# Introduction to GAMS

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# GAMS

- The General Algebraic Modeling System (GAMS) is a high-level modeling system for mathematical programming problems. It consists of a language compiler and a stable of integrated high-performance solvers.
- Different types of optimization models can be solved using GAMS.

# GAMS Model Types

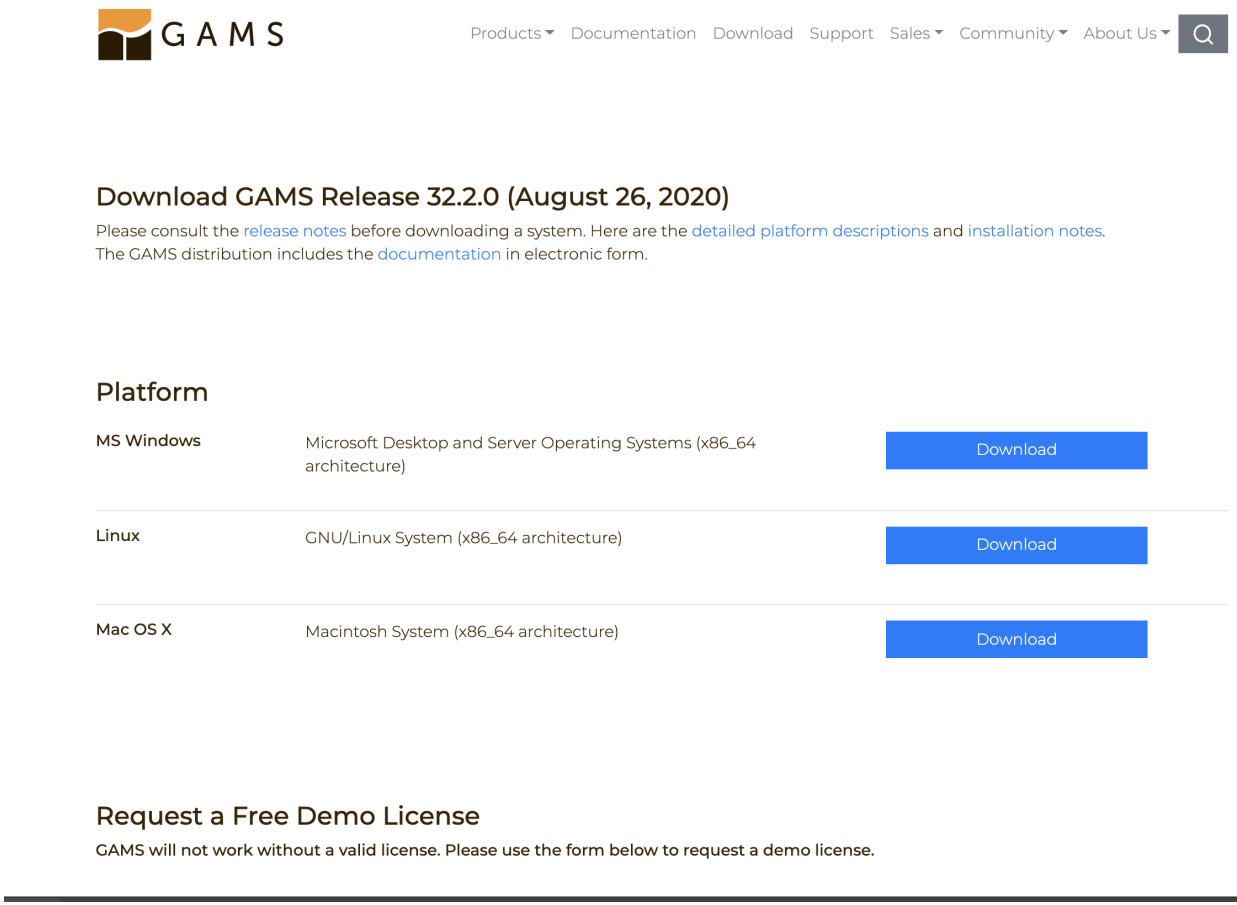
| GAMS Model Type | Model Type Description | Requirements and Comments |
|---|---|---|
| LP | Linear Program | Model with no nonlinear terms or discrete (i.e. binary, integer, etc) variables. |
| NLP | Nonlinear Program | Model with general nonlinear terms involving only *smooth* functions, but no discrete variables. For a classification of functions as to smoothness, see section **Functions**. |
| QCP | Quadratically Constrained Program | Model with linear and quadratic terms, but no general nonlinear terms or discrete variables. |
| DNLP | Discontinuous Nonlinear Program | Model with *non-smooth* nonlinear terms with discontinuous derivatives, but no discrete variables. This is the same as `NLP`, except that non-smooth functions may appear as well. These models are more difficult to solve than normal `NLP` models and we strongly advise not to use this model type. |
| MIP | Mixed Integer Program | Model with binary, integer, SOS and/or semi variables, but no nonlinear terms. |
| RMIP | Relaxed Mixed Integer Program | Like `MIP`, except that the discrete variable requirement is relaxed. See the note below on relaxed model types. |
| MINLP | Mixed Integer Nonlinear Program | Model with both nonlinear terms *and* discrete variables. |
| RMINLP | Relaxed Mixed Integer Nonlinear Program | Like `MINLP` except that the discrete variable requirement is relaxed. See the note below on relaxed model types. |
| MIQCP | Mixed Integer Quadratically Constrained Program | Model with both quadratic terms *and* discrete variables, but no general nonlinear term. |
| RMIQCP | Relaxed Mixed Integer Quadratically Constrained Program | Like `MIQCP` except that the discrete variable requirement is relaxed. See the note below on relaxed model types. |
| MCP | Mixed Complementarity Problem | A square, possibly nonlinear, model that generalizes a system of equations. Rows and columns are matched in one-to-one complementary relationships. |
| CNS | Constrained Nonlinear System | Model solving a square, possibly nonlinear system of equations, with an equal number of variables and constraints. |
| MPEC | Mathematical Programs with Equilibrium Constraints | A difficult model type for which solvers and reformulations are currently being developed. |
| RMPEC | Relaxed Mathematical Program with Equilibrium Constraints | A difficult model type for which solvers and reformulations are currently being developed. See the note below on relaxed model types. |
| EMP | Extended Mathematical Program | A family of mathematical programming extensions. |
| MPSGE | General Equilibrium | Not actually a model type but mentioned for completeness, see **MPSGE**. |

# GAMS Solver-Model Matrix

| | LP | MIP | NLP | MCP | MPEC | CNS | DNLP | MINLP | QCP | MIQCP | Stoch. | Global |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALPHAECP | | | | | | | | ✔ | | ✔ | | |
| ANTIGONE | | | ✔ | | | ✔ | ✔ | ✔ | ✔ | ✔ | | ✔* |
| BARON | ✔ | ✔ | ✔ | | | ✔ | ✔ | ✔ | ✔ | ✔ | | ✔* |
| BDMLP | ✔ | ✔ | | | | | | | | | | |
| BONMIN | | | | | | | | ✔ | | ✔ | | |
| CBC | ✔ | ✔ | | | | | | | | | | |
| CONOPT 3 | ✔ | | ✔ | | | ✔ | ✔ | | ✔ | | | |
| CONOPT 4 | ✔ | | ✔ | | | ✔ | ✔ | | ✔ | | | |
| COUENNE | | | ✔ | | | ✔ | ✔ | ✔ | ✔ | ✔ | | ✔* |
| CPLEX | ✔ | ✔ | | | | | | | ✔ | ✔ | | |
| DECIS | ✔ | | | | | | | | | | ✔ | |
| DICOPT | | | | | | | | ✔ | | ✔ | | |
| GLOMIQO | | | | | | | | | ✔ | ✔ | | ✔* |
| GUROBI | ✔ | ✔ | | | | | | | ✔ | ✔ | | |
| GUSS | ✔ | ✔ | ✔ | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | | |
| IPOPT | ✔ | | ✔ | | | ✔ | ✔ | | ✔ | | | |
| KESTREL | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | | |
| KNITRO | ✔ | | ✔ | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | | |
| LGO | ✔ | | ✔ | | | | ✔ | | ✔ | | | ✔ |
| LINDO | ✔ | ✔ | ✔ | | | | ✔ | ✔ | ✔ | ✔ | ✔ | ✔* |
| LINDOGLOBAL | ✔ | ✔ | ✔ | | | | ✔ | ✔ | ✔ | ✔ | | ✔* |
| LOCALSOLVER | | ✔ | ✔ | | | ✔ | ✔ | ✔ | ✔ | ✔ | | |
| MILES | | | | ✔ | | | | | | | | |
| MINOS | ✔ | | ✔ | | | ✔ | ✔ | | ✔ | | | |
| MOSEK | ✔ | ✔ | ✔ | | | | ✔ | ✔ | ✔ | ✔ | | |
| MSNLP | | | ✔ | | | | ✔ | | ✔ | | | ✔ |
| NLPEC | | | | ✔ | ✔ | | | | | | | |
| ODHCPLEX | | ✔ | | | | | | | | ✔ | | |
| PATH | | | | ✔ | | ✔ | | | | | | |
| SBB | | | | | | | | ✔ | | ✔ | | |
| SCIP | | ✔ | ✔ | | | ✔ | ✔ | ✔ | ✔ | ✔ | | ✔* |
| SHOT | | | | | | | | ✔ | | ✔ | | |
| SNOPT | ✔ | | ✔ | | | ✔ | ✔ | | ✔ | | | |
| SOLVEENGINE | ✔ | ✔ | | | | | | | | | | |
| SOPLEX | ✔ | | | | | | | | | | | |
| XA | ✔ | ✔ | | | | | | | | | | |
| XPRESS | ✔ | ✔ | ✔ | | | ✔ | ✔ | ✔ | ✔ | ✔ | | |

# Download GAMS

https://www.gams.com/download/



# GAMS Licenses

- Demo (Default) :For linear models (LP, RMIP, and MIP) GAMS will generate and solve models with up to 2000 constraints and 2000 variables.
- Community: Users can request a free community license from sales@gams.com. The community license lets you generate and solve linear models (LP, MIP, and RMIP) that do not exceed 5000 variables and 5000 constraints.
- Purchase license.

# Alternative

If your model exceeds Demo/Community license limits and you don't have money: Neos Solver.
The NEOS Server offers the IBM ILOG CPLEX Optimizer for the solution of linear programming (LP), mixed-integer linear programming (MILP), and second-order conic programming (SOCP) problems.
Acceptable input formats for CPLEX on the NEOS server include AMPL, GAMS, LP, MPS, and NL formats.

# The basic components of a GAMS model

| | |
|---|---|
| Inputs | **Sets**<br>Declaration<br>Assignment of members |
| | **Data** (`Parameters, Tables, Scalars`)<br>Declaration<br>Assignment of values |
| | **Variables**<br>Declaration<br>Assignment of type |
| | **Assignment of Variable Bounds and/or Initial Values** (optional) |
| | **Equations**<br>Declaration<br>Definition |
| | **Model and Solve Statements** |
| | **Display Statements** (optional) |

# The basic components of a GAMS model

| | |
|---|---|
| Outputs | **Echo Prints** |
| | **Reference Maps** |
| | **Equation Listings** |
| | **Status Reports** |
| | **Solution Reports** |

# General Rules For Formating and Ordering Statements

- GAMS is case insensitive. The user-defined name "const" is identical to "CONst" and "CONST".
- Individual GAMS statements may be formatted in almost any style. Multiple lines may be used for a statement, blank lines may be embedded and any number of spaces or tabs may be inserted.
- Each statement should terminated with a semicolon
- Statements must be ordered such that identifiers are declared before they are used.

# Example

(Diet Problem ,Winston 3.4., p. 69)

$$Minz = 50x_1 + 20x_2 + 30x_3 + 80x_4$$

$$s.t$$

$$400x_1 + 200x_2 + 150x_3 + 500x_4 \geq 500$$

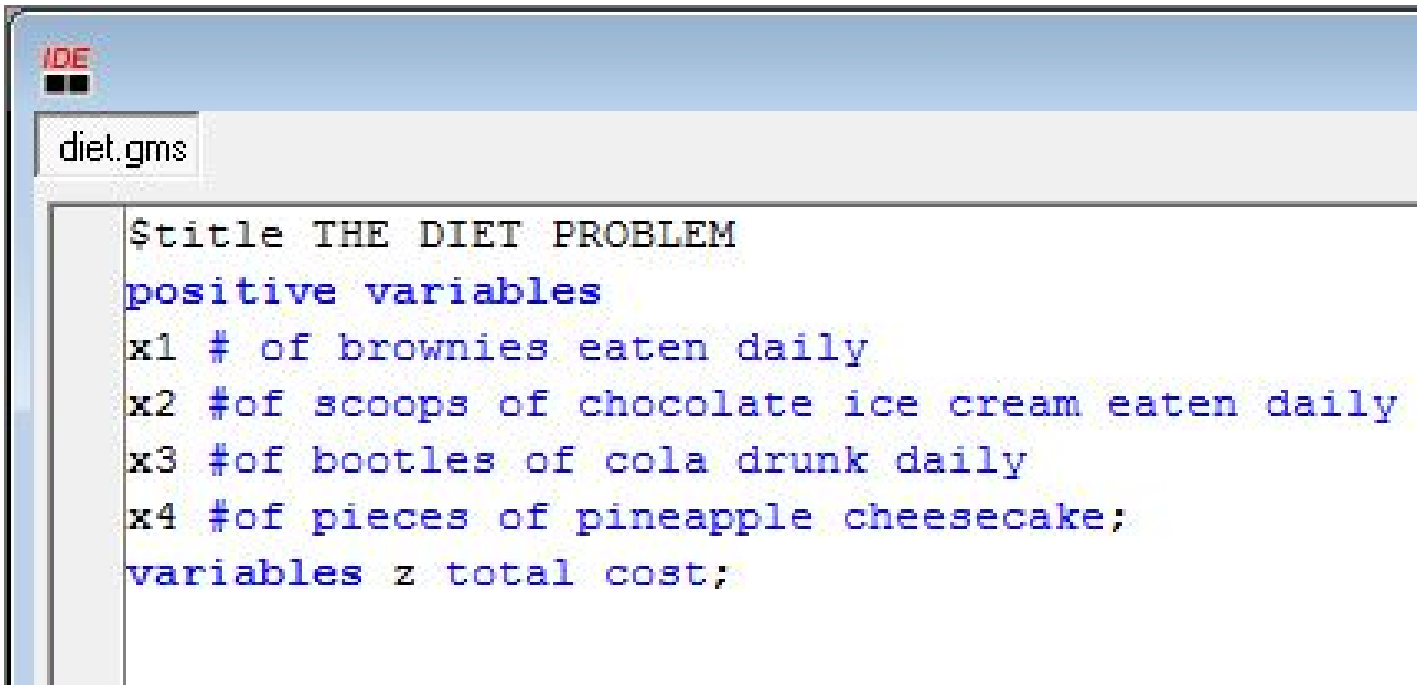
$$3x_1 + 2x_2 \geq 6$$

$$2x_1 + 2x_2 + 4x_3 + 4x_4 \geq 10$$

$$2x_1 + 4x_2 + x_3 + 5x_4 \geq 8$$

$$x_1, x_2, x_3, x_4 \geq 0$$

# Variables




- $title sets the title of the pages in the file. Optional.
- x1, x2, x3, x4, z are variable names.
- "# of brownies eaten daily", "# of scoops of chocolate ice cream eaten daily", " #of bottles of cola drunk daily", "# of pieces of pineapple cheesecake", "total cost" are explanatory text. Explanatory text is optional.

# Equations Declaration

```
equations
obj objective function
const1 calorie constraint
const2 chocolate constraint
const3 sugar constraint
const4 fat constraint;
```

- obj, const1, const2, const3, const4 are equations names.
- "objective function", "calorie constraint", "chocolate constraint", "sugar constraint", "fat constraint" are explanatory text. Explanatory text is optional.

# Equations Definition

```
obj.. z=e=50*x1+20*x2+30*x3+80*x4;
const1.. 400*x1+200*x2+150*x3+500*x4=g=500;
const2.. 3*x1+2*x2=g=6;
const3.. 2*x1+2*x2+4*x3+4*x4=g=10;
const4.. 2*x1+4*x2+x3+5*x4=g=8;
```

Note:

| | |
|---|---|
| =e= | Equality: right-hand side must equal left-hand side. |
| =g= | Greater than: left-hand side must be greater than or equal to right-hand side. |
| =l= | Less than: left-hand side must be less than or equal to right-hand side. |

# Model Statement

```
model diet /all/;
```

or

```
model diet /obj,const1,const2, const3, const4/;
```

- "diet" is model name.
- "all" is a shorthand notation to include all known (declared) equations a model.

# Solve Statement

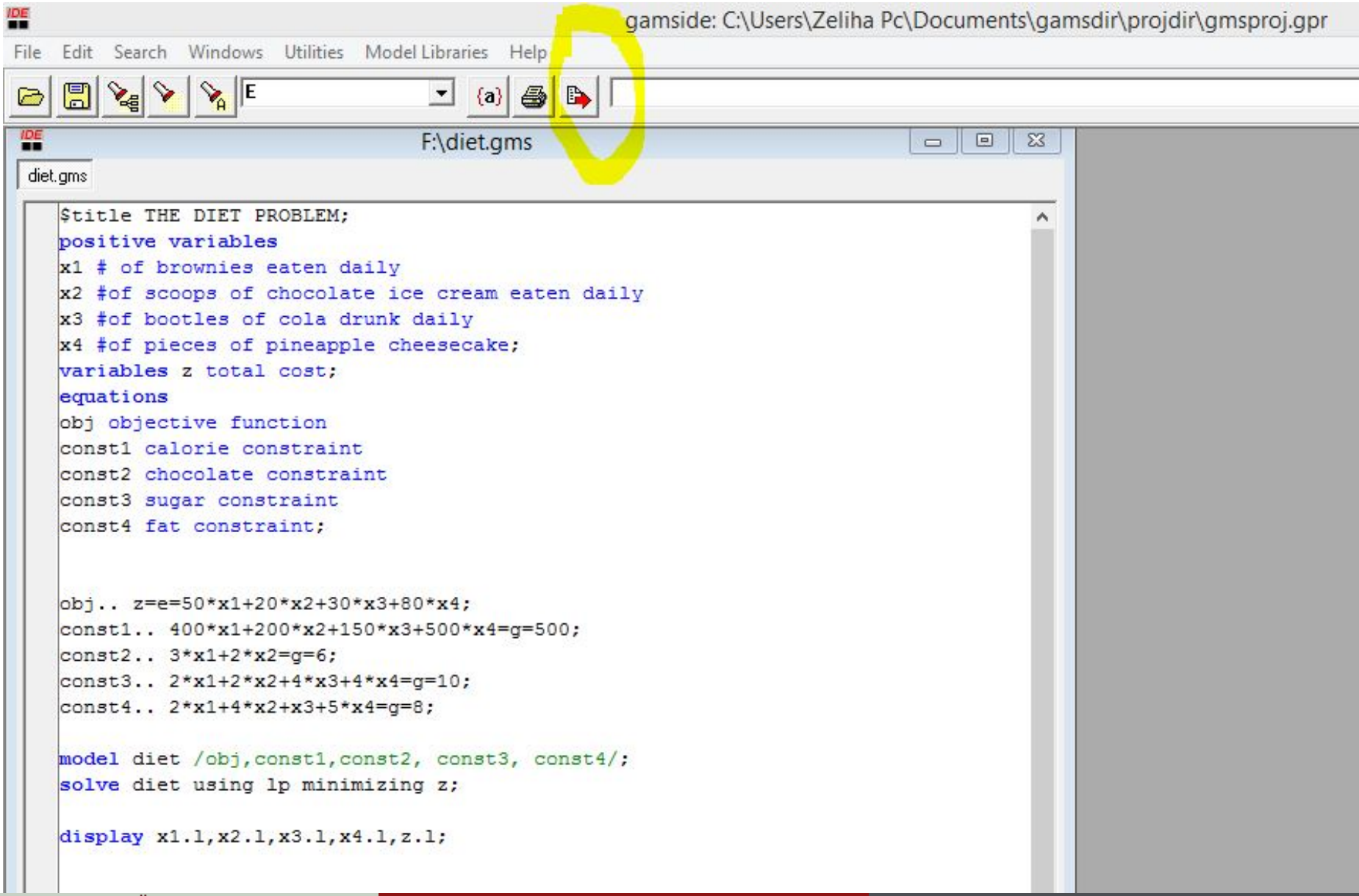
```
solve diet using lp minimizing z;
```

- "Solve" and "using" are reserved words,
- "diet" is the model name,
- "lp" is the model type(linear programming),
- "minimizing" is the direction of optimization
- z is the objective variable

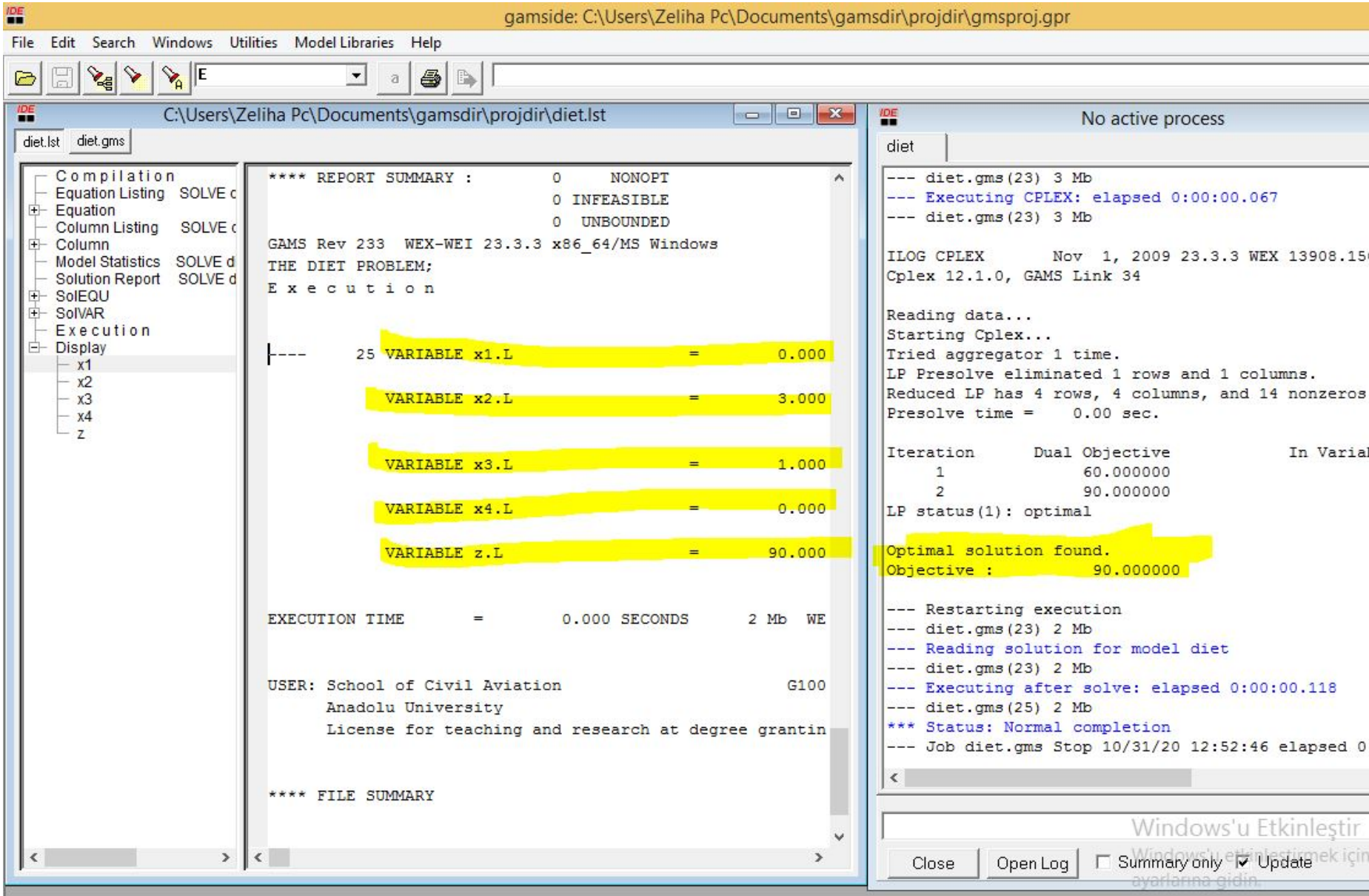
# Display Statement

```
display x1.l,x2.l,x3.l,x4.l,z.l;
```

# Running a model



# Output


gamside: C:\Users\Zeliha Pc\Documents\gamsdir\projdir\gmsproj.gpr
File Edit Search Windows Utilities Model Libraries Help
C:\Users\Zeliha Pc\Documents\gamsdir\projdir\diet.lst
diet.lst diet.gms
Compilation
Equation Listing SOLVE c
Equation
Column Listing SOLVE c
Column
Model Statistics SOLVE d
Solution Report SOLVE d
SolEQU
SolVAR
Execution
Display
x1
x2
x3
x4
z
**** REPORT SUMMARY : 0 NONOPT
0 INFEASIBLE
0 UNBOUNDED
GAMS Rev 233 WEX-WEI 23.3.3 x86_64/MS Windows
THE DIET PROBLEM;
E x e c u t i o n
---- 25 VARIABLE x1.L = 0.000
VARIABLE x2.L = 3.000
VARIABLE x3.L = 1.000
VARIABLE x4.L = 0.000
VARIABLE z.L = 90.000
EXECUTION TIME = 0.000 SECONDS 2 Mb WE
USER: School of Civil Aviation G100
Anadolu University
License for teaching and research at degree grantin
**** FILE SUMMARY
No active process
diet
--- diet.gms(23) 3 Mb
--- Executing CPLEX: elapsed 0:00:00.067
--- diet.gms(23) 3 Mb
ILOG CPLEX Nov 1, 2009 23.3.3 WEX 13908.15
Cplex 12.1.0, GAMS Link 34
Reading data...
Starting Cplex...
Tried aggregator 1 time.
LP Presolve eliminated 1 rows and 1 columns.
Reduced LP has 4 rows, 4 columns, and 14 nonzeros
Presolve time = 0.00 sec.
Iteration Dual Objective In Varial
1 60.000000
2 90.000000
LP status(1): optimal
Optimal solution found.
Objective : 90.000000
--- Restarting execution
--- diet.gms(23) 2 Mb
--- Reading solution for model diet
--- diet.gms(23) 2 Mb
--- Executing after solve: elapsed 0:00:00.118
--- diet.gms(25) 2 Mb
*** Status: Normal completion
--- Job diet.gms Stop 10/31/20 12:52:46 elapsed 0
Close
Open Log
Summary only
Update

# Sources for GAMS

- User's Guide: https://www.gams.com/latest/docs/UG_MAIN.html
- A GAMS Tutorial by Richard E. Rosenthal: https://www.gams.com/latest/docs/UG_Tutorial.html
- Teach Yourself GAMS, Deniz AKSEN,