TI-89 / TI-92 Plus Calculus Tools

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Important Information

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What is the Calculus Tools Application?

The Calculus Tools application (App) is a Concept software application for the TI-89 / TI-92 Plus. Concept software applications are calculator software application prototypes that demonstrate a new concept area.

The Calculus Tools App extends the built-in power of your TI-89 / TI-92 Plus by providing more specialized functionality. Use the Calculus Tools App to investigate applications of differentiation; compare numerical integration techniques; and explore sequences, series, vector calculus, Fourier series, and more.

The Calculus Tools App is based on programs written or evaluated by CAS (Computer Algebra System) experts and educators Bernhard Kutzler, Bhuvanesh Bhatt, David R. Stoutemyer, Josef Böhm, Ray Barton, Ruth Dover, and Wolfgang Pröpper. We appreciate their contributions and evaluations.

Additional documentation for many of the Calculus Tools App features can be found at series.bk-teachware.com. Other teaching and learning materials written for the TI-89 and TI-92 Plus are also available at the Web site, including *Exploring Integration with the TI-89/92/92+* by Josef Böhm and Wolfgang Pröpper.

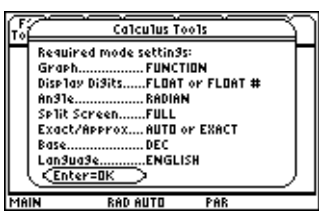
Before You Begin

Concept applications are shared with our customers, educators, and students before product definition and testing is complete. These applications may contain software imperfections and/or incomplete coding areas. They are "alpha" software versions.

TI invites feedback from teachers and students concerning the functionality and educational value of the Calculus Tools App. Please send your comments and questions to concept@list.ti.com.

Mode settings

The Calculus Tools App requires specific mode settings to run correctly. If you try to access the application with incorrect mode settings, this error dialog box will appear:



Before starting the Calculus Tools App, set modes to the required values as follows:

1. From the Home screen, press [MODE] to display the MODE dialog box.
2. Ensure that the following modes are set as indicated:

Mode	Setting
Graph	FUNCTION
Display Digits	FLOAT or FLOAT # (1 - 12)
Angle	RADIAN
Split Screen	FULL
Exact/Approx	AUTO or EXACT
Base	DEC
Language	ENGLISH

3. Press [ENTER]. The Home screen displays.

MEMORY and VAR-LINK screens unavailable

The MEMORY and VAR-LINK screens, accessed by the [2nd] [MEM] and [2nd] [VAR-LINK] keys, are unavailable for the Calculus Tools App.

TI-89 dialog boxes

The TI-89 Calculus Tools App dialog boxes default to alpha-lock. Press [alpha] to turn alpha-lock off before entering numbers.

Using variables from the Main folder

Using variables from the Main folder places those stored values in the Calculus Tools App functions. The Calculus Tools App, however, clears the following types of variables for specified functions. As a result, the data stored in these variables is lost.

Variable defined as …	Menu option				
	F2	F3	F4	F5	F6
Independent var	1 and 2; 4-7				4
Dependent var	4				
Angle Parameter	7				
Index var			1		
Coordinate variables				All	
Integration variables					5-8
Var n			2 and 3		
x	3	All			

Viewing answers in split screen

The Calculus Tools App uses a split screen view to display the numerical and graphical representations of selected solutions.

- For answers that are partially hidden when viewed in a split screen, press ESC to view the answer in full screen.
- For answers that are too long to be viewed in a full screen, use the Display Answer option.
- You cannot switch back and forth between the split screen portions.

Using Calculus Tools App Menus

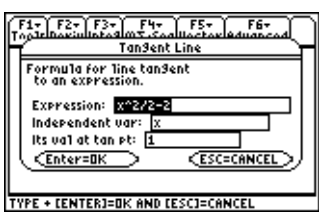
Access the Calculus Tools App menus using the F1 through F6 function keys. F1 menu options let you change the configuration of what you see on the screen, such as viewing the complete answer or data entered as a string, changing split screen settings, and restoring window defaults.

F2 through F6 menu options let you access calculus operations and are organized under the broad categories of derivatives, integrals, sequences, vectors, and advanced functions.

Most F2 through F6 options access a problem-entry dialog box that includes an example problem to help you get started. Work through the example problem, or replace it as desired.

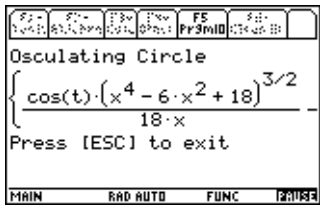
Dialog boxes for most F2 through F6 menu options revert to default values after data is entered. Dialog boxes for the F3 menu options, however, display the values entered last.

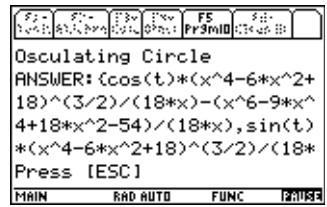
This is the problem-entry dialog box for F2 **1:Tangent Line**.



F1 1:Display ANSWER

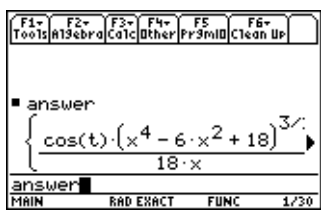
Lets you view an answer that is too long to fit on the screen. (Answers are displayed as a string.)





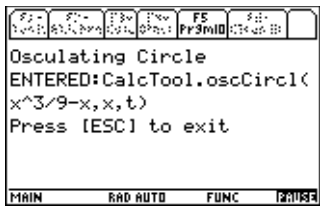
Tip

You can also go to the Home screen, type *answer*, and press ENTER. Scroll to see the complete answer displayed in Pretty Print.



F1 2:Display ENTERED

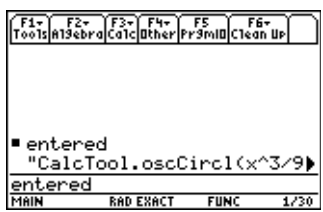
Lets you view executed commands or functions as a string, including the Calculus Tools App functions and operations entered from the problem-entry dialog box.



Tip

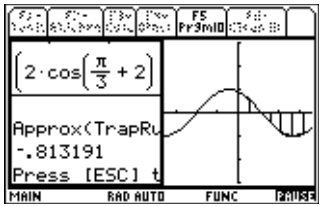
To run a Calculus Tools App function from the Home screen, type *entered* and press ENTER. The last command (function and instructions) executed appears.

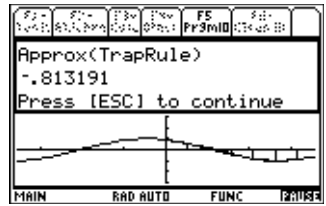
Be sure to remove the quotes from the string before executing the command.



F1 3:Change Split Screen

Lets you choose between left-right (default) and top-bottom split screens.





The TI-92 Plus lets you change the ratio of the split screen views.

- 1:1 displays the answer and graph views at the same size.
- 1:2 displays the answer view at half the size of the graph view.
- 2:1 displays the answer view at twice the size of the graph view.

F1 4:Restore Window Defaults

Restores the Calculus Tools App window parameters to default values. Dialog boxes accessed using the F3 menu options are also restored to default values.

Function Graph Window Parameters

Parameter	Default Value
xmin	-3.55102040816
xmax	3.55102040816
xscl	1
ymin	-3
ymax	3
yscl	1
xres	2

F1 5:Special Thanks

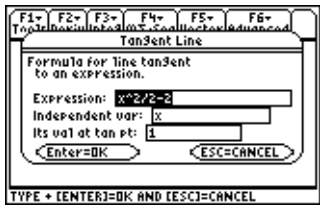
Acknowledges some of the Calculus Tools App contributors.

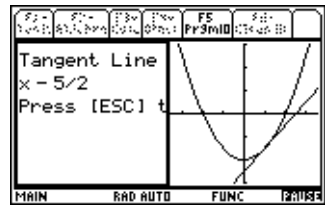
F1 6:About

Displays a variety of information about the application, including the version number.

F2 1:Tangent Line

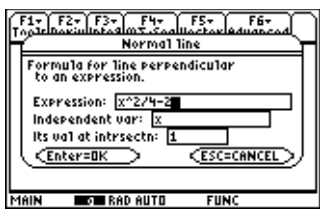
Displays the problem-entry dialog box for the tanLine(...) function along with an example problem (page 35).

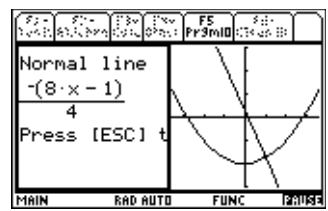




F2 2:Normal Line

Displays the problem-entry dialog box for the prpendic(...) function along with an example problem (page 34).





F2 3:Newton's Method

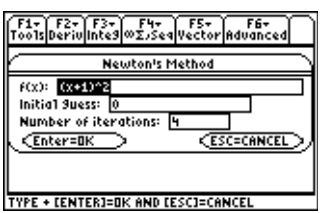
Displays the problem-entry dialog box for Newton's Method along with an example problem. Enter a function $f(x)$, Initial guess, and Number of iterations.

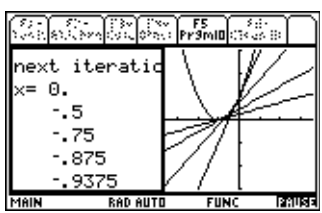
Note The number of iterations must be an integer ≥ 1.

The solution appears in a split screen. One portion of the split screen displays a sequence of approximations to a real root of the functions.

The other portion of the split screen displays a graph of the function and draws tangent lines corresponding to consecutive iterations.

The application draws the first guess for you. Press either ENTER or ESC to view the consecutive guesses. This example shows four iterations.



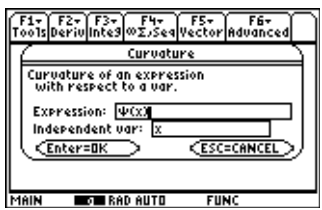


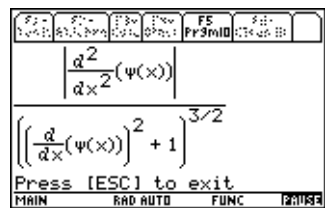
F2 4:Implicit Derivative

Displays the problem-entry dialog box for the impDifN(...) function along with an example problem (page 32).

F2 5:Curvature

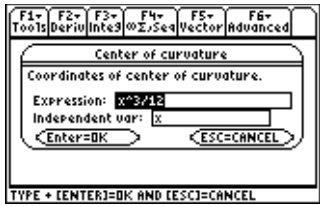
Displays the problem-entry dialog box for the curvatur(...) function along with an example problem (page 31).

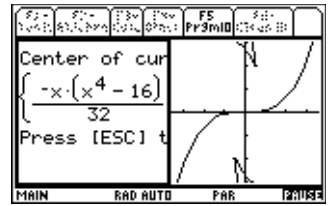




F2 6:Center of Curvature

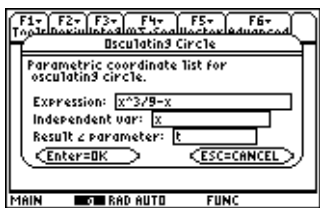
Displays the problem-entry dialog box for the cntrCurv(...) function along with an example problem (page 30).

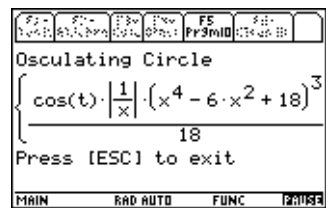




F2 7:Osculating Circle

Displays the problem-entry dialog box for the oscCircl(...) function along with an example problem (page 33).





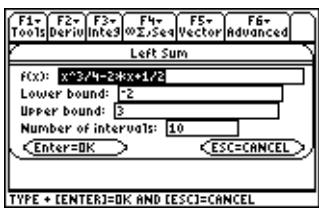
F3:Integ

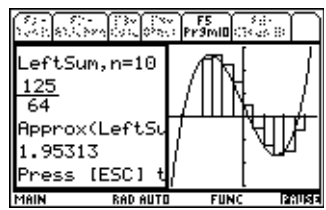
F3 1:Left Sum

Displays the problem-entry dialog box for the Left Sum integration method along with an example problem. Enter a function $f(x)$, Lower bound, Upper bound, and Number of intervals.

The answer appears in a split screen. One portion of the split screen displays the sum of the areas of the rectangles.

The other portion of the split screen displays the graph of the function and draws the rectangles.



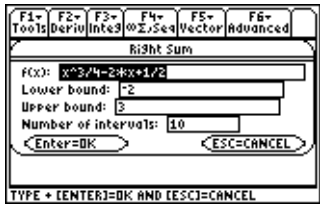


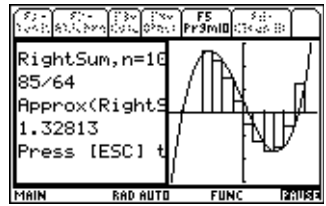
F3 2:Right Sum

Displays the problem-entry dialog box for the Right Sum integration method along with an example problem. Enter a function $f(x)$, Lower bound, Upper bound, and Number of intervals.

The answer appears in a split screen. One portion of the split screen displays the sum of the areas of the rectangles.

The other portion of the split screen displays the graph of the function and draws the rectangles.



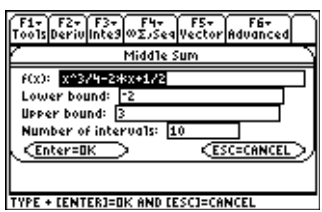


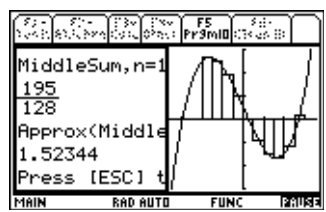
F3 3:Midpoint Rule

Displays the problem-entry dialog box for the Midpoint Rule along with an example problem. Enter a function $f(x)$, Lower bound, Upper bound, and Number of intervals.

The answer appears in a split screen. One portion of the split screen displays the sum of the areas of the rectangles.

The other portion of the split screen displays the graph of the function and draws the rectangles.



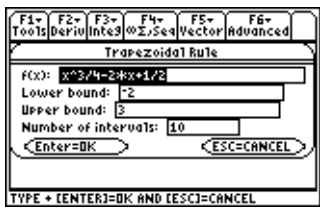


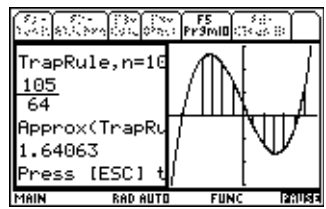
F3 4:Trapezoidal Rule

Displays the problem-entry dialog box for the Trapezoidal Rule along with an example problem. Enter a function $f(x)$, Lower bound, Upper bound, and Number of intervals.

The answer appears in a split screen. One portion of the split screen displays the sum of the areas of the trapezoids.

The other portion of the split screen displays the graph of the function and draws the trapezoids.





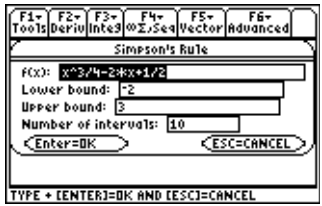
F3 5:Simpson's Rule

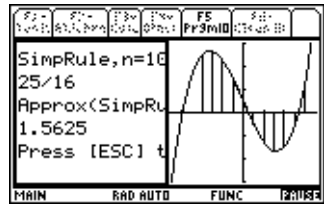
Displays the problem-entry dialog box for Simpson's Rule along with an example problem. Enter a function $f(x)$, Lower bound, Upper bound, and Number of intervals.

Note The number of intervals must be an even integer ≥ 2.

The answer appears in a split screen. One portion of the split screen displays the Simpson's Rule approximation to the definite integral by using parabolic arcs.

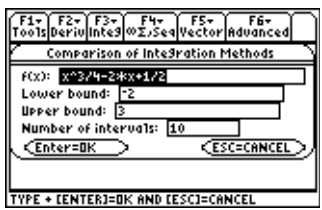
The other portion of the split screen displays the graph of the function and draws the parabolic arcs.

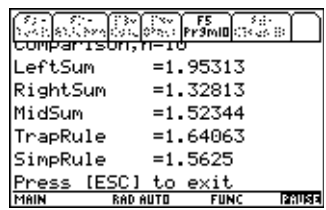




F3 6:Comparison

Returns the approximation to the definite integral using these previously mentioned methods: Left Sum, Right Sum, Midpoint Rule, Trapezoidal Rule, and Simpson's Rule (pages 16 through 18).

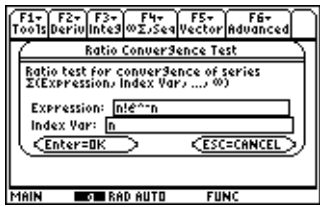




F4:Seq (infinite series, sequences)

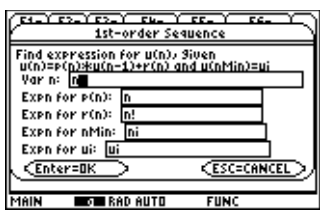
F4 1:Ratio Convergence Test

Displays the problem-entry dialog box for the ratioTst(...) function (page 34) along with an example problem.



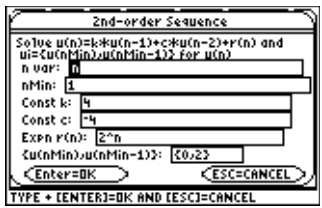
F4 2:1st-Order Sequence

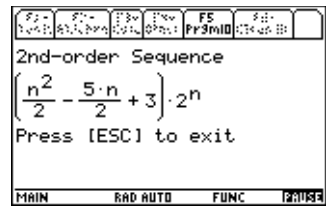
Displays the problem-entry dialog box for the seq1Solv(...) function (page 34) along with an example problem.



F4 3:2nd-Order Sequence

Displays the problem-entry dialog box for the seq2Solv(...) function (page 35) along with an example problem.

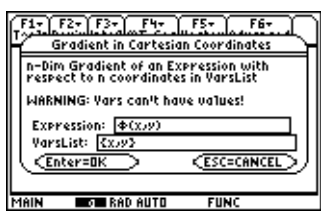


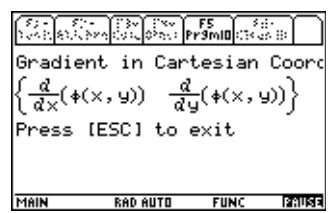


F5:Vector

F5 1:Gradient

Displays the problem-entry dialog box for the grad(...) function (page 32) along with an example problem.





F5 2:Divergence

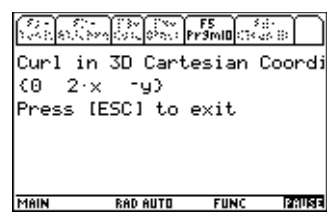
Displays the problem-entry dialog box for the div(...) function (page 31) along with an example problem.

Note

The number of components in *exprList* must equal the number of variables in *varList*.

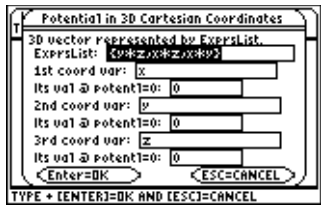
F5 3:Curl

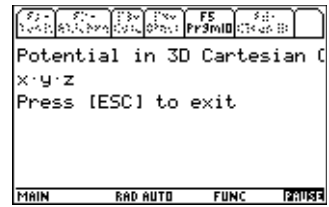
Displays the problem-entry dialog box for the curl(...) function (page 30) along with an example problem.



F5 4:Potential

Displays the problem-entry dialog box for the potentl(...) function (page 33) along with an example problem.

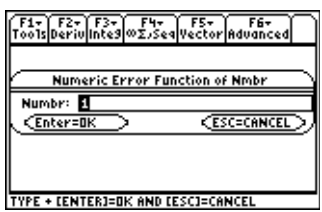


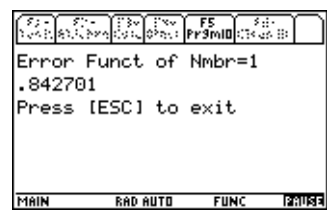


F6:Advanced

F6 1:Error Function, erf

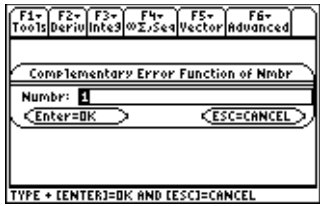
Displays the problem-entry dialog box for the erf(...) function (page 31) along with an example problem.





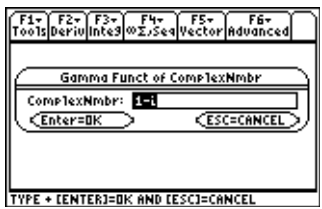
F6 2:Comp. Error Function

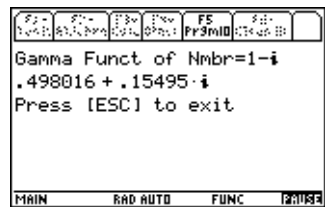
Displays the problem-entry dialog box for the erfc(...) function (page 31) along with an example problem.



F6 3:Gamma Function

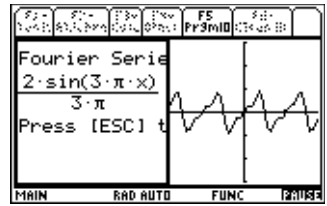
Displays the problem-entry dialog box for the gamma(...) function (page 32) along with an example problem.





F6 4:Fourier Series

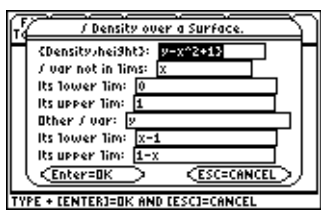
Displays the problem-entry dialog box for the fourirCf(...) function (page 32) along with an example problem.

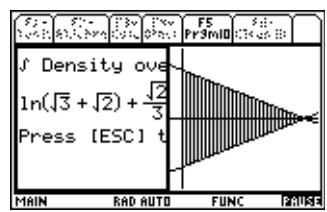


F6 5:Integral of Density

F6 5:Integral of Density > 1:over a Surface

Displays the problem-entry dialog box for the surfIntg(...) function (page 35) along with an example problem.



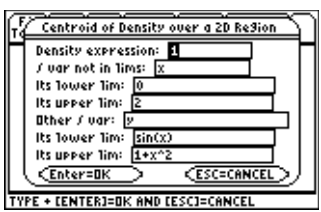


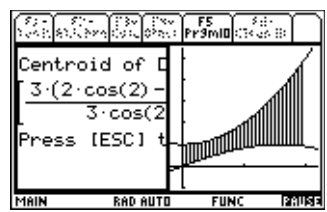
F6 5:Integral of Density > 2:over a Polar Region

Displays the problem-entry dialog box and example problem to set up an iterated integral to integrate a density over a region in polar coordinates. Use *density* 1 for an unweighted polar area.

F6 6:Centroid of Density

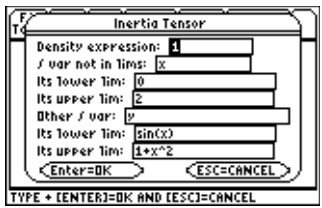
Displays the problem-entry dialog box for the aCntroid(...) function (page 29) along with an example problem.

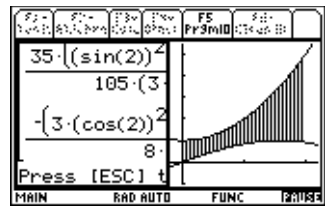




F6 7:Inertia Tensor

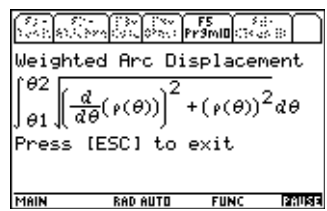
Displays the problem-entry dialog box for the aInertia(...) function (page 30) along with an example problem.





F6 8:Arc Displacement

Displays the problem-entry dialog box for the plrArcLn(...) function along with an example problem (page 33).



Working with Calculus Tools App Functions

Use Calculus Tools App functions outside the application when working with programs or other built-in, user-defined, and Flash application functions.

Note

Calculus Tools App functions cannot be called from within the application. If you try to call a function using the application's problem-entry dialog boxes, the error message, *Protected memory violation*, will appear. Exit and re-enter the application to ensure normal operation.

Accessing Calculus Tools App functions from the Catalog

1. From the Home screen, press [CATALOG] (TI-89) / [2nd] [CATALOG] (TI-92 Plus). The catalog appears.
2. Press [F3]. The list of Flash application functions appears.
3. Scroll through the list and select the function you want to use.
4. Press [ENTER]. The function appears on the Home screen entry line in the form

   CalcTool.*function name*
5. Add the required arguments to complete the command and press [ENTER].

Tip

To view help for a function, select a function from the catalog and press [F1].

Accessing Calculus Tools App functions from VAR-LINK

1. From the Home screen, press 2nd [VAR-LINK]. The VAR-LINK [ALL] screen appears.
2. Press 2nd [F7] (TI-89) / F7 (TI-92 Plus). The list of Flash application functions appears.
3. Scroll through the list and select the function you want to use. You may need to expand the application's folder before you can view its functions.
4. Press ENTER. The function appears on the entry line as **CalcTool**.*function name*
5. Add the required arguments to complete the command and press ENTER.

List of Calculus Tools App Functions

aCntroid*(density, var1, lower1, upper1, var2, lower2(var1), upper2(var1))*

Returns a two-element list denoting the *{var1, var2}* coordinates of the centroid of a *density* over a 2D region. *var1* varies from *lower1* to *upper1*, which must be independent of *var1* and *var2*. *var2* varies from expression *lower2* to expression *upper2*, which might depend on *var1*. Use *density* 1 for an area centroid.

Use F6 6:Centroid of Density to display the problem-entry dialog box and example for this function.

alnertia*(density, var1, lower1, upper1, var2, lower2(var1), upper2(var1))*

Returns a 2x2 matrix denoting the inertia tensor of a density over a two-dimensional region. *var1* varies from *lower1* to *upper1*, which must be independent of *var1* and *var2*. *var2* varies from expression *lower2* to expression *upper2*, which might depend on *var1*. Use *density* 1 for an area inertia tensor.

Use F6 7:Inertia Tensor to display the problem-entry dialog box and example for this function.

cntrCurv*(expression, var)*

Returns a two-element list that is a parametric representation of the center of curvature of *expression* with respect to *var*.

Use F2 6:Center of Curvature to display the problem-entry dialog box and example for this function.

curl*(exprList, xVar, yVar, zVar)*

Returns the three-dimensional rectangular Cartesian curl of the vector represented by *exprList* with respect to the coordinate variables *xVar, yVar, zVar*.

Use F5 3:Curl to display the problem-entry dialog box and example for this function.

curvatur*(expression, var)*

Returns the curvature of *expression* with respect to *var*.

Use F2 5:Curvature to display the problem-entry dialog box and example for this function.

div*(exprList, varList)*

Returns the rectangular Cartesian *n*-dimensional divergence of the vector represented by *exprList* with respect to the *n* coordinate variables in *VarList*.

Use F5 2:Divergence to display the problem-entry dialog box and example for this function.

Note The number of components in *exprList* must equal the number of variables in *varList*.

erf*(complexNumber)*

Returns the approximate numeric error function of *complexNumber*.

Use F6 1:Error Function, erf to display the problem-entry dialog box and example for this function.

erfc*(complexNumber)*

Returns the approximate complementary error function of *complexNumber*.

Use F6 2:Comp. Error Function to display the problem-entry dialog box and example for this function.

fourirCf*(expression, var, lowerLimit, upperLimit, n)*

Returns the truncated Fourier series of *expression* for *var* from *lowerLimit* to *upperLimit*, through the *n*th harmonic.

Use F6 4:Fourier Series to display the problem-entry dialog box and example for this function.

gamma*(complexNumber)*

Returns the approximate gamma function of *complexNumber*.

Use F6 3:Gamma Function, Γ(z) to display the problem-entry dialog box and example for this function.

grad*(expression, VarList)*

Returns the rectangular Cartesian *n*-dimensional gradient of *expression* with respect to the *n* coordinate variables in *VarList*.

Use F5 1:Gradient to display the problem-entry dialog box and example for this function.

impDifN*(equation, IndependentVar, DependentVar, n)*

Returns the *n*th derivative of the function implicitly defined by *equation*.

Use F2 4:Implicit Derivative to display the problem-entry dialog box and example for this function.

oscCircl*(expression, var, circleParameter)*

Returns a two-element list that is a parametric representation of the circle that osculates *expression*.

Use F2 7:Osculating Circle to display the problem-entry dialog box and example for this function.

plrArcLn*(r(θVar), θVar, low, up, weight(θVar))*

Returns the weighted arc displacement in polar coordinates, where var *θVar* varies from *lowerLimit* to *upperLimit*, with *r(θVar)* and *weight(θVar)* being expressions that might depend on *θVar*. Use *weight* 1 for an unweighted arc displacement.

Use F6 8:Arc Displacement to display the problem-entry dialog box and example for this function.

potentl*(exprList, xVar, yVar, zVar, x0, y0, z0)*

Returns the scalar potential of the three-dimensional rectangular Cartesian gradient represented by *exprList*, with the potential = 0 at *{x0, y0, z0}*.

Note

> Does not verify that *exprList* is a gradient, so first see if **curl***(exprList, xVar, yVar, zVar)* simplifies to {0,0,0}, as it should for a gradient.

Use F5 4:Potential to display the problem-entry dialog box and example for this function.

prpendic*(expression, var, varValue)*

Returns an expression for the line that is normal to *expression* at *var* = *varValue*.

Use F2 2:Normal Line to display the problem-entry dialog box and example for this function.

ratioTst*(expression, indexVar)*

Conducts the ratio test for the convergence of an infinite series, returning one of the strings *converges*, *diverges*, *test inconclusive*, or *unable to complete test*.

Use F4 1:Ratio Convergence Test to display the problem-entry dialog box and example for this function.

seq1Solv*(p(n), r(n), n, nMin, ui)*

Attempts to return an exact symbolic expression for u(n) that satisfies the linear 1st-order sequence equation

$u(n)=p(n)*u(n-1)+r(n) \quad \text{with} \quad u(nMin)=ui.$

Use F4 2:1st-Order Sequence to display the problem-entry dialog box and example for this function.

seq2Solv*(k, c, r(n), n, nMin, {u(nMin), u(nMin-1)})*

Attempts to return an exact symbolic expression for u(n) that satisfies the linear 2nd-order constant-coefficient sequence equation
u(n)=k∗u(n-1)+c∗u(n-2)+r(n) and ui={u(nMin) , u(nMin-1)}.

Use F4 3:2nd-Order Sequence to display the problem-entry dialog box and example for this function.

surfIntg*(density, height, var1, lower1, upper1, var2, lower2(var1), upper2(var1))*

Returns the integral of a *density* over surface whose *height* might vary with *var1* and *var2*. *var1* varies from *lower1* to *upper1*, which must be independent of *var1* and *var2*. *var2* varies from expression *lower2* to expression *upper2*, which might depend on *var1*. Use *density* 1 for a surface area.

Use F6 5:Integral of Density > 1:over a Surface to display the problem-entry dialog box and example for this function.

tanLine*(expression, var, varValue)*

Returns an expression for the line that is tangent to *expression* at *var* = *varValue*. (In contrast, the built-in LineTan command draws the tangent line but does not reveal its formula.)

Use F2 1:Tangent Line to display the problem-entry dialog box and example for this function.

Installing the Calculus Tools App

Detailed Flash application installation instructions are available from education.ti.com/guides.

You will need:

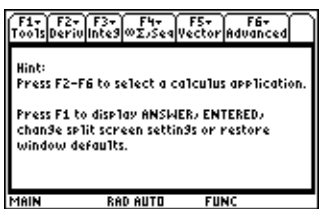
- A TI-89 / TI-92 Plus with the latest Advanced Mathematics Software Operating System. Download a free copy from education.ti.com/softwareupdates.
- A computer using either Microsoft® Windows® or Apple® Macintosh® operating system software.
- A TI-GRAPH LINK™ computer-to-calculator cable, available for purchase from the TI Online Store at education.ti.com/buy.
- TI-GRAPH LINK connectivity software for the TI-89 / TI-92 Plus. Download a free copy from education.ti.com/softwareupdates.

Starting and Quitting the Application

Starting the Calculus Tools App

The instructions in this guidebook refer to this Flash application only. For help using the TI-89 / TI-92 Plus, refer to the comprehensive guidebook at education.ti.com/guides.

1. Ensure modes are set to the required values.
2. Press [APPS] **1:FlashApps** and select **Calculus Tools**.
3. Press [ENTER]. The Hint screen displays.



Quitting the Calculus Tools App

Press [2nd] [QUIT] from the Calculus Tools App Hint screen.

Deleting an Application

Deleting an application removes it from the calculator and increases space for other applications. Before deleting an application, consider storing it on a computer for reinstallation later.

1. Quit the application.
2. Press [2nd] [VAR-LINK] to display the VAR-LINK [ALL] screen.
3. Press [2nd] [F7] (TI-89) / [F7] (TI-92 Plus) to display the list of applications.
4. Select the application you want to delete.
5. Press [F1] **1:Delete**. The VAR-LINK delete confirmation dialog box displays.
6. Press [ENTER] to delete the application.

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(Including Preview, Prototype, and Demo APPS)

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Page Reference

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