CS524 – Problem Set #7

Due Date: November 10, 2023, 09.00AM

Instructions for Handing In Homework

Formulate the following problems in GAMS and solve them. Please follow the instructions given in the problems and on canvas closely. Submit this assignment electronically to the drop box. You should hand in a single zip file containing files with the following names: `hw7-1.gms`,`hw7-2.gms`, `hw7-3.gms`, `hw7-1.lst`, `hw7-2.lst`, `hw7-3.lst`

1 Are There Any Women Engineers?

Nowdays, thankfully, there are quite a few. But way back when Prof. Ferris was an engineering student, this was legimate question. Consider the following (nearly real) situation about students in a class.

- There are 50 people in a class.
- All of them have taken either 300 or 340, with at least 10 taking each of these classes.
- 15 of them have taken 400.
- 15 of them are female.
- 20 of them are undergraduates.
- 25 of them are in CS, 15 in Math, 10 in IE.
- 12 are graduating in December.
- At least two thirds of the IE undergrads are male.
- Of the male IE undergraduates, 2 have taken both 400 and 300 OR will graduate in December.

1.1 Problem

Is it possible that there is a female IE undergraduate, graduating in December, that has taken both 300 and 400? If so, what is the maximum number of people that fall into this category? In addition, display the number of female IE undergraduates, and the number of male IE undergraduates.

The following code should be part of your solution:

```
parameter results(*);
results('exists') = ...
results('max howmany') = ...
results('femIEugrads') = ...
results('maleIEudrads') = ...
display results;
```

Hint: You (I believe) will need to use the QAP "trick" for products of binary variables (or the AND of two statements) when modeling this one

2 Nucular

In this problem, we are scheduling a set of power plants P over a set of time periods $T = \{1, 2 \ldots, |T|\}$ to meet power demand d_t in each period. If a power plant $p \in P$ is turned on, it is able to produce any amount of power in the numerical range given by values $[\ell_p, u_p]$ $\forall p \in P$. The cost (per MWh) of producing energy at plant $p \in P$ is c_p. The plants P are of two type–nuclear plants N and coal-fired plants C ($P = N \cup C$).

- The objective is to minimize the total cost of delivering energy over the time horizon
- Power demand *must be* met in each period
- To meet environmental regulations, if 2 or more Coal generation plants are operating in period t, then at least 3 Nuclear generating plants must also be operating in period t
- In order to not cause a meltdown, if a nuclear generator $i \in N$ is initially turned on (started up) in period $t \in T$, then it must also be turned on for the subsequent 3 time periods.

2.1 Problem

Write a mixed integer linear program that will meet demand and minimum cost that achieves the objective and obeys all the problem restrictions. Please use the following code to load your instance.

```
sets T, P, C(P), N(P);
parameters d(T), cost(P), ell(P), u(P);
$gdxin ucdata.gdx
$load T,P,C,N,d,cost,ell,u
$gdxin
```

Make sure your output lists the plants operating at each time period using

```
set oper(P,T);
oper(P,T) = ...
option oper:0:0:1;
display oper;
```

3 Filtch's Paint Company

As part of his weekly production, the caretaker of Hogwarts, Augustus Filtch must produce n batches of magical paints, always the same. Every paint batch is produced in a single production process, all in the same blender that needs to be cleaned between two batches.

The cleaning times depend of the colors and the paint types. For example, a long cleaning period is required if an oil-based paint is produced after a water-based paint, or to produce white paint after a dark color. The times are given in minutes in the following table `CLEAN` where `CLEAN`(i, j) denotes the cleaning time between batch i and batch j. The durations of blending paint batches are given in the parameter `DUR`(i) below:

```
set i /1*10/;
alias(i,j);

table clean(i,j)
   1  2  3  4  5  6  7  8   9  10
1     11 7  13 11 12 4  9   7  11
2  5     13 15 15 6  8  10  9   8
3  13 15    23 11 11 16 18  5   7
4  9  13 5     3  8  10 12 14   5
5  3  7  7  7     9  10 11 12  13
6  10 6  3  4  14    8  5  11  12
7  4  6  7  3  13 7     10  4   6
8  7  8  9  9  12 11 10    10   9
9  9  14 8  4  9  6  10 8      12
10 11 17 11 6  10 4  7  9  11
;

parameter dur(i) /1 40, 2 35, 3 45, 4 32, 5 50, 6 42, 7 44, 8 30, 9 33, 10 55 /;
```

Since Filch has other activities, he wishes to deal with this weekly production in the shortest possible time (blending and cleaning). What is the corresponding order of paint batches? The order will be applied every week, so the cleaning time between the last batch of one week and the first of the following week needs to be accounted for in the total duration of cleaning.

3.1 Problem

Write a GAMS model that will determine the order of the paint batches. We would like to print out the total time to process all batches (both blending and cleaning), as well as the order in which the batches are processed. Hint: you may want to look at Miller-Tucker-Zemlin subtour elimination constraints.

If `obj` is the variable representing the length of the blending and cleaning process, and `y(I)` is a variable representing the position of batch `I`, then the following code should do the trick.[1]

```
parameter batchlength;
batchlength = obj.L;

parameter order(i) ;
loop(j,
  order(i)$(abs(y.L(j) - ord(i)) < 0.5) = ord(j);
);

display batchlength;
display order;
```

[1] We assume without loss of generality that we do the first batch (1) first in the order.