

DEMONSTRATING THE TI-92

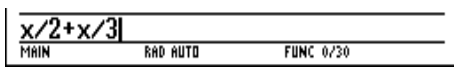
IN 10 MINUTES

Texas Instruments' new TI-92 offers the features of programs like DERIVE and CABRI GEOMETRE - among other things - and still gives the user the full independence of a calculator that is small in size, light in weight, and utterly robust (so that it is perfectly suitable for a student's school bag). In the following 10 minutes I will demonstrate a small portion of what the TI-92 can do for you.

We start with a simple symbolic operation:

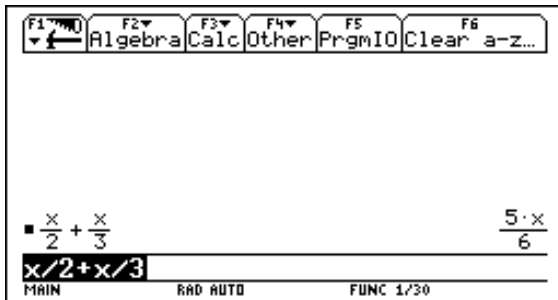
- o $x \div 2 + x \div 3$

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



We press (ENTER) to conclude the input and perform an automatic simplification.

- o (ENTER)



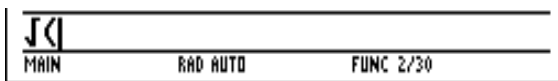
The first *history pair* is now displayed in the *history area* (this is the space between the menu bar and the line editor). A history pair consists of the *entry* (left) and the *answer* (right). As a next example we will enter the expression $\sqrt{\frac{x+1}{x-1}}$ in two steps:

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



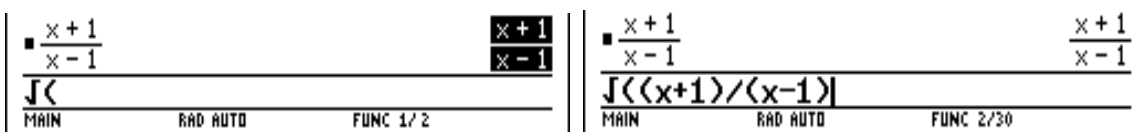
Pressing the square root key inserts a square root symbol *and* an opening parenthesis into the line editor:

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



To copy the last answer into the line editor, we highlight it and press (ENTER) for the copying.

- o \uparrow (ENTER)



It remains to type the closing parenthesis and to conclude the input with (ENTER):

- o $)$ (ENTER)

Calculus

The next example shows how the TI-92 can do calculus. The differential operator can be entered, for example, by using the (d) key (which is the second function of the key (8), left picture). In order to differentiate the last answer, we highlight it (right picture),

- o (d) \uparrow

copy it into the line editor, and insert a comma, the differentiation variable x and a closing parenthesis.

- o (ENTER), x) (ENTER)

It is simple to evaluate this derivative at a specific point, e.g. at $x=2$. Since the last entry still is displayed in the line editor, we use the right arrow to remove the highlighting and position the cursor at the end of the expression. Then we enter the »With« operator (denoted by a vertical bar) and the constraint $x=2$:

- o \rightarrow [|] $x=2$ (ENTER)

To obtain a numeric approximation instead of the above exact result, we use [\blacklozenge] (ENTER):

- o [\blacklozenge] (ENTER)

How about computing $\int \frac{1}{1+x^3} dx$? We first enter the expression $\frac{1}{1+x^3}$:

- o $1 \div (1+x^3)$ (ENTER)

We then enter the integral operator via the keyboard and highlight and copy the last answer:

- o [\int] \uparrow

We copy the expression into the line editor, insert a comma, the integration variable x , and a closing parenthesis, and conclude the input with (ENTER).

- o (ENTER), x) (ENTER)

$f\left(\frac{1}{x^3+1}\right)$
 MAIN RAD AUTO FUNC 7/30

$\int \left[\frac{1}{x^3+1} \right] dx$

$$\frac{\ln\left(\frac{(x+1)^2}{|x^2-x+1|}\right)}{6} + \frac{\sqrt{3} \cdot \tan^{-1}\left(\frac{\sqrt{3} \cdot (2x-1)}{3}\right)}{3}$$

 $f\left(\frac{1}{x^3+1}\right), x$
 MAIN RAD AUTO FUNC 8/30

Solving equations

We want to store 150 bottles of wine in the form of a triangle: n bottles in the first row, $n-1$ bottles in the second row, etc. With how many bottles should we start the first row? Employing the formula $\sum_{i=1}^n i = \frac{(n+1)n}{2}$, this leads to the problem of solving a quadratic equation. We will use the TI-92 to find n :

- o $(n+1)n/2=150$ (ENTER)

$\frac{(n+1) \cdot n}{2} = 150$ $\frac{n \cdot (n+1)}{2} = 150$
 $(n+1)n/2=150$
 MAIN RAD AUTO FUNC 9/30

There is no Solve key on the keyboard, but we find a respective function in the ALGEBRA pull-down menu:

- o (F2):ALGEBRA

Algebra Calc Other PrgmIO Clear a-z...
 1:solve(
 2:factor(
 3:expand(
 4:zeros(
 5:approx(
 6:comDenom(
 7:propFrac(
 8:nSolve(
 9:Trig
 A:Complex
 B:Extract
 $(n+1)n/2=150$
 $(n+1)n/2=150$
 TYPE OR USE \leftrightarrow + (ENTER)=OK AND (ESC)=CANCEL

We use (ENTER) to copy the highlighted option, which happens to be SOLVE, into the editor.

- o (ENTER)

$solve($
 MAIN RAD AUTO FUNC 9/30

We also copy the last answer and add the variable with respect to which the equation should be solved.

- o \uparrow (ENTER), n (ENTER)

$\int \left[\frac{1}{x^3+1} \right] dx$

$$\frac{\ln\left(\frac{(x+1)^2}{|x^2-x+1|}\right)}{6} + \frac{\sqrt{3} \cdot \tan^{-1}\left(\frac{\sqrt{3} \cdot (2x-1)}{3}\right)}{3}$$

 $\frac{(n+1) \cdot n}{2} = 150$ $\frac{n \cdot (n+1)}{2} = 150$
 $solve(n*(n+1)/2=150$
 MAIN RAD AUTO FUNC 9/30

$solve\left(\frac{n \cdot (n+1)}{2} = 150, n\right)$
 $n = \frac{-\sqrt{1201} + 1}{2}$ or $n = \frac{\sqrt{1201} - 1}{2}$
 $solve(n*(n+1)/2=150,n)$
 MAIN RAD AUTO FUNC 10/30

To obtain a numerical approximation also, we repeat the computation with [\blacklozenge] (ENTER).

- o [\blacklozenge] (ENTER)

$solve\left(\frac{n \cdot (n+1)}{2} = 150, n\right)$
 $n = 16.8277$ or $n = -17.8277$
 $solve(n*(n+1)/2=150,n)$
 MAIN RAD AUTO FUNC 11/30

There are more methods of entering a function: there is a Catalog to choose from and there is the Math menu, both of which can be accessed via the keyboard. Or one simply types the function name:

- o $solve(x^4-1=0, x)$ (ENTER)

The SOLVE function produces the real solutions only (properly separated by the logical OR operator), which is what most teachers prefer. For obtaining the complex solutions also, we need to change the function name to CSOLVE, which can be done e.g. by inserting the letter >C< in front of the expression.

- o \leftarrow C (ENTER)

In the next example we *restrict* the domain for the solution to the positive real numbers. This is done by copying the penultimate entry into the editor and adding the »With« operator and the constraint $x > 0$.

- o $\uparrow\uparrow\uparrow\uparrow$ (ENTER) [|] $x > 0$ (ENTER)

So far, the TI-92 was used as a »symbolic calculator« for processing algebraic data (as opposed to the »scientific calculator« which processes only numbers). However, the TI-92 also is a very useful educational tool for learning mathematical skills like, for example, solving equations.

We start with the simple equation $5x - 6 = 2x + 15$ and then we will choose and apply equivalence transformations step by step, aiming at gradually transforming the given equation into the form $x = \dots$

- o $5x - 6 = 2x + 15$ (ENTER)

The (ANS) key (which is the second function of the >negative< key) introduces the expression ANS(1), which refers to the last answer. This provides a useful method for applying an equivalence transformation to an equation:

- o (ANS) $-2x$ (ENTER)

A useful next step would be to add 6 to both sides:

- o (ANS) $+6$ (ENTER)

Many beginners make a fatal (but typical) mistake here by arguing that »there is a 3 in front of the variable x. To get rid of the 3 I need to subtract 3«. In a hand calculation they would end up with the wrong solution $x = 18$ and would have difficulties in detecting this error. If, however, they use the TI-92 as shown here, thus delegating the application of the equivalence transformation to the calculator,

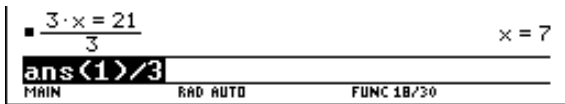
- o (ANS) -3 (ENTER)

they receive an immediate feedback on the >quality< of their choice: Since -3 did not *simplify* the equation further, this equivalence transformation was not a good choice. So we better delete the last history pair

- o \uparrow (CLEAR)

and try something different:

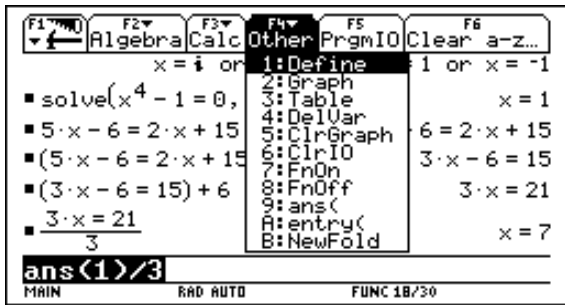
- o \downarrow (ANS) $\div 3$ (ENTER)



Plotting graphs

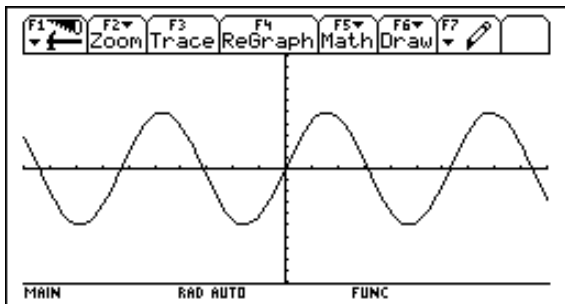
The command for plotting a graph can be found in the OTHER pull-down menu.

- o (F4):OTHER



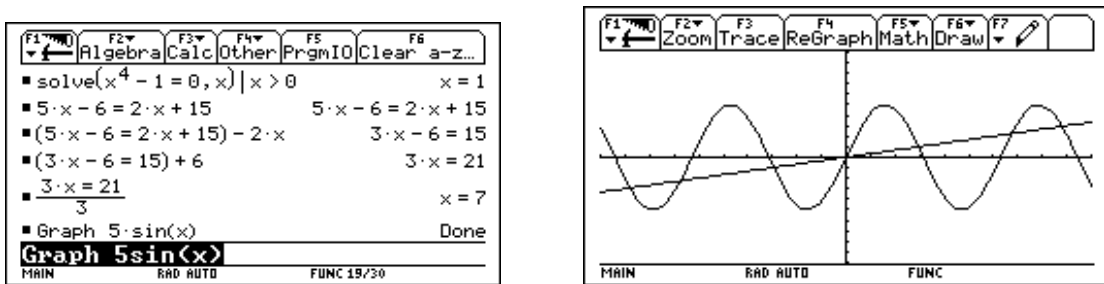
A shortcut for selecting one of the menu options is pressing the key that corresponds to the character left of the option, e.g. the key (2) for the GRAPH command.

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



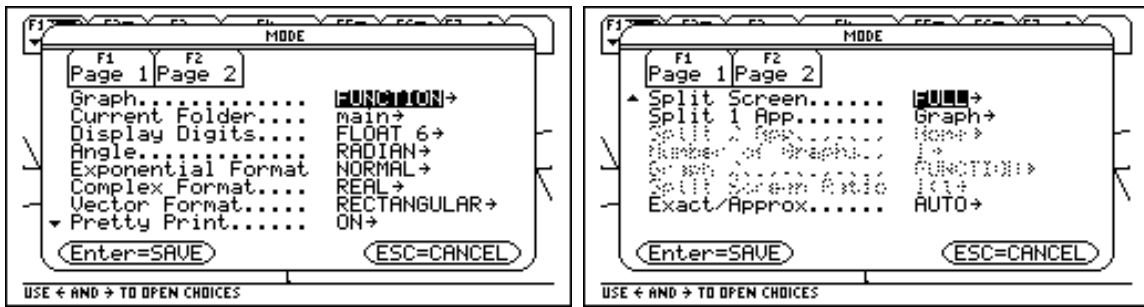
This command automatically switches to the graphics screen, which is overlaid the home screen we have been using so far. (HOME) (= [\blacklozenge] (Q)) is the hot key for switching back to the home screen. We use it for plotting another graph.

- o (HOME) graph $x+3$ (ENTER)



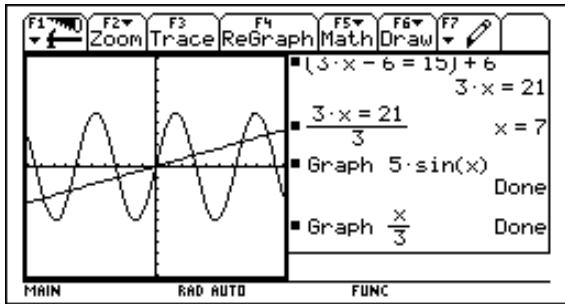
However, it would be nice to see the home screen and the graphics screen at the same time. This can be achieved by splitting the screen via the MODE menu. We open the MODE menu, change to its second page

- o (MODE) (F2):PAGE 2



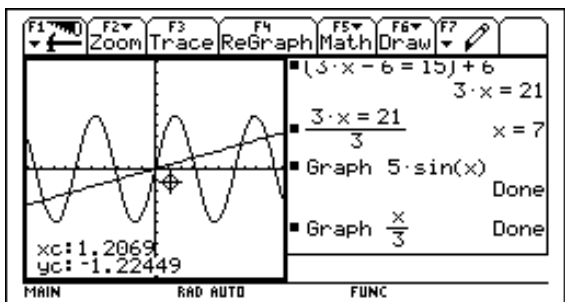
and select the LEFT-RIGHT option from the SPLIT SCREEN selection menu.

- o → (3):LEFT-RIGHT (ENTER)



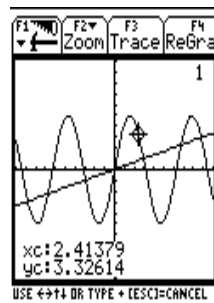
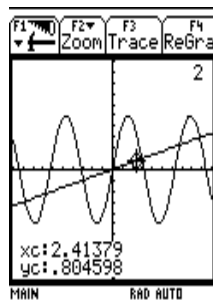
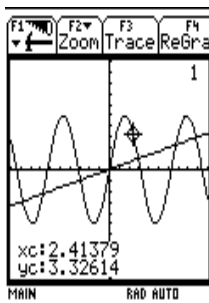
Pressing any edge of the cursor pad switches on the display of a graphics cursor. This cursor can be moved via the cursor pad. Its coordinates are displayed in the lower left corner.

- o →... ↓...



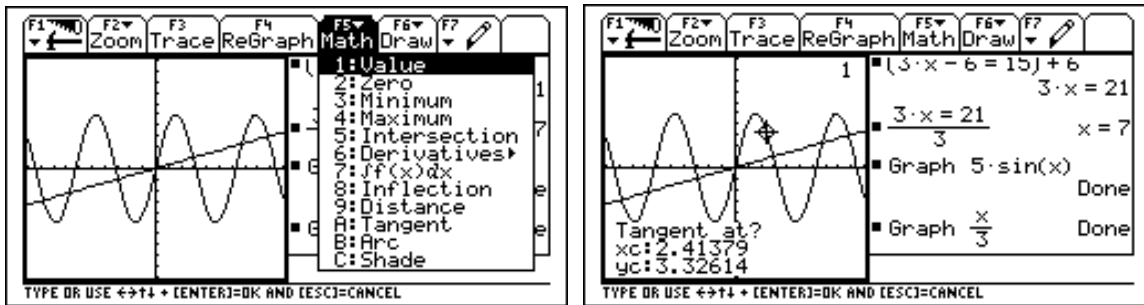
The (F3) function key switches on the *trace mode*. In trace mode, → and ← move the cursor along a curve. ↑ and ↓ let you set the cursor on another curve (in case there is one).

- o (F3):TRACE →... ↓ ↑



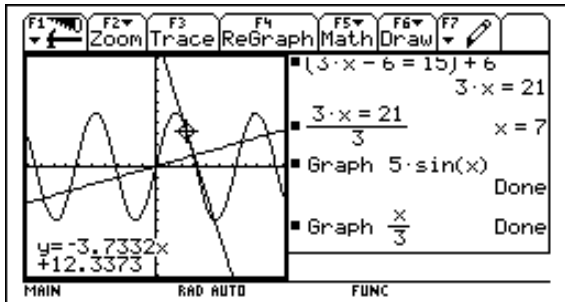
The MATH menu offers a wide range of commands for analysing a graph or drawing something to it. We demonstrate the TANGENT command.

- o (F5):MATH (A):TANGENT



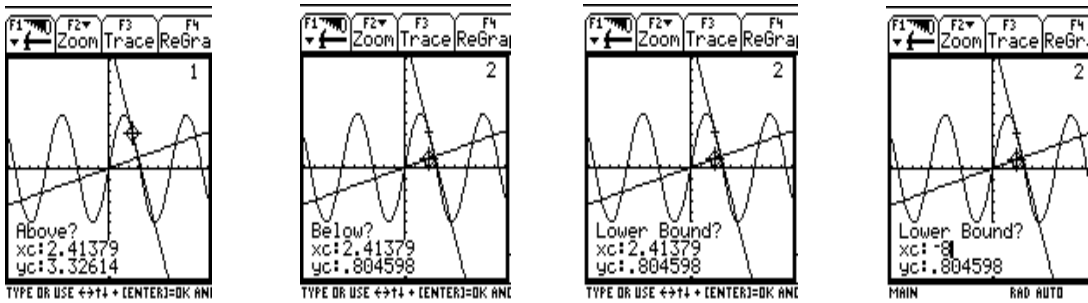
Note the question above the cursor coordinates. We need to specify a point at which the tangent should be drawn. Since we are happy with the current cursor position, we simply press

- o (ENTER)

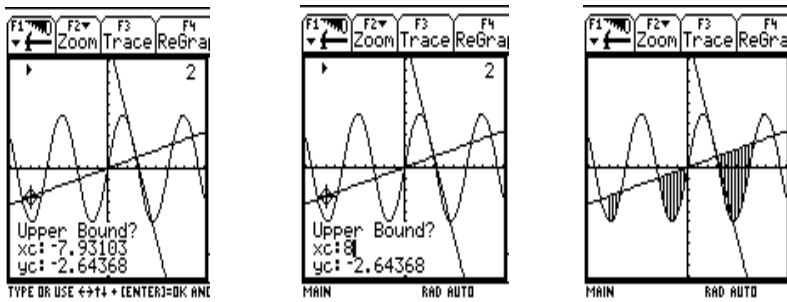


We conclude the demonstration of the graphics capabilities by shading the area between the two curves. Again, we need to answer a couple of relevant questions.

- o (F5):MATH (C):SHADE (ENTER) (ENTER) - 8

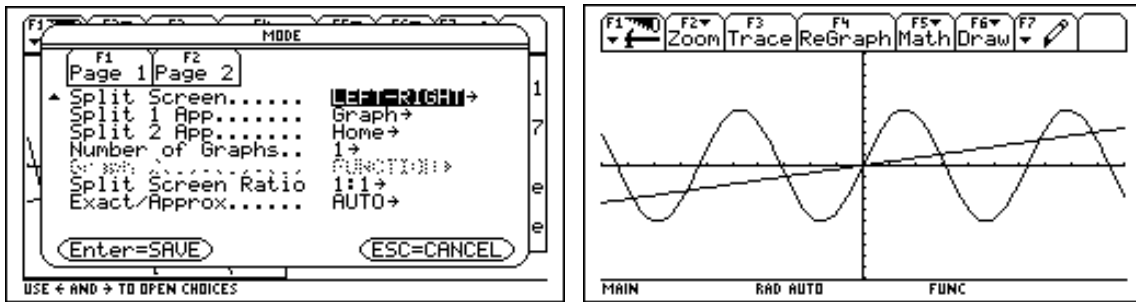


- o (ENTER) 8 (ENTER)



Before we continue with demonstrating the interactive geometry application, we set the calculator back to full screen mode.

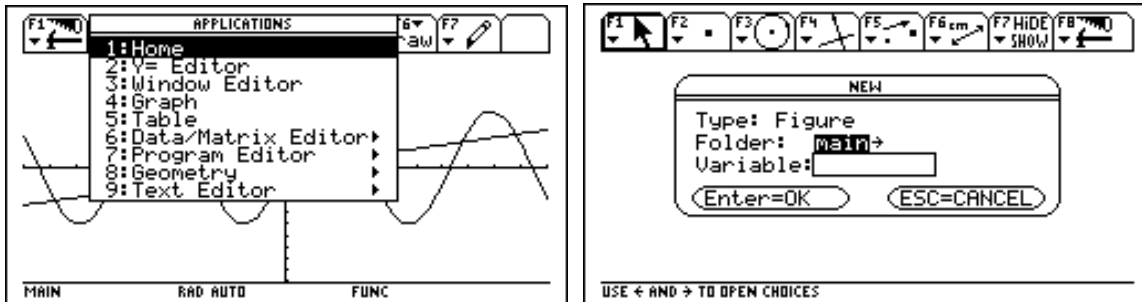
- o (MODE) (F2):PAGE 2 → (1):FULL (ENTER)



Interactive Geometry

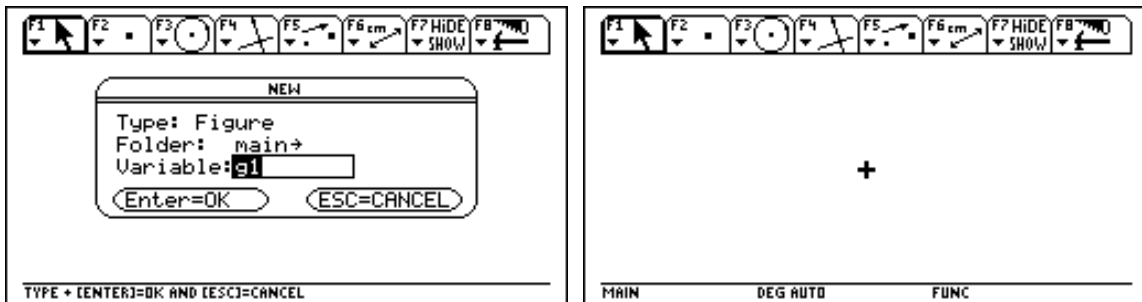
To start the interactive geometry module, we open the APPLICATIONS menu by pressing the (APPS) key. We select the GEOMETRY submenu the option NEW from therein.

- o (APPS) (8):GEOMETRY (3):NEW



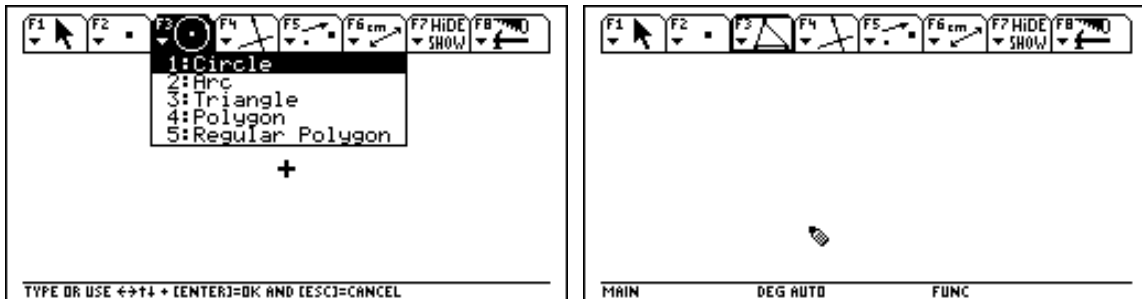
The TI-92 requests a name of the geometry figure. We call it G1.

- o ↓ g1 (ENTER) (ENTER)



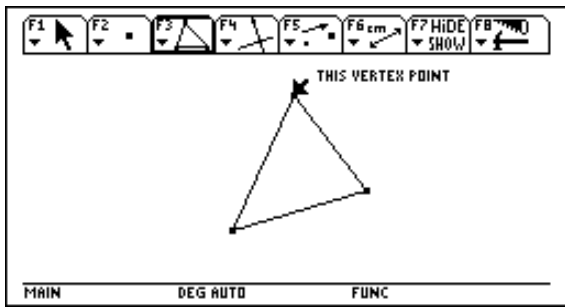
The screen now shows an electronic drawing board with a geometry cursor. The menu bar offers groups of tools. To construct a triangle, we open the (F3) menu (left picture), from which we select the TRIANGLE tool. We move the graphics cursor to the position where the first vertex should be and press (ENTER) to draw the point.

- o (F3) (3):TRIANGLE ↓ ... ↓ ... (ENTER)



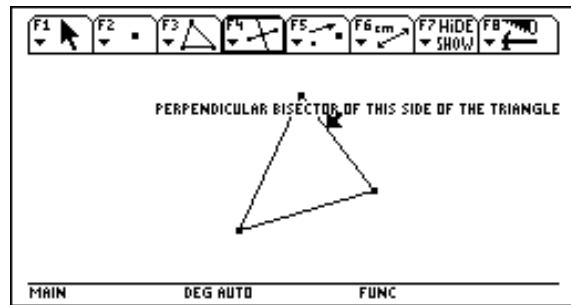
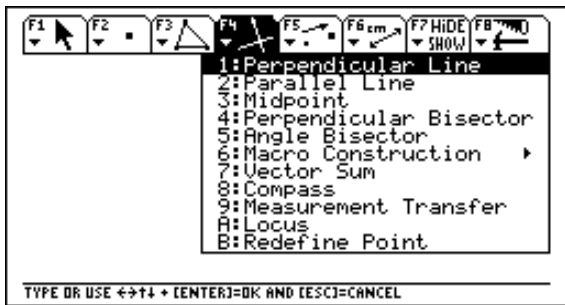
Then we select the other two vertices, thus completing the drawing of the triangle.

- o ↗ ... (ENTER) ↖ ... (ENTER)



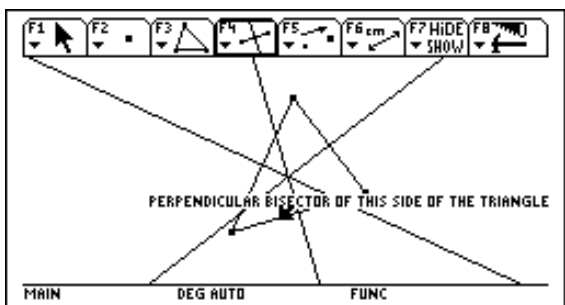
To construct the three perpendicular bisectors of the three sides, we open the (F4) menu (left picture) and start the PERPENDICULAR BISECTOR tool. We move the graphics cursor so that it points to the upper right triangle side until the message »PERPENDICULAR BISECTOR OF THIS SIDE OF THE TRIANGLE« appears.

- o (F4) (4):PERPENDICULAR BISECTOR ↘ ...



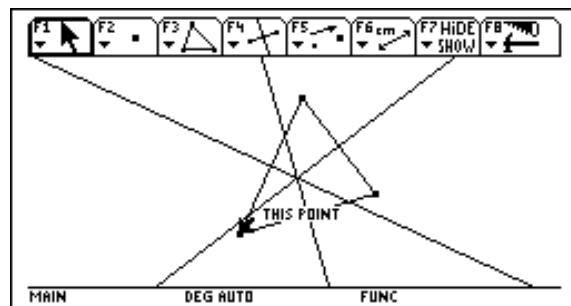
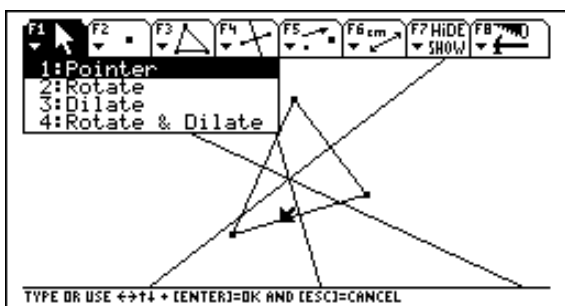
Pressing (ENTER) introduces the said perpendicular bisector. We then move the cursor to the upper left side, introduce its perpendicular bisector and repeat the procedure for the lower side. Clearly, all three perpendicular bisectors intersect in one point.

- o (ENTER) ← ... (ENTER) ↓ ... (ENTER)



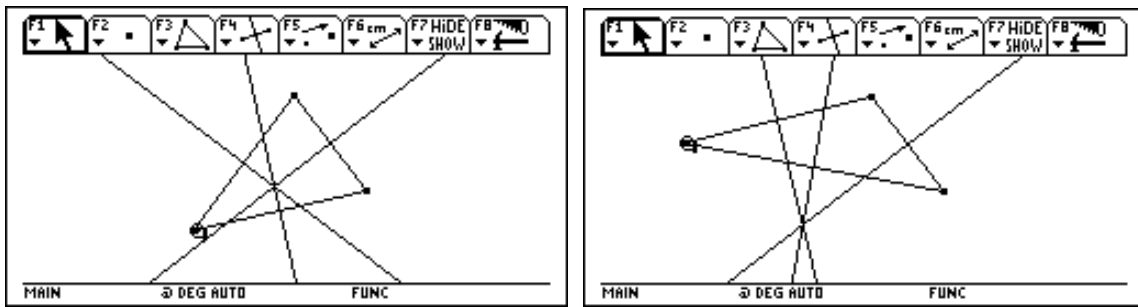
Now we can move one of the three vertices and observe how the triangle and the three perpendicular bisectors change their positions respectively. We prepare this task by selecting the POINTER tool from the (F1) menu and moving the pointer to the lower left vertex.

- o (F1) (1):POINTER ↙ ...



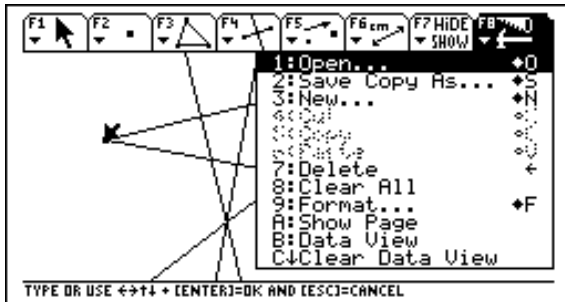
We press the hand key [⌨] and, while holding it down, we use the cursor pad to move the vertex. Observe how the whole figure changes its appearance.

- o [⌨]-← ... [⌨]-↖ ...

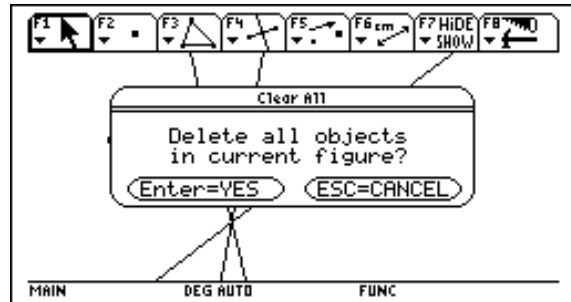


Before proceeding with the last example, we delete all objects in the current figure.

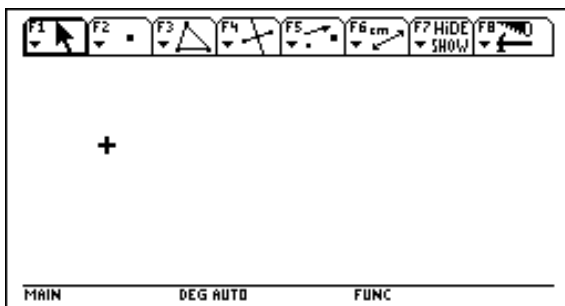
- o (F8)



- (8):CLEAR ALL

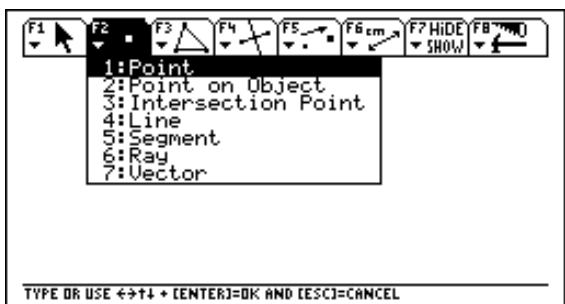


- o (ENTER)

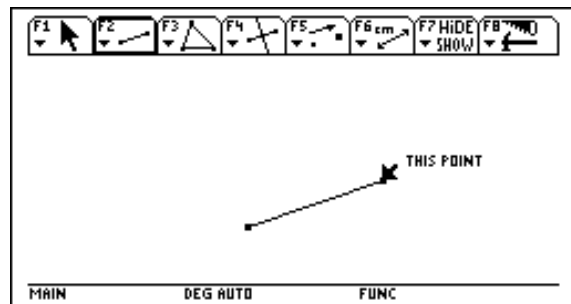


The next example shows a more advanced geometrical feature and a nice visualization technique that is available on the TI-92. We start by drawing a segment.

- o (F2)



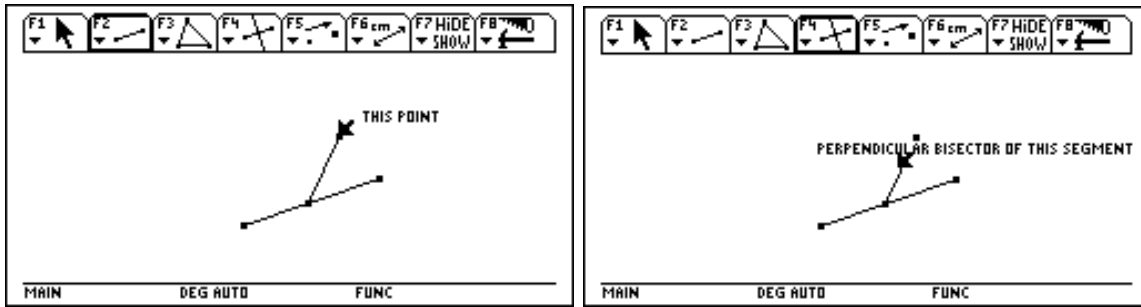
- (5):SEGMENT ↘... (ENTER) ↗... (ENTER)



Now we draw another segment, whose lower end lies on the first segment and whose upper end is somewhere arbitrary (left picture). Then we start the PERPENDICULAR BISECTOR tool again and move the cursor so that it points to the second segment.

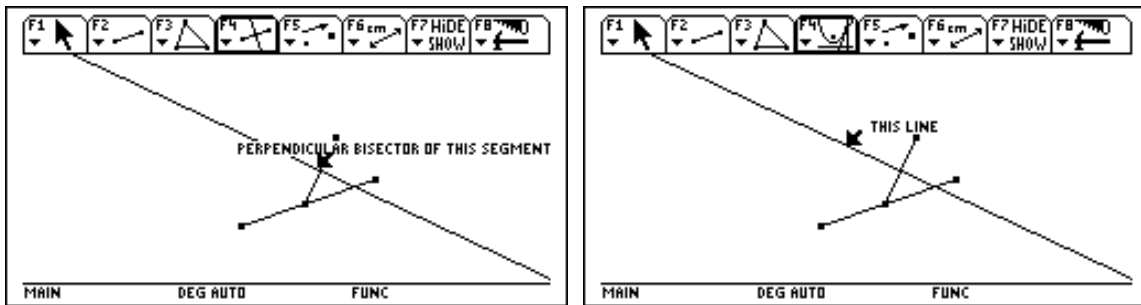
- o ↙... (ENTER) ↗... (ENTER)

- (F4) (4):PERPENDICULAR BISECTOR ↙...



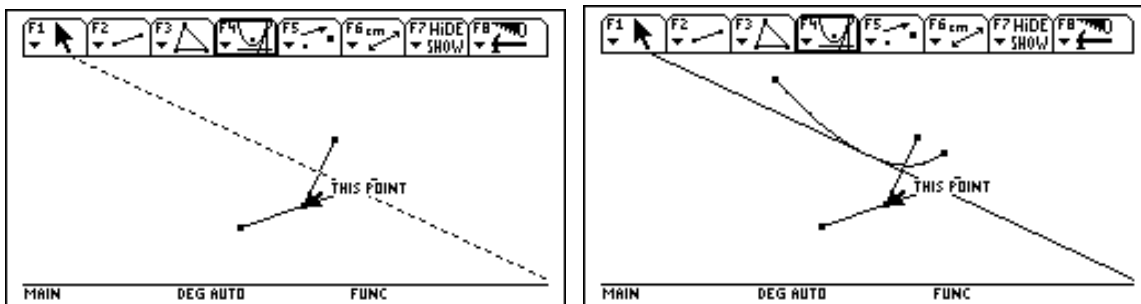
(ENTER) introduces the perpendicular bisector. We start the LOCUS tool from the (F4) menu. This tool expects two arguments as input: The object whose locus we want to construct and the object whose movement determines the locus. We then move the cursor to the perpendicular bisector.

- o (ENTER) (F4) (A):LOCUS ←...



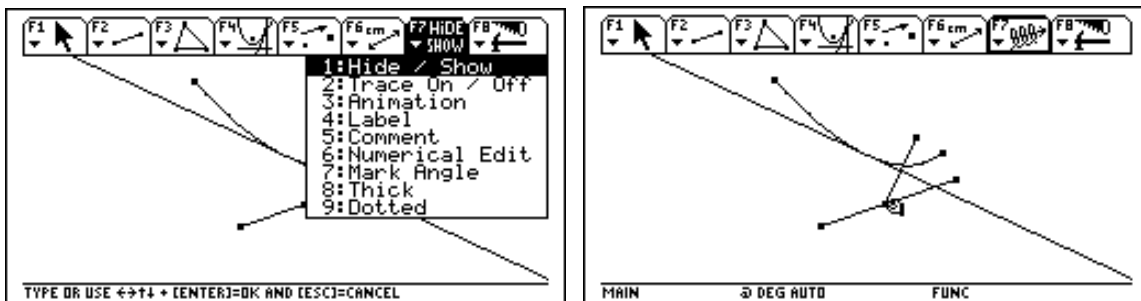
We select this line as the LOCUS tool's first argument by pressing (ENTER). The line changes its appearance and is dotted now. (This remains until we have selected the the second argument.) We move the cursor to the lower point of the second segment (since this point should move) and press (ENTER).

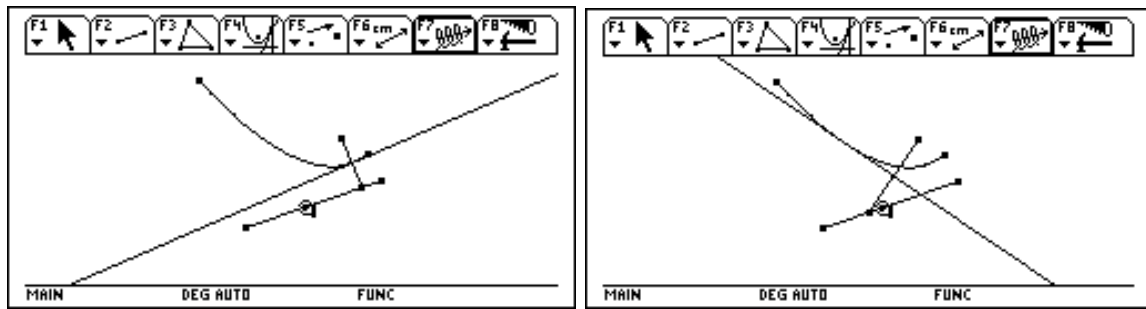
- o (ENTER) ↘... (ENTER)



A part of a parabola appears as the *envelope* of the locus (alternatively we could produce a family of lines). In order to make this result really obvious for the students, we apply the TI-92's animation tool:

- o (F7) (3):ANIMATION [] (ENTER)








This was only a glimpse of what the TI-92 can do. Other applications include:

- plotting of 3D graphs, polar graphs and parameter graphs
- a data and matrix editor
- a program editor with a full programming language
- a text editor with a notebook facility
- various options for linking the TI-92 to another TI-92, a PC, a Macintosh, a CBL or a VIEWSCREEN.

One Page Summary of the Demonstration

- o $x \div 2 + x \div 3$ (ENTER) $x/2 + x/3$
- o $(x+1) \div (x-1)$ (ENTER) [$\sqrt{}$] \uparrow (ENTER)) (ENTER) $\sqrt{\frac{x-1}{x+1}}$
- o (d) \uparrow (ENTER) , x) (ENTER) $\frac{d}{dx} \sqrt{\frac{x-1}{x+1}}$
- o \rightarrow [|] x=2 (ENTER) evaluate at $x = 2$
- o [\blacklozenge] (ENTER) numeric approximation
- o $1 \div (1+x^3)$ (ENTER) [\int] \uparrow (ENTER) , x) (ENTER) $\int \frac{1}{1+x^3} dx$
- o $(n+1)n \div 2 = 150$ (ENTER) $\frac{(n+1)n}{2} = 150$
- o (F2): ALGEBRA (1): SOLVE \uparrow , n) (ENTER) solve $\frac{(n+1)n}{2} = 150$ w.r.t. n
- o [\blacklozenge] (ENTER) numeric approximation
- o solve $(x^4 - 1 = 0, x)$ (ENTER) zeros of $x^4 - 1 = 0$
- o \leftarrow c (ENTER) compute complex solutions of $x^4 - 1 = 0$
- o $\uparrow\uparrow\uparrow\uparrow$ (ENTER) [|] $x > 0$ (ENTER) compute positive zeros of $x^4 - 1 = 0$
- o $5x - 6 = 2x + 15$ (ENTER) $5x - 6 = 2x + 15$
- o (ANS) $-2x$ (ENTER) $(5x - 6 = 2x + 15) - 2x$
- o (ANS) $+6$ (ENTER) $(3x - 6 = 15) + 6$
- o (ANS) -3 (ENTER) $(3x = 21) - 3$
- o \uparrow (CLEAR) delete last history pair
- o (ANS) $\div 3$ (ENTER) $(3x = 21) / 3$
- o (F4): OTHER (2): GRAPH $5 \sin(x)$ (ENTER) plot $5 \sin(x)$
- o (HOME) graph $x \div 3$ (ENTER) plot $x/3$
- o (MODE) (F2): PAGE 2 \rightarrow (3): LEFT-RIGHT (ENTER) set split screen mode
- o \rightarrow ... \downarrow move the graphics cursor
- o (F3): TRACE \rightarrow ... \downarrow \uparrow switch on trace mode and move cursor
- o (F5): MATH (A): TANGENT (ENTER) draw a tangent
- o (F5): MATH (C): SHADE (ENTER) (ENTER) -8 (ENTER) 8 (ENTER) shade area above $5 \sin(x)$, below $x/3$

-for $-8 < x < 8$
- o (MODE) (F2):PAGE 2 → (1):FULL (ENTER) set full screen mode
 - o (APPS) (8):GEOMETRY (3):NEW ↓ g1 (ENTER) (ENTER) open geometry figur
 - o (F3) (3):TRIANGLE ↓... ↙...(ENTER) ↗... (ENTER) ↖... (ENTER) draw triangle
 - o (F4) (4):PERPENDICULAR BISECTOR ↘... (ENTER) ← ... (ENTER) ↓ ... (ENTER) draw all perpendicular
.....bisectors
 - o (F1) (1):POINTER ↙... start POINTER tool
 - o []-←... []-↖... move one triangle point
 - o (F8) (8):CLEAR ALL (ENTER) clear all objects
 - o (F2) (5):SEGMENT ↘... (ENTER) ↗... (ENTER) ↙... (ENTER) ↖... (ENTER) draw two segments
 - o (F4) (4):PERPENDICULAR BISECTOR ↙... (ENTER) draw perpendicular bisector of second segment
 - o (F4) (A):LOCUS ←... (ENTER) ↘... (ENTER) apply LOCUS tool to bisector and point
 - o (F7) (3):ANIMATION [] (ENTER) apply ANIMATION tool to point