IEMS 313
Winter 2015
Project Phase II
Due Thursday, March 12, before midnight.

NOTE: All project files MUST be submitted electronically. Please combine all submitted files into a single zip (or similar) file.

This project must be done in the same groups from Phase I. You should not discuss your work with students outside your project group. However, you may do whatever research you feel necessary to understand and approach the problem. This includes any online resources as well as course materials, instructor and TA.

After you developed heuristics for finding good schedules that balance the workload of classes over quarters or group the prerequisites, the goal of this phase is to develop a Mathematical Programming model to compute truly *optimal* class curricula.

Your tasks (Part 1):

1. Formulate Mixed-Integer Linear Programming (MILP) models that finds the optimal curricula for the two different objectives that were defined in Phase I. There are several formulations, and you might want to try more than one. You need to find one formulation for each of the two objectives
2. Write data-independent AMPL models for your formulations.
   As a starting point, download the AMPL files from blackboard provided for Phase II. This already includes preambles for the model where (some of the) sets and parameters are already declared. One version ("`schedule.mod`") assumes that the data will be given in a data file (such as "`phase1example2.dat`"), the other version ("`schedule_random.mod`") works with a randomly generated instance. Your models should go into the files "`obj1_model.inc`" and "`obj2_model.inc`". AMPL will insert those files into the right place in `schedule.mod` and `schedule_random.mod`. In this way you can easily make sure that you are using the same models in both files. You can use the AMPL script "`all.run`" to get started.
   If you find that your formulation is too big for AMPL to handle, you need to look for an alternative.
3. Solve Examples 2 and 3 from Phase I for each of the two objectives. Report the optimal solutions and compare them with the solutions that you obtained with your heuristic methods in Phase I.
4. Solve the random instance with 12 quarters provided and report the optimal solution.
5. Increase the number of quarter in the random instance and report how long it takes to solve the problems. Go as large as you can with reasonable computing time.

In the first phase, we considered the two objectives (balanced workload and grouped prerequisites) individually. However, one is often interested in "optimizing both objectives at the same time." (also known as bi-objective optimization.) Of course, there is usually a conflict between different objectives, but we can ask ourselves what the trade-off looks like.

For example, when we minimize the number of intermediate quarters of prerequisites, the final schedule is not unique. So, we can ask ourselves which among the optimal ones has the most balanced workload (as a secondary objective) – or which of the most balanced schedules has the fewest gaps for prerequisites.

Your tasks (Part 2):

6. Modify your models so that you can optimize one objective while setting a limit for the other one
7. Use this model to find the schedule with the most balanced workload among those schedules that have the least number of intermediate quarters.
8. Use this model to find the schedule with the least number of intermediate quarters among those schedules that have the most balanced workload.

You need only submit one project report per group. Your project submission should consist of the following items:

1. A project report with

a. a precise mathematical statement of your MILP model (i.e., variable definitions, objective, constraints; be VERY careful with the indexing). Use the notation from class, not AMPL notation;
b. a detailed discussion of your model: What is the interpretation of the different variables, the objective function, and the individual constraints? How is the optimal curriculum obtained from the variable values?
c. if you research formulations, cite your sources;
d. the optimal schedules for Examples 2 and 3 from Phase I for both objectives (in table format). Include the optimal object value, and compare with the heuristic solutions you obtained in Phase I;
e. the optimal schedule for the random instance generated with the `schedule_random.mod` file as it was downloaded from blackboard (12 quarters, random seed 2);
f. a discussion of your experiments with increasing problem sizes. Report the sizes you tried, the computation time, and the optimal objective value. What do you observe?
g. a short description how you generated the bi-objective solutions.

2. All AMPL files (give them meaningful names):
   a. your model and data files. **You must use the files `schedule_obj?.mod` and `schedule_random_obj?.mod` without modification!**; (This makes it easier for us to figure out what is wrong in a model that produces incorrect results.)
   b. an AMPL script to run the model to produce the optimal solutions in your report (except for the experiment with varying problem size and for the Pareto curve). Make sure your AMPL script runs!
   c. a log file with the output from your AMPL script.

If you have any problems with AMPL-your code won't run or AMPL isn't working correctly for some reason-then don't wait to ask for help from the instructor or the TA. Although you should make some effort to correct the problems on your own first, it is important that you get help with problems *early* so that you can make good progress on the project.