Math 441
January 2009

Term Projects

This project will count for 50% of your grade, replacing the final exam. Groups of up to three students will be allowed. Depending on the project chosen, it may be desirable to have one member of the group familiar with computing; it will certainly be desirable to have someone with good writing skills.

By Monday February 9, the groups should all be formed and projects chosen and reported to me. In many cases you'll need to come to me for some of the data. All groups should see me and hand in a progress report by February 27. It is vital that groups have made progress by this time. The projects are due April 3 although there can be some prearranged flexibility. I will be gone the week of March 30 through April 3 at a conference. I am available as a consultant for your projects. Don't hesitate to come and discuss the problem with me.

Quite a variety of problems have been tackled by students over the years. Some may involve substantial amounts of data collection, others may require computer programming. Try to choose one that is likely to fit well with your group's skills. Most of the problems are rather open-ended. Try to avoid trivial or hopelessly complicated formulations. In some cases you will not be able to get the exact "best" solution, but will have to settle for a "good" solution obtained using heuristic techniques or approximations. If you can solve the stated problem easily, then you must try variations on it. Questions of sensitivity analysis will be interesting. Remember, **you** are responsible for making your project interesting and challenging. Originality will be rewarded. Presentation is also very important.

The projects will not be returned to you. Perhaps they will make it into a future Math 441 lecture. You may wish to keep a copy of your own.

Roll Your Own

If you have a good idea for a project you'd like to do, write up a brief proposal (including what methods you think might work) and submit it to me for approval. Some of the best projects have been done this way.

Diet Problem

You will be eating all your meals at the Pacific Spirit Place cafeteria on campus (or some other favorite eatery). What choices will give you the best diet over a period of one week? What "best" means in this context is up to you — possible criteria include price, nutrition, variety and personal preferences. Don't forget the daily specials. The 2007 Canada Food Guide contains useful data for this problem.

Cut a Rug

A manufacturer produces broadloom carpet 40 feet wide for use in office buildings. This is cut into rectangular pieces of various sizes according to the orders received. Orders have been received for carpets to fit 300 rooms of 30 different sizes. You must decide how to cut the carpet to minimize the amount of waste.

An Offer You Can't Refuse

"I tell ya, Buggsy, we gotta quit fightin' each other. Dis town's big enough for da both of us."

"Sure, Al. Whatta ya got in mind?"

"We gotta divide da town up between us. You run your territory, I run mine, and nobody gets hurt."

"Dat's fine wit' me. A 50-50 split."

"Hey, 60-40, take it or leave it."

"OK, OK, I'll take it. But we gotta make sure it's a fair 60-40. Everyt'ing get split 60-40."

"Not to worry, Buggsy. I got dis chart here listing all da 30 wards, and da yearly take in each one from booze, gambling, and hookers. It also shows da ones where da alderman is on da take. We'll split up da town, you get some wards and I get da rest, so it all gets divided 60-40: da wards, da alderman, and da take from each racket."

"Sure, Al. But we also split up da take from booze so it's 60-40 in each end of town."

"Fine. Now how are we gonna do it? Dis is getting complicated."

"No sweat, Al. Lets find a MATH 441 student and make him an offer he can't refuse"

I have the da data.

Sports Team Selection

Consider the problem of selecting a sports team subject to various constraints such as a salary cap. Do you want to make the playoffs? How do you keep the fans happy and willing to pay the price of admission? Or perhaps you are assembling a team for a sports pool. The CBC hockey pool information provides lots of data for hockey teams.

Garbage Collection

Plan a route for garbage collection for a neighbourhood (in Vancouver or any other place you choose). An area (such as some Richmond subdivisions or Fraserview) that doesn't have a simple rectangular grid would be the most interesting. Remember that the truck can only collect garbage from one side of a street at a time in certain situations but perhaps (you both sides of a lane or quiet street. Current technology in Vancouver only allows pickup of bins from one side. It is important to avoid left turns onto busy two-way streets.

Estimating Sales prices

Students who read my criticisms of the Wiltshaw paper tried there own mechanized price estimation. For this project you would have to acquire a lot of sales data which is mostly viewed as confidential.

Sports Scheduling

You are asked to make up next season's schedule for your favourite sports league. Each team plays certain numbers of "home" and "away" games against each other team. Important considerations may include minimizing the distance each team must travel, while ensuring that teams are not on the road for too long at a stretch.

Bus problem

Consider the general problem of getting from point A at time t to point B in the lower mainland using the bus system. Typically your objective is to minimize transit time. The bus schedule must be used and so the optimal route will probably be a function of the start time at point A. Choose sample problems to analyze such as the best route between UBC and SFU. Perhaps you could consider the effect of adding a new skytrain routes.

Pacific Pilotage Authority

There are 110 ships' pilots currently working on the West Coast. Each works 182.5 days per year, with a four-year schedule that alternates on-duty periods of up to 20 days with off-duty periods of at least 10 days. There are three longer vacations each year, two of at least 30 days and one of at least 50 days. The system now in use, which was worked out by hand many years ago, provides an almost constant level of service (about 55 pilots on duty each day). However, the demand for pilots' services is greater in summer than in winter. The management would like a schedule that provides at least 57 pilots each day from June 1 to September 30, and at least 52 each day the rest of the year. One additional requirement: each pilot must be off duty at least every second December 25 and November 11 (the day of their annual banquet).

Flight Crew Assignments

Given the schedule of a small to medium-sized airline, assign crews to the flights in the best way possible. Various crews have their homes in various cities on the airline's routes. Government and union regulations affect such matters as the number of hours of flight time in a 24 hour period and the number of hours off between flights. Criteria for "best" might include minimizing the number of crews, minimizing the number of nights spent away from home, etc. (keeping both the airline and the crews as happy as possible).

Our Daily Bread

A bakery needs to deliver baked goods by van to 50 stores. Each store has a different standing order, taking up from 6% to 30% of the capacity of a van. Determine an optimal delivery routing — either minimize total mileage, or get all deliveries done as quickly as possible using 5 vans. The stores are at randomly chosen locations on a rectangular grid (provide your own data, or ask me for some).

Space Shuttle Scheduling

NASA would like to schedule 27 space shuttle missions over a period of 9 months. Each mission has an early start time (the first day it could be launched) and a late start time (if not launched by this time, it is considered late). You should assign a launch date to each mission, trying to minimize the number of late missions.

Each mission is assigned to either the Eastern or Western test range (ETR and WTR). A mission requires six resources: a launch pad, tower, test equipment, crew, orbiter, and solid rocket motors (SRM). The ETR and WTR share the six orbiters and six SRM's; the other resources are permanently assigned to one or the other. After use on a particular mission, a resource must undergo refurbishment and recertification (R & R), which requires a certain time interval. Also there is a minimum of 5 days between successive launches at the same test range.

Data provided: numbers of resources at each test range, R & R periods; for each mission, the duration, early and late start times.

Exam Scheduling

We have a file containing course schedules for 1000 UBC undergraduates (suitably anonymized). Determine an optimal conflict-free exam schedule — optimal in the sense that it uses as few exam periods as possible. Some variations:

— Try reducing the number of exam periods by one, and find a schedule with as few conflicts as possible.

— Try to avoid having students write three consecutive exams.

I can give you access to some C++ code if that helps but I suspect a lot of programming is required here.

TA Lab Assignment

You have been asked to make up a work schedule for TA's in a computer lab for the next term. The lab will be open 12 hours a day, 5 days a week. There are 25 TA's, each of whom must be assigned 2 or 3 hours per week in the lab. Each has indicated his/her preferences for times on a questionnaire. It may be impossible to satisfy everyone completely, but you should try to make as few people as possible really unhappy.

The Die is Cast

Fifteen armies in Alaska confront twelve armies in Kamchatka, as the fate of the world hangs in the balance. Not the Cold War, it's the game of Risk. Taking a situation from this or some other game involving both chance and strategy, find an optimal strategy and the probability of winning.