BUSINESS ANALYTICS CLUB

Workshop Series 10.17

Excel Solver
& Google Ads

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Learning Objectives

1. Learn the basics of Excel Solver and linear programming
2. Understand search engine advertising, costs per click, and second price auctions
3. Apply solver techniques in evaluating ideal bid placement for an online advertising campaign

Excel Solver

- Excel Solver is an add-in within excel that uses techniques from operations research to find optimal solutions to decision problems

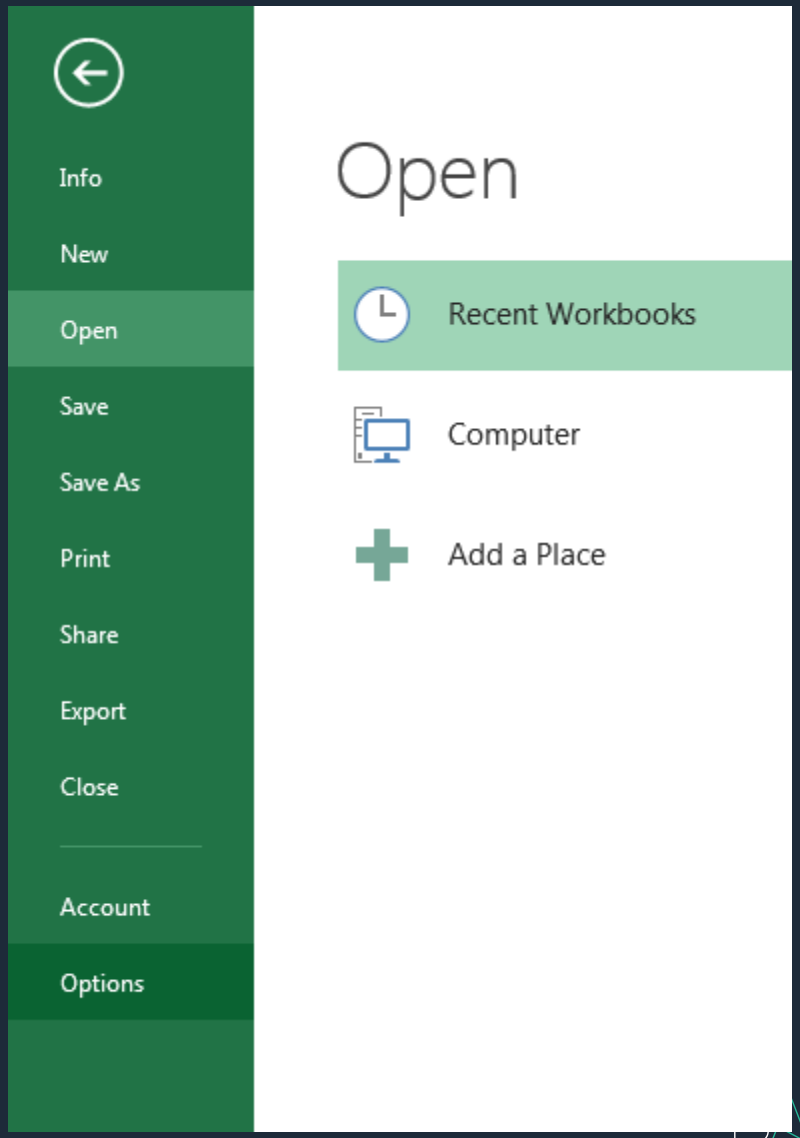
Setup

Setup

- In order to use Excel Solver you must have either a windows computer with Excel installed or a Mac Office 2011 and above
- If you do not have the correct office version for mac please see appendix for Citrix set-up instructions

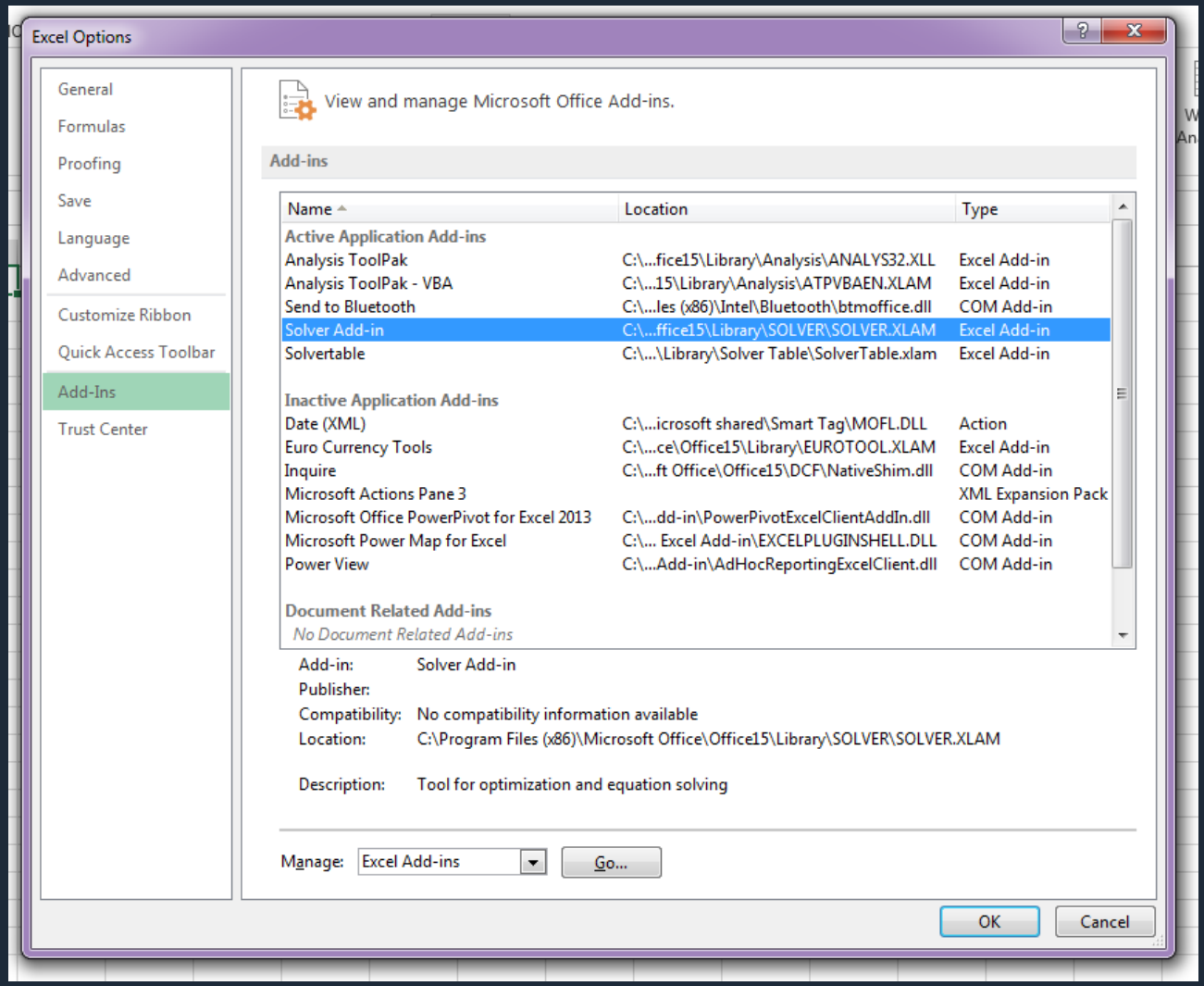
Windows Users

1. On the [File] tab, click [Options]



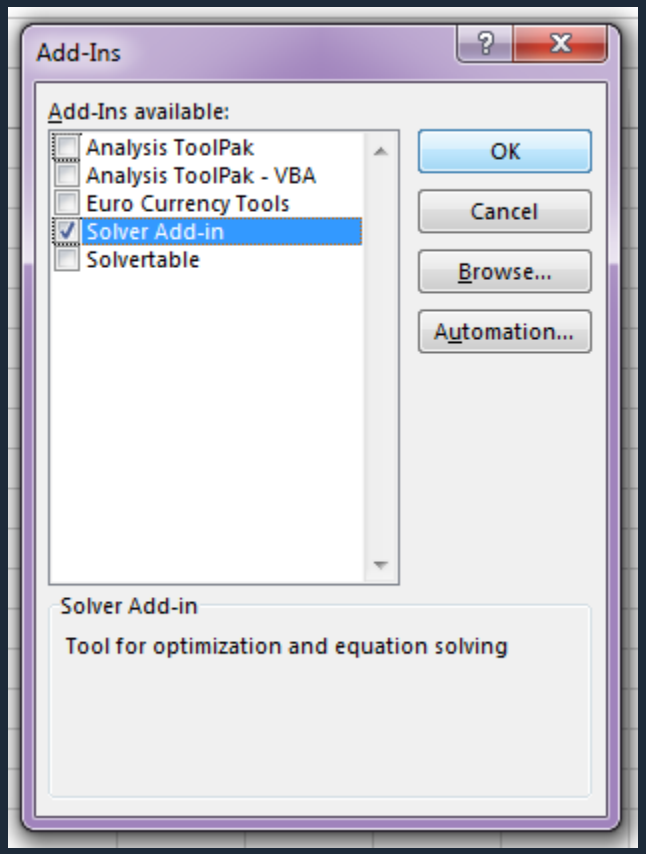
Windows Users

2. Under [Add-ins] select [Solver Add-in] and click [Go]



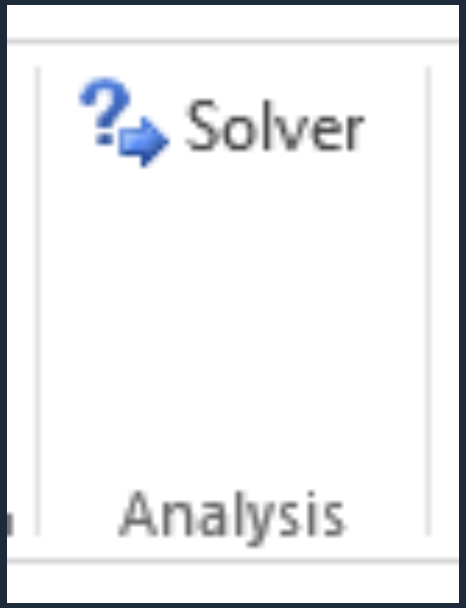
Windows Users

3. Make sure [Solver Add-in] is checked and click [OK]



Windows Users

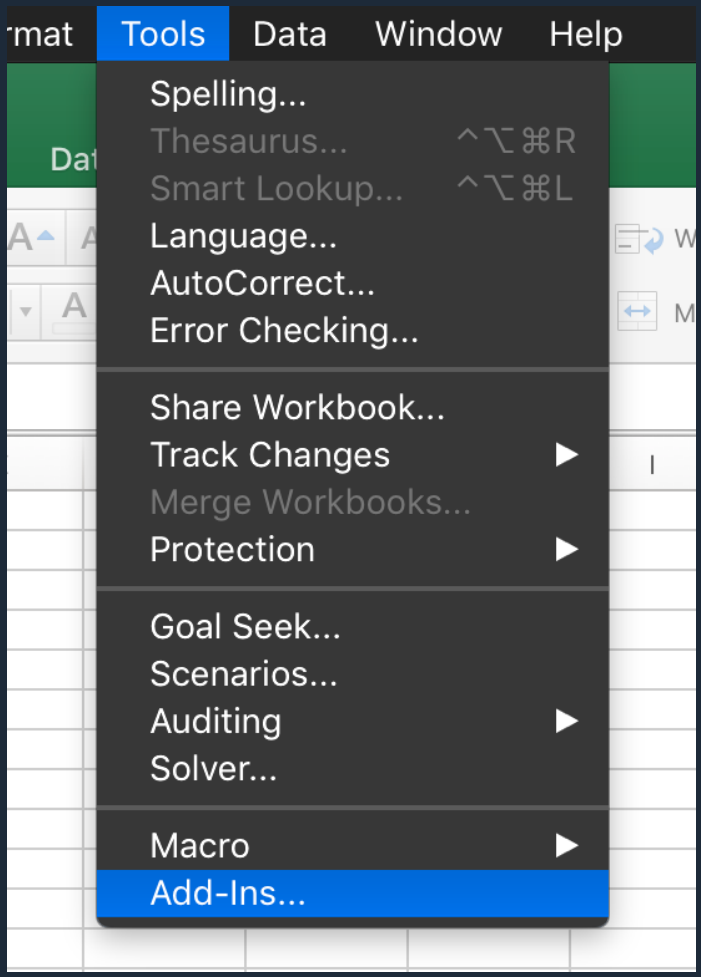
4. Under the [Data] tab you should see a button [Solver]



Mac Users

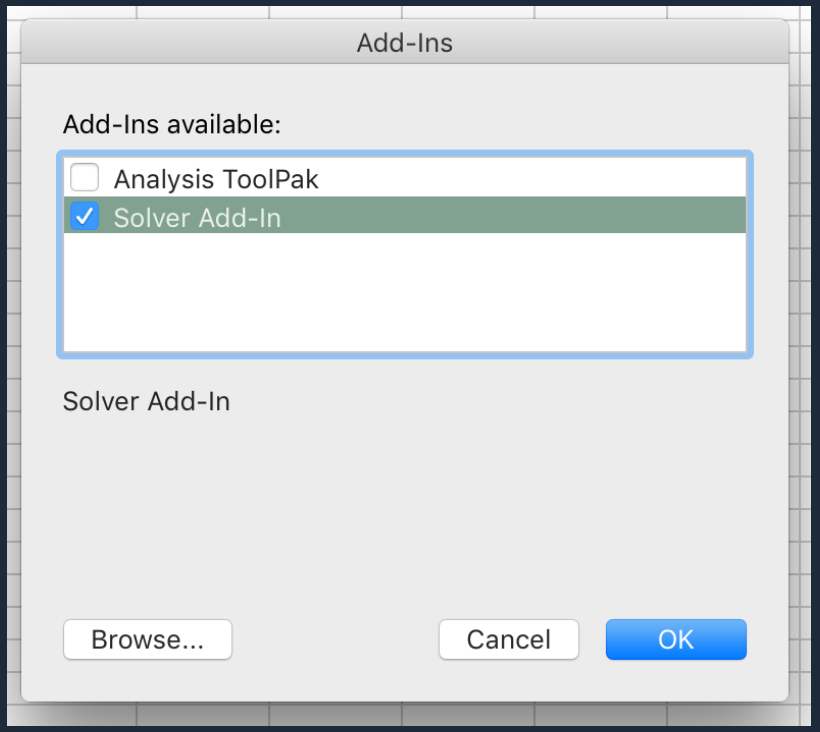
Note: this tutorial is for mac users with Office 2011 or above

1. Under the [Tools] menu click on [Add-Ins…]



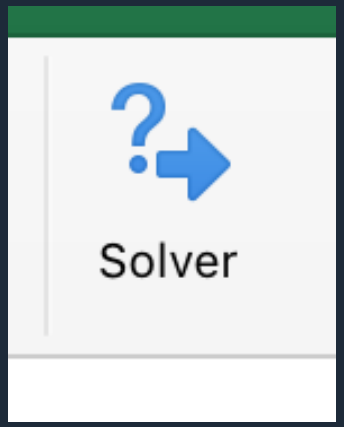
Mac Users

2. Select the box for [Solved Add-In] and click [OK]



Mac Users

3. Under the [Data] tab a solver button should be visible



Linear Programming with Solver

Lego Furniture

- We are a furniture manufacturing company that builds furniture using LEGOs
- Our available resources include 6 (large) orange blocks and 8 (small) green blocks
- Operation costs are zero, we can make chairs and tables
- Tables sell for $16 and require 2 green + 2 orange blocks
- Chairs sell for $10 and require 2 green + 1 orange block

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Lego Furniture

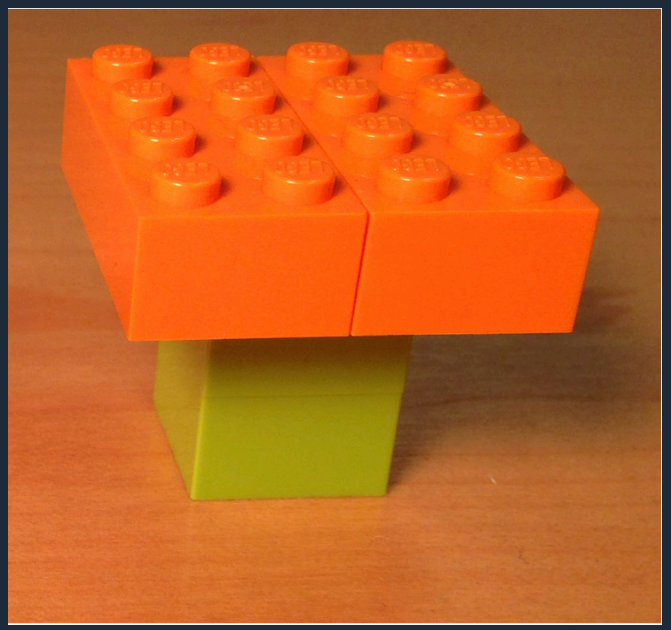
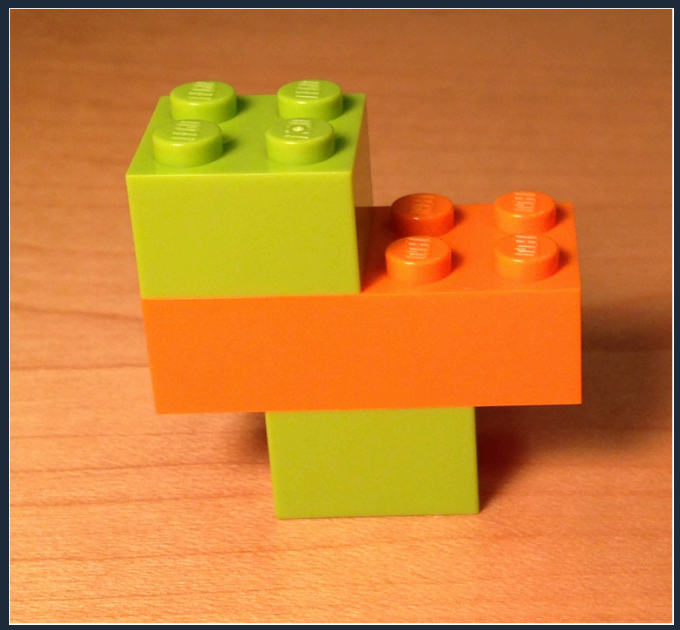


Table
sell for $16
requires:
2 green + 2 orange



Chair
sell for $10
requires:
2 green + 1 orange

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Assuming everything we make will be sold...
How should we operate our production to maximize profits?

Possible Approaches

Algebraic Process

1. Collect given information
2. Write out formulas
3. Find objective
    a) Maximize
4. Solve w/ Mathematical & Graphical Method
    a) Find optimal corner

Solver Process

5. Define Decision Variables
6. Create Objective Function
7. Set Constraints

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Algebraic Approach

Algebraic Approach

Algebraic Process

1. Collect given information
2. Write out formulas
3. Find objective
   a) Maximize
4. Solve w/ Mathematical & Graphical Method
   a) Find optimal corner

Algebraic Approach

x - # of chairs being made
y - # of tables being made

Objective: Max Profit
Maximize $10x + 16y$

Restrictions:
$2x + 2y \leq 8$ – # of green blocks used
$x + 2y \leq 6$ – # of orange blocks used
$x, y \geq 0$ – non-zero variables

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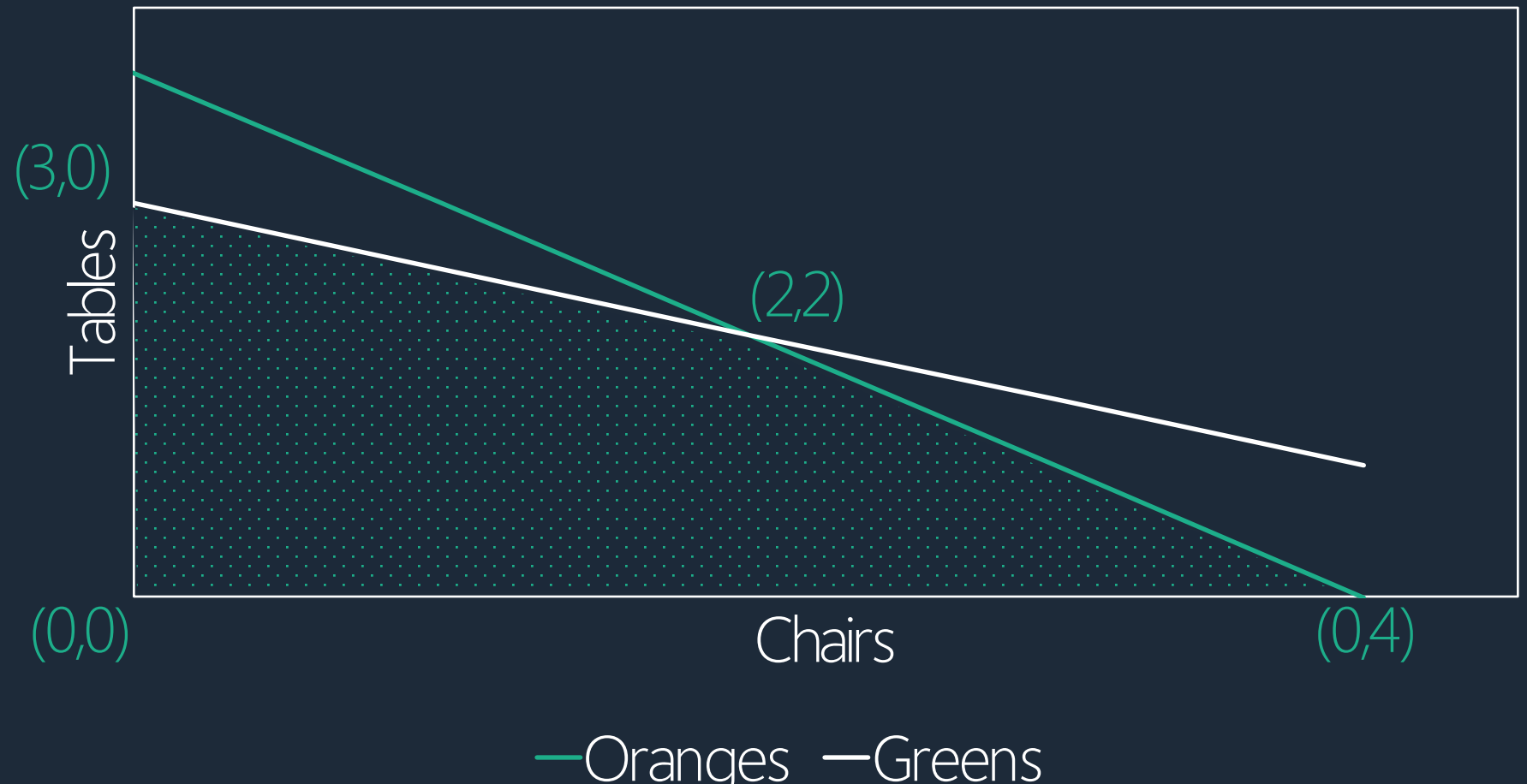
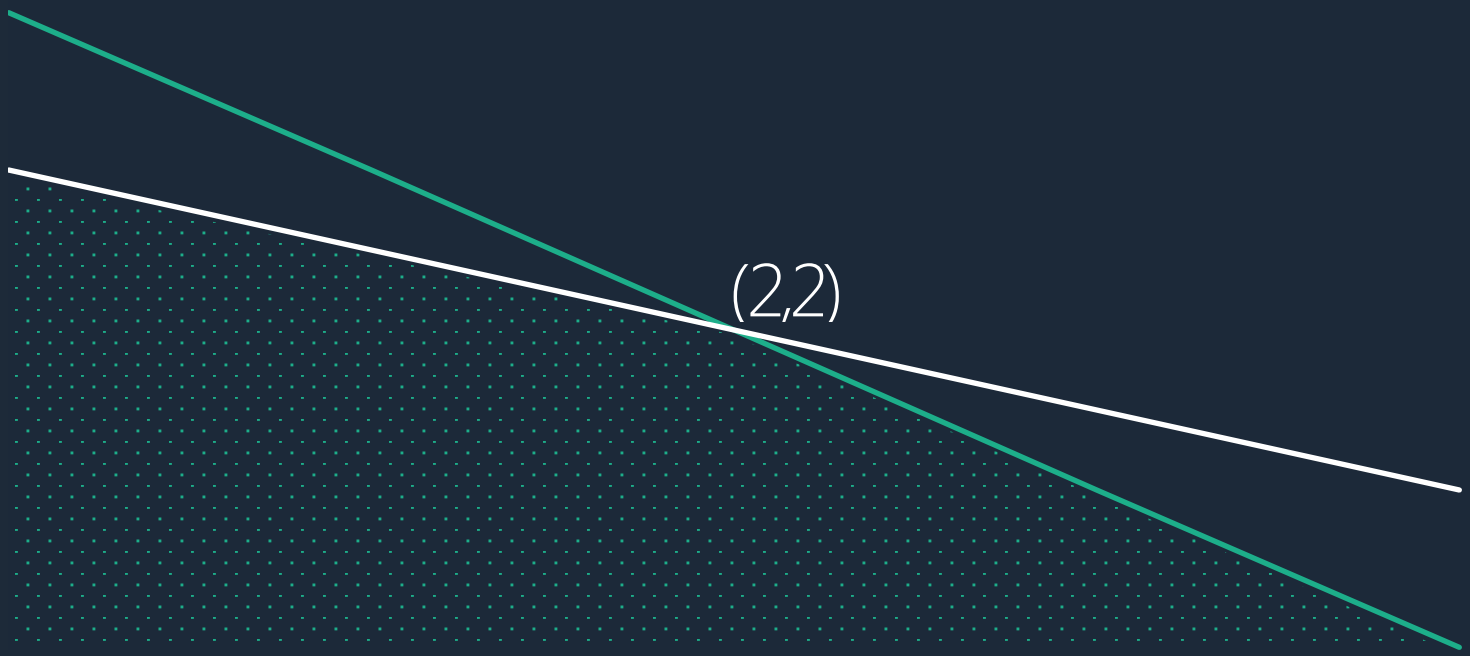
Algebraic Approach



Algebraic Approach



The optimal solution is the corner point which maximizes our profit

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Excel Solver Approach

Solver Approach

Let's fill in the Template File [Lego Furniture.xlsx]

Lego Furniture	Chairs	Tables						
Production Choices						yellow=decision variables		
				Total Profit		orange=objectives		
Profit per Unit						blue=data		
			In Use		Resources			
Green Blocks				<=				
Orange Blocks				<=				

Solver Approach

Decision Variables:

x - # of chairs being made

y - # of tables being made

Objective Function:

Max(10x + 16y)

Constraints:

$2x + 2y \leq 8$ – # of green blocks used

$x + 2y \leq 6$ – # of orange blocks used

$x, y \geq 0$ – non-zero variables

Plug in the variables, click solver, and enter in your constraints…

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Solver Solution

Lego Furniture	Chairs	Tables						
Production Choices	2	2				yellow=decision variables		
				Total Profit		orange=objectives		
Profit per Unit	10	16		52		blue=data		
			In Use		Resources			
Green Blocks	2	2	8	<=	8			
Orange Blocks	1	2	6	<=	6			

Solver has found THE optimal solution with 2 chairs and 2 tables

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Search Engine Advertising

Google Advertising

laptop

Web | Shopping | Images | News | Maps | More | Search tools

About 533,000,000 results (0.41 seconds)

Surface™ Book - Microsoft.com
Ad www.microsoft.com/Surface
4.3 ★★★★½ rating for microsoft.com
Introducing The Ultimate **Laptop**. Do Great Things.

Official Dell Laptops - dell.com
Ad www.dell.com/**Laptops**
4.0 ★★★★☆ rating for dell.com
Buy Powerful & Affordable **Laptops** For Home & Work, with Intel® Core™.
Free HDTV Offer · Free Shipping · Price Match Guarantee
Ratings: Features 9.5/10 - Ease of use 9/10 - Appearance 9/10
Dell Windows 10 PCs - Business Laptops - Alienware Computers

HP® Days Sale - Intel® Core™ PCs: Intel Inside® - hp.com
Ad store.hp.com/
3.5 ★★★½☆ rating for hp.com
Extraordinary Performance Outside.
Ratings: Features 10/10 - Ease of use 9/10 - Appearance 9/10 - Prices 8.5/10
HP® Lowest Priced PCs - HP® Laptops & Hybrid PCs - Top Laptop Deals at HP®

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OC Rugged L...


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$269.99
hp.com
★★★★½ (22)


Toshiba - Satellite 11.6...
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Best Buy
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In store


Dell Inspiron Black 15.6 inc...
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Walmart

Ads

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Free Shipping Site to Store.

Laptops Cheap
www.tigerdirect.com/
4.2 ★★★★☆ rating for tigerdirect.com
Wide Selection, Low Prices.

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Google Advertising

- Search engines have organic search results and sponsored advertisements
- Google sells ad spaces through an auction system
- Advertisers bid on ad spaces in the form of $/click

Second Price Auctions

- Google auctions space using a second price auction
- In a second price auction you will pay the price of the bidder you displace
- Example: If I bid $11, my ad will be placed in Slot 2 and will cost only $10

Ad-Slot	Highest Bid $/Click
1	$12
2	$10
3	$4
4	$2
5	$0.40
6	$0.29
7	$0.023
8	$0.01

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Today's Case

Google Ad Bidding

- You are running a campaign for a Refurbished Laptop website
- In order to advertise, you must get high ad placement against competitors for the following keyword slots: "Laptop", "Refurbished Laptop", "Cheap Laptop", and "Used Laptop"
- Overall goal is to maximize clicks given Ad budget

Template

Let's fill in the Template File [Ad Bidding.xlsx]

Bid Necessary to Win a Given Slot

Slot	"Laptop"	"Refurbished Laptop"	"Cheap Laptop"	"Used Laptop"
1	6.73	1.29	0.59	0.93
2	6.72	0.95	0.58	0.85
3	2.00	0.80	0.56	0.84
4	1.70	0.79	0.55	0.70
5	1.56	0.78	0.51	0.58
6	1.42	0.77	0.42	0.46
7	1.13	0.57	0.40	0.43
8	0.95	0.54	0.39	0.40

Expected Number of Clicks from Winning a Slot

Slot	"Laptop"	"Refurbished Laptop"	"Cheap Laptop"	"Used Laptop"
1	1539	370	45	38
2	1099	264	32	27
3	785	189	23	19
4	561	135	16	14
5	401	96	12	10
6	286	69	8	7
7	204	49	6	5
8	146	35	4	4

Slot chosen

Slot	"Laptop"	"Refurbished Laptop"	"Cheap Laptop"	"Used Laptop"
1				
2				
3				
4				
5				
6				
7				
8				

Total Costs

Total Clicks

Given Information

- Daily Budget is $550
- First table in template is # expected clicks per slot+keyword
- Second table is cost per click for given slot+keyword
- Third table is blank for determining which keyword and which slot to take

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Solution

Slot chosen					
Slot	"Laptop"	"Refurbished Laptop"	"Cheap Laptop"	"Used Laptop"	
1	0	0	1	1	
2	0	1	0	0	
3	0	0	0	0	
4	0	0	0	0	
5	0	0	0	0	
6	0	0	0	0	
7	1	0	0	0	
8	0	0	0	0	
	=SUM(H3:H10)	=SUM(I3:I10)	=SUM(J3:J10)	=SUM(K3:K10)	
	<=	<=	<=	<=	
	1	1	1	1	
	Total Costs	=SUMPRODUCT(B3:E10,B14:E21,H3:K10)		Total Clicks	=SUMPRODUCT(B14:E21,H3:K10)
		<=			
		550			

More Practice

Café Work Schedule

- Situation: You manage a café where every week you must schedule which employees work which days
- Due to capacity issues only one employee can work per day
- As manager you want to make employees happy, find the best way to maximize their happiness with your work schedule given a measure of their preferences.

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Preferences Schedule

- In order to be fair, the days must be split evenly between the Employees (each Employee works 2 days)

- A rating of 10 means extremely interested and 1 means that not interested at all

	Mon	Tue	Wed	Thu	Fri	Sat
Veronica	9	9	8	8	4	4
Thomas	7	6	5	6	9	5
Bill	8	7	6	5	7	6

Decision Variables

- Binary Decision Variable on whether the employee will work a given day

  X(i, j) for all i = 1,…,6 and n = 1, 2, 3

  i is the specific shift day, and n is the emloyee

  So X(3,1) = 1 means that on Day 3 (Wednesday) Employee 1 (Veronica) is working

Objective Function

- Maximize happiness i.e. maximize employee preferences
- Create a variable called Pref(i,n) which measures preference on a specific day

$$\max\left(\sum \left(X_{i,n} * Pref_{i,n} \right) \right) \text{ for all } i \,\&\, n$$

Constraints

- Employees must work 2 out of 6 days

$$\Sigma X_{i,1} = 2 \, , \; \Sigma X_{i,2} = 2 \, , \quad \Sigma X_{i,3} = 2$$

- Only one employee can work a shift

$$\Sigma X_{1,n} = 1 \, , \; \Sigma X_{2,n} = 1 \, , \ldots , \; \Sigma X_{6,n} = 1$$

- X(i,n) must be set as binary so we don't end up scheduling half an employee, either work (1) or don't work (0) on a given day

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Create in Excel

Create this in Excel yourself where blue is preference data, yellow is binary decision variable, orange is objective

Preferences						
	Mon	Tues	Wed	Thur	Fri	Sat
Veronica	9	9	8	8	4	4
Thomas	7	6	5	6	9	5
Bill	8	7	6	5	7	6
Assignments						
	Mon	Tues	Wed	Thur	Fri	Sat
Veronica	0	0	0	0	0	0
Thomas	0	0	0	0	0	0
Bill	0	0	0	0	0	0
Total satisfaction						

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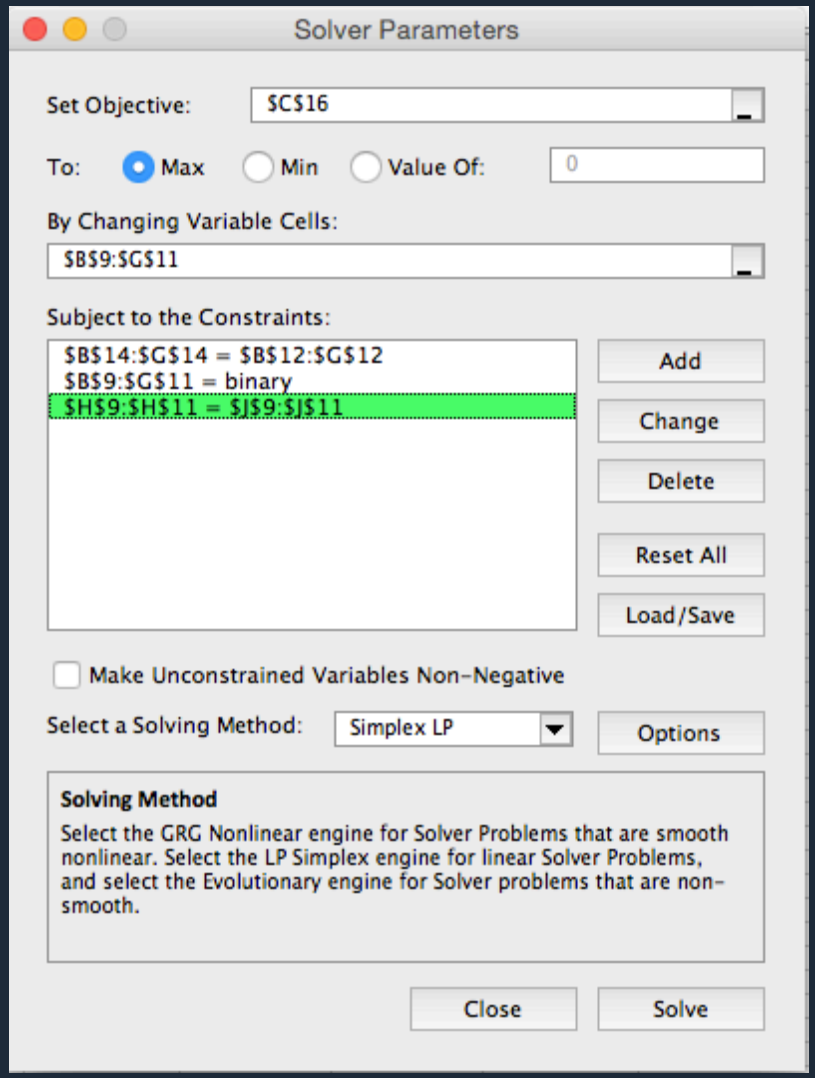
Add the Constraints

Preferences									
	Mon	Tues	Wed	Thur	Fri	Sat			
Veronica	9	9	8	8	4	4			
Thomas	7	6	5	6	9	5			
Bill	8	7	6	5	7	6			
Assignments									
	Mon	Tues	Wed	Thur	Fri	Sat			
Veronica	0	0	0	0	0	0	=SUM(B9:G9)	=	2
Thomas	0	0	0	0	0	0	=SUM(B10:G10)	=	2
Bill	0	0	0	0	0	0	=SUM(B11:G11)	=	2
	=SUM(B9:B11)	=SUM(C9:C11)	=SUM(D9:D11)	=SUM(E9:E11)	=SUM(F9:F11)	=SUM(G9:G11)			
	=	=	=	=	=	=			
	1	1	1	1	1	1			
Total satisfaction		=SUMPRODUCT(B3:G5,B9:G11)							

Setup Solver

- Fill out the necessary information in solver



Solution

- Make sure Solver is labeled as Simplex LP!
- Once you hit solve, Solver will calculate and fill the objective cell
- Veronica will work Tuesday & Wednesday, Thomas Thursday & Friday, Bill Monday & Saturday

Assignments						
	Mon	Tues	Wed	Thur	Fri	Sat
Veronica	0	1	1	0	0	0
Thomas	0	0	0	1	1	0
Bill	1	0	0	0	0	1
	1	1	1	1	1	1
	=	=	=	=	=	=
	1	1	1	1	1	1
Total satisfaction		46				

Acknowledgement

Ilan Lobel

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