Contents

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How to Use This Book

The *Solver Guide* describes how to use the Solver to solve what-if problems in your worksheets. This book also describes the sample applications included with 1-2-3® for Windows™ applications that show you how to solve business problems using the Solver.

Who should read this book

Topic

The *Solver Guide* is designed for readers who have a working knowledge of 1-2-3.

Conventions used in this book

Topic

The *Solver Guide* uses the conventions below to indicate notes, tips, cautions, and references to help.

Note introduces additional technical information about a command or procedure.

Tip introduces additional information you may find helpful when you perform a command or procedure.

Caution introduces information that is essential to the safety of data and software.

Help introduces a reference to Help.

The *Solver Guide* uses the conventions below for function keys and key names.

- Function keys appear in small capitals and are identified by the 1-2-3 key name. For example, F1 (HELP).
- Key names separated by a + (plus sign) indicate that you must press and hold down the first key, press the second key, and then release both keys. For example, ALT+F3.
- Key names separated by a space indicate that you must press the first key and release it, and then press the second key and release it. For example, END HOME.

The *Solver Guide* may illustrate Solver Table Reports differently than they appear on your screen. For example, borders around and within sections of data were added in our illustrations to improve readability, and in cases where the Solver reports a value that is too long for the default column width, the columns are illustrated wide enough to display the long value.

Organization

Topic

The *Solver Guide* contains nine chapters.

- **Chapters 1 and 2** introduce the Solver and the steps you use to solve problems. Read these chapters first.
- **Chapters 3 and 4** step you through two sample applications: planning production levels and structuring an investment portfolio. You can read these applications in any order.
- **Chapters 5 through 8** explain the dialog boxes, commands, and @functions you use with the Solver. You can read through each chapter or refer to the commands as you need them.
- **Chapter 9** provides answers to questions you may have about the Solver.

Sample files

Topic

The Install program transferred several sample worksheet files to the subdirectory SAMPLE in your 1-2-3 program directory when you installed 1-2-3. (If you are using the network version of 1-2-3, SAMPLE is a subdirectory in your personal directory. See your network administrator for more information.) These worksheet files contain sample what-if problems that you can use with the Solver. Chapters 2, 3, and 4 each use a sample file as an example and provide instructions on how to open the sample file.

1 What Is the Solver?

The Solver is a 1-2-3 for Windows tool that finds one or more answers for problems in a 1-2-3 worksheet. A **problem** is a set of 1-2-3 worksheet cells that contain the values and formulas the Solver will work with. You define the problem and the Solver does the work. Using the goals you specify, the Solver shows you the answers that meet your needs. Most importantly, the Solver can find the answer that best matches what you want to accomplish.

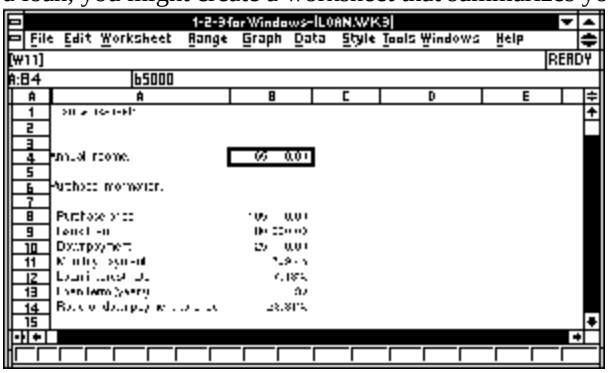
When to use the Solver

Topic

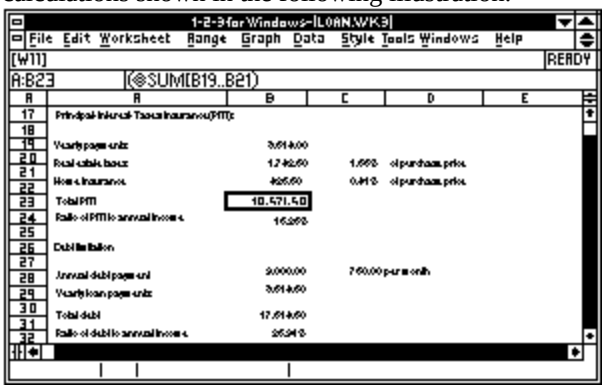
The Solver can find answers for many types of what-if problems.

- If you are planning production levels at your company, the Solver can show you the most profitable mix to produce, given available resources.
- If you are structuring an investment portfolio, the Solver can evaluate income, appreciation, and diversification factors to show you the combination of investments that provides the best total return.

You can use the Solver with any problem you create in a 1-2-3 worksheet. It uses the formulas that are already in your worksheets and shows you the answers for the problem you have identified. For example, suppose you are trying to decide whether you can afford to purchase a house. Before you make an offer to buy the house or apply for a loan, you might create a worksheet that summarizes your income and projects housing costs.



You might also set up the worksheet to compute your monthly loan payments and the percentage of your income that would cover housing costs. To see if you qualify for the loan, you might also have the worksheet perform the calculations shown in the following illustration.



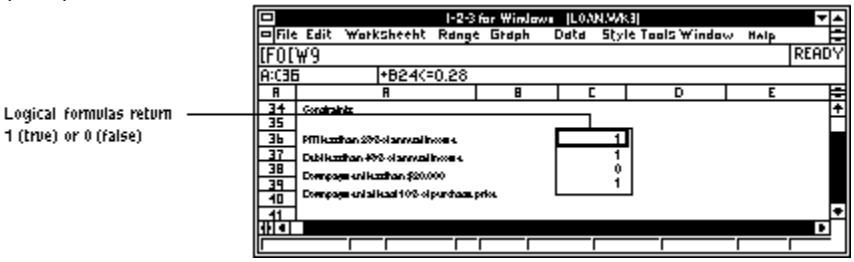
Once you set up the worksheet, you can have the Solver display an answer that shows you the most expensive house you can afford. You can also have the Solver display other answers that give you an idea of what your options would be if, for example, you choose to purchase a less expensive house or make a larger down payment.

How the Solver works

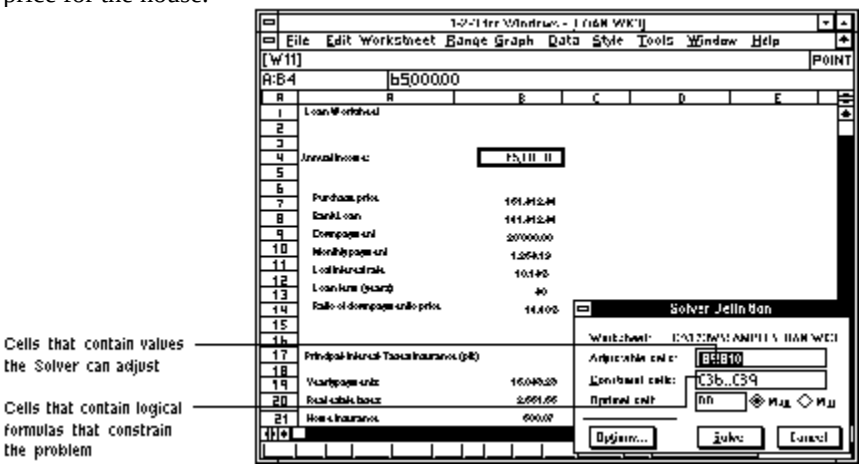
Topic

To set up a problem, you enter logical formulas in the worksheet that specify conditions you want each answer to satisfy. A logical formula is a formula that returns either 1 (true) or 0 (false) depending on whether a condition is satisfied. For example, +INTEREST<.13 specifies that the interest rate must be less than 13%, and +LOAN<=150000 specifies that the loan amount must not exceed $150,000.

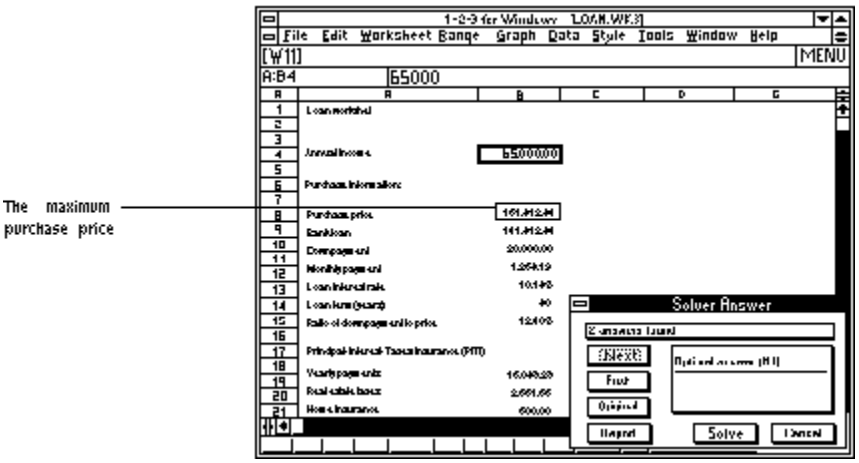
The following illustration shows the results of logical formulas you might enter for the loan problem. The values that are in the worksheet satisfy three of the formulas. One of the formulas is not satisfied, however, and it returns 0 (false).



After you set up the problem, you choose Tools Solver and specify the cells that define the problem. You specify cells the Solver can adjust (adjustable cells), such as the loan amount and the down payment amount; cells that contain formulas that constrain the problem (constraint cells), such as +DOWN_PMT<=20000; and (optionally) the single cell that the Solver is to maximize or minimize to find the optimal answer (optimal cell), such as the purchase price for the house.



The Solver uses the cells you specify, as well as other information in the worksheet, to solve the problem. After you select Solve, the Solver evaluates the problem and looks for answers. When the Solver is finished solving the problem, it displays each answer, one at a time, in the worksheet.



The Solver provides reports about the answers it found. For example, the Solver can list all answers, show how it found an answer, compare answers, show upper-value and lower-value limits for adjustable cells, or report formulas used to find answers. You can print, graph, or use the database commands with the answers that appear in reports.

Problems you define for the Solver are saved when you save the worksheet.

The following chapter, **"Using the Solver,"** shows you in greater detail how to define a problem and have the Solver find answers.

2 Using the Solver

Subtopics +

This chapter guides you through the steps you take to solve a problem with the Solver. It provides the basic rules for using the Solver with a worksheet model, and it explains the Solver dialog boxes and some Solver commands.

The chapter shows you how to start and close the Solver, set up a problem in a worksheet, define and solve the problem using the Solver, modify the problem, review the answers the Solver finds, and save the worksheet that contains the problem.

As you read this chapter, you can follow the instructions using a sample worksheet file called SALES.WK3.

2 Using the Solver

Subtopics

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Setting up a problem

Topic

You can use the Solver with any model created in 1-2-3 for Windows. The models can be simple or complex and can span multiple worksheets or files.

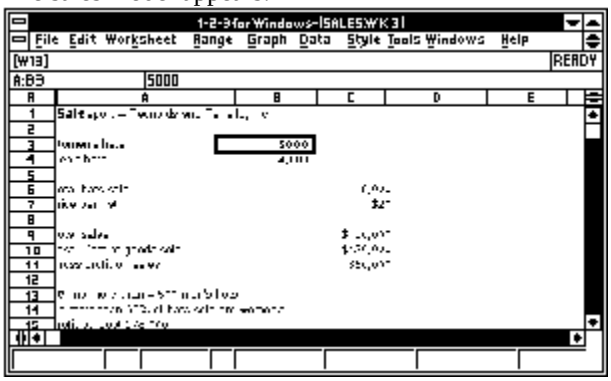
This section explains how to set up a model for solving. It uses the sample model, SALES.WK3, which the Install program copied to the subdirectory SAMPLE in the directory that contains your 1-2-3 program files. The instructions that follow explain how to open the sample worksheet file. After you open the file, you will set up the adjustable, constraint, and optimal cells the Solver uses to find answers for the problem.

To open the sample worksheet file

1. Choose File Open.
2. Select the directory that contains your sample worksheet files in the Directories list box (for example, C:\123W\SAMPLE) and press ENTER.

   When you installed 1-2-3, the Install program copied the sample files to this directory.
3. Select SALES.WK3 in the Files list box.
4. Select OK.

The sales model appears.



To set up the problem, you must do the following:

- Determine the adjustable cells
- Enter the constraints
- Determine the optimal cell (optional)

Each is discussed below.

Determining adjustable cells

Adjustable cells contain values the Solver can change when it searches for an answer. You specify these cells and the Solver automatically finds new values for them. Adjustable cells may not be blank or contain formulas or labels, and they must not be protected. To decide which cells in the model are adjustable cells, think about the cells that contain values you would experiment with in a manual what-if calculation. The cells containing the values you would change are the ones you identify to the Solver as adjustable cells.

For example, in the sales model, the cells that contain the figures for the number of men's and women's hats sold are

adjustable cells. An increase or decrease in the number of hats sold affects the values for total sales and gross profit on sales. The sales model uses only two cells that the Solver can adjust, but the problems you create may have more adjustable cells. The number of adjustable cells in a Solver problem is limited by the complexity of your worksheet and the amount of available memory your computer has.

Entering constraints

Constraints are the logical formulas that the Solver uses to find answers to a problem. A **logical formula** is a formula that returns either 1 (true) or 0 (false), depending on whether a condition is satisfied. The following are examples of logical formulas: +D37>=3200, +PROFIT>=SALES*.2, and +B4=B6*B7. You enter the constraint formulas in the worksheet before solving the problem.

The Solver searches for sets of values for the adjustable cells that satisfy each of the constraints you specify. Each Solver answer comprises a different set of values for the adjustable cells that satisfy all constraints.

The sales model has guidelines for the number of men's and women's hats sold, as well as a minimum amount of profit. For example, after taking inventory, you know that you cannot sell more than 4,500 men's hats. You also know that women's hats will not account for more than 65% of sales. Finally, you want gross profit on sales to be at least $75,000. When you set up the problem, you enter logical formulas that tell the Solver to show only answers that satisfy all three of these constraints.

The instructions below explain how to enter logical formulas that specify the constraints for the problem. The example in this chapter uses only three logical formulas, but the problems you create may contain more constraints. Problems with many constraints generally take longer for the Solver to solve, however. In addition, the number of constraint cells in a Solver problem is limited by the complexity of your worksheet and the amount of available memory your computer has.

To set up constraint cells

1. Move to a blank area of the worksheet.

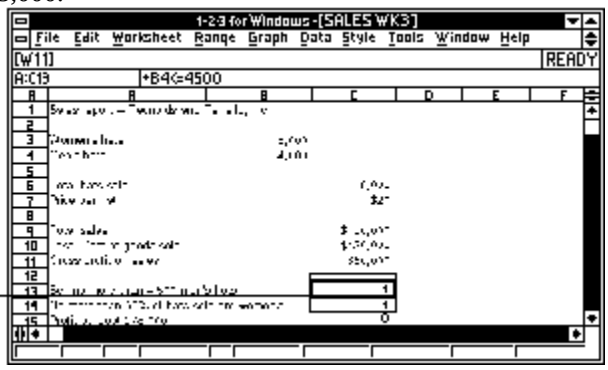
   If you are using SALES.WK3, move to C13.

2. Enter the constraint formula(s) to specify the conditions you want each answer to satisfy.

   For example, enter +b4<=4500 to tell the Solver that you can sell no more than 4,500 men's hats. The formula returns 1 (true) because the amount in B4 is currently less than 4,500.

   To enter the second constraint formula, move to C14 and enter +b3<=c6*.65 to tell the Solver that women's hats can make up no more than 65% of total hats sold. The formula returns 1 (true) because the amount in B3 is currently less than 65% of total hats sold.

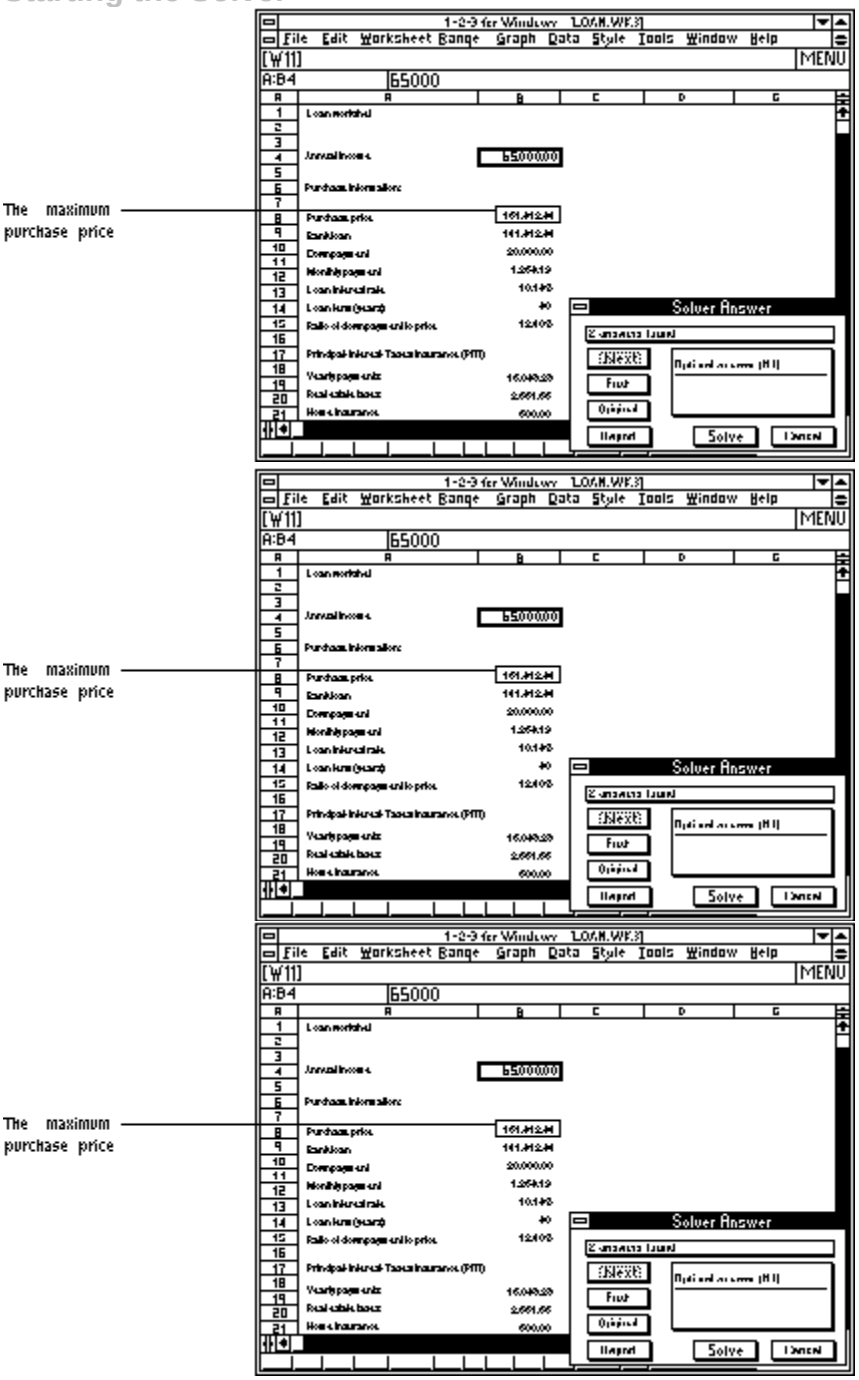
   To enter the third constraint formula, move to C15 and enter +c11>=75000 to tell the Solver that you want gross profit on sales to be greater than or equal to $75,000. The formula returns 0 (false) because the amount in C11 is currently less than $75,000.



Determining an optimal cell (optional)

An **optimal cell** is a cell for which you want the Solver to find the highest or lowest possible value. The optimal cell in a problem may be an adjustable cell or a cell whose value depends on an adjustable cell. In the sales model, C11 contains the amount for gross profit on sales, which you want to maximize. Specifying this cell as the optimal cell tells the Solver that you want to find the answer that gives the highest possible gross profit on sales.

Starting the Solver



To start solving a problem, you choose Tools Solver and then use the Solver Definition dialog box to tell the Solver which cells you want it to use as the adjustable and constraint cells, and (optionally) the optimal cell. The Solver uses the values in the adjustable cells and the logical formulas in the constraint cells, along with the values and formulas in the model, to find answers for the problem.

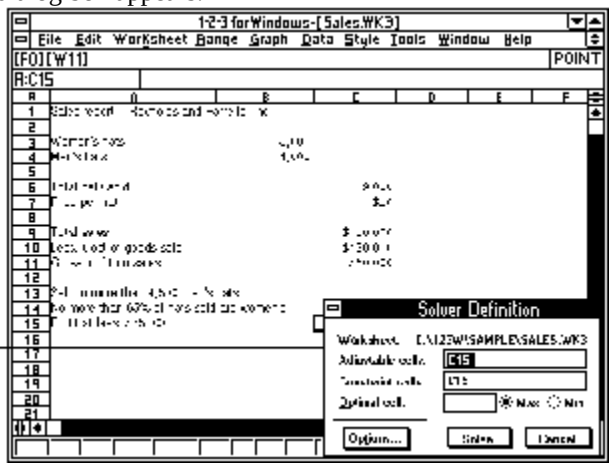
To start the Solver

1. Retrieve or make current the worksheet file that contains the problem you want to solve.

   If you are using SALES.WK3, make it the current worksheet file.

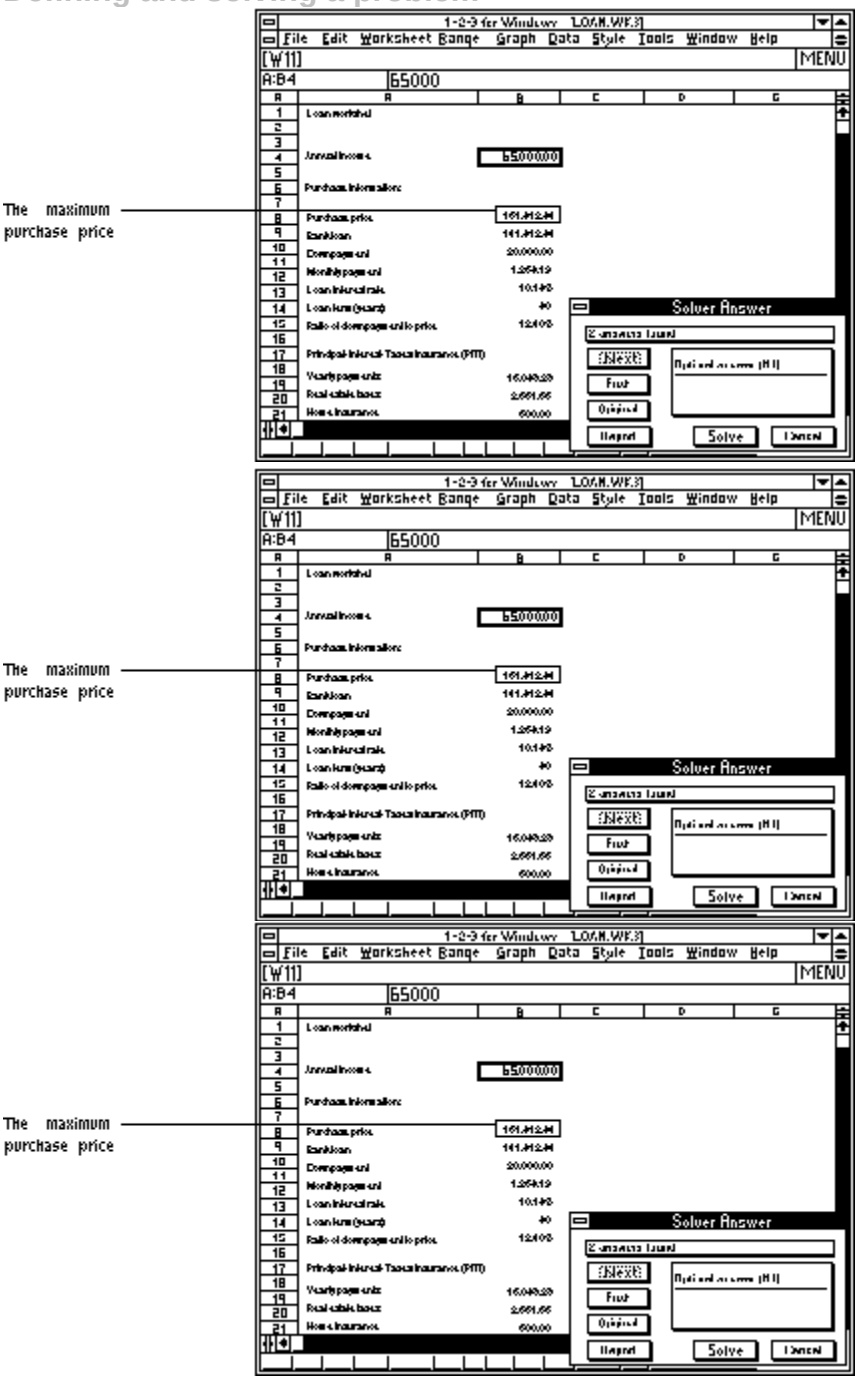
2. Choose Tools Solver.

The Solver Definition dialog box appears.



The Solver Definition dialog box

Defining and solving a problem



The Solver Definition dialog box lets you define and solve the problem. To define the problem, you specify the adjustable cells, constraint cells, and (optionally) an optimal cell that you want the Solver to use to find answers.

To define and solve a problem

1. Select the Adjustable cells text box.
2. Specify the adjustable cells.

For example, specify B3 and B4 as the adjustable cells. You can use the mouse or press , ↓, →, and ← to select these cells in the worksheet, or you can enter the cell addresses, separated by a , (comma), in the Adjustable cells text box. You can also enter these cells as a range, such as B3..B4.

3. Select the Constraint cells text box.
4. Specify the constraint cells.

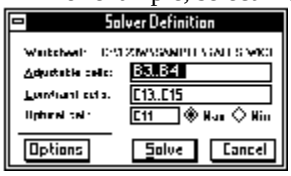
   For example, specify C13 through C15 as the constraint cells. You can use the mouse or press , ↓, →, and ← to select these cells in the worksheet, or you can enter the cell addresses, separated by a , (comma), in the Constraint cells text box. You can also enter these cells as a range, such as C13..C15.

5. Select the Optimal cell text box.
6. Specify the optimal cell.

   For example, specify C11 as the optimal cell. You can use the mouse or press , ↓, →, and ← to select this cell, or you can enter the cell address in the Optimal cell text box.

7. Select Max to find the highest value for the optimal cell or Min to find the lowest value for the optimal cell.

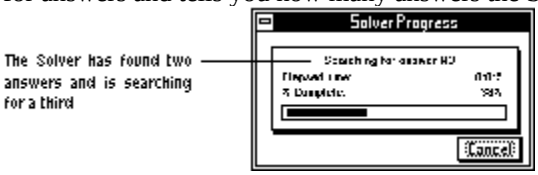
   For example, select Max to find the highest value for gross profit on sales.



After you define a problem, you can have the Solver begin looking for answers.

8. Select Solve.

While the Solver looks for answers, the Solver Progress dialog box shows you that the Solver is analyzing the problem. After the Solver analyzes the problem, the Solver Progress dialog box shows you that the Solver is looking for answers and tells you how many answers the Solver has found (if any).

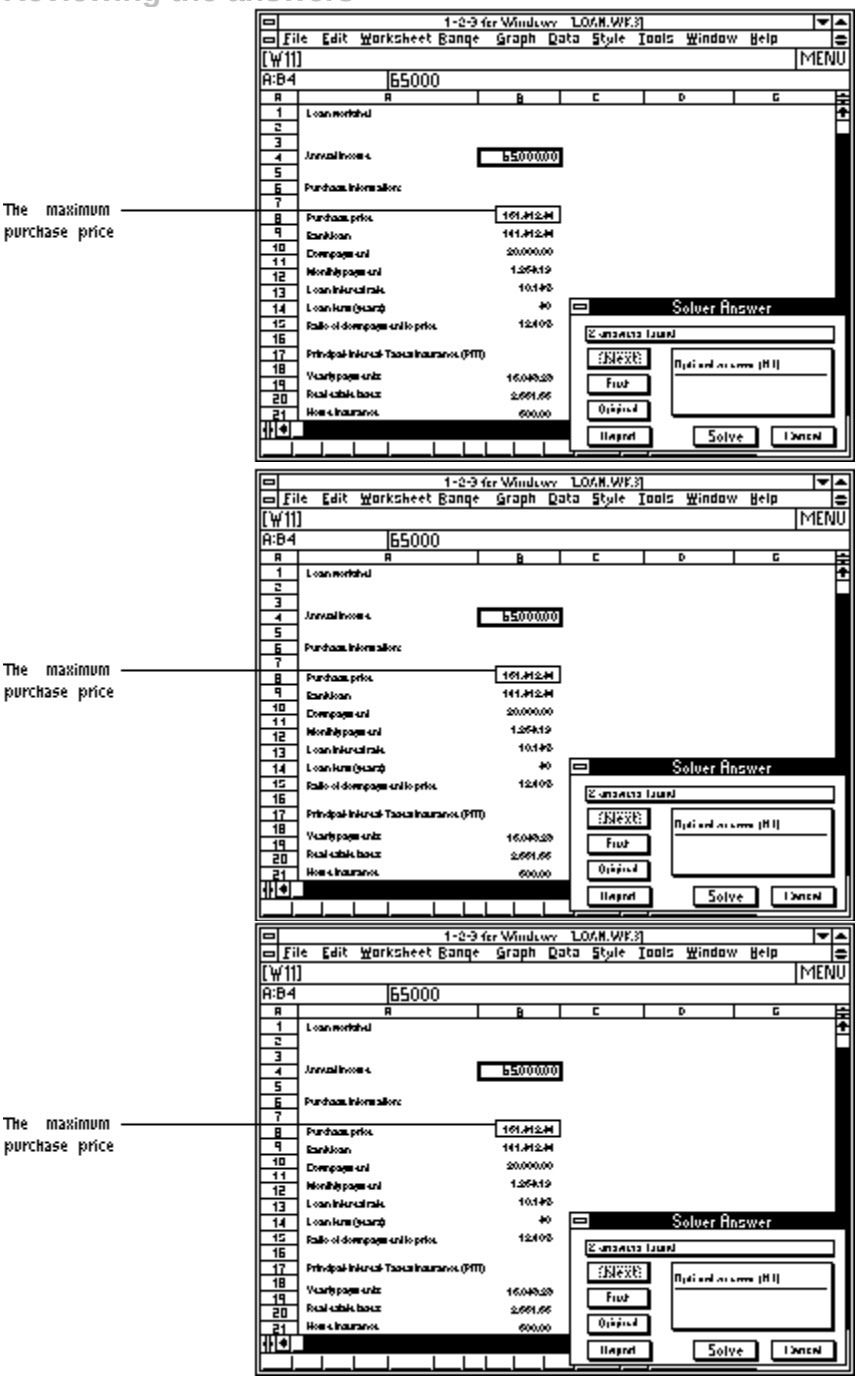


Note You cannot do other 1-2-3 tasks while the Solver is solving. To cancel the solving process, press CTRL+BREAK or select Cancel.

When the Solver finds answers, it displays the Solver Answer dialog box. If the Solver does not find an answer because you made an error entering information in the Solver Definition dialog box, it displays a message and returns you to the Solver Definition dialog box. The Solver also displays a message if 1-2-3 runs out of memory while the Solver is trying to solve the problem.

If the Solver cannot find an answer that satisfies each of the constraint formulas, it provides representative attempts in the Solver Answer dialog box and sometimes asks you to supply more information. (See **"Attempts"** and **"Guesses."**)

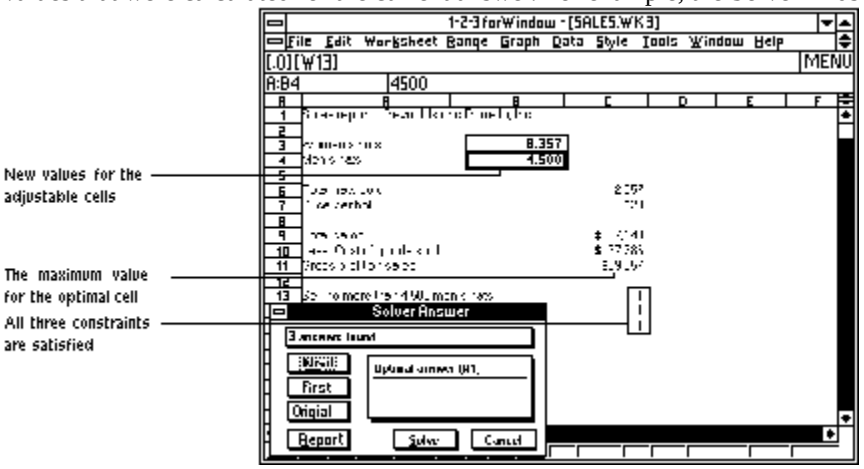
Reviewing the answers



After the Solver finds answers or attempts for a problem, it displays the Solver Answer dialog box. The Solver Answer dialog box tells you how many answers or attempts the Solver found and lets you display them in the worksheet. The Solver automatically displays the first answer in the worksheet.

If you specified an optimal cell, the first answer is the optimal answer or the best answer the Solver could find. The adjustable cells show values the Solver used to find the current answer. The constraint cells show that each constraint was satisfied for the current answer (subject to minor roundoff differences). All the other cells show the

values that were calculated for the current answer. For example, the Solver finds three answers for the sales model.



The Solver displays the optimal answer in the worksheet. The optimal answer shows that gross profit on sales can be $89,357 if you sell approximately 8,357 women's hats and 4,500 men's hats. (Because the cells are formatted for 0 decimal places, 1-2-3 does not display any decimals for the values the Solver found.)

To see more answers

1. Select Next to see the next answer the Solver found.

   The Solver displays the second answer that meets all three constraints.

2. Select Next again to see the third answer the Solver found.

   The Solver displays the third answer that meets all three constraints. To see the first answer again, you select First.

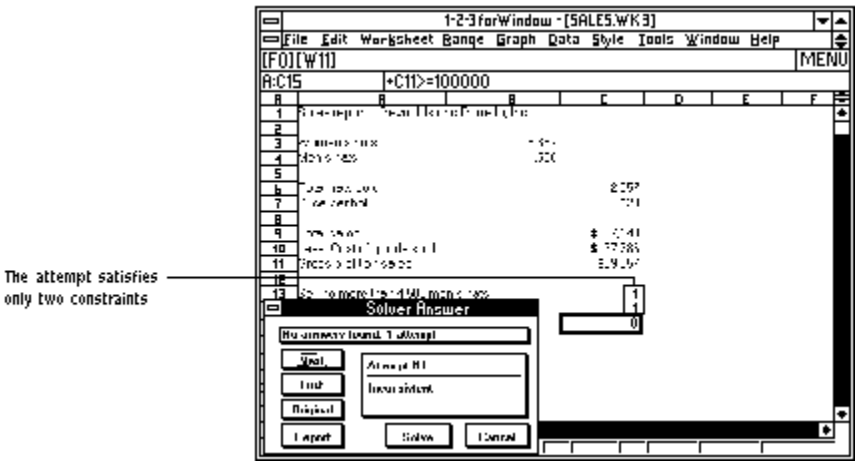
You can also create reports of the answers the Solver finds. For details, see **Chapter 7**.

Attempts

If the Solver cannot find any answers for the problem, the Solver Answer dialog box reports representative attempts the Solver may have found.

Each attempt returns 0 (false) for at least one constraint cell. The Solver Answer dialog box displays a message (Inconsistent) to tell you the attempt does not satisfy all constraints.

For example, if you changed the constraint formula in C15 to specify that profits be at least $100,000, and then tried to solve the problem, the Solver would not be able to find an answer that satisfied all three constraints. It would return an attempt with one constraint unsatisfied. For more information on attempts, see **Chapter 6**.

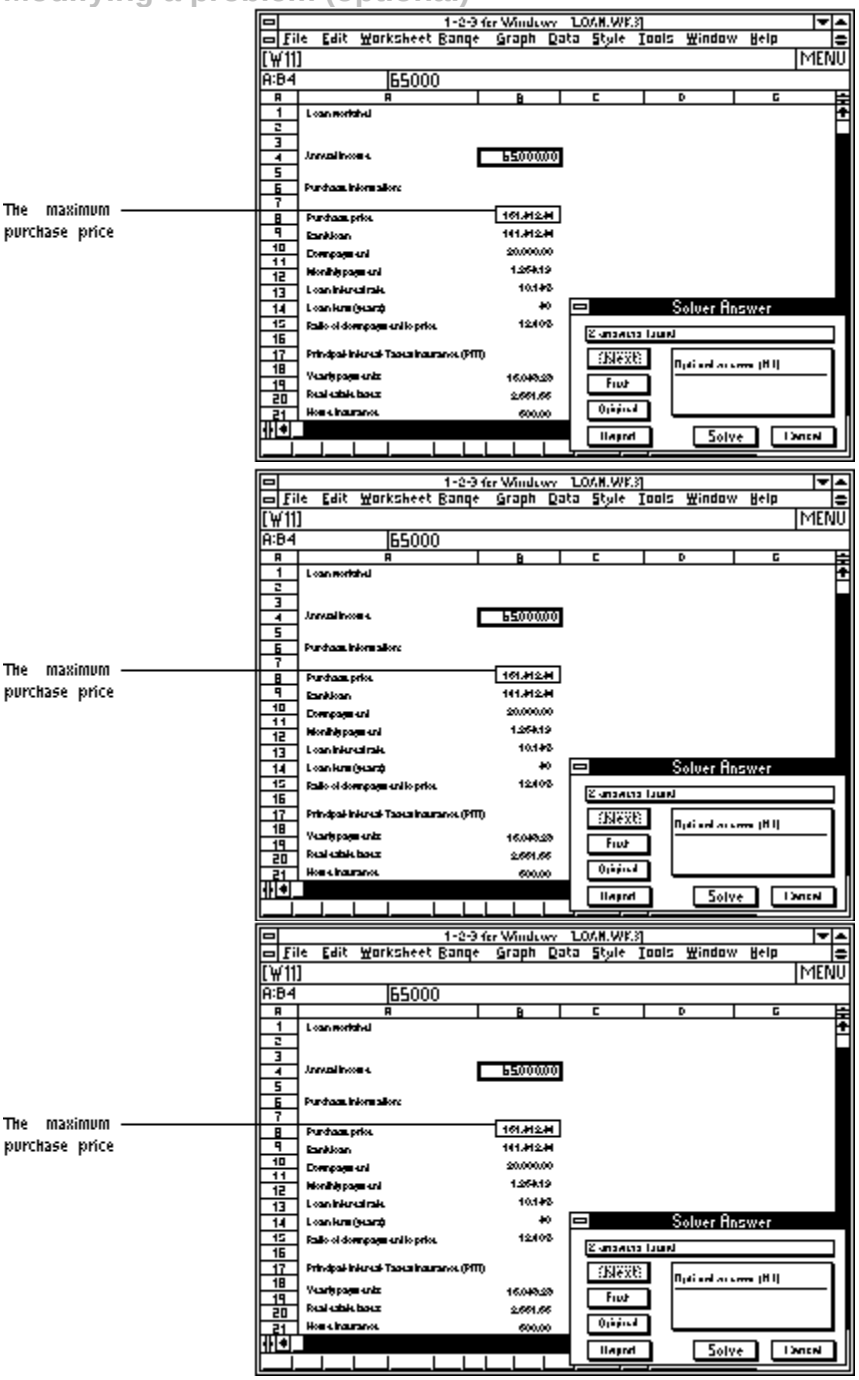


Guesses

Sometimes a problem is too complex or does not contain enough information for the Solver to find an answer. When either situation occurs, the Solver attempts to solve the problem and asks you for more information. The Solver displays a message (Guesses required) in the Solver Answer dialog box and replaces the Solve command button with the Guess command button to let you know that it needs guess values for one or more adjustable cells.

Selecting Guess opens the Solver Guess dialog box. You can enter guess values in the Solver Guess dialog box for the adjustable cells that the Solver selects. The Solver uses values you enter in the Solver Guess dialog box to help find an answer. For more information on guesses, see **"Solver Guess dialog box"** in Chapter 6, and **"Reviewing answers"** in Chapter 9.

Modifying a problem (optional)



After you review answers or attempts, you may want to modify the problem.

Caution When you change data or make changes that cause 1-2-3 to recalculate an active worksheet file, the Solver discards all of the answers it found.

To change a problem

1. Retrieve or make current the worksheet you want to modify.

2. Make changes to the worksheet as necessary.

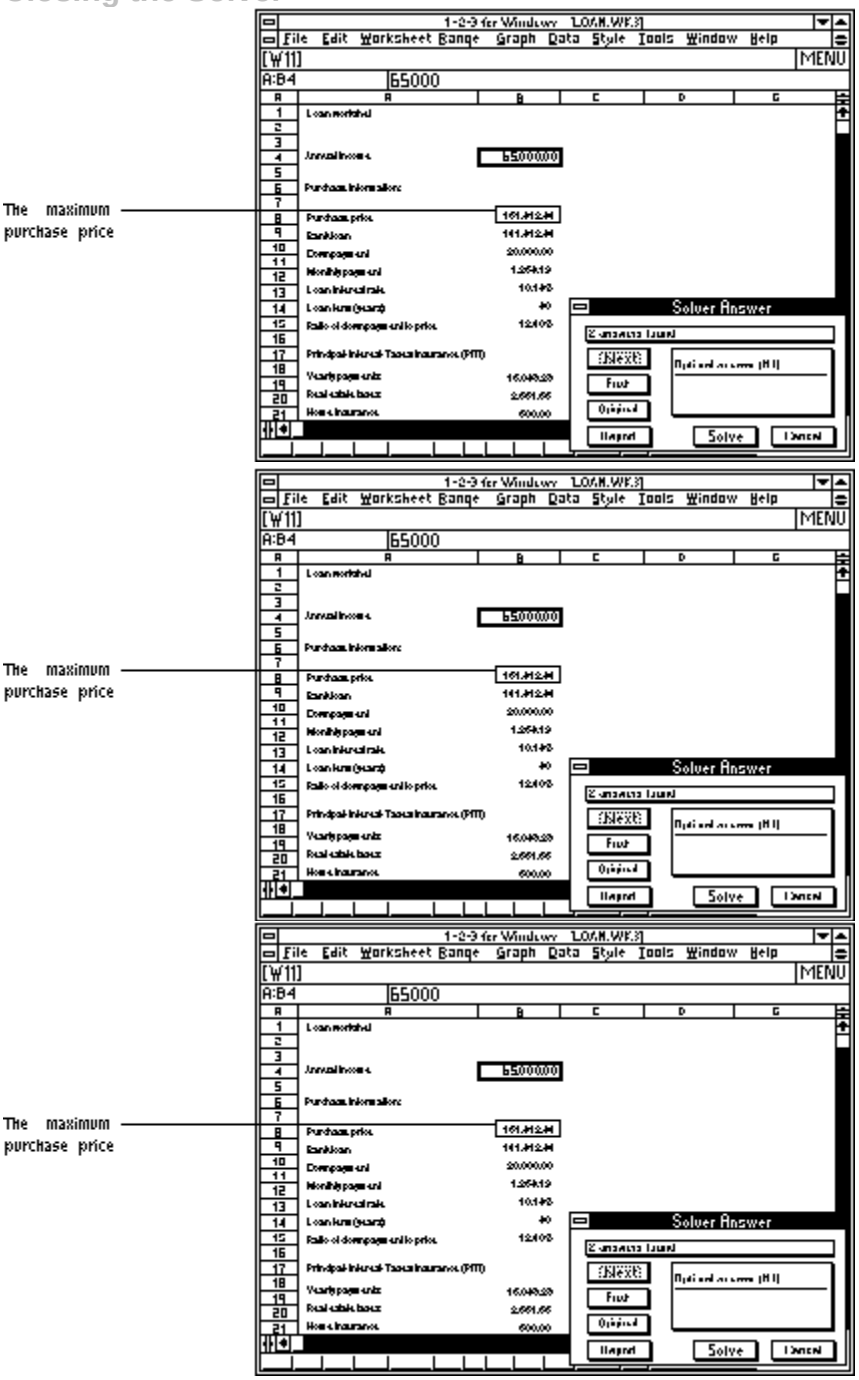
If the worksheet is recalculated, the Solver discards any current answers. If this occurs, follow the steps below to solve the problem again.

To solve a modified problem

1. Choose Tools Solver.
2. Modify the cell addresses in the Solver Definition dialog box, if necessary.
3. Select Solve.

The Solver solves the modified problem.

Closing the Solver



This section explains how to close the Solver after you are finished using it.

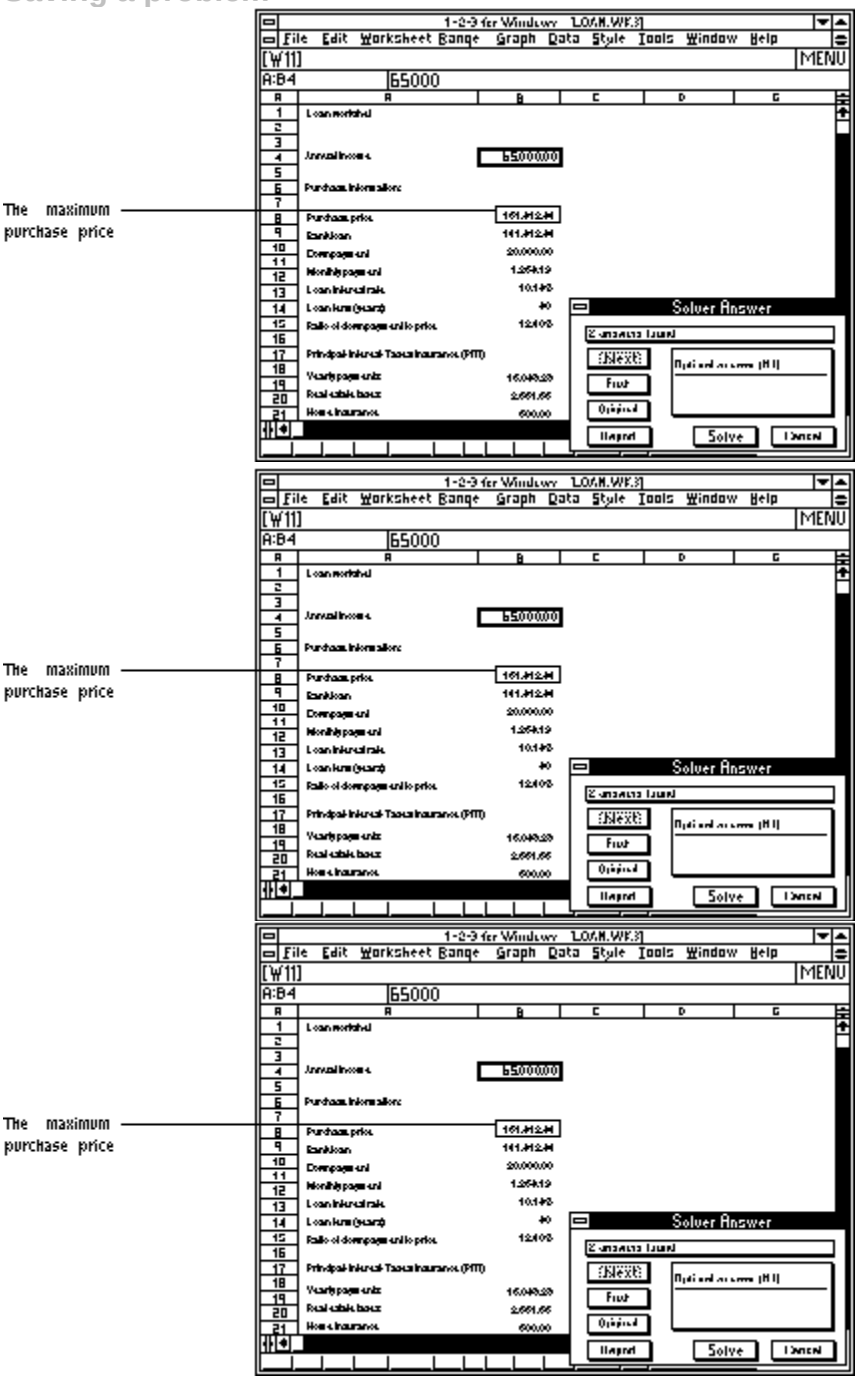
To close the Solver

1. Select Original in the Solver Answer dialog box if you want to return the worksheet to its original values, or select Next until the values you want to save are displayed in the worksheet.
2. Select Cancel to close the Solver Answer dialog box.

3. Select Cancel to close the Solver Definition dialog box.

When you close the Solver Answer and Definition dialog boxes, the Solver retains the answers it found until you change or close any active worksheet. If you do not make changes to any worksheets, when you choose Tools Solver again, the Solver bypasses the Solver Definition dialog box, displays the Solver Answer dialog box, and places the answer that was displayed when you closed the Solver in the worksheet.

Saving a problem



After you solve a problem, you can save the data in the Solver Definition dialog box along with the problem in the worksheet file. Once you have used the Solver to solve a problem, saving the worksheet file saves the contents of the Solver Definition dialog box. 1-2-3 saves the list of cell addresses in the Solver Definition dialog box even if the dialog box is not open.

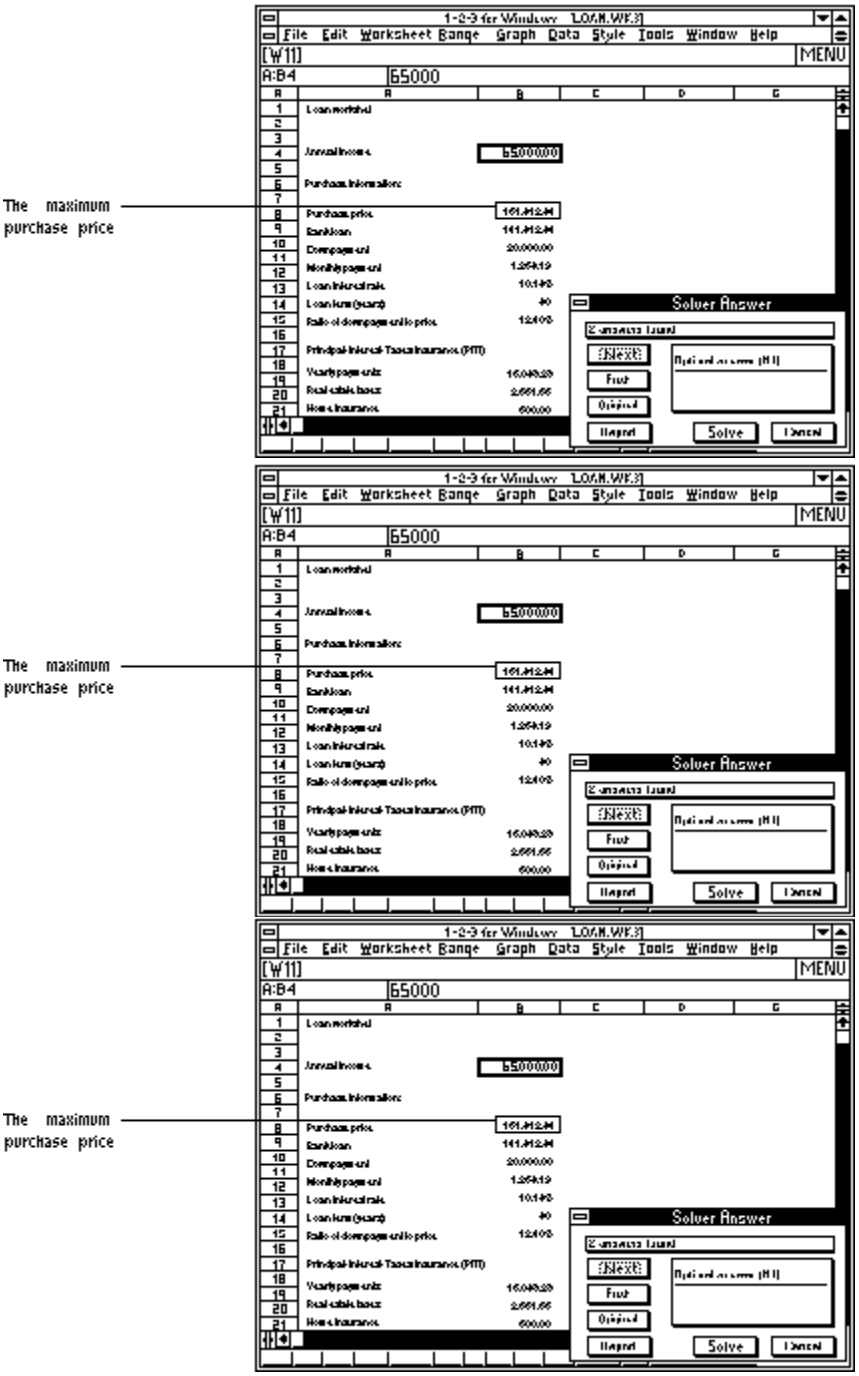
Note To save the data in the Solver Definition dialog box, you must save the worksheet file as a .WK3 file.

To save a problem

1. Make the worksheet file that you want to save the current worksheet file, if necessary.
2. Choose File Save As.
3. Specify a name for the file you want to save, or accept the existing name.

   For example, specify SALESX.WK3 to save the sales model under a new file name. That way, you will have a copy of the original file (SALES.WK3) if you want to follow the example in this chapter again.
4. Select OK.

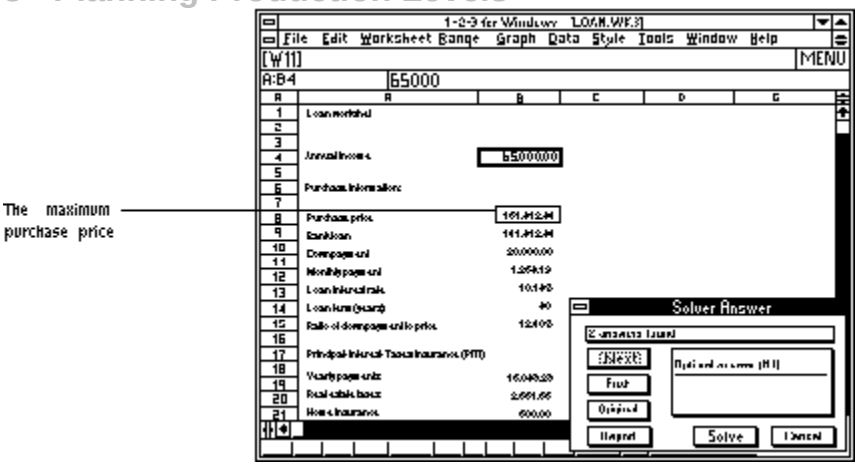
What to do next



Once you have finished reading this chapter, you can learn more about the Solver's capabilities.

- To see examples of how to use the Solver in your work, refer to **Chapter 3** and **Chapter 4**.
- To learn more about the Solver dialog boxes and commands, refer to **Chapters 5 through 7**.

3 Planning Production Levels



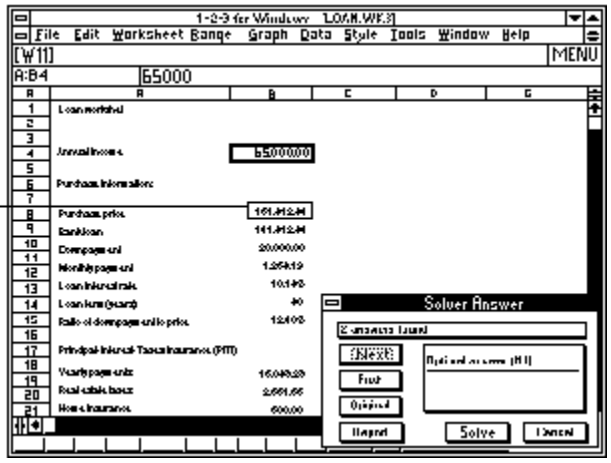
If you are planning production levels at your company, the Solver can show you the most profitable mix to produce, given available resources. Suppose your bakery makes three types of bread: low-calorie, high-fiber, and white. You know the cost and number of person hours it takes to produce a case of each type of bread. Can you determine the amounts to produce that will result in the highest profit for your company?

The Solver can help you determine various production levels for the three types of bread. It can also show you the production level that stays within the limits of available resources and maximizes profit.

This model shows you how to find the level of production that results in the highest profit, and how to create reports that show how much you can vary the amount of any one type of bread during a production run and show how the Solver solved the problem.

> **Note** The *Solver Guide* may illustrate Solver Table Reports differently than they appear on your screen. For example, borders around and within sections of data were added in our illustrations to improve readability, and in cases where the Solver reports a value that is too long for the default column width, the columns are illustrated wide enough to display the long value.

3 Planning Production Levels



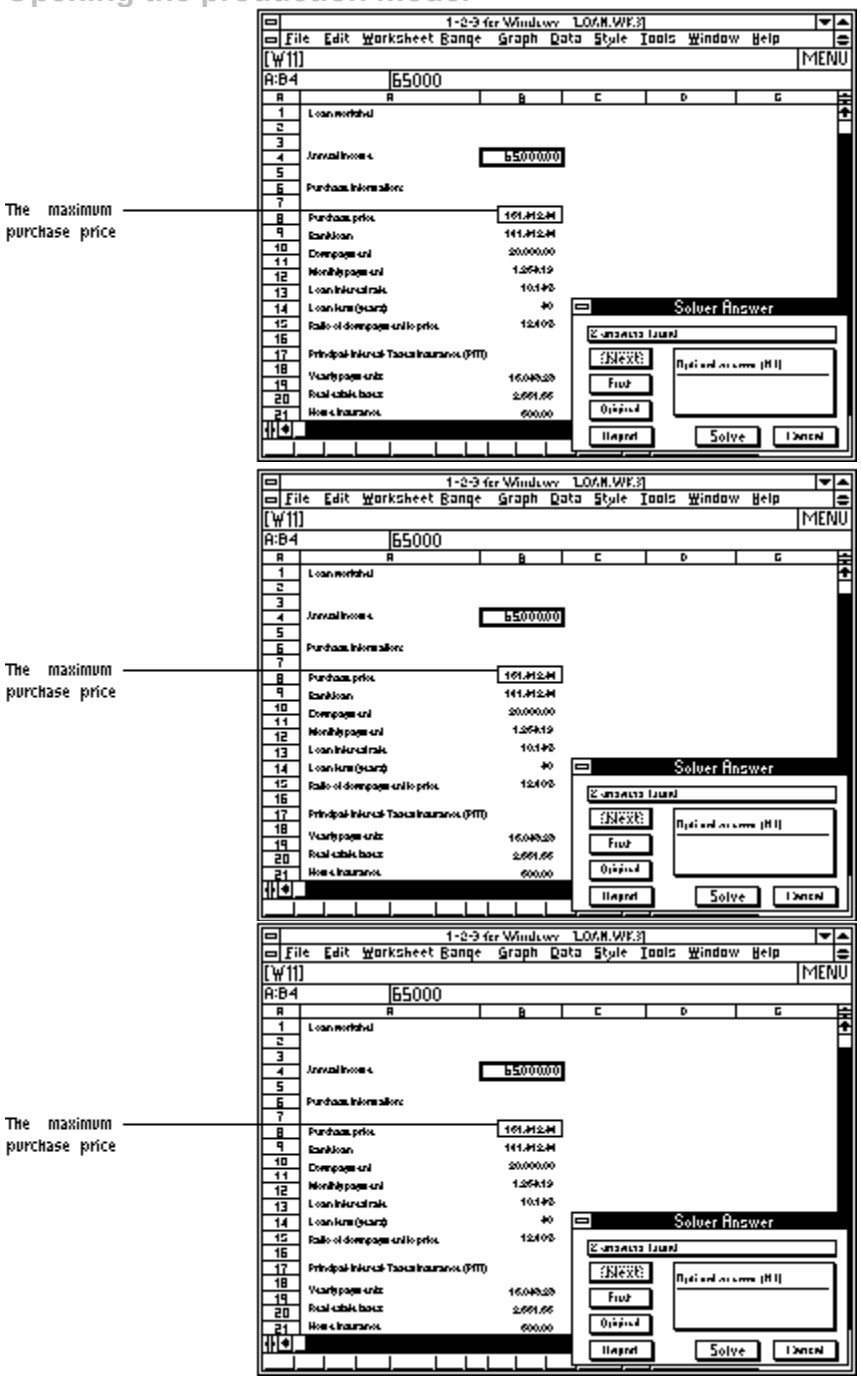
If you are planning production levels at your company, the Solver can show you the most profitable mix to produce, given available resources. Suppose your bakery makes three types of bread: low-calorie, high-fiber, and white. You know the cost and number of person hours it takes to produce a case of each type of bread. Can you determine the amounts to produce that will result in the highest profit for your company?

The Solver can help you determine various production levels for the three types of bread. It can also show you the production level that stays within the limits of available resources and maximizes profit.

This model shows you how to find the level of production that results in the highest profit, and how to create reports that show how much you can vary the amount of any one type of bread during a production run and show how the Solver solved the problem.

> **Note** The *Solver Guide* may illustrate Solver Table Reports differently than they appear on your screen. For example, borders around and within sections of data were added in our illustrations to improve readability, and in cases where the Solver reports a value that is too long for the default column width, the columns are illustrated wide enough to display the long value.

Opening the production model



The worksheet file PRODUCT.WK3 contains the production model. The Install program copied this file to your computer's hard disk when you installed 1-2-3 for Windows. To use this file, you need to change to the subdirectory SAMPLE in your 1-2-3 program directory and then open the file.

To open the production model

1. Choose File Open.

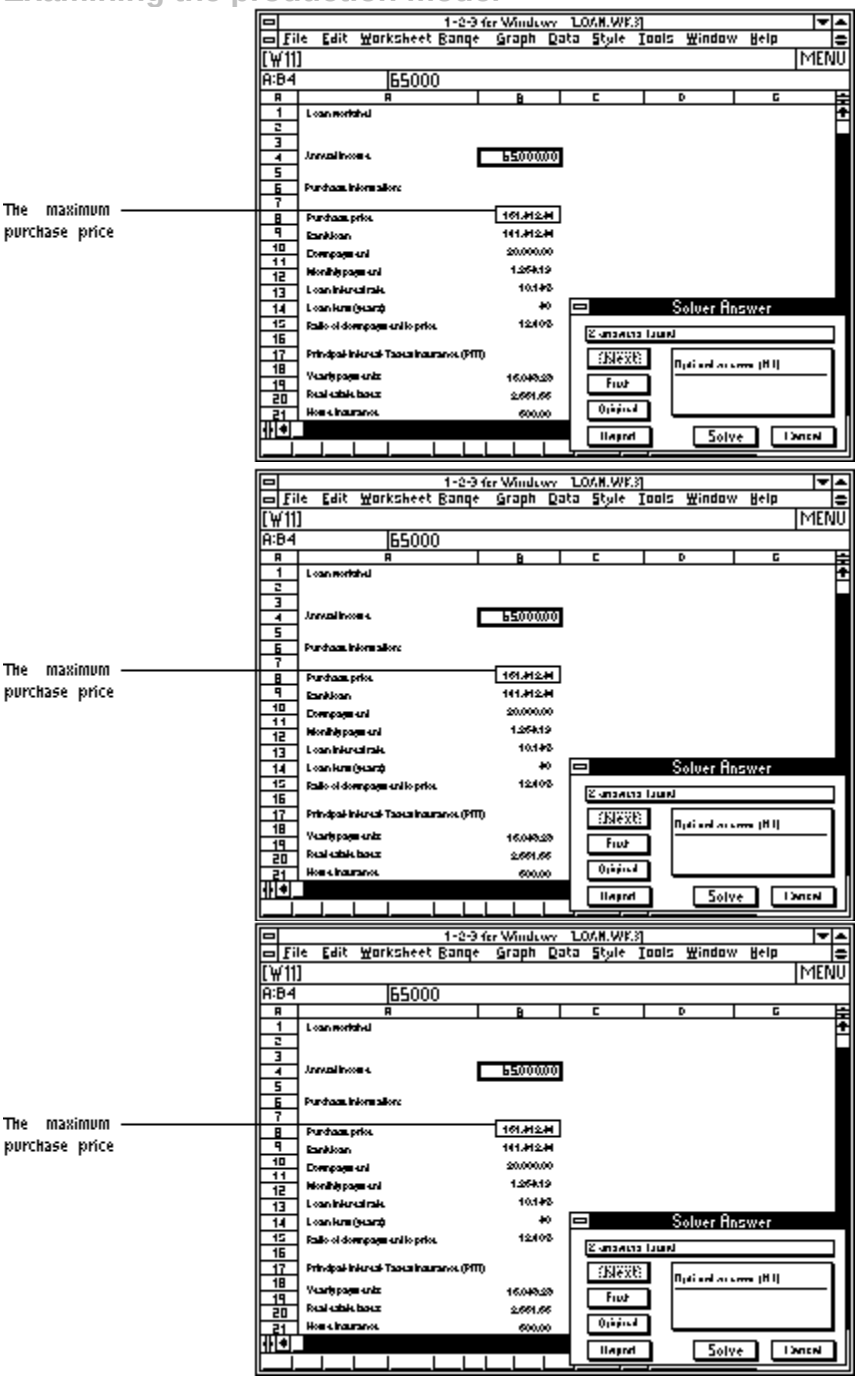
2. Select the directory that contains your sample worksheet files in the Directories list box (for example, C:\123W\SAMPLE) and press ENTER.

   When you installed 1-2-3, the Install program copied the sample files to this directory.

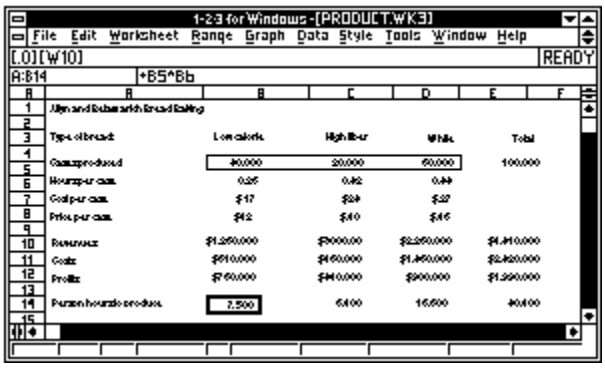
3. Select PRODUCT.WK3 in the Files list box.

4. Select OK.

Examining the production model



The production model shows figures for the number of cases produced for each type of bread, the number of hours required, the cost and price per case. Based on these figures, the model calculates revenues, costs, profit, and person hours.



The production model has the following variables:

Cases produced is the number of cases of each type of bread.

Hours per case is the number of hours it takes your company to produce a case of each type of bread.

Cost per case is the amount it costs your company to produce each case.

Price per case is the amount your company charges per case.

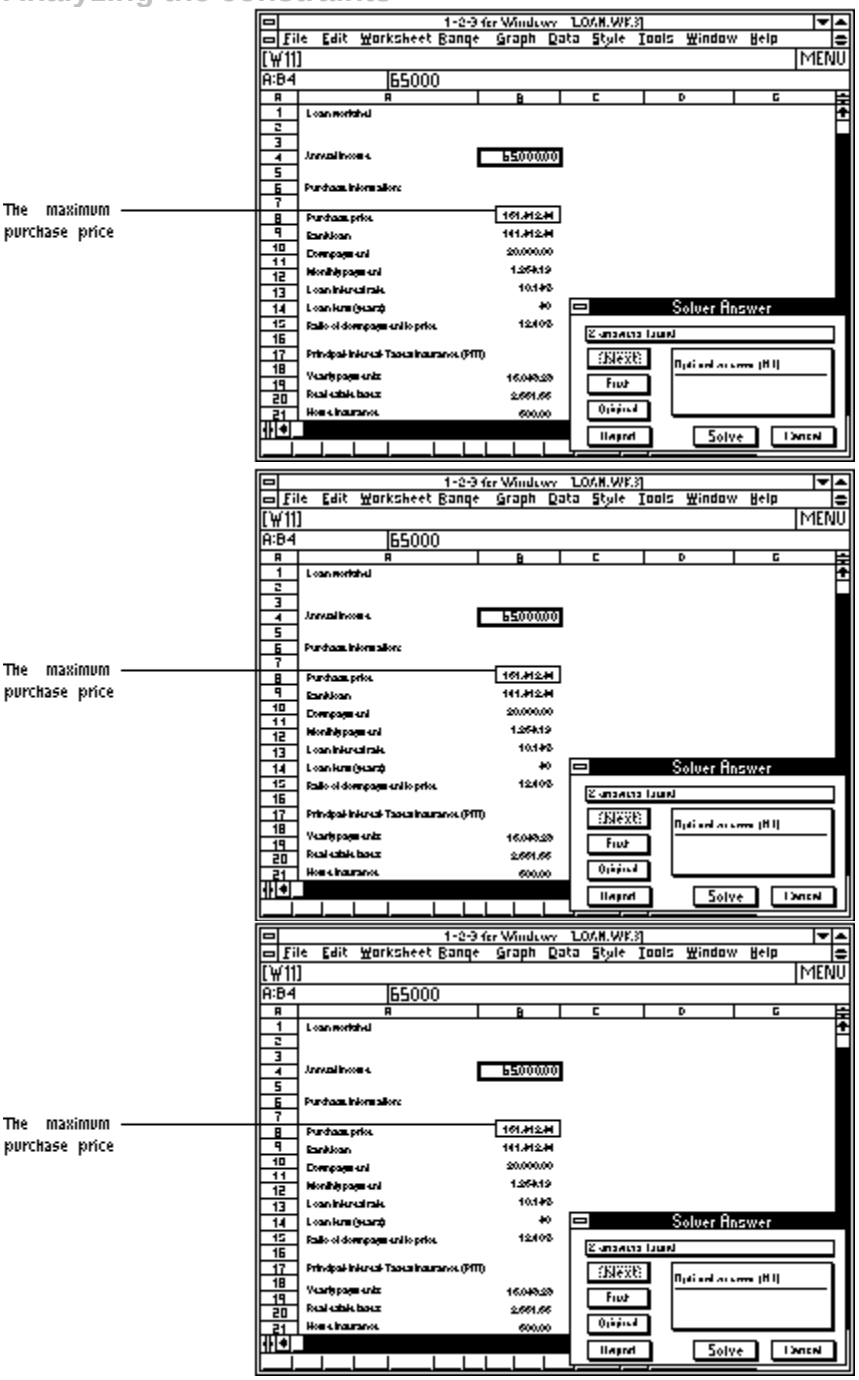
Revenues is the number of cases produced times price per case.

Costs is the number of cases produced times cost per case.

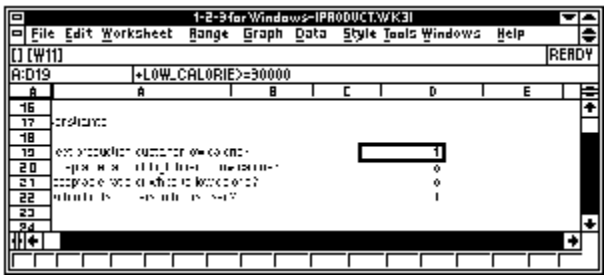
Profit is revenues minus costs for each product.

Person hours to produce is the number of hours to produce each case times the number of cases produced.

Analyzing the constraints



The constraint formulas in D19..D22 specify the bakery's production guidelines for low-calorie, high-fiber, and white bread.



The Solver looks for answers that satisfy the following constraints:

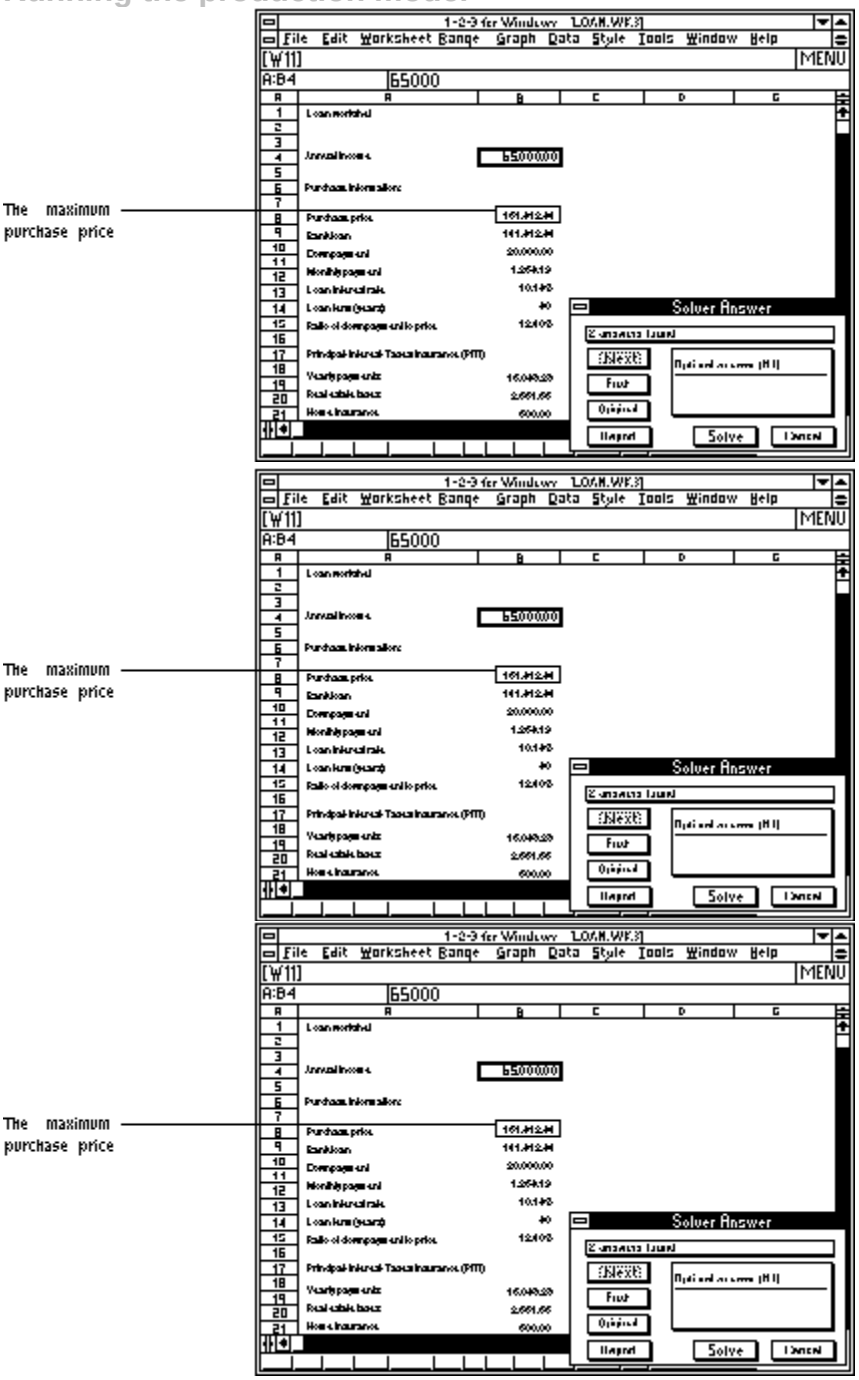
Meet production quota for low calorie specifies that the minimum quota for low-calorie bread is 30,000 cases (+LOW_CALORIE>=30000).

Acceptable ratio of high fiber to low calorie specifies that the company must produce at least one and a half cases of high-fiber bread for each case of low-calorie bread (+HIGH_FIBER>=1.5*LOW_CALORIE).

Acceptable ratio of white to low calorie specifies that the company must produce at least two cases of white bread for each case of low-calorie bread (+WHITE>=2*LOW_CALORIE).

Within limits for person hours used specifies that the total number of person hours must not exceed 60,000 (+TOTAL_PERS_HRS<=60000).

Running the production model



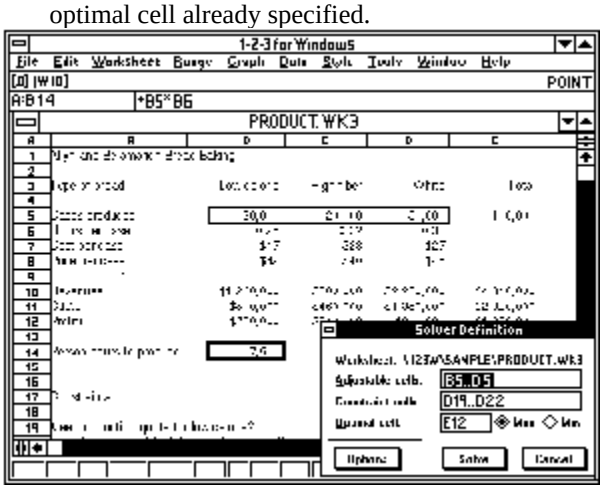
Follow the instructions below to solve the problem and examine the answers the Solver finds. You will have the Solver find the answer that results in the highest profit, and you will see other answers the Solver finds.

After you review the answers, you will create reports that show the amount the production levels can vary and how the Solver found the optimal answer. Finally, you will save the optimal answer, which shows the most profitable mix of breads to produce.

To run the production model

1. Choose Tools Solver.

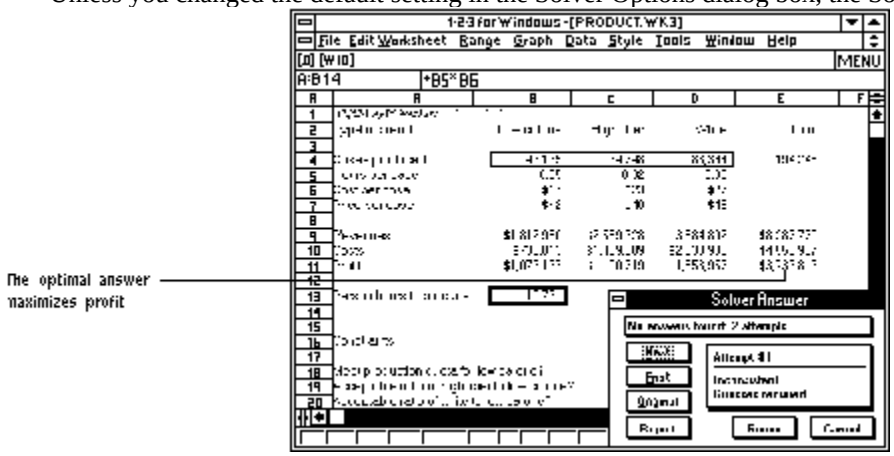
   The Solver Definition dialog box appears with the addresses of the adjustable cells, constraint cells, and the optimal cell already specified.



2. Select Solve.

   The Solver analyzes the problem and informs you of its progress. Then, the Solver displays the Solver Answer dialog box and places the first answer in the worksheet. If you selected optimization, the first answer is the optimal answer.

   Unless you changed the default setting in the Solver Options dialog box, the Solver will find four answers.



   The Solver displays the optimal answer in the worksheet. This is the answer that maximizes the value in E12, Total profit. The optimal answer shows that your bakery could make a profit of $3,733,813 while remaining within its production guidelines.

3. Select Next.

   The Solver displays another answer in the worksheet. You can continue to select Next to see each of the other answers the Solver found. These answers also satisfy the constraints of the problem.

To report limits for production levels

1. Choose Tools Solver to open the Solver Answer dialog box, if necessary.

2. Select First.

   The Solver displays the optimal answer in the worksheet.

3. Select Report.

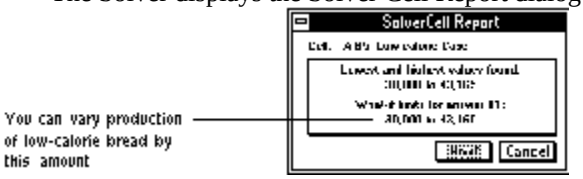
   The Solver displays the Solver Report dialog box.

4. Under Type, select What-if limits.

5. Under Format, select Cell.

6. Select OK.

   The Solver displays the Solver Cell Report dialog box for What-if limits.



   The Solver Cell Report dialog box shows that low-calorie bread production can vary from 30,000 to 43,165 cases and still satisfy all three constraints.

7. Select Next.

   The report shows that high-fiber bread production must remain at 64,748 cases to satisfy all three constraints.

8. Select Next, again.

   The report shows that white bread production must remain at 86,331 cases to satisfy all three constraints.

The report information shows that you cannot change the amounts of the white and high-fiber breads that are in your production run. You have some flexibility, however, in how much low-calorie bread you can produce.

To close the report

1. Select Cancel twice to close the Solver Cell Report and Solver Report dialog boxes.

   The Solver redisplays the Solver Answer dialog box.

To report how solved

1. Choose Tools Solver to open the Solver Answer dialog box, if necessary.

2. Select First.

   The Solver displays the optimal answer in the worksheet.

3. Select Report.

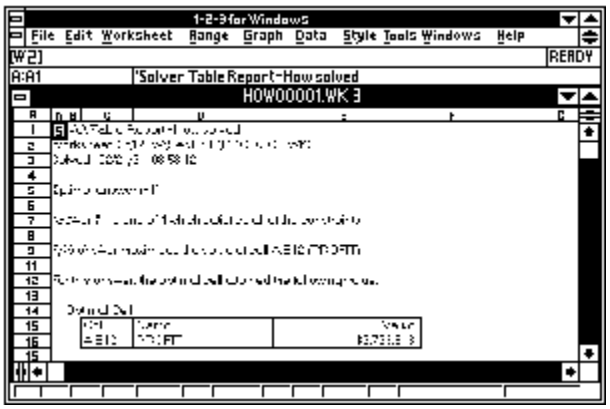
   The Solver Report dialog box is displayed.

4. Under Type, select How solved.

5. Under Format, select Table.

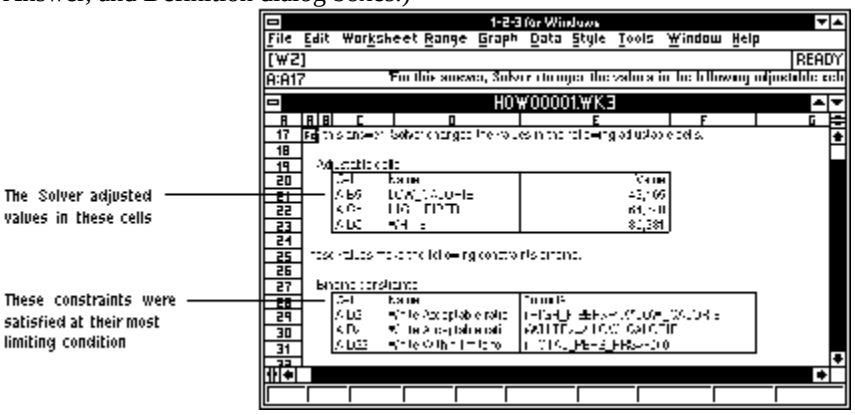
6. Select OK.

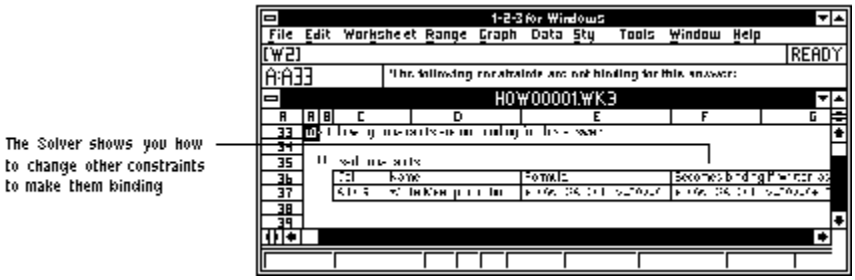
The Solver Table Report for How solved appears in worksheet file HOW00001.WK3. The Solver generates this file name based on the name of the report type you selected.



The Solver Table Report explains that answer #1 is the optimal answer, which maximizes total profit.

You can use the mouse or press , ↓, →, and ← to see the entire report. (You must first close the Solver Report, Answer, and Definition dialog boxes.)

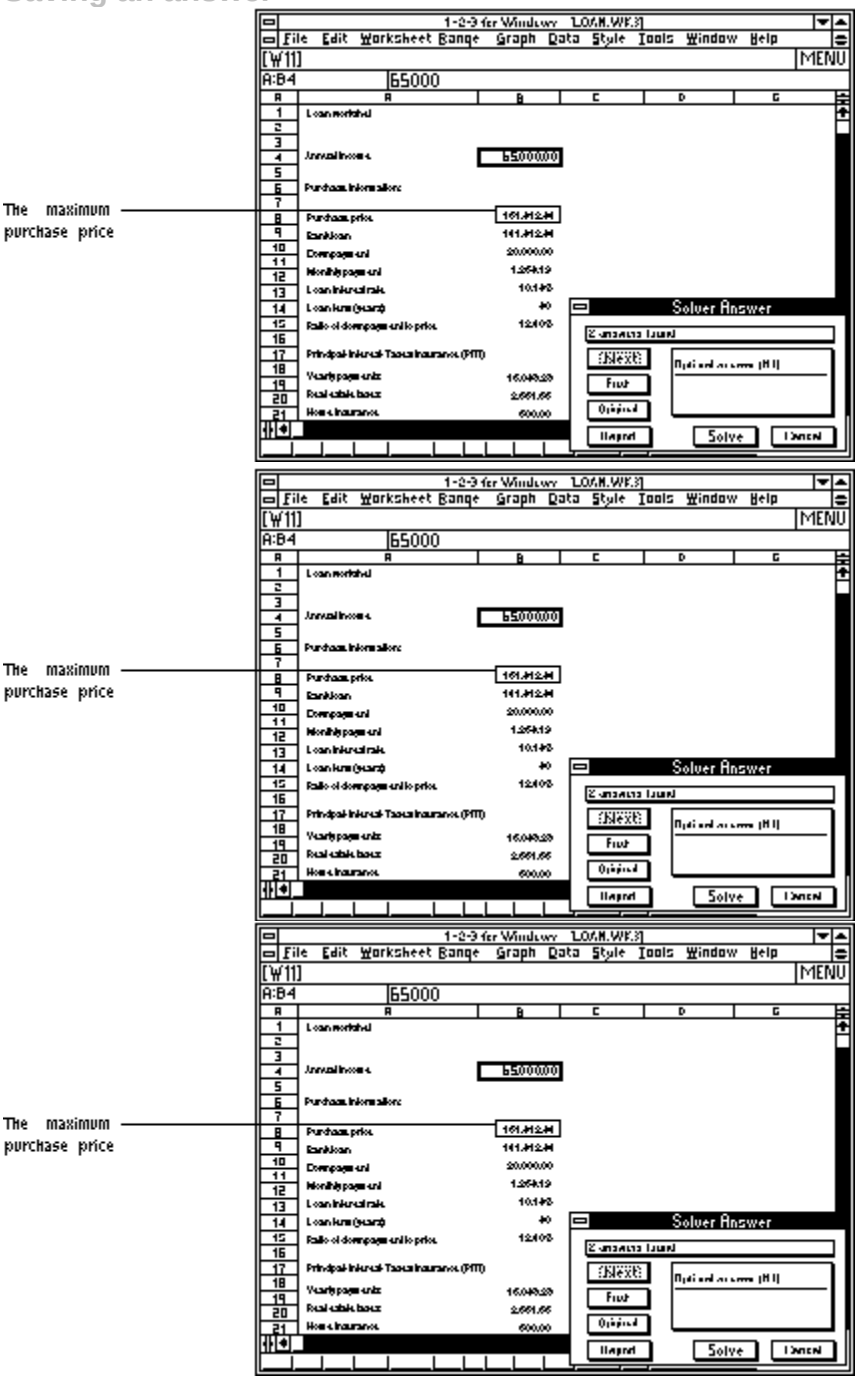




To save the report

1. Select Cancel three times to close the Solver Report, Answer, and Definition dialog boxes.
2. Make the worksheet that contains the report the current worksheet, if necessary.
3. Choose File Save to save the file with the name HOW00001.WK3, or choose File Save As to save the file with a different name.

Saving an answer



You can save the answer that shows the highest profit by saving it in worksheet file PRODUCTX.WK3.

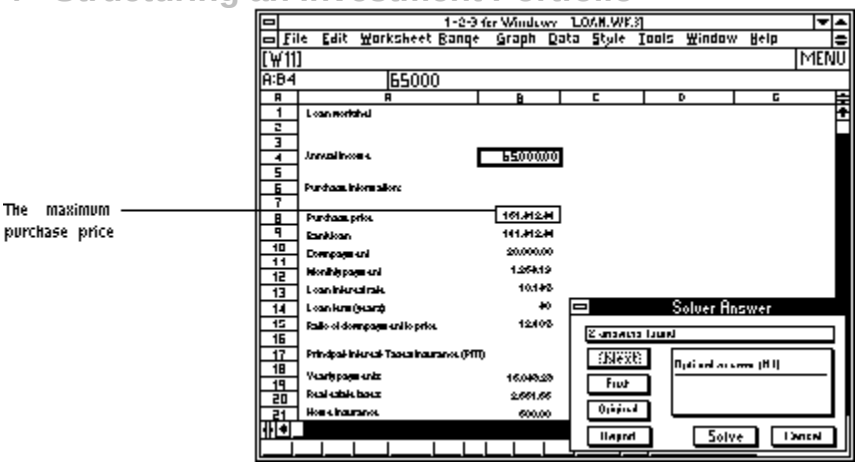
To save an answer

1. Make PRODUCT.WK3 the current worksheet, if necessary.
2. Choose Tools Solver to open the Solver Answer dialog box, if necessary.

3. Select First.

   The Solver displays the optimal answer in the worksheet.
4. Select Cancel twice to close the Solver Answer dialog box and the Solver Definition dialog box.
5. Make the worksheet containing the answer the current worksheet.
6. Choose File Save As.
7. Specify PRODUCTX.WK3 as the name of the worksheet file.
8. Select OK.

4 Structuring an Investment Portfolio



If you are structuring an investment portfolio, the Solver can evaluate income, appreciation, and diversification factors to show you the combination of investments that provides the best total return. Suppose you have $100,000 to invest. How can your investments attain the highest possible return, while satisfying each of your other investment objectives?

The Solver can help you decide how to invest your money in a combination of stocks, bonds, and money market instruments to provide acceptable total returns and diversification. It can also show you the scenario that results in the best return on your investments.

This model shows you how to maximize the total return on your investments and create a report that shows constraints the Solver did not need to use to find the optimal answer.

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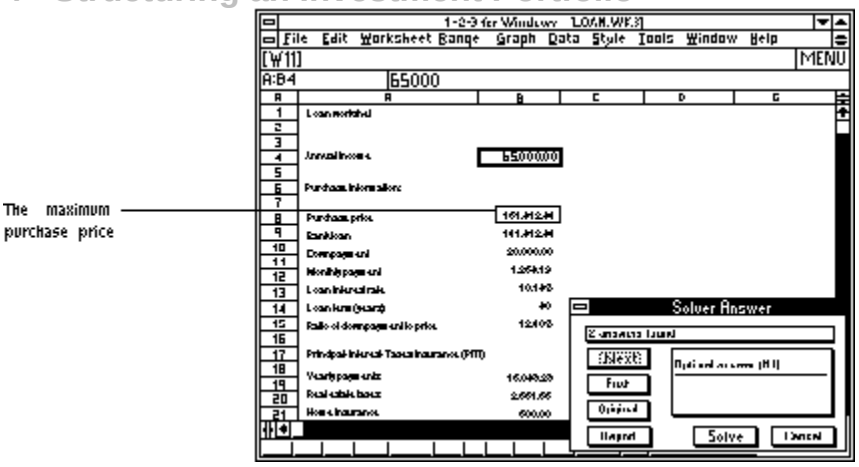
4 Structuring an Investment Portfolio



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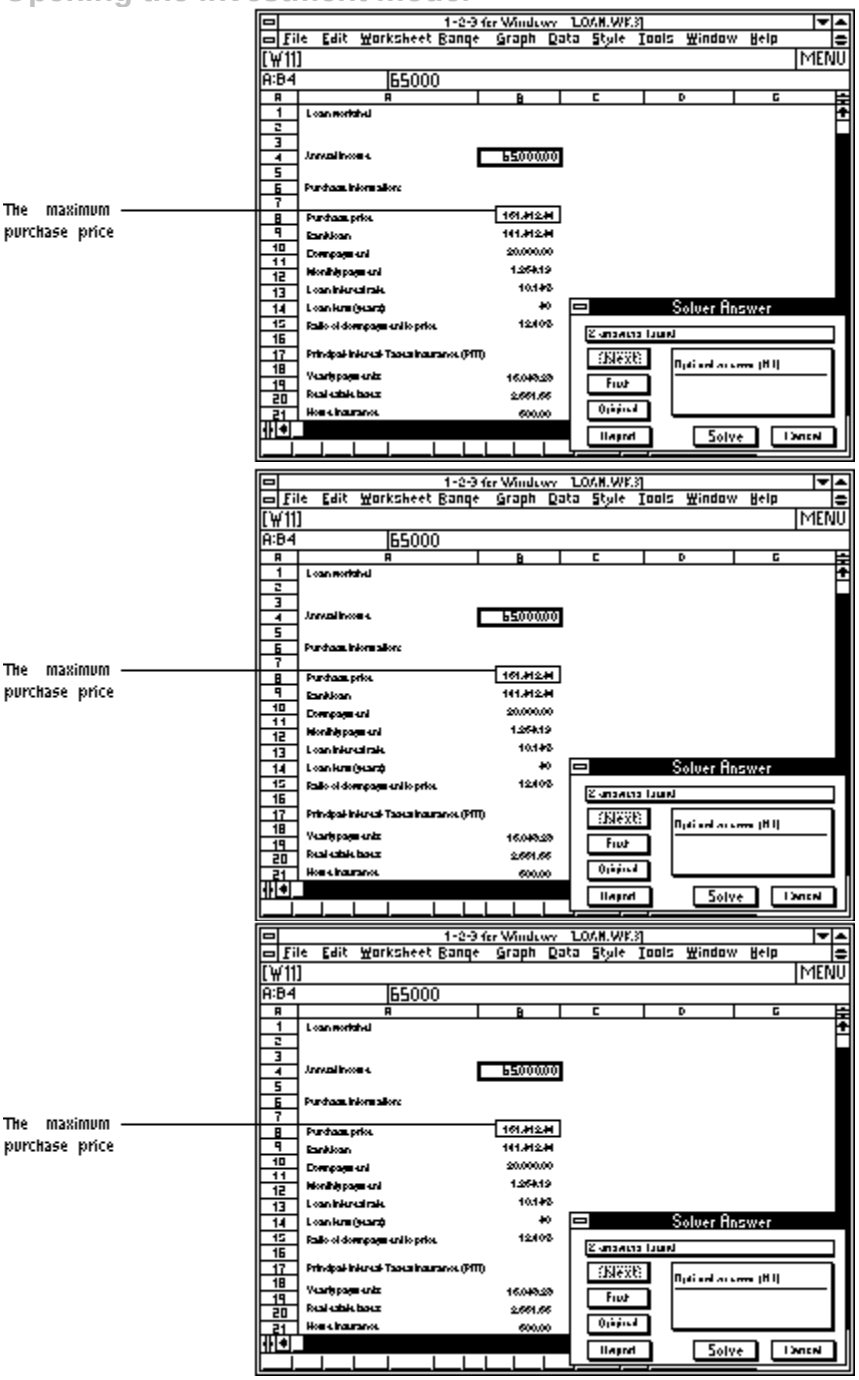
Opening the investment model



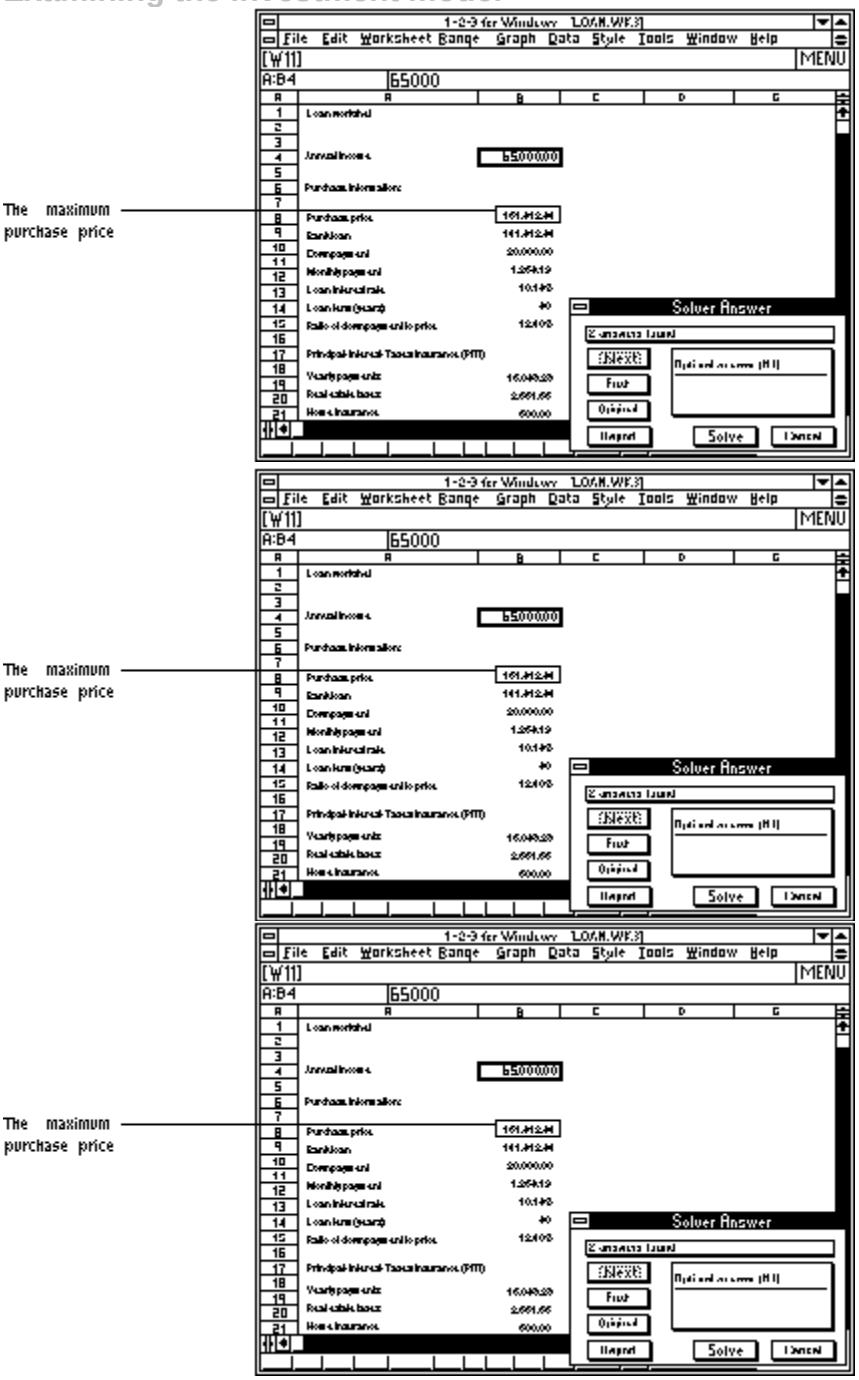
The worksheet file INVEST.WK3 contains the investment model. The Install program copied this file to your computer's hard disk when you installed 1-2-3 for Windows. To use this file, you need to change to the subdirectory SAMPLE in your 1-2-3 program directory and then open the file.

To open the investment model

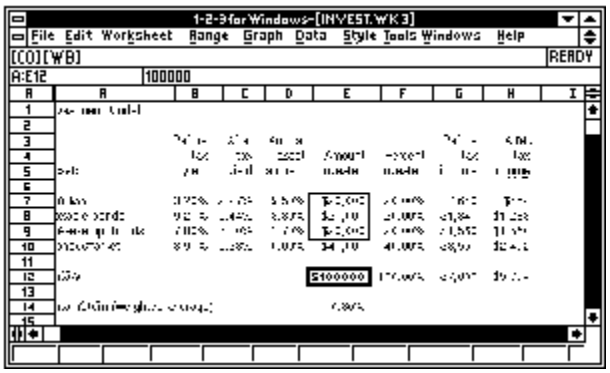
1. Choose File Open.

2. Select the directory that contains your sample worksheet files in the Directories list box (for example, C:\123W\SAMPLE) and press ENTER.
3. Select INVEST.WK3 in the Files list box.
4. Select OK.

Examining the investment model



The investment model shows various types of investment instruments and the amount to invest in each one. The model calculates the total amount invested as well as the before and after tax income.



The model has the following variables:

Asset shows the investment instruments among which you will distribute your investment dollars.

Before tax yield shows the pre-tax yield of each asset independent of tax considerations.

After tax yield shows the yield of each asset in your portfolio after you meet your tax obligations.

Annual asset appreciation shows the estimated appreciation of each asset in your portfolio during a 12-month period, based on the asset's track record.

Amount invested shows the dollars invested in each asset and the available total dollars. Here, the portion of the $100,000 not invested in stocks and bonds is automatically invested in money market funds.

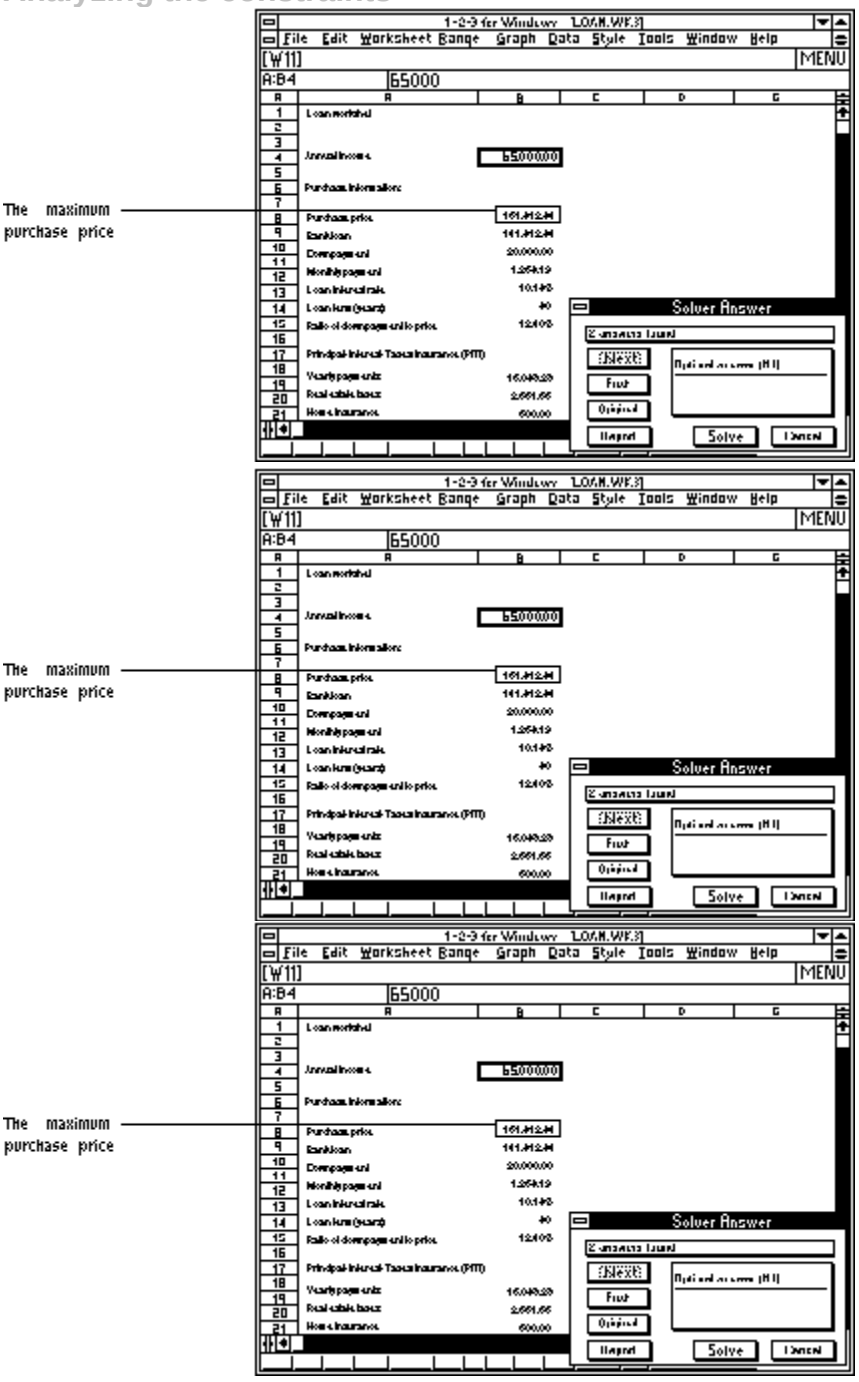
Percent invested calculates the percentage distribution of your investment dollars among the various assets.

Before tax income shows the pre-tax income earned on the amount invested in each asset independent of tax considerations.

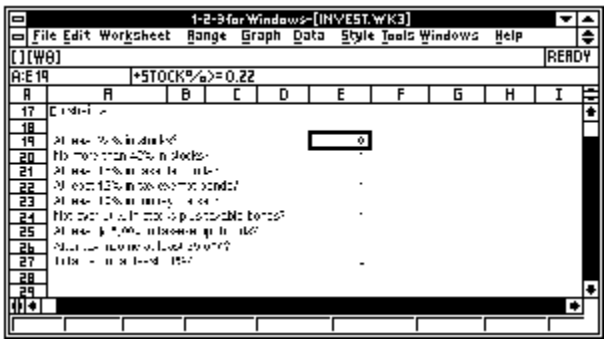
After tax income shows income earned on the amount invested in each asset after you meet your tax obligations.

Total return (weighted average) shows overall return on the investment portfolio.

Analyzing the constraints



The constraint formulas in E19..E27 specify your diversification, income, and appreciation requirements.



The Solver looks for answers that satisfy the following constraints:

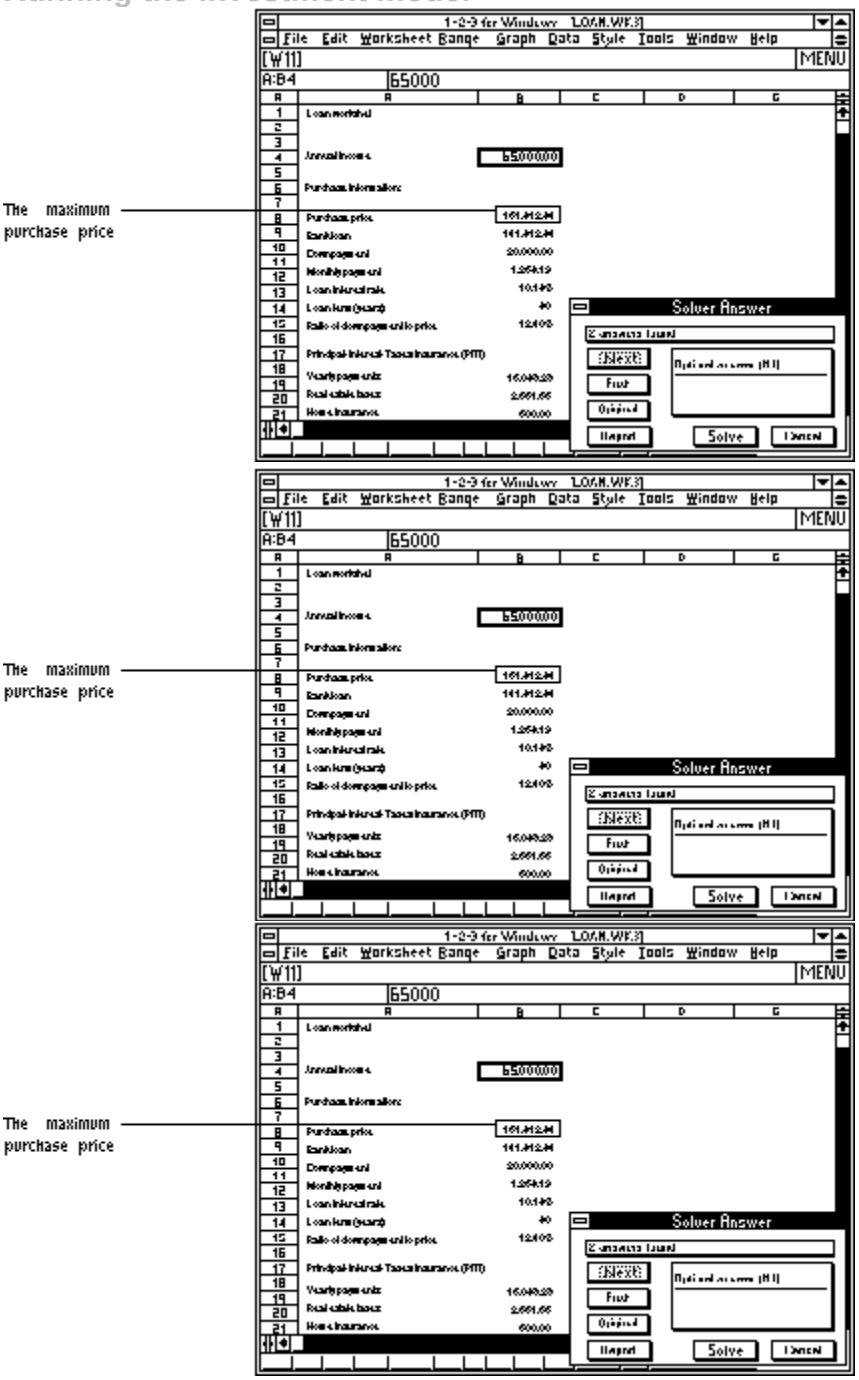
At least 22% in stocks specifies that you want to invest at least 22% of your portfolio in stocks (+STOCK%>=0.22).

No more than 45% in stocks specifies that you do not want to invest more than 45% of your portfolio in stocks (+STOCK%<=0.45).

At least 15% in taxable bonds specifies that you want to invest at least 15% of your portfolio in taxable bonds (+BOND%>=0.15).

The remaining formulas specify the additional requirements.

Running the investment model



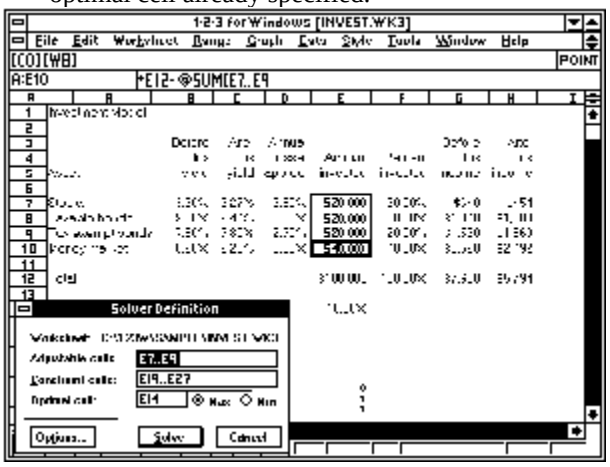
Follow the instructions below to solve the problem and examine the answers the Solver finds. You will see the Solver find the answer that results in the best total return on your investments.

In addition, you will create a report that shows constraints the Solver did not need to use to find the optimal answer. Finally, you will save this report, as well as the optimal answer that you display in the worksheet.

To run the investment model

1. Choose Tools Solver.

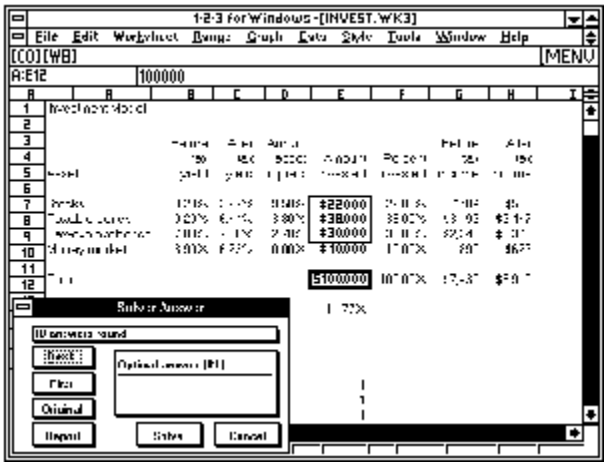
   The Solver Definition dialog box appears with the addresses of the adjustable cells, constraint cells, and the optimal cell already specified.



2. Select Solve.

   The Solver analyzes the problem and informs you of its progress. Then, the Solver displays the Solver Answer dialog box and places the first answer in the Worksheet window. If you selected optimization, the first answer is the optimal answer.

   Unless you changed the default setting in the Solver Options dialog box, the Solver will find 10 answers for the investment model.



   The Solver displays the optimal answer in the worksheet. This is the answer that maximizes the value in E14, Total return (weighted average).

3. Select Next.

   The Solver displays another answer in the worksheet. You can continue to select Next to see each of the other answers the Solver found.

To report unused constraints

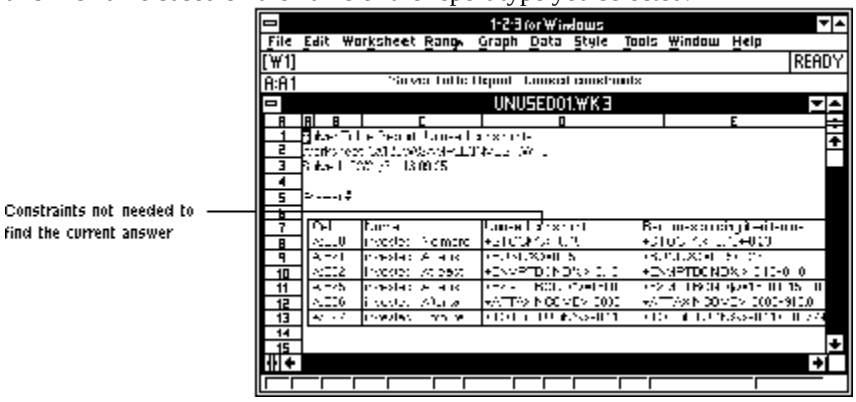
1. Choose Tools Solver to open the Solver Answer dialog box, if necessary.
2. Select First.

   The Solver displays the optimal answer in the worksheet. This is the answer that maximizes total return.

3. Select Report.

4. Under Type, select Unused constraints.
5. Under Format, select Table.
6. Select OK.

The Solver Table Report for Unused constraints appears in worksheet file UNUSED01.WK3. The Solver generates this file name based on the name of the report type you selected.



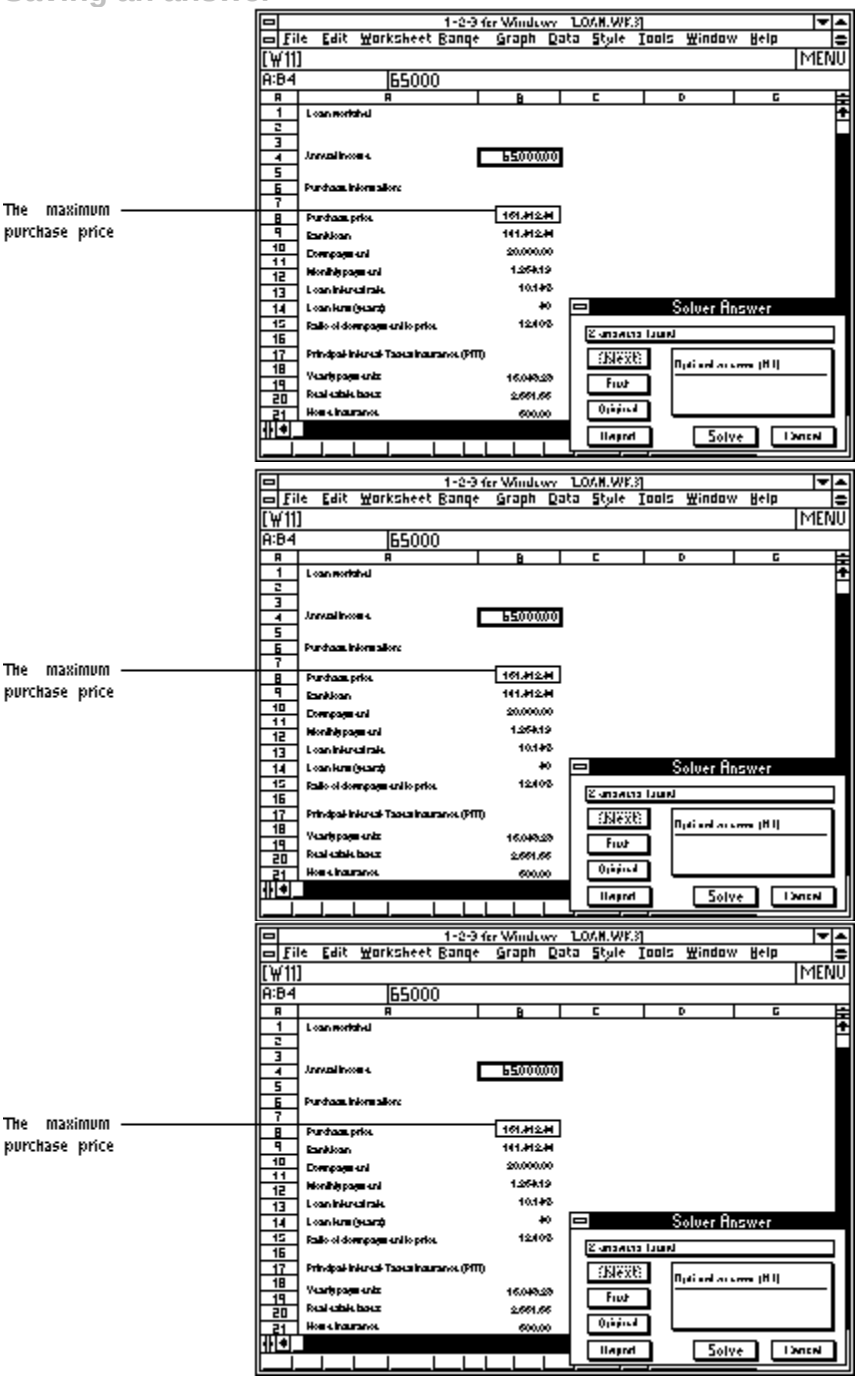
The Solver Table Report shows six constraint formulas that the Solver did not need to find the answer. (The Solver needed only three of the constraints you originally specified to find the optimal answer.)

You can use the mouse or press , ↓, →, and ← to see the entire report. (You must first close the Solver Report, Answer, and Definition dialog boxes.)

To save the report

1. Select Cancel three times to close the Solver Report, Answer, and Definition dialog boxes.
2. Make the worksheet that contains the report the current worksheet, if necessary.
3. Choose File Save to save the file with the name UNUSED001.WK3, or choose File Save As to save the file with a different name.

Saving an answer



You can save the optimal answer by saving it in worksheet file INVESTX.WK3.

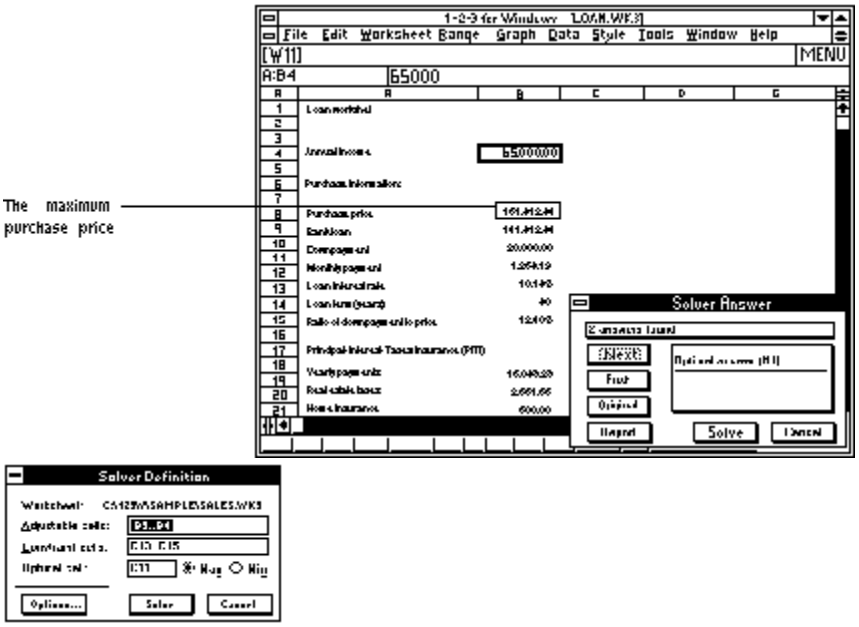
To save an answer

1. Make INVEST.WK3 the current worksheet, if necessary.
2. Choose Tools Solver to open the Solver Answer dialog box, if necessary.
3. Select First.

The Solver displays the optimal answer in the worksheet.

4. Select Cancel twice to close the Solver Answer dialog box and the Solver Definition dialog box.
5. Make the worksheet containing the optimal answer the current worksheet.
6. Choose File Save As.
7. Specify INVESTX.WK3 as the name of the worksheet file.
8. Select OK.

5 Problem Definition

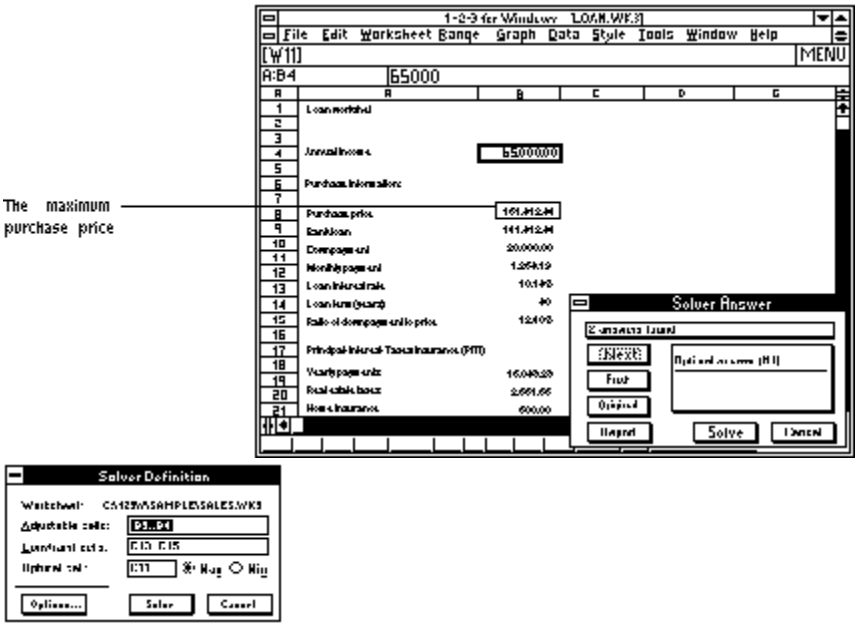


The Solver Definition dialog box defines the problem for the Solver. Examples of Solver problems are "What is the advertising mix that reaches the most readers?" or "What is the hiring scenario that produces the highest profit?"

The Solver Definition dialog box is where you supply the information the Solver must have to solve a problem. It contains text boxes in which you specify the set of adjustable cells, constraint cells, and the optimal cell (if any) the Solver will use to solve the problem.

Defining the problem

5 Problem Definition



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Defining the problem

- Text boxes in the Solver Definition dialog box
- Command buttons in the Solver Definition dialog box
- Solver Progress dialog box

Defining the problem

The Solver Definition dialog box displays the name of the worksheet file that is current when you choose Tools Solver.

Note The worksheet name shown is informational only; you cannot edit it. If you want to use the Solver with another worksheet, select Cancel to close the Solver Definition dialog box, make a different worksheet current, and choose Tools Solver again.

When you save the worksheet in the Worksheet text box as a .WK3 file, 1-2-3 also saves the list of constraint cells, adjustable cells, and the optimal cell (if any) contained in the Solver Definition dialog box. When you open the worksheet file and choose Tools Solver, the Solver Definition dialog box displays the cell addresses of the constraint cells, adjustable cells, and the optimal cell.

Note You can save the contents of the Solver Definition dialog box only *after* the Solver solves the problem.

An easy way to specify cells is to select a text box in the Solver Definition dialog box and then specify cells in the worksheet file. You can specify cells from more than one active worksheet file. You can specify cells even if they are in worksheet files that have been minimized to icons. You cannot specify cells from files on disk. The maximum size of a problem depends on how much memory your computer has. If a problem contains many formulas or complicated references, it can take longer to solve or solving the problem can use all computer memory. For more information, see **Chapter 9.**

To edit text in the Solver Definition dialog box, use any of the 1-2-3 editing techniques. For information about editing techniques, see **Chapter 2** in the *User's Guide*.

Text boxes in the Solver Definition dialog box

The Solver Definition dialog box contains the following text boxes:

Adjustable cells -- Specifies the cells containing values that the Solver can change when it searches for an answer. The Solver changes the values in these cells to satisfy the constraints of the problem you are trying to solve. These are the cells you change when you are manually solving a what-if problem.

Specify only unprotected cells that contain values. The Solver does not use cells that are blank or contain formulas or labels as adjustable cells. You can specify up to 512 characters in the Adjustable cells text box. Specify a path for cells from other active worksheet files. Separate multiple entries with a , (comma). You may also point to the cells or ranges that you want to include as adjustable cells.

If you specify a single cell address, the Solver adjusts the value in the cell. If you specify a range name, range address, worksheet, column, row, or worksheet file, the Solver uses any unprotected cells containing values as adjustable cells. It does not enter values in any blank cells, protected cells, or cells containing formulas or labels if they are specified as part of a range.

Constraint cells -- Specifies cells whose logical (or two-sided) formulas the Solver must satisfy for each answer. A constraint is satisfied when the Solver changes the values in the adjustable cells and causes the logical formula to return 1 (true) instead of 0 (false) (subject to minor roundoff differences).

Specify cells that use the = >= <= > or < operators (simple logical formulas). The Solver does not accept compound logical formulas that use #AND#, #NOT#, #OR#, or <> (not equal). To specify the equivalent of compound logical formulas, enter simple formulas across several cells. For example, the formula +A1>=50#AND#A1<=100 is not a

valid constraint formula, but the formulas +A1>=50 and +A1<=100 entered in separate cells are valid constraint formulas.

You can specify up to 512 characters in the Constraint cells text box. Specify a path for cells from other active worksheet files. Separate multiple entries with a , (comma). You may also point to the cells or ranges that you want to include as constraint cells.

If you specify a single-cell address, range name, range address, worksheet, column, row, or worksheet file, the Solver uses the logical formulas in the cells as constraints. If any cell is blank or contains labels or a formula that is not a logical formula, the Solver does not recognize the cell as a constraint.

> **Note** The formulas contained in the cells that the Solver uses to find answers can use some, but not all, of the 1-2-3 @functions. For more information about using @functions with the Solver, see **Chapter 8.**

Optimal cell -- Specifies the single cell for which you want the Solver to find either the highest or lowest value. Specifying an optimal cell is optional.

Specify a single cell that is one of the adjustable cells or specify a cell whose formula depends on an adjustable cell. You can specify either a cell address or the range name of a cell. If you specify a range, the Solver uses the top left cell in the range as the optimal cell.

If you do not specify an optimal cell, the Solver finds a set of representative answers that satisfy each of the constraints.

After you specify an optimal cell, use the mouse or press → and ← to move between the Max and Min option buttons.

Max -- Finds the highest value for the optimal cell (default).

Min -- Finds the lowest value for the optimal cell.

Command buttons in the Solver Definition dialog box

The Solver Definition dialog box contains the following command buttons:

Cancel -- Closes the Solver Definition dialog box.

Options -- Lets you specify the number of answers you want the Solver to find. Options applies to the worksheet file that is named in the Solver Definition dialog box. 1-2-3 saves the options you specify when you save the worksheet file as a .WK3 file. When you select Options, the Solver displays the Solver Options dialog box. For information, see "Solver Options dialog box" below.

Solve -- Analyzes the problem, then begins to look for answers to the problem using the information in the Solver Definition dialog box. The Solver looks for the number of answers you specify in the Solver Options dialog box.

> **Note** The Solver keeps a record of the original data in the worksheet file before you started solving. To restore cells to the values they contained before you last selected Solve, select Original in the Solver Answer dialog box. For more information, see **Chapter 6.**

Solver Options dialog box

When you select Options, the Solver displays the Solver Options dialog box.

The dialog box contains the following text box and command buttons:

Cancel -- Closes the Solver Options dialog box and returns you to the Solver Definition dialog box.

Number of answers -- Lets you specify an approximate number of answers you want the Solver to find. Enter a number between 1 and 999. The default is 10.

OK -- Accepts the options you specified, closes the Solver Options dialog box, and returns you to the Solver Definition dialog box.

The number you specify is an estimate; the Solver may find fewer or more answers than you request. For example, the Solver may find only 2 answers for a problem, even if you request 10 answers.

If the Solver can find more answers than the amount you request, when you select Solve in the Solver Answer dialog box, the Solver uses the estimate you specified in the Solver Options dialog box to find the next group of answers.

Solver Progress dialog box

When you select Solve, the Solver displays the Solver Progress dialog box to inform you of the Solver's progress in analyzing the problem and finding answers. To stop solving, select Cancel or press CTRL+BREAK.

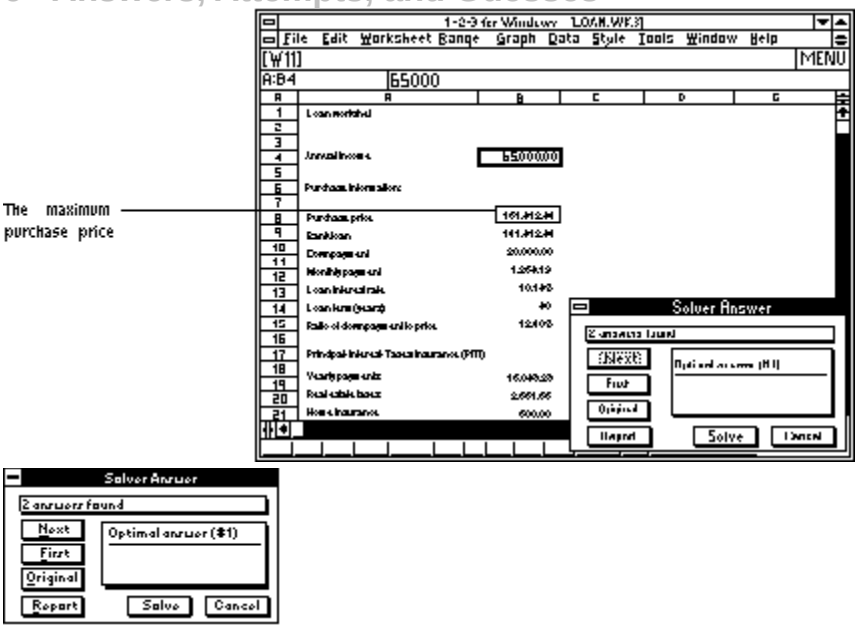
The Solver Progress dialog box displays the following messages:

- **Analyzing problem** indicates that the Solver is examining the worksheet to locate the values, formulas, and other information it needs to solve the problem.
- **Searching for answer #** indicates how many answers the Solver has found and which answer the Solver is looking for.
- **Elapsed time** is the amount of time the Solver has taken so far to solve the problem.
- **% Complete** is the Solver's estimate of its progress in solving the problem.

While it solves a problem, the Solver looks for the number of answers you specified in the Solver Options dialog box.

When the Solver begins solving, you cannot perform any other 1-2-3 tasks until the Solver completes solving or you select Cancel to stop solving. You may want to choose a time for solving when you do not need to do other work in 1-2-3.

6 Answers, Attempts, and Guesses

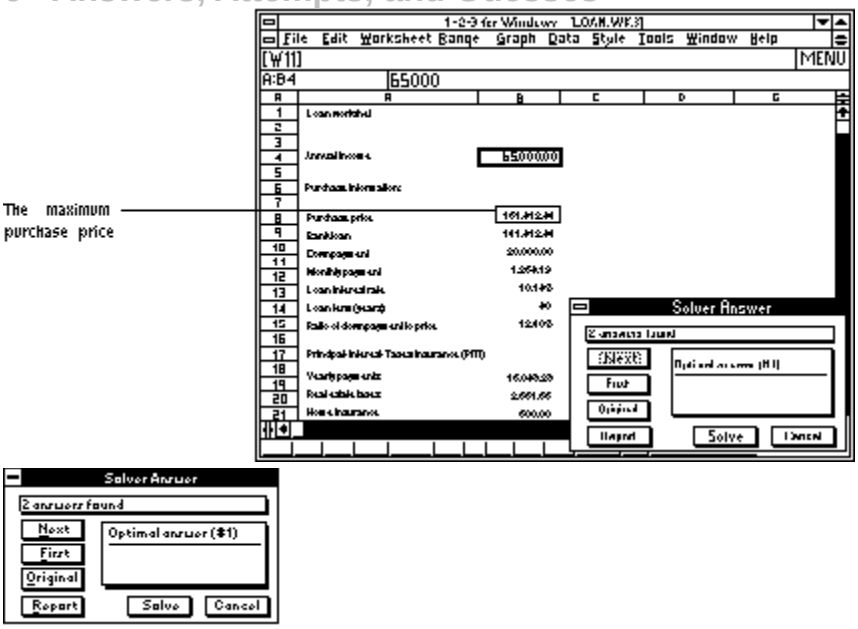


When Solver finishes solving the problem, it displays the Solver Answer dialog box. The Solver Answer dialog box displays the number of answers the Solver finds and places the first or optimal answer in the worksheet, replacing the values that were there before you selected Solve. If the Solver does not find any answers, the Solver Answer dialog box displays the number of attempts it found, places the first attempt in the worksheet, and may let you specify guesses.

The Solver displays answers or attempts in the worksheet file specified in the Solver Definition dialog box and in any other files that contain cells the Solver used to solve the problem. You select the command buttons in the Solver Answer dialog box to display answers or attempts in the worksheet one at a time.

Types of results
Command buttons in the Solver Answer dialog box

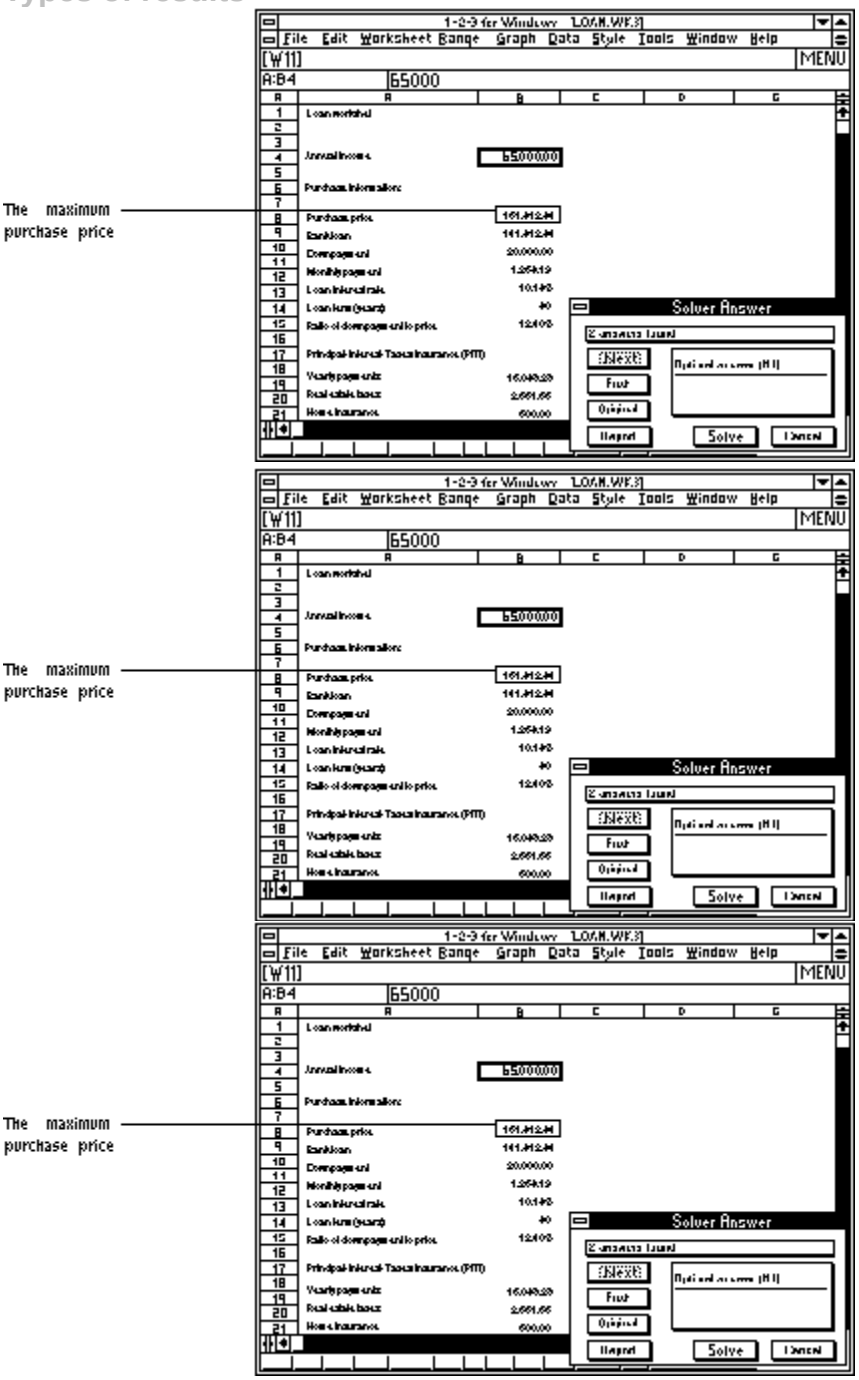
6 Answers, Attempts, and Guesses



When Solver finishes solving the problem, it displays the Solver Answer dialog box. The Solver Answer dialog box displays the number of answers the Solver finds and places the first or optimal answer in the worksheet, replacing the values that were there before you selected Solve. If the Solver does not find any answers, the Solver Answer dialog box displays the number of attempts it found, places the first attempt in the worksheet, and may let you specify guesses.

The Solver displays answers or attempts in the worksheet file specified in the Solver Definition dialog box and in any other files that contain cells the Solver used to solve the problem. You select the command buttons in the Solver Answer dialog box to display answers or attempts in the worksheet one at a time.

Types of results

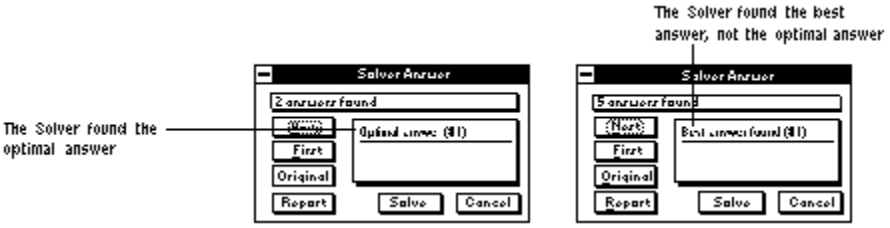


The Solver Answer dialog box displays the following types of results for a problem:

- **Answer** is a solution the Solver finds for a problem. An answer can be the optimal answer, the best answer, or a sample answer. Depending on the problem, the Solver will find one sample answer or several.
- **Attempt** is a result the Solver finds that does not satisfy all constraints you specified for a problem. When you display an attempt in a worksheet, one or more constraints are not satisfied and cause the logical formula to return a result of 0 (false). The Solver displays attempts only when it finds no answers.

The Solver assigns a number to each answer or attempt it finds. If you specified an optimal cell, the Solver sorts answers by the optimal cell's value, with answer 1 being the optimal answer (answer 1 has the highest or lowest value for the optimal cell, depending on whether you specified Max or Min). You can select Report and then select Answer table to create a .WK3 file that lists all answers and the numbers the Solver assigns to them. For more information, see **Chapter 7.**

Answers



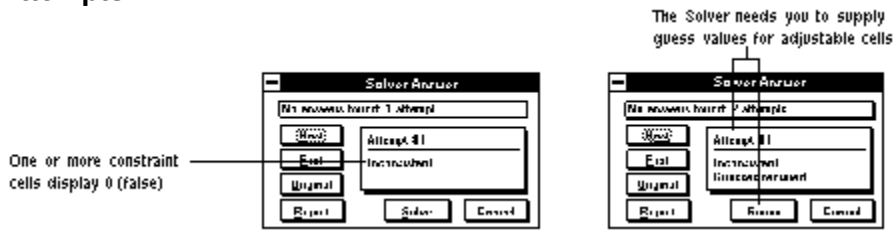
When the Solver finds answers, the Solver Answer dialog box displays one of the following messages in the information box:

- **Best answer found** appears when you specify an optimal cell and the Solver is not certain whether it has found the true mathematical optimum. The answer the Solver displays is the best one it could find. You may be able to find a better answer by changing the values in the adjustable cells.
- **Optimal answer** is the mathematical optimum for the cell you specify as the optimal cell. The answer is the highest or lowest value, depending on whether you selected Max or Min.
- **Sample answer** is an answer the Solver finds that causes the logical formulas in all the constraint cells to return a value of 1 (true).

  Note If the message Roundoff error appears in the Solver Answer dialog box, the Solver has found an answer but one or more constraint cells return 0 (false) after rounding off the constraint to 5 decimal places. If the message Minor roundoff appears in the Solver Answer dialog box, all constraints are satisfied to at least 5 decimal places, but one or more constraint cells return 0 (false) after rounding off the constraint to 16 decimal places. For more information about roundoff errors, see **"Reviewing answers"** in Chapter 9.

1-2-3 for Windows does not automatically save answers the Solver finds. To save a specific answer, display the answer in a worksheet and then choose File Save from the 1-2-3 main menu.

Attempts



When the Solver finds attempts, the Solver Answer dialog box displays one or both of the following messages in the information box:

- **Inconsistent** appears when a constraint cell containing a logical formula was not satisfied.
- **Guesses required** appears (for certain attempts) when the Solver needs more information to find an answer. When an attempt requires guesses, the Guess command button replaces the Solve command button. You select Guess to display the Solver Guess dialog box and specify new values for the adjustable cells.

Solver Guess dialog box

The Solver Guess dialog box lets you enter guess values for adjustable cells and then tries to solve the problem using these values. The dialog box is available only for attempts that require guesses.

The Solver Guess dialog box contains the following information:

- **Cell** specifies the address and name of an adjustable cell for which the Solver needs a new guess value. If the cell has no name, the Solver uses the row and column labels closest to the cell.
- **Initial guess** specifies the initial value of the adjustable cell (before the Solver attempted to solve the problem).
- **Current value** specifies the value of the adjustable cell for the current attempt in the worksheet.

The Solver Guess dialog box contains the following text box:

New guess -- Specifies the new guess value for the adjustable cell. Enter a number or a formula in the text box. When you enter the new guess value, you give the Solver additional information to find an answer. In most cases, the closer the guess value is to the value that results in an answer, the more easily the Solver will be able to find an answer.

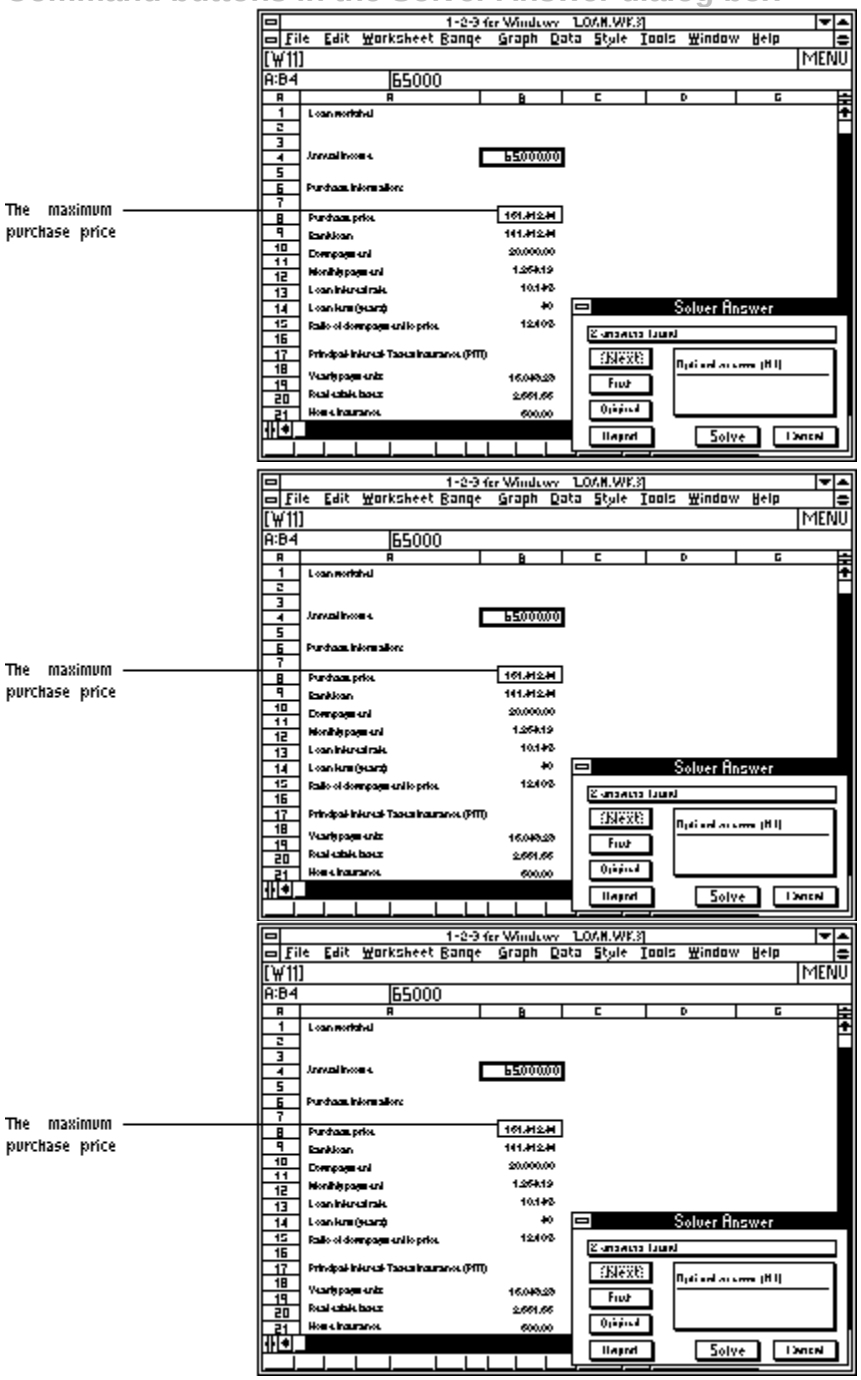
The Solver Guess dialog box contains the following command buttons:

Cancel -- Closes the Solver Guess dialog box and returns you to the Solver Answer dialog box.

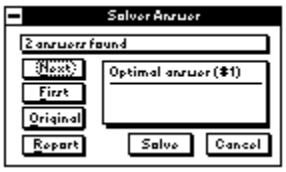
Next -- Displays information about the next adjustable cell that requires a guess value.

Solve -- Solves the problem again by using the new guess values. If the Solver is successful, it displays the answer in the worksheet and discards any previous attempts it found. If the Solver is unsuccessful, it displays an updated attempt in the worksheet.

Command buttons in the Solver Answer dialog box



You can use the command buttons in the Solver Answer dialog box to scroll through the answers or attempts the Solver found, restore the original worksheet values, indicate that you want to see a report, open the Solver Guess dialog box, or look for more answers.



The Solver Answer dialog box contains the following command buttons:

Cancel -- Closes the Solver Answer dialog box and redisplays the Solver Definition dialog box.

First -- Displays the first answer or attempt. If you specified an optimal cell, the Solver displays the optimal or best answer.

Guess -- Opens the Solver Guess dialog box. The Guess command button appears only for an attempt that requires guesses. For more information about the Solver Guess dialog box, see **"Solver Guess dialog box."**

Next -- Displays the next answer or attempt the Solver found. If no more answers exist, the Solver displays the first answer or attempt.

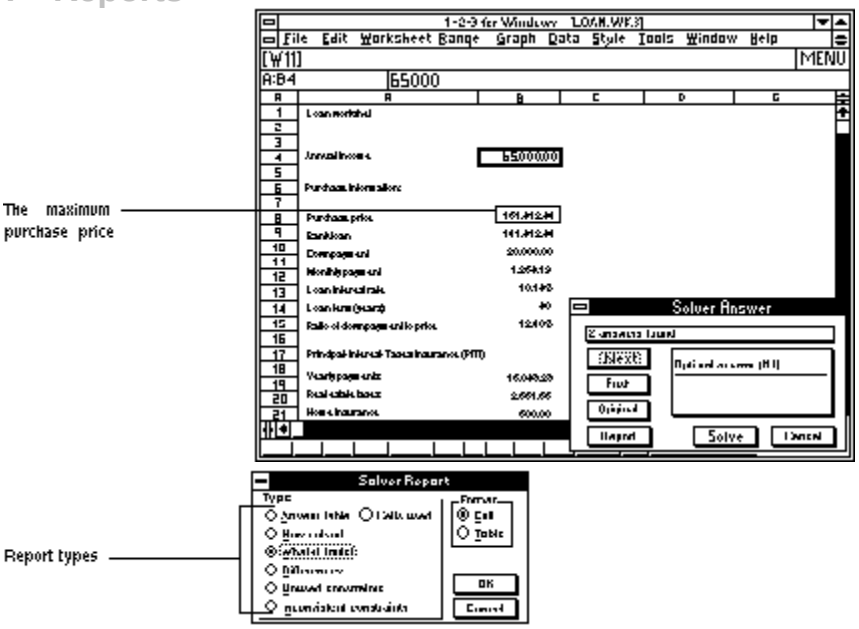
Original -- Restores the worksheet values that were displayed before you last solved the problem.

Report -- Displays a dialog box, from which you specify the type of report you want. See **Chapter 7** for more information.

Solve -- Continues solving the problem, looking for more answers. The Solver looks for the number of answers you specified with the Solver Options dialog box. For more information about the Solver Options dialog box, see **Chapter 5.** The Solve command button changes to the Guess command button when an attempt that requires guesses is displayed.

> **Note** If you close the Solver Answer and Definition dialog boxes to return to the worksheet while an answer or attempt is displayed, and subsequently change the worksheet, the Solver discards all other answers or attempts.

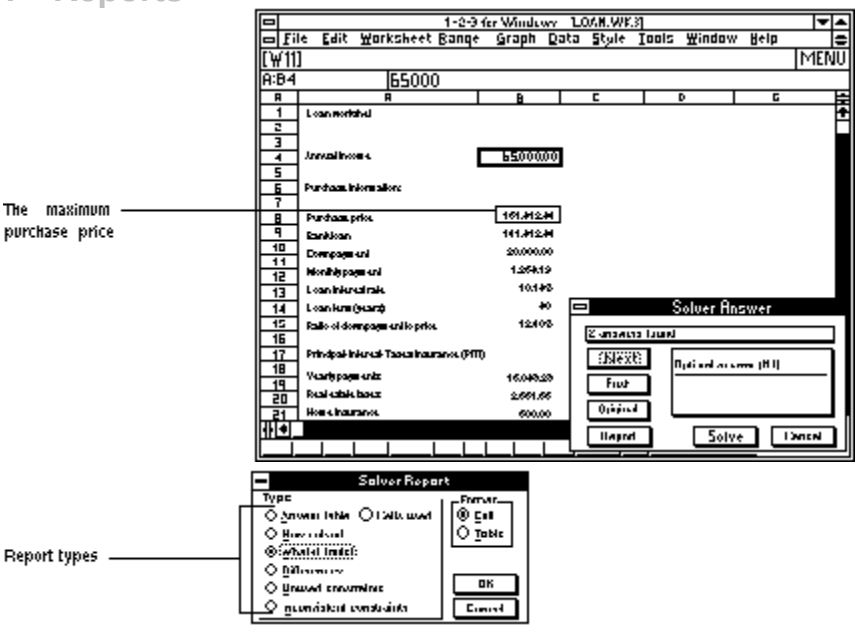
7 Reports



Solver reports provide information about answers or attempts the Solver finds. The Solver Report dialog box offers seven types of reports. You can choose to see a report in table format or cell format. The report format you choose depends on the level of detail you need for a specific answer.

Note The *Solver Guide* may illustrate Solver Table Reports differently than they appear on your screen. For example, borders around and within sections of data were added in our illustrations to improve readability, and in cases where the Solver reports a value that is too long for the default column width, the columns are illustrated wide enough to display the long value.

7 Reports



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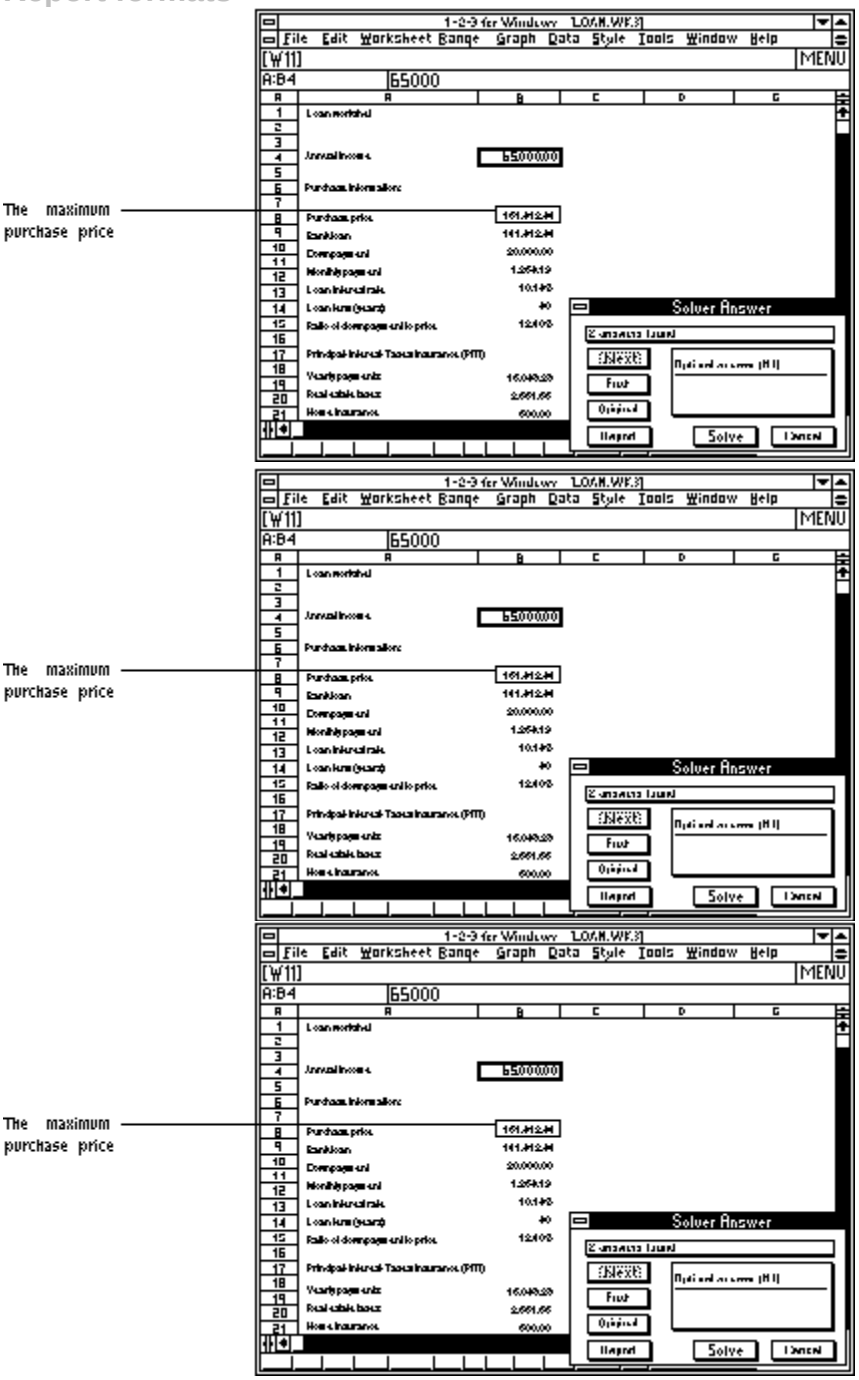
Report formats



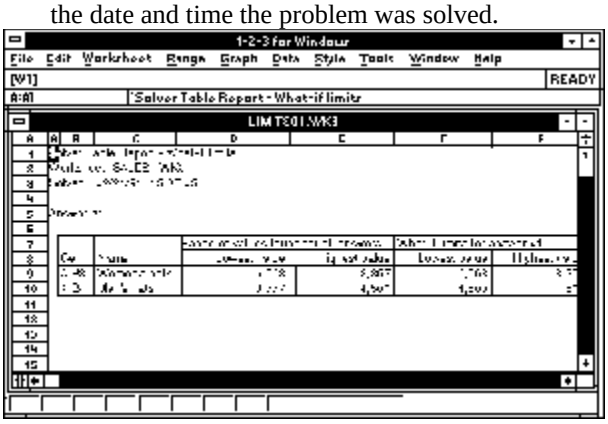
The Solver has the following report formats:

- **Cell format** displays report information in a Solver Cell Report dialog box. A Solver Cell Report dialog box lets you scroll through information about the cells in a Solver problem. You select Next to display information about the next cell.

- **Table format** displays report information in a Solver Table Report, which appears in a new worksheet file that the Solver creates. The Solver creates a default file name for the new worksheet file that is similar to the report name. You can rename the file by saving it with a different file name.

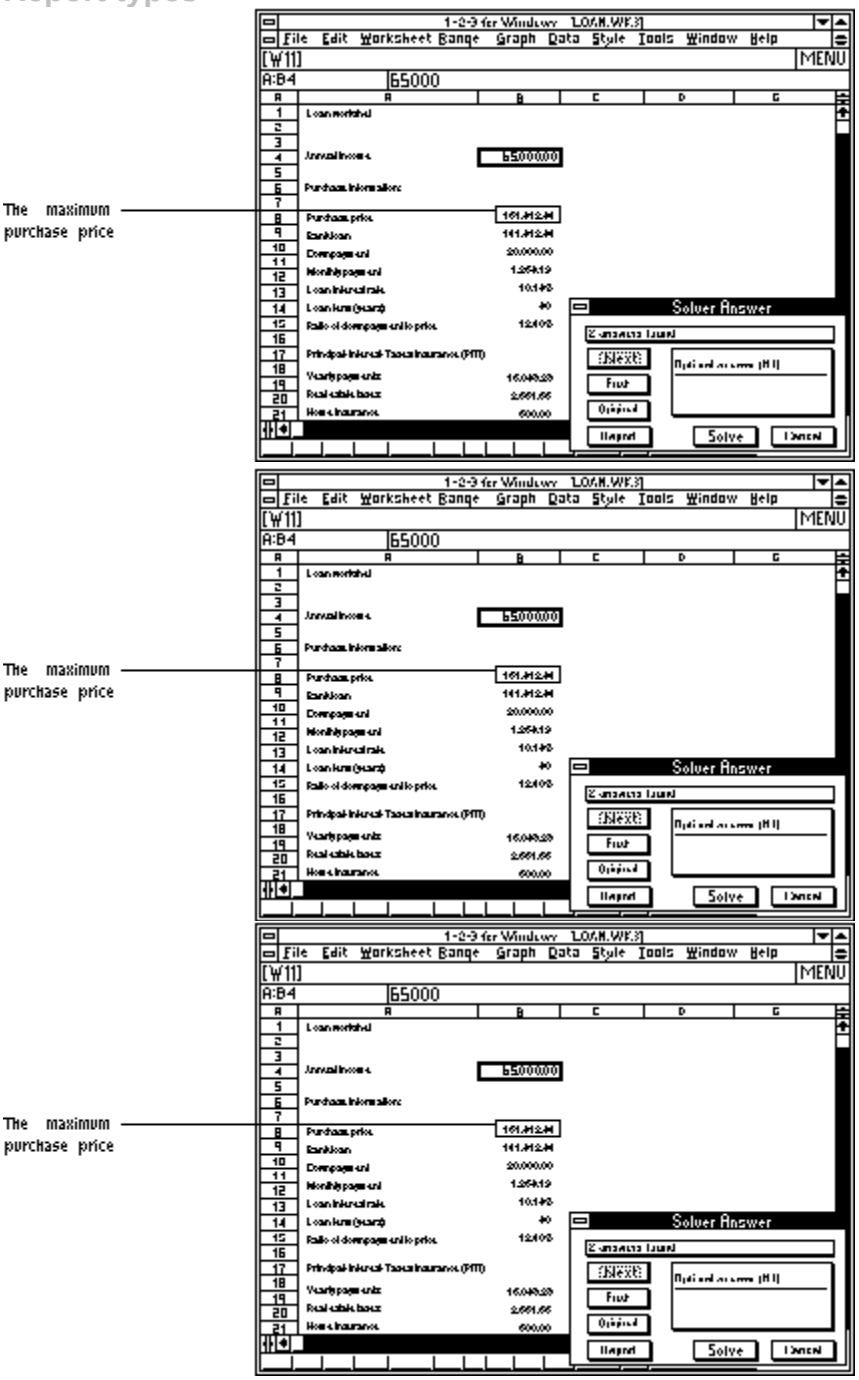
  A worksheet file containing a Solver Table Report is like any other 1-2-3 for Windows worksheet file: You can print, graph, or edit the data it contains, and you can save the file for later use.

  Each Solver Table Report lists the type of report, the name of the worksheet file that contains the problem, and the date and time the problem was solved.



All reports list both cell addresses and range names for the cells the Solver used in the problem. If you did not name a cell, the Solver combines the first label it finds above the cell and the first label it finds to the left of the cell to create a name.

Report types



The Solver Report dialog box offers the following types of reports:

- Answer table
- Cells used
- Differences
- How solved

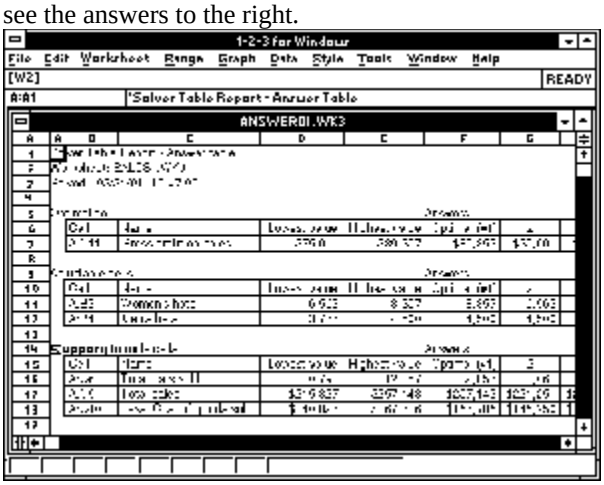
- Inconsistent constraints
- Unused constraints
- What-if limits

The Answer table and How solved reports are available in table format only. All other report types are available in both table and cell formats.

Answer table

The Answer table report shows all answers for the problem. If the Solver does not find answers, the report shows all attempts. The Solver creates a worksheet file in which to display the answers.

When an optimal answer exists, it appears first, followed by all other answers. You can use the mouse or press → to see the answers to the right.



The Solver Table Report (for Answer table) has the following sections:

- **Optimal cell** reports the range of values for the optimal cell in all answers, followed by the value of the optimal cell in each answer. If the problem has no optimal cell, the report does not display an optimal cell section.
- **Adjustable cells** reports the range of values for adjustable cells in all answers, followed by the individual values of adjustable cells in each answer.
- **Supporting formula cells** reports the values of all other cells the Solver used to solve the problem, except for constraint cells. The range of values for these cells for all answers appears first, followed by the values of the cells in each answer.

In each of the sections above, the Solver Table Report lists the cells and their names.

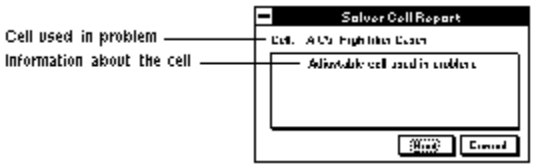
- **Cell** shows the address of the cell whose values appear to the right.
- **Name** shows the range name of the cell, if available, or identifies column and row labels closest to the cell. The report displays range names in uppercase letters and displays column and row labels as they appear in the worksheet.

Cells used

The Cells used report shows the adjustable, constraint, and optimal cells the Solver used to solve the problem. The Cells used report is available when the Solver finds answers or attempts.

Cell format

The Solver Cell Report dialog box (for Cells used) displays information about cells that the Solver used to solve the problem.



The Solver Cell Report dialog box displays the following information:

- **Cell** shows the address and name of a cell that the Solver used to solve the problem. If the cell has no name, the Solver uses the row and column labels closest to the cell.

The information box below the cell address contains information about the cell.

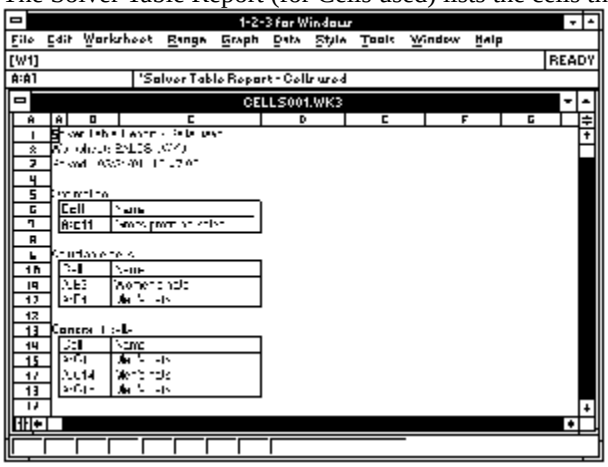
The Solver Cell Report dialog box has the following command buttons:

Cancel -- Closes the Solver Cell Report dialog box and returns you to the Solver Report dialog box.

Next -- Displays information about the next selected cell.

Table format

The Solver Table Report (for Cells used) lists the cells the Solver used to solve the problem.



The Solver Table Report has the following sections:

- **Optimal cell** reports the cell address and name of the optimal cell. If the problem has no optimal cell, the report does not include an optimal cell section.
- **Adjustable cells** shows the cell address and name of each adjustable cell the Solver used to solve the problem.
- **Constraint cells** shows the cell address and name of each constraint cell the Solver used to solve the problem.

In each of the sections, the Solver Table Report lists the cells and their names.

- **Cell** shows the address of the cell whose name appears to the right.
- **Name** shows the range name of the cell, if available, or identifies column and row labels closest to the cell. The report displays range names in uppercase letters and displays column and row labels as they appear in the worksheet.

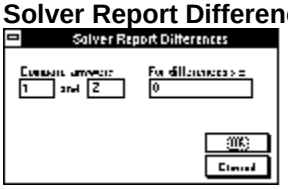
Differences

The Differences report compares two answers (or two attempts) and reports on the cells whose values differ by at least the amount you specify.

Before creating the Differences report, the Solver displays the Solver Report Differences dialog box. You specify the numbers for the answers or attempts you want the Solver to compare and an amount for the comparison.

> **Tip** Create an Answer table report to list the numbers the Solver assigned to the answers or attempts you want to compare. For information on how to create an Answer table report, see **"Answer table"** earlier in this chapter.

Solver Report Differences dialog box



The Solver Report Differences dialog box contains the following text boxes:

Compare answers -- Specifies the numbers of the two answers or the two attempts you want to compare. When the Solver Report Differences dialog box appears, the first text box, under Compare answers, displays 1 (the optimal answer, if you requested it). The second text box, under Compare answers, displays the number of the answer or attempt that is currently in the worksheet. (If the first or optimal answer is displayed in the worksheet, the second text box, under Compare answers, displays 2 as the default.)

For differences >= -- Specifies a number to use for the comparison. For example, enter 25 to compare answers that differ by at least $25.

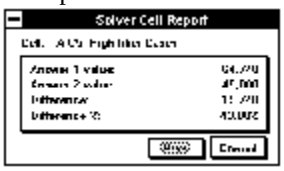
The Solver Report Differences dialog box contains the following command buttons:

Cancel -- Closes the Solver Report Differences dialog box and returns you to the Solver Report dialog box.

OK -- Accepts the numbers you specified, closes the Solver Report Differences dialog box, and displays the Differences report in the format you specified.

Cell format

The Solver Cell Report dialog box (for Differences) shows the amount and percentage by which two answers or attempts differ.



The Solver Cell Report dialog box displays the following information:

- **Cell** shows the address and name of the cell whose values appear in the dialog box. If the cell has no name, the Solver uses the row and column labels closest to the cell.
- **Answer # value** reports the cell's values for the answers or attempts being compared.
- **Difference** reports the amount by which the values for the two answers or attempts differ.
- **Difference %** reports the percentage by which the values for the two answers or attempts differ.

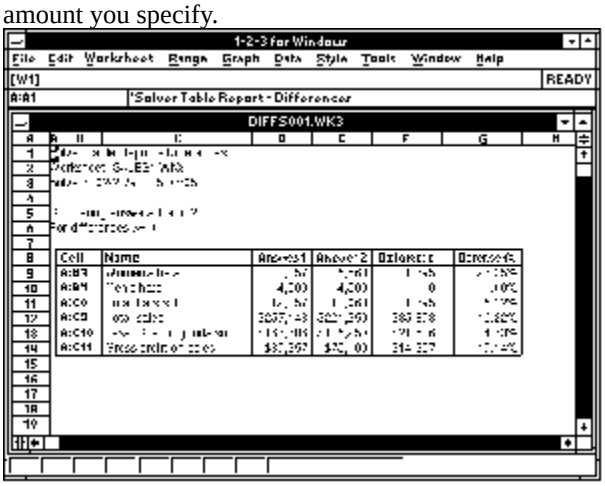
The Solver Cell Report dialog box has the following command buttons:

Cancel -- Closes the Solver Cell Report dialog box and returns you to the Solver Report dialog box.

Next -- Displays information about the next selected cell.

Table format

The Solver Table Report (for Differences) lists the cells for two answers or attempts whose values differ by the amount you specify.



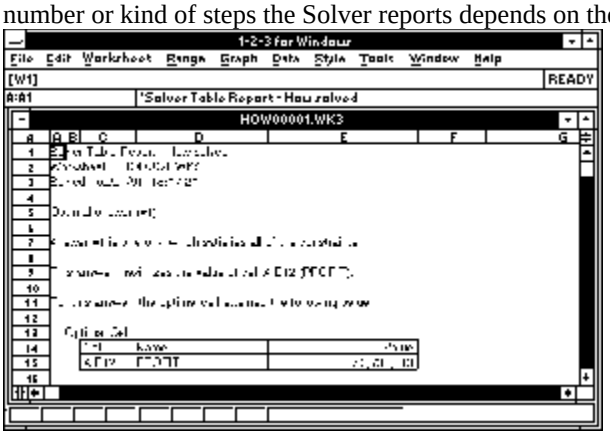
The Solver Table Report displays the following information:

- **Cell** shows the address of the cell whose values appear to the right.
- **Name** shows the range name of the cell, if available, or identifies column and row labels closest to the cell. The report displays range names in uppercase letters and displays column and row labels as they appear in the worksheet.
- **Answer #** reports the cell's value for the answer or attempt.
- **Difference** reports the amount by which the values for this cell differ in the two answers or attempts.
- **Difference %** reports the percentage by which the values for this cell differ in the two answers or attempts.

How solved

The How solved report shows how the Solver found the answer or attempt currently displayed in the worksheet.

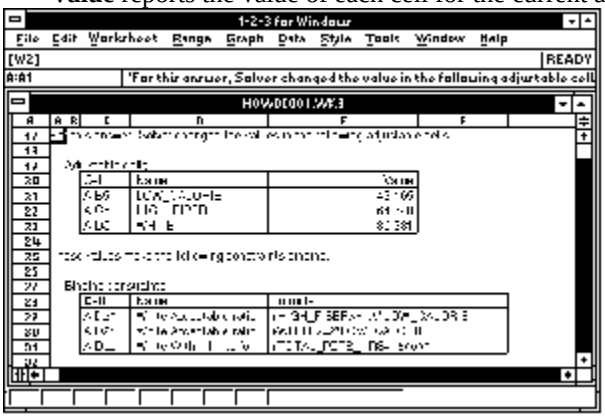
The Solver lists the steps in a Solver Table Report. (The How solved report is not available in cell format.) The number or kind of steps the Solver reports depends on the complexity of the problem.



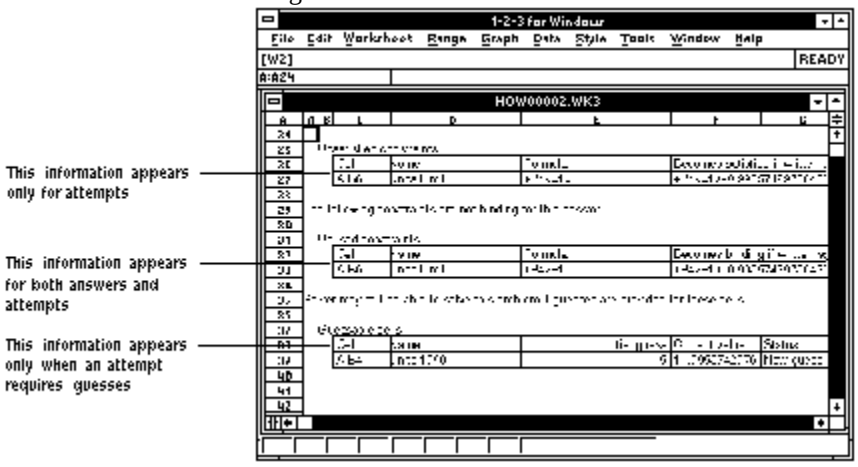
The Solver Table Report (for How solved) displays the following information:

- **Optimal cell** reports the cell address, name, and value for the cell you specified as the optimal cell. (Appears only if you specified an optimal cell.)

- **Cell** shows the address of the cell whose values appear to the right.
- **Name** shows the range name of the cell, if available, or identifies column and row labels closest to the cell. The report displays range names in uppercase letters and displays column and row labels as they appear in the worksheet.
- **Value** reports the value of each cell for the current answer or attempt.



- **Adjustable cells** reports all adjustable cells and their values for the current answer or attempt.
- **Binding constraints** reports the constraints that are binding for the current answer or attempt. A **binding constraint** is a constraint formula that is satisfied at its most limiting condition for the current answer. For example, if a problem contains the constraint formula +B4>=5 and an answer contains the value 5 in cell B4, that constraint formula is binding for the answer.
- **Formula** shows the logical formula for each constraint cell.



- **Unsatisfied constraints** appears only when the Solver has found attempts instead of answers, and reports cells containing constraints that were not satisfied by the current attempt.
- **Becomes satisfied if written as** appears only when the Solver has found attempts instead of answers, and shows you how you could change the logical formula in the constraint cell to make it result in 1 (true).
- **Unused constraints** reports constraint cells the Solver did not use to find the current answer or attempt.
- **Becomes binding if written as** shows how you can change the logical formula to make it binding for the current answer or attempt.
- **Guessable cells** appears only when an attempt requires guesses, and reports adjustable cells that require guess

values. For each cell that requires a guess, shows the cell's initial value, current value, and guess status.

- **Initial guess** appears only when an attempt requires guesses, and specifies the value of the adjustable cell before the Solver attempted to solve the problem.
- **Current value** appears only when an attempt requires guesses, and shows the current value of an adjustable cell.
- **Status** appears only when an attempt requires guesses, and shows the current status of an adjustable cell for which you can provide guess values.

Inconsistent constraints

The Inconsistent constraints report shows the constraint cells that return 0 (false) for the current attempt. The Inconsistent constraints report is available only when you display an attempt in the worksheet. For each inconsistent constraint, the Solver also reports a revised logical formula that would return 1 (true).

Cell format

The Solver Cell Report dialog box (for Inconsistent constraints) displays information on the cells containing formulas that return 0 (false). The dialog box shows you how you can change the logical formula in the constraint cell so it returns 1 (true).

The Solver Cell Report dialog box displays the following information:

- **Cell** shows the address and name of the cell whose formulas appear below. If the cell has no name, the Solver uses the row and column labels closest to the cell.
- **This constraint was not satisfied** shows the constraint formula that returned 0 (false) for the current attempt.
- **Becomes satisfied if written as** shows you how you can change the constraint formula so it returns 1 (true).

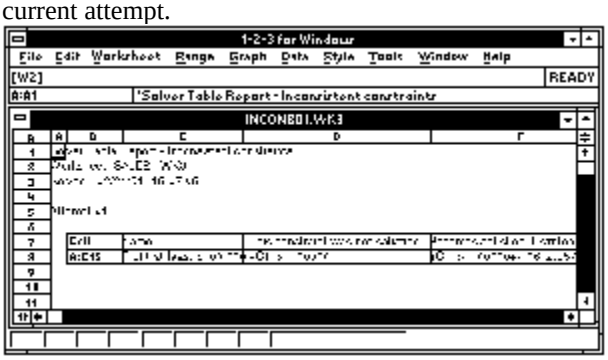
The Solver Cell Report dialog box has the following command buttons:

Cancel -- Closes the Solver Cell Report dialog box and returns you to the Solver Report dialog box.

Next -- Displays information about the next selected cell.

Table format

The Solver Table Report (for Inconsistent constraints) lists all constraint cells whose formulas return 0 (false) for the current attempt.



The Solver Table Report displays the following information:

- **Cell** shows the address of the cell whose formulas appear to the right.
- **Name** shows the range name of the cell, if available, or identifies column and row labels closest to the cell. The report displays range names in uppercase letters and displays column and row labels as they appear in the worksheet.
- **This constraint was not satisfied** shows the constraint cell's formula that returned 0 (false) for the current attempt.
- **Becomes satisfied if written as** shows how you could change the constraint formula so it returns 1 (true).

Unused constraints

The Unused constraints report shows the constraint cells that the Solver did not need to find the current answer or attempt.

Unused constraints are constraint cells containing formulas that the Solver did not require to find the answer. For example, if the problem contains the two constraints +B1>=10 and +B1>=12, the Solver uses only the second constraint to find each answer.

For each unused constraint, the Solver reports how you need to change the logical formula so the constraint will become binding. The change the Solver proposes is an approximation of what will make the constraint binding and return a result of 1 (true).

The Unused constraints report is available only when an answer or attempt is in the worksheet.

Cell format

The Solver Cell Report dialog box (for Unused constraints) shows information about the cells containing constraints that the Solver did not need to find the answer or attempt.

The Solver Cell Report dialog box displays the following information:

- **Cell** shows the address and name of the cell that contains the unused constraint. If the cell has no name, the Solver uses the row and column labels closest to the cell.
- **This constraint was not used** shows the logical formula in the current constraint cell.
- **Becomes binding if written as** shows how you can change the logical formula so it becomes binding for the answer or attempt.

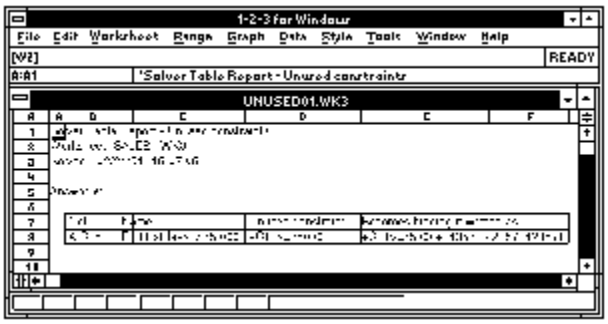
The Solver Cell Report dialog box has the following command buttons:

Cancel -- Closes the Solver Cell Report dialog box and returns you to the Solver Report dialog box.

Next -- Displays information about the next selected cell.

Table format

The Solver Table Report (for Unused constraints) lists the cells containing constraints that the Solver did not need to find the answer or attempt.



The Solver Table Report displays the following information:

- **Cell** shows the address of the cell that contains the unused constraint.
- **Name** shows the range name of the cell, if available, or identifies column and row labels closest to the cell. The report displays range names in uppercase letters and displays column and row labels as they appear in the worksheet.
- **Unused constraint** shows the logical formula the current constraint cell contains.
- **Becomes binding if written as** shows how you can change the logical formula so it becomes binding for the answer.

What-if limits

The What-if limits report shows the range of values you can use in one adjustable cell and still have all constraints for the current answer return 1 (true), assuming no other adjustable cell values are changed.

The What-if limits report is available only when you display an answer in the worksheet.

> **Note** In some cases, the range of values for adjustable cells that the Solver reports is an approximation and not the absolute lowest and highest values.

Cell format

The Solver Cell Report dialog box (for What-if limits) displays information about adjustable cells the Solver used. The Solver Cell Report dialog box shows the highest and lowest values for all the answers the Solver found. It also shows how much the value in each adjustable cell can change for the current answer and still allow all the constraint formulas to return 1 (true).

The Solver Cell Report dialog box displays the following information:

- **Cell** shows the address and name of the cell whose values appear below. If the cell has no name, the Solver uses the row and column labels closest to the cell.
- **Lowest and highest values found** shows the range of values for this adjustable cell for all of the answers the Solver found.
- **What-if limits for answer #** shows, for the current answer, the estimated range of values within which you can adjust the value in the cell and have all constraint formulas return 1 (true), provided you change no other adjustable cells.

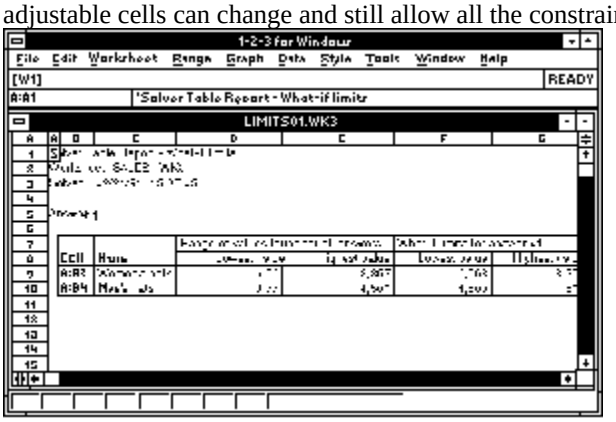
The Solver Cell Report dialog box has the following command buttons:

Cancel -- Closes the Solver Cell Report dialog box and returns you to the Solver Report dialog box.

Next -- Displays information about the next selected cell.

Table format

The Solver Table Report (for What-if limits) displays information about adjustable cells for the problem. The report shows the highest and lowest values for all the answers the Solver found. It also shows how much the values in the adjustable cells can change and still allow all the constraint formulas to return 1 (true).



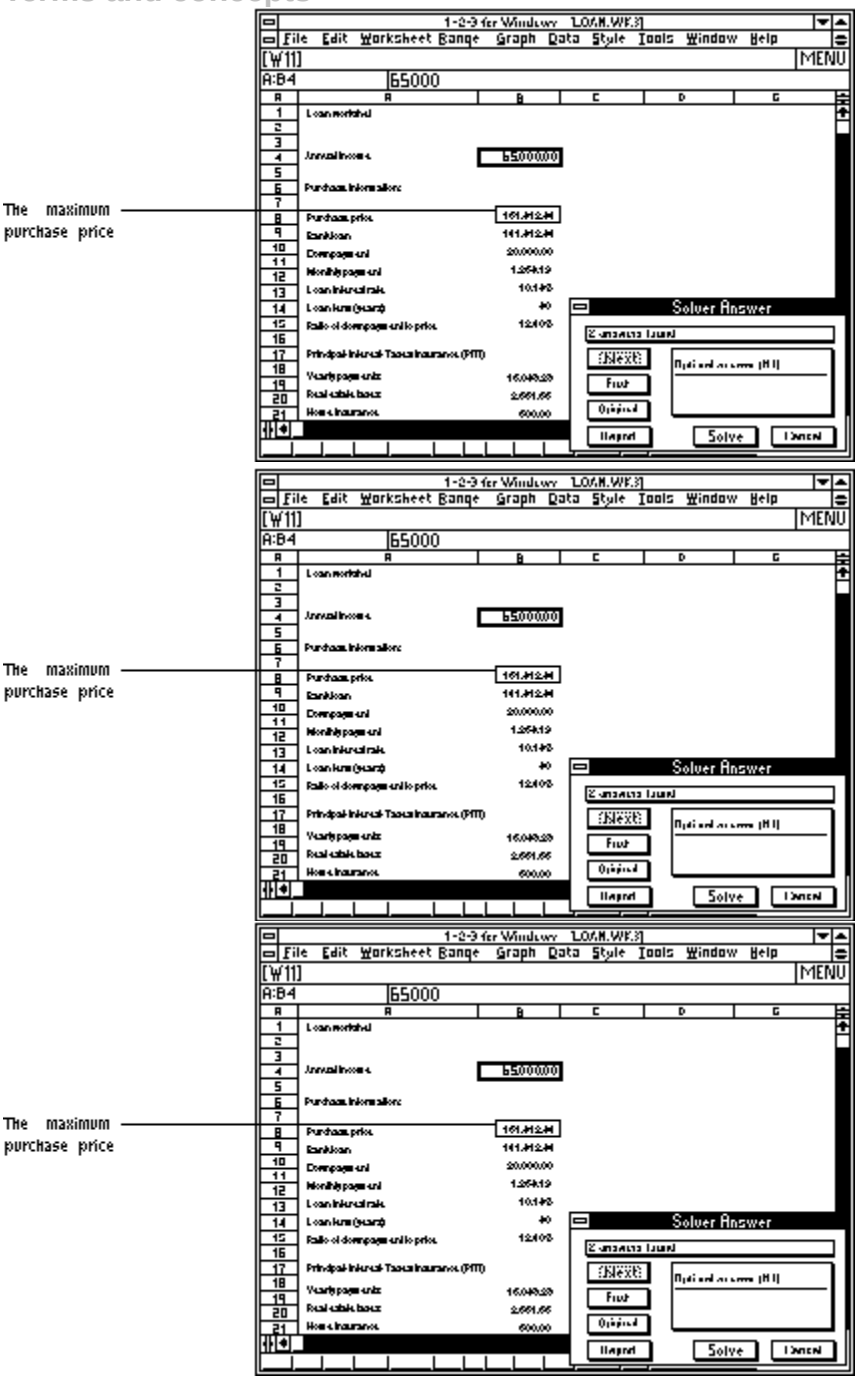
The Solver Table Report displays the following information:

- **Cell** shows the address of the cell whose values appear to the right.
- **Name** shows the range name of the cell, if available, or identifies column and row labels closest to the cell. The report displays range names in uppercase letters and displays column and row labels as they appear in the worksheet.
- **Range of values found for all answers** shows the highest and lowest values the Solver finds for this adjustable cell for all answers.
- **What-if limits for answer #** shows, for the current answer, the estimated range of values within which you can adjust the value in the cell and have all constraint formulas return 1 (true), provided you change no other adjustable cells.

8 Using @Functions in Problems

This chapter explains the use of @functions in Solver problems and how the Solver processes @functions.

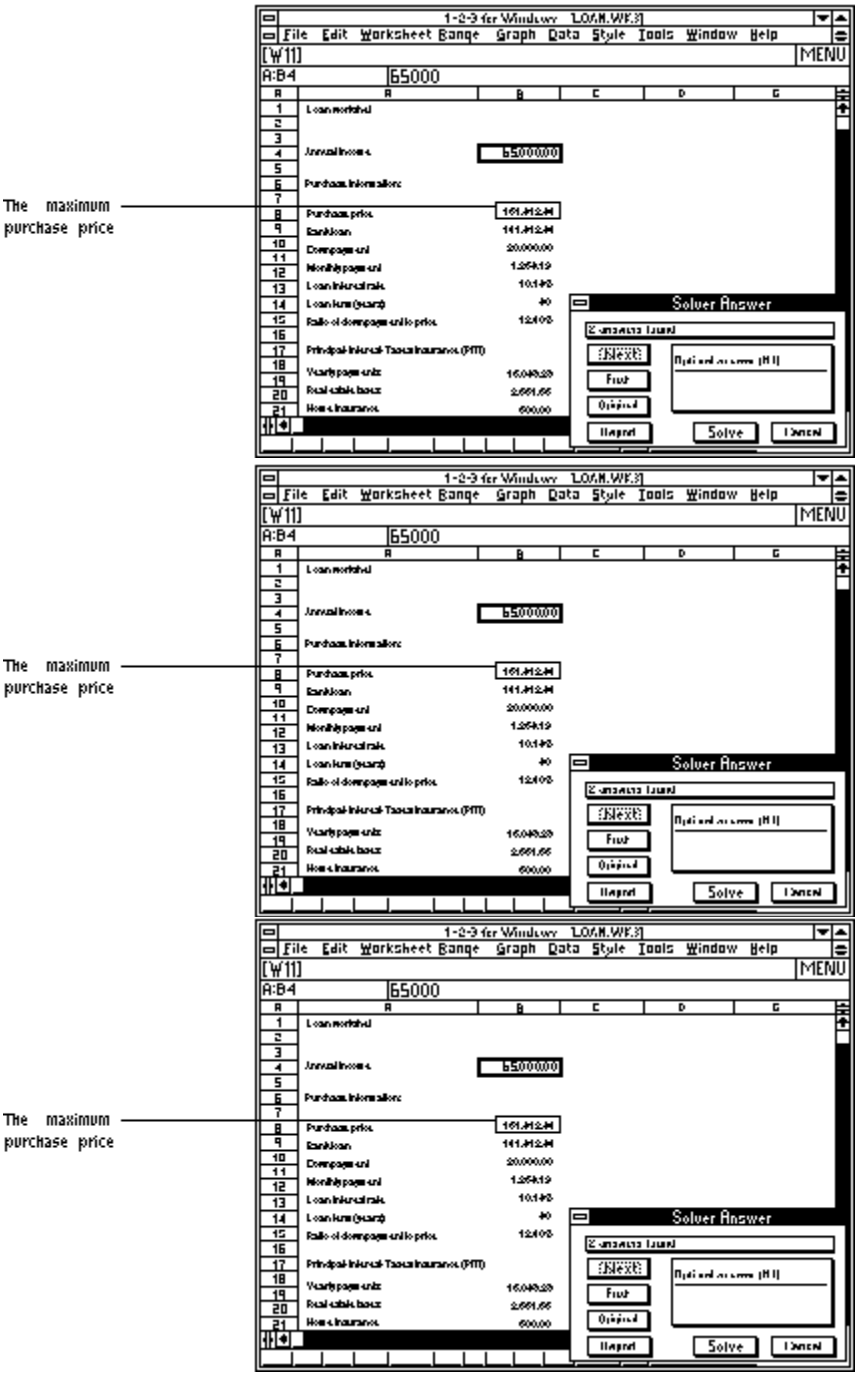
Terms and concepts



The Solver solves a problem using information in the adjustable cells, constraint cells, the optimal cell (if any), and any other cells containing values or formulas that affect the result of one or more constraint cells or the optimal cell. Collectively, these cells are called **problem cells**.

You can create a Cells used report to see the adjustable cells, the constraint cells, and the optimal cell (if any), or create an Answer table report to see all the problem cells, except the constraint cells. These are the cells from one or more worksheet files that comprise a Solver problem.

Problems the Solver cannot solve



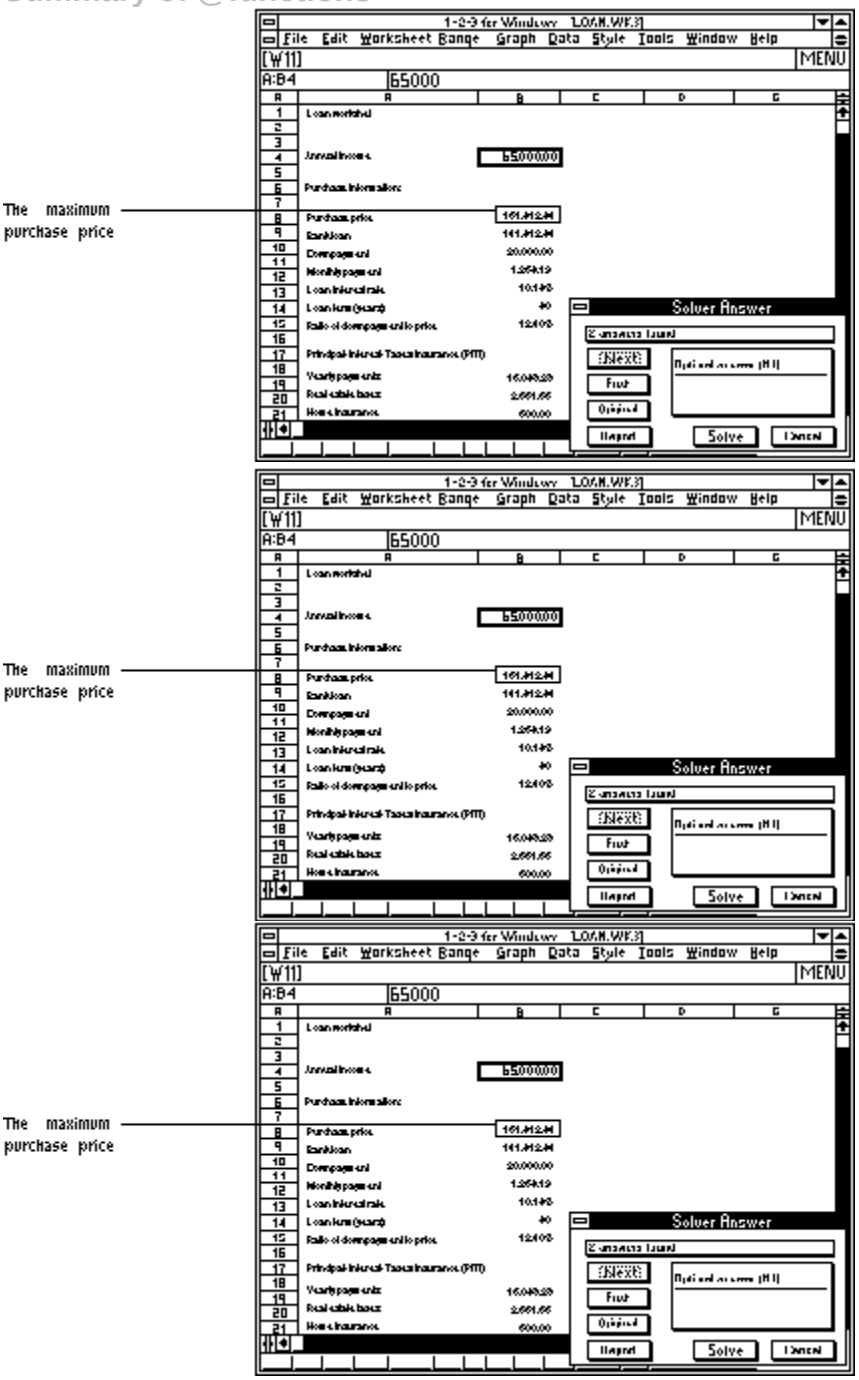
The Solver cannot solve a problem that contains @functions if a formula in a problem cell contains an @function that is not in the **"Summary of @functions" table.** When you try to solve such a problem, the Solver analyzes the problem and then displays a message informing you that the Solver cannot solve the problem because the function is not supported or contains a string argument.

In general, these unsupported @functions include string @functions, date and time @functions, database @functions, @functions with string arguments, and some of the special @functions.

For more information about using @functions in Solver problems, see **Chapter 9.**

If you are not sure whether a problem uses @functions the Solver can solve, try solving the problem. If the Solver detects an @function that will keep the problem from being solved, it displays a message informing you of the cell that contains the @function.

Summary of @functions



The following table shows @functions you can use in any Solver problem.

Help Press F1(HELP) and choose **@Function Index** for detailed information about @functions.

@Function	Task
@ABS	Calculates the absolute (positive) value of a value.

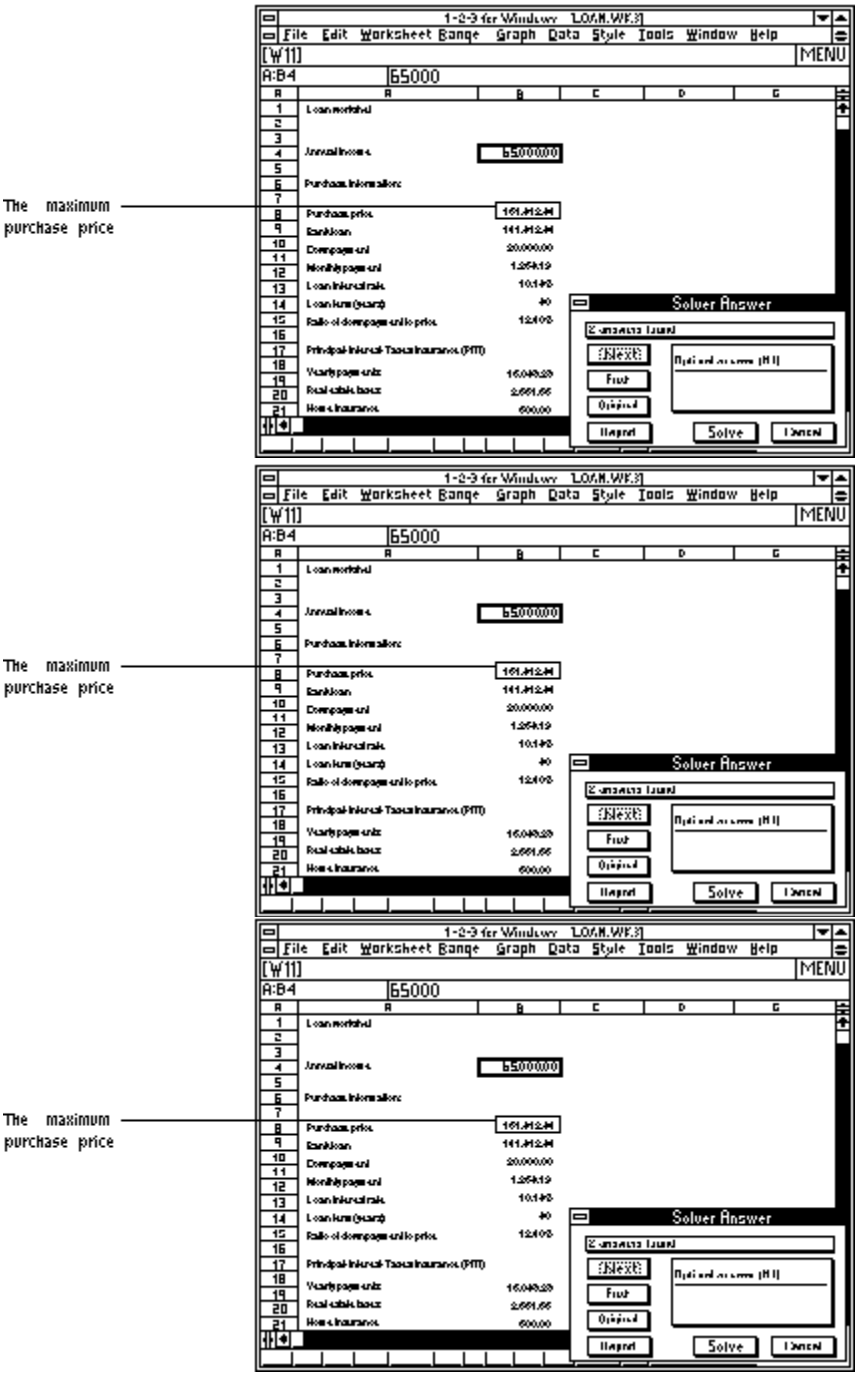
@ACOS	Calculates the arc cosine of a value.
@ASIN	Calculates the arc sine of a value.
@ATAN	Calculates the arc tangent of a value.
@ATAN2	Calculates the four-quadrant arc tangent of two values.
@AVG	Averages a list of values.
@CHOOSE	Finds a specified value or string in a list of values and/or strings -- valid for values only.
@COLS	Counts the columns in a range.
@COS	Calculates the cosine of an angle.
@COUNT	Counts the nonblank cells in a list of ranges.
@CTERM	Calculates the number of compounding periods necessary for an investment to grow to a future value.
@DDB	Calculates the double-declining balance depreciation allowance of an asset.
@EXP	Calculates the value *e* raised to a specified power.
@FALSE	Returns the logical value 0 (false).
@FV	Calculates the future value of a series of equal payments.
@HLOOKUP	Finds the contents of a cell in a specified row in a horizontal lookup table -- valid for values only.
@IF	Takes one action if a condition is true; another if the condition is false -- valid for values only. For example, @IF(SALES>COSTS,SALES-COSTS,0) returns the result of SALES minus COSTS if sales are greater than costs, or 0 if sales are less than or equal to costs.
@INDEX	Finds the contents of the cell in a specified row, column, and worksheet in a range.
@INT	Returns the integer portion of a value.
@IRR	Calculates the internal rate of return for a series of cashflows.
@ISNUMBER	Returns 1 (true) for a value or a blank cell; 0 (false) for a string.
@LN	Calculates the natural logarithm (base *e*) of a value.
@LOG	Calculates the common logarithm (base 10) of a value.
@MAX	Finds the maximum value in a list of values.
@MIN	Finds the minimum value in a list of values.
@MOD	Calculates the remainder (modulus) of two values.
@NPV	Calculates the net present value of a series of cashflows.
@PI	Returns the value (calculated at 3.14159265358979324).
@PMT	Calculates the amount of the periodic payment needed to pay off a loan.
@PV	Calculates the present value of a series of equal payments.

@RATE	Calculates the periodic interest rate necessary for an investment to grow to a future value.
@ROUND	Rounds a value to a specified number of decimal places.
@ROWS	Counts the rows in a range.
@SHEETS	Counts the worksheets in a range.
@SIN	Calculates the sine of an angle.
@SLN	Calculates the straight-line depreciation allowance of an asset for one period.
@SQRT	Calculates the positive square root of a value.
@STD	Calculates the population standard deviation of a list of values.
@STDS	Calculates the sample standard deviation of a list of values.
@SUM	Sums a list of values.
@SUMPRODUCT	Sums the products of corresponding elements in multiple ranges.
@SYD	Calculates the sum-of-the-years'-digits depreciation allowance of an asset.
@TAN	Calculates the tangent of an angle.
@TERM	Calculates the number of payment periods of an investment.
@TRUE	Returns the logical value 1 (true).
@VAR	Calculates the population variance of a list of values.
@VARS	Calculates the sample variance of a list of values.
@VDB	Calculates depreciation using the double-declining balance method and allows the percentage of straight-line depreciation to be values other than 200%.
@VLOOKUP	Finds the contents of a cell in a specified column in a vertical lookup table -- valid for values only.

9 Solver Questions and Answers

This chapter answers some frequently asked questions about the Solver.

How the Solver works



How is the Solver different from a linear programming package?

There are two differences. First, the Solver can solve non-linear as well as linear problems. A linear programming package can solve only linear problems. Second, the Solver can provide several answers to a problem, including the optimal answer. A linear programming package provides only the optimal answer.

The Solver determines whether the problem you define is linear or non-linear and solves it accordingly.

What is a non-linear problem?

Non-linear problems include most models you create in a 1-2-3 for Windows worksheet. A problem is non-linear if it has equations that are calculated (directly or indirectly) using any of the following:

- Multiplication of two adjustable cells
- Division, where the divisor depends upon the value of an adjustable cell
- Exponentiation
- Square and other roots
- Most @functions

The Solver can solve a non-linear problem that uses these calculations to determine the value of one or more constraint cells or the optimal cell.

What is an example of a problem that the Solver cannot solve?

The Solver cannot solve large problems that require more memory than your personal computer can provide. For example, if a problem requires the Solver to use 3,000 formulas to find answers, and contains 50 adjustable cells and 100 constraint cells, the combined total of 3,150 cells would cause most personal computers to be out of memory.

What method does the Solver use to solve problems?

The Solver uses a combination of symbolic (algebraic) and numeric techniques (or "rules") to find answers. First, the Solver tries to solve each problem using symbolic techniques. Then it turns to numeric techniques, such as iteration, when it cannot find an answer using symbolic techniques.

The Solver determines when to apply symbolic or numeric solving techniques to solve a problem. You do not need to be aware of the solving technique that the Solver is using to solve a particular problem.

What is the difference between symbolic and numeric solving techniques?

Symbolic solving techniques use the rules of algebra. For example, suppose A2 contains the formula +A1+5. The Solver and the worksheet know that +A2=A1+5. Unlike the worksheet, however, the Solver also knows that A1=A2-5. The Solver uses hundreds of these rules to solve problems that you cannot solve with normal worksheet recalculation.

Numeric solving techniques are essentially trial and error, based on guessing (or iteration). When it uses numeric solving techniques, the Solver starts by guessing a value for the adjustable cells and then repetitively adjusts these guesses until it finds an answer. The Solver uses numeric techniques only if it cannot solve the problem using symbolic techniques. For example, the formula +A1^9/B1^9+A1^7+5=-25 is too complicated for symbolic techniques, so the Solver would try to solve it using numeric techniques.

What size problem can the Solver solve? What is the maximum number of adjustable cells and constraint cells?

The number of cells you can specify depends on the complexity of the problem and the amount of virtual memory available for your personal computer. Here are some general guidelines:

- The Solver uses the combined total of adjustable cells, constraint cells, the optimal cell, and any other cells it needs to determine values for adjustable cells, constraint cells, and the optimal cell. Try to keep this combined total to fewer than 1,000 cells.
- Increasing the number of adjustable cells typically increases the number of answers the Solver will find and the time required to find all answers.
- Increasing the number of @functions other than @SUM and @AVG increases the chance that the Solver will use numeric instead of symbolic techniques to solve the problem. In general, numeric techniques are significantly slower than symbolic techniques in finding answers. Also, using @functions other than @SUM and @AVG increases the chance that the Solver will need you to supply guess values before it can find an answer.

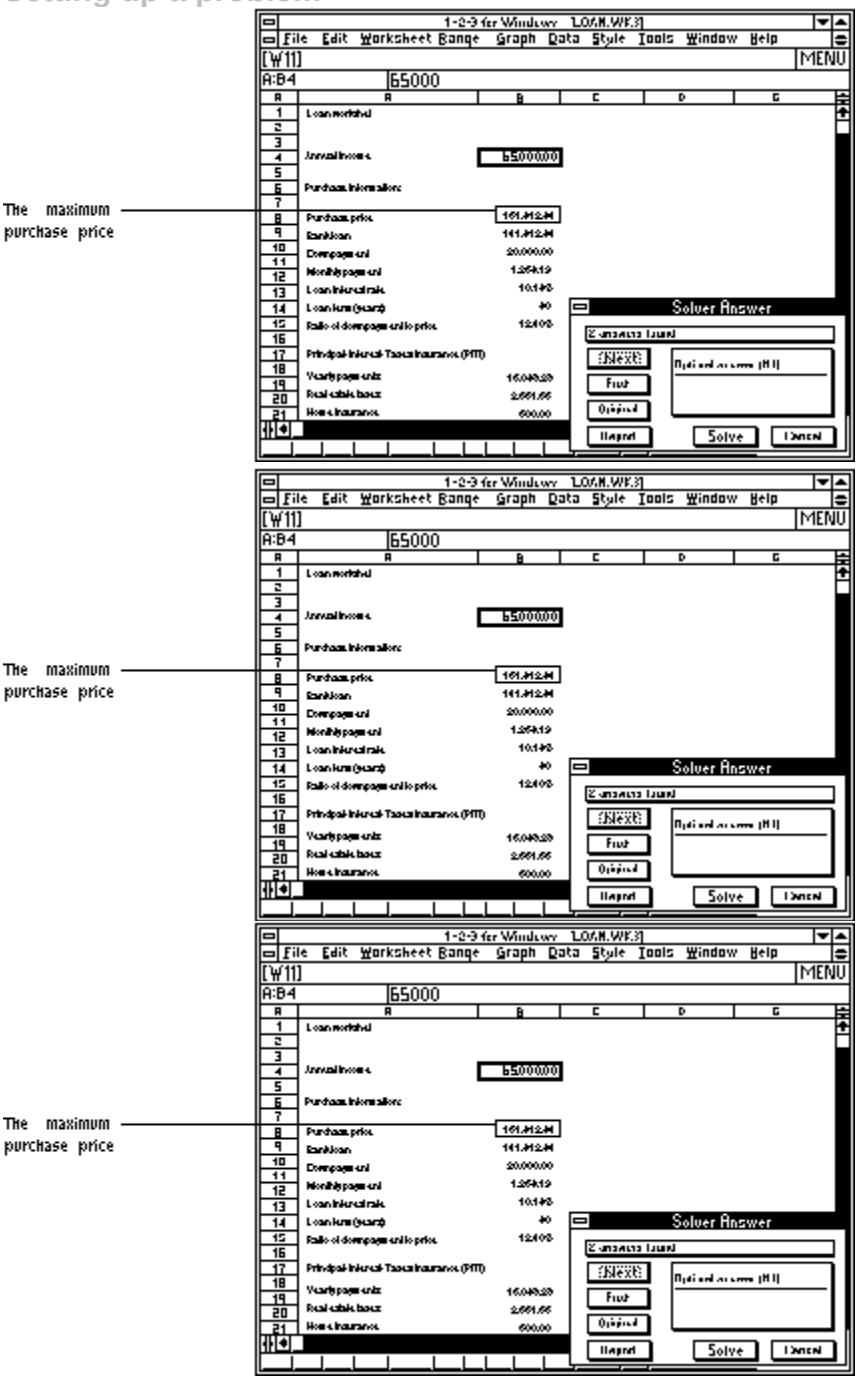
- Increasing the number of adjustable cells and @functions increases the chance that 1-2-3 may not have enough memory to solve the problem.

When I run my Solver problem, 1-2-3 tells me that it is out of memory. Why does this happen?

1-2-3 is out of memory for any of the following reasons:

- While solving your problem, the Solver tries to store all answers in random access memory (RAM). However, when there is not enough memory available to temporarily store all answers in RAM, the Solver stores some answers on disk in temporary files. If there is not enough space on disk for the temporary files to grow, 1-2-3 reports that it is out of memory. To avoid this situation, make sure your disk has enough space available. For more information, see **Appendix C** in the *User's Guide.*
- Before the Solver solves a problem, it scans the number of adjustable cells, constraint cells, and other cells that contain values or formulas to determine the anticipated size and/or complexity of the problem. If the Solver determines that the problem is too large to solve, it displays a message to tell you that not enough memory is available.

Setting up a problem



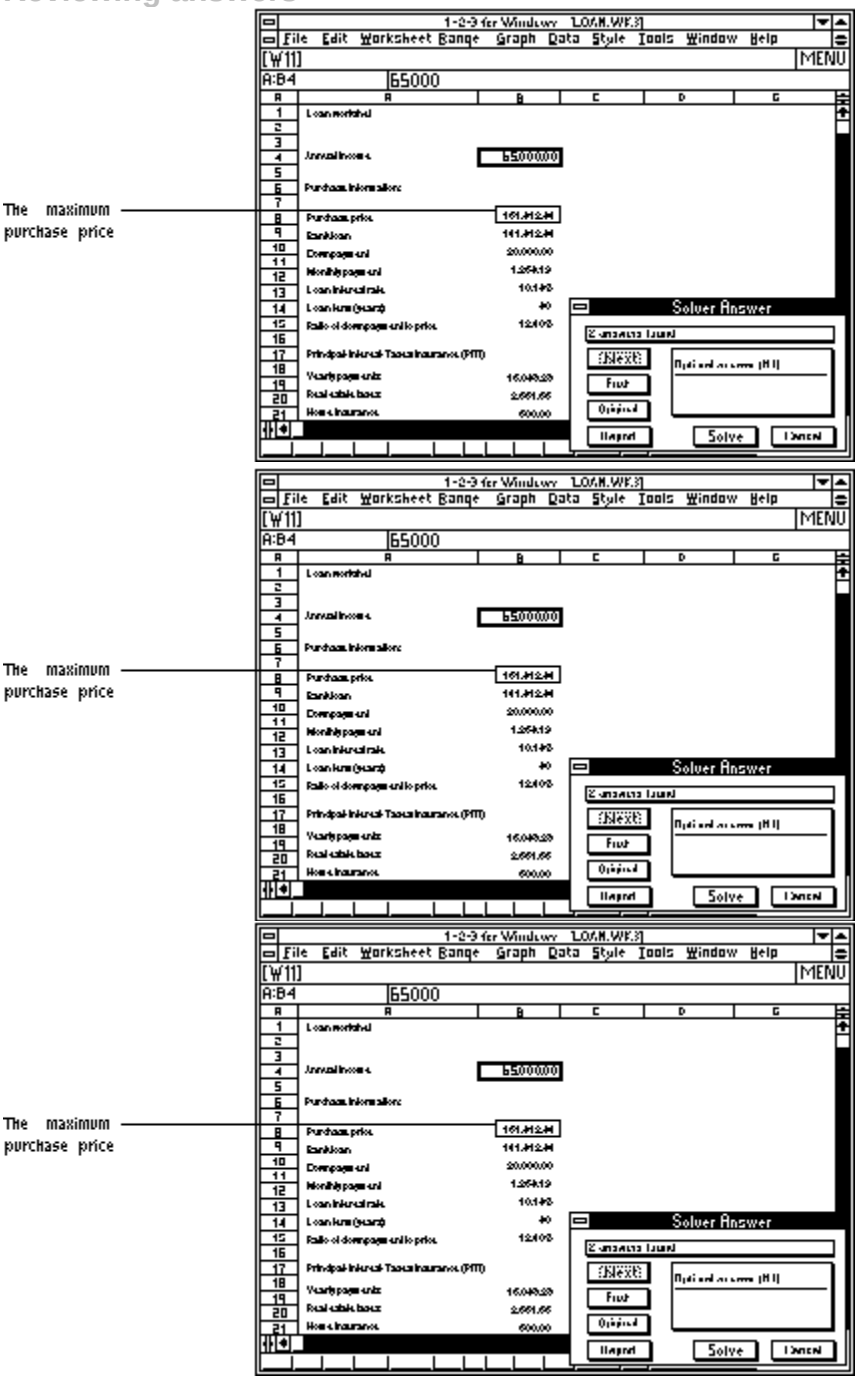
Can constraint cells or any cells I use in a Solver problem be in different worksheets or worksheet files?

Yes. The Solver can use cells in any active worksheet or worksheet file. You can have many active worksheet files in 1-2-3, thus cells in your Solver problem can span more than one active worksheet file. However, if you make changes to any of these worksheet files that cause 1-2-3 to recalculate after the Solver solves the problem, the Solver discards all answers it found.

What are some guidelines for using @functions in my Solver problem?

- Make sure the formulas in your model do not contain @functions that are not supported by the Solver. For more information, see **Chapter 8.**
- Adding and multiplying @functions together, or using large ranges in @HLOOKUP, @VLOOKUP, or statistical @functions, may make a problem difficult to solve.
- Limit the number of @functions (other than @SUM and @AVG) in the Solver problem.
- Limit the use of @CHOOSE, @HLOOKUP, @IF, @INDEX, @INT, @MOD, @ROUND, and @VLOOKUP. Also, do not combine these @functions in a formula. Although the Solver supports these @functions, they can make a problem difficult to solve.
- Limit the use of nested @functions, especially @IF. If the Solver cannot solve a problem that has many nested @functions, rewrite the @functions across several cells.
- Do not make changes that will cause a recalculation in a file containing the following @functions: @@, @CELL, @CELLPOINTER, @INFO, @ISNAME, @ISRANGE, @NOW, @RAND, @TODAY, and any @D function that refers to an external table. Such changes will not only recalculate the file containing the @function, but also every other open file. The Solver will interpret the recalculation as a change to the problem and will discard any answers it may have found.

Reviewing answers



How can I save answers that the Solver finds?

Select First and Next in the Solver Answer dialog box to display the answer you want to save in the worksheet, and then close the Solver Answer and Definition dialog boxes. Make the worksheet you want to save current, and choose File Save or File Save As.

To save a list of all answers, select Answer table in the Solver Report dialog box, and then close the Solver Answer and Definition dialog boxes. Make the worksheet containing the Answer table report current, and choose File Save

or File Save As to save the worksheet.

How do I know that the Solver found a valid answer?

When the Solver displays the Solver Answer dialog box, it places values in the adjustable cells you defined and allows the worksheet to perform its normal calculations. The Solver displays the message Roundoff error in the Solver Answer dialog box if one or more constraint cells return 0 (false) for 5 or fewer decimal places of precision. The Solver displays the message Minor roundoff if one or more constraints returns 0 (false) for between 6 to 16 decimal places of precision.

The Solver sometimes returns negative numbers when I minimize the optimal cell. What can I do to avoid this when answers should not have negative numbers?

If you want the values of your adjustable cells and the optimal cell to always be positive, enter a new constraint (logical formula) for each adjustable cell and the optimal cell to specify that the cells must be greater than or equal to 0. For example, if A1 is an adjustable cell for which you want to see only positive values, include the new constraint cell +A1>=0. Make sure you specify the new constraint cells in the Solver Definition dialog box.

The message Roundoff error appears in the Solver Answer dialog box. How can I change my Solver problem to avoid this?

Roundoff errors occur for any of the following reasons:

- One or more constraint cells return 0 (false) for 5 or fewer decimal places of precision. In most cases, roundoff errors in the fifth decimal place should not affect how you use the answer that the Solver found.
- A mathematically valid Solver answer recalculates to ERR when displayed in the worksheet. For example, the Solver can find both negative and positive values that satisfy odd-numbered roots, but the worksheet only recognizes the positive values and displays ERR when the negative value is displayed in the worksheet.
- Tools User Setup Recalculation is set to either Columnwise or Rowwise. In this case, reset the calculation to Natural and then solve the problem again.

To avoid a roundoff error, revise formulas to limit operations that can cause roundoff errors (such as square and other roots, and exponentiation). Then solve the problem again.

When the message Roundoff error appears in the Solver Answer dialog box, you can select Report, and then select Inconsistent constraints to locate the constraint cells that are affected by roundoff errors.

What is the difference between an attempt and an answer that has roundoff errors?

When an attempt is displayed, the Solver has not found a valid answer and has returned a set of adjustable cell values that caused at least one constraint cell to return 0 (false). When the message Roundoff error appears for an answer, the Solver has found a valid answer, but calculation differences between the Solver and the worksheet caused at least one constraint to display 0 (false) for 5 or fewer decimal places of precision.

How many attempts will the Solver make before it gives up?

The number of attempts the Solver makes to find an answer varies with the number of constraint cells you specify for the problem and whether the problem is set up correctly. The Solver tries many different combinations of values in the adjustable cells to try to make all constraint cells return 1 (true). When these combinations are exhausted, the Solver selects a few representative attempts from the many attempts that it has tried and returns them to you for review.

What type of problem requires guesses and why?

Guesses are needed for some problems in which the Solver resorts to numeric techniques (as opposed to typically used symbolic techniques) to find answers. With numeric techniques, Solver calculations sometimes either move (iterate) away from the correct values for one or more adjustable cells or move toward the correct result. At some point in its search, the Solver may stop solving and request your guess value to help point it in the right direction.

Your guess values give the Solver new starting values with which to continue its iterative search to find values for adjustable cells that can result in an answer.

Why does the Solver automatically find only ten answers? Why doesn't the Solver just find all my answers for me?

Many problems have a large number of answers. In these cases, you probably want to see a representative sample of answers, not all answers. The Solver Options dialog box lets you specify the number of answers you want.

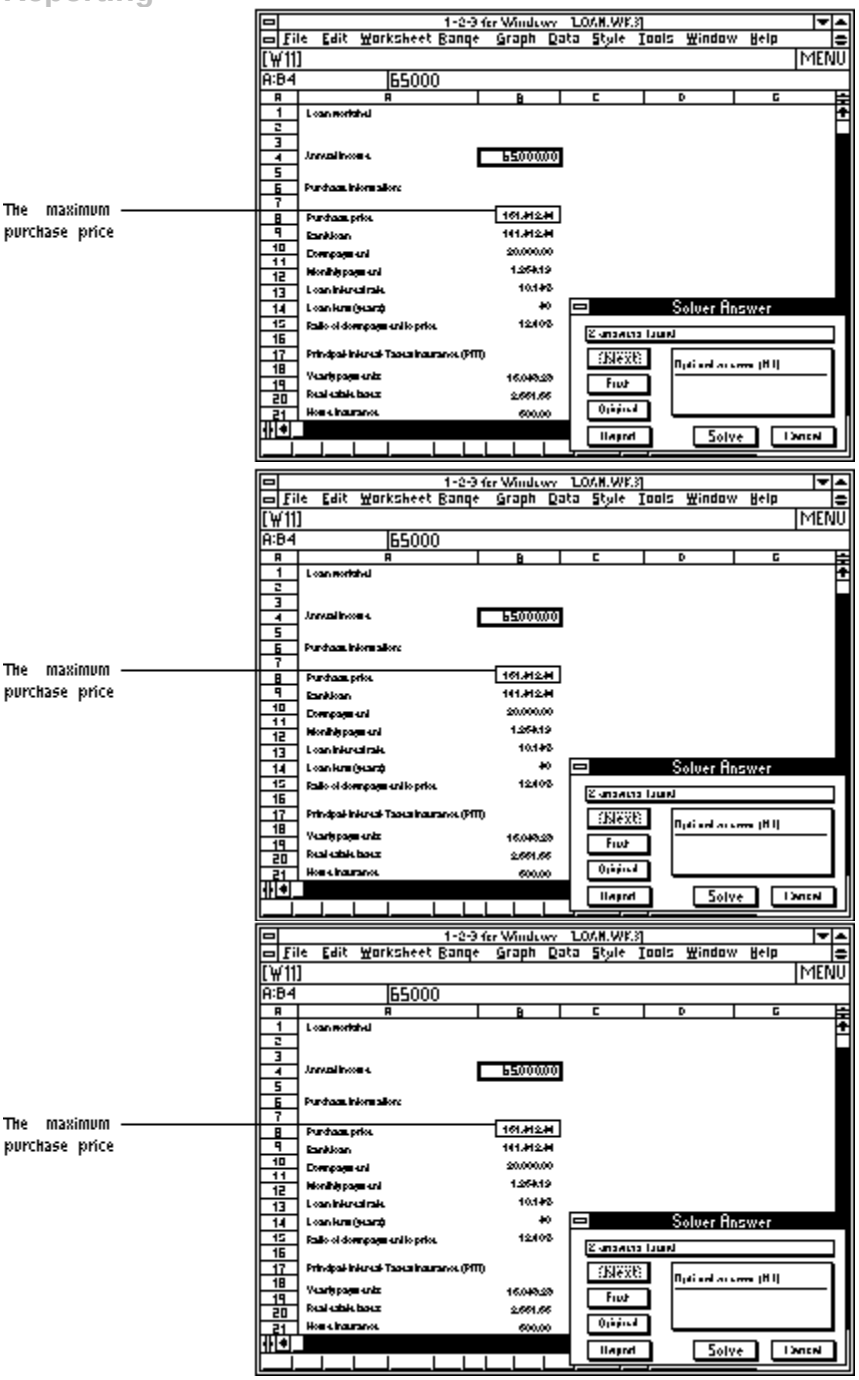
I want the Solver to find the optimal answer, but I always get a group of answers. How can I have the Solver give me the one answer I want?

Select Options in the Solver Definition dialog box and specify an estimate of one answer. The Solver will find one or two answers, stop solving, and display the Solver Answer dialog box. The Solver Answer dialog box specifies whether the Solver has found the optimal answer or the best answer it could find. If the Solver found the best answer instead of the optimal answer, you can choose Solve again to find other, possibly better answers.

Why does the Solver discard answers when the worksheet is changed?

The Solver discards answers or attempts for two reasons. First, changes to the worksheet have the potential of changing the Solver's problem and invalidating the answers and report information that the Solver has gathered. Second, changes to the worksheet may alter the location of adjustable cells, constraint cells, and the optimal cell -- the Solver depends on the location of these cells to create reports and display answers in the worksheet.

Reporting



The Solver offers many reports. What are some benefits of using these reports?

The Solver reports help you to understand how answers were determined, how one answer compares to other answers, and how much flexibility you have in changing an answer. This information can help you to select the answer that is most appropriate for you.

- **Answer table** is useful if you want to list, print, or save all the Solver's answers. Since the answers are displayed side-by-side, you can also use the Data commands or macro commands to compare answers. To graph

answers, select the adjustable cells or optimal cell section of the report and then choose Graph New from the 1-2-3 main menu.

- **Cells used** shows whether you defined the problem correctly for the Solver. This report provides information on whether all cells you specified for adjustable cells and constraint cells were used by the Solver to solve the problem.
- **Differences** compares two answers. This report is helpful when the Solver returns several answers and you want to know the difference between two answers. You'll find this report particularly helpful when problem cells are scattered throughout the worksheet. The Differences report quickly highlights the cells that differ by the amount (or tolerance) you specify so you can review the difference between the answers and select the one answer that is most appropriate.
- **How solved** is a summary of information about the current answer. The report summarizes what the Solver did to find the current answer or attempt. It provides information about the optimal cell's value, the adjustable cells' values, binding constraints, unused constraints, inconsistent constraints, and any cells for which the Solver needs you to supply guess values.
- **Inconsistent constraints** explains why the Solver was unable to find an answer for your problem. This report highlights constraint cells that were not satisfied and shows you how you can adjust their formulas to get a valid answer. For example, if the Inconsistent Constraint report shows that a constraint formula such as +A1>=B1*5 must be rewritten as +A1>=B1*5+1000, you know that you can add 1,000 to the formula to get a valid answer.
- **Unused constraints** identifies constraint cells that were not needed to find the current answer and may be irrelevant to the problem. For example, in a problem where a sales commission is being negotiated in the range of 10% to 30%, you may have specified a constraint such as +COMMISSION<=0.3. If this constraint was not used and it appears as +COMMISSION<=0.3-0.1 in the Unused constraints report, you might infer that the 30% commission is an unrealistic expectation, given other constraints in the problem.
- **What-if limits** is useful if you want to change an answer. This report provides an estimated range of values for each adjustable cell. The values represent the range within which you can modify the current answer and still satisfy all constraints. For example, in a hiring model, the Solver may return an answer where 2.7 employees should be hired. If the What-if Limits for this cell is between 2.5 and 5, you can use this information to adjust 2.7 to 3, 4, or 5.

In the What-if limits report, what is the difference between the Lowest and highest values found and the What-if limits for answer #?

The Lowest and highest values found section lists the lowest and highest values you will find for each adjustable cell if you browse through all the Solver's answers. For example, if the Solver finds 100 answers, the lowest and highest values for the number of employees to hire might be from 50 to 80.

The What-if limits for answer # section contains an estimate of the minimum and maximum values you can assign to each adjustable cell in the current answer and still satisfy all constraints. This range assumes that the values of all other adjustable cells remain constant. For example, suppose an answer has a value of 3 and 7 for adjustable cells A1 and B1, respectively. If the what-if limits for A1 are from 2 to 4 and the what-if limits for B1 are from 5 to 10, then the Solver is reporting that you can vary A1 within the range of 2 to 4 and still satisfy all constraints as long as B1 is left at its current value of 7. Similarly, you can vary the value in B1 within the range of 5 to 10 as long as A1 remains at 3.