Operations Research, Spring 2022 (110-2)
Suggestions for Common Issues in Homework

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In homework 1, we (TAs) found couple of common issues varying from notations usage to formulation logic. Thus, we list these common issues to help you feel more comfortable and obtain higher grades in arriving homework, case assignments, and most importantly, the final exam and the term project.

The content of this suggestion document is fourfold. First, we want to show you the benefits and the skills of parametrizing and variable expression in Section 1. In addition, we list several typical formatting issues in your homework 1 and provide better ways to conquer these issues in Section 2. Moreover, in Section 3 we list two miscellaneous but essential matters you may read before starting your homework 2. Last but not least, to incentive you to dive into LaTeX, we deliver a few selected example topics about LaTeX in Section 4.

1 Notation Usage

Parameters and variables: Parametrizing the problem is the initial step to formulate tasks, and properly defining and naming sets, indices, parameters, and variables are helpful for readability for sure. Typically, we use the capital letter to denote the parameters, and use the lower case letter to denote the decision variables.

Properly define set: Parametrizing may also significantly ease your work. For example, in problem 1, tens of students define a few sets and parameters and use the exact number to indicate which player can play as a setter or an opposite. It's fine if typing all of them correctly and whenever the problem is not complicated. Nonetheless, we see lots of typos happening in the case of using an exact number as an index. Establishing a parameter or a set to demonstrate your idea is more flexible and scalable despite typos,. You may be rescued from plenty of typing by a well-defined precedent parameter or set, and it's more efficient if you want or need to extend your formulations.

Set expression: In problem 1, we see some students try to use numbers to represent positions, and they write sentences such as

$$\text{Let } J \text{ be the set of position, } J = \{1,2,3,4,5\}(S,L,H,M,O),$$
$$\text{Let } i \in I \text{ be the index of position, where } I = \{1(S), 2(L), 3(H), 4(M), 5(O)\}.$$

We may understand what you want to express, but it will confuse your set definition. It's better to explain your idea in additional words or sentences.

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Define what you exactly need: We see several students defining redundant or dependent parameters and variables, and never using them or messily using them in the formulation. We don't deduct this issue this time, but you should check what you write before submitting.

2 Formatting issues

Incorrect symbol: Many students use mathematical symbols pretty professional, but still a few have some problems. For example, the symbol representing less equal is $\leq$, not <=. Several documents, guidance, and introductions on the Internet teach about mathematical writing, and you can search for them easily.[1]

Operator and verb: We see several students writing

$$\text{Let } x_{ij} = \text{number of something},$$

or quite similar sentences. It would help if you did not use a mathematical symbol as a verb. In contrast, you can write

$$\text{Let } x_{ij} \text{ be the number of something},$$
$$\text{Denote the number of something by } x_{ij},$$

or other equivalent sentences.

Italics or regular: This is a common error, and plenty of students lose their grades by this issue. For example, in problem 3, if you want to represent a shift i belonging to the afternoon type in a parameter, says $B_{i,\text{afternoon}}$, you need to specify the type afternoon by a regular font, instead of an *italics*. The same argument is applicable to the definition of set. You can see how the instructor writes when defining a set $S = \{\text{morning}, \text{afternoon}, \text{night}, \text{leave}\}$.

In contrast, if you want to type your variables, parameters, or sets in the text, use italics.

Punctuation: When you finish your formulation, please don't forget to type a comma or a period (', not ' ∘ ') in the end.

3 Miscellaneous issues

Course name: This course is called **Operations Research**, instead of Operation Research, Operation Researchs, Operations Researchs, or Operating research.

LaTeX: We strongly encourage you to type your work in LaTeX. For those who have a weak preference to install LaTeX locally, you can use Overleaf, an online LaTeX editor which is easy to use without installation and environment setting. Overleaf also supports real-time collaboration and version control, and its gallery contains hundreds of LaTeX templates. Using LaTeX can easily make your work professional in mathematical writing, and save you a lot of time.

4 LaTeX Tips

In this section, we summarize some basic LaTeX syntax and tips which may be useful and save your time.

[1] For example, I (one of the TAs) usually reference this document.

Frequent syntax: You can search lots of LaTeX resources and detailed documents online. This section only demonstrates some useful skills you may use in the following assignments.

1. We take the solution for problem 2 in homework 1 for example.

$$\begin{aligned} \min \quad & \sum_{k\in K} x_k \\ \text{s.t.} \quad & \left(\sum_{k\in K}\sum_{m=1}^{4}\sum_{n=m+1}^{5} A_{mnk}\right)\sum_{k\in K} x_k \geq D_{ij} \quad \forall i \in I,\ j \in J \\ & x_k \geq 0 \quad \forall k \in K. \end{aligned}$$

   To format this IP formulation, you may use the following two methods. A tip is that you can auto-adjust the size of the brackets by adding `\left` and `\right` before your left and right brackets, respectively.

```
\[
    \begin{split}
        \min \quad & \sum_{k\in K}x_k \\
        \mbox{s.t.} \quad & \left(\sum_{k\in K}\sum_{m=1}^4\sum_{n=m+1}^5
        A_{mnk}\right)\sum_{k\in K}x_k \geq D_{ij}
        \quad \forall i\in I, \ j\in J \\
        & x_k \geq 0 \quad \forall k\in K.
    \end{split}
\]
```

```
\[
    \begin{array}{RLL}
        \min & \sum_{k\in K}x_k & \\
        \mbox{s.t.} & \left(\sum_{k\in K}\sum_{m=1}^4\sum_{n=m+1}^5
        A_{mnk}\right)\sum_{k\in K}x_k \geq
        D_{ij} & \forall i\in I, \ j\in J \\
        & x_k \geq 0 \quad \forall k\in K. &
    \end{array}
\]
```

   Note that you have to invoke `amsmath` and `array` packages before writing equations, respectively. You can read the `amsmath` and `array` package details to extend your program.

2. To draw a matrix, for example,

$$\begin{bmatrix} 1 & 2^x & 3y \\ \frac{3}{4} & f(q) & c \end{bmatrix},$$

   you can use the method like

```
\[
    \begin{bmatrix}
        1 & 2^x & 3y\\
        \frac{3}{4} & f(q) & c
    \end{bmatrix}
\]
```

   and check the document for further use.

3. In homework 2, you need to implement a branch-and-bound algorithm and depict the full branch-and-bound tree. You can follow the steps to draw a tree in LaTeX. Note that this method requires a `tikz` package and set `\newdimen\nodeDist` and `\nodeDist=35mm` (or another preferred distance) before begining your document, i.e., before `\begin{document}`. Here I draw an example from the previous course slide.

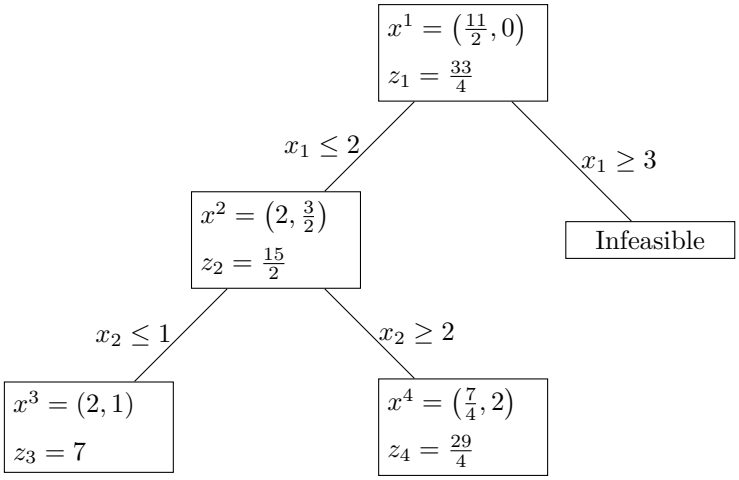

Figure 1: An example of a branch-and-bound tree

```
\begin{figure}
\centering
\begin{tikzpicture}[
 node/.style={
  draw,rectangle,
  },]
    \node [node,text width=2cm, align=left] (A)
    ↪  {$x^1=\left(\frac{11}{2},0\right)$ \\[2mm] $z_1=\frac{33}{4}$};
    \path (A) ++(-135:\nodeDist) node [node,text width=2cm, align=left] (B)
    ↪  {$x^2=\left(2,\frac{3}{2}\right)$ \\[2mm] $z_2=\frac{15}{2}$};
    \path (A) ++(-45:\nodeDist) node [node,text width=2cm, align=center] (C)
    ↪  {Infeasible};
    \path (B) ++(-135:\nodeDist) node [node,text width=2cm, align=left] (D)
    ↪  {$x^3=\left(2,1\right)$ \\[2mm] $z_3=7$};
    \path (B) ++(-45:\nodeDist) node [node,text width=2cm, align=left] (E)
    ↪  {$x^4=\left(\frac{7}{4},2\right)$ \\[2mm] $z_4=\frac{29}{4}$};
    \draw (A) -- (B) node [left,pos=0.5] {$x_1\leq2$}(A);
    \draw (A) -- (C) node [right,pos=0.5] {$x_1\geq3$}(A);
    \draw (B) -- (D) node [left,pos=0.5] {$x_2\leq1$}(A);
    \draw (B) -- (E) node [right,pos=0.5] {$x_2\geq2$}(A);
\end{tikzpicture}
\caption{An example of a branch-and-bound tree}
\end{figure}
```

4. We have learned the simplex method in the course, and we are available to draw tableaus of linear programming as well. Here I also take the previous course slide for example.

$$\begin{array}{cccc|c} -2 & -3 & 0 & 0 & 0 \\ \hline 1 & 2 & 1 & 0 & x_3 = 6 \\ \boxed{2} & 1 & 0 & 1 & x_4 = 8 \end{array} \quad \rightarrow \quad \begin{array}{cccc|c} 0 & -2 & 0 & 1 & 8 \\ \hline 1 & \boxed{\frac{3}{2}} & 1 & -\frac{1}{2} & x_3 = 2 \\ 1 & \frac{1}{2} & 0 & \frac{1}{2} & x_1 = 4 \end{array}$$

```
\[
    \begin{array}{ccc}
        \begin{array}{cccc|c}
            -2 & -3 & 0 & 0 & 0 \\
            \hline
            1 & 2 & 1 & 0 & x_3=6 \\
            \fbox{2} & 1 & 0 & 1 & x_4=8
        \end{array}
        & \rightarrow &
        \begin{array}{cccc|c}
            0 & -2 & 0 & 1 & 8 \\
            \hline
            1 & \fbox{$\frac{3}{2}$} & 1 & -\frac{1}{2} & x_3=2 \\
            1 & \frac{1}{2} & 0 & \frac{1}{2} & x_1=4
        \end{array}
    \end{array}
\]
```