

<https://towardsdatascience.com/python-basics-for-data-science-6a6c987f2755>

**ORTEC**  
OPTIMIZE YOUR WORLD

# Optimization with Python

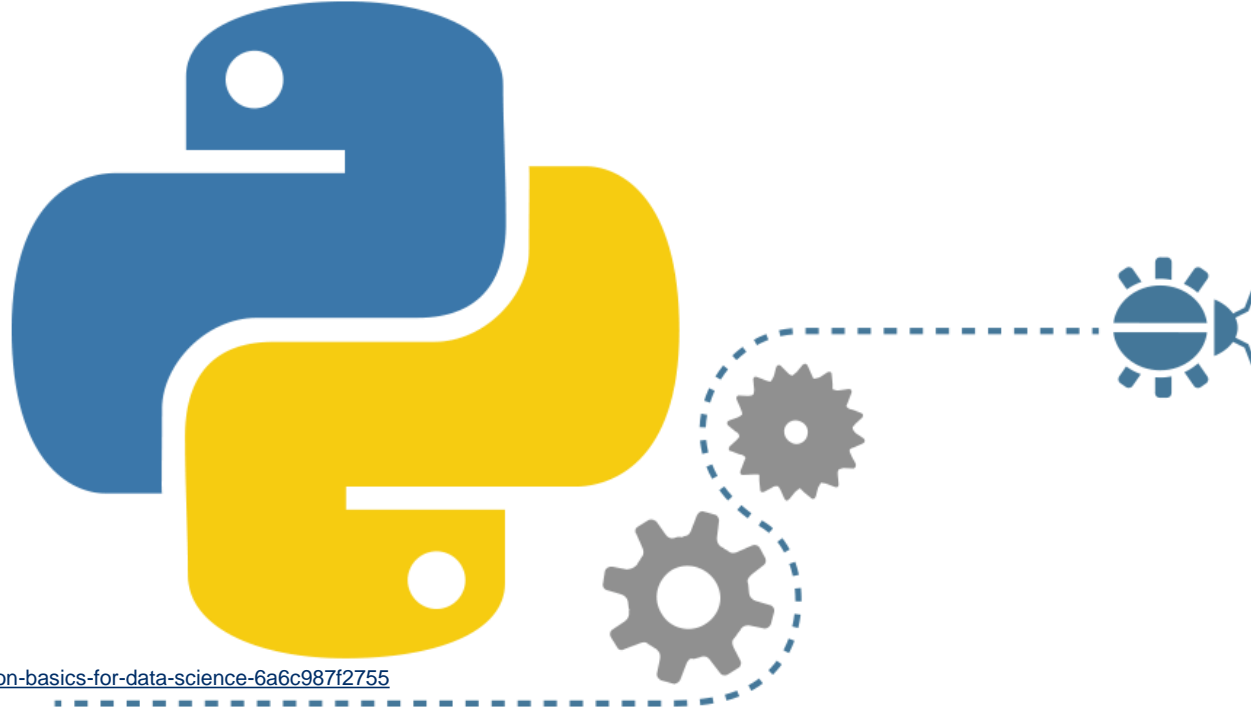
[joaquim.gromicho@ortec.com](mailto:joaquim.gromicho@ortec.com)

**EWG**  
POR  
PRACTICE OF OR

**VU**  
VRIJE  
UNIVERSITEIT  
AMSTERDAM

School of Business  
and Economics

**EURO**  
2019



<https://towardsdatascience.com/python-basics-for-data-science-6a6c987f2755>

**ORTEC**  
OPTIMIZE YOUR WORLD

## Optimization with Python

[joaquim.gromicho@ortec.com](mailto:joaquim.gromicho@ortec.com)

**EWG**  
POR  
PRACTICE OF OR

**VU**  
VRIJE  
UNIVERSITEIT  
AMSTERDAM

School of Business  
and Economics

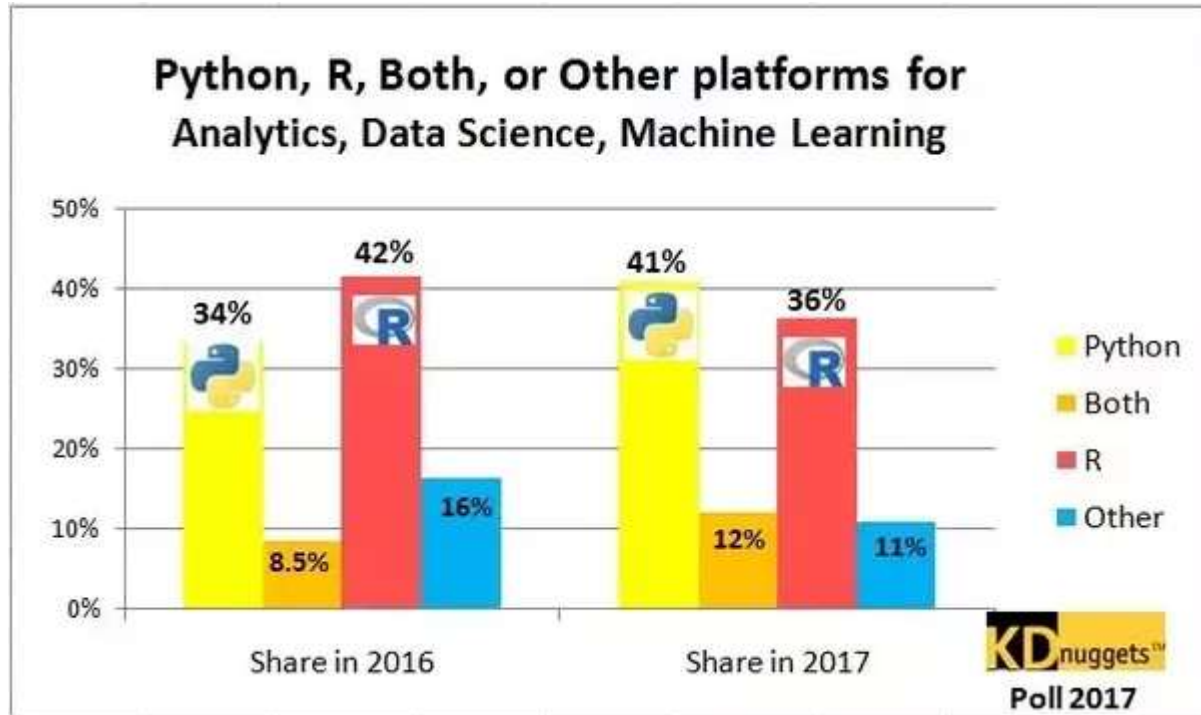
**EURO**  
2019

# The making an impact stream

- Organized by the EWG Practice of OR
- <https://www.euro-online.org/websites/or-in-practice/>
- Please consider to <https://www.euro-online.org/websites/or-in-practice/register/>

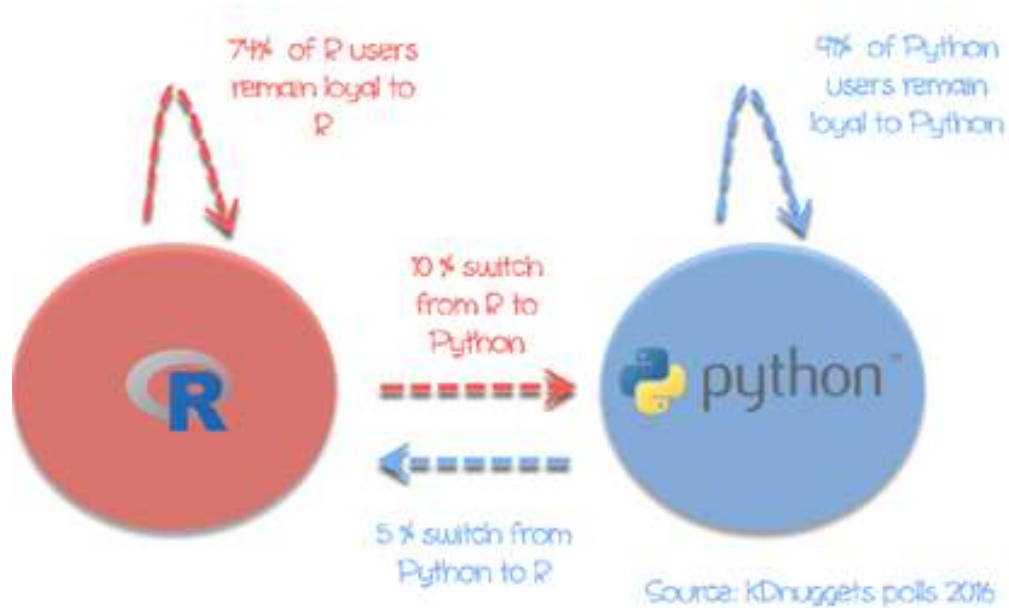


# There seem to be two major camps



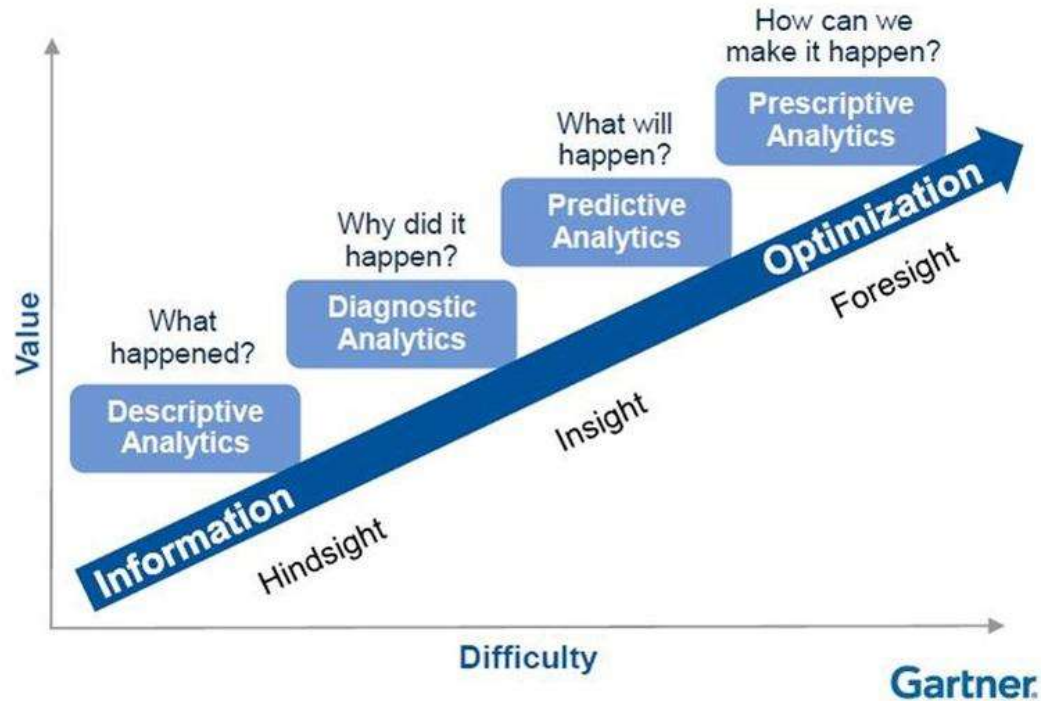
<https://www.kdnuggets.com/2017/08/python-overtakes-r-leader-analytics-data-science.html>

# And python is winning

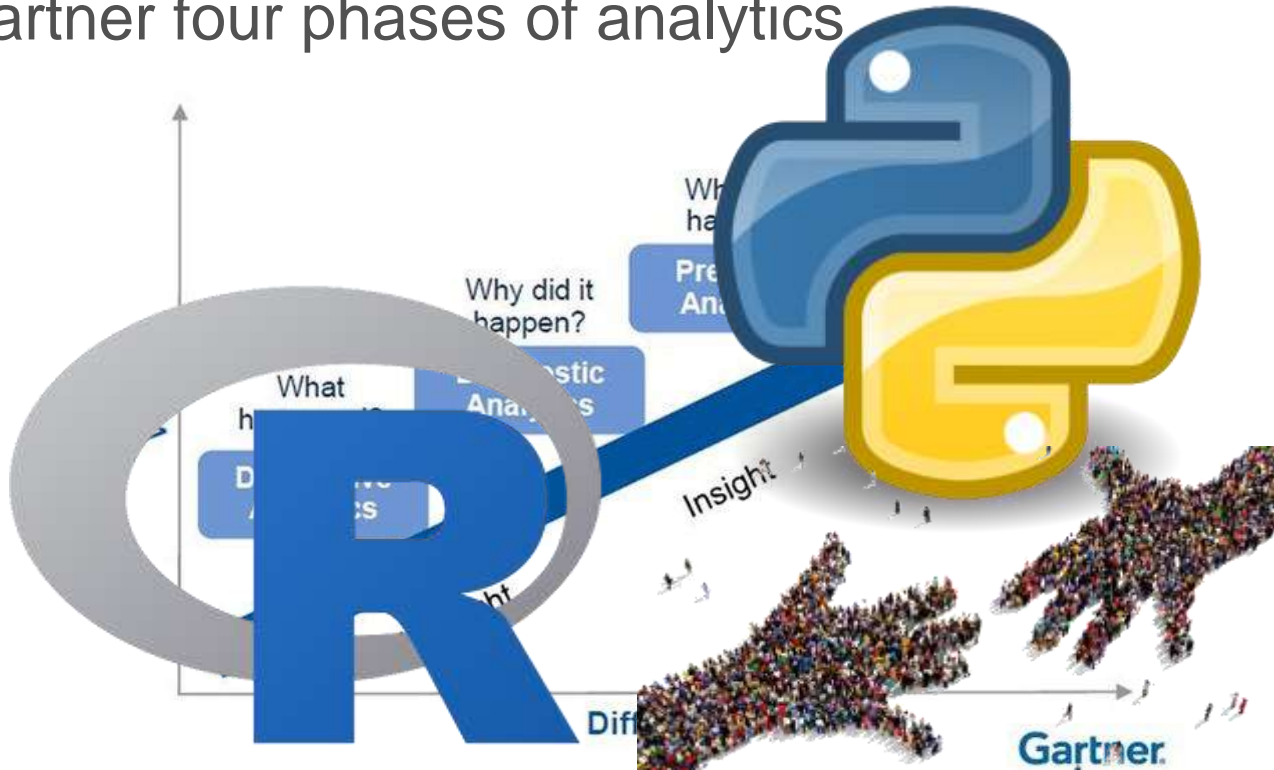


<https://www.guru99.com/r-vs-python.html>

# The Gartner four phases of analytics



# The Gartner four phases of analytics



# Who is my target audience?





# Two possibilities

- A data scientist who knows python and is curious about mathematical optimization.
- An optimization specialist who wants to move closer to the big data community at large and his curious about the possibilities of python for optimization.



# Data Scientist: *The Sexiest Job of the 21st Century*

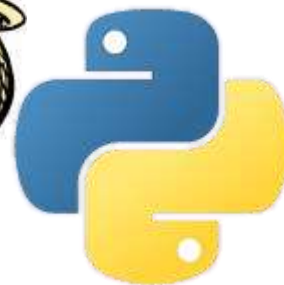
**Meet the people who  
can coax treasure out of  
messy, unstructured data.**

*by Thomas H. Davenport  
and D.J. Patil*

**W**hen Jonathan Goldman arrived for work in June 2006 at LinkedIn, the business networking site, the place still felt like a start-up. The company had just under 8 million accounts, and the number was growing quickly as existing members invited their friends and colleagues to join. But users weren't seeking out connections with the people who were already on the site at the rate executives had expected. Something was apparently missing in the social experience. As one LinkedIn manager put it, "It was like arriving at a conference reception and realizing you don't know anyone. So you just stand in the corner sipping your drink—and you probably leave early."

70 Harvard Business Review October 2012





## <https://www.kdnuggets.com/2018/05/poll-tools-analytics-data-science-machine-learning-results.html>

Python, 65.6% (was 59.0% in 2017), 11% up

R, 48.5% (was 56.6%), 14% down

SQL, 39.6% (was 39.2%), 1% up

Java, 15.1% (was 15.5%), 3% down

Unix, shell/awk/gawk, 9.2% (was 10.8%), 15% down

Other programming and data languages, 6.9%, (was 7.6%), 9% down

C/C++, 6.8%, (was 7.1%), 3% down

Scala, 5.9%, (was 8.3%), 29% down

Perl, 1.0% (was 1.9%), 46% down

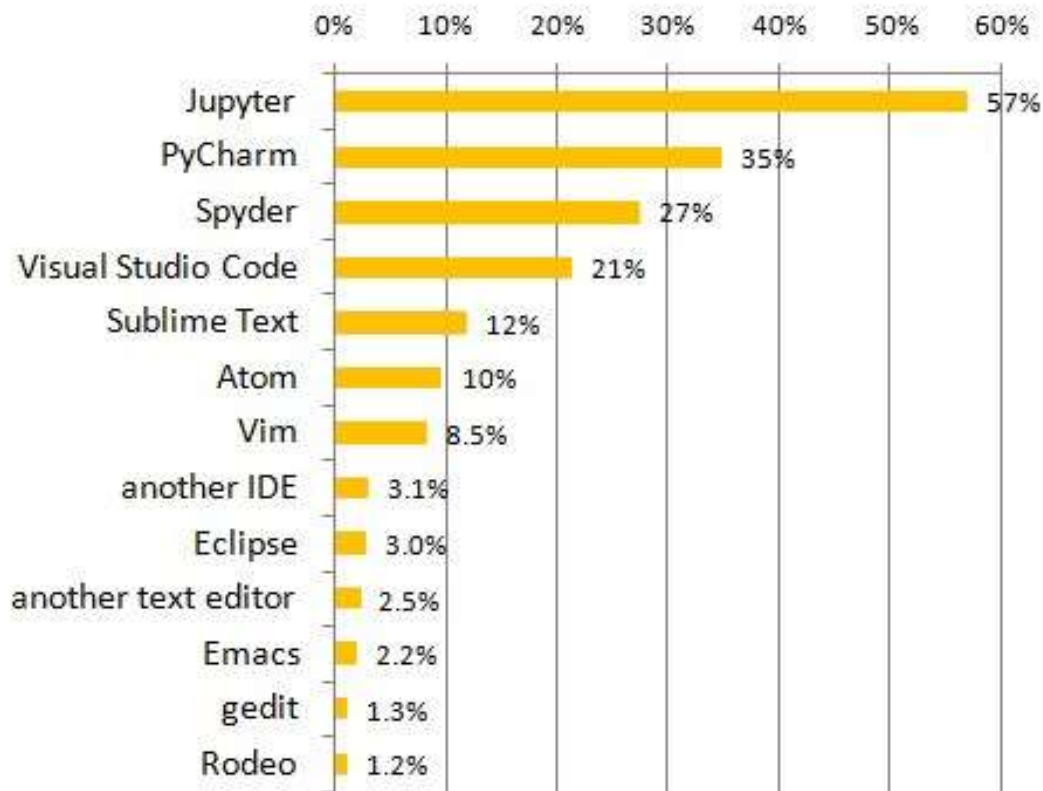
Julia, 0.7% (was 1.2%), 45% down

Lisp, 0.3% (was 0.4%), 25% down

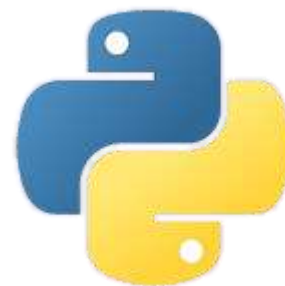
Clojure, 0.2% (was 0.3%), 38% down

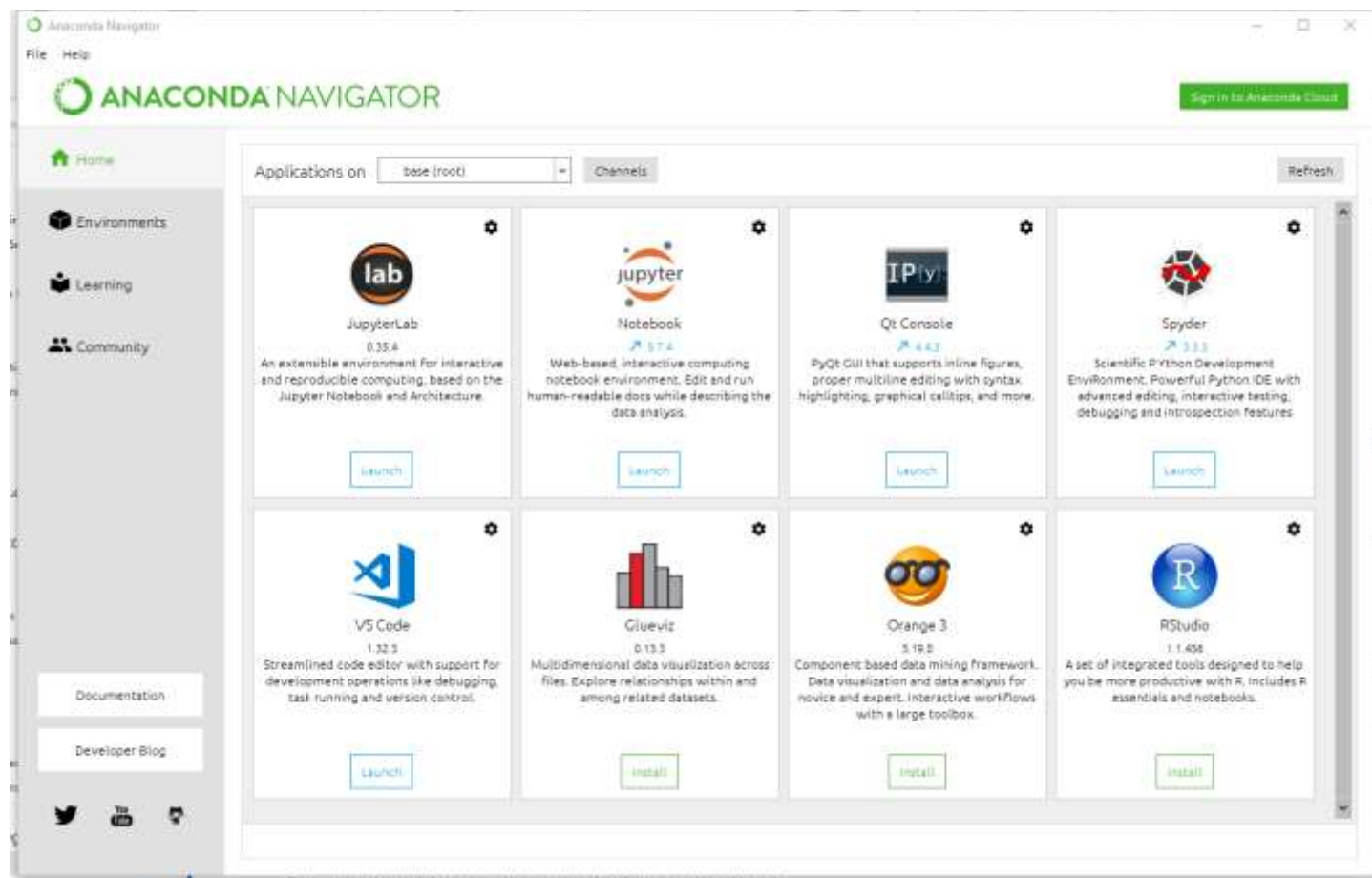
F, # 0.1% (was 0.5%), 73% down

## Most Popular Python IDE, Editors



<https://www.macinchem.org/blog/files/category-jupyter.php>





# Linear Optimization example



# Betty's Trophy Factory

- Betty owns a company that produces trophies for
  - football
    - wood base, engraved plaque, brass football on top
    - €12 profit and uses 4 dm of wood
  - golf
    - wood base, engraved plaque, golf ball on top
    - €9 profit and uses 2 dm of wood
- Betty's current stock of raw materials
  - 1000 footballs
  - 1500 golf balls
  - 1750 plaques
  - 480 m (4800 dm) of wood



Betty wonders what the **optimal** production plan should be, in other words: **how many** football and **how many** golf trophies should Betty produce to **maximize** his profit while **respecting** the availability of raw materials?

Leonid V. Kantorovich,  
Russia 1912-1986

- Invented linear optimization as a powerful **modeling** instrument in 1939.
- This was kept secret at first but ended up awarding him the **Nobel** prize in economics in 1975.



Start by identifying and **naming** the decisions

■ Number of football trophies to produce:

$x_1$

■ Number of golf trophies to produce:

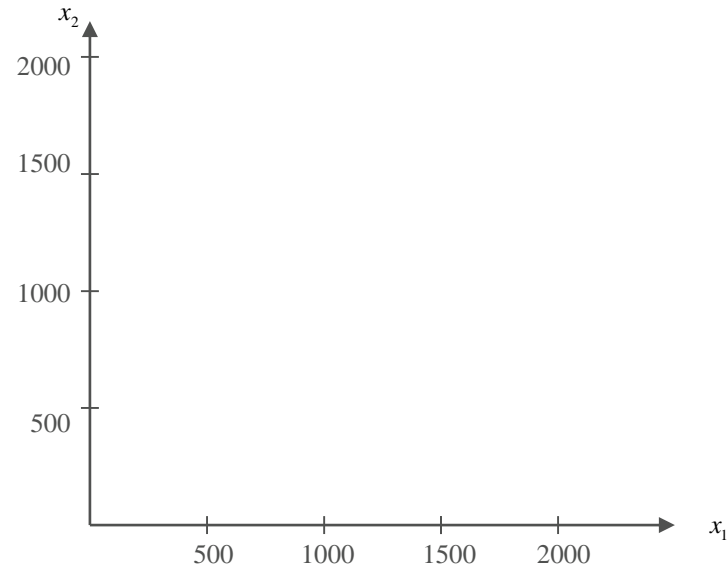
$x_2$

## Complete model of Betty's production optimization

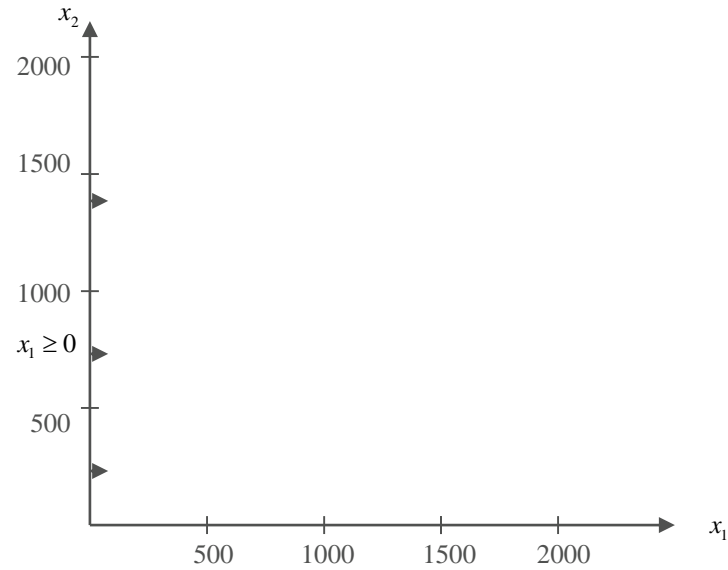
### ■ Also read this one out loud!

$$\begin{array}{ll} \max & 12x_1 + 9x_2 \\ \text{s.t.} & x_1 \leq 1000 \quad \text{Footballs} \\ & x_2 \leq 1500 \quad \text{Golf balls} \\ & x_1 + x_2 \leq 1750 \quad \text{Plaques} \\ & 4x_1 + 2x_2 \leq 4800 \quad \text{Wood} \\ & x_1, x_2 \geq 0 \end{array}$$

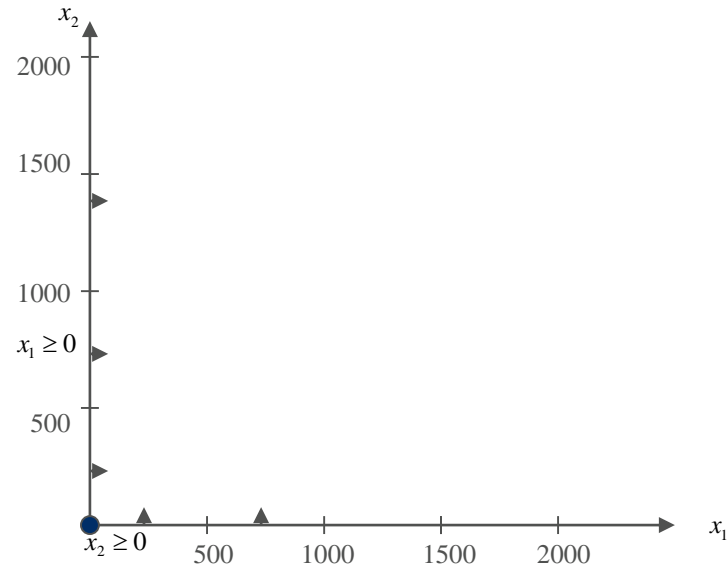
# Graphical Solution



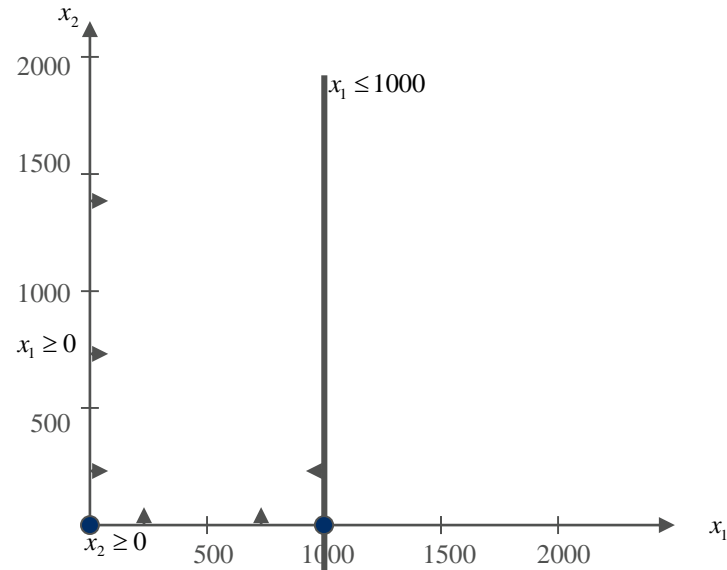
# Graphical Solution



# Graphical Solution

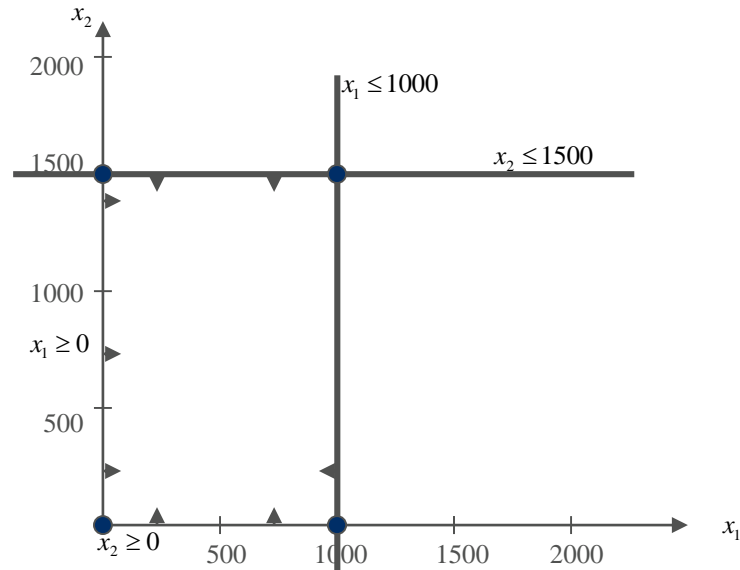


# Graphical Solution

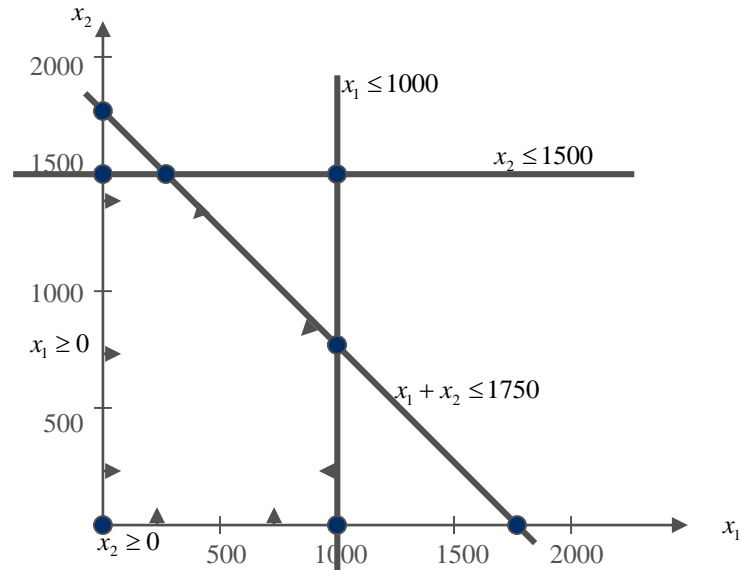




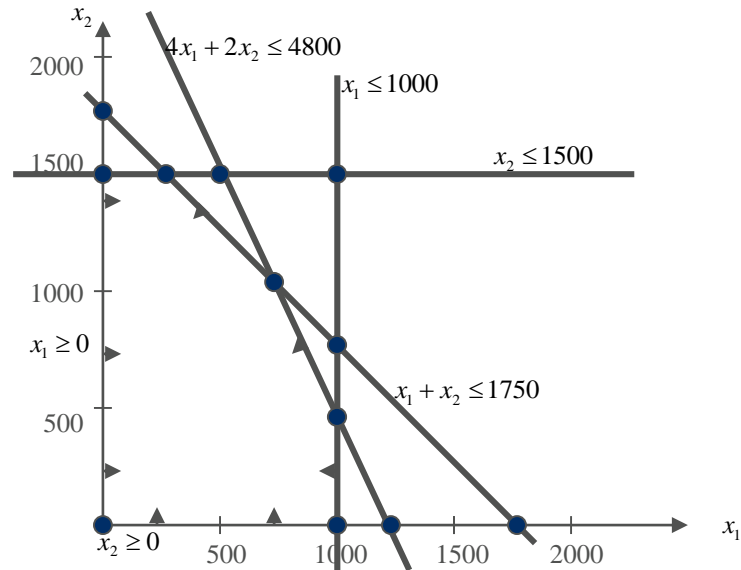
# Graphical Solution



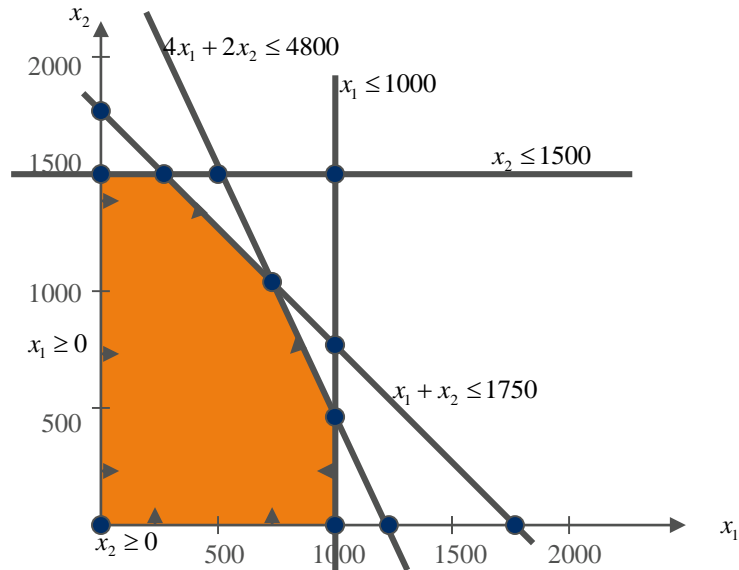
# Graphical Solution



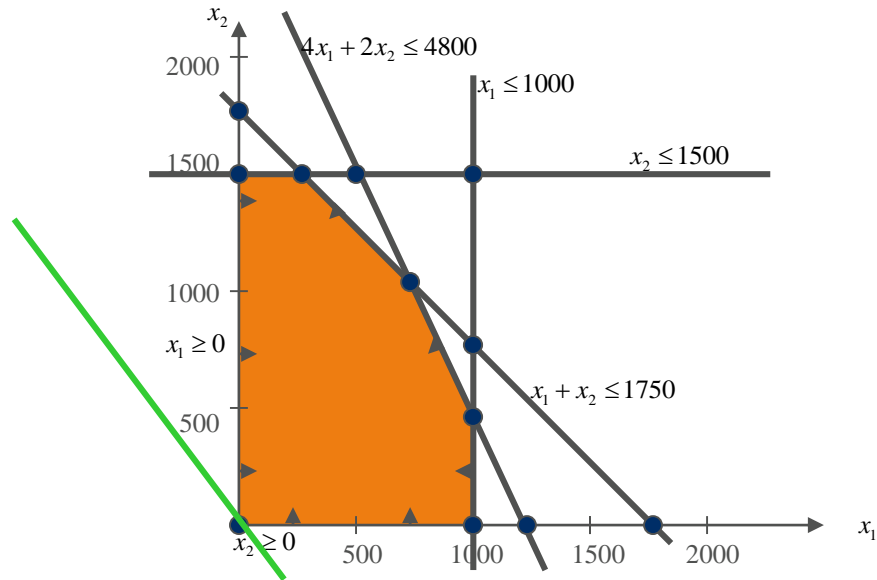
# Graphical Solution



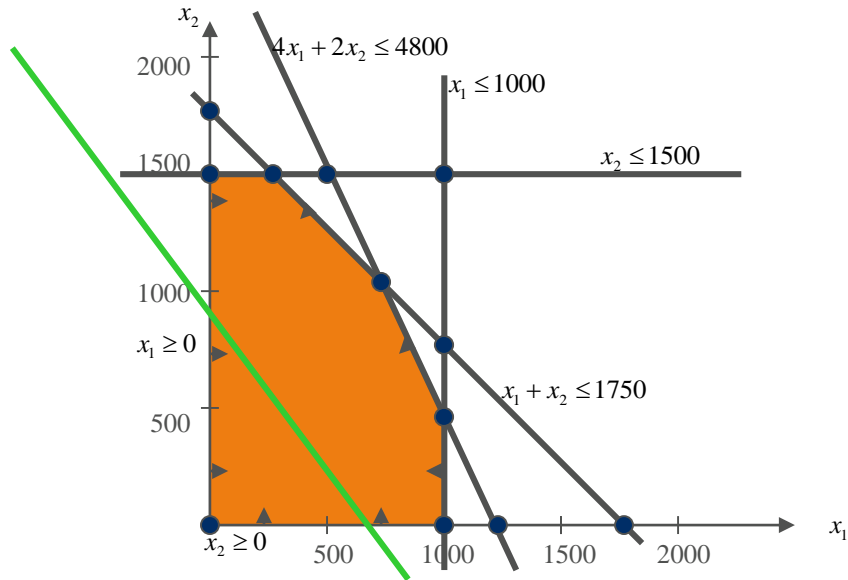
# Graphical Solution



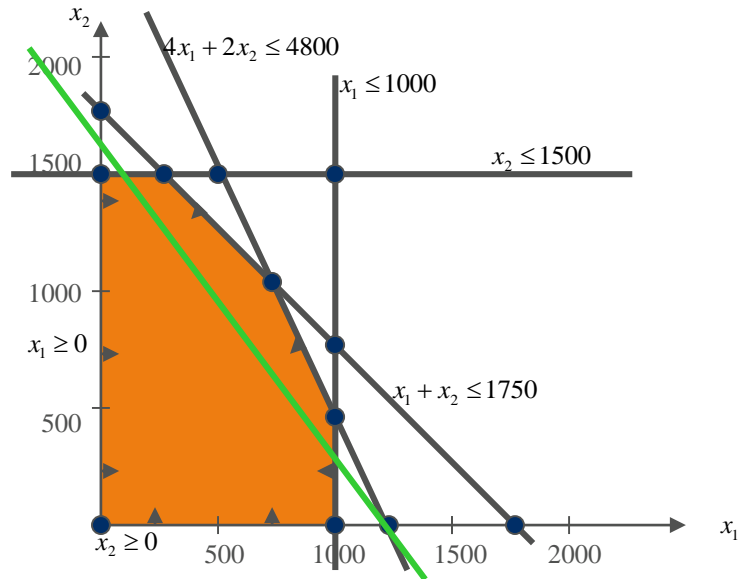
# Graphical Solution



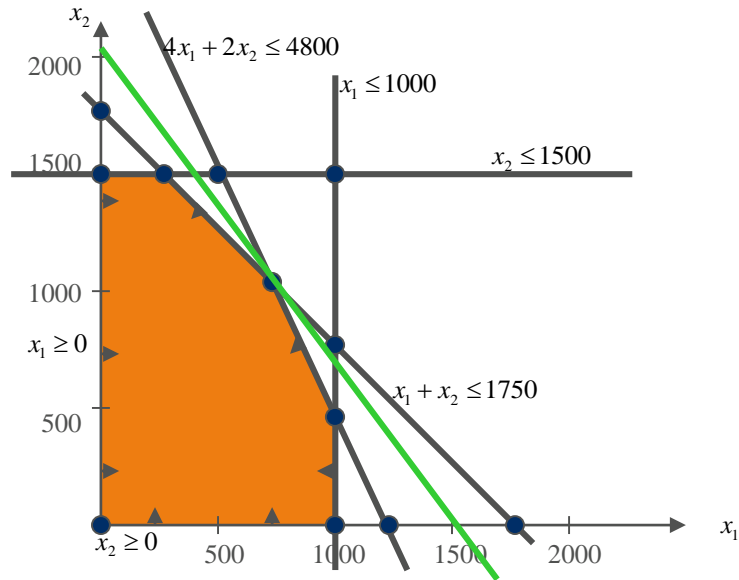
# Graphical Solution



# Graphical Solution

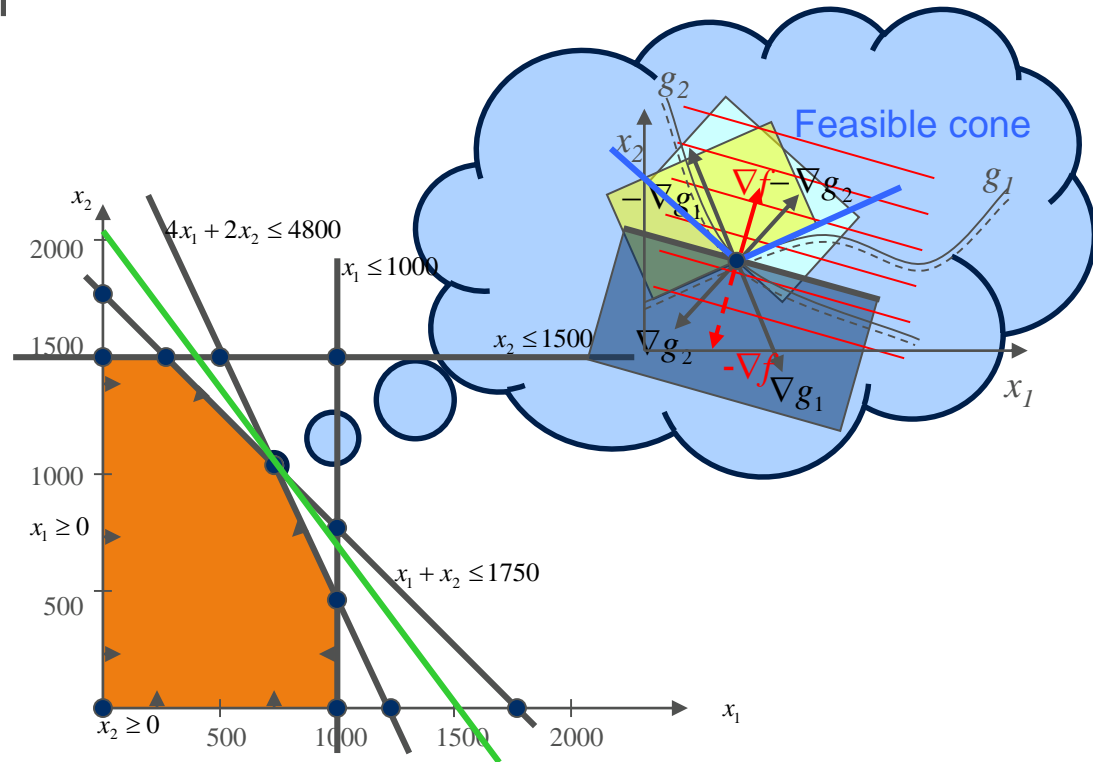


# Graphical Solution

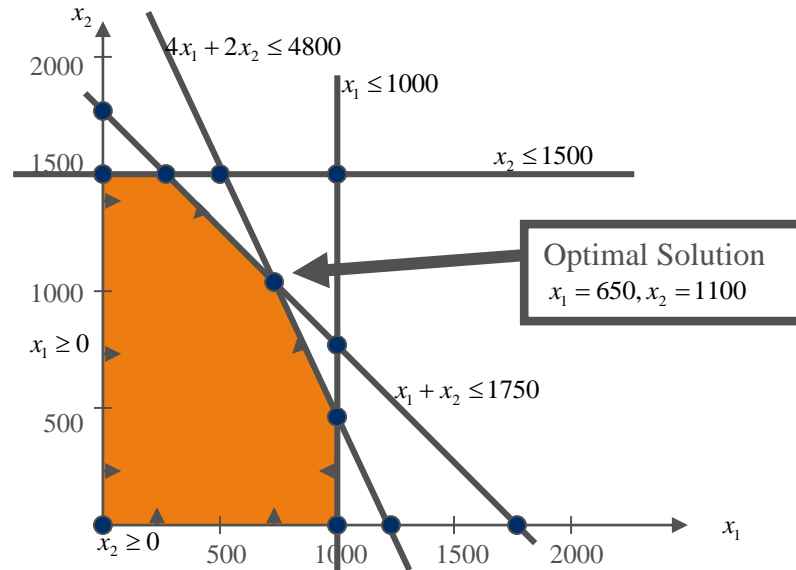




# Graphical Solution



# Graphical Solution

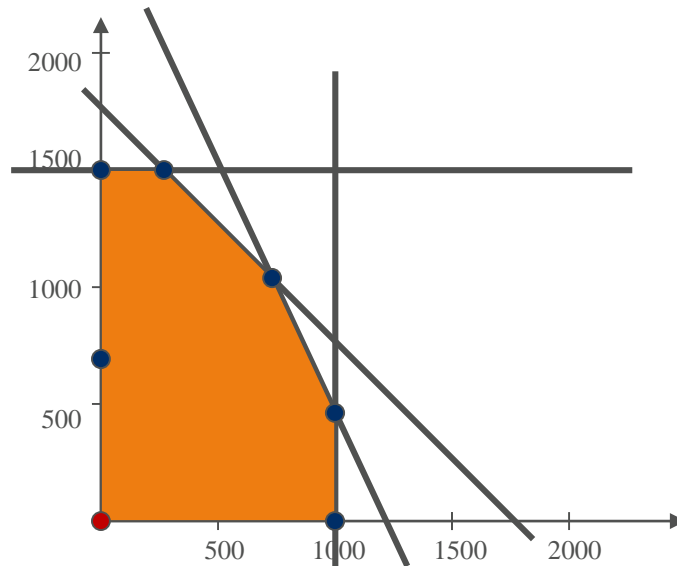


# George Dantzig, USA 1914-2005

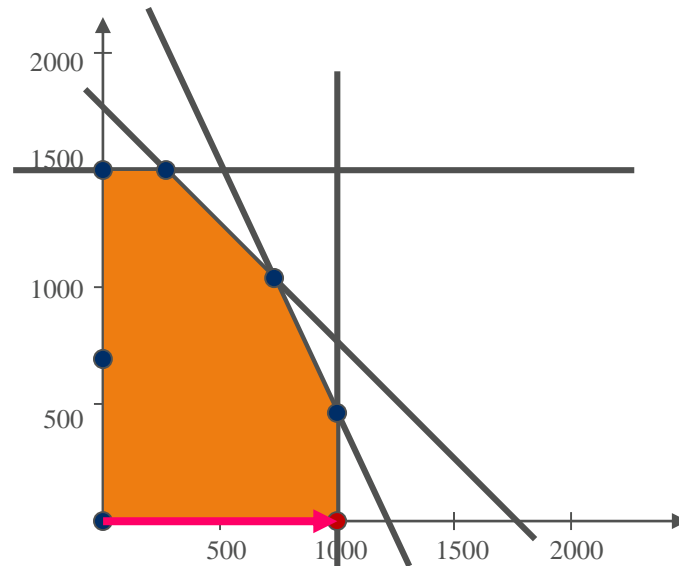
- Designed and implemented the first practical **algorithm** to **solve** linear optimization problems: the **simplex** method.
- That did not award him anything like a Nobel prize...
- The moral of this story: technology is a commodity, the power is in the models!



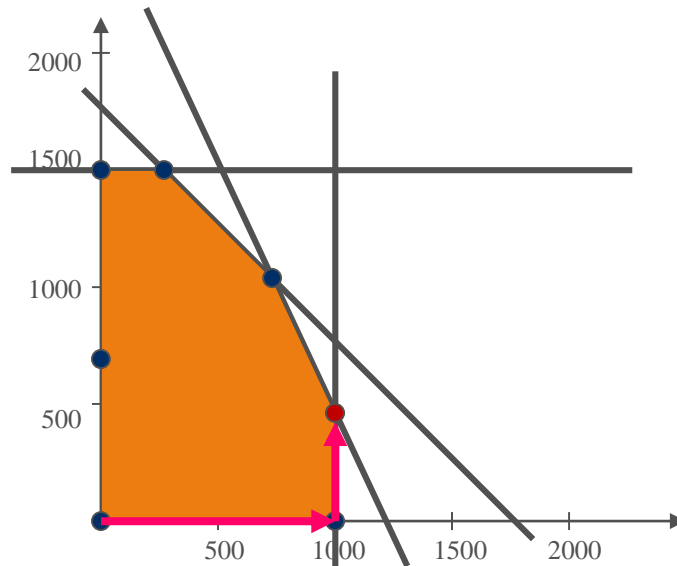
# How the simplex method works



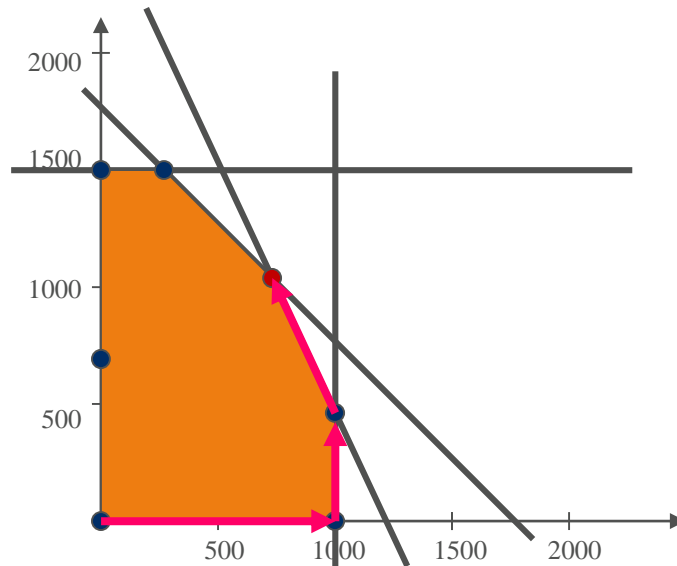
# How the simplex method works



# How the simplex method works



# How the simplex method works



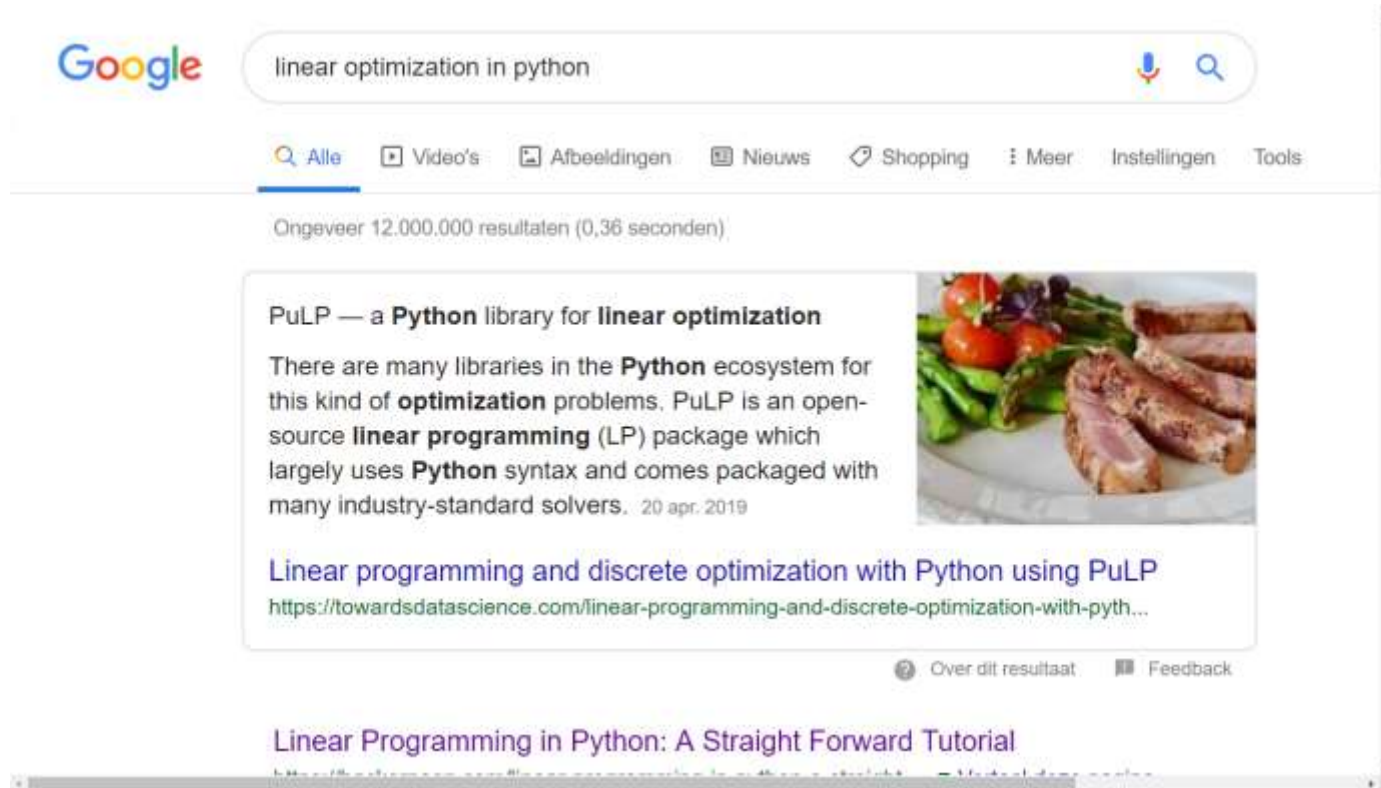
# Solution

- Achieve the maximum attainable profit of € 17.700
- producing 650 football trophies
- and producing 1100 golf trophies
- while using all but 350 brass footballs,
- using all but 400 golf balls,
- using all the plaques,
- and using all of the wood.



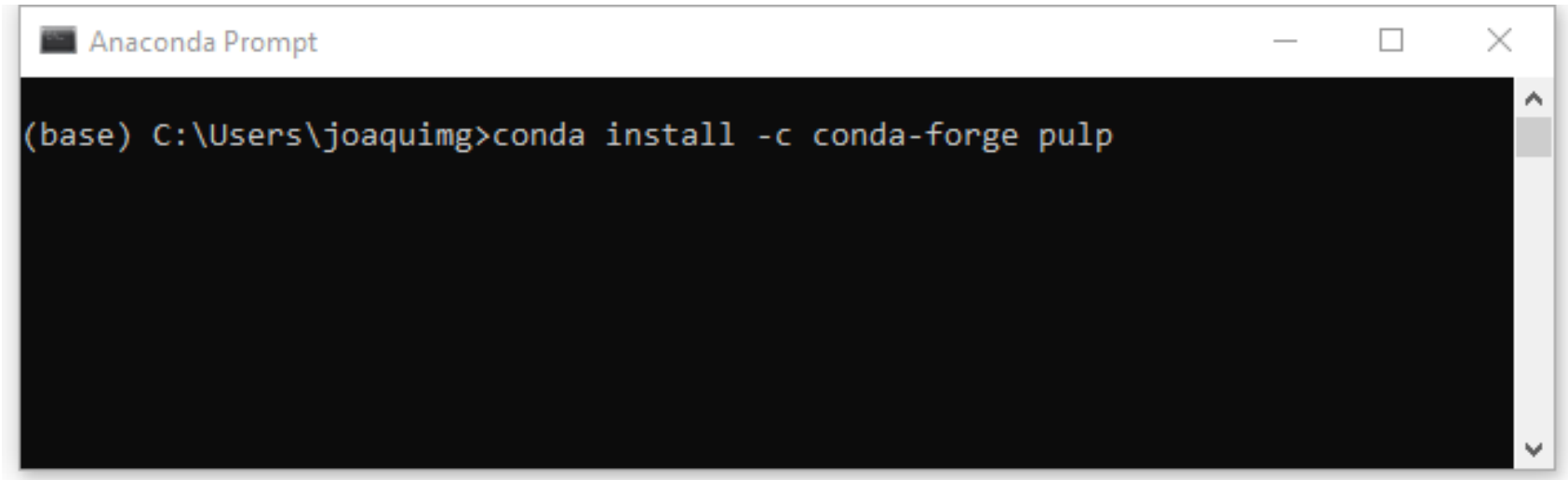


# How to solve it with python?



# Search for: conda pulp

<https://anaconda.org/conda-forge/pulp>



```
Anaconda Prompt
(base) C:\Users\joaquimg>conda install -c conda-forge pulp
```