Homework 5

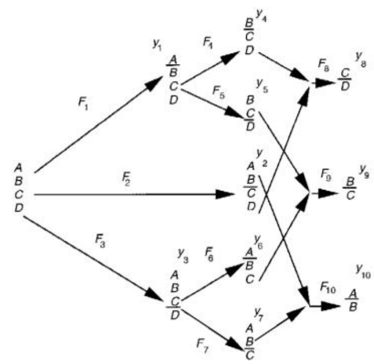
NO HANDWRITTEN SOLUTIONS WILL BE ACCEPTED

Problem 1: consider the following integer programming problem

$$\max 1.2y_1 + y_2$$
$$y_1 + y_2 \leq 1$$
$$s.t. \, 1.2y_1 + 0.5y_2 \leq 1$$
$$y_1, y_2 \in \{0,1\}$$

A. Solve the *first* relaxed LP subproblem by hand using the simplex method and derive Gomory cuts based on the LP relaxation.
B. Solve the above problem with the branch and bound method by enumerating nodes in the tree and solving the LP subproblems using GAMS

Problem 2: Consider the following superstructure for the separation of four chemical components using sharp distillation columns.



The total cost of a distillation column is calculated as follows:

$$cost_k = \alpha_k + \beta_k F_k + \gamma^{Hot} Q_k^{Hot} + \gamma^{Cold} Q_k^{Cold}$$

α_k represents a fixed capital cost, β_k represents the variable investment cost, $\gamma^{Hot/cold}$ is the cost of hot/cold utilities, and $Q_k^{Hot/cold}$ is the total demand of hot and cold utilities (you can assume that they are equal). Considering an initial fed of 1000 Kmol/h, and a composition of the feed stream (mol fraction) of A=0.15, B=0.3, C=0.35 and D=0.2. And considering the following data:

k	Separator	Investment cost α_k, fixed (10^3\$/yr)	Investment cost β_k, variable (10^3\$hr/kmol yr)	Heat duty coefficients, K_k, (10^6kJ /kgmol)
1	*A/BCD*	145	0.42	0.028
2	*AB/CD*	52	0.12	0.042
3	*ABC/D*	76	0.25	0.054
6	*A/BC*	125	0.78	0.024
7	*AB/C*	44	0.11	0.039
4	*B/CD*	38	0.14	0.040
5	*BC/D*	66	0.21	0.047
10	*A/B*	112	0.39	0.022
9	*B/C*	37	0.08	0.036
8	*C/D*	58	0.19	0.044

Cost of utilities:

Cooling water $C_C = 1.3$ (10^3\$/10^6kJyr)
Steam $C_H = 34$ (10^3\$/10^6kJyr)

A. Formulate an MILP problem to find the optimal sequence of distillation columns
    a. Identify at least 2 logic based equations that can be formulated to tighten the problem formulation.
B. Solve the problem using GAMS
C. Once you find the solution, identify which binaries are active, formulate an equation that allow you to exclude this solution from the feasible space (this is called an integer cut) and solve the problem again.

Problem 3: Given are three candidate reactors for the reaction A-B, where we would like to produce 10 kmol/h of B. Up to 15 kmol/hr of reactant A are available at a price of $2/kmol. The data on the three reactors is as follows:

Reactor	**Conversion**	**Cost**
1	0.8	8+1.5Feed
2	0.667	5.4+Feed
3	0.555	2.7+0.5Feed

a. Design a superstructure to represent this problem
b. Determine an MILP formulation
c. Solve in GAMS