TI-89 / TI-92 Plus Symbolic Math Guide

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Important Information

Texas Instruments makes no warranty, either expressed or implied, including but not limited to any implied warranties of merchantability and fitness for a particular purpose, regarding any programs or book materials and makes such materials available solely on an “as-is” basis.

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What is Symbolic Math Guide?

Symbolic Math Guide is a concept calculator software application that is part of Texas Instruments' ongoing research aimed at helping students learn how to apply symbolic and algebraic transformations using the TI‑89 and the TI‑92 Plus. It is currently available only in a pre-beta release version.

Because it is more faithful to the mathematics and mathematical notation found in textbooks than other calculator-based computer algebra systems (CAS), Symbolic Math Guide makes it easier for students to relate to the mathematics in their textbooks.

Symbolic Math Guide provides step-by-step problem-solving transformations for several classes of symbolic computations from algebra, pre-calculus, and calculus, including the following:

Simplify	Solve	Compute
Expressions using powers	Linear equations	Derivatives
Polynomial expressions	Quadratic equations	
Rational expressions	Rational equations	
Radical expressions	Radical equations	
Logarithmic & Exponential expressions	Logarithmic & Exponential equations	
Difference quotients		

Symbolic Math Guide performs all operations in strict REAL mode. It treats non-real sub-expressions, +∞, and -∞ as undefined. Symbolic Math Guide provides the corresponding domain of definition for which the original expression is real and finite. It also generates domain preservation constraints whenever a selected transformation would otherwise enlarge the domain of definition. Symbolic Math Guide attempts to produce solutions consisting of equivalent expressions or of equivalent equations.

The current version of Symbolic Math Guide does not support languages other than English. The calculator language mode must be set to English to ensure that the application performs correctly.

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

What You Will Need

To install and run TI-89 / TI-92 Plus Symbolic Math Guide, you need:

- A TI-89 or TI-92 Plus with version 2.05 or later of the Advanced Mathematics software. You can download a free copy of the latest Advanced Mathematics software from the Online Store at http://education.ti.com/.
- A computer with Windows® 95/98, Windows NT®, or Mac® OS 7.1 or later installed.
- A TI-GRAPH LINK™ computer-to-calculator cable. If you do not have this cable, call your distributor, or order the cable from the Online Store at http://education.ti.com/..
- A 25-pin to 9-pin cable adapter (required only if you are connecting to a 9-pin serial port on the computer).
- TI-GRAPH LINK™ software that is compatible with the TI-89 or TI-92 Plus. You can download a free copy of this software from the Online Store at http://education.ti.com/.

Where to Find Installation Instructions

You can find detailed instructions for installing this and other Flash software applications at this web site:

http://education.ti.com/product/prselect.html

Keystroke Differences

There are certain differences in keystrokes using the TI-89 / TI-92 Plus for various operations. The following table shows the keystrokes for major commands for the two calculators.

Function	TI-89	TI-92 Plus
LETTERS		
One lowercase letter (a-s, u,	alpha A-S, U-W	A-S, U-W
One lowercase letter (t, x, y,	T, X, Y, Z	T, X, Y, Z
Several lowercase letters	2nd [a-lock]	
End several lowercase letters	alpha	
Several uppercase letters	⇧ [a-lock]	2nd [CAPS]
End several uppercase letters	alpha	2nd [CAPS]
FUNCTION KEYS		
F6	2nd [F6]	F6
F7	2nd [F7]	F7
F8	2nd [F8]	F8
NAVIGATION		
Scroll tall objects up or down	⇧ ▲, ⇧ ▼	▲, ▼
Move cursor far left or far	2nd ◀, 2nd ▶	2nd ◀, 2nd ▶

Function	TI-89	TI-92 Plus
Diagonal movement	▲ and ◀ ▲ and ▶ ▼ and ◀ ▼ and ▶	↖ ↗ ↙ ↘
FUNCTIONS		
Display Home screen	HOME	♦ [HOME]
Cut	♦ [CUT]	♦ X
Copy	♦ [COPY]	♦ C
Paste	♦ [PASTE]	♦ V
Catalog	CATALOG	2nd [CATALOG]
Display Units dialog box	2nd [UNITS]	♦ [UNITS]
Sin	2nd [SIN]	SIN
Cos	2nd [COS]	COS
Tan	2nd [TAN]	TAN
LN	2nd [LN]	LN
e^x	♦ [e^{x}]	2nd [e^{x}]
EE	EE	2nd [EE]
SYMBOLS		
_ (Underscore)	♦ [_]	2nd [_]
θ (Theta)	♦ [θ]	θ
| (“With”)	|	2nd [|]

Function	TI-89	TI-92 Plus
' (Prime)	2nd [′]	2nd [′]
° (Degree)	2nd [°]	2nd [°]
∠ (Angle)	2nd [∠]	2nd [∠]
Σ (Sigma)	CATALOG Σ (	2nd [Σ]
x^{-1} (Reciprocal)	CATALOG ^-1	2nd [x^{-1}]
Space	alpha [␣]	Space bar
HIDDEN SHORTCUTS		
Place data in sysdata variable	♦ ,	♦ D
Greek characters	♦ (alpha or ♦	♦ G or ♦ G ⇧
Keyboard map	♦ EE	♦ [KEY]
Place data in Home screen	♦ (-)	♦ H
Grave (à, è, ì, ò, ù)	2nd [CHAR] 5	2nd A a, e, i, o, u
Cedilla (ç)	2nd [CHAR] 5 6	2nd C c
Acute (á, é, í, ó, ú, ý)	2nd [CHAR] 5	2nd E a, e, i, o, u,
Tilde (ã, ñ, õ)	2nd [CHAR] 5 6	2nd N a, n, o
Caret (â, ê, î, ô, û)	2nd [CHAR] 5	2nd O a, e, i, o, u
Umlaut (ä, ë, ï, ö, ü, ÿ)	2nd [CHAR] 5	2nd U a, e, i, o, u,
? (Question mark)	2nd [CHAR] 3	2nd Q
β (Beta)	2nd [CHAR] 5 6	2nd S
# (Indirection)	2nd [CHAR] 3	2nd T

Function	TI-89	TI-92 Plus
& (Append)	♦ × (times)	2nd H
@ (Arbitrary)	♦ STO▸	2nd R
≠ (Not equal to symbol)	♦ =	2nd V
! (Factorial)	♦ ÷	2nd W
Comment (Circle-C)	♦) ◕	2nd X ◕
New	F1 3	♦ N
Open	F1 1	♦ O
Save copy as	F1 2	♦ S
Format dialog box	♦ [	♦ F

Memory Requirements

Symbolic Math Guide requires that at least 5000 bytes RAM be free and that a sufficient number of unused memory blocks in RAM be available while the application is running. If these memory requirements are not met, an error message displays and the application closes automatically.

The following table shows memory error messages and what to do if you receive them.

Error message	Recovery
Memory Error You must free up some RAM memory or open a new problem set.	The amount of free RAM has dropped below 5000 bytes. You can do one of the following: • Delete some user variables, programs, lists, etc. to free some RAM. • Open a new problem set
Memory Error You must delete some user variables or open a new problem set.	The number of available memory blocks in RAM is too low. You can do one of the following: • Delete some user variables. • Open a new problem set

Starting and Quitting Symbolic Math Guide

Note The current version of Symbolic Math Guide does not support languages other than English. The calculator language mode must be set to English to ensure that the application performs correctly. To change the language mode, press MODE F3, and then press ⊙ to highlight the language. Press ⊙ to display a list of languages on your calculator, and then select English. Press ENTER to save the change.

Starting Symbolic Math Guide

1. Press APPS.
2. Select **FlashApps** to display the list of applications on your calculator.
3. Select **Symbolic Math Guide**.
4. Select the type of file to open:
   Current opens the problem set you worked with most recently
   Open opens an existing problem set
   New creates a new problem set
5. Select or specify the folder name and variable name for the problem set.
6. Press ENTER.

Quitting Symbolic Math Guide

- From any screen, press 2nd [QUIT]
- You can temporarily leave Symbolic Math Guide by pressing HOME. To return to the Symbolic Math Guide, press 2nd [⊡].

Note This user guide shows TI-92 Plus keystrokes. There are some keystroke differences between the TI-89 and the TI-92 Plus. Please refer to Keystroke Differences for more information on these differences.

Creating Problem Sets

Work through this exercise to become familiar with creating problem sets in Symbolic Math Guide. In this exercise, you create a problem set that contains four problems.

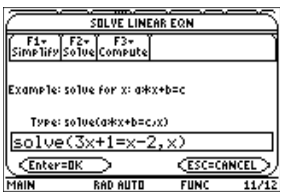
▶ Start the application, and then create a new problem set:

Press [APPS] and select **FlashApps** to display a list of applications on your calculator.

7. Select **Symbolic Math Guide**.
8. Select **New…**to create a new problem set.
9. Move the cursor to the Variable field, and then type an unused name (such as demo1) for the problem set.
10. Press [ENTER].

▶ Add the first problem, 3x + 1 = x – 2, to the problem set:

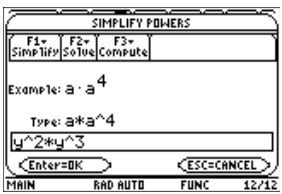
1. Press F2, and then select **New Problem…**
2. Press F2, and then select **Linear Eqn**.
3. Type the equation, adding **,x** to complete the solve() command, and then press ENTER.



▶ Add the second problem, $y^2 \cdot y^3$:

1. Press [F2], and then select **New Problem…**
2. Press [F1], and then and select **Powers**.
3. Type the expression, and then press [ENTER].

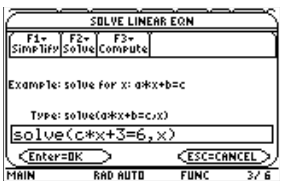
Tip To enter $y^2 \cdot y^3$, press the following keys: **Y** [^] **2** [×] **Y** [^] **3**.



▶ Add the third problem, c•x + 3 = 6:

1. Press F2, and then select **New Problem…**
2. Press F2, and then select **Linear Eqn**.
3. Type the equation, and then press ENTER.

Tip To enter c • x, you must type **C** × **X**, not CX.

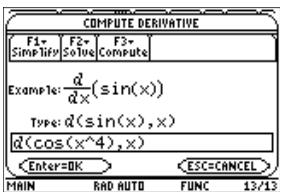


► Add the fourth problem, $\frac{d}{dx}\cos(x^4)$:

1. Press F2, and then select **New Problem…**
2. Press F3, and then select **Derivative**.
3. Type the expression, and then press ENTER.

Tip

To enter $\frac{d}{dx}\cos(x^4)$, press the following keys: 2nd [COS] **X** ^ **4**) , **X** ENTER.



Solving Problems

Work through this exercise to become familiar with solving problems using Symbolic Math Guide. In this exercise, you open a problem set that you either downloaded from the online store (*tourps.9xy* or *tourps.89y*), or entered manually as described in the previous section, and solve those problems.

To follow the steps in this exercise, Symbolic Math Guide's TIME TO THINK mode must be on. This mode displays the transformations you choose on the screen so that you can think about what happens when you apply them before you see the result. It is initially turned on. You can turn TIME TO THINK mode on or off by pressing F1, selecting **Format**, and then selecting **ON** or **OFF**.

Tip

When you use the TIME TO THINK mode:

- To apply the transformation currently displayed, press ENTER.
- To choose a different transformation, press ESC to clear the current transformation, and then press F4 to select another transformation.

▶ Start the application and open the problem set.

1. Press [APPS], and then select **Flash Apps** to display a list of applications on your calculator.

2. Select **Symbolic Math Guide**, select **Open**, and then press [ENTER]. The OPEN dialog box is displayed.

3. Press ⊙ to highlight the Variable field, and then press ⊙ to display a list of problem sets on your calculator.

4. Select the problem set name (either **tourps** that you downloaded or the name of the problem set that you created in the previous section), and then press [ENTER].

5. Press [ENTER] again to display the Symbolic Math Guide main screen. Problem 1 is displayed.

▶ Solve problem 1, linear equation 3x + 1 = x – 2:

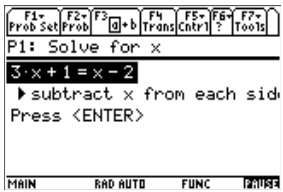
1. Think about how you need to solve the problem. You can press F6, and then select **Goal** to display the goal for solving the problem. (Press ENTER to clear the Goal window.)

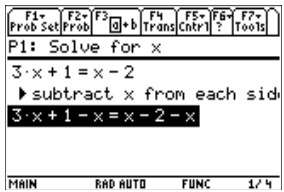
2. Press F4 to display a list of possible transformations that you can apply to the problem. Do you see the transformation you want to apply?

3. An appropriate choice is to subtract x from each side so that only the left side depends on x. Select **subtract ? from each side**. A dialog box is displayed so that you can specify the value to subtract from each side.

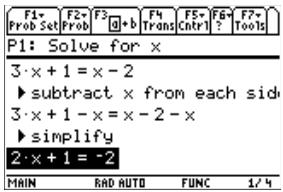
4. Enter **x**, and then press ENTER. The transformation is displayed, giving you time to think about what will happen when you apply it.

5. Press [ENTER] to apply the transformation.





6. Press [ENTER] twice to simplify both sides of the equation.



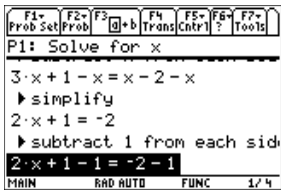
7. Press [F4] to display the transformations menu, and then select another transformation to apply.

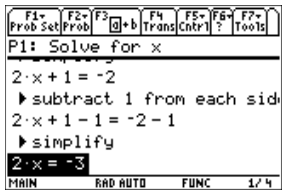
8. An appropriate choice is to subtract 1 from both sides so that there is no constant term on the left side. Select **subtract ? from each side**. A dialog box is displayed so that you can specify the value to subtract from each side.

9. Press **1**, and then press [ENTER]. The transformation is displayed, giving you time to think about what happens when you apply it.

10. Press [ENTER] once to apply the transformation.

11. Press [ENTER] twice to simply the equation.



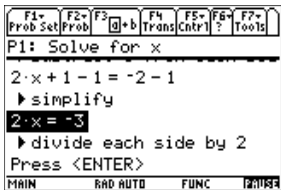


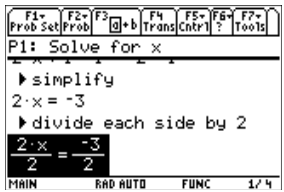
12. Press [F4] to display the transformations menu, and then select another transformation to apply.

13. An appropriate choice is to divide both sides by 2 so that the left side becomes x. Select **divide each side by ?**. A dialog box is displayed so that you can specify the value to divide by.

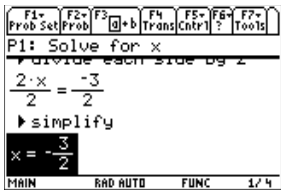
14. Press **2**, and then press [ENTER]. The transformation is displayed, giving you time to think about what happens when you apply it.

15. Press ENTER to apply the transformation.





16. Press ENTER twice to simplify both sides of the equation.



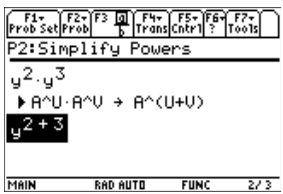
▶ Solve problem 2, simplify $y^2 \cdot y^3$:

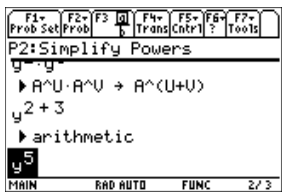
1. Press F5, and then select **Next Problem**.
2. Think about how you need to solve the problem.
3. Press F4 to display a list of possible transformations that you can apply to the problem. Do you see the transformation you want to apply?

4. Select **A^U•A^V → A^(U+V)**. The transformation is displayed, giving you time to think about what happens when you apply it.

5. Press ENTER to apply the transformation.

6. Press ENTER twice to perform the arithmetic.





▶ Solve problem 3, linear equation c• x + 3 = 6:

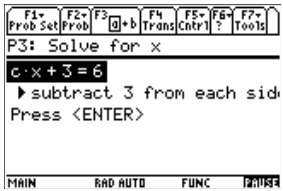
1. Press F5, and then select **Next Problem**.

2. Think about how you need to solve the problem.

3. Press F4 to display a list of possible transformations that you can apply to the problem. Do you see the transformation you want to apply?

4. Select **subtract ? from each side**. A dialog box is displayed so that you can specify what value to subtract.

5. Press **3**, and then press ENTER. The transformation is displayed, giving you time to think about what happens when you apply it.

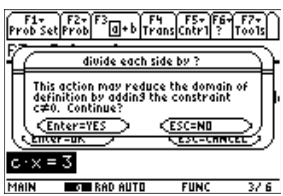


6. Press ENTER to apply the transformation.

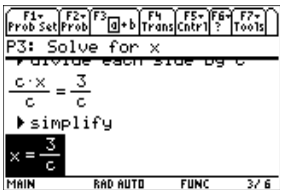
7. Press ENTER twice to simplify the equation.

8. Press F4, and then select the next transformation: **divide each side by?**. A dialog box is displayed so that you can specify what value to divide by.

9. Press **C** and then press ENTER. A warning is displayed to remind you that the constraint $c \neq 0$ will be added to the problem, which might reduce the domain of definition.



10. Press [ENTER] to continue.
11. Press [ENTER] again to apply the transformation.
12. Press [ENTER] twice to simplify the equation.



▶ Solve problem 4, compute derivative $\frac{d}{dx}\left(\cos\left(x^4\right)\right)$:

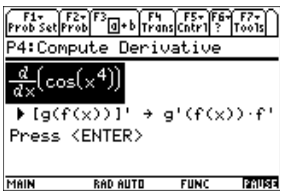
1. Press [F5], and then select **Next Problem**.
2. Think about how you need to solve the problem.

3. Press F4 to display a list of possible transformations that you can apply to the problem. Do you see the transformation you want to apply?

Note

> Symbolic Math Guide will not allow you to choose transformations that cannot be performed. For Compute Derivative problems, F4 might display inapplicable transformations. "Transformation not applicable" is displayed if you select an inapplicable transformation. To see this, choose [(f•g)′➔f•g′+g•f′] for this example.

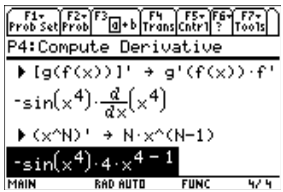
4. Select **[g(f(x))]′→g′(f(x))•f' (x)**. The transformation is displayed, giving you time to think about what happens when you apply it.



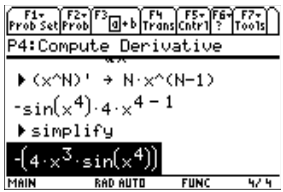
5. Press ENTER to apply the transformation.

6. Press F4, and then select the next appropriate transformation: **(x^N)′ → N• x^(N-1)**. The transformation is displayed, giving you time to think about what happens when you apply it.

7. Press ENTER to apply the transformation.



8. Press ENTER twice to simplify the expression.



Now that you have learned how to solve problems, you can read further to learn more about other Symbolic Math Guide features. For example, you can

- Select a part of an expression
- Define a function
- Substitute a variable for a sub-expression
- Rewrite an expression

Creating Problem Sets

Note This user guide shows TI-92 Plus keystrokes. There are some keystroke differences between the TI-89 and the TI-92 Plus. Please refer to Keystroke Differences for more information on these differences.

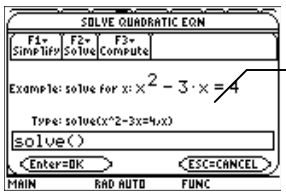
When you create a problem set, you have a blank screen to enter individual problems. In an existing problem set, you can add, delete, or edit problems. Students open the problem set and then work through the problems step by step, getting help and hints along the way.

Tip If you don't have sufficient RAM, you might not be able to save your problem set in its entirety. Before you create a new problem set, check the amount of available memory ([2nd] [MEM]). You can also check the sizes of other problem sets ([2nd] [VAR-LINK]). Problem sets are limited to 50 problems, but that number may be too many to save if you don't have enough free RAM. Also, keep in mind that users generally prefer problem set that have a maximum of 25-30 problems.

1. Press [F2].
2. Select **New Problem**. The New Problem screen is displayed. (If the problem set already contains problems, the problem type for the previous problem is displayed.)

3. Press a function key ([F1]-[F3]) to select a problem type category. The corresponding menu shows the problem types in that category.

4. Select a problem type. An example is displayed, as well as the keystrokes you would use to create that example.



The SOLVE QUADRATIC EQN. Screen ([F2], Quadratic Eqn.)

Note It is important to choose the most appropriate problem type category, because the available transformations might depend upon the category.

5. Type the problem.

6. Press [ENTER].

The F2 menu gives you the following options to use to create the problem set:

Use this F2 menu option…	To do this…
New Problem	Create a new problem and add it to the end of the problem set.
Edit Problem	Change the problem that is currently displayed.
Insert Problem	Create a new problem and place it before the current problem in the problem set.
Cut Problem	Delete a problem so that you can paste it to a new location.
Copy Problem	Copy a problem so that you can paste it to a new location.
Paste Problem	Pastes a copied problem into the problem set before the currently displayed problem.
Delete Problems	Delete a problem without storing it to the clipboard.

Navigating within a Problem Set

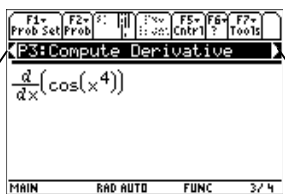
There are two ways to move from problem to problem within a problem set: use the navigation bar or the F5 menu.

Navigating Using the Navigation Bar

The problem number and the problem type are always displayed at the top of the screen. When you move the cursor to the problem number, the line becomes a navigation bar. Press ▶ or ◀ to display a different problem.

◀ displays the previous problem in the problem set.

2nd ◀ or ◀ displays the first problem in the problem set.



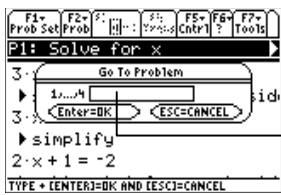
▶ displays the next problem in the problem set.

2nd ▶ or ▶ displays the last problem in the problem set.

Navigating Using the F5 Menu

The F5 menu gives you options to go to the next problem, the previous problem, or a specific problem in the problem set.

Use this F5 menu option…	To do this…
Next Problem	Display the next problem in the problem set.
Previous Problem	Display the previous problem in the problem set.
Go To Problem	Display a specific problem in the problem set (e.g., problem 10). Type the problem number, then press ENTER.



Type the problem number and press ENTER to display a specific problem.

Learning with Problem Sets

Note This user guide shows TI-92 Plus keystrokes. There are some keystroke differences between the TI-89 and the TI-92 Plus. Please refer to Keystroke Differences for more information on these differences.

1. Start the application and select a problem set. (See Starting and Quitting Symbolic Math Guide if you need more information.)

2. Select a problem to solve.

Applying Transformations to Equations

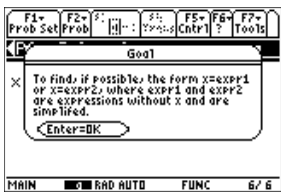
When you solve a problem, you apply a series of transformations to it until you reach an answer. Think of the transformations as the separate steps you take to reach the answer.

Consider the following example:

Problem	**Manual Solution**
Solve for *x*: $x^2 - 4 = 0$	1. Add 4 to both sides of the equation: $x^2 - 4 + 4 = 0 + 4$ which simplifies to $x^2 = 4$ 2. Take the square root of the left side and ± the square root of the right side: $\sqrt{x^2} = \sqrt{4}$ or, $x = \sqrt{4}$ or $x = -\sqrt{4}$ 3. Simplify the equations: $x = 2$ or $x = -2$ 4. Verify solution.

Symbolic Math Guide takes you through each of these steps. Let's look at the same problem solved using Symbolic Math Guide:

1. If you don't know how to solve the equation, you can press F6 and select **Hint** to display the goal for the problem.



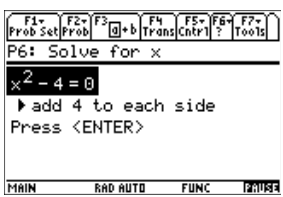
2. Press F4 to display some transformations that might apply to this problem type.

3. Select a transformation. For this problem, select **add ? to each side**.

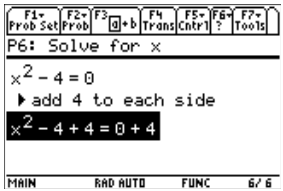
Note

For solving equations, most transformations that are displayed are applicable. However, many of them might be unwise choices because if they are applied, the problem is no closer to a solution.

4. Enter the value **4** to add to each side. Symbolic Math Guide displays your choice and pauses so that you can consider what the outcome of the transformation will be.



5. Press ENTER to see the transformation carried out.

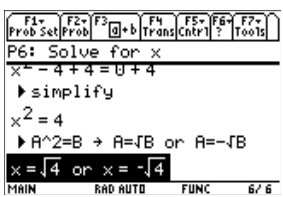


6. Press ENTER twice to simplify both sides of the equation.

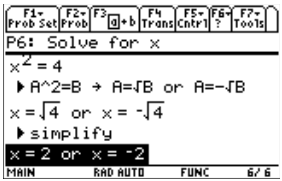
7. Now, you must select the next transformation to perform. Press F4 to display the list of transformations.

8. Select the next transformation to perform (**A^2=B → A=√B or A= -√B**). Symbolic Math Guide displays your choice and pauses so that you can consider the outcome of the transformation.

9. Press ENTER to see the transformation carried out.



10. Press ENTER twice to simplify the equation.

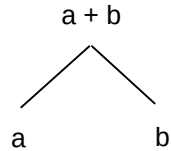
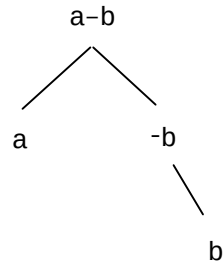
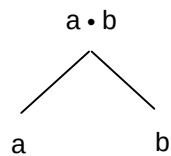


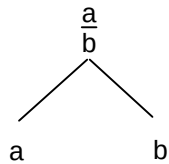
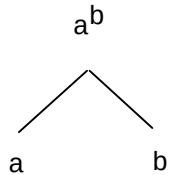
Selecting Part of an Expression

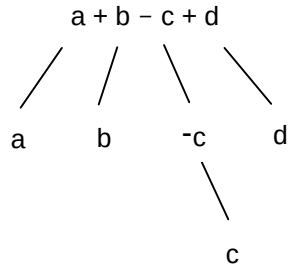
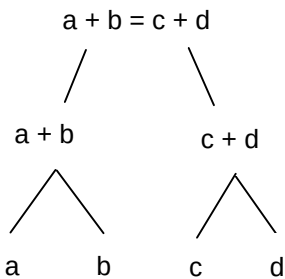
You can select a smaller part of an expression and perform transformations on it using the sub-expression selection tool (F3). Sometimes you must do this because F4 offers some transformations only if they are applicable to the entire expression or to a selected sub-expression.

You use the arrow keys and 2nd plus the arrow keys to select a sub-expression. It helps to understand the tree structure of the expression so that you know which arrow keys to press to select the sub-expression that you want. The following examples show expressions with their tree structures, including parent nodes, children nodes, and leaf nodes.

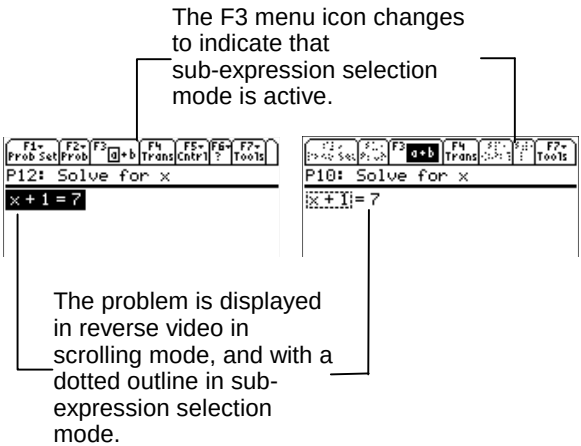
- A parent node is an expression.
- Children nodes are smaller sub-expressions that make up the parent node.
- Leaf nodes are either numbers or variables and have no children.

Expression	Tree Structure
For **a + b**: • **a + b** is the parent node of **a** and **b**. • **a** and **b** are children nodes of **a + b**. • **a** and **b** are leaf nodes.	
For **a − b**: • **a − b** is the parent node of **a** and **−b**. • **a** and **−b** are children nodes of **a − b**. • **−b** is the parent node of **b**. • **a** and **b** are leaf nodes.	
For **a • b**: • **a • b** is the parent node of **a** and **b**. • **a** and **b** are children nodes of **a • b**. • **a** and **b** are leaf nodes.	

Expression	Tree Structure
For $\frac{\mathbf{a}}{\mathbf{b}}$: • $\frac{\mathbf{a}}{\mathbf{b}}$ is the parent node of **a** and **b**. • **a** and **b** are the children nodes of $\frac{\mathbf{a}}{\mathbf{b}}$. • **a** and **b** are leaf nodes.	
For $\mathbf{a^b}$: • $\mathbf{a^b}$ is the parent node of **a** and **b**. • **a** and **b** are the children nodes of $\mathbf{a^b}$. • **a** and **b** are leaf nodes.	
For **sin(a)** : • **sin(a)** is the parent node of **a**. • **a** is the child node of **sin(a)**. • **a** is a leaf node.	

Expression	Tree Structure
For **a + b − c + d**: • **a + b − c + d** is the parent node of **a**, **b**, **c**, and **d**. • **a**, **b**, **-c**, and **d**, are the children nodes of **a + b − c + d**. • **-c** is the parent node of **c**. • **a**, **b**, **c**, and **d** are leaf nodes.	
For **a + b = c + d**: • **a + b = c + d** is the parent node of **a + b** and **c + d**. • **a + b** and **c + d** are the children nodes of **a + b = c + d**. • **a + b** is the parent node of **a** and **b**. • **c + d** is the parent node of **c** and **d**. • **a**, **b**, **c**, and **d** are leaf nodes.	

▶ To enter sub-expression selection mode, press F3.

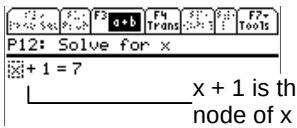
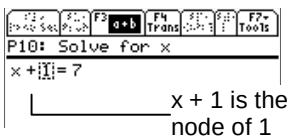
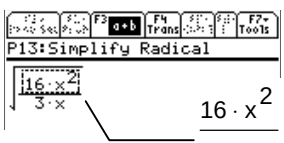
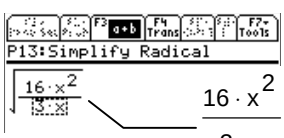


▶ To select a parent or a child node:

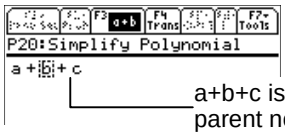
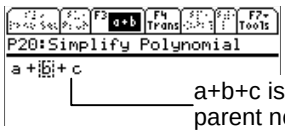
- Press ▲ to select the parent of the selected expression.
- Press ▼ to select a child of the selected expression.

Initial selection	Key pressed	New selection
	▲	
	▼	

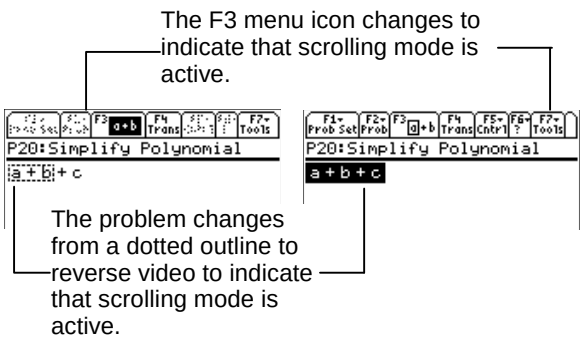
▶ To select a sibling node (another child node when a child node is currently selected), press ⊙ or ⊙.

Initial selection	Key pressed	New selection
	⊙	
	⊙	
	⊙	
	⊙	

▶ To select an adjacent sibling node (select both the currently selected child node and an adjacent child node), press [↑] ⊙ or [↑] ⊙.

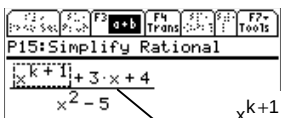
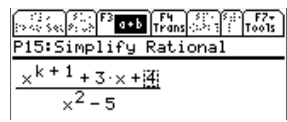
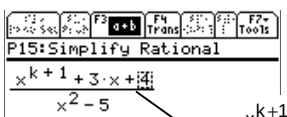
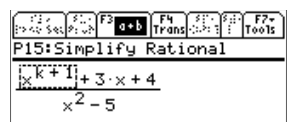
Initial selection	Keys pressed	New selection
	[↑] ⊙	
	[↑] ⊙	

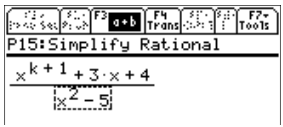
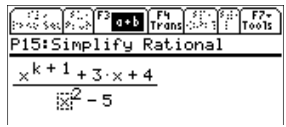
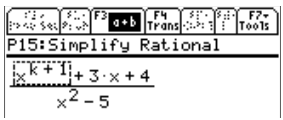
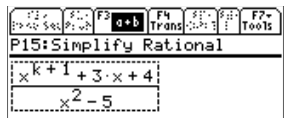
▶ To exit sub-expression selection mode, press [F3] or [ESC].



Shortcuts

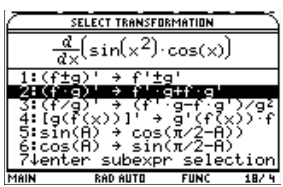
- Press 2nd ▶ to select the rightmost child node of the current parent node.
- Press 2nd ◀ to select the leftmost child node of the current parent node.
- Press 2nd ▼ to select the leftmost leaf of the selected expression.
- Press 2nd ▲ to select the entire expression.

Initial selection	Keys pressed	New selection
 $x^{k+1}+3x+4$ is the parent node of x^{k+1}.	2nd ▶	
 $x^{k+1}+3x+4$ is the parent node of 4.	2nd ◀	

Initial selection	Keys pressed	New selection
	2nd ⌄	
	2nd ⌃	

▶ Compute the derivative $\frac{d}{dx}(\sin(x^2) \bullet \cos(x))$:

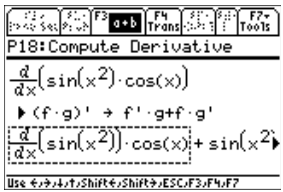
1. Create the problem in your problem set.
2. Press F4 to display possible transformations.



3. Select the transformation **(f • g)′ → f′ • g+f • g′** and press ENTER.

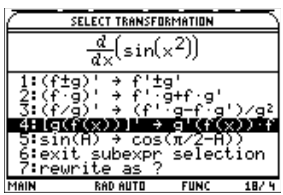
4. Press ENTER again to apply the transformation.

5. Press F3 to change to sub-expression selection mode.



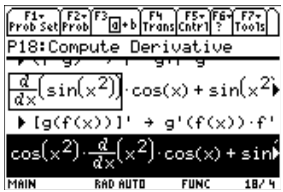
6. Press ▼ to select $\frac{d}{dx}(\sin(x^2))$.

7. Press F4 to display possible transformations.

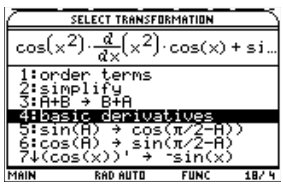


8. Select **[g(f(x))]′ → g′(f(x))·f′(x)]** and press ENTER.

9. Press ENTER again to apply the transformation.

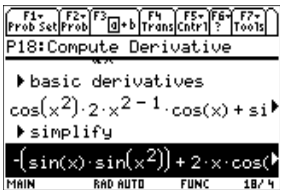


10. Press F4. The transformation menu now provides the transformation **basic derivatives**, that would not have appeared on any transformation menu if you had not first applied a transformation to the sub-expression $\frac{d}{dx}\left(\sin\left(x^2\right)\right)$.



11. Select basic derivatives, and then press ENTER.

12. Press ENTER again to simplify the derivative.

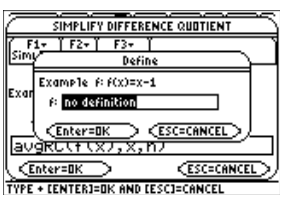


Defining a Function

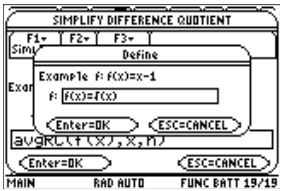
Symbolic Math Guide lets you simplify expressions and solve equations that contain functions. You can also define the function, if you want to. When you create a problem that contains a function, a dialog box is displayed that lets you define the function.

▶ Simplify the difference quotient $\frac{f(x+h)-f(x)}{h}$ for $f(x) = \sqrt{(x)}$:

1. Press F2, and then select **New Problem**.
2. Press F1, and then select **Difference Quotient**.
3. Enter the problem: avgRC(**f(x),x,h)**, and then press ENTER. The Define dialog box is displayed.



4. Enter the definition **f(x)=√(x)**, and then press ENTER.



Tip

To change a function definition:

1. Press F2 and select **Edit Problem**.
2. Press ENTER to display the Define dialog box.
3. Make your changes and press ENTER to save them.

Substituting, Back-substituting, Rewriting, and Verifying Equations

Symbolic Math Guide lets you transform expressions in several ways that make it easier for you to solve problems:

- Substituting – You can substitute a variable for an expression or sub-expression to represent it more concisely.
- Back-substituting – You can substitute the original sub-expression back into the problem to complete a solution.
- Rewriting – You can rewrite an expression in a form that is easier for you to operate upon.
- Verifying – After you have solved an expression, you can verify the solution.

Substituting a Variable for an Expression

▶ Solve the exponential equation $(2^x)^2 + 2 \cdot 2^x - 3 = 0$.

You can make a substitution to make this equation easier to solve.

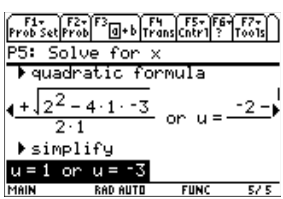
1. Press F7, and then select **Substitute** to display the substitute ?1 for ?2 dialog box.

Note The ?2 field automatically displays the part of the equation that might warrant a substitution. The resulting equation is displayed in the rewrite field. You can change both of these values, if needed.

2. Enter the variable that you want to substitute in the ?1 field (for example, **u**), and then press ENTER to accept the proposed substitution: **u** for **2^x**.

3. Press ENTER again to apply the transformation.

The resulting equation, $u^2 + 2u - 3 = 0$ is a quadratic equation in standard form. When you solve this equation, you find that $u = 1$ or $u = -3$.



Back-Substituting into the Equation

When you make a substitution in a problem, you need to substitute the original expression back into the problem so that you can solve the original problem.

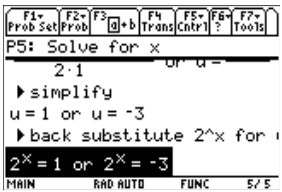
▶ In the previous example, you found that u = 1 or u = -3, but in the original problem, $(2^x)^2 + 2 \cdot 2^x - 3 = 0$, you needed to solve for x. To solve for x, back-substitute $u = 2^x$ into the original problem:

1. Press [F7], and then select **Back Substitute**. The back substitute ?1 for ?2 dialog box is displayed, showing the substitutions you made in the problem.

Note If you made more than one substitution, press ▲ or ▼ to select the back-substitution you want and press [ENTER] to select it.

2. Press [ENTER] to make the back-substitution.

3. Press [ENTER] again to apply the transformation.



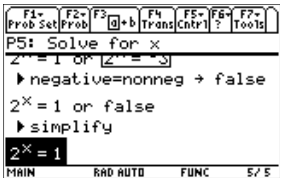
Rewriting and Expression and Verifying an Equation

You can use the Verify Solution option on the F7 menu to check your solution.

▶ Solve the exponential equation $(2^x)^2 + 2 \cdot 2^x - 3 = 0$, and then verify the solution:

1. Use sub-expression selection to select **2x = -3**.
2. Press [F4] to display possible transformations.
3. Select **negative=nonneg** → **false** and press [ENTER].
4. Press [ENTER] again to apply the transformation.

5. Press [ENTER] twice to simplify.



6. Use sub-expression selection to select **1**.

7. Press [F7] and select **Rewrite**. The rewrite as ? dialog box is displayed.

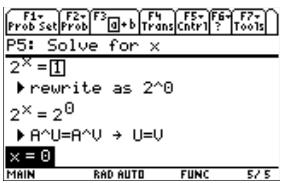
8. Enter **2^0** to rewrite 1 as 2^0 and press [ENTER].

9. Press [ENTER] again to apply the transformation.

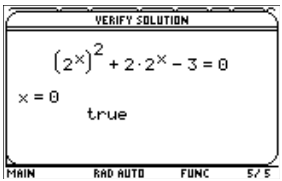
10. Press [F4] to display possible transformations.

11. Select **A^U=A^v → U=V** and press [ENTER].

12. Press [ENTER] to apply the transformation.



13. Press F7 and select **Verify Solution**.



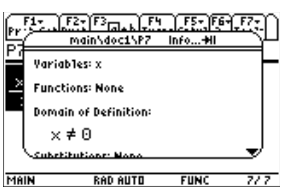
Domain of Definition and Domain Preservation Constraints

The following examples show how to display the domain of definition for a problem, and how Symbolic Math Guide applies domain preservation constraints.

In the first example, the original expression, $\frac{x^2}{x}$, is undefined at $x = 0$; therefore, it has a domain of definition of $x \neq 0$. However, $\frac{x^2}{x}$ simplifies to the expression x, which has an apparent domain of definition which includes $x = 0$. When you apply **divide like factors**, $\frac{x^2}{x}$ is transformed into $x \mid x \neq 0$. The solution indicates that the constraint $x \neq 0$ still applies. The transformation constrained the apparent domain of definition of the expression x.

▶ Simplify the rational expression $\frac{x^2}{x}$:

1. Press F7 and select Info to display information about this expression.

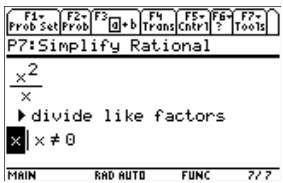


2. Press [ESC] to exit the information screen.

3. Press [F4] to display possible transformations.

4. Select **divide like factors** and press [ENTER].

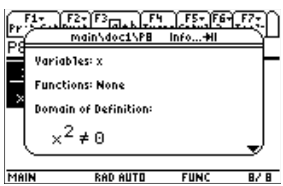
5. Press [ENTER] again to apply the transformation. The solution is displayed.



In the next example, the transformation **divide like factors** simplifies the expression $\frac{x}{x^2}$ into $\frac{1}{x}$ without any indication of domain because both the original expression and the simplified expression have the same domain of definition, $x \neq 0$.

▶ Simplify the rational expression $\frac{x}{x^2}$:

1. Press F7 and select Info to display information about this expression.



2. Press ESC to exit the information screen.

3. Press F4 to display possible transformations.

4. Select divide like factors and press ENTER.

5. Press ENTER again to apply the transformation. The solution is displayed.

Shortcuts – Scrolling Mode

Keystrokes	Description	Problem Types
2nd ▶ or ♦ ▶	Displays the last problem in the problem set, with the problem statement highlighted	All
2nd ◀ or ♦ ◀	Displays the first problem in the problem set, with the problem statement highlighted	All
2nd ▲ or ♦ ▲	Moves the cursor to the first math object	All
2nd ▼ or ♦ ▼	Moves the cursor to the last math object	All
♦ ▲	Moves the cursor to the top of the problem	All
♦ ▼	Moves the cursor to the bottom of the problem	All

Keystrokes	Description	Problem Types
[ENTER]	In time to think mode:	All
	Applies the selected transformation	
	In normal mode:	
	• Performs arithmetic on these problem types: simplify powers and simplify polynomial	Simplify powers and polynomial
	• Performs arithmetic and the 0 & 1 identities on simplify problems problem type	Simplify rational, radical, log & differential, and difference quotient
	• Simplifies the expression	Solve equations (all) and compute derivatives
I	Displays Info screen for the problem	All
S	Substitutes a variable for an expression	All
B	Back-substitutes an expression for a variable	All
[♦] [ENTER]	Approximates the solution	All
V	Verifies the solution	All

Keystrokes	Description	Problem Types
+	When an expression is selected, applies the following transformation: add 0=?-? to the expression	All
×	When an expression is selected, applies the following transformation: multiply the expression by 1=?/?	All
STO▸	When an expression is selected, applies the following transformation: rewrite expression as ?	All
+	When an equation is selected, applies the following transformation: add ? to each side	
−	When an equation is selected, applies the following transformation: subtract ? to each side	
×	When an equation is selected, applies the following transformation: multiply each side by ?	All

Keystrokes	Description	Problem Types
÷	When an equation is selected, applies the following transformation: divide each side by ?	All
[LN]	When an equation is selected, applies the following transformation: apply ln to each side	All
[^]	When an equation is selected, applies the following transformation: raise both sides to ? power	All
[2nd] [√]	When an equation is selected, applies the following transformation: take square root of each side	All

Shortcuts – Sub-expression Selection Mode

Keystrokes	Description
2nd ▶	Selects the rightmost child node of the current parent node
2nd ◀	Selects the leftmost child node of the current parent node
2nd ▼	Selects the leftmost leaf of the selected expression
2nd ▲	Selects the entire expression

Frequently Asked Questions

What is the Domain of Definition (F7 Info)?

It is the set of all finite real values of the variables in an expression for which the expression and all of its sub-expressions are finite and real. For example, the domain of definition for $\left(\sqrt{x}+\ln(y)+\sin^{-1}(z)+\frac{1}{t}\right)$ is $t \neq 0$, $x \geq 0$, $y > 0$, $z \geq -1$ and $z \leq 1$.

Why does applying "divide like factors" to $\frac{x^2}{x}$ produce $x \mid x \neq 0$, whereas applying "divide like factors" to $\frac{x}{x^2}$ produces $\frac{1}{x}$, with no constraint?

The domain of definition for $\frac{x^2}{x}$ is $x \neq 0$, whereas the domain of definition for x is all finite real values of x. Therefore, the constraint is adjoined to x to preserve the domain of definition. In contrast, $\frac{x}{x^2}$ and $\frac{1}{x}$ both have the same domain of definition: $x \neq 0$. Therefore, it isn't necessary to adjoin a constraint on $\frac{1}{x}$ to avoid enlarging the domain of definition. You can always use F7 **Info: Domain of Definition** to compute the complete domain of definition whenever you wish.

Why does applying "0·A → 0" to $0\cdot\sqrt{x}$ produce 0 | x ≥ 0, whereas applying "0+A → A" to $0+\sqrt{x}$ produces $\sqrt{x}$ with no constraint?

The domain of definition for $0\cdot\sqrt{x}$ is x ≥ 0, whereas the domain of definition for 0 is all finite real values of x. Therefore, the constraint is adjoined to 0 to preserve the domain of definition. In contrast, $0+\left(\sqrt{x}^{2}\right)$ and $\sqrt{x}$ both have the same domain of definition: x ≥ 0.

Therefore, it isn't necessary to adjoin a constraint to $\sqrt{x}$ to avoid enlarging the domain of definition. You can always use F7 **Info: Domain of Definition** to compute the complete domain of definition whenever you wish.

Why does applying "1^A → 1" to $1^{\ln(x)}$ produce 1 | x > 0, whereas applying "1·A → A" to 1·ln(x) produce ln(x) with no constraint?

The domain of definition for $1^{\ln(x)}$ is x > 0, whereas the domain of definition for 1 is all finite real values of x. Therefore, the constraint is adjoined to 1 to preserve the domain of definition. In contrast, 1•ln(x) and ln(x) both have the same domain of definition: x > 0. Therefore, it isn't necessary to adjoin a constraint to ln(x) to avoid enlarging the domain of definition. You can always use F7 **Info: Domain of Definition** to compute the complete domain of definition whenever you wish.

Why doesn't the home screen generate domain preservation constraints such as when transforming $0 \cdot \sqrt{x}$ to 0?

On the home screen | is used only for input, and REAL mode means only that the *resulting expressions* must be real. In contrast, Symbolic Math Guide also uses | for output to constrain variables so that *all sub-expressions* are also real.

Why doesn't the home screen generate domain preservation constraints such as when transforming x^0 to 1?

In keeping with their use in limits and improper integrals, infinite magnitude results such as +∞ and -∞ are considered to be *defined* on the home screen. In contrast, +∞ and -∞ are considered to be *undefined* in Symbolic Math Guide where there are no limit or improper integral problems.

Why does the F4 menu offer ln(A^B) → B·ln(A) for examples such as $\ln(2^y)$, $\ln(x^3)$, $\ln(x^{5/3})$ and $\ln(x^{3/4})$, but not for $\ln(x^y)$?

This transformation is valid if A is non-negative or if B is odd or a reduced ratio of two odd integers or has even reduced denominator. If A might be negative and B is even or has an even reduced numerator, then the appropriate transformation is ln(A^B) → B ln(|A|). Symbolic Math Guide must know enough about the specific A and B to determine which of these two transformations is applicable. For example, adjoin "| x > 0" to your original problem input. Alternatively, use F7 **Rewrite** to force the transformation you desire.

Why does the F4 menu offer (A^B)^C → A^(B•C) for examples such as $(2^y)^t$, $(x^3)^t$, $(x^y)^3$, $(x^{5/3})^t$, and $(x^y)^{5/3}$, but not for $(x^y)^t$, $(x^2)^t$, $(x^y)^2$, and $(x^y)^{3/4}$?

This transformation is valid if A is non-negative or if B and/or C is odd or a reduced ratio of two odd integers. Otherwise, depending on B, C and B•C, the appropriate transformation might be (A^B)^C → |A|^(B•C) or (A^B)^C → A^(B•C) | A ≥ 0. For example, $(x^2)^{1/2} \rightarrow |x|^{2\ 1/2}$, and $(x^{1/2})^2 \rightarrow x^{1/2.2}$ | x ≥ 0. Symbolic Math Guide must know enough about the specific A, B and/or C to determine which of these three transformations is applicable. For example, adjoin "| x > 0" to your original problem input. Alternatively, use F7 **Rewrite** to force the transformation you desire.

Why does the F4 menu offer (-A)^B → A^B for examples such as $(-x)^2$, and offer (-A)^B → -A^B for examples such as $(-x)^3$, but offer neither for examples such as $(-x)^y$ and $(-x)^{1/2}$?

The first transformation is valid if B is odd or a reduced ratio of two odd integers. The second transformation is valid if B is even or a reduced ratio of an even over an odd integer. Neither is valid if B is a reduced ratio of an odd over an even integer. For example, $(-(-1))^{1/2}$ is 1, but $(-1)^{1/2}$ and $-(-1)^{1/2}$ are both non-real. Symbolic Math Guide must know enough about the specific B to determine which of these two transformations is applicable, if any. For example, adjoin "| x > 0" to your original problem input. Alternatively, use F7 **Rewrite** to force the transformation you desire.

Why does the F4 menu offer (A•B)^C → A^C•B^C for examples such as $(2•y)^t$, $(x•y)^2$ and $(x•y)^3$, and offer (A•B)^C → |A|^C•|B|^C) | A•B ≥ 0 for examples such as $(x•y)^{1/2}$, but offer neither for examples such as $(x•y)^t$?

The first transformation is valid if A or B is non-negative or if C is odd or a reduced fraction having an odd denominator. The second transformation is valid if C is a reduced fraction having an even denominator. Symbolic Math Guide must know enough about the specific A, B or C to determine which of these two transformations is applicable. For example, adjoin "| x > 0" to your original problem input. Alternatively, use F7 **Rewrite** to force the transformation you desire.

Why does the F4 menu offer (A/B)^C → A^C/B^C for examples such as $(2/y)^t$, $(x/y)^2$ and $(x/y)^3$, and offer (A/B)^C → |A|^C/|B|^C) | A/B ≥ 0 for examples such as $(x/y)^{1/2}$, but offer neither for examples such as $(x/y)^t$?

The first transformation is valid if A or B is non-negative or if C is odd or a reduced fraction having an odd denominator. The second transformation is valid if C is a reduced fraction having an even denominator. Symbolic Math Guide must know enough about the specific A, B or C to determine which of these two transformations is applicable. For example, adjoin "| x > 0" to your original problem input. Alternatively, use F7 **Rewrite** to force the transformation you desire.

Why does the F4 menu offer $\tan(\tan^{-1}(A)) \rightarrow A$ for examples such as $\tan(\tan^{-1}(\pi/2))$ but not for examples such as $\tan(\tan^{-1}(y))$?

This transformation is valid in Symbolic Math Guide only if $A > -\pi/2$ and $A < \pi/2$. The application must know enough about the specific A to determine if the transformation is applicable. For example, adjoin "| $x > -\pi/2$ and $x < \pi/2$" to your original problem input. Alternatively, use F7 **Rewrite** to force the transformation you desire. (The reason the transformation isn't valid for $A = \pi/2$ or $A = -\pi/2$ is that $\tan(\pi/2)$ and $\tan(-\pi/2)$ are considered undefined in Symbolic Math Guide.)

Why don't the usual equation-solving transformations appear on the F4 menu?

When the problem was created, a problem type from the Simplify category was probably used instead of a problem type from the Solve category.

The Compute Derivative problem type doesn't allow a third argument for *d(expression,variable)*. How can I compute higher order derivatives?

You can enter a *d(…, …)* in the first argument of *d(…,…)* as deeply nested as you wish. For example, to compute the third derivative of x^3 with respect to x, the entire entry is *d(d(d(x^3,x),x),x)*.

How can I turn off the TIME TO THINK mode so that I only have to press ENTER once after selecting each transformation?

1. Press F1 and select Format.
2. Press ▶ to display the drop-down list and press ▼ and then press ENTER to select OFF.
3. Press ENTER to save the setting change.

Pressing ENTER seems to accomplish different things. Can you explain?

When the TIME TO THINK mode is on, the application pauses to let you consider what will happen when you apply the selected transformation. You must press ENTER after you select each transformation to apply that transformation.

Pressing ENTER is also a shortcut to "clean up" the equation or expression currently displayed. "Cleaning up" means:

- Performing arithmetic for the following problem types: **Simplify: Powers** or **Simplify: Polynomial**
- Performing arithmetic or applying the 0 and 1 identity for the following problem types: **Simplify: Rational**, **Simplify: Radical**, **Simplify: Log & Exponential**, or **Simplify: Difference Quotient**
- Simplifying the expression for all **Solve** problem types and for **Compute: Derivatives**

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