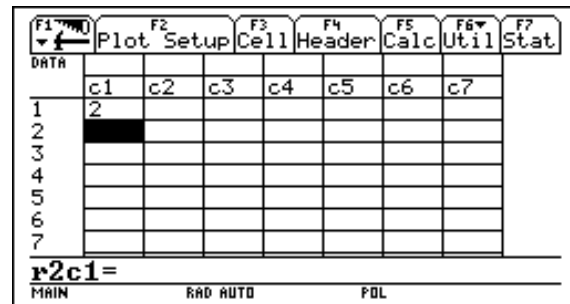
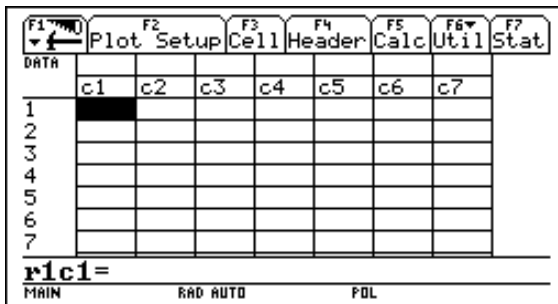
o (APPS) (6): DATA/MATRIX EDITOR

(3): NEW ↓↓ dat (ENTER)



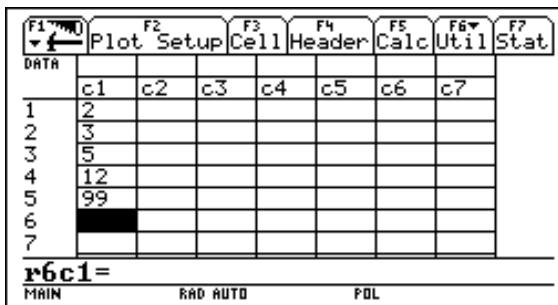
An empty data file appears (left picture). The first column shall be filled with arbitrary integers. We start by entering the number '2' as the first element of column C1 (right picture).

- o (ENTER) 2 (ENTER)



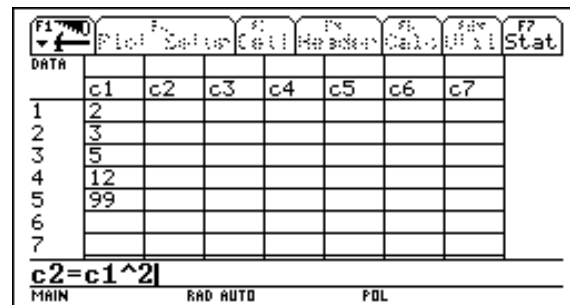
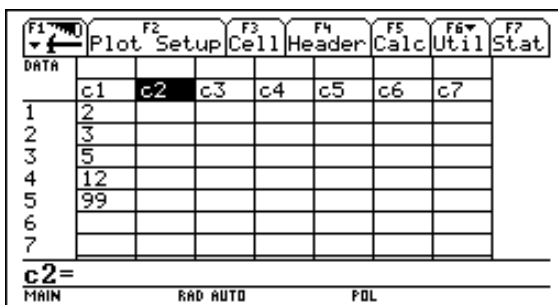
We enter four more integers.

- o 3 (ENTER) 5 (ENTER) 12 (ENTER) 99 (ENTER)



Each element of the second column shall equal the square of the corresponding element of the first column. To enter this definition, the highlighting must be moved to the second column's label 'C2' (left picture). Then we enter the definition (right picture).

- o ↑ ... → c1²



As soon as this input is confirmed with (ENTER), all elements of the second column are filled with the squares of their left hand neighbors.

- o (ENTER)

	F1 Plot	F2 Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	c1	c2	c3	c4	c5	c6	c7
1	2	4					
2	3	9					
3	5	25					
4	12	144					
5	99	9801					
6							
7							

r1c2=4
MAIN RAD AUTO PDL

When the third element of the first column is updated by the user, the third element of the second column will be updated automatically. This is just like a spreadsheet program would do it.

- o $\leftarrow \downarrow \downarrow$

(ENTER) 35 (ENTER)

	F1 Plot	F2 Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	c1	c2	c3	c4	c5	c6	c7
1	2	4					
2	3	9					
3	5	25					
4	12	144					
5	99	9801					
6							
7							

r3c1=5
MAIN RAD AUTO PDL

	F1 Plot	F2 Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	c1	c2	c3	c4	c5	c6	c7
1	2	4					
2	3	9					
3	35	1225					
4	12	144					
5	99	9801					
6							
7							

r4c1=12
MAIN RAD AUTO PDL

The third column shall be filled with the cubics of the first five integers. This can be achieved by entering the following definition for the column header C3:

- o $\uparrow \dots \rightarrow$

seq($n^3, n, 1, 5$) (ENTER)

	F1 Plot	F2 Setup	F3 Cell
DATA	c1	c2	c3
1	2	4	
2	3	9	
3	35	1225	
4	12	144	
5	99	9801	
6			
7			

c3=
MAIN RAD AUTO

	F1 Plot	F2 Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	c1	c2	c3	c4	c5	c6	c7
1	2	4					
2	3	9					
3	35	1225					
4	12	144					
5	99	9801					
6							
7							

c3=seq($n^3, n, 1, 5$)
MAIN RAD AUTO PDL

	F1 Plot	F2 Setup	F3 Cell
DATA	c1	c2	c3
1	2	4	1
2	3	9	8
3	35	1225	27
4	12	144	64
5	99	9801	125
6			
7			

r1c3=1
MAIN RAD AUTO

Each element of the forth column shall equal the sum of the respective elements of the second and third column. This is how to do it:

- o $\uparrow \rightarrow c2+c3$

(ENTER)

	F1 Plot	F2 Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	c1	c2	c3	c4	c5	c6	c7
1	2	4	1				
2	3	9	8				
3	35	1225	27				
4	12	144	64				
5	99	9801	125				
6							
7							

c4=c2+c3
MAIN RAD AUTO PDL

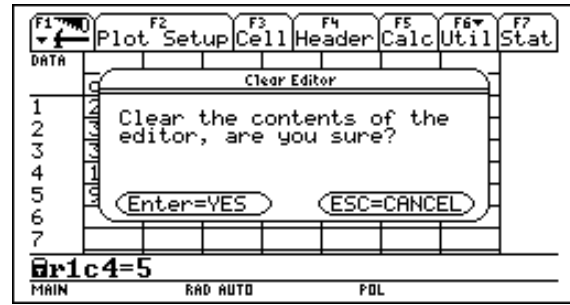
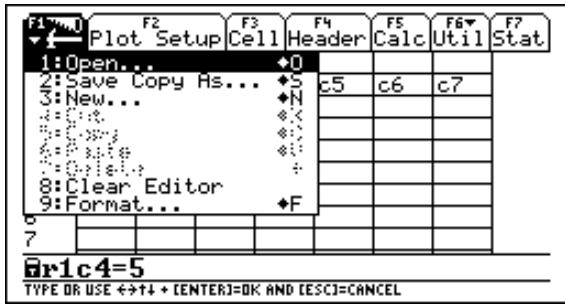
	F1 Plot	F2 Setup	F3 Cell	F4 Header	F5 Calc	F6 Util	F7 Stat
DATA	c1	c2	c3	c4	c5	c6	c7
1	2	4	1	5			
2	3	9	8	17			
3	35	1225	27	1252			
4	12	144	64	208			
5	99	9801	125	9926			
6							
7							

r1c4=5
MAIN RAD AUTO PDL

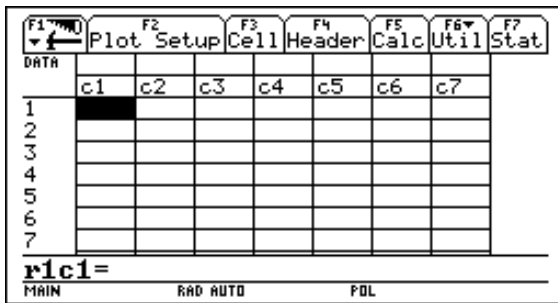
Before moving on to another example we delete all entries:

- o (F1)

(8): CLEAR EDITOR

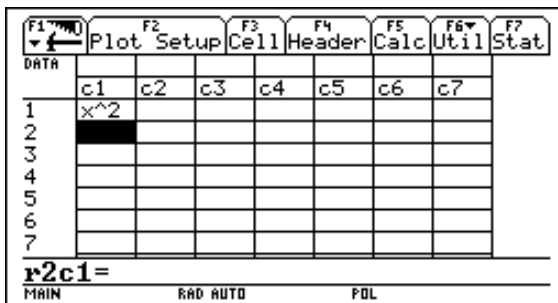


- o (ENTER)

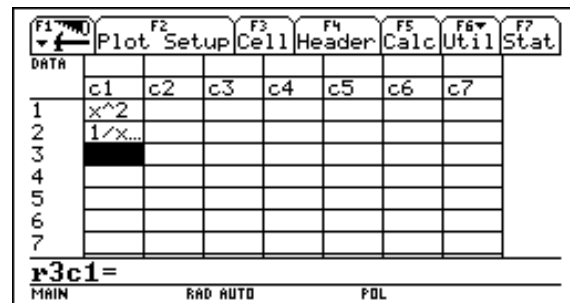


The spreadsheet features can be used with algebraic expressions as well. We fill the first column with various expressions.

- o x^2 (ENTER)

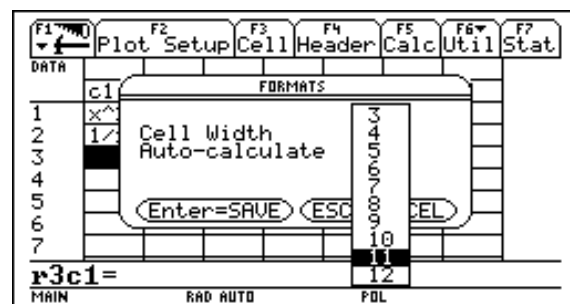
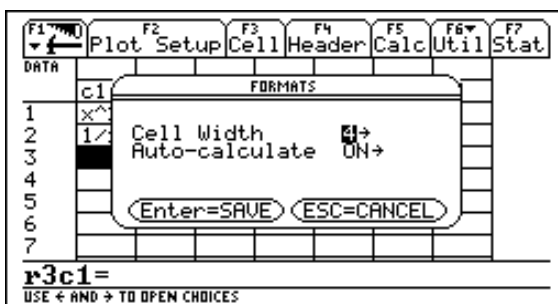


- o x^{-3} (ENTER)



The column is too narrow to display the second element fully. One has to increase the cell width via the FORMAT menu in order to change this. In all applications of the TI-92 the FORMAT menu is opened with the hot key

- o [♦](F)



We select cell-width 11 and continue filling the first column.

- o (ENTER) (ENTER)

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2					
2	1/x^3					
3						
4						
5						
6						
7						
r3c1=						
MAIN RAD AUTO PDL						

- sin(x) (ENTER)

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2					
2	1/x^3					
3	sin(x)					
4						
5						
6						
7						
r4c1=						
MAIN RAD AUTO PDL						

- o cos(x) (ENTER) ln(x) (ENTER) 10^x (ENTER)

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2					
2	1/x^3					
3	sin(x)					
4	cos(x)					
5	ln(x)					
6	10^x					
7						
r7c1=						
MAIN RAD AUTO PDL						

Each element of the second column shall equal the derivative of the corresponding element of the first column. The differential operator key is used to enter this definition just like one would enter it in the Home screen.

- o ↑ ... ↑ →

- [d] c1, x)

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2					
2	1/x^3					
3	sin(x)					
4	cos(x)					
5	ln(x)					
6	10^x					
7						
c2=						
MAIN RAD AUTO PDL						

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2					
2	1/x^3					
3	sin(x)					
4	cos(x)					
5	ln(x)					
6	10^x					
7						
c2=d(c1,x)						
MAIN RAD AUTO PDL						

(ENTER) concludes the input and starts the computation of all six derivatives (left picture). The third column shall include all antiderivatives (indefinite integrals), so we enter a respective definition for the column label C3.

- o (ENTER)

- ↑ →

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2	2*x				
2	1/x^3	-3/x^4				
3	sin(x)	cos(x)				
4	cos(x)	-sin(x)				
5	ln(x)	1/x				
6	10^x	ln(5)*10^x...				
7						
∫r1c2=2*x						
MAIN RAD AUTO PDL						

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2	2*x				
2	1/x^3	-3/x^4				
3	sin(x)	cos(x)				
4	cos(x)	-sin(x)				
5	ln(x)	1/x				
6	10^x	ln(5)*10^x...				
7						
c3=						
MAIN RAD AUTO PDL						

- o [] c1, x) (ENTER)

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2	2*x				
2	1/x^3	-3/x^4				
3	sin(x)	cos(x)				
4	cos(x)	-sin(x)				
5	ln(x)	1/x				
6	10^x	ln(5)*10^x...				
7						
r3c1=f(c1,x)						
MAIN	RAD	AUTO	FDL			

The demonstration of the data/matrix editor is concluded by updating two of the six elements of the first column. Observe how the respective elements of the second and third column are updated automatically.

- o ← ← (ENTER) x^5 (ENTER)

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^2	2*x		x^3/3		
2	1/x^3	-3/x^4		-1/(2*x^2)		
3	sin(x)	cos(x)		-cos(x)		
4	cos(x)	-sin(x)		sin(x)		
5	ln(x)	1/x		x*ln(x)-x		
6	10^x	ln(5)*10^x...		10^x/(ln(1...		
7						
r1c1=x^2						
MAIN	RAD	AUTO	FDL			

- o (ENTER) [√] x) (ENTER)

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^5	5*x^4		x^6/6		
2	f(x)	1/(2*f(x))		2*x^(3/2)/3		
3	sin(x)	cos(x)		-cos(x)		
4	cos(x)	-sin(x)		sin(x)		
5	ln(x)	1/x		x*ln(x)-x		
6	10^x	ln(5)*10^x...		10^x/(ln(1...		
7						
r3c1=sin(x)						
MAIN	RAD	AUTO	FDL			

The TI-92 is fully programmable. Programs can include standard programming constructs like if-then-else, loops, subroutines, and can use all the algebraic, graphic, and numeric functions that are available in the catalog. In the sequel we edit a very short program in order to demonstrate how the program editor works. The editor is started via the APPLICATIONS menu and a new program named PROG is opened.

- o (APPS) (7): PROGRAM EDITOR (3): NEW ↓ ↓ prog (ENTER)

F1	F2	F3	F4	F5	F6	F7
Plot	Setup	Cell	Header	Calc	Util	Stat
DATA						
	c1	c2		c3		
1	x^5	5*x^4		x^6/6		
2	f(x)	1/(2*f(x))		2*x^(3/2)/3		
3	sin(x)	cos(x)		-cos(x)		
4	cos(x)	-sin(x)		sin(x)		
5	ln(x)	1/x		x*ln(x)-x		
6	10^x	ln(5)*10^x...		10^x/(ln(1...		
7						
r3c1=sin(x)						
TYPE OR USE ←→+ [ENTER]=OK AND [ESC]=CANCEL						

F1	F2	F3	F4	F5	F6	F7
Control	I/O	Var	Find...	Mode		
NEW						
Type: Program →						
Folder: main →						
Variable: prog						
(Enter)=OK			(ESC)=CANCEL			
TYPE + [ENTER]=OK AND [ESC]=CANCEL						

- o (ENTER)

```

F1 Control F2 I/O F3 Var F4 Find... F5 Mode F6
:prog()
:Prgm
:
:
:EndPrgm
MAIN RAD AUTO PDL

```

The program editor already displays the start and end statements that are required for all program definitions. The program shall begin by requesting the input of an expression via a dialog box. This is achieved with the REQUEST command.

- o request "enter an expression",ex (ENTER)

```

F1 Control F2 I/O F3 Var F4 Find... F5 Mode F6
:prog()
:Prgm
:request "enter an expression",ex
:
:EndPrgm
MAIN RAD AUTO PDL

```

Since the REQUEST command reads a *string*, the contents of EX must be converted into an expression before it can be processed with some of the algebraic functions. This conversion is done using the function EXPR.

- o expr(ex) (STO) ex (ENTER)

```

F1 Control F2 I/O F3 Var F4 Find... F5 Mode F6
:prog()
:Prgm
:request "enter an expression",ex
:expr(ex)→ex
:
:EndPrgm
MAIN RAD AUTO PDL

```

This simple program shall do nothing but the computation and display of the input's derivative with respect to the variable x:

- o disp "1st derivative w.r.t. x:", [d]ex,x)

```

F1 Control F2 I/O F3 Var F4 Find... F5 Mode F6
:prog()
:Prgm
:request "enter an expression",ex
:expr(ex)→ex
:disp "1st derivative w.r.t. x",d(ex,x)
:
:EndPrgm
MAIN RAD AUTO PDL

```

This concludes the definition of the program. The hot key [\blacklozenge]-[HOME] leads us into the Home screen. From there we start the programm by entering its name with an empty list of arguments (left picture). Remember that no arguments were used in the program definition. The program requests an input through a dialog box (right picture).

- o [HOME] prog() (ENTER)

```

F1 Algebra F2 Calc F3 Other F4 PrgmIO F5 Clear a-z... F6
Graph x/3 Done
z^2 + 1 → f(z) Done
|f(x + i·y)| √(x^4 + 2·x^2·(y^2 + 1) + (y^2 - 1)^2)
Graph |f(x + i·y)| Done
CyclePic "pic", 3, .2, 10 Done
prog()
MAIN RAD AUTO PDL 26/30

```

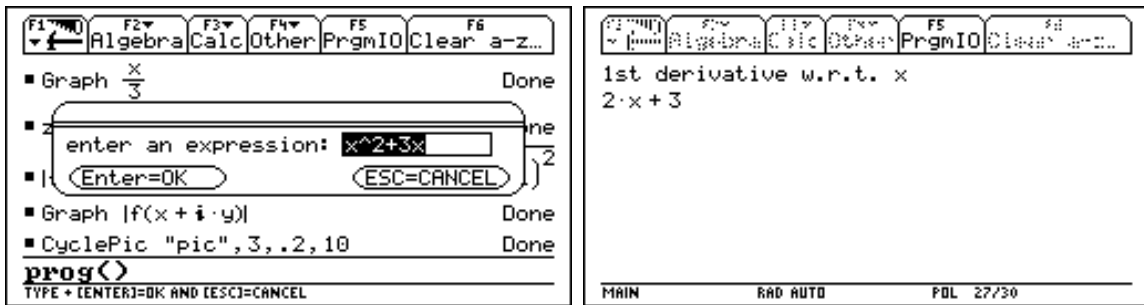
```

F1 Algebra F2 Calc F3 Other F4 PrgmIO F5 Clear a-z... F6
Graph x/3 Done
"enter an expression:" [x^2+3x] Done
(Enter=OK) (ESC=CANCEL)
Graph |f(x + i·y)| Done
CyclePic "pic", 3, .2, 10 Done
prog()
MAIN RAD AUTO PDL 26/30

```

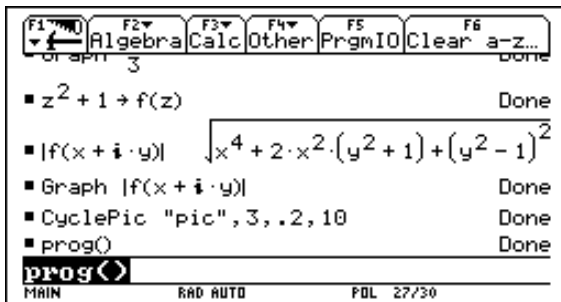
We enter the expression $x^2 + 3x$ into the dialog box (left picture). The program's output is displayed in the PROGRAM I/O screen (right picture).

- o x^2+3x (ENTER) (ENTER)



Use the (F5) function key to flip between the Home screen and the PROGRAM I/O screen.

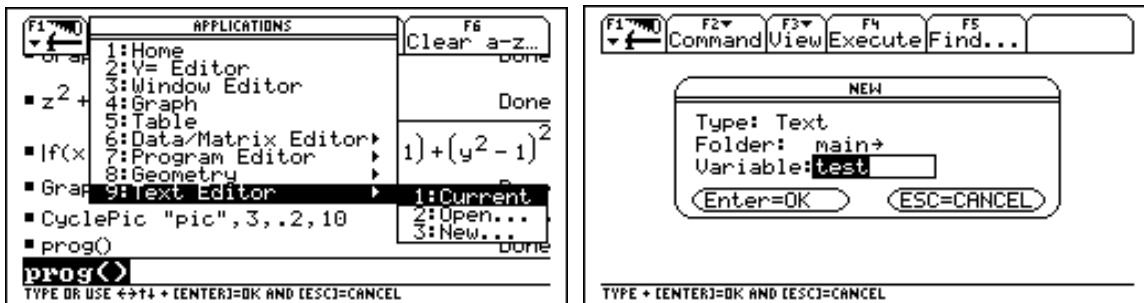
- o (F5)



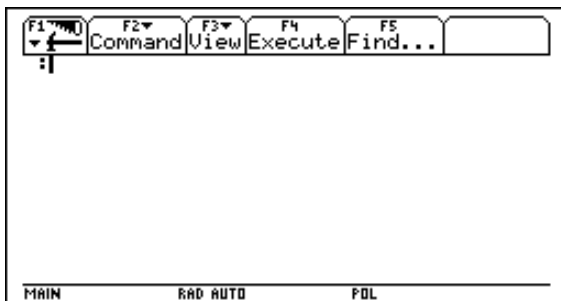
This concludes the demonstration of the program editor.

Last - but not least - the TI-92's text editor is demonstrated. The text editor not only includes the usual cut, copy and paste features, but also the use of command scripts for typing command lines that can be executed on the Home screen. This feature is demonstrated with the following example. We start the text editor from the APPLICATIONS menu and open a new text file named TEST.

- o (APPS) (9): TEXT EDITOR (3): NEW ↓ test (ENTER)



- o (ENTER)



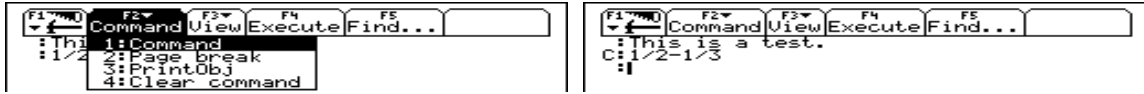
This will be the first line of text:

- o This is a test. (ENTER) $1+2-1+3$ (ENTER)



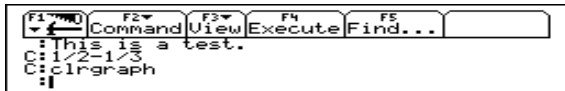
To make the second line an executable command, one has to apply the COMMAND command from the (F2): INSERT menu. As can be seen in the right picture, a command line is marked with a C.

- o (F2): COMMAND (1): COMMAND (ENTER)



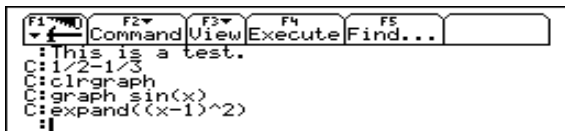
The CLRGRAPH command clears the plot screen from previous plots. It is advisable to use this command before starting a new plotting sequence (in particular in case it is unclear whether or not the plot window contains some plots from previous activities).

- o clrgraph (F2):COMMAND (1): COMMAND (ENTER)



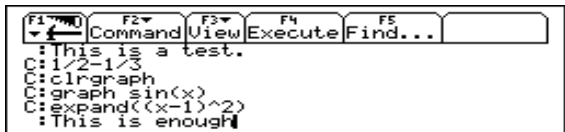
Two more command lines are entered:

- o graph sin(x) (F2):COMMAND (1): COMMAND (ENTER)
- o expand((x-1)^2) (F2):COMMAND (1): COMMAND (ENTER)



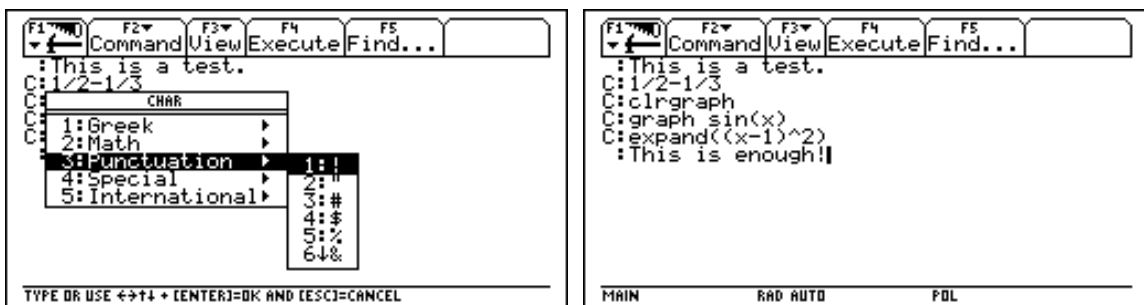
This will be the last line of text.

- o This is enough



Even the smallest example must serve a purpose in this demonstration. We wish to end this last sentence with an exclamation mark. But there is no such key on the keyboard. Therefore we consult the CHARACTER menu, for which there is a key. The exclamation mark can be found as the first symbol in the PUNCTUATION submenu (left picture). (ENTER) copies it into the editor (right picture).

- o [CHAR] (3): PUNCTUATION (ENTER)

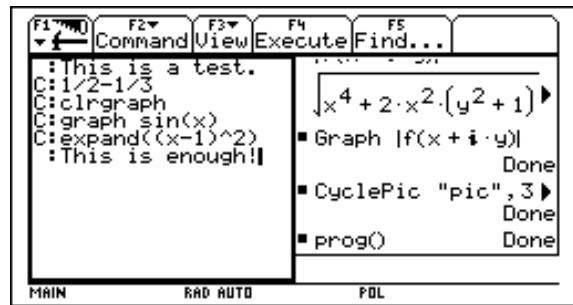


The SCRIPT VIEW mode allows to see the text file *and* the Home screen, which is nice when executing the command lines.

o (F3): VIEW



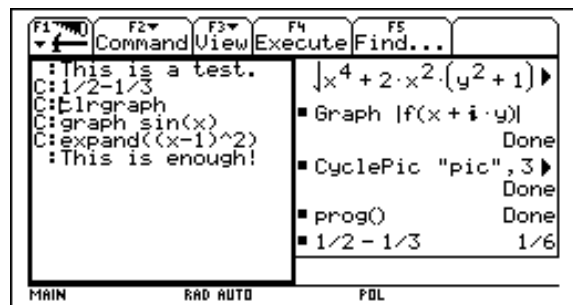
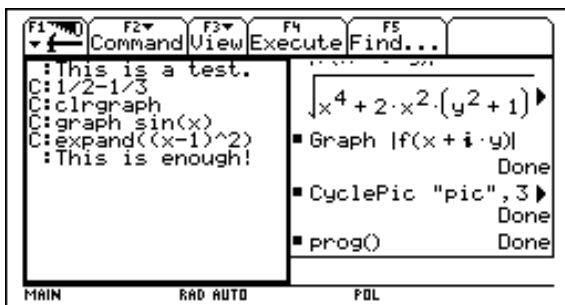
(1): SCRIPT VIEW



We move the cursor to the first command line (left picture) and then hit the (F4) function key. This sends the command line as an entry to the Home screen, where the respective calculation is performed. Afterwards control is returned to the text editor and the text cursor is placed at the beginning of the next line (right picture).

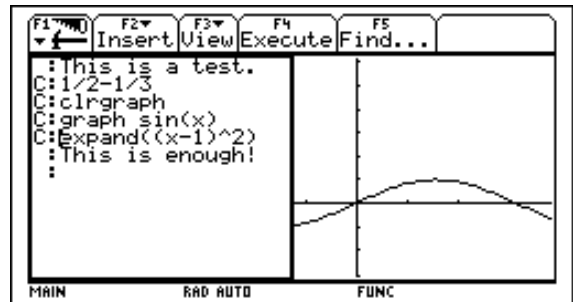
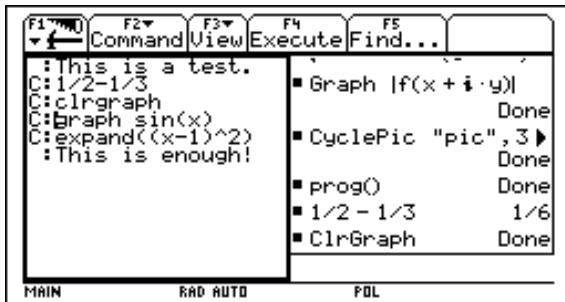
o ↑ ... ↑

(F4): EXECUTE

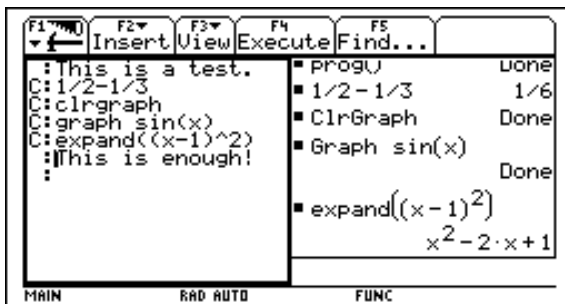


o (F4): EXECUTE

(F4): EXECUTE

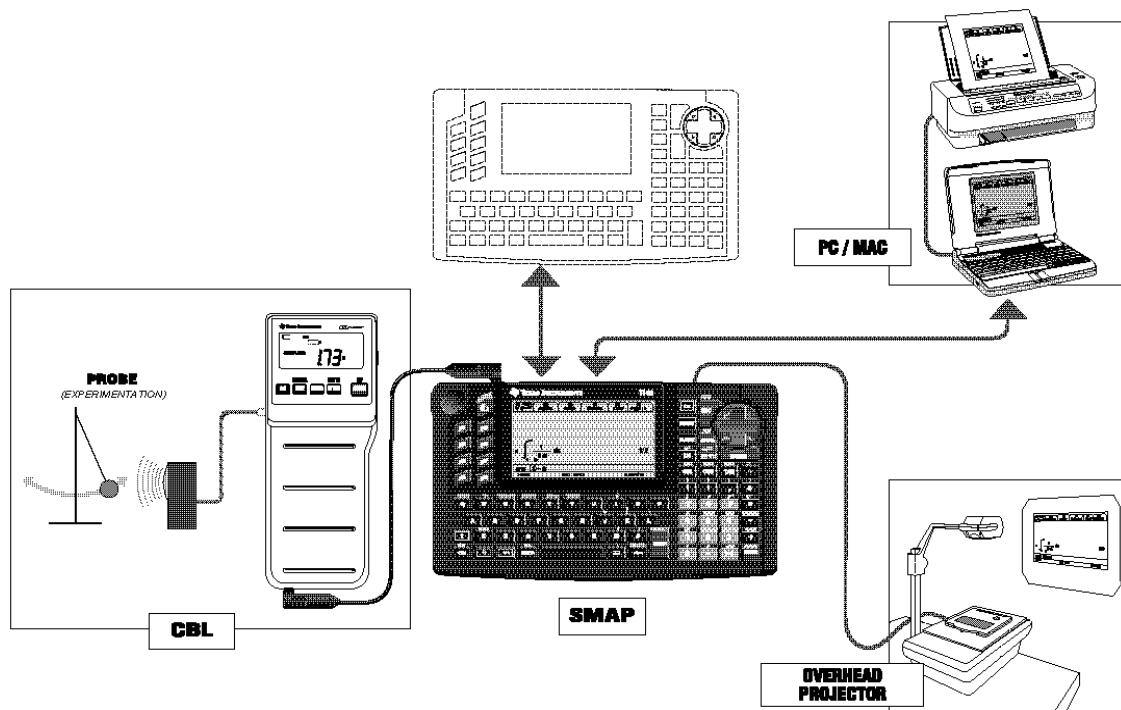


o (F4): EXECUTE



This concludes the demonstration of selected features of the TI-92.

(5) Connecting the TI-92 with ...



The TI-92 can be linked

- to another TI-92 for exchanging data,
- to a PC or a Macintosh for exchanging data and for printing,
- to a VIEWSCREEN™ for projecting the monitor via an overhead projector,
- to a CBL™ (Calculator Based Laboratory) for importing sample data from physical or chemical probes.

For more information write to:

Texas Instruments, Hubert Colombat, Haggertystr. 1, D-85356 Freising, Germany

Summary of the Demonstration:

(1) Demonstrating symbolic manipulation in the Home screen

- o $1 \div 2 + 1 \div 3$ (ENTER) $1/2 + 1/3$
- o $1 + x + 2x + 3$ (ENTER) $1 + x + 2x + 3$
- o $(x - 1) \div (x + 1)$ (ENTER) $\frac{x - 1}{x + 1}$
- o $[\sqrt{\quad}] \uparrow \uparrow \uparrow \uparrow \downarrow \downarrow \downarrow$ (ENTER)) (ENTER) $\sqrt{\frac{x - 1}{x + 1}}$ - using above expression
- o $[d] x^2 + a (*) x + b, x$ (ENTER) $\frac{d}{dx}(x^2 + a \cdot x + b)$
- o (F3): CALC (ENTER) $\uparrow \uparrow \uparrow$ (ENTER) , x) (ENTER) $\frac{d}{dx}\left(\sqrt{\frac{x - 1}{x + 1}}\right)$ - using above expression
- o $\rightarrow [|] x = 2$ (ENTER) evaluate last answer at $x = 2$
- o $[\approx]$ numeric approximation of last answer

- o $[\sqrt{ }] 1-x^2$ (ENTER) $\sqrt{1-x^2}$
- o $[\int] \uparrow$ (ENTER) , x) (ENTER) $\int \sqrt{1-x^2} dx$ - using last expression
- o $\rightarrow \leftarrow$, («-»)1, 1 (ENTER) $\int_{-1}^1 \sqrt{1-x^2} dx$ - updating last entry
- o x^3-3x^2+4x-2 (STO) exp (ENTER) $x^3-3x^2+4x-2 \rightarrow exp$
- o (F2): ALGEBRA (1): SOLVE exp=0, x) (ENTER) solve $exp=0$ nach x
- o (F2): ALGEBRA (B): COMPLEX exp=0, x) (ENTER) complex-solve $exp=0$ nach x
- o [CATALOG] (F) (ENTER) exp) (ENTER) factorize exp - taking FACTOR from the catalog
- o $\leftarrow c$ (ENTER) complex-factorize exp - adding the letter C
- o zeros(x^2-2 , x) (ENTER) zeros of x^2-2
- o $\rightarrow [|] x>0$ (ENTER) restrict search for zeros to positive case - updating last entry

- o (APPS) (6): DATA/MATRIX (3): NEW start matrix editor
- o MATRIX m with 3 rows and 3 columns (ENTER) 3 by 3 matrix named M
- o t (ENTER) t-1 (ENTER) 1 (ENTER) ... enter $\begin{pmatrix} t & t-1 & 1 \\ 1 & t^2 & t \\ 0 & t & t^2 \end{pmatrix}$ row by row
- o [HOME] m (ENTER) enter the M in home screen
- o [MATH](4): MATRIX (2): DET m) (ENTER) determinant of M
- o [VAR-LINK] \downarrow (F6): CONTENTS view contents of exp - using VAR-LINK
- o (ESC) (ESC) exit

(2) Demonstrating 2D and 3D plotting

- o (MODE) (F2): PAGE 2 \rightarrow (3): LEFT-RIGHT (ENTER) set Left-Right mode
- o (F4): OTHER (2): GRAPH $5\sin(x)$ (ENTER) plot $5\sin(x)$
- o [\leftarrow] (= (2nd) (APPS)) home screen
- o graph $x \div 3$ (ENTER) plot $x/3$
- o $\rightarrow \rightarrow \dots \downarrow$ move graphics cursor
- o (F3): TRACE trace mode on
- o $\rightarrow \dots \uparrow \rightarrow \dots$ («-»)5 (ENTER) use trace cursor
- o (F5): MATH (C): SHADE (ENTER) (ENTER) («-») 8 (ENTER) 8 (ENTER) shade between graphs
- o (F2): ZOOM (1): ZBOX $\uparrow \dots \leftarrow \dots$ zoom box + select 1st corner
- o (ENTER) $\leftarrow \leftarrow \leftarrow \dots \downarrow \downarrow \downarrow \dots \downarrow \downarrow \downarrow \dots$ (ENTER) select 2nd corner
- o (F7) (7): TEXT $\uparrow \dots \leftarrow \dots$ text tool + select position
- o t $\uparrow e \uparrow x \uparrow t \uparrow \uparrow \uparrow \uparrow \uparrow$ enter text

- o (MODE) \rightarrow (5): 3D (ENTER) 3D mode
- o [\blacklozenge](F) FORMAT menu
- o $\downarrow \rightarrow$ (2): AXES (ENTER) axes on
- o [WINDOW] WINDOW screen
- o $\downarrow \downarrow -2 \downarrow 2 \downarrow 20 \downarrow -2 \downarrow 2 \downarrow 20 \downarrow -.5 \downarrow 1.5 \downarrow .2$ change plot screen parameters
- o [GRAPH] PLOT screen
- o [\leftarrow] flip windows

- o z^2+1 (STO) $f(z)$ (ENTER) store z^2+1 as $f(x)$
- o $\text{abs}(f(x+iy))$ (ENTER) $|f(x+iy)|$
- o $\uparrow \rightarrow \rightarrow \rightarrow \downarrow \leftarrow$ show side scrolling
- o (F4): OTHER (2): GRAPH (ENTER) plot last answer

- o (MODE) \rightarrow (3): POLAR polar mode
- o (F2): PAGE2 \rightarrow (1): FULL (ENTER) full screen
- o [Y=] Y= editor
- o 1 (ENTER) 1 - i.e. circle with radius 1
- o [GRAPH] plot curve
- o (F2): ZOOM (4): ZOOMDEC zoom decimal
- o (F1) (2): SAVE COPY AS \rightarrow (2): PICTURE $\downarrow \downarrow$ pic1 (ENTER) (ENTER) save picture as *pic1*
- o [Y=] \uparrow (ENTER) 2 (ENTER) [GRAPH] enter 2 and plot circle with radius 2
- o [\blacklozenge](S) \rightarrow (2): PICTURE $\downarrow \downarrow$ pic2 (ENTER) (ENTER) save picture as *pic2*
- o [Y=] \uparrow (ENTER) 3 (ENTER) [GRAPH] enter 3 and plot circle with radius 3
- o [\blacklozenge](S) \rightarrow (2): PICTURE $\downarrow \downarrow$ pic3 (ENTER) (ENTER) save picture as *pic3*
- o [HOME] home screen
- o `cyclepic "pic",3,.2,10` (ENTER) make "movie" from *pic1*, *pic2* and *pic3*

(3) Demonstrating interactive geometry

- o (APPS) (8):GEOMETRY (3):NEW \downarrow geo (ENTER) (ENTER) start new geometry screen
- o (F2) (5):SEGMENT $\leftarrow \dots \swarrow \dots \downarrow$ SEGMENT
- o (ENTER) a point A
- o $\rightarrow \dots \nearrow \dots$ (ENTER) b point B
- o $\leftarrow \dots \swarrow \dots$ (ENTER) c point C - lying on AB
- o $\uparrow \dots \nearrow \dots$ (ENTER) d point D
- o (F4) (4):PERPENDICULAR BISECTOR PERPENDICULAR BISECTOR
- o $\swarrow \dots \swarrow$ (ENTER) $\uparrow \dots \uparrow$ select segment CD
- o (F1) (1):POINTER POINTER
- o $\leftarrow \dots \swarrow \dots \downarrow \dots (\text{⦿}) (\text{⦿})-\downarrow \dots (\text{⦿})-\rightarrow \dots$ move point A
- o (F4) (A): LOCUS LOCUS
- o $\uparrow \dots \uparrow$ (ENTER) select bisector
- o $\downarrow \dots \swarrow \dots$ (ENTER) select point C
- o (F7) (3): ANIMATION ANIMATION
- o $(\text{⦿}) (\text{⦿})-\leftarrow \leftarrow \leftarrow (\text{⦿})-\leftarrow \leftarrow \leftarrow \dots$ release the hand... applying to C
- o (ENTER) stop
- o (F8) (8): CLEAR ALL (ENTER) CLEAR ALL

- o (F2) (4): LINE LINE
- o $\uparrow \dots \nearrow \dots$ (ENTER) $\nearrow \nearrow \nearrow \dots$ (ENTER) select point and direction for 1st line
- o $\downarrow \downarrow \downarrow \dots$ (ENTER) $\uparrow \dots \nwarrow \dots$ (ENTER) select point and direction for 2nd line
- o (F2) (3): INTERSECTION POINT INTERSECTION POINT
- o (ENTER) $\rightarrow \dots \rightarrow$ (ENTER) select both lines
- o (F6) (5): EQUATION & COORDINATES EQUATION & COORDINATES

- o \blacktriangleleft ... \blacktriangleleft (ENTER) select intersection point
- o (F6) (7): COLLECT DATA COLLECT DATA
- o (2): DEFINE ENTRY DEFINE ENTRY
- o \uparrow ... \nearrow ... \rightarrow ... (ENTER) select first coordinate
- o \rightarrow ... (ENTER) select second coordinate
- o (F6) (7): COLLECT DATA (1): STORE DATA COLLECT DATA - STORE DATA
- o (F8) (B): DATA VIEW DATA VIEW
- o \uparrow ... \leftarrow move line
- o [\blacklozenge](D) hotkey for STORE DATA
- o \leftarrow move line
- o [\blacklozenge](D) hotkey for STORE DATA
- o (F8) (C): CLEAR DATA VIEW CLEAR DATA VIEW

(4) A glimpse at the various editors

- o (APPS) (6): DATA/MATRIX EDITOR (3): NEW $\downarrow\downarrow$ dat (ENTER) (ENTER)..... start data editor
- o 2 (ENTER) 1st column: 2;
- o 3 (ENTER) 5 (ENTER) 12 (ENTER) 99 (ENTER) 3; 5; 12; 99
- o \uparrow ... \rightarrow $c1^2$ (ENTER) 2nd column = $c1^2$
- o $\leftarrow\downarrow\downarrow$ (ENTER) 35 (ENTER) update 3rd element of 1st column to 35
- o \uparrow ... \rightarrow $seq(n^3, n, 1, 5)$ (ENTER) 3rd column = $seq(n^3, n, 1, 5)$
- o \uparrow \rightarrow $c2+c3$ (ENTER) 4th column = $c3+c4$
- o (F1) (8): CLEAR EDITOR (ENTER) clear data editor
- o x^2 (ENTER) x^{-3} (ENTER) 1st column: x^2 ; x^{-3} ;
- o [\blacklozenge](F) $\rightarrow\downarrow$... \downarrow (ENTER) (ENTER) set cell width to 11
- o $\sin(x)$ (ENTER) $\sin(x)$;
- o $\cos(x)$ (ENTER) $\ln(x)$ (ENTER) 10^x (ENTER) $\cos(x)$; $\ln(x)$; 10^x
- o \uparrow ... \uparrow \rightarrow [d] $c1, x$ (ENTER) 2nd column = $\frac{d}{dx} c1$
- o \uparrow \rightarrow [\int] $c1, x$ (ENTER) 3rd column = $\int c1 dx$
- o $\leftarrow\leftarrow$ (ENTER) x^5 (ENTER) change 1st element of 1st column to x^5
- o (ENTER) [\sqrt] x (ENTER) change 2nd element of 1st column to \sqrt{x}
- o (APPS) (7): PROGRAM EDITOR (3): NEW $\downarrow\downarrow$ prog (ENTER) (ENTER) start program editor
- o request "enter an expression", ex (ENTER) 1st line: "enter an expression", ex
- o expr(ex) (STO) ex (ENTER) 2nd line: $expr(ex) \rightarrow ex$
- o disp "1st derivative w.r.t. x:", [d] ex, x) 3rd line: "1st derivative w.r.t. x", $\frac{d}{dx} ex$
- o [HOME] home screen
- o prog() (ENTER) start program: prog()
- o x^2+3x (ENTER) (ENTER) enter $x^2 + 3x$
- o (F5) exit from program i/o page
- o (APPS) (9): TEXT EDITOR (3): NEW \downarrow test (ENTER) (ENTER) start text editor

- o This is a test. (ENTER) 1st line: *This is a test.*
- o $1 \div 2 - 1 \div 3$ (ENTER) 2nd line: $1/2 - 1/3$
- o (F2):COMMAND (1): COMMAND (ENTER) make it a command line
- o `clrgraph` (F2):COMMAND(1): COMMAND (ENTER) 3rd line: *clrgraph*; make it command line
- o `graph sin(x)` (F2):COMMAND(1): COMMAND (ENTER) .. 4th line: *graph sin(x)*; make it command line
- o `expand((x-1)^2)` (F2):COMMAND(1): COMMAND (ENTER)
..... 5th line: *expand((x-1)^2)*; make it command line
- o This is enough 6th line: *This is enough*
- o (2nd)[CHAR] (3): PUNCTUATION (ENTER) select *exclamation mark* from CHAR menu

- o (F3): VIEW (1): SCRIPT VIEW SCRIPT VIEW mode
- o \uparrow ... \uparrow (F4): EXECUTE execute 2nd line
- o (F4): EXECUTE (F4): EXECUTE (F4): EXECUTE execute all other lines