



wbs
WARWICK BUSINESS SCHOOL
THE UNIVERSITY OF WARWICK

For the
Open
Minded


Mathematical Programming I



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Agenda

- What is Mathematical Programming
- Math Programming & Operational Research
- Syllabus
- Who is teaching
- Have you reflected on how we learn?
- What is to focus on ...
- What we do next
- Summary

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<https://www.britannica.com/science/mathematical-programming>

Article History

Mathematical programming, theoretical tool of management science and economics in which management operations are described by mathematical equations that can be manipulated for a variety of purposes. If the basic descriptions involved take the form of linear algebraic equations, the technique is described as linear programming. If more complex forms are required, the term nonlinear programming is applied. Mathematical programming is used in planning production schedules, in transportation, in military logistics, and in calculating economic growth, by inserting assumed values for the variables in the equations and solving for the unknowns. Computers are widely used in obtaining solutions.

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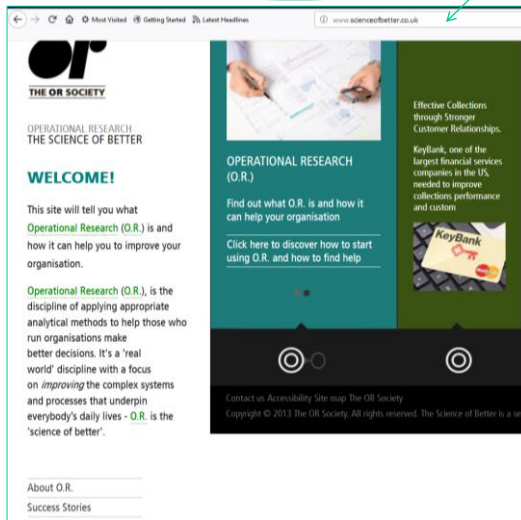
Management science = Operational Research

Mathematical programming, theoretical tool of management science and economics in which management operations are described by mathematical equations that can be manipulated for a variety of purposes. If the basic descriptions involved take the form of linear algebraic equations, the technique is described as linear programming. If more complex forms are required, the term nonlinear programming is applied. Mathematical programming is used in planning production schedules, in transportation, in military logistics, and in calculating economic growth, by inserting assumed values for the variables in the equations and solving for the unknowns. Computers are widely used in obtaining solutions.

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Operational Research

<http://www.scienceofbetter.co.uk/>



...analytical methods...

...better decisions...

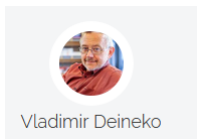
...real world...

...systems and processes...

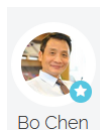
...everybody's daily lives...

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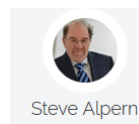


1. Formulation of Linear Programming Models (LP)
2. Solving Linear Programming Problems



3. Duality in LP
4. Algorithm for the Transportation Problem

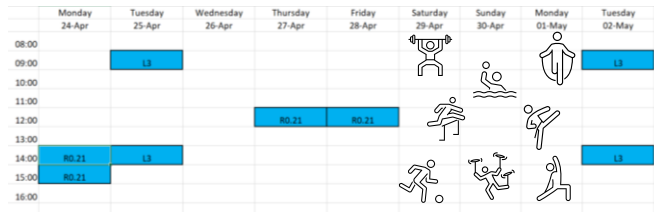
5. Introduction to game theory



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Mathematical Programming I

1. Formulation of Linear Programming Models (LP)
2. Solving Linear Programming Problems



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Business Analytics Consultancy Project

In the dim and distant past

presses to be delivered over the rail network.

heavy presses plant

minimise number of wagons
s.t.
centre of gravity constraint

Two dimensional bin packing

Allocation of Students to Working Teams

Binary vector packing problem

We want groups with the same number of

- male/female
- maths / non-maths
- leaders
- collaborators
- mature students ...

Student A being allocated to Group X should not be disadvantaged (compared with student B being allocated to Group Y)

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[Operational Research](#) · [Discrete Mathematics](#) · [Solvability in Combinatorial ...](#)

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Business Analytics Consultancy Project

Industrial consultancy projects

- Project Title: **Vehicle routing problems (VRP)**
- Participating organisations:
 - Coventry City Council (CCC)
 - Slickers (waste oil collecting services)
- Key results: Savings for real life VRPs instances up to: 20%





Partition of customers found by the new algorithm (up to 20% savings in transportation costs)

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Few tips

$$1+1+1+1 \gg 10$$

much greater than

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Few tips

THE WALL STREET JOURNAL.

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Can Handwriting Make You Smarter?

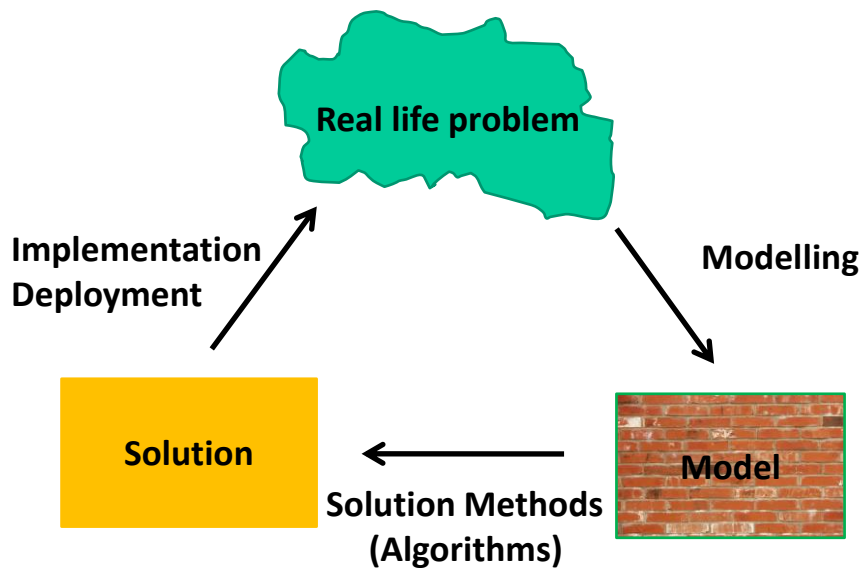
Students who take notes by hand outperform students who type, and more type these days,



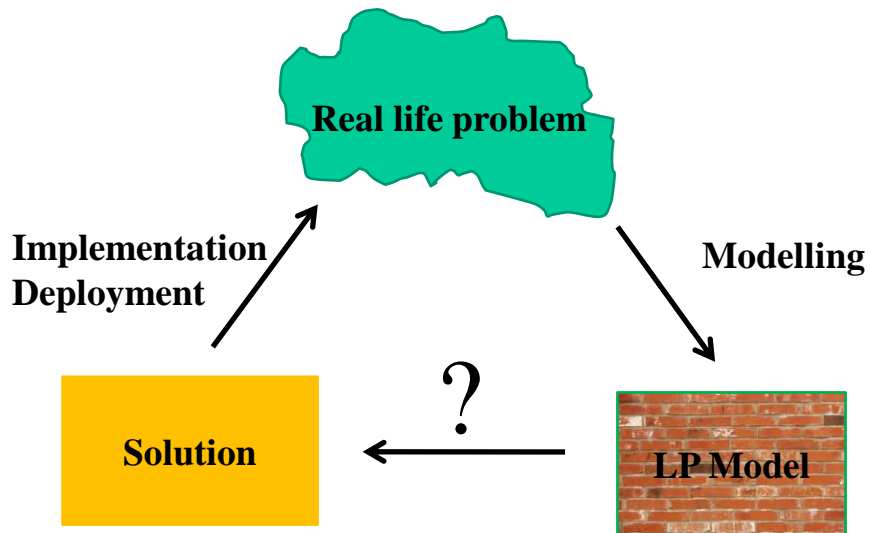
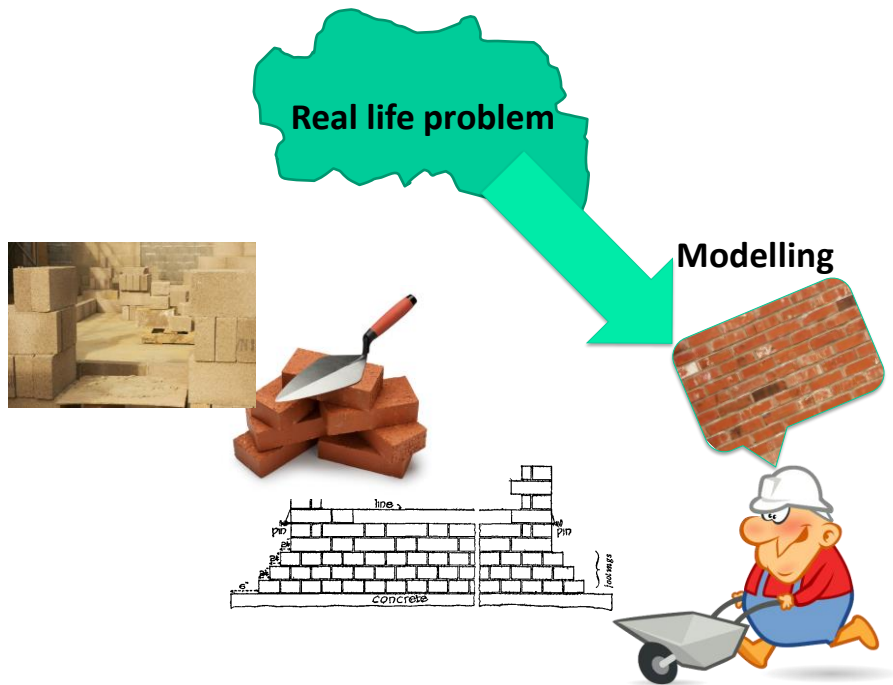
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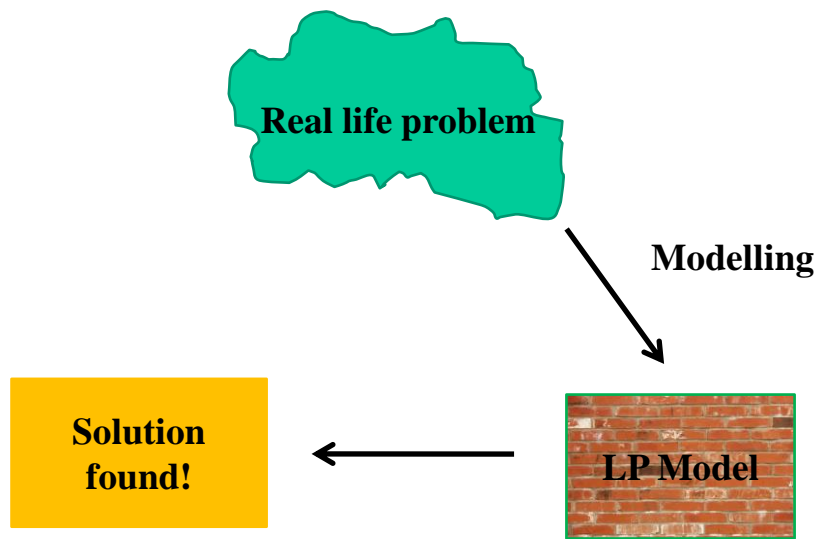
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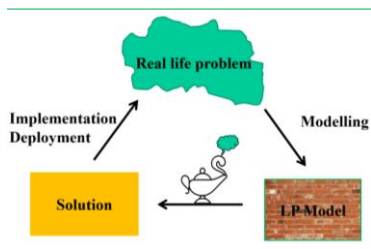


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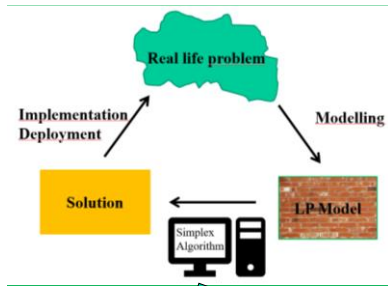
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There are many LP Solvers that implement various algorithms

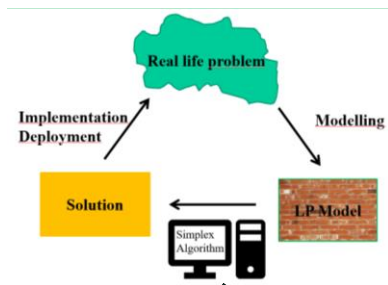
in libraries in R, Python,...
or as stand-alone: Cplex, Concord (commercial)

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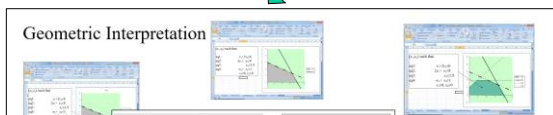


Improved versions of the very first
LP algorithm – Simplex algorithm
– is still in Excel Solver

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Simplex algorithm



The Simplex Method

Step 1
Convert the L.P to standard form (tableau) with non-negative RHS.

Step 2
Obtain a basic feasible solution from the tableau (if possible)

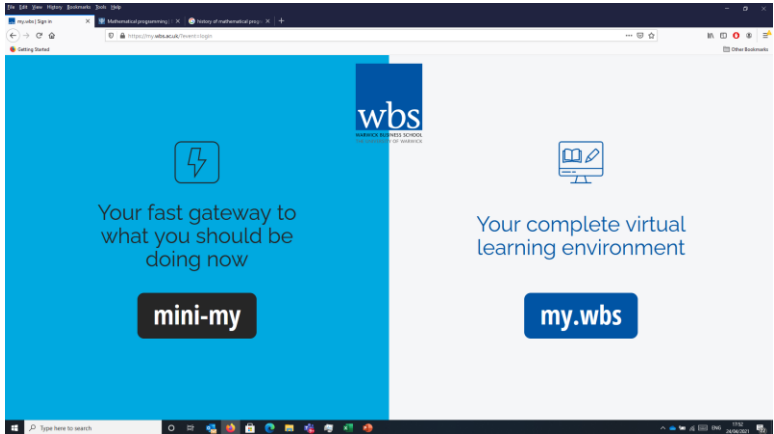
Step 3
Determine whether the current basic feasible solution is optimal.

If all the coefficients in the objective row (row 0) are non-negative, then the algorithm is complete and the function maximised by putting all non-basic variables $x_j = 0$.

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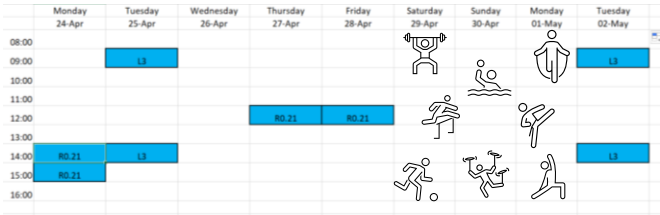
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All teaching material is here



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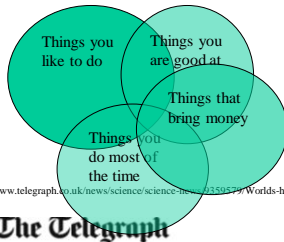
Tasks to accomplish



Introduction to LP1
Introduction to LP2



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<https://www.telegraph.co.uk/news/science/science-news/9359579/Worlds-hardest-sudoku-can-you-crack-it.html>

The Telegraph

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World's hardest sudoku: can you crack it?

Readers who spend hours grappling in vain with the Telegraph's daily sudoku puzzles should look away now.



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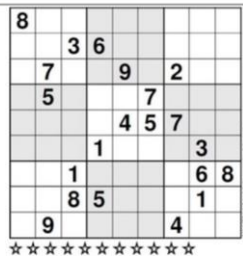
The Telegraph

<https://www.telegraph.co.uk/news/science/science-news/9359579/Worlds-hardest-sudoku-can-you-crack-it.html>

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- In one of the papers published in a maths journal this instance was claimed to be the most difficult to solve

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The Telegraph <https://www.telegraph.co.uk/news/science/science-news/9359579/Worlds-hardest-sudoku-can-you-crack-it.html>

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LP MODEL with 729 variables and 27 constraints

https://pythonhosted.org/PuLP/CaseStudies/a_sudoku_problem.html
 Authors: Antony Phillips, Dr Stuart Mitchell

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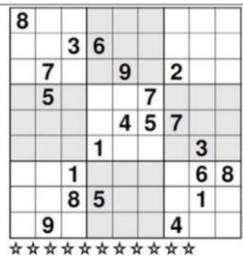
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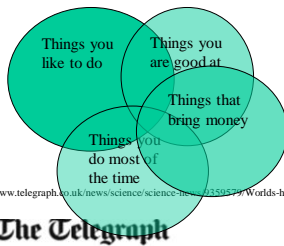
8	1	2	7	5	3	6	4	9
9	4	3	6	8	2	1	7	5
6	7	5	4	9	1	2	8	3
1	5	4	2	3	7	8	9	6
3	6	9	8	4	5	7	2	1
2	8	7	1	6	9	5	3	4
5	2	1	9	7	4	3	6	8
4	3	8	5	2	6	9	1	7
7	9	6	3	1	8	4	5	2

My Python solution

LP MODEL with 729 variables and 27 constraints

https://pythonhosted.org/PuLP/CaseStudies/a_sudoku_problem.html
 Authors: Antony Phillips, Dr Stuart Mitchell

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<https://www.telegraph.co.uk/news/science/science-news/2015/05/29/Worlds-hardest-sudoku-can-you-crack-it.html>

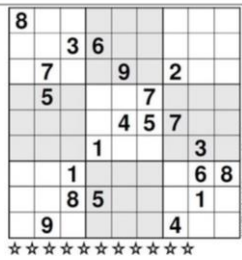
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