

## 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:

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

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-83 graphing calculator. The methods will include two graphing methods, tables and using the solver.

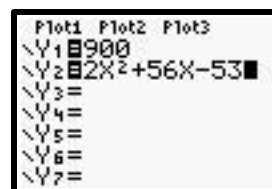
To answer the previous question, let  $y = 900$ . The new equation is  $900 = 2x^2 + 56x - 53$ , where  $x$  is the number of years after 1980. Solve the equation for  $x$ . Since it is a quadratic, there will be two solutions. (Only one can be used in the context of this problem.)

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

The TI-83 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 “intersect” 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. Hit “Y=” and type the equations into Y1 and Y2. Make sure Plot1, 2 and 3 are turned off (NOT highlighted).

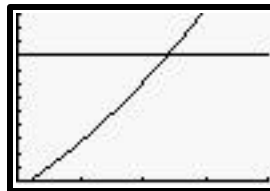


2. Set the window by hitting **WINDOW**. Use the values in the screen to the right.

```

WINDOW
Xmin=0
Xmax=20
Xscl=5
Ymin=0
Ymax=1200
Yscl=100
Xres=1
  
```

3. To view the graphs hit **GRAPH**.

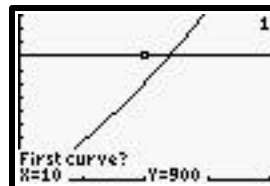


```

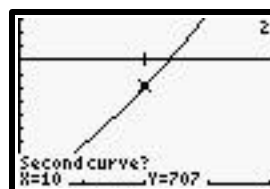
CALCULATE
1:value
2:zero
3:minimum
4:maximum
5:intersect
6:dy/dx
7:∫f(x)dx
  
```

4. To find one intersection of the two graphs, hit 2<sup>nd</sup> **CALC** and then choose 5: **intersect**.

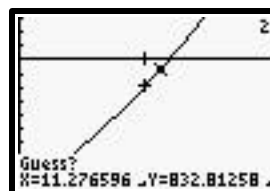
5. The calculator asks if the curve the cursor is on is the first curve. Hit **ENTER** to respond 'yes'.



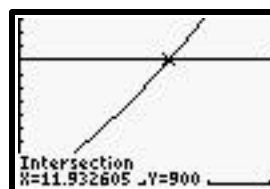
6. The calculator then asks if the curve the cursor is on is the second curve. Hit **ENTER** to respond 'yes'. (If there were 3 graphs it would need to know which two to use.)



7. The calculator now asks for a guess. Place the cursor near the one intersection to be found, and hit **ENTER**.



8. 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 remaining 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.)

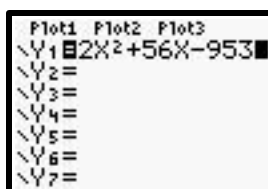
**METHOD #2:** Graphing on the graphing calculator – the x-intercept method

The TI-83 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 (zeros) of the graph.

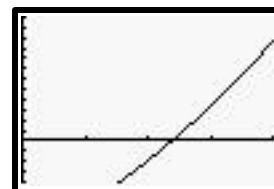
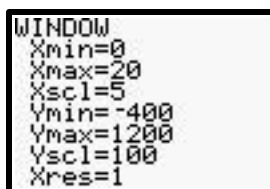
To use the “zero” feature, the window must be set so the x-intercept(s) of the graph can be seen. Set the x values to be between 0 and 20 (Xmin and Xmax) to search between 1980 and 2000. Set Xscl to be 5, to show a tick mark every 5 units.

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. Hit “Y=” and type the equation into Y1. Make sure Plot1, 2 and 3 are turned off (NOT highlighted).

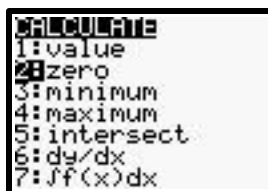


2. Set the window by hitting **WINDOW**. Use the values in the screen to the right.

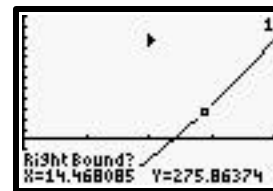
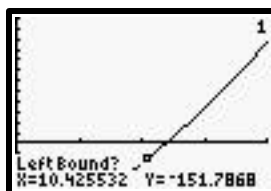


3. To view the graph hit **GRAPH**.

4. To find one x-intercept of the graph, hit 2<sup>nd</sup> **CALC** and choose 2: zero.

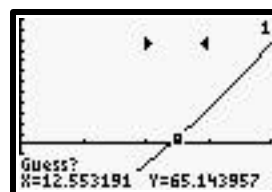


5. The calculator asks for a “Left Bound”. Place the cursor to the LEFT of the x-intercept (zero) and hit **ENTER**. (A triangle should appear at the top of the screen.)



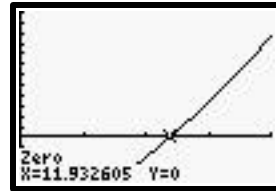
6. The calculator then asks for a “Right Bound”. Place the cursor to the RIGHT of the x-intercept (zero) and hit **ENTER**. (A second triangle should appear at the top of the screen.)

7. The calculator now asks for a guess. Place the cursor near the x-intercept and hit **ENTER**.



8. The x-intercept (zero) 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 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-83 is capable of showing a table of values for the equation(s) stored in the "Y=" screen. 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 (TblStart). 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 ( $\Delta Tbl$ ). These values will eventually need to be changed to get a progressively more accurate answer.

1. Hit "Y=" and type the equation into Y1. Make sure Plot1, 2 and 3 are turned off (NOT highlighted).

Plot1	Plot2	Plot3
$\sqrt{Y1=}$	$2X^2+56X-953$	
$\sqrt{Y2=}$		
$\sqrt{Y3=}$		
$\sqrt{Y4=}$		
$\sqrt{Y5=}$		
$\sqrt{Y6=}$		
$\sqrt{Y7=}$		

TABLE SETUP	
TblStart=	5
$\Delta Tbl=$	1
Indent:	Auto Ask
Depend:	Auto Ask

2. Hit 2<sup>nd</sup> TBL SET. Set TblStart to be 5 and  $\Delta Tbl$  to be 1.

X	Y1
5	-623
6	-545
7	-465
8	-377
9	-287
10	-193
11	-95

X=5

X	Y1
8	-377
9	-287
10	-193
11	-95
12	7
13	113
14	223

X=12

3. Hit 2<sup>nd</sup> TABLE to view the table. Scroll down using the arrow keys. For Y1 to be 0, one x value must be between 11 and 12.

4. For better accuracy, reset the table to start at  $x = 11$  (TblStart) and set  $\Delta Tbl$  to be 0.1.

TABLE SETUP	
TblStart=	11
$\Delta Tbl=$	.1
Indent:	Auto Ask
Depend:	Auto Ask

X	Y1
11.1	-95
11.1	-84.98
11.2	-74.92
11.3	-64.82
11.4	-54.68
11.5	-44.5
11.6	-34.28

X=11

5. Scroll down to see that Y1 is 0 between  $x = 11.9$  and 12.

X	Y1
11.6	-34.28
11.7	-24.02
11.8	-13.72
11.9	-3.38
12	7
12.1	17.42
12.2	27.88

X=12

The table could continually be reset for more accuracy, but for this 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 this 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

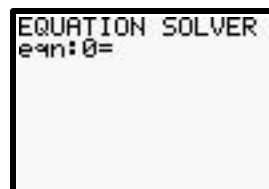
The TI-83 is capable of solving an equation using the solver. First, move everything to one side of the equation, leaving the new equation:  $0 = 2x^2 + 56x - 953$ . This method works well if there is only one solution. The user must know how many solutions and approximately where they exist to be able to find all solutions, if more than one exists.

1. To access the solver, hit **MATH**. Use the down arrow and Choose **0: Solver...**
2. If no equation has been stored in the solver, the statement "eqn:0 =" will appear. Type in the right hand side of the equation after the equal sign. Hit **ENTER**.

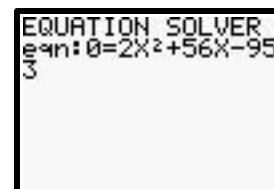


MATH NUM CPX PRB  
4: I( )  
5: \*J  
6: fMin(  
7: fMax(  
8: nDeriv(  
9: fnInt(  
0: Solver...

If an equation was already stored in the solver, it will show up. Use the **up arrow** to get back to the above screen and hit **CLEAR** to erase the unwanted equation. Type the new equation in its place, then hit **ENTER**.

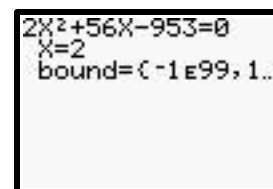


EQUATION SOLVER  
eqn:0=

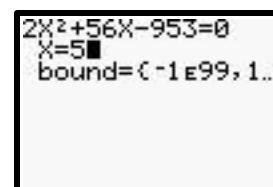


EQUATION SOLVER  
eqn:0=2X^2+56X-95  
3

3. The equation appears, along with the cursor on the statement: "x = 2". (This value may be different.) Although a guess is already supplied, a new guess, near the desired answer, must be given. Type in "5" after the equal sign. (Guessing the answer is near 1985.)
4. To run the solver, hit **ALPHA** (the green key) **SOLVE** (above ENTER).

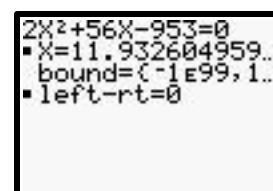


2X^2+56X-953=0  
X=2  
bound=(-1E99,1...



2X^2+56X-953=0  
X=5  
bound=(-1E99,1...

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).



2X^2+56X-953=0  
X=11.932604959...  
bound=(-1E99,1...  
left-rt=0

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 this example. If this were strictly an algebra equation to be solved, both answers would be necessary.