An Introduction to the *Symbolic Math Guide*

> *Purpose of Symbolic Math Guide (SMG): To help students learn algebra and some aspects of calculus by guiding them as they develop correct textbook-like solutions. SMG can be used when a student first learns a topic or as quick review.*

SMG is a tool for learning algebra that provides additional help to support textbooks and teachers. It is not a powerful computer algebra system that can solve large classes of difficult problems. If you wish to expand $(x + y)^{15}$ or do other complicated problems, you should use the Home screen of the TI-89, TI-92 Plus, Voyage™ 200, TI-Interactive!™, or Derive™.

Features:

- Work is organized by problem sets. *SMG* comes with sample problems. Teachers, publishers, and students can create their own sets.
- Students work problems by choosing from problem-solving options that *SMG* provides based on the problem and the current solution step.
- Students learn strategy in the absence of arithmetic mistakes and lower level algebra.
- Students learn to think about math objects, how to classify them, and what transformations apply to them at various stages of solving problems.
- The transformations suggested are designed to focus on the new material being learned.

A Brief Guided Tour

You will need:

- TI-89/TI-92 Plus or Voyage™ 200 with the Advanced Mathematics operating system version 2.08 or higher)
- Symbolic Math Guide (ver 1.5 or higher).
- Problem Set Tourps.

Let's start solving problems with Symbolic Math Guide!

1. Press ON to start the calculator.

2. Press APPS and highlight **Symbolic Math Guide**.

3. Press ENTER ENTER.

4. Choose **Open** and then press ENTER.

5. Open **Tourps**, which contains the problems we will use for this guided tour. Note that the first problem is ready for you to work.


> **MAIN PROCESS:** For each step
>
> A. Think about what you want to do next.
> B. Press F4 to see a list of possible transformations.
> C. If you see what you want to do, press the corresponding number and follow the instructions. Anticipate the result produced by your choice.
> D. If you don't see what you want to do, choose the best choice offered or choose a different part of the current math object (See below after Problem 5.).
> E. If you need help understanding the goal of solving a problem, press [F7:1].

Problem 1: Solve linear equation $3 \cdot x + 1 = x - 2$ for *x*.

> *SMG* **feature:** For maximum learning, students should anticipate the result of each transformation. Writing each step down with pencil and paper helps some students. When in the TIME TO THINK mode, *SMG* gives students extra time to write their next step by waiting until they press ENTER to show the result. Students will probably not want to use this mode when they are using *SMG* to review material previously learned. To turn TIME TO THINK mode ON and OFF, go to Format screen (F1: 9).

1. Press F4 and choose a transformation that will accomplish this goal. For example, press F4 and choose **subtract ? from each side** and type **x** when prompted.

2. Press ENTER to clean-up the result.

3. Move the 1 to the right-side. Press F4 and choose **subtract…**

4. Press ENTER to clean-up the result.

5. Press F4 and choose **divide…**

6. Press ENTER to clean-up the result.

7. Press ⊙ repeatedly to scroll through your solution.
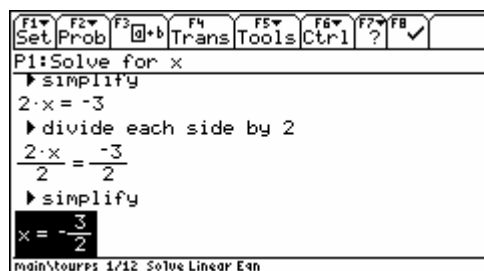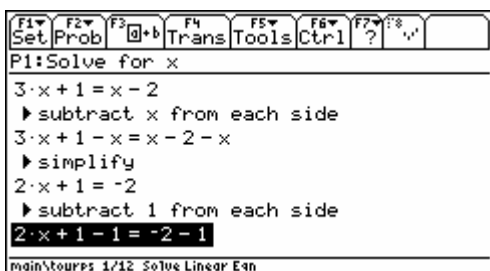
> *SMG* **Feature:** As you have just seen, *SMG* will show the details of a transformation. To clean-up the result of a transformation without choosing a transformation from F4, press ENTER. This allows students to focus on the current new material without having to go through the details of previous work. If you want your students to handle the details themselves, have them choose appropriate transformations from F4.

8. To move to the next problem, press F6:1.

Problem 2: Simplify monomial $y^2 \cdot y^3$.

1. Press [[F6]:1] if you haven't already.

2. Press [F4] and choose **A^U • A^V -> A^(U+V)**.

3. Press [ENTER] to clean up the previous result.

4. Press the up cursor to go up to the original math object $y^2 \cdot y^3$.

5. Choose a different transformation. The old transformation and result are replaced.
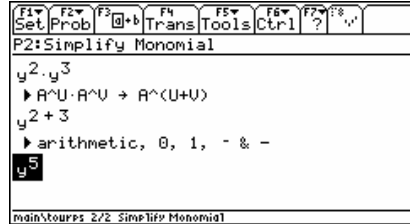
SMG **Feature**: *SMG* has 'quick keys' for certain frequently used transformations. For example press [+] to **add ? to each side** of an equation.

SMG **Feature:** *SMG* implements domain constraints. When a transformation changes the domain of definition, new conditions are displayed as part of the result.

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6. To move to the next problem, press [F6]:1.

Problem 3: Solve linear equation $c \cdot x + 3 = b$ for x.

1. If you are not sure of the goal of solving this problem, press [F7]:1. We want to move the 3 on the left side to the right side.

2. Press quick key [−]. Type **3**. Press [ENTER].

3. Press [ENTER].

4. Press [÷]. Type **c**. Press [ENTER]. Dialog box "This action …" shows up.

5. Press [ENTER] to continue. Please note that the Problems statement has been modified to include the constraint $c \neq 0$.

6. Press [ENTER] to simplify the result.
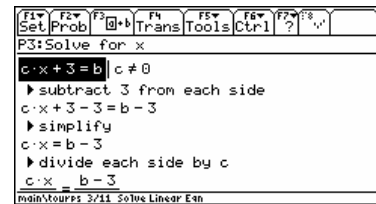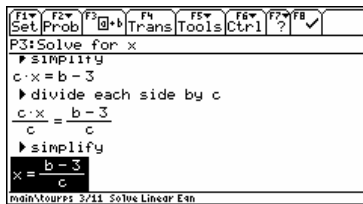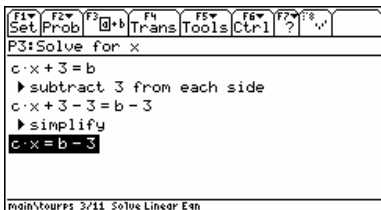
7. Press [F6]:1 to move to the next problem in the current problem set.

Problem 4: Compute the derivative $\dfrac{d}{dx}\cos\left(x^4\right)$

1. Press F4 and apply **derivative of composition**.

2. SMG provides a dialog box which requests definitions for the outside function, *f*, and the inside function, *g*. Enter the information or press F1 for Help (SMG will provide possible choice for the two functions.) Make sure that the choice is the one you want. Change it if it is not. Press ENTER twice to continue to the display.

3. Think about the result (or write it down). Then press ENTER to see SMG's result.

4. Compare results and explain any significant differences.

5. Press F4 and look for a way to transform the remaining derivative. Choose, for example,
$$\frac{d}{dx}x^r \rightarrow r \cdot x^{r-1}\,.$$
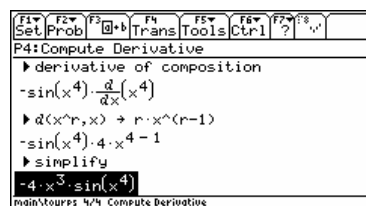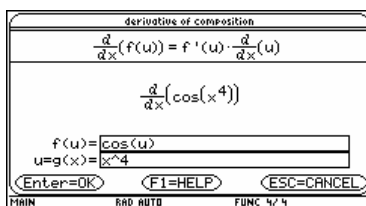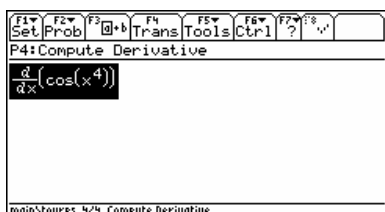
6. Press F6:1 to move to the next problem in the current problem set.

Next, consider several examples that use subexpression selection.

Experts solve algebra problems by recognizing that they can perform a certain transformation on a particular part of a math object and that this transformation moves toward the goal of the problem. For example, one might want to factor the left-hand side of an equation when trying to solve the equation.


REVISED MAIN PROCESS: For each step

A. Think about what part (or whole) of the object you want to change; select it.
B. Press F4 (Trans).
C. If you see what you want to do, press the corresponding number.
D. If you don't see what you want to do, choose a different part of the current math object. [See **SUBEXPRESSION SELECTION PROCESS** immediately below.]
E. Press F4 again to see what you can do with the currently selected math object.
F. If you are not sure what you are supposed to be doing, check F7:1 for a hint or for the goal of this particular type of problem.

SUBEXPRESSION SELECTION PROCESS: [This information is available under F7:3.]
A. To start press F3 or F4: enter subexpr selection.
B. To move to a smaller part of the object press ⊙.
C. To move to an object at the same level press ⊙ or ⊙.
D. To move to a larger object press ⊙.
E. To exit subexpression selection press F3 or F4: exit subexpr selection.

Problem 5: Compute the derivative $\dfrac{d}{dx}\sin(x^2)\cdot\cos(x)$

1. Press F4 and choose **derivative of product**.

2. SMG provides a dialog box which requests definitions for the functions *f* and *g*. Enter the information or press F1 for Help (SMG will provide possible choices for the two functions.) Press ENTER twice to continue to the display.

3. Press F3. Press ⊙ ⊙ to select $\dfrac{d}{dx}\sin(x^2)$.

4. Press F4 and choose **derivative of composition**.

5. SMG provides a dialog box which requests definitions for the outside function, *f*, and the inside function, *g*. Enter the information or press F1 for Help (SMG will provide possible choice for the two functions.) Make sure that the choice is the one you want. Change it if it is not. Press ENTER twice to continue to the display.

6. Press F4 and choose **basic derivatives**. Press ENTER to clean-up.
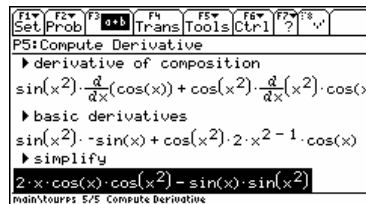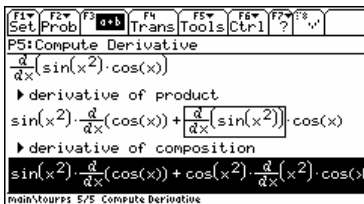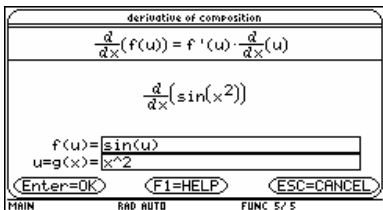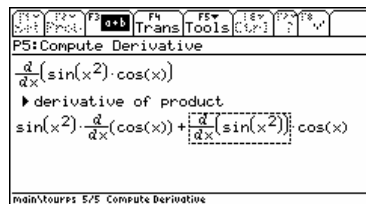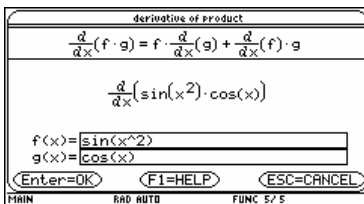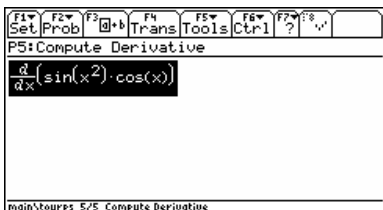
7. Press F6:1 to move to the next problem in the current problem set.

Problem 6: Solve quadratic equation $x^2 - 3x = 4$.

- Press F3 to try subexpression selection. Press ◐ followed by ◑. Press ◒. Try your own arrow choices. Press F3 or ESC to exit subexpression selection. If x^2 is selected, how do you select 4?

- Before trying to solve this problem, under F7:1, find the goal of solving quadratic equations.

Students should be able to factor the left-hand side of this equation once it is in the proper form.

1. Press − to **subtract…**, Type **4**. Press ENTER ENTER.

2. Press F3 to select the left-hand side.

3. Press F4 and choose **factor**. Note how the left side remains boxed so that you can tell what part of the equation was factored.

4. Press F4 and choose **A·B = 0 -> A = 0 or B = 0**.

5. Press F4 and choose **solve linear equation(s)**. Note that students don't need to figure out how to use *SMG* to finish this problem. A teacher could require students to provide the details, in which case they finish by selecting the individual equations and choosing appropriate transformations.
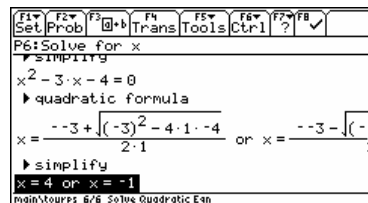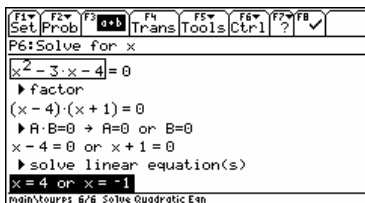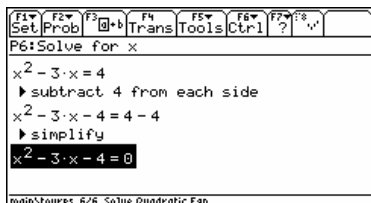
Let's try to solve this in a different way. The quadratic formula is useful for solving quadratic equations.

SMG **Feature:** Students can perform legal steps that are not necessarily the best steps and students can use different methods to solve a given problem. So *SMG* makes it easy for students to go back to any previous step and try a different transformation. Press ◓ to get back to the step you wish to change. Then choose a new transformation.

1. Press ◓ until you get to the original equation. (You could use the 3rd equation.)

2. Check F4 to see if we can use the quadratic formula now. It's not there. We need to modify the equation first.

3. Press − to **subtract…**, Type **4**. Press ENTER ENTER.

4. Now, choose **quadratic formula** from F4. Press ENTER to simplify the answers.

If you wish, you can go back to the first step, press 2nd ◓ and solve this quadratic equation by completing the square. (You are on your own.)

5. Press F6:1 to move to the next problem in the current problem set.

**Problem 7:** Simplify rational expression $\dfrac{x^3 - 2x^2 + x}{x - 1}$.

1. Press F4 and choose **factor numerator**.

2. Press F4 and choose **divide like factors**. Press ENTER.
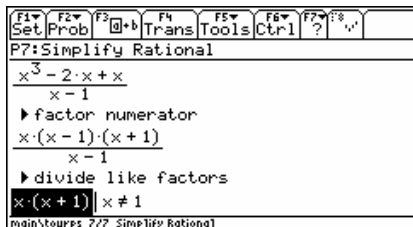
3. Press F6:1 to move to the next problem in the current problem set.

Problem 8: Simplify the polynomial $x^2 + x + y + 1 - (x + y)$.

1. Press F4 and choose **A-(B+C)->A-B-C**.

2. Press F4 and choose **order terms**.
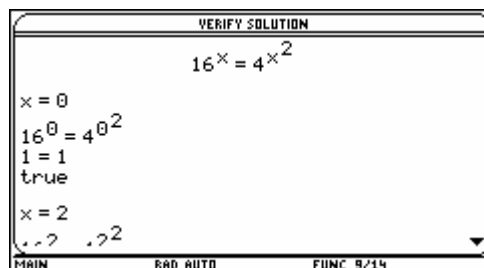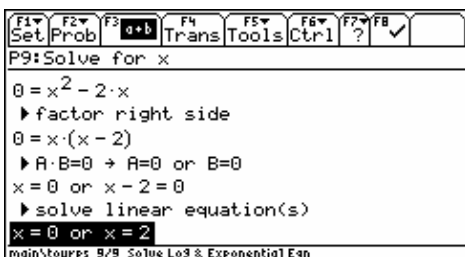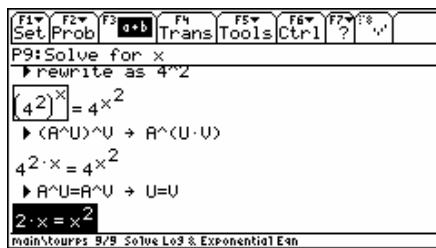
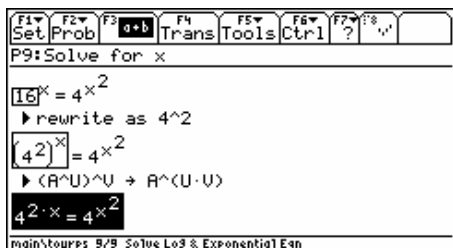3. Press F4 and choose **combine like terms**. Press ENTER again to clean-up.
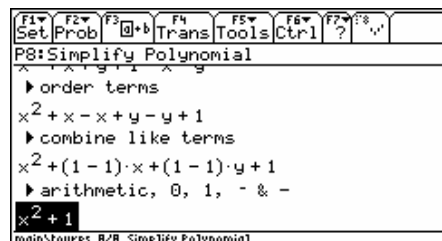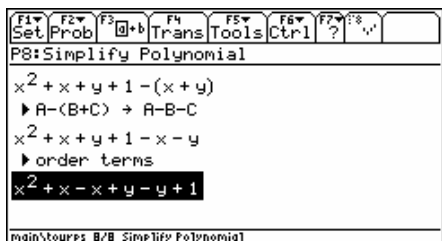
SMG **Feature:** To give the student flexibility to handle special situations, *SMG* allows students to select a subexpression and replace it with an equivalent expression. *SMG* will test for equivalence of the two expressions. Select the subexpression to change and press the STO▶ key.

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4. Press F6:1 to move to the next problem in the current problem set.

Problem 9: Solve the exponential equation $16^x = 4^{x^2}$.

1. Press F3. Press ⊙ to select **16**. Press the STO▶ key or choose F7: Rewrite. Type **4^2**. Press ENTER.

2. Press F3 to select the left-hand side; press F4 and choose **(A^U)^V -> A^(U*V)**.

3. Press F4 and choose **A^U = A^V -> …**

4. Press F4 and subtract $2x$ from each side. Press ENTER. Press ENTER again to clean-up.

5. Press F4 and select **factor right side**.

6. Press F4 and choose **A•B=0 -> …**

7. Press F4 and choose **solve linear equation(s)**.

8. Press F8 to verify solution.

> *SMG* **Feature:** To give the student flexibility to handle special situations, *SMG* allows students to substitute variables for expressions. Select the subexpression to substitute for and press
> F7 : Substitute

9. Press ENTER to return to the problem.

10. Press F6 :1 to move to the next problem in the current problem set.

Problem 10: Simplify difference quotient $\dfrac{f(x+h) - f(x)}{h}$, where f(x)= $\sqrt{x}$.

1. Press F4 and choose **apply definition of f** .

2. Press F4 and choose **rationalize numerator** .

3. Press F4 and choose **expand & simplify numerator**.

4. Press F4 and choose **divide like factors**.
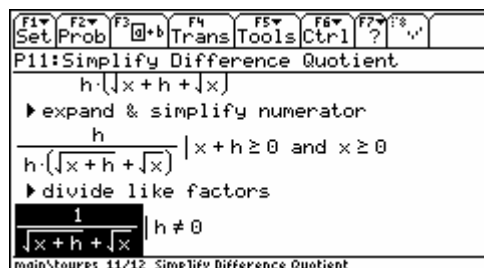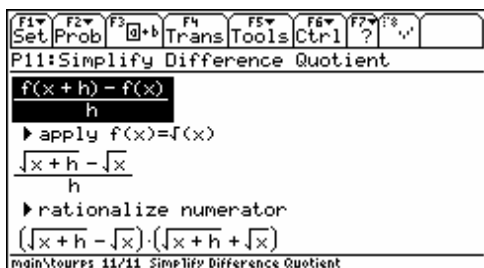
5. Press F6 :1 to move to the next problem in the current problem set.

Problem 11: Solve the exponential equation $(2^x)^2 + 2*2^x - 3 = 0$.

1. Choose F5:Substitute.

2. SMG provides a dialog box which requests substitution information.definitions. Enter the information or press F1 for Help (SMG will provide possible substitution information). Make sure that the choice is the one you want. Change it if it is not. Press ENTER twice to continue to the display.

3. Press F4 and choose **factor left side**.

4. Press F4 and choose **A·B=0 -> …**.

5. Press F4 and select **solve linear equation**.

6. Press F5 4: Back Substitute to back substitute 2^x for u.

7. Press F3. Press ⟩ to select $2^x = -3$ and conclude that there are no solutions for this equation by pressing F4 and selecting **negative = nonneg ->false**.

8. Pressing ENTER will get rid of "false".

9. Press F4 and choose **A^U = B -> …** Press ENTER to clean-up.

10. Press F8 to verify solution.
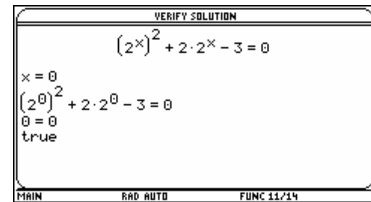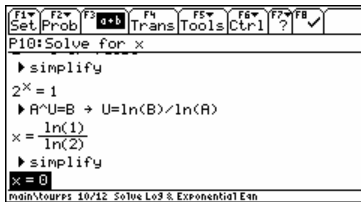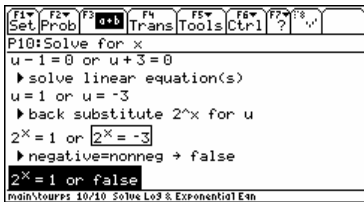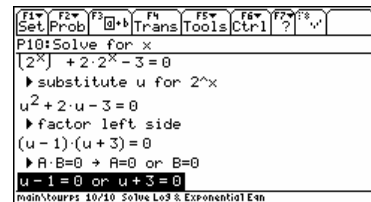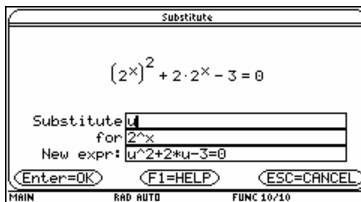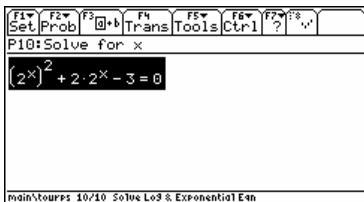
*SMG* **Feature:** Symbolic Math Guide lets you simplify expressions and solve equations that contain functions. When you create a problem that contains a function, a dialog box is displayed that lets you define the function. Transformation "Apply definition of …" applies the definition of the defined function into the expression or equation.

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11. Press F6:1 to move to the next problem in the current problem set.

Problem 12: Compute the indefinite integral $\int x \cdot \sin(x)dx$

1. Press F4 and choose **integration by parts**.

2. SMG provides a dialog box which requests f(x) and g'(x). Enter the information or press F1 for Help (SMG will provide possible choice for f(x) and g'(x)). Make sure that the choice is the one you want. Change it if it is not.

3. Press ENTER until a dialog with f(x), f'(x), g(x) and g'(x) is displayed.

4. Press ENTER.

5. Press F4 and choose $\int (c \cdot f(x))dx \rightarrow c \cdot \int (f(x))dx$.

6. Press ENTER to simplify.

7. Press F4 and choose $\int \cos(x)dx \rightarrow \sin(x)$.
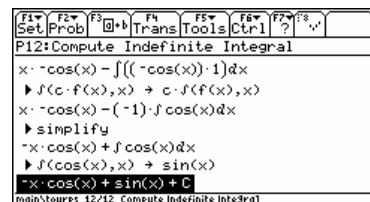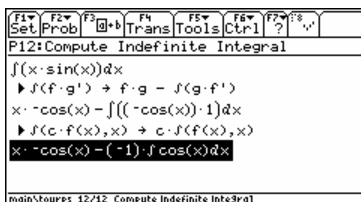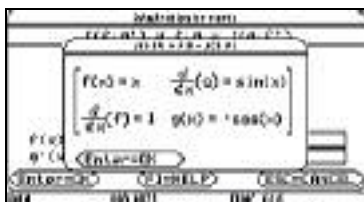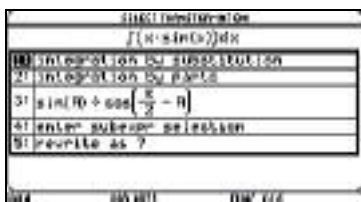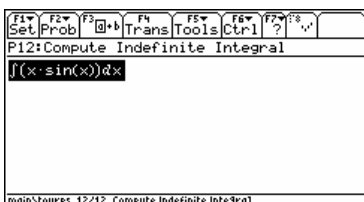
> *SMG* **Feature:** The key SMG transformations to help students learn to solve indefinite integration problems are substitution, integration by parts and partial fractions. SMG also includes sum/difference and scalar product transformations as well as transformations for indefinite integrals of basic functions.