

Lesson 4. Solving Optimization Models with a Computer, Resource Allocation Models

1 What are GMPL, GLPK, and GUSEK?

- **GMPL** is a programming language for optimization models
 - GMPL is also called **MathProg**
 - GMPL is very similar to **AMPL**, a popular commercial optimization modeling language
- **GLPK** is a software package that solves various types of optimization models, including linear programs
- **GUSEK** is an application that lets easily you write models in GMPL and solve them with GLPK

2 Some useful pointers

- On the course website:
 - A link to the GLPK Wikibook
 - The official GMPL language reference manual
 - Instructions on how to submit GMPL exercises
- Google can be your friend
 - Searching for “AMPL” can be useful as well

3 Installing GUSEK

- Download zip file from here:

<http://sourceforge.net/projects/gusek/files/latest/download>

- Unzip the file to any folder: Right-click the file, then select
- To run GUSEK, open the folder, double-click on `gusek.exe`

4 Modeling and solving Farmer Jones’s problem with GMPL

- Recall the linear program for Farmer Jones’s problem:

C = number of chocolate cakes to bake

V = number of vanilla cakes to bake

$$\begin{aligned} & \text{maximize} && 3C + 4V \\ & \text{subject to} && 4C + 2V \leq 32 && (1) \\ & && 4C + 6V \leq 48 && (2) \\ & && C \geq 0 && (3) \\ & && V \geq 0 && (4) \end{aligned}$$

- Let's write GMPL code for this linear program

- Start a new file (if one isn't open already)
- Type in the following MathProg code

```
# Define decision variables and variable bounds
var C >= 0;
var V >= 0;

# Objective function
maximize total_profit: 3*C + 4*V;

# General constraints
subject to eggs: 4*C + 2*V <= 32;
subject to flour: 4*C + 6*V <= 48;

end;
```

- Save as farmerjones.mod
 - ◊ .mod is the usual extension for GMPL code
- Make sure **Tools >> Generate Output File on Go** is checked
- Select **Tools >> Go**
- If all is well, a window with the output file (farmerjones.out) will appear on the left, and a log will appear on the right

- In the output file:

- Status tells you if the model has an optimal solution, is unbounded, or is infeasible
- Objective tells you the optimal value, if it exists
- The table with Column name and Activity tells you the optimal solution

- Some GMPL tips:

- You can write comments (code that will be ignored when run) like this:

```
# This is a comment.

/* This is also a comment. */
```

- Objective functions and constraints require unique names
 - ◊ Use something short and descriptive; no spaces allowed
- End every statement with a semi-colon!

- In Lesson 3, we showed that if the profit margin for vanilla cakes a satisfies $-2 \leq -\frac{3}{a} \leq -\frac{2}{3}$, then the current optimal solution remains optimal
- Try solving the model for Farmer Jones's problem with different profit margins for vanilla cakes
- Does our sensitivity analysis from Lesson 3 match up with what you see?

Example 1. The Terre Haute Door Company (THDC) designs three types of steel doors: Standard, High Security, and Maximum Security. Each door requires different amounts of machine and labor time and has different profit margins; this information is given in the following table.

	Machine 1		Machine 2		Profit Margin
	Hours	Manpower	Hours	Manpower	
Standard	3	5	4	6	\$35
High Security	6	8	5	7	\$45
Maximum Security	8	11	6	9	\$65

Each door must go through both machine 1 and machine 2 before it can be sold. Each worker is assigned to work on only one of the doors at a time, which means they work on both machines. In addition, management has decided not to sell more Maximum Security doors than the combined total of Standard and High Security doors sold, in order to keep demand high for Standard and High Security doors. THDC has available only 120 hours per week on machine 1 and 100 hours on machine 2 before required maintenance, and 280 hours of manpower available per week.

Write a linear program that determines how many of each door should be produced each week in order to maximize profits. Assume that every door produced is sold, and that fractional solutions are acceptable.