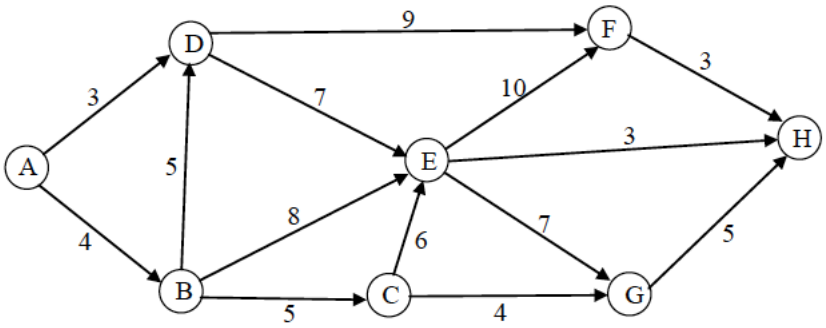
ISyE/CS635 – Problem Set #5

Due Date: March 7, 2015 (1PM)

Formulate the following problems in GAMS and solve them. Please follow the instructions given in the problems closely. Submit this assignment electronically to the drop box as a single zip file. This zip archive should contain exactly 3 files with the following names: `hw5-1.gms, hw5-2.gms, hw5-3.gms`

1 Critical Path Method

Consider the example given in the Figure. Note that this is an example of activities-on-arcs



formulation (not an activities-on-nodes as shown in class).

Perhaps the pouring of the concrete foundation (activity A-B), happens at the same time as the pre-assembly of the roof trusses (activity A-D). However, the finalization of the roof (activity D-E), cannot begin until both A-D and B-D (assembly of the house frame), are done. Of course B-D cannot start until the concrete foundation has been poured (A-B). All of this precedence and parallelism information is neatly captured in the PERT diagram.

1.1 Problem

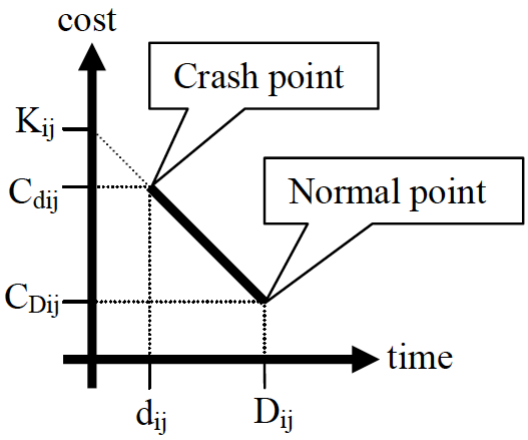
Find the critical path and the project completion time. Make sure you explicitly list out the critical activities in your listing file.

1.2 Problem

If the project takes longer to complete than you have available, then you will have to spend some money to speed things up. But which activities should you speed up? Suppose that the following time/cost tradeoff is allowed for certain activities:

Now every activity can have a duration somewhere d_{ij} and D_{ij}. The values for D_{ij} are given in the figure, $C_{d_{ij}} = 5$ and $C_{D_{ij}} = 3$ while the values of d_{ij} are given in the table below.

How much would it cost to complete the overall project in 25? What about 20? Do the critical activities change? Be sure to note the critical activities and the start times explicitly.



1.3 Problem

Now suppose that you only have 8 workers to complete the project and that each activity requires the following number of employees:

Activity	Workers needed	d_{ij}
A-B	3	3
A-D	4	2
B-C	2	2
B-D	2	4
B-E	3	6
C-E	2	5
C-G	1	2
D-E	3	5
D-F	1	8
E-F	1	6
E-G	1	4
E-H	1	2
F-H	1	2
G-H	1	4

Can you set up and solve a mixed integer program to find the minimum makespan under the constraint that no more that 8 workers are used at any given time?

2 Dragon Transport

Given your great Optimization Wizard training, the Ministry of Magic has asked that you transport 20 dragons from Romania to Hogwarts for the Triwizard tournament. The dragons will be transported on a route through five cities, with a choice of three different modes of transport between each of the pairs of cities on the route. The route to be followed is exactly:

1. Romania
2. Transylvania

3. Egypt
4. Godric's Hollow
5. Hogwarts

On each leg of the rout, the dragons are to all be transported by Hogwarts Express (Train), Portkey, or Thestral. In any of the intermediate cities, it is possible to change the mode of transport, but you must use a single mode of transport for all the dragons between two consecutive cities. Table 1 lists the cost of transport in galleons per dragon between the pairs of cities.

Table 1: Transportation Costs Between Locations on Route

	Pairs of cities			
	1-2	2-3	3-4	4-5
Train	30	25	40	60
Portkey	25	40	45	50
Thestral	40	20	50	45

Table 2 shows the cost of changing the mode of transport in galleons/dragon. (This cost is independent of the location at which the change is made).

Table 2: Mode Change Costs

From/To	**Train**	**Portkey**	**Thestral**
Train	0	5	12
Portkey	8	0	10
Thestral	15	10	0

2.1 Problem

How should the transport be organized to minimize the cost? What is the minimum cost for transporting the 20 dragons?

3 Generation capacity

PSI believes they will need the amounts of generating capacity shown below during the next 5 years:

```
set year /1*5/;
set plant /p1*p4/;

parameter reqCap(year) "in million Kwh" /
        1       80
        2       100
        3       120
        4       140
```

```
        5       160
/;
```

The company has a choice of building (and then operating) power plants with the specifications shown below:

```
set dfields /
        genCap  generating capacity in Million Kwh
        cCost   construction cost in Million $
        opCost  annual operating cost in Million $
/;

table data(plant,dfields)
        genCap  cCost   opCost
p1      70      20      1.5
p2      50      16      0.8
p3      60      18      1.3
p4      40      14      0.6 ;
```

3.1 Problem

Formulate and solve an IP to minimize the total costs of meeting the generating capacity requirements of the next five years.

3.2 Problem

Now suppose that at the beginning of year 1, power plants 1-4 have been constructed and are in operation. At the beginning of each year, PSI may shut down a plant that is operating or reopen a shut-down plant. The costs associated with reopening or shutting down a plant are shown below:

```
set action /reopen,shutdown/;

table costs(plant,action) in Million $
        reopen  shutdown
p1      1.9     1.7
p2      1.5     1.2
p3      1.6     1.3
p4      1.1     0.8 ;
```

Formulate and solve an IP to mimimize the total cost of meeting the demands of the next five years.