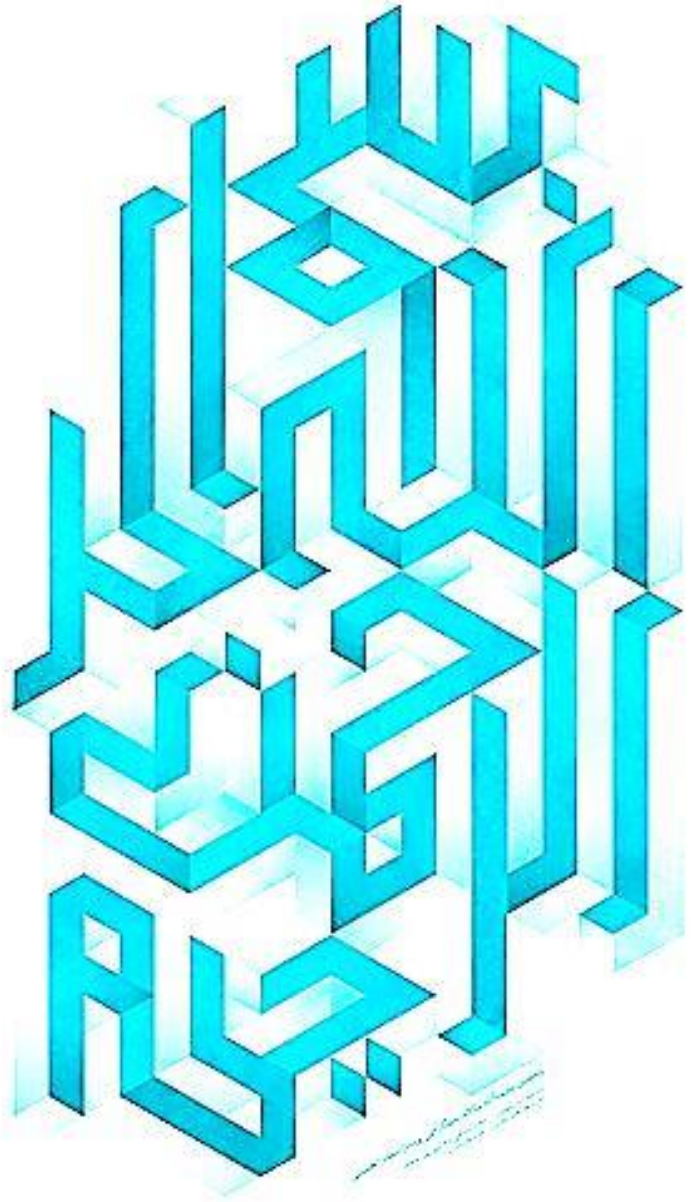

University Of Tehran
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Introduction To

GLPK

GNU Linear Programming Kit

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INTRODUCTION TO GLPK

- What is GLPK?
  - GLPK stands for **GNU Linear Programming Kit**
  - It was developed, and is maintained, by Andrew Makhorin
    - *Department for Applied Informatics, Moscow Aviation Institute*
- GLPK is free, **open source software**
  - The package is part of the GNU Project and is released under the GNU
  - General Public License 3 (GPL3)

WHAT DOES GLPK DO?

- It is a software package to solve large-scale mathematical programs
- Specifically, it solves linear programs (LPs) via:
  - Revised simplex method
  - Primal-dual interior point method
- It solves (linear) mixed-integer programs (MIPs) via:
  - Branch-and-bound algorithm, together with advanced cut routines

VERSIONS

- Today we will be using the latest version of GLPK, version 4.55
- The Windows binaries can be downloaded from the Pitt INFORMS
- GLPK's main website is:
  - http://www.gnu.org/software/glpk
- Pre-compiled binaries from GLPK can be downloaded here:
  - http://winglpk.sourceforge.net
- Note that GLPK can also be used on **Linux** or **Macintosh**
- Solve a CPLEX problem **online**
  - http://hgourvest.github.io/glpk.js

GMPL

- GNU MathProg is a high-level language for creating mathematical programming models.
  - MathProg is specific to GLPK
  - GNU Mathematical Programming Language
- Online Mathematical Programming in GNU MathProg
  - http://www3.nd.edu/~jeff/mathprog/mathprog.html

GUSEK

- Open source LP/MIP IDE for GLPK.
- Models can be developed in the GLPK modeling language (GMPL) and also using the MPS, CPLEX LP, and GLPK LP/MIP problem formats.
- You can edit and run models, check errors, and convert between these formats.
- GLPK examples and some Gusek tips can be found within the package.
- Gusek can be downloaded here:
  - http://gusek.sourceforge.net/gusek.html

SHORT EXAMPLE

- The following MathProg example implements the linear constrained optimization model:

$$\text{maximize } 0.6x_1 + 0.5x_2$$
$$\text{subject to } x_1 + 2x_2 \leq 1$$
$$3x_1 + x_2 \leq 2$$

- In this model, there is no requirement for x_1 and x_2 to be non-negative:

```
# short example
var x1;
var x2;
maximize obj: 0.6 * x1 + 0.5 * x2;
s.t. c1: x1 + 2 * x2 <= 1;
s.t. c2: 3 * x1 + x2 <= 2;
solve;
display x1, x2;
end;
```

```
$ glpsol --math short.mod
```

EXAMPLE LP

- A factory produces health food. There are four raw materials, A, B, C, and D, that can be used to produce the food. At least 18 kg of protein, 31 kg of carbohydrate, and 25 kg of fat are required to produce the food. Ingredients of each raw material are shown in follow Table.

Raw Material	Nutrient ratio			Price ($/kg)
	Protein	Carbohydrate	Fat	
A	0.18	0.43	0.31	5.00
B	0.31	0.25	0.37	7.50
C	0.12	0.12	0.37	3.75
D	0.18	0.50	0.12	2.50

EXAMPLE LP (CONT.)

Raw Material	Nutrient ratio			Price ($/kg)
	Protein	Carbohydrate	Fat	
A	0.18	0.43	0.31	5.00
B	0.31	0.25	0.37	7.50
C	0.12	0.12	0.37	3.75
D	0.18	0.50	0.12	2.50

- The factory wants to produce the food while minimizing the **nutrient** cost. Formulate an LP problem.

EXAMPLE LP (CONT.)

- Let x_1, x_2, x_3, and x_4 be the raw materials *A*, *B*, *C*, and *D* (kg), respectively.
- Let **z** be the nutrient cost. The optimization problem of minimizing **z** is formulated as an LP problem as follows.

EXAMPLE LP (CONT.)

Objective

$$\min z = 5.00x_1 + 7.50x_2 + 3.75x_3 + 2.50x_4$$

Contraints

$$0.18x_1 + 0.31x_2 + 0.12x_3 + 0.18x_4 \geq 18$$

$$0.43x_1 + 0.25x_2 + 0.12x_3 + 0.50x_4 \geq 31$$

$$0.31x_1 + 0.37x_2 + 0.37x_3 + 0.12x_4 \geq 25$$

$$x_1 \geq 0$$

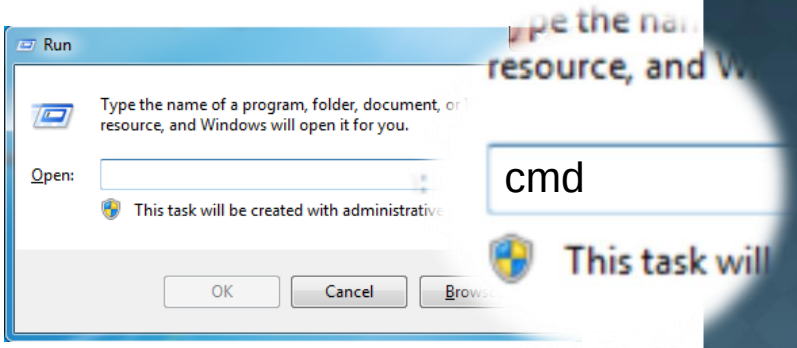
$$x_2 \geq 0$$

$$x_3 \geq 0$$

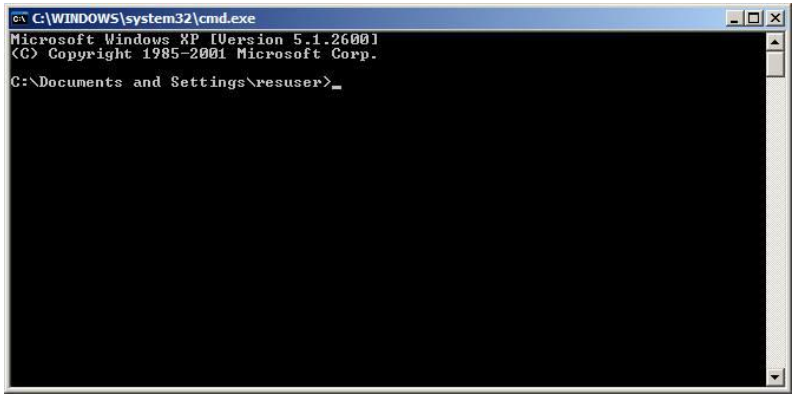
$$x_4 \geq 0$$

FINDING GLPK INTERACTIVE OPTIMIZER: GLPSOL

- cmd window
  - Start → Run →“Cmd”, or
  - WinKey + R →“Cmd”



  - The cmd window looks like:



FINDING GLPK INTERACTIVE OPTIMIZER: GLPSOL

- Navigating to GLPK\bin directory
  - Switch to drive where GLPK folder is installed
- Type cd "<folder names> \ . . ." to navigate to the directory that contains the GLPK folder
- Now, type cd "GLPK\bin" (version 4.55) OR
- type cd "GLPK\w64" or "GLPK\w32"

- GLPSOL is now available from this directory

CREATE MODEL FILE

- Insert Modeled problem into … .mod file

```
Var x1 >=0 ;
Var x2 >=0 ;
Var x3 >=0 ;
Var x4 >=0 ;

minimize z: 5*x1 + 7.5*x2 + 3.75*x3 + 2.5*x4 ;
s.t.st1: 0.18*x1 + 0.31*x2 + 0.12*x3 + 0.18*x4 >= 18 ;
s.t.st2: 0.43*x1 + 0.25*x2 + 0.12*x3 + 0.5*x4 >= 31 ;
s.t.st3: 0.31*x1 + 0.37*x2 + 0.37*x3 + 0.12*x4 >= 25 ;

end;
```

CREATE LP MODEL FILE

- Insert lp Model problem into … .lp file

```
Minimize
  obj: 5 x1 + 7.5 x2 + 3.75 x3 + 2.5 x4
Subject To
c1: .18 x1 + .31 x2 + .12 x3 + .18 x4 >= 18
c2: .43 x1 + .25 x2 + .12 x3 + .5 x4 >= 31
c3: .31 x1 + .37 x2 + .37 x3 + .12 x4 >= 25
End
```

CREATE OUTPUT FILE

- Type in CMD Console: