ADS4293 LAB12

Chapter 18: Optimization

TA: Malak Al-Hanafi

December 4 , 2025

LAB SETUP

- Submission:
  - Submit your **Excel file** on Brightspace (Owl)

QUESTION 1

24. Consider the following NLP problem.

$$\textit{Minimize} \quad z = 1 - 2e^{-(5x_1^2 + 2x_2^2)},$$

subject to

$$\begin{aligned} \textit{Constraint 1}: &\quad 2x_1 + 1.1x_2 \geq 2, \\ \textit{Constraint 2}: &\quad x_1, x_2 \geq 0, \\ \textit{Constraint 3}: &\quad x_1, x_2 \leq 1, \end{aligned}$$

where x_1 and x_2 represent the decision variables. Solve this NLP problem and answer the following questions.

a. What are the values of x_1 and x_2 at the optimal solution? What is the minimum value of *z*?

b. If the first constraint changes to $2x_1 + 1.1x_2 \geq 2.5$, what are the values of x_1 and x_2 at the optimal solution? What is the minimum value of *z*?

A.1 NONLINEAR PROGRAMMING IN EXCEL

1. Create **parameter table**
   a. **First row** label: “Constraint 1”, **2 columns**: x1, x2
   b. Under the column for **x1** enter the coefficient **2**
   c. Under the column for **x2** enter the coefficient **1.1**
2. **Decision variable:**
   a. Create two columns labelled **x1** and **x2**
   b. Enter **0** as the starting value for both x1 and x2.
3. **Objective function:**
   a. enter the z formula: =1-2*EXP(-(5*x1^2+2*x2^2))
   b. for x1 & x2, choose the starting values from the decision variables

$$Minimize \quad z = 1 - 2e^{-(5x_1^2+2x_2^2)}$$

$$\begin{aligned} &Constraint\ 1: && 2x_1 + 1.1x_2 \geq 2, \\ &Constraint\ 2: && x_1, x_2 \geq 0, \\ &Constraint\ 3: && x_1, x_2 \leq 1, \end{aligned}$$

4. **Constraint 1 table:**
   a. **LHS:** use cells from the **parameters table** and **decision variables** to compute constraint 1: =**2*****x1**+**1.1*****x2**
   b. **Sign:** >=
   c. **RHS:** 2
5. **Using Solver:**
   a. **Objective:** objective function cell
   b. **To:** Min
   c. **By Changing Variable Cells:** the two decision variable cells
   d. **Add constraints:** step 4, constraint 3 (using decision variable for x1 and x2)
   e. **For constraint 2:** check “Make Unconstrained Variables Non-Negative”
   f. **Solving method:** select GRG Nonlinear
   g. Click **Solve**

A.1 IN EXCEL

b. If the first constraint changes to $2x_1 + 1.1x_2 \geq 2.5$, what are the values of x_1 and x_2 at the optimal solution? What is the minimum value of z?

1. **You don't have to copy anything**
    a. In the RHS cell for Constraint 1, change the value from 2 to 2.5
    b. Keep the same Solver setup
    c. Run Solver again

A.1

a. $x_1 = 0.5694$, $x_2 = 0.7829$, and $z = 0.8840$

b. $x_1 = 0.7118$, $x_2 = 0.9786$, and $z = 0.9766$

QUESTION 2

30. Jim Markowitz is enrolled in a prestigious MBA program and participates in a student investment fund competition. A total investment amount of $1,000,000 is allocated to his portfolio, and he has three investment options to choose from. The expected returns from the three investment options are 2.6%, 3.7%, and 5.8%, respectively. One of the competition criteria is to ensure that each portfolio has a minimum return of 3.5%, but to increase his chance of advancing to the second round, Jim needs to minimize the investment risk of his portfolio. He uses the following formula to estimate his portfolio's risk: $0.15x_1^2 + 0.23x_2^2 + 0.41x_3^2 + 0.0207x_1x_2 + 0.0123x_1x_3 + 0.0943x_2x_3$, where x_1, x_2, and x_3 are the proportions of his budget of $1,000,000 (in %). Help Jim formulate this problem as an NLP model and answer the following questions. Use 1/3 of the total investment amount as an initial value for x_1, x_2, and x_3.

    a. How much money should Jim invest in each of the three investment options? What are the minimum risk and expected return from the portfolio?

A.2 IN EXCEL

a. How much money should Jim invest in each of the three investment options? What are the minimum risk and expected return from the portfolio?

1. Create **parameter table**
    a. **First row** label: “Constraint 1”, **3 columns**: x1, x2. x3
    b. Under each column enter the expected return: **x1: 2.60%, x2: 3.70%, x3: 5.80%**
2. **Decision variable:**
    a. Create three columns labelled **x1, x2, x3** (investment amounts in dollars)
    b. Enter **=1/3*1000000** as the starting value for each, (this represents 1/3 of the $1,000,000 budget)
3. **Constraint table**
    a. **Constraint 1: Minimum required return**
        i. **LHS** (total expected return): **=SUMPRODUCT(step1,step2)**
        ii. **Sign:** >=
        iii. **RHS**: **35000** *(from the question “minimum return of 3.5%, 3.5%*1000000")*
    b. **Constraint 2: Budget**
        i. **LHS: =SUM(step2)**
        ii. **Sign:** =
        iii. **RHS: 1000000**

A.2 IN EXCEL

a. How much money should Jim invest in each of the three investment options? What are the minimum risk and expected return from the portfolio?

$$0.15x_1^2 + 0.23x_2^2 + 0.41x_3^2 + 0.0207x_1x_2 + 0.0123x_1x_3 + 0.0943x_2x_3$$

4. **Objective function:**
   a. Enter the portfolio risk formula using the Decision variable cells for **x1,x2,x3**
   b. Each x must be divided by 1,000,000 inside the formula, because the risk equation uses proportions, not dollar amounts
5. **Using Solver:**
   a. **Objective:** objective function cell
   b. **To:** Min
   c. **By Changing Variable Cells:** only x1, x2 decision variable cells *(bc x3 is automatically forced by the budget constraint)*
   d. **Add constraints:** step 3
   e. **Check** “Make Unconstrained Variables Non-Negative”
   f. **Solving method:** select GRG Nonlinear
   g. Click **Solve**

A.2

a. Invest $445,588.64, $221,078.02, and $333,333.33 in investment options 1, 2, and 3, respectively. The minimum risk is 0.0974, and the return on investment is $39,098.52.

Thank you!