EET 110 – Assignment 1: Problem Formulation

Instructor: Parikshit Pareek

Assignment Goals

The objective of this assignment is to develop the skill of mathematical modeling. For each of the following scenarios, identify the decision variables, objective function, and all relevant constraints to formulate a standard Linear Programming (LP) model.

1. Manufacturing Optimization

Problem 1: Solar Panel Assembly

A renewable energy startup in Bengaluru is assembling two types of solar panels: the "Ganga-Mono" (high efficiency) and the "Yamuna-Poly" (standard). Each Ganga-Mono panel sold yields a profit of ₹ 5,000, while each Yamuna-Poly yields ₹ 3,000. Assembly requires two main resources: high-purity silicon and labor hours. A Ganga-Mono panel requires 5 kg of silicon and 4 hours of labor, whereas a Yamuna-Poly panel requires 3 kg of silicon and 2 hours of labor. For the next week, the factory has 1,500 kg of silicon and 1,200 labor hours available. Market research suggests that at most 200 Ganga-Mono panels can be sold due to their high price. Formulate a linear program to maximize the total weekly profit.

2. Logistics and Transportation

Problem 2: Coal Logistics for Thermal Plants

The North Indian Power Grid needs to transport coal from two major mines—Dhanbad and Korba—to two thermal power stations—A and B. The Dhanbad mine has 400 tons of coal available, while Korba has 500 tons. Station A requires at least 300 tons to maintain operations, and Station B requires at least 450 tons. The cost of transporting one ton of coal from Dhanbad to Station A is ₹ 600, and to Station B is ₹ 800. From Korba, the transport cost is ₹ 700 per ton to Station A and ₹ 500 per ton to Station B. Formulate an optimization model to minimize the total transportation cost while meeting the fuel requirements of both power stations.

3. Power Systems and Environment

Problem 3: Hybrid Green-Dispatch

A regional load center must meet a constant power demand of 800 MW using a combination of a Natural Gas plant and a Coal plant. The cost of generating 1 MW from the Coal plant is ₹ 4,500, and from the Gas plant is ₹ 6,000. However, the Coal plant is heavily polluting, emitting 0.9 tons of CO_2 per MW, while the Gas plant emits only 0.4 tons per MW. The local environmental regulator has mandated that the total CO_2 emissions from these two plants must not exceed 500 tons per hour. Additionally, due to technical constraints, the Coal plant cannot generate more than 600 MW, and the Gas plant must always maintain a minimum generation of 100 MW to stay synchronized with the grid. Formulate the model to minimize the total generation cost.

EET 110 – Assignment 1: Solution Key

Instructor: Parikshit Pareek

Solution: Solar Panel Assembly

Formulation 1

Decision Variables:
Let x_1 = Number of Ganga-Mono panels assembled per week.
Let x_2 = Number of Yamuna-Poly panels assembled per week.
Objective Function:
Maximize total weekly profit Z (in ₹):

$$\text{Maximize } Z = 5000x_1 + 3000x_2$$

Subject to Constraints:

$$\begin{aligned} 5x_1 + 3x_2 &\leq 1500 && \text{(Silicon Limit in kg)} \\ 4x_1 + 2x_2 &\leq 1200 && \text{(Labor Limit in hours)} \\ x_1 &\leq 200 && \text{(Market Demand for Mono)} \\ x_1, x_2 &\geq 0 && \text{(Non-negativity)} \end{aligned}$$

Solution: Coal Logistics

Formulation 2

Decision Variables:
x_{DA}, x_{DB}: Tons of coal from Dhanbad to Stations A and B.
x_{KA}, x_{KB}: Tons of coal from Korba to Stations A and B.
Objective Function:
Minimize total transportation cost C (in ₹):

$$\text{Minimize } C = 600x_{DA} + 800x_{DB} + 700x_{KA} + 500x_{KB}$$

Subject to Constraints:

$$\begin{aligned} x_{DA} + x_{DB} &\leq 400 && \text{(Dhanbad Supply)} \\ x_{KA} + x_{KB} &\leq 500 && \text{(Korba Supply)} \\ x_{DA} + x_{KA} &\geq 300 && \text{(Station A Demand)} \\ x_{DB} + x_{KB} &\geq 450 && \text{(Station B Demand)} \\ x_{DA}, x_{DB}, x_{KA}, x_{KB} &\geq 0 && \text{(Non-negativity)} \end{aligned}$$

Solution: Hybrid Green-Dispatch

Formulation 3

Decision Variables:
P_c = Generation from Coal plant (MW).
P_g = Generation from Gas plant (MW).
Objective Function:
Minimize total hourly generation cost C (in ₹):

$$\text{Minimize } C = 4500P_c + 6000P_g$$

Subject to Constraints:

$$\begin{aligned} P_c + P_g &= 800 && \text{(Power Balance)} \\ 0.9P_c + 0.4P_g &\leq 500 && \text{(Emission Limit in tons/hr)} \\ P_c &\leq 600 && \text{(Coal Plant Pmax)} \\ P_g &\geq 100 && \text{(Gas Plant Pmin)} \\ P_c, P_g &\geq 0 && \text{(Non-negativity)} \end{aligned}$$