

What is Solver?

View	Example conventions
View	What can Solver do?
View	Using Solver
View	Getting Online Help
View	Solver answers
View	Using Solver models

Example conventions

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable
User Data

The examples in this file use a color key required to solve the problem. Solver Definition dialog box. For adjustable cell, "A:A1" is entered in the Solver Definition dialog box.

What can Solver do?

Solver can solve most problems using the algebraic and logical relationships that already exist in your spreadsheet. Regardless of the complexity of the problem, work is done before you start Solver. Solver finds the relationships that already exist in your spreadsheet.

For example, you might use a spreadsheet to determine a manufacturer's profits and losses. Solver can determine how to maximize profit by finding the optimal mix of hats produced. This is the purpose of this file.

Solver can provide several answers to a problem. An optimal answer. By finding multiple optimal answers, you can determine the values of all the variables for each answer. This gives you a wider range of possibilities to choose from. This is more useful than the mathematical solution.

For more information, see Chapter 10 of the User's Guide.

Using Solver

Solver is located in the Range p
two ways to start Solver:

∅ Choose Range Analyze and c
menu.

∅ Press ALT, then press R, A, a
correspond to the underlined let

For more information on using S
Solver" in the User's Guide or s
"Range Analyze Solver" topic.

Getting Online Help about Solver

Solver Help is available by:

∅ Pressing F1 (HELP) when a S

∅ Using the Search facility in He

Using the Search facility

1. Choose Help Search.
2. Type "solver" in the text box.
3. Choose Show Topics.

A list of topics appear in the list
window.

4. Select a topic by choosing G

Note If you are a new Solver user, th
useful introductory information:
"Solver Definition".

Viewing Solver answers and attempts

As Solver is working to solve th
appears and informs you of the
problem.

If Solver says it has found an ar
constraints you placed on the pi
one or more of the constraints is

To view answers or attempt

1. To view answers or attempts, dialog box.

∅ Next displays the next answer

∅ First displays the optimal answer the first answer or attempt.

∅ Original displays the values that ran Solver.

1-2-3 changes the values in the answer or attempt to the next. A dependent formulas may also change.

Note You can move the Answer dialog worksheet.

For more information on answer "Using Solver" in the User's Guide and go to the "Solver Answer" topic.

Using Solver models

This file contains several Solver models on each sheet in the file. These models use Solver and provide you with real-world applications.

You can run Solver on the model button that appears at the top of each sheet.

Model Conventions

This file uses cell coloring conventions to indicate cells required for Solver to solve the model.

Note Some models let you replace the data in the model. This is referred to as "user data".

Sheet Name

Car Loan

Mortgage

PL

Mix

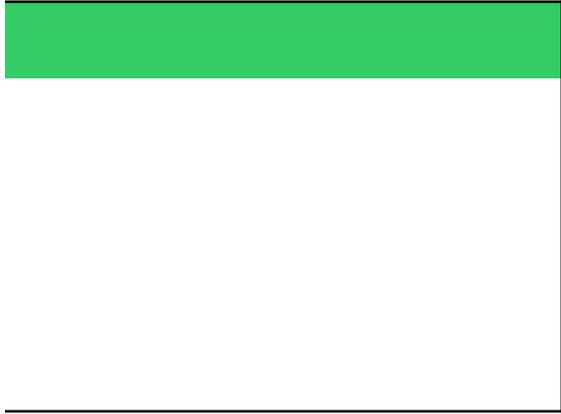
Math

Quotas

Advert

Invest

Break even
IRR



color key to identify cells that are
These cells are entered in the
For example, if cell A:A1 is the
entered in the Adjustable cells text

s that can be described
relationships in a worksheet.
the problem, most of your
Solver, since Solver uses the
n your worksheet.

Worksheet to analyze a hat
s. You can use Solver to
fits by varying the number
problem is in worksheet D (P/L)

vers to a problem, including the
iple answers and presenting the
ch answer, Solver can provide
ilities, one of which might be
ically optimal answer.

ter 20, "Using Solver" in the

ull-down menu. There are two

hoose Solver from the cascade

ind S in that order. These letters
iters in the commands.

olver, see Chapter 20, "Using
earch on "Solver" and go to the

olver dialog box appears.

lp.

box at the bottom of the Search.

To or by double-clicking the topic.

e following Help topics provide
"Setting Up a Solver Problem" and

e problem, a Progress dialog box
progress being made in solving the

answer, this result satisfies all the
roblem. A result that does not satisfy
s called an attempt.

ts

, choose an option in the Answer

r or attempt.

ver (if any), the best answer found, or

at were in the worksheet before you

adjustable cells as you go from one

as a result, cells that contain

change.

g box so that you can see the

rs and attempts, see Chapter 20,

de or search on "Answers" in Help

opic.

· models. There is a different model

models illustrate the capabilities

models to create your own Solver

els by pressing the "Example"

f the sheet next to the introduction.

entions to identify the different types

olve the problem.

e sample data with your own data.

".

Description

Car Loan Monthly Payment Model

Home Mortgage Planning Model

Basic Profit-Loss Statement

Product Mix Optimization

Simple Mathematical Models

Adjusting Sales Quotas

Advertising Placements

Investment Asset Allocation Model

Asset Purchasing Model
Buying a company

Car Loan Monthly-Payment Model

You are purchasing a new car and want to arrange financing. You want to determine what the monthly payments are given your purchase facts. Try some variations by changing the Purchase Facts and re-running Solver.

Purchase Facts

Years to Pay	4	1	Monthly pmt <= M
Car Price	\$24000.00	1	Monthly pmt >= 0
Interest Rate	9.00%	0	Down pmt <= Max
Max payment per Month	\$700.00	1	Down pmt >= 0
Maximum Down-Payment	\$3000.00		

Monthly Payment **\$500.00**

Loan Facts:

Down-Payment	\$3907.61
Loan Amount	\$20092.39
Total Interest Paid	\$3907.61

{Solver-Define? "D16";"F10..F13";"OFF";;;2}

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable
User Data

lax monthly pmt

κ down pmt

Home Mortgage Planning Model

You are buying a home and want to determine the largest bank mortgage you can afford given your income and expenses. In this model the Bank Loan amount is Solver's adjustable and optimal cell. Try some variations by changing the User Data cells and re-running Solver.

Purchase Facts:

Bank Loan	###
Downpayment	\$10000.00
Purchase Price	###
Mortgage Payment	\$877.57
Interest Rate (APR)	10.00%
Total Payments (months)	360

1	Expense % <= Max %
1	Debt % <= Max %

Personal Information:

Existing Debt	\$7000.00
Gross Income	\$75000.00
Tax Bracket	35.0%

Monthly PITI Limitation:

P/I	\$877.57
Taxes	\$229.17
Home Ins	\$28.42
PMI	\$91.67
Total PITI	###
Expenses % of Income	19.63%

Real Estate Expenses:

Insurance
Maintenance
Utility
Taxes
Total Expenses

Monthly Debt Limitation:

Existing Debt	\$583.33	Max Exp % of Income
Total PITI	###	Max Debt % of Income
Total Debt	###	
Debt % of Income	28.96%	

{Solver-Define? "C11";"E11..E12";"On";C11;"I

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjust.
User Data

< %

\$341.00
 \$2750.00
 \$550.00
 \$2750.00
 \$6391.00

28.00%
36.00%

Max";1}

Basic Profit and Loss Statement

In this profit and loss model you want to maximize the gross profit from sales of women's and men's hats, subject to guidelines on production capacity and the ratio of men's to women's hats.

Women's hats	5000
Men's hats	4000
Total hats sold	9000

Price per hat \$20

Total sales	\$180000
Less: Cost of goods sold	\$120000
Gross profit on sales	\$60000

Sell no more than 4,500 men's hats	1
No more than 65% of hats sold are v	1
Profit at least \$75,000	0

{Solver-Define? "C8..C9";"C1

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable

8..C20";"On";C16;Max;1}

Product Mix Optimization Model

Your bakery produces 3 types of bread: low-calorie, high-fiber, and white. You are the bakery manager and track revenues, costs, and profits from production. You are to determine the number of cases for each type of bread that maximize total profit while satisfying production limit guidelines.

More
and
Example

Type of bread:	low calorie	High fiber	White	Total
Cases produced	30000	20000	50000	100000
Hours per case	0.25	0.32	0.33	
Person hr. to produ	7500.00	6400.00	16500.00	30400.00
Cost per case	\$17.00	\$23.00	\$27.00	
Price per case	\$42.00	\$40.00	\$45.00	
Revenues	\$1260000	\$800000	\$2250000	###
Costs	\$510000	\$460000	\$1350000	###
Profit	\$750000	\$340000	\$900000	###

Constraints:

1	Meet production quota for low calorie?
0	Acceptable ratio of high fiber to low calorie?
0	Acceptable ratio of white to low calorie?
1	Within limits for person hours used?

{Solver-Define? "C11..E11";"B21..B24";"On";f

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable

{18;"Max";1}

Simple Mathematical Solver Models - Mo

The model below solves

$$x^2 - 4 = 0 \text{ for } x.$$

Solver will find both roots +2 and -2.

Example

Next

0
0

$$x^2 - 4 = 0$$

Mathematical Model 2

Solver can also be used to find the "optimal" answer. This model finds the largest Y where two curves intersect.

Curve 1: $A = (1 - Z)^2$

Curve 2: $B = 10Z + 1$

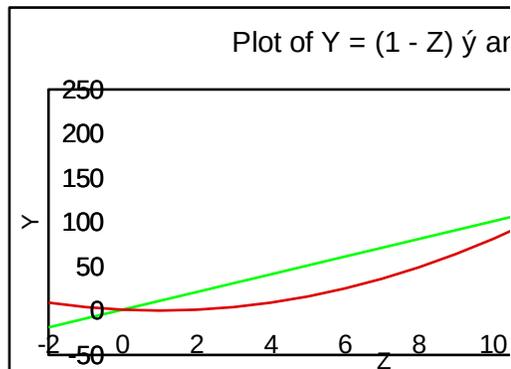
These curves intersect at 2 points. Solver uses the following constraint to find those points:

$$A - B = 0$$

Example

A	0
B	11

1	Z
0	A - B = 0
1	



Z	A	B
-2	9	-19
-1	4	-9

0	1	1
1	0	11
2	1	21
3	4	31
4	9	41
5	16	51
6	25	61
7	36	71
8	49	81
9	64	91
10	81	101
11	100	111
12	121	121
15	196	151

{Solver-Define? "C14";"C15";"Off";;;2}

{Solver-Define? "C34";"C35";"On";C36;Max;2}

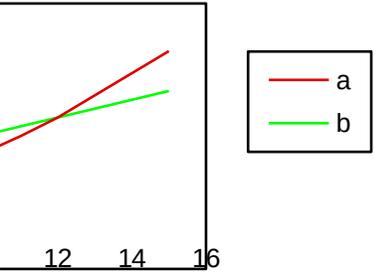
Key:

Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable

Key:

Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable

nd $Y = 10Z - 1$



Adjusting Sales Quotas

You are North American Sales Director. It is now five months into the year and you realize that you must adjust your year-end targets and sales quotas for each region. By defining the criteria as constraints, not specifying optimization and requesting more than one answer, Solver generates multiple answers - each a different set of quotas satisfying the criteria. To find additional answers, press the Solve button on the Solver Answer dialog.

More

Example

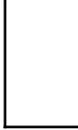
Region:	(\$millions) Adjust	(\$millions) Starting Quota	(\$millions) Adjusted Quota	(\$millions) YTDTD Quota	(\$millions) Actual Revenue
Canada	\$0.000	\$28.76	\$28.76	\$11.98	\$15.36
Northeast	\$0.000	\$49.81	\$49.81	\$20.75	\$19.94
New York	\$0.000	\$2.79	\$2.79	\$1.29	\$1.57
Federal	\$0.000	\$16.59	\$16.59	\$4.98	\$3.66
Southern	\$0.000	\$35.31	\$35.31	\$14.71	\$16.54
Great Lakes	\$0.000	\$16.30	\$16.30	\$8.01	\$5.89
Northwest	\$0.000	\$71.64	\$71.64	\$29.85	\$28.64
Southwest	\$0.000	\$106.70	\$106.70	\$44.46	\$34.18
Total	\$0.000	\$327.89	\$327.89	\$136.04	\$125.78

CONSTRAINTS:

1	+CANADA%>=(NEW YORK%*1.05)
1	+NEW YORK%>=(SOUTHERN%*1.07)
1	+SOUTHERN%>=(NORTHEAST%*1.16)
1	+NORTHEAST%>=(NORTHWEST%*1.001)
1	+NORTHWEST%>=SOUTHWEST%
0	+SOUTHWEST%-GREAT LAKES%<=0.03
1	+SOUTHWEST%-GREAT LAKES%>=-0.03
1	+SOUTHWEST%>=FEDERAL%
1	+CANADA%>=1.13
1	+CANADA%<=1.3
1	+NORTHEAST\$>=0
1	+NEW YORK\$>=0
1	+FEDERAL\$>=0
1	+SOUTHERN\$>=0
1	+\$GREAT LAKES\$<=0

Solve
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1	+NORTHWEST\$	>=0
1	+SOUTHWEST\$	<=0
1	+TOTAL ADJUST\$	=0

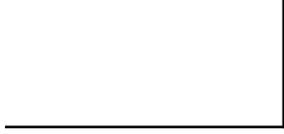


{Solver-Define? "D16..D23";"C27..C44";"Off";;;3}

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable

Adjusted Performance
1.2817
0.9611
1.2113
0.7357
1.1240
0.7354
0.9594
0.7688

Solver can find 20+ alternatives which satisfy constraints. After running Solver you can select the answer that best represents the answer that best reflects your intended performance. Solver will point to alternatives which would never have been considered with manual experimentation.



Advertising Placements Model

You are the advertising manager for a new product promotion. Each media type is subject to diminishing returns -- each ad reaches fewer new viewers than the previous ad. You have a budget of \$500,000 and your goal is to reach as many viewers as possible.

	TV	Radio	Print
Cost per placement	\$15000	\$2500	\$1000.00
Number of placements	1	1	1
Total cost	\$15000	\$2500	\$1000.00
Budget			
Projected exposure	100000	25000	15000
Marginal exposure	100000	25000	15000
Marginal cost per expo	\$0.15	\$0.10	\$0.07
Average cost per expo	\$6.67	\$10.00	\$15.00

Constraints:

Minimum	1	1	1
Meet budget limit?			

Projecting Diminishing Returns

This example uses a weighted natural log curve (@LN) to forecast the curve is shifted by 1 to force exposure to 0 at 0 placements. predicted by the following formula:

$$\text{WEIGHT} * @LN(\#PLACEMENTS + 1)$$

Weight 144269.50 36067.38 21640.43

{Solver-Define? "C11..E11";"B23..G24";"O

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable

Total
3
\$18500.00
\$500000.00
140000

1

--

st total exposure. In addition,
The cumulative exposure is

n";G15;Max;1}

Investment Asset Allocation Model

As an investor you wish to optimize an investment of \$100,000 in stocks, taxable bonds, tax-exempt bonds, and money market funds. All money not invested in stocks and bonds is invested in money market funds. You want to determine how much should be invested in each type of asset to maximize total expected return on the investments, while satisfying certain investment criteria.

More

Example

Key:

Adjustable
Constraint
Optimal/
Optimal/

Asset	Before tax yield	After tax yield	Annual asset apprec.	Amount invested	Percent invested	Before tax income
Stocks	3.20%	2.27%	9.50%	\$20000.00	20.00%	\$640.00
Taxable bonds	9.20%	6.44%	3.80%	\$20000.00	20.00%	###
Tax-exempt bonds	7.80%	7.80%	2.70%	\$20000.00	20.00%	###
Money market	8.90%	6.23%	0.00%	\$40000.00	40.00%	###
Total				\$100000.00	100.00%	\$7600.00
Total return (weighted average)					10.80%	

Constraints:

0	At least 22% in stocks?
1	No more than 45% in stocks?
1	At least 15% in taxable bonds?
1	At least 12% in tax-exempt bonds?
1	At least 10% in money market?
1	Not over 60% in stocks plus taxable bonds?
1	At least \$15,000 in tax-exempt bonds?
1	After tax income at least \$5,000?
0	Total return at least 11%?

{Solver-Define? "F16..F19";"B24..B32";"On";F21;Max;3}

le cell
int cell
nal cell
Adjustabl

After tax income
\$454.40
###
###
###
\$5794.40

Break-even analysis

As the office manager for a small firm, you must replace the existing copy machine service. You want to determine how much can be spent on a copier and still break even over a 4 year period, compared to out-sourcing the service. There is an upper limit of \$5,000 on the purchase.

More

Example

Inputs:

Purchase Price	\$5000	Tax Rate	34.00%
Delivery	\$0	Cost of Money	11.00%
Installation	0		
Useful Life	4	Price per Copy	\$0.10
Depreciation	SL	Copies per Year	15000
Salvage Value	\$0	Blank Paper	\$0.01
Investment Tax Credit	0.00%	Cartridges per Co	\$0.04
		Service Contract	\$66.00

Constraints:

	1	\$0	Minimum Price
	1	\$5000	Maximum Price
	0	0	Minimum NPV

{Solver-Define? "C11";"B21..B23";"On";C11;

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable
User Data

Cash flow by year

Outflows (After Tax): year 1

Capital	Photocopy Machine	\$5000.00
Operatin	Paper	\$79.20
	Cartridges	\$346.50
	Service Contract	\$43.56
Total Outflows		\$5469.26
Capital	Invest. Tax Credit	\$0.00
	Trade-In Value	
Operatin	Depreciation Tax Sh	\$425.00
	Copy Expense Saved	\$990.00
Total Inflows		\$1415.00
Net After-Tax Cash F		-\$4054.26
Net Present Value		-\$1570.40
Internal Rate of Retu		-15.93%

"Max";1}

year 2	year 3	year 4
\$79.20	\$79.20	\$79.20
\$346.50	\$346.50	\$346.50
\$43.56	\$43.56	\$43.56
\$469.26	\$469.26	\$469.26
		\$0.00
\$425.00	\$425.00	\$425.00
\$990.00	\$990.00	\$990.00
\$1415.00	\$1415.00	\$1415.00
\$945.74	\$945.74	\$945.74

Buying a Business (using internal rate of r

You have agreed to buy a business. You will pay the seller a total of \$1.5m over 3 years. The seller will allow you to pay as little as \$400,000 and as much as \$600,000 at the end each of the 3 years, as long as the total principal amount paid is \$1.5m. Interest on the outstanding principal is computed at 12% per annum. You expect to generate the operating income shown below. Use Solver to determine the payment stream that maximizes your internal rate of return on investment.

More

Example

Purchase facts:

Tax rate
 Interest rate

	PAYMENT AMOUNT	PAYMENT >= 400K?	PAYMENT <= 600K?
YEAR 1	\$400000	1	1
2	\$400000	1	1
3	\$400000	1	1

IRR: TOTAL \$1200000 Total payme

YR	PURCHASE BALANCE	PAYMENTS	INTEREST	OPERATING INCOME	NET INCOME	TAXES
1	\$1500000	\$400000	\$180000	\$357250	\$177250	\$60265
2	\$1100000	\$400000	\$132000	\$400120	\$268120	\$91161
3	\$700000	\$400000	\$84000	\$448134	\$364134	\$123806
4	\$300000	\$0	\$36000	\$501911	\$465911	\$158410
5	\$300000	\$0	\$36000	\$562140	\$526140	\$178888
6	\$300000	\$0	\$36000	\$629597	\$593597	\$201823
7	\$300000	\$0	\$36000	\$705148	\$669148	\$227510
8	\$300000	\$0	\$36000	\$789766	\$753766	\$256280
TOTALS		\$1200000		\$4394065		

{Solver-Define? "F16..F18";"G16..H18;G20";"On";D20}

Key:
Adjustable cell
Constraint cell
Optimal cell
Optimal/Adjustable
User Data

nts = 1.5M?

AFTER TAX CASH FLOW
-\$283015
-\$223041
-\$159671
\$307501
\$347252
\$391774
\$441638
\$497486
\$1319923

0;Max;2}