Due: Thursday, September 26th 4:30 p.m.

Problems for Math 408 and Math 708

1. You will have each solved a *personal knapsack problem* in your first assignment. You will now form a *team multi-constrained knapsack 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[1] and add 10 to each digit to get four sequences of nine numbers $a_{11}, a_{12}, \ldots, a_{19}$; $a_{21}, a_{22}, \ldots, a_{29}$; $a_{31}, a_{32}, \ldots, a_{39}$; and $a_{41}, a_{42}, \ldots, a_{49}$. Similarly, add 10 to each of the first nine digits of π to get a sequence $b_1, b_2, \ldots, b_n$. Your *team multi-constrained knapsack problem* is:

$$\text{Maximize } \sum_{j=1}^{9} b_j x_j$$

$$\text{Subject to } \sum_{j=1}^{9} a_{ij} x_j \leq \frac{1}{2} \sum_{j=1}^{9} a_{ij} \text{ for } i = 1, 2, 3, 4$$

$$x_j \in \{0, 1\} \text{ for } j = 1, \ldots, 9.$$

a. Check if any of the solutions to your personal knapsack problems are feasible for your team multi-constrained knapsack problem.

b. If one of them is feasible (whether this happened or not), what does this imply about the team multi-constrained knapsack problem? Why?

c. Solve this team multi-constrained knapsack problem using `AMPL`. Use the `Cplex` solver. Please include a screen shot of the final solution with your written solutions.

d. How does the objective value that you found for the team multi-constrained knapsack 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 multi-constrained knapsack problem.

a. Check if any of the solutions to your relaxed personal knapsack problems are feasible for your relaxed team multi-constrained knapsack problem.

b. If one of them is feasible (whether this happened or not), what does this imply about the relaxed team multi-constrained knapsack problem? Why?

c. Solve this relaxed team multi-constrained knapsack problem using `AMPL`. Use the `Cplex` solver. Please include a screen shot of the final solution with your written solutions.

d. How does the objective value of the relaxed team multi-constrained knapsack problem relate to the objective values of your relaxed personal knapsack problems?

[1] 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.

3. The *team travelling salesperson problem* will be a geographical routing problems. Teams will pick a theme which involves at least 20 (for Math 708 groups, 50) distinct locations, with the points fairly well dispersed. 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, 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, but more imaginative themes are encouraged. Themes are first come, first served – please consult with the instructor in making your choice. 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.

A two-location example is the Shrum Bowl. This was[2] a football series, between SFU and UBC, which alternated between Terry Fox Field and Thunderbird Stadium. Here is the table of locations:

Team	**Stadium**	**Address**
SFU	Terry Fox Field	8888 University Dr. W., Burnaby, BC
UBC	Thunderbird Stadium	6288 Stadium Rd, Vancouver, BC

And here is the table of pairwise distances in kilometres:

From $\downarrow$ | To $\rightarrow$	**Terry Fox Field**	**Thunderbird Stadium**
Terry Fox Field	0	33.7
Thunderbird Stadium	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 problem, which will be included in the file names of your submission. Please include 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.

[2] SFU recently stopped sponsoring varsity football.