SOLVING EQUATIONS
(Finding the input, given an output value)

Q: According to the **Toys R Us** *1995 annual report*, the number of stores between the years 1984 and 1994 can be modeled by the following equation:

$y = 2x^2 + 56x - 53$ stores, where x is the number of years after (the end of) 1980.

Use this model to estimate the year in which there were 900 stores.

This handout will teach four methods of solving an equation on the TI-85 graphing calculator. The methods will include two graphing methods, tables and using the solver.

To answer the previous question, let y = 900. The new equation is $900 = 2x^2 + 56x - 53$, where x is the number of years after 1980. Solve the equation for x. Since it is a quadratic, there will be two solutions. (Only one can be used in the context of this problem.)

METHOD #1: Graphing on the graphing calculator – the multi-graph method

The TI-85 is capable of using multiple graphs to solve an equation. First, treat each side of the equation as a separate equation and graph them on the same screen. The solution(s) will be where the two graphs intersect, or where y1=y2. Let y1 = 900, and $y2 = 2x^2 + 56x - 53$.

To use the "ISECT" feature, the window must be set so the intersection of the two graphs can be seen. Set the x values to be between 0 and 20 (xMin and xMax) to search between 1980 and 2000. Set xScl to be 5, to show a tick mark every 5 units. The y value of 900 must appear in the window; set those values to be between 0 and 1200 (yMin and yMax). Set yScl to be 100.

1. Type the equations into y1and y2:
    Hit **GRAPH**, then choose **"y(x)="** .
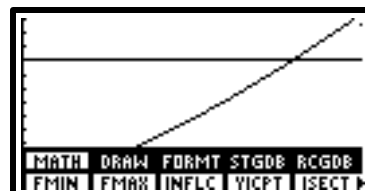   Hit **EXIT** once.
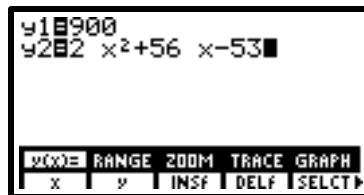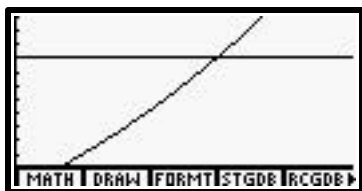
2. Set the window by choosing
    RANGE. Use the values
    in the screen to the right.
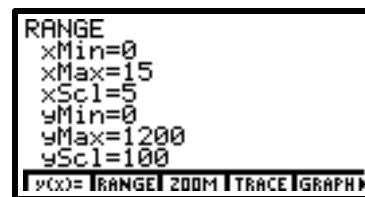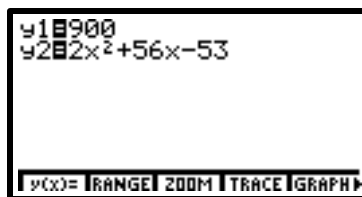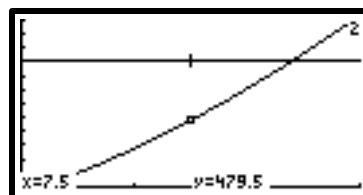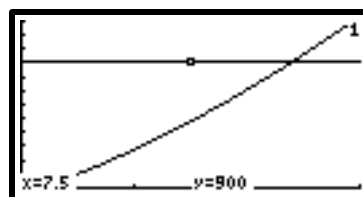
3. To view the graphs hit **GRAPH**.

4. To find <u>one</u> intersection of the
    two graphs, hit **MORE** and
    then choose **MATH**. Hit **MORE**
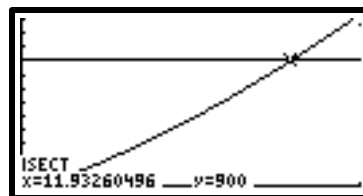   again and choose **ISECT**.

5. The calculator places
    the cursor on the first curve.
    Hit **ENTER** to respond 'yes'.

6. The calculator then places
    the cursor on the second
    curve. Hit **ENTER** to
    respond 'yes'. (If there were 3
    graphs it would need to know
    which two to use.)

7. The intersection occurs at x=11.9,
    or 11.9 years after the end of 1980
    (late 1992).

    There were 900 stores in 1992.

*There are actually two intersections: x = 11.9 and x = -39.9. The second value is not a solution to this problem because negative values will not be considered in **this** example. If this were strictly an algebra equation to be solved, both answers would be necessary.

For the next two methods, the equation will need to be set equal to zero. To do this, move the 900 to the right side of the equation and simplify, yielding the new equation: $0 = 2x^2 + 56x - 953$.   (The right side of the equation does NOT need to be simplified, especially when using a more complex equation.)

METHOD #2: Graphing on the graphing calculator – the x-intercept method

The TI-85 is capable of using a single graph to solve an equation. First, move everything to one side of the equation, leaving the new equation: $0 = 2x^2 + 56x - 953$. Replace the 0 in the equation with the variable "y" (or y1, for the calculator). Type the equation into y1 and graph. The solutions will be where "y" (y1) is equal to zero, which are the x-intercepts (roots) of the graph.

To use the "ROOT" feature, the window must be set so the x-intercept(s) of the graph can be seen. Set the x values to be between 0 and 20 (xMin and xMax) to search between 1980 and 2000. Set xScl to be 5, to show a tick mark every 5 units.

The y value of 0 (the x-axis) must appear in the window; set those values to be between -400 and 1200 (yMin and yMax). The reason for setting yMin so low is to ensure space below the x-axis to be able to read the calculator responses. Set yScl to be 100.

1. Type the equation into y1:
    Hit **GRAPH**, then choose **"y(x)="** .
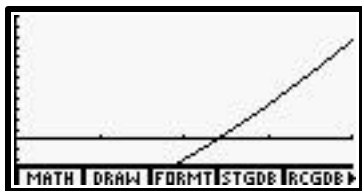   Hit **EXIT** once.

2. Set the window by hitting
    RANGE. Use the values
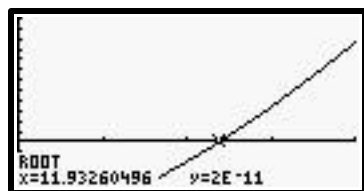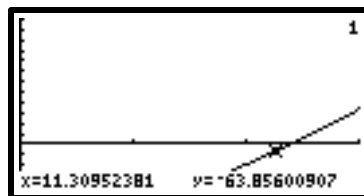   in the screen to the right.
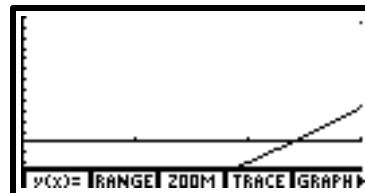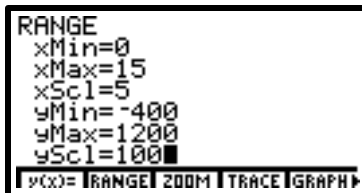
3. To view the graph hit **GRAPH**.

4. To find one x-intercept of the
    graph, hit **MORE** and choose
    MATH. Choose **ROOT**.

5. Place the cursor near the
    x-intercept and hit **ENTER**.

6. The x-intercept (root) occurs at x =11.9,
    or 11.9 years after the end of 1980
    (late 1992). The y value can be close
    to zero or exactly zero.

    There were 900 stores in 1992.

*There are actually two x-intercepts: x = 11.9 and x = -39.9. The second value is not a solution to this problem because negative values will not be considered in **this** example. If this were strictly an algebra equation to be solved, both answers would be necessary.

METHOD #3: Using a table on the graphing calculator

The TI-85 is capable of showing a table of values for the equation(s) stored in the "Y="
screen when using a program called TABLE.   First, move everything to one side of the
equation, leaving the new equation: $0 = 2x^2 + 56x - 953$.   Replace the 0 in the
equation with the variable "y" (or y1, for the calculator). Type the equation into y1 and
look at the table of values for the equation. The solution(s) will be where "y" (y1) is
equal to zero in the table.

The table can be set to begin at any value of x. Set the table to begin at x = 5 to start
the search in 1985 (TblMin). The table must also be set for a distance between x values.
Since x represents the number of years after 1980 it would make sense to let the
distance between x values start at 1 (DTblMin). These values will eventually need to be
changed to get a progressively more accurate answer.

1. Hit **GRAPH** and choose "**y(x)=**".
    Type the equation into y1 Hit **EXIT**
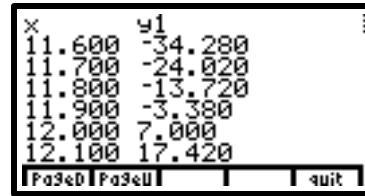   twice.

2. To run the program hit **PRGM**,
    then choose **NAMES**. Choose
    the program named **TABLE**.
    (You may have to hit **MORE** to
    find it.) Hit **ENTER**.

3. Set TblMin to be **5**. Hit **ENTER**.
    Set DTblMin to be **1**. Hit **ENTER**.

4. Scroll   down   the   table   using
    PageD. For y1 to be 0, one
    x value must be between 11
    and 12.

5. For better accuracy, reset the
    table to start at x = 11 (TblMin)
    and set DTblMin to be 0.1. To
    do this choose **quit**, then run the
    program again using the new
    values.

6. Scroll down to see that y1 is 0
    between x = 11.9 and 12.0.

    The table could continually be reset
    for more accuracy, but for <u>this</u>
    problem it is acceptable to stop
    at this point and say that the solution is in
    late 1992 (11.9 years after the end of 1980).

    There were 900 stores in 1992.

*There are actually two solutions: x = 11.9 and x = -39.9. The second value is not a solution to this problem because negative values will not be considered in <u>this</u> example. If this were strictly an algebra equation to be solved, both answers would be necessary.

METHOD #4: Using the solver on the graphing calculator

The TI-85 is capable of solving an equation using the solver. The equation can be used as is (it does not have to be set equal to zero): $900 = 2x^2 + 56x - 53$. This method works well if there is only one solution. The user must know how many solutions and approximately where they exist to be able to find all solutions, if more than one exists.
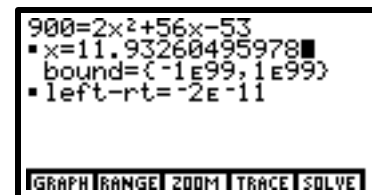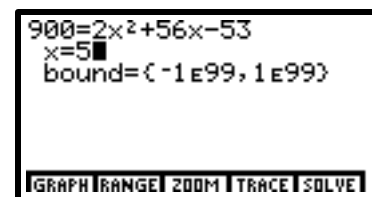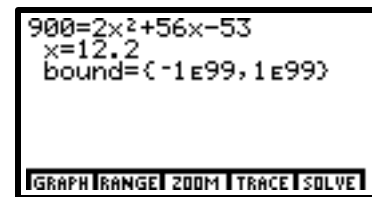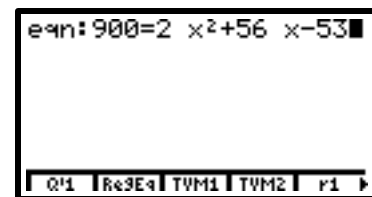
The solver on the TI-85 can actually solve an equation with multiple variables, as long as values are supplied for all variables but the one to be solved for.

1. To access the solver, hit **2nd SOLVER**.

2. If no equation has been stored in the solver, the statement "eqn:" will appear. Type in the entire equation. To type the equal sign hit **ALPHA** (the blue key) "**=**" (above **STO⮕**). Hit **ENTER**.

   If an equation was already stored in the solver, it will show up. Hit **CLEAR** to erase the unwanted equation. Type the new equation in its place, then hit **ENTER**.

3. The equation appears, along with the cursor on the statement: "x = 12.2". (This value may be different.) Although a guess is supplied, a new guess, near the desired answer, must be given. Type a "**5**" after the equal sign. (Guessing the answer is near 1985.) Choose **SOLVE**.

   The calculator returns with the value x = 11.9, which is the closest solution to the guess of x = 5 (11.9 years after the end of 1980, or late 1992).

   There were 900 stores in 1992.

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