EET 110 Algorithms for Power Grid

Spring 2025-26 — Power System Optimization

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Lecture 3: Practicing Linear Programs

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Problem 1: The Punjab Farmer (Agriculture)

Scenario:
A farmer in Punjab has **10 acres** of land to plant Wheat (x_1) and Mustard (x_2).

- **Wheat:** Profit Rs. 20,000/acre, requires 3 days labor/acre.
- **Mustard:** Profit Rs. 30,000/acre, requires 1 day labor/acre.
- **Resources:**
  - Land available: 10 acres.
  - Labor available: 15 days (Harvest season shortage).

Goal: Maximize total profit in Rupees.

Problem 1: Mathematical Formulation

Decision Variables:

- x_1: Acres of Wheat
- x_2: Acres of Mustard

Objective Function:

$$\text{Maximize } Z = 20000x_1 + 30000x_2$$

Subject to:

$$\begin{aligned} x_1 + x_2 &\leq 10 \quad \text{(Land Constraint)} \\ 3x_1 + 1x_2 &\leq 15 \quad \text{(Labor Constraint)} \\ x_1, x_2 &\geq 0 \quad \text{(Non-negativity)} \end{aligned}$$

Quiz Problem: Refinery Optimization Model

$$
\begin{aligned}
\underset{x_s, x_c, y_e, y_v}{\text{maximize}} \quad & Z = 65y_e + 110y_v - 3200x_s - 22000x_c & \\
\text{subject to} \quad & x_s + x_c \leq 10,000 & \text{(Milling Tonnage)} \\
& 80x_s + 400x_c \leq 2,000,000 & \text{(Fermentation Volume)} \\
& y_e + y_v = 80x_s + 400x_c & \text{(Yield Mass Balance)} \\
& y_e \geq 1,200,000 & \text{(Ethanol Contract)} \\
& y_v \leq 500,000 & \text{(Catalyst Availability)} \\
& x_s, x_c, y_e, y_v \geq 0 & \text{(Non-negativity)}
\end{aligned}
$$

- x_s: Quantity of Sugarcane purchased (Tons/month).
- x_c: Quantity of Corn purchased (Tons/month).
- y_e: Quantity of Ethanol sold directly to oil companies (Liters/month).
- y_v: Quantity of Industrial Solvent produced and sold (Liters/month).

Lab Exercise: Simulating the Indian E-Commerce Giant

Scenario: You are the Operations Analyst for a major delivery hub (e.g., Flipkart or Blinkit). You need to test your optimization model, but real data is restricted. You must generate **Synthetic Data** using NumPy.

1. **System Dimensions**
   - **Products (n):** 50 unique items (Variables x_j)
   - **Warehouses (m):** 20 regional centers (Constraints i)
2. **Data Generation Specs (Use `np.random.randint`):**
   1. **Profit Vector (c):** The profit earned per unit of product.
      - Range: Rs. 100 to Rs. 5000
      - Shape: size 50
   2. **Usage Matrix (A):** Space (sq ft) used by product j in warehouse i.
      - Range: 1 to 20 sq ft
      - Shape: 20×50 (Rows $\times$ Cols)
   3. **Capacity Limits (b):** Total space available at each warehouse.
      - Range: 500 to 2000 sq ft
      - Shape: size 20

Python Implementation: Data Generation

```python
import numpy as np

# 1. Define Dimensions
num_products = 50
num_warehouses = 20

# 2. Generate Random Data
# Profit (c): Rs 100 to 5000
c_data = np.random.randint(100, 5000, size=num_products)

# Usage Matrix (A): 20x50 matrix
A_data = np.random.randint(1, 20, size=(num_warehouses, num_products))

# Capacity (b)
b_data = np.random.randint(500, 2000, size=num_warehouses)

print(f"Generated Matrix Shape: {A_data.shape}")
```