Lesson 4. Solving Optimization Models with a Computer

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
    ○ GMPL exercise submission form

- 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 ⎡Extract All...⎤

- 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:

$$C = \text{number of chocolate cakes to bake}$$
$$V = \text{number of vanilla cakes to bake}$$

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

- Let's write GMPL code for this linear program

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

- Next, let's solve the linear program

  - 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
  - If not, a log will appear on the right with error messages in purple
    Click on the error messages to see the relevant part of your code

- 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?