

Due: Wednesday, September 30rd (noon)

## Problems for Math 408 and Math 708

1. **Updated to correct indexing.** You will have each solved a *personal knapsack problem* in your first assignment. You will now form a *team warm-up problem* by taking constraints for *each* student. That is: number yourselves 1,2,3 and 4. (If there are only 3 of you, use a phantom fourth student with id number 271828182.) Take each of your nine digit student id numbers<sup>1</sup> and add 10 to each digit to get a four sequences of nine numbers  $a_{11}, a_{12}, \dots, a_{19}$ ;  $a_{21}, a_{22}, \dots, a_{29}$ ;  $a_{31}, a_{32}, \dots, a_{39}$ ; and  $a_{41}, a_{42}, \dots, a_{49}$ . Similarly, add 10 to each of the first nine digits of  $\pi$  to get a sequence  $b_1, b_2, \dots, b_n$ . Your *team warm-up problem* is:

$$\begin{aligned} &\text{Maximize } \sum_{j=1}^9 b_j x_j \\ &\text{Subject to } \sum_{j=1}^9 a_{ij} x_j \leq \frac{1}{2} \sum_{j=1}^9 a_{ij} \text{ for } i = 1, 2, 3, 4 \\ &\quad x_j \in \{0, 1\} \text{ for } j = 1, \dots, 9. \end{aligned}$$

- Check if any of the solutions to your personal knapsack problems are feasible for your team warm-up problem.
  - If one of them is feasible (whether this happened or not), what do you learn about the team warm-up problem? Why?
  - Solve this team warm-up problem using AMPL. Use the Cplex solver. Please include a screen shot of the final solution in with your written solutions.
  - How does the objective value that you found for the team warm-up problem relate to the objective values of your personal knapsack problems?
2. Now consider the linear programming relaxations of your personal knapsack problems and your team warm-up problem.
- Check if any of the solutions to your relaxed personal knapsack problems are feasible for your relaxed team warm-up problem.
  - If one of them is feasible (whether this happened or not), what do you learn about the relaxed team warm-up problem? Why?
  - Solve this relaxed team warm-up problem using AMPL. Use the Cplex solver. Please include a screen shot of the final solution in with your written solutions.
  - How does the objective value of the relaxed team warm-up problem relate to the objective values of your relaxed personal knapsack problems?

<sup>1</sup>If you do not want to share your student id number, take another 9 digit number for this exercise. In this case, you will need to resolve questions 1a. and 1b. from your first homework using this number. Incidentally, our SFU ids are already widely known.

3. The main project will involve geographical routing problems. Teams will pick a theme which involves at least 20 (for Math 708 projects, 30) distinct locations. For this assignment, your task will simply be to pick a theme and gather data about it. Note that while this course focuses on techniques for solving discrete optimization problems, generally much of the work in real applications involves gathering, vetting and preparing data.

A simple way to do this is to pick a sports league such as the NHL or the Spanish soccer league, but more imaginative themes are encouraged. Themes are first come, first served – please consult with the instructor in making your choice. For your theme, you will find the street addresses of each location, and driving distances between each pair of locations. You can get this, for instance, from Google Maps. However you get them, please document how you got the information, with an eye to making it as reproducible as possible. Make a table of the relevant locations, and a table of the pairwise distances.

As an example, the Shrum Bowl is a (currently inactive) football series, between SFU and UBC, which most recently alternated between Terry Fox Field and Thunderbird Stadium. Here is the table of locations:

Team	Stadium	Address
<b>SFU Football Team</b>	Terry Fox Field	8888 University Dr. W., Burnaby, BC
<b>UBC Thunderbirds</b>	Thunderbird Stadium	6288 Stadium Rd, Vancouver, BC

And here is the table of pairwise distances in kilometres:

From ↓   To →	SFU	UBC
<b>SFU</b>	0	33.7
<b>UBC</b>	34.0	0

Note that I used the top route suggested by Google Maps. In fact, this can depend on traffic, among other things, so the answer is not consistent over time.

This assignment will be submitted directly to the instructor by e-mail. Once you have chosen your theme, your group will get a unique identifier (such as “nhl”) related to your project, which will be included in the file names of your submission. Please submit a single file named `team_hw1_name.pdf` containing all your written work, along with files `team_hw1_name.dat` and `team_hw1_name.mod` corresponding to the AMPL calculations in question 1c. Substitute your team’s unique identifier for `name` in the file names above.