What is Solver?

Example conventions

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

The examples in this file use a c
required to solve the problem.
Solver Definition dialog box. Fc
adjustable cell, "A:A1" is ent
box.

What can Solver do?

Solver can solve most problems
using the algebraic and logical r
Regardless of the complexity of
work is done before you start So
relationships that already exist i

For example, you might use a w
manufacturer's profits and losse
determine how to maximize prof
and mix of hats produced. This
of this file.

Solver can provide several answ
optimal answer. By finding multi
values of all the variables for ea
you with a wider range of possib
more useful than the mathemati

For more information, see Chap
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 p
one or more of the constraints is

To view answers or attemp

1. To view answers or attempts,
dialog box.
° Next displays the next answer
° First displays the optimal answ
the first answer or attempt.
° Original displays the values th
ran Solver.

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

Note You can move the Answer dialo
worksheet.

For more information on answe
"Using Solver" in the User's Gui
and go to the "Solver Answer" t

Using Solver models

This file contains several Solver
on each sheet in the file. These
of Solver and provide you with r
applications.

You can run Solver on the mode
button that appears at the top o

Model Conventions

This file uses cell coloring conve
of cells required for Solver to so

Note Some models let you replace th
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
r example, if cell A:A1 is the
tered in the Adjustable cells text

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

orksheet 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 21, "Using Solver" in the

ull-down menu. There are two

hoose Solver from the cascade

nd S in that order. These letters
tters in the commands.

Solver, see Chapter 21, "Using
earch on "Solver" and go to the

---

olver dialog box appears.

lp.

box at the bottom of the Search.

o 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

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

ots

, choose an option in the Answer

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

at were in the worksheet before you

adjustable cells as you go from one
s a result, cells that contain
hange.

g box so that you can see the

s and attempts, see Chapter 21,
de or search on "Answers" in Help
pic.

---

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
lve 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.

Example

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 Mont	$700.00	1	Down pmt >= 0
Maximum Down-Payme	$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

‹ 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.

More Example

Purchase Facts:

Bank Loan	###	1	Expense % <= Max
Downpayment	$10000.00	1	Debt % <= Max %
Purchase Price	###		
Mortgage Payment	$877.57		
Interest Rate (APR)	10.00%		
Total Payments (mor	360		

Personal Information:

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

Monthly PITI Limitation:

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

Real Estate Expenses:

Monthly Debt Limitation:

Existing Debt	$583.33	Max Exp % of Incom
Total PITI	###	Max Debt % of Inco
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}

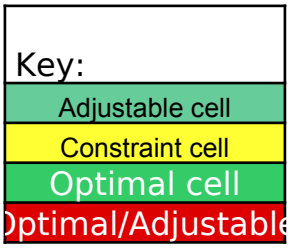
Basic Profit and Loss Statement

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.

Example

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 w	1
Profit at least $75,000	0

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



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.

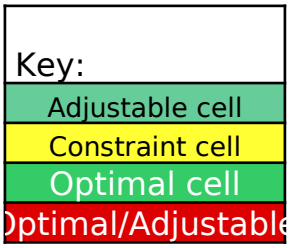
More Example

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	$4310000
Costs	$510000	$460000	$1350000	$2320000
Profit	$750000	$340000	$900000	$1990000

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

$x^2 - 4 = 0$ for x.

Solver will find both roots +2 and -2.

Example

Next

0	
0	^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: $B = 10Z + 1$

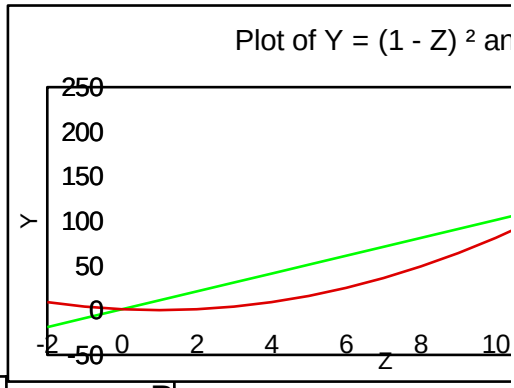
These curves intersect at 2 points. Solver uses the following constraint to find those points:

$A - B = 0$

Example

A	0
B	11

1	Z
0	A - B = 0
1	



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

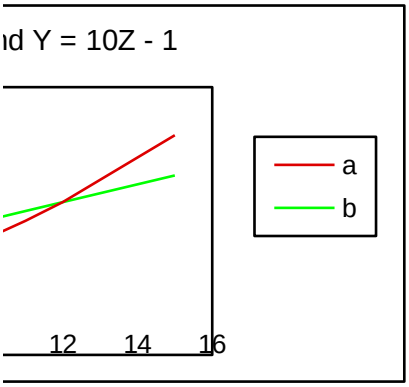
0	1	1
1	0	11
2	1	21
3	4	31
4	9	41
5	16	51
6	25	61
7	36	71
8	49	81
9	64	91
10	81	101
11	100	111
12	121	121
15	196	151

{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



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 that 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 Actual Quota	$millions) 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 Lake	$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	$0.00	$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
answ
the c
using
selec
appe
reasc
expe
Perha
out a
woul
consi
"wha
expe

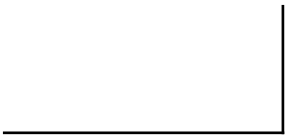
1	+NORTHWEST$>=0
1	+SOUTHWEST$<=0
1	+TOTAL ADJUST$=0

{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

er can find 20+
ers which satisfy
onstraints. After
g Solver you can
t the answer that
ars to most
onably reflect your
cted performance.
aps Solver will point
lternatives which
d never have been
idered with manual
t-if"
rimentation.



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.

More Example

	TV	Radio	Print	
Cost per placement	$15000	$2500	$1000	
Number of placements	1	1	1	
Total cost	$15000	$2500	$1000	
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 forecas
the curve is shifted by 1 to force exposure to 0 at 0 placements.
predicted by the following formula:

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:

Adjustab

Constrai

Optir

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 bon	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
mal 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	$0.008
Investment Tax Cred	0.00%	Cartridges per Co	$0.035
		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	34.00%
Interest rate	12.00%

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

IRR: 29.34%

TOTAL $1200000 0 Total payme

YR	BALANCE	PURCHASE 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";D2

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}