

AM121/ES121 Mathematical Programming Style Guide

This is a class in which clear and precise expression is essential. When formulating mathematical programs, you must say what you mean and make sure that others can understand what it is that you mean. We believe the act of making things clear for others is often an important step to understanding for yourself what it is that you mean (and what it is that you don't mean). Here we have provided a few general guidelines and advice, followed by an example solution to give you a concrete sense of exactly what we are looking for. The solutions to exercises in the section notes from week 1 will give you further examples.

Note that further example formulations and \LaTeX code templates for mathematical programs is available in the “Useful code snippets” file on the Resources tab. This code for formatting a linear program may be copied and inserted into your assignment write-up, and modified to reflect the model you have designed.

General guidelines and advice:

- **Declare.** Define sets, parameters, and variables.
- **In English.** Each line of math should be accompanied by an English description that helps the reader make sense of that part of the model. For sets, parameters, and variables, what do the mathematical symbols represent? For the objective function, what are you maximizing or minimizing? For each constraint or set of constraints, what limitation is the constraint imposing on the solution space?
- **Label Components.** Make explicit the parts of the model. Which lines refer to sets? Which lines refer to parameters? Variables? Be sure to start the objective function line with the word maximize or minimize. Use the words ‘subject to’ (or ‘s.t.’) to demarcate defining constraints.
- **In order.** Write down set definitions, followed by parameters, then variables. Below that, write the objective function, followed by the constraints.
- **Explain when necessary.** If a part of your model is somewhat complicated, you should explain the process by which you arrive at the equations for that part of your model. For example, we took a number of steps to arrive at the objective function in the football example in the first section, and noted the steps in the solution.
- **The solution is secondary.** For most problems on the homeworks, you will be expected to come up with a generalized mathematical model that works for any valid values of the parameters. We will sometimes ask you to find the solution for a particular instance of the problem, but this is in addition to formulating the model and not in place of it. When in doubt, contact the course staff.

- **Descriptive symbols.** When defining sets, parameters, and variables, use descriptive symbols. For example, if defining a cost parameter over a set of products, try using c_p .

Example: The Diet Problem

[Question] Consider the problem of finding the cheapest combination of foods that will satisfy all the daily nutritional requirements of a person. You are given the cost of food items, how much of each nutrient a unit of that food contains (e.g., calories, fats, minerals, etc.), and the upper and lower limits on how much of each nutrient a person needs. Formulate a linear program for this problem.

Here is a sample solution writeup:

Sets	F	set of food items
	N	set of nutrients
Parameters	$c_i, i \in F$	cost of food i
	$n_{ji}, j \in N, i \in F$	amount of nutrient j in food i
	$n_j^L, j \in N$	minimum amount of nutrient j required
	$n_j^U, j \in N$	maximum amount of nutrient j allowed
Variables	$X_i, i \in F$	amount of food i to consume

Minimize:

$$\sum_{i \in F} c_i X_i \quad \text{minimize total cost of food}$$

Subject to:

$$n_j^L \leq \sum_{i \in F} n_{ji} X_i \leq n_j^U \quad \forall j \in N \quad \text{consumption of nutrients in allowable range}$$

This sample solution is concise; it gives the linear program formulation with text describing each element of the model but nothing more. For writing down formulations in your homework, this is all that is required (unless there is a part of the formulation that is complicated, in which case you should clarify further with explanations beyond the formulation itself). If you prefer, you can declare sets, parameters, and variables in English sentences instead of listing them as we did here (e.g., ‘Let F represent the set of food items’). You can also discuss and develop each piece of your model in prose, but do make sure that you end up writing down the complete mathematical program as well. Whatever you end up doing, your model should be fully specified and described in a manner that makes it easy for someone else to read and understand.