Chemical Engineering 4G03

Tutorial 8 Practice Problem

Discrete Programming and Formulation Practice – Optimizing Process Improvement

Here for your own benefit and practice (best to do it individually)
Recommended completion: Week 09.
Grading: 0% (Practice for assignments and tests)

A microelectronics manufacturing facility is considering six projects to improve operations as well as profitability. However, not all these projects can be implemented due to budget limitations and engineering personnel constraints.

Each project requires a certain amount of money in each stage, and each stage has a well-defined budget from the government. In the **table below** is a list of prospective projects and their anticipated cost at each stage of the budgeting plan. Furthermore, in the table is the expected NPV "benefit" (an aggregate score based on likelihood of success and information gathered as a result of the mission) of each project. Below the table is a list of projects that depend on or are mutually exclusive to other projects. Note that if you choose a project in the table below, you **must pay for all costs in each stage for that project**.

i	Project	First Year Cost	Second Year Cost	Engineer Hours	Net Present Value
1	Upgrade & automate existing production line	$300,000	$0	4000	$100,000
2	Build new production line	$100,000	$200,000	5000	$120,000
3	Automate new production line	$0	$200,000	2500	$40,000
4	Install plating line	$50,000	$100,000	4000	$80,000
5	Build waste recovery plant	$50,000	$300,000	3000	$80,000
6	Subcontract waste disposal	$100,000	$200,000	600	$60,000
7	Dump waste illegally	$200,000	$200,000	4000	$100,000
	Budget	**$450,000**	**$400,000**	**10,000**	

A new or modernized production line MUST be chosen (project 1 or 2). Automation of the new line is only feasible if a new line is built. Only one of projects 5, 6, and 7 can be selected, but no more.

Questions

1. Define the variables for this problem, clearly indicating if they are continuous or binary.

2. Define the objective for this problem. You may write this out in terms of hard-coded numbers or define new parameters as you see fit.

3. Define the constraint(s) that correspond(s) to the available budget and engineering hours for each stage in each for this problem. Try to be as concise as possible.

4. Code your formulation *so far* (that is, DO NOT include the mutual exclusivity or dependence constraints) in GAMS and find the solution.

5. Define the mandatory selection constraint(s) for projects 1 and 2 and the mutual exclusivity constraint(s) for projects 5, 6 & 7 in this problem. Note that these should look slightly different from each other (Think about why).

6. Add the above constraints to GAMS and re-run the problem. Comment on the results and how adding the mutual exclusivity constraints affect your solution.

7. Define the dependency constraints for projects 2 & 3 in this problem.

8. Re-run your GAMS code with *all* the mutual exclusivity *and* dependency constraints included. Comment on *this* solution.

9. Your company's CEO has decided that project 7 is unethical and has decided to veto it. Re-run your GAMS code without this project option and comment on *this* solution.

10. Confirm the (global) optimum for this problem by performing a Branch and Bound Search by hand using the **depth-first** node selection heuristic for the previous scenario (with *all* the mutual exclusivity constraints *and* dependency constraints *and without* project 7) solving the LP relaxation at each node in GAMS. When branching, always branch in the direction $y_i = 0$ first.