# Operations Research - Assignment 1 Report

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## 1. Introduction

This report presents the implementation of a Linear Programming (LP) solver using the Simplex Method and its variations. The solver is designed to handle different types of LP problems efficiently and provides a step-by-step solution process.

## 2. Objective

The objective of this assignment is to develop a software tool capable of solving LP problems using:

- **Standard Simplex Method** for standard form LP problems (≤ constraints, non-negative variables).
- **BIG-M Method** to handle "greater-than-or-equal-to" (≥) and equality (=) constraints.
- **Two-Phase Method** as an alternative to the BIG-M method for artificial variables.
- **Preemptive Method for Goal Programming** for multi-objective optimization.

Additionally, support for unrestricted variables has been included.

# 3. Implementation Details

## 3.1 Programming Language

The solver was implemented using **Python**.

## 3.2 Input Format

The program accepts LP problems in the following standard format:

- Objective function coefficients
- Constraint coefficients
- Right-hand side values
- Constraint types (≤, ≥, =)
- Variable restrictions (non-negative, unrestricted)
- Chosen method (BIG-M or Two-Phase, if applicable)
- Goal values and priority levels for goal programming

## 3.3 Output Format

The program provides:

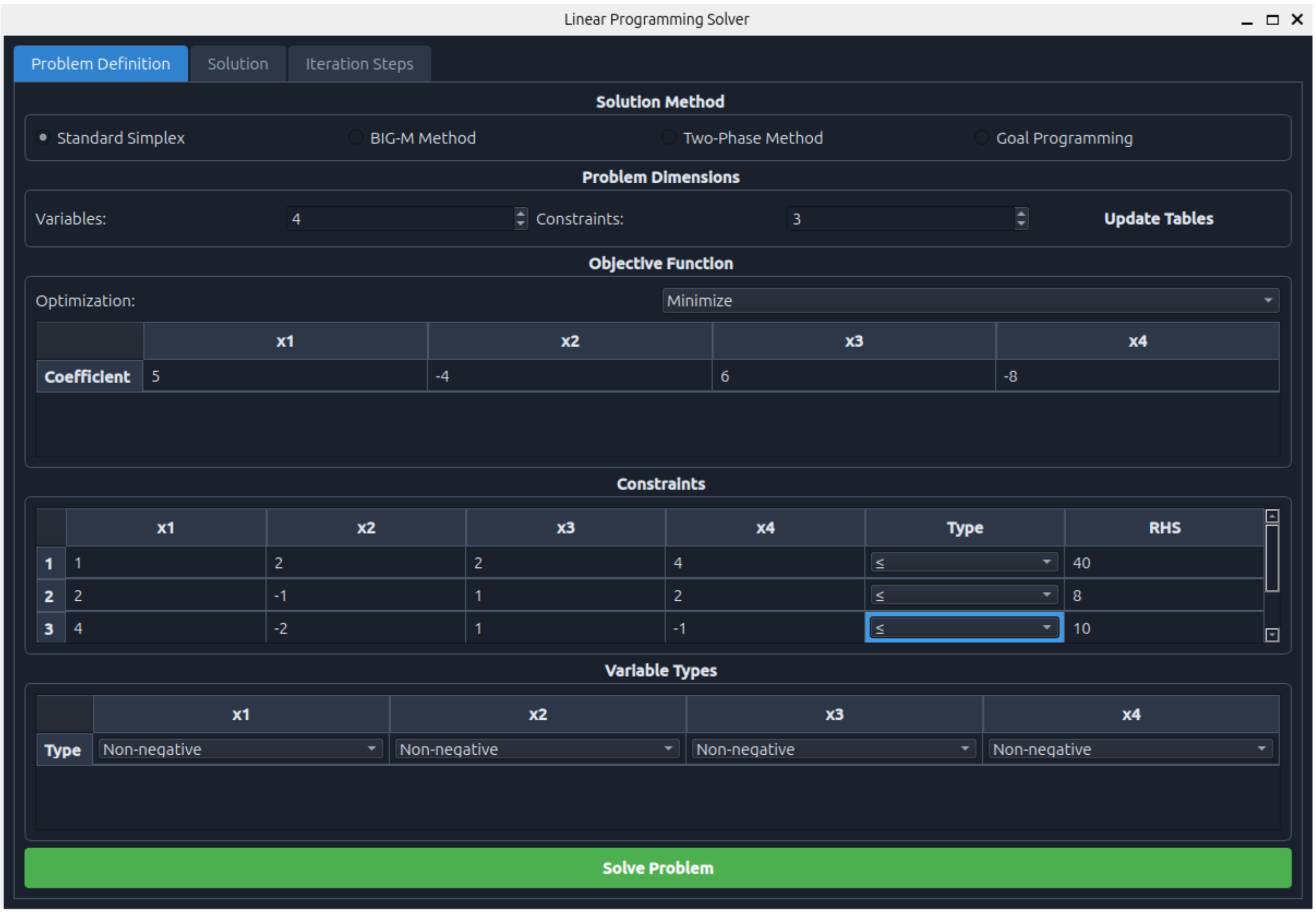
- **Optimal solution** (values of decision variables)
- **Optimal objective function value**
- **Problem status** (optimal, infeasible, unbounded)
- **Goal satisfaction (for goal programming)**
- **Step-by-step solution tables**

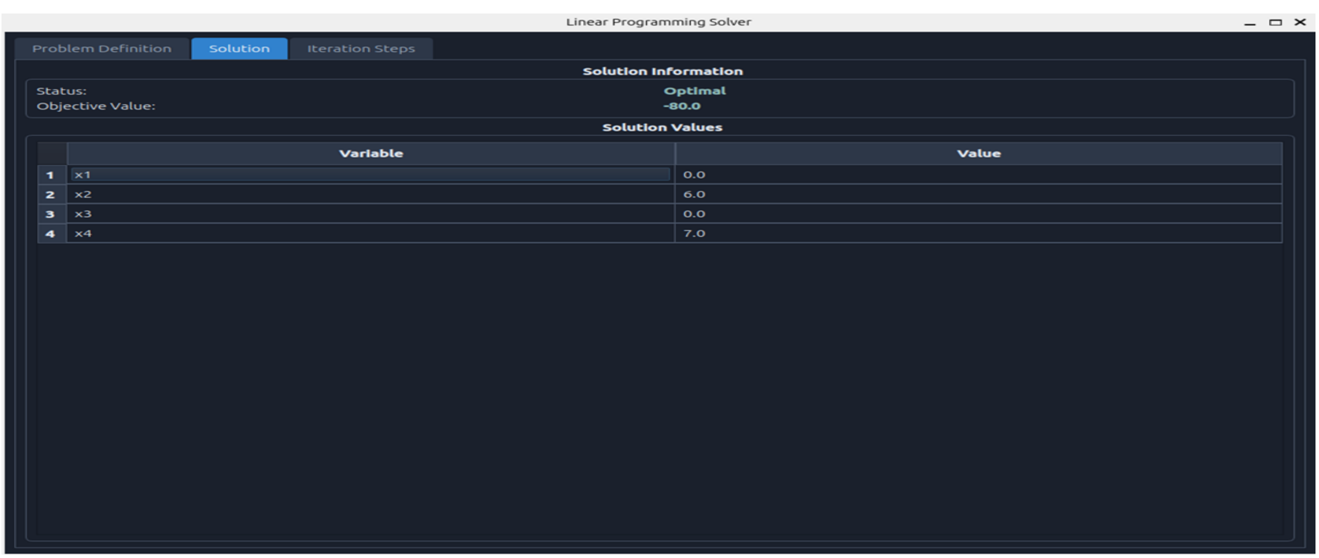
# 4. Sample Runs

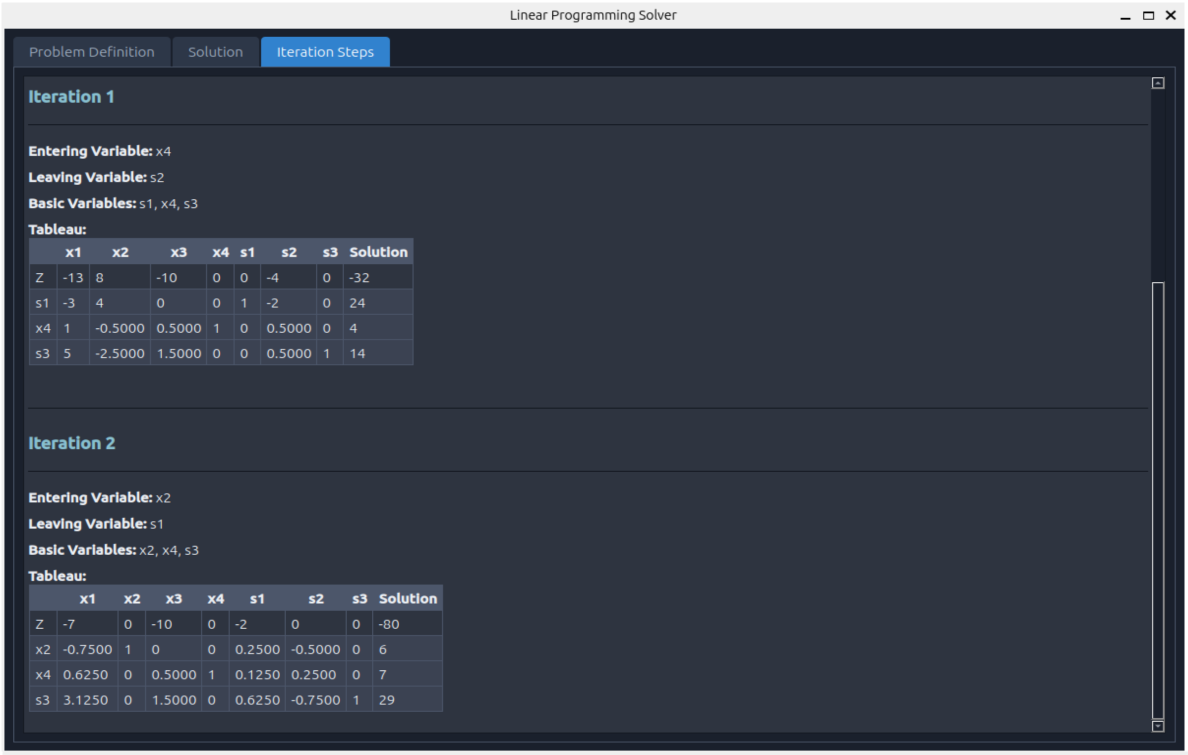
Below is example cases solved using our program:

# 4.1 Example 1 - Simplex Method

Minimize Z = 5x1 – 4x2 +6x3 - 8x4
x1 + 2x2 +2x3 +4x4 ≤ 40
2x1 – x2 +x3 +2x4 ≤ 8
4x1 – 2x2 +x3 - x4 ≤ 8
2x1 – x2 +x3 +2x4 ≤ 10
x1, x2, x3 ,x4 ≥ 0





Linear Programming Solver

Problem Definition | Solution | Iteration Steps

### Iteration 1

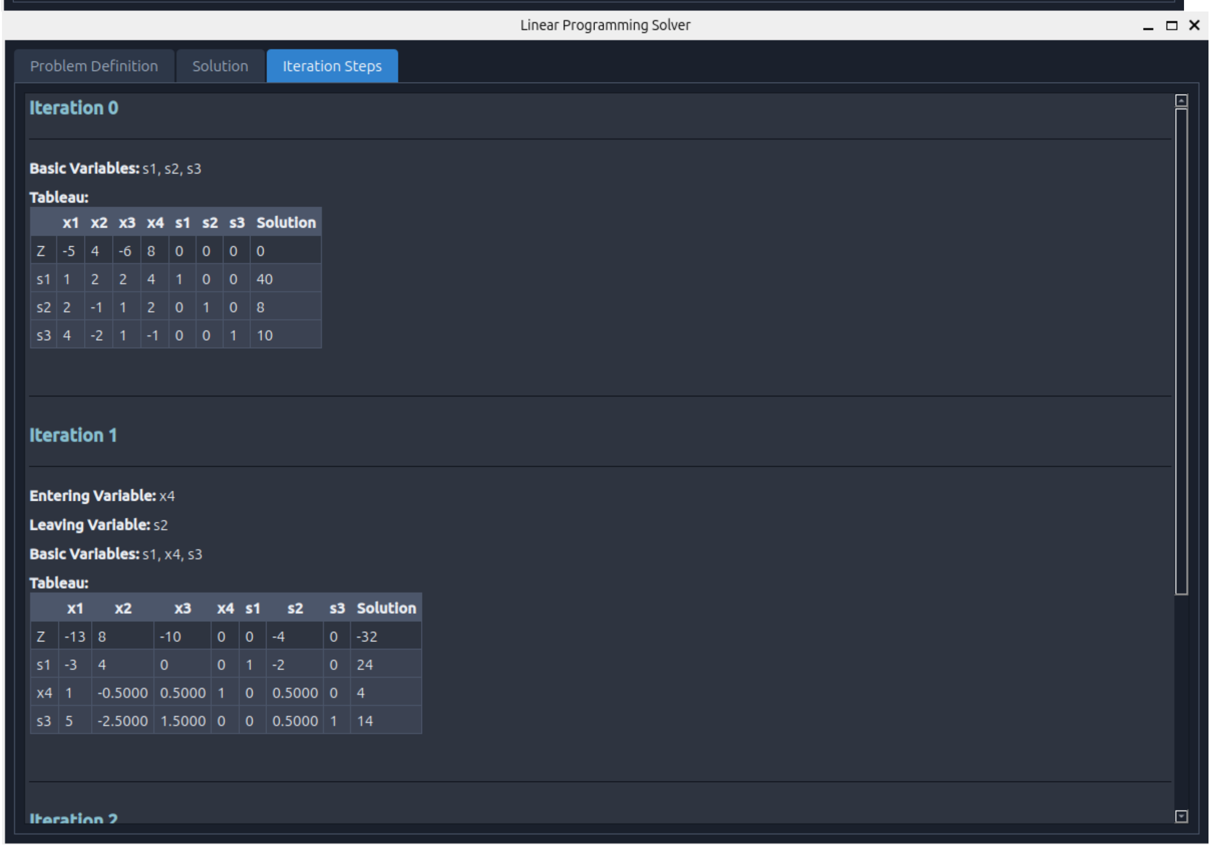
**Entering Variable:** x4
**Leaving Variable:** s2
**Basic Variables:** s1, x4, s3
**Tableau:**

| | x1 | x2 | x3 | x4 | s1 | s2 | s3 | Solution |
|---|---|---|---|---|---|---|---|---|
| Z | -13 | 8 | -10 | 0 | 0 | -4 | 0 | -32 |
| s1 | -3 | 4 | 0 | 0 | 1 | -2 | 0 | 24 |
| x4 | 1 | -0.5000 | 0.5000 | 1 | 0 | 0.5000 | 0 | 4 |
| s3 | 5 | -2.5000 | 1.5000 | 0 | 0 | 0.5000 | 1 | 14 |

### Iteration 2

**Entering Variable:** x2
**Leaving Variable:** s1
**Basic Variables:** x2, x4, s3
**Tableau:**

| | x1 | x2 | x3 | x4 | s1 | s2 | s3 | Solution |
|---|---|---|---|---|---|---|---|---|
| Z | -7 | 0 | -10 | 0 | -2 | 0 | 0 | -80 |
| x2 | -0.7500 | 1 | 0 | 0 | 0.2500 | -0.5000 | 0 | 6 |
| x4 | 0.6250 | 0 | 0.5000 | 1 | 0.1250 | 0.2500 | 0 | 7 |
| s3 | 3.1250 | 0 | 1.5000 | 0 | 0.6250 | -0.7500 | 1 | 29 |



Linear Programming Solver

Problem Definition | Solution | Iteration Steps

### Iteration 0

**Basic Variables:** s1, s2, s3
**Tableau:**

| | x1 | x2 | x3 | x4 | s1 | s2 | s3 | Solution |
|---|---|---|---|---|---|---|---|---|
| Z | -5 | 4 | -6 | 8 | 0 | 0 | 0 | 0 |
| s1 | 1 | 2 | 2 | 4 | 1 | 0 | 0 | 40 |
| s2 | 2 | -1 | 1 | 2 | 0 | 1 | 0 | 8 |
| s3 | 4 | -2 | 1 | -1 | 0 | 0 | 1 | 10 |

### Iteration 1

**Entering Variable:** x4
**Leaving Variable:** s2
**Basic Variables:** s1, x4, s3
**Tableau:**

| | x1 | x2 | x3 | x4 | s1 | s2 | s3 | Solution |
|---|---|---|---|---|---|---|---|---|
| Z | -13 | 8 | -10 | 0 | 0 | -4 | 0 | -32 |
| s1 | -3 | 4 | 0 | 0 | 1 | -2 | 0 | 24 |
| x4 | 1 | -0.5000 | 0.5000 | 1 | 0 | 0.5000 | 0 | 4 |
| s3 | 5 | -2.5000 | 1.5000 | 0 | 0 | 0.5000 | 1 | 14 |

### Iteration 2

## Output:

- Optimal Solution: x1 = 0, x2 = 6, x3 = 0, x4 = 7
- Optimal Objective Value: Z = -80

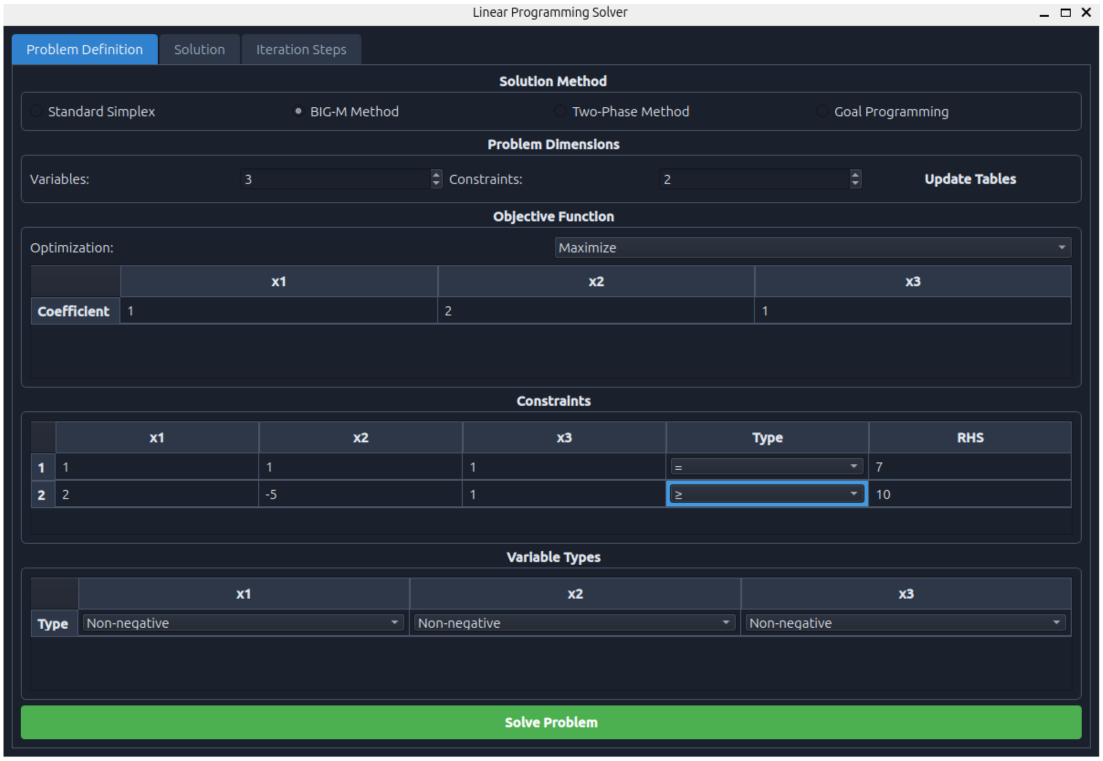
# 4.2 Example 2 - Big-M Method

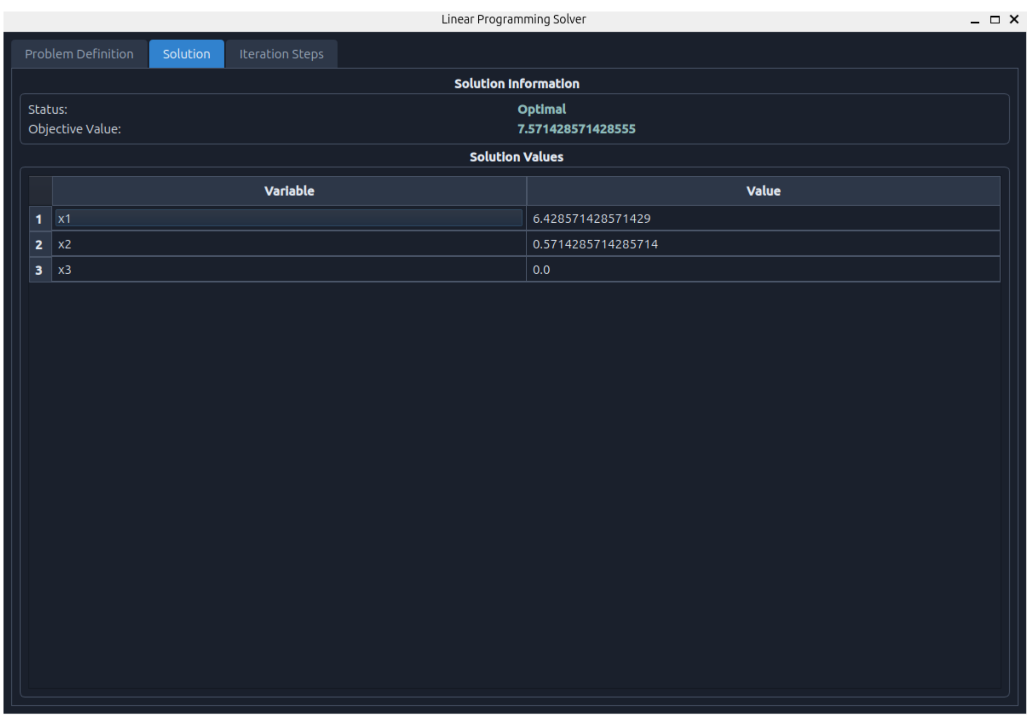
Maximize Z = x1 + 2x2 +x3

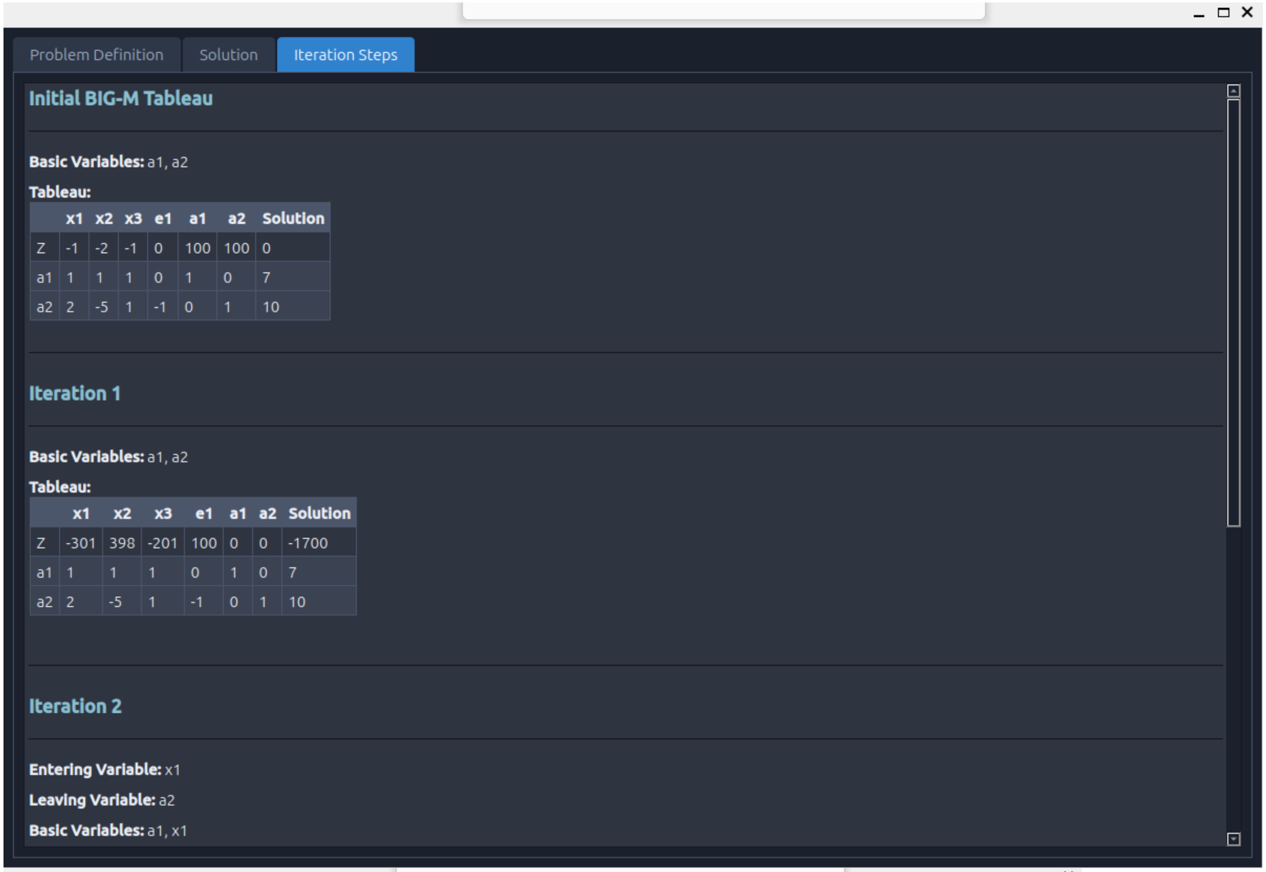
x1 + x2 +x3=7

2x1 + 5x2 +x3= 10

x1 + 2x2 +x3≥ 0





Problem Definition | Solution | Iteration Steps

### Initial BIG-M Tableau

**Basic Variables:** a1, a2

**Tableau:**

| | x1 | x2 | x3 | e1 | a1 | a2 | Solution |
|---|---|---|---|---|---|---|---|
| Z | -1 | -2 | -1 | 0 | 100 | 100 | 0 |
| a1 | 1 | 1 | 1 | 0 | 1 | 0 | 7 |
| a2 | 2 | -5 | 1 | -1 | 0 | 1 | 10 |

### Iteration 1

**Basic Variables:** a1, a2

**Tableau:**

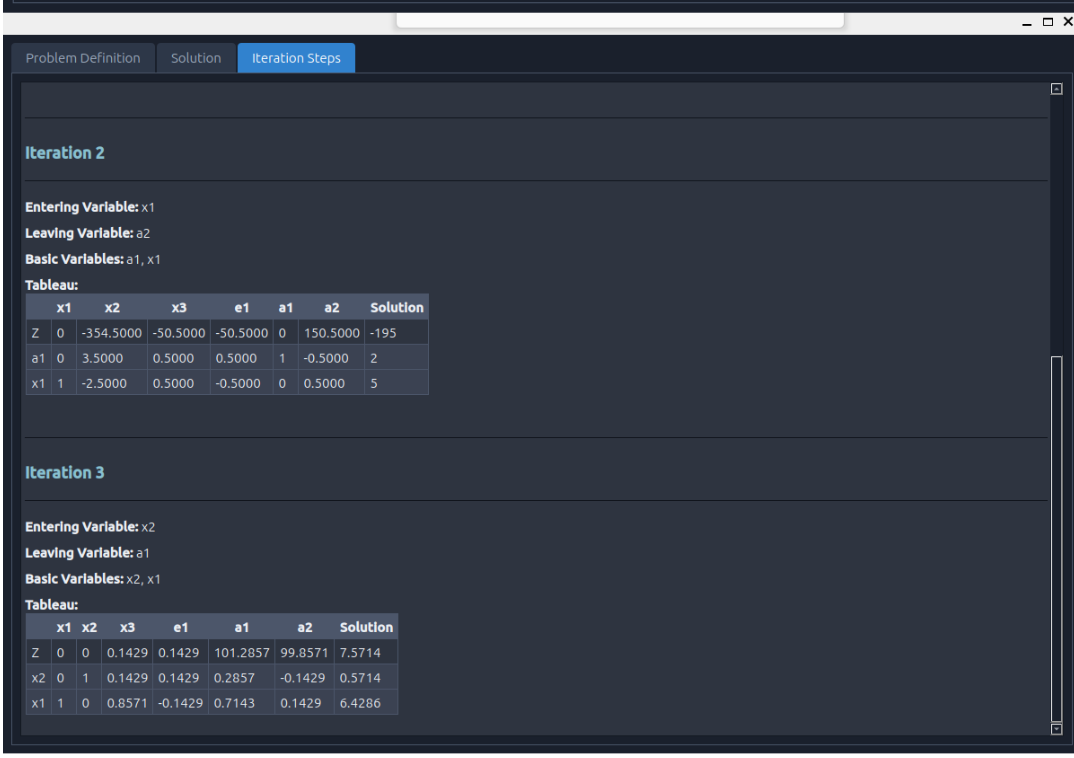
| | x1 | x2 | x3 | e1 | a1 | a2 | Solution |
|---|---|---|---|---|---|---|---|
| Z | -301 | 398 | -201 | 100 | 0 | 0 | -1700 |
| a1 | 1 | 1 | 1 | 0 | 1 | 0 | 7 |
| a2 | 2 | -5 | 1 | -1 | 0 | 1 | 10 |

### Iteration 2

**Entering Variable:** x1

**Leaving Variable:** a2

**Basic Variables:** a1, x1



Problem Definition | Solution | Iteration Steps

### Iteration 2

**Entering Variable:** x1

**Leaving Variable:** a2

**Basic Variables:** a1, x1

**Tableau:**

| | x1 | x2 | x3 | e1 | a1 | a2 | Solution |
|---|---|---|---|---|---|---|---|
| Z | 0 | -354.5000 | -50.5000 | -50.5000 | 0 | 150.5000 | -195 |
| a1 | 0 | 3.5000 | 0.5000 | 0.5000 | 1 | -0.5000 | 2 |
| x1 | 1 | -2.5000 | 0.5000 | -0.5000 | 0 | 0.5000 | 5 |

### Iteration 3

**Entering Variable:** x2

**Leaving Variable:** a1

**Basic Variables:** x2, x1

**Tableau:**

| | x1 | x2 | x3 | e1 | a1 | a2 | Solution |
|---|---|---|---|---|---|---|---|
| Z | 0 | 0 | 0.1429 | 0.1429 | 101.2857 | 99.8571 | 7.5714 |
| x2 | 0 | 1 | 0.1429 | 0.1429 | 0.2857 | -0.1429 | 0.5714 |
| x1 | 1 | 0 | 0.8571 | -0.1429 | 0.7143 | 0.1429 | 6.4286 |

## Output:

- Optimal Solution: x1 = 45/7, x2 = 4/7
- Optimal Objective Value: Z = 53/7

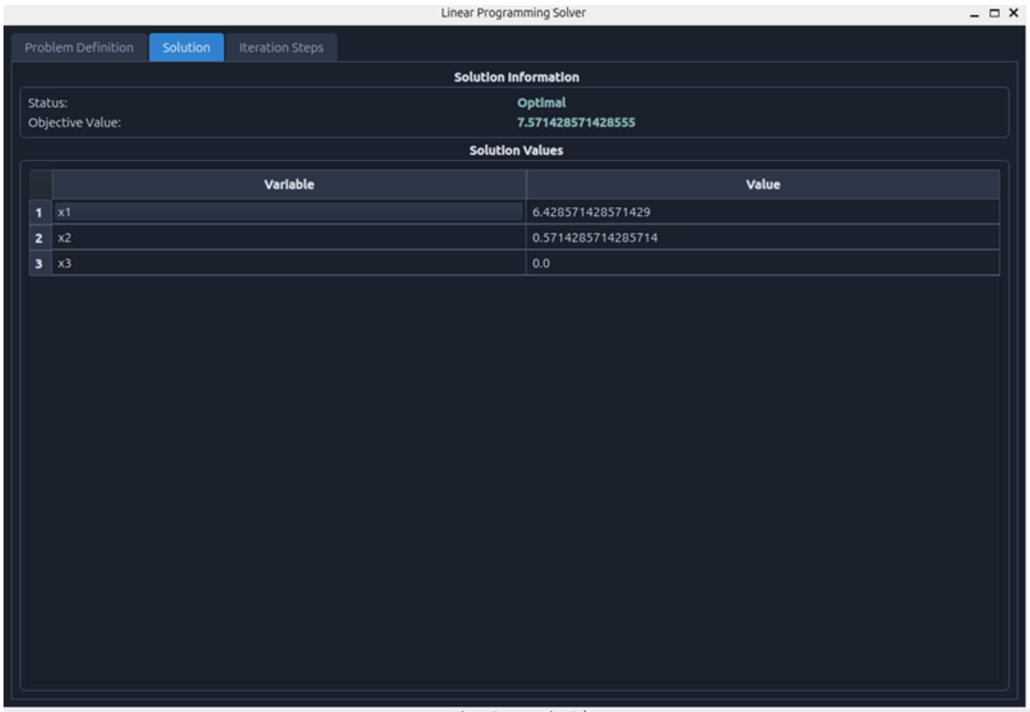
## 4.3 Example 3 - Two-Phase Method

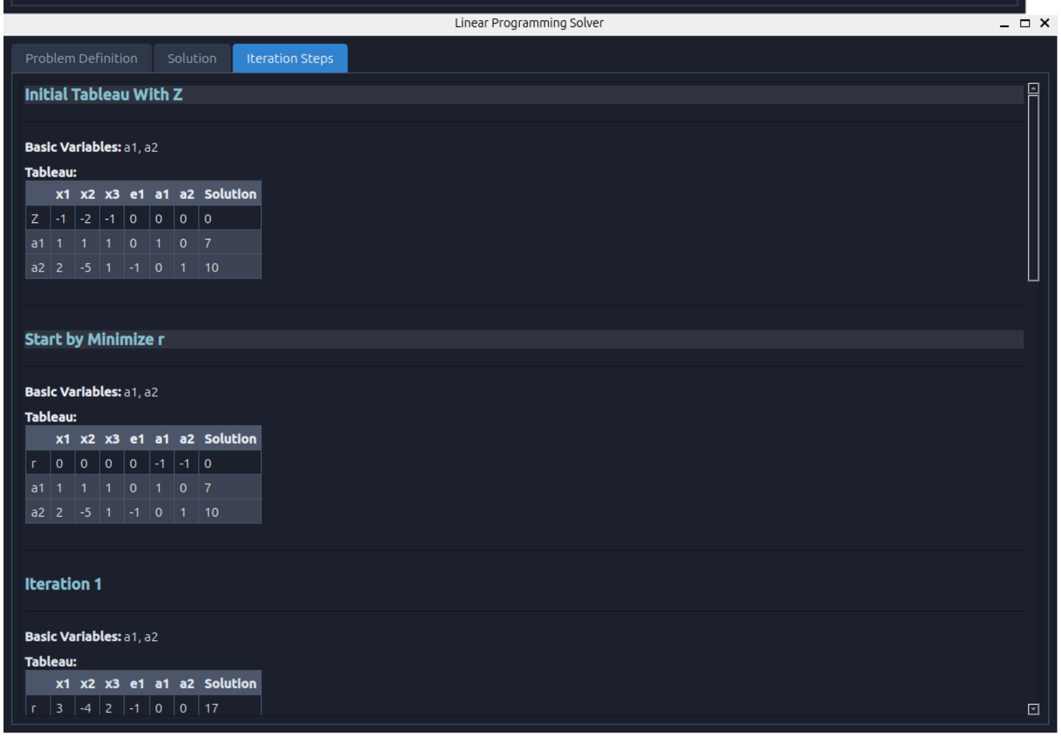
Maximize Z = x1 + 2x2 +x3

x1 + x2 +x3=7

2x1 + 5x2 +x3= 10

x1 + 2x2 +x3≥ 0



Problem Definition | Solution | Iteration Steps

### Iteration 1

**Basic Variables:** a1, a2

**Tableau:**

| | x1 | x2 | x3 | e1 | a1 | a2 | Solution |
|---|---|---|---|---|---|---|---|
| r | 3 | -4 | 2 | -1 | 0 | 0 | 17 |
| a1 | 1 | 1 | 1 | 0 | 1 | 0 | 7 |
| a2 | 2 | -5 | 1 | -1 | 0 | 1 | 10 |

### Iteration 2

**Entering Variable:** x1

**Leaving Variable:** a2

**Basic Variables:** a1, x1

**Tableau:**

| | x1 | x2 | x3 | e1 | a1 | a2 | Solution |
|---|---|---|---|---|---|---|---|
| r | 0 | 3.5000 | 0.5000 | 0.5000 | 0 | -1.5000 | 2 |
| a1 | 0 | 3.5000 | 0.5000 | 0.5000 | 1 | -0.5000 | 2 |
| x1 | 1 | -2.5000 | 0.5000 | -0.5000 | 0 | 0.5000 | 5 |

### Iteration 3

Problem Definition | Solution | Iteration Steps

### Iteration 3

**Entering Variable:** x2

**Leaving Variable:** a1

**Basic Variables:** x2, x1

**Tableau:**

| | x1 | x2 | x3 | e1 | a1 | a2 | Solution |
|---|---|---|---|---|---|---|---|
| r | 0 | 0 | 0 | 0 | -1 | -1 | 0 |
| x2 | 0 | 1 | 0.1429 | 0.1429 | 0.2857 | -0.1429 | 0.5714 |
| x1 | 1 | 0 | 0.8571 | -0.1429 | 0.7143 | 0.1429 | 6.4286 |

### Replace r with Z

**Basic Variables:** x2, x1

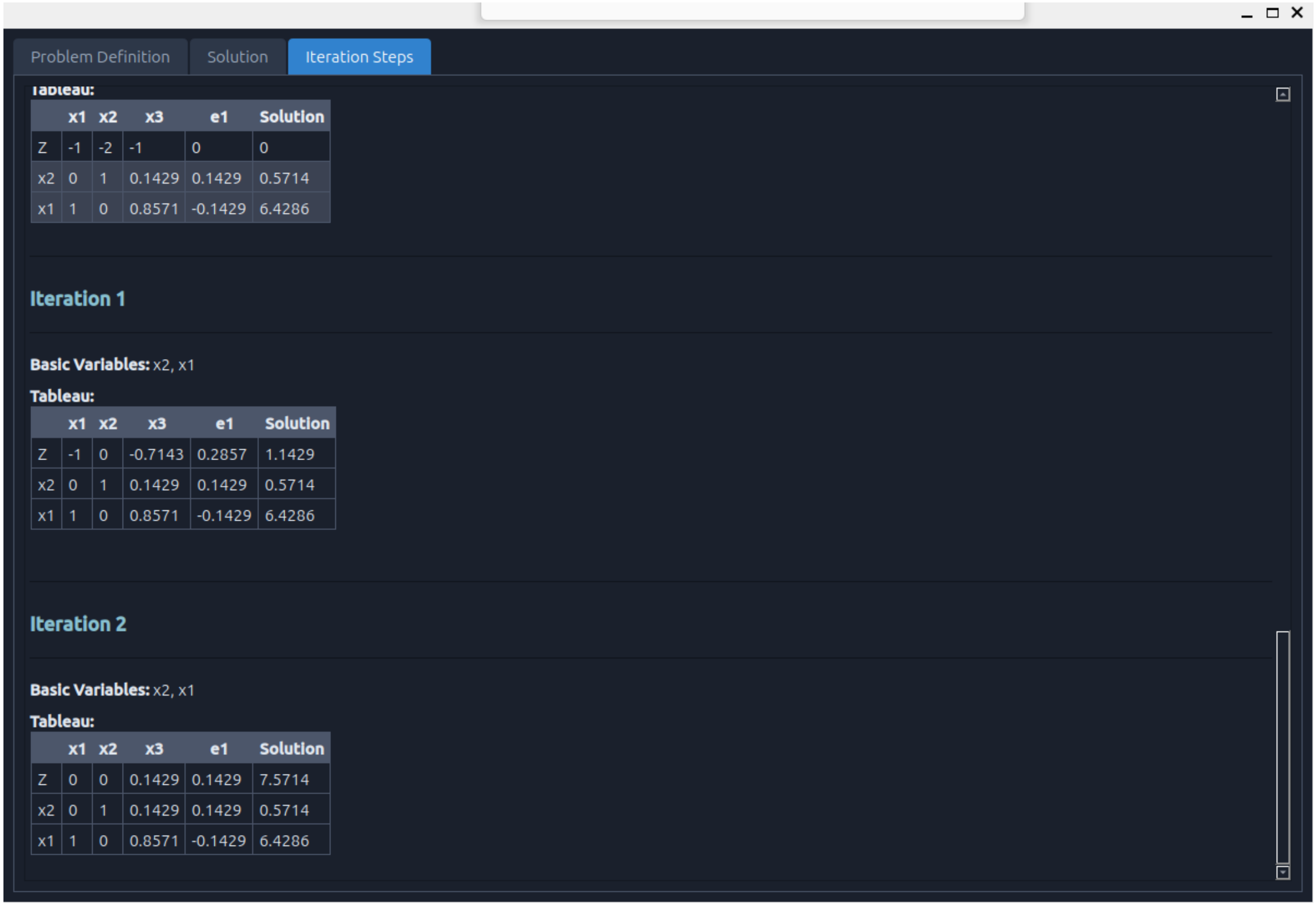
**Tableau:**

| | x1 | x2 | x3 | e1 | Solution |
|---|---|---|---|---|---|
| Z | -1 | -2 | -1 | 0 | 0 |
| x2 | 0 | 1 | 0.1429 | 0.1429 | 0.5714 |
| x1 | 1 | 0 | 0.8571 | -0.1429 | 6.4286 |

### Iteration 1

**Basic Variables:** x2, x1

**Tableau:**



Problem Definition | Solution | Iteration Steps

Tableau:

| | x1 | x2 | x3 | e1 | Solution |
|---|---|---|---|---|---|
| Z | -1 | -2 | -1 | 0 | 0 |
| x2 | 0 | 1 | 0.1429 | 0.1429 | 0.5714 |
| x1 | 1 | 0 | 0.8571 | -0.1429 | 6.4286 |

Iteration 1

**Basic Variables:** x2, x1

**Tableau:**

| | x1 | x2 | x3 | e1 | Solution |
|---|---|---|---|---|---|
| Z | -1 | 0 | -0.7143 | 0.2857 | 1.1429 |
| x2 | 0 | 1 | 0.1429 | 0.1429 | 0.5714 |
| x1 | 1 | 0 | 0.8571 | -0.1429 | 6.4286 |

Iteration 2

**Basic Variables:** x2, x1

**Tableau:**

| | x1 | x2 | x3 | e1 | Solution |
|---|---|---|---|---|---|
| Z | 0 | 0 | 0.1429 | 0.1429 | 7.5714 |
| x2 | 0 | 1 | 0.1429 | 0.1429 | 0.5714 |
| x1 | 1 | 0 | 0.8571 | -0.1429 | 6.4286 |

**Output:**

- Optimal Solution: x1 = 45/7, x2 = 4/7
- Optimal Objective Value: Z = 53/7
-

## 4.4 Example 4 - Goal-programming Method

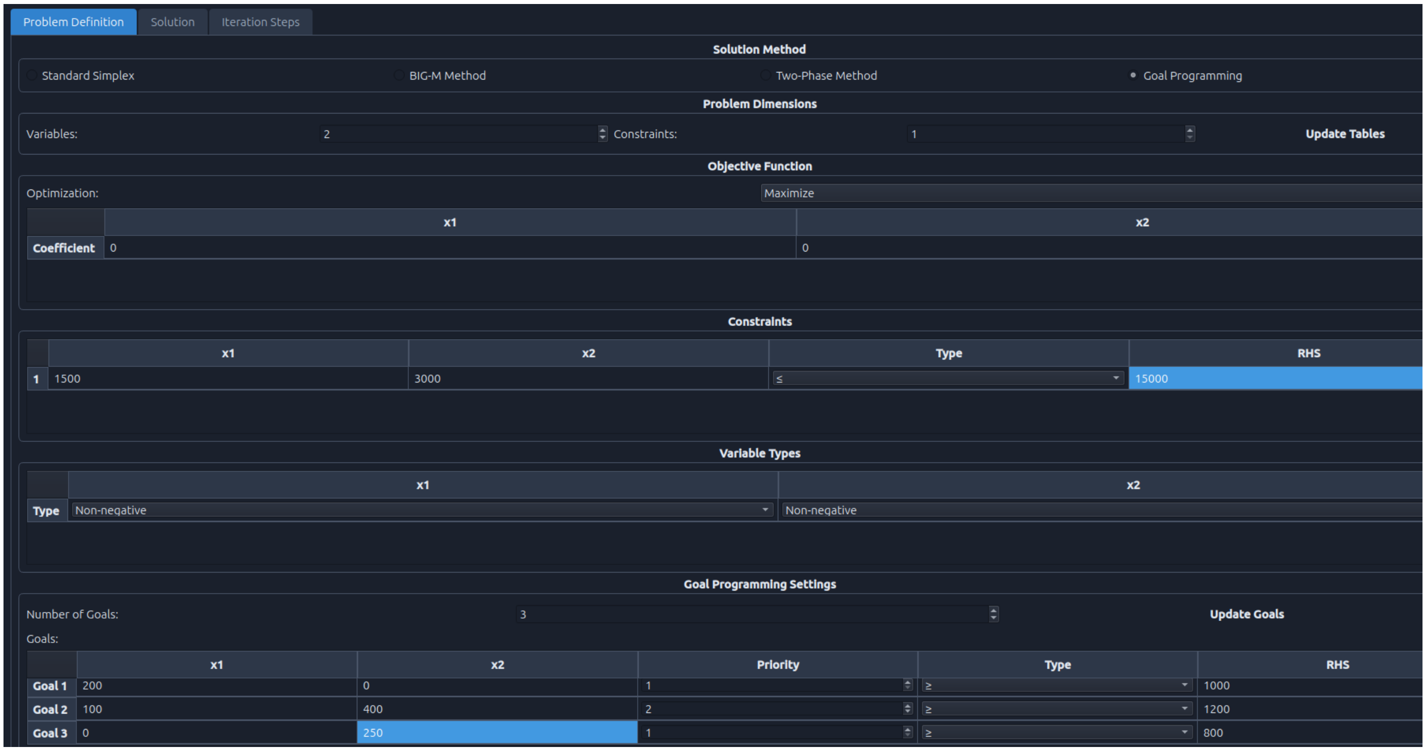
Goals: 200x1>=1000     priority:1

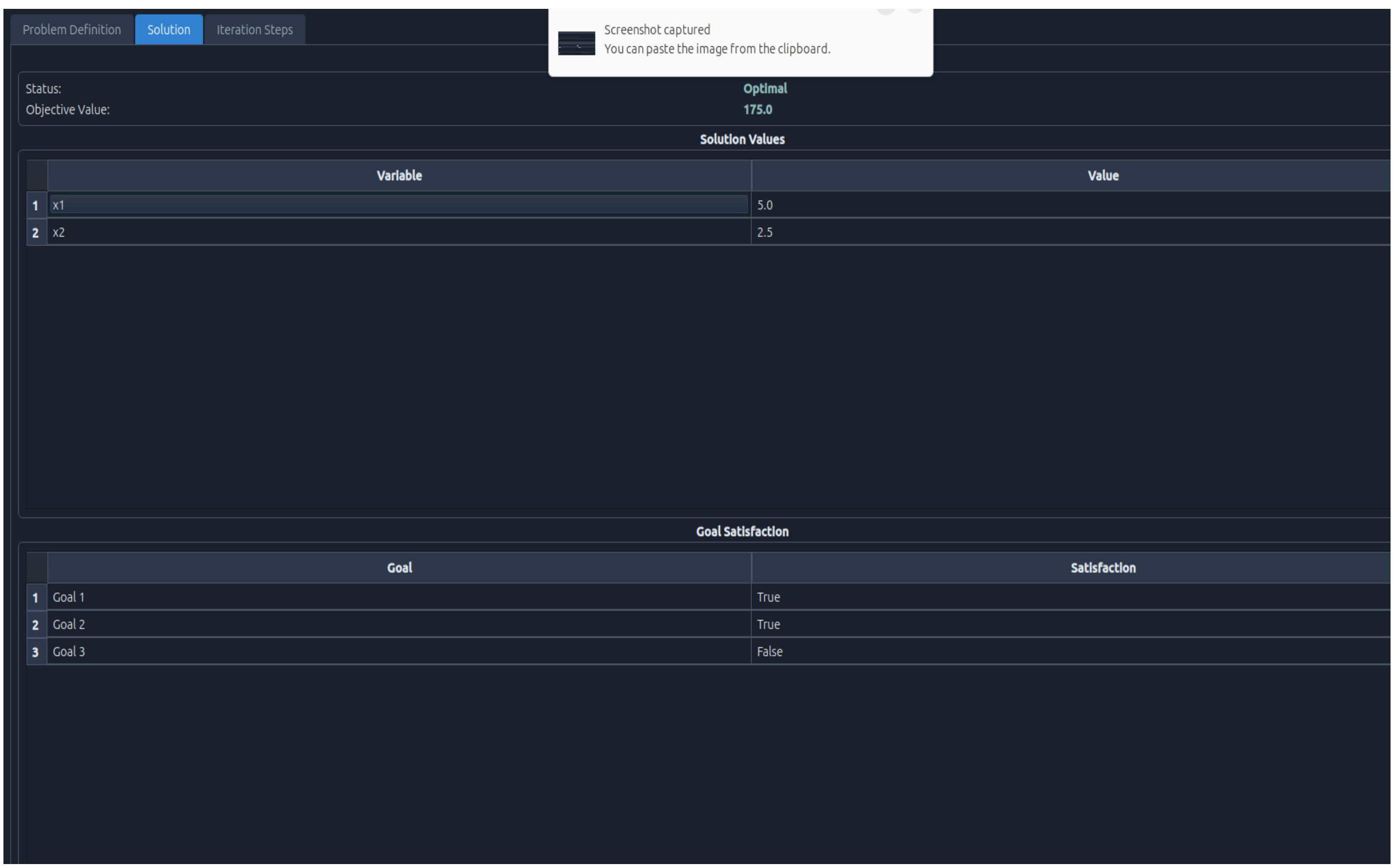
100x1+ 400x2 >=1200   priority:2

250x2 >=800     priority:1

Constraints:

1500x1+3000x2<=15000


Problem Definition
Solution
Iteration Steps
Solution Method
Standard Simplex
BIG-M Method
Two-Phase Method
Goal Programming
Problem Dimensions
Variables: 2
Constraints: 1
Update Tables
Objective Function
Optimization: Maximize
x1
x2
Coefficient 0 0
Constraints
x1 x2 Type RHS
1 1500 3000 ≤ 15000
Variable Types
x1 x2
Type Non-negative Non-negative
Goal Programming Settings
Number of Goals: 3
Update Goals
Goals:
x1 x2 Priority Type RHS
Goal 1 200 0 1 ≥ 1000
Goal 2 100 400 2 ≥ 1200
Goal 3 0 250 1 ≥ 800


Problem Definition
Solution
Iteration Steps
Screenshot captured
You can paste the image from the clipboard.
Status: Optimal
Objective Value: 175.0
Solution Values
Variable Value
1 x1 5.0
2 x2 2.5
Goal Satisfaction
Goal Satisfaction
1 Goal 1 True
2 Goal 2 True
3 Goal 3 False

Problem Definition | Solution | Iteration Steps

**Basic Variables:** d1-, d2-, d3-, s1

**Tableau:**

| | x1 | x2 | d1- | d1+ | d2- | d2+ | d3- | d3+ | s1 | Solution |
|---|---|---|---|---|---|---|---|---|---|---|
| Z1 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Z2 | 0 | 0 | 0 | 0 | -2 | 0 | 0 | 0 | 0 | 0 |
| Z3 | 0 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 0 | 0 |
| d1- | 200 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 1000 |
| d2- | 100 | 400 | 0 | 0 | 1 | -1 | 0 | 0 | 0 | 1200 |
| d3- | 0 | 250 | 0 | 0 | 0 | 0 | 1 | -1 | 0 | 800 |
| s1 | 1500 | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 15000 |

## Iteration 1

**Basic Variables:** d1-, d2-, d3-, s1

**Tableau:**

| | x1 | x2 | d1- | d1+ | d2- | d2+ | d3- | d3+ | s1 | Solution |
|---|---|---|---|---|---|---|---|---|---|---|
| Z1 | 200 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 1000 |
| Z2 | 200 | 800 | 0 | 0 | 0 | -2 | 0 | 0 | 0 | 2400 |
| Z3 | 0 | 250 | 0 | 0 | 0 | 0 | 0 | -1 | 0 | 800 |
| d1- | 200 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 1000 |
| d2- | 100 | 400 | 0 | 0 | 1 | -1 | 0 | 0 | 0 | 1200 |
| d3- | 0 | 250 | 0 | 0 | 0 | 0 | 1 | -1 | 0 | 800 |
| s1 | 1500 | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 15000 |

## Iteration 2

**Entering Variable:** x2

**Leaving Variable:** d2-

**Basic Variables:** d1-, x2, d3-, s1

**Tableau:**

| | x1 | x2 | d1- | d1+ | d2- | d2+ | d3- | d3+ | s1 | Solution |
|---|---|---|---|---|---|---|---|---|---|---|
| Z1 | 200 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 1000 |
| Z2 | 0 | 0 | 0 | 0 | -2 | 0 | 0 | 0 | 0 | 0 |
| Z3 | -62.5000 | 0 | 0 | 0 | -0.6250 | 0.6250 | 0 | -1 | 0 | 50 |
| d1- | 200 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 1000 |
| x2 | 0.2500 | 1 | 0 | 0 | 0.0025 | -0.0025 | 0 | 0 | 0 | 3 |
| d3- | -62.5000 | 0 | 0 | 0 | -0.6250 | 0.6250 | 1 | -1 | 0 | 50 |
| s1 | 750 | 0 | 0 | 0 | -7.5000 | 7.5000 | 0 | 0 | 1 | 6000 |

Problem Definition | Solution | Iteration Steps

**Tableau:**

| | x1 | x2 | d1- | d1+ | d2- | d2+ | d3- | d3+ | s1 | Solution |
|---|---|---|---|---|---|---|---|---|---|---|
| Z1 | 200 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 1000 |
| Z2 | 0 | 0 | 0 | 0 | -2 | 0 | 0 | 0 | 0 | 0 |
| Z3 | -62.5000 | 0 | 0 | 0 | -0.6250 | 0.6250 | 0 | -1 | 0 | 50 |
| d1- | 200 | 0 | 1 | -1 | 0 | 0 | 0 | 0 | 0 | 1000 |
| x2 | 0.2500 | 1 | 0 | 0 | 0.0025 | -0.0025 | 0 | 0 | 0 | 3 |
| d3- | -62.5000 | 0 | 0 | 0 | -0.6250 | 0.6250 | 1 | -1 | 0 | 50 |
| s1 | 750 | 0 | 0 | 0 | -7.5000 | 7.5000 | 0 | 0 | 1 | 6000 |

### Iteration 3

**Entering Variable:** x1

**Leaving Variable:** d1-

**Basic Variables:** x1, x2, d3-, s1

**Tableau:**

| | x1 | x2 | d1- | d1+ | d2- | d2+ | d3- | d3+ | s1 | Solution |
|---|---|---|---|---|---|---|---|---|---|---|
| Z1 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Z2 | 0 | 0 | 0 | 0 | -2 | 0 | 0 | 0 | 0 | 0 |
| Z3 | 0 | 0 | 0.3125 | -0.3125 | -0.6250 | 0.6250 | 0 | -1 | 0 | 362.5000 |
| x1 | 1 | 0 | 0.0050 | -0.0050 | 0 | 0 | 0 | 0 | 0 | 5 |
| x2 | 0 | 1 | -0.0013 | 0.0013 | 0.0025 | -0.0025 | 0 | 0 | 0 | 1.7500 |
| d3- | 0 | 0 | 0.3125 | -0.3125 | -0.6250 | 0.6250 | 1 | -1 | 0 | 362.5000 |
| s1 | 0 | 0 | -3.7500 | 3.7500 | -7.5000 | 7.5000 | 0 | 0 | 1 | 2250 |

### Iteration 4

**Entering Variable:** d2+

**Leaving Variable:** s1

**Basic Variables:** x1, x2, d3-, d2+

**Tableau:**

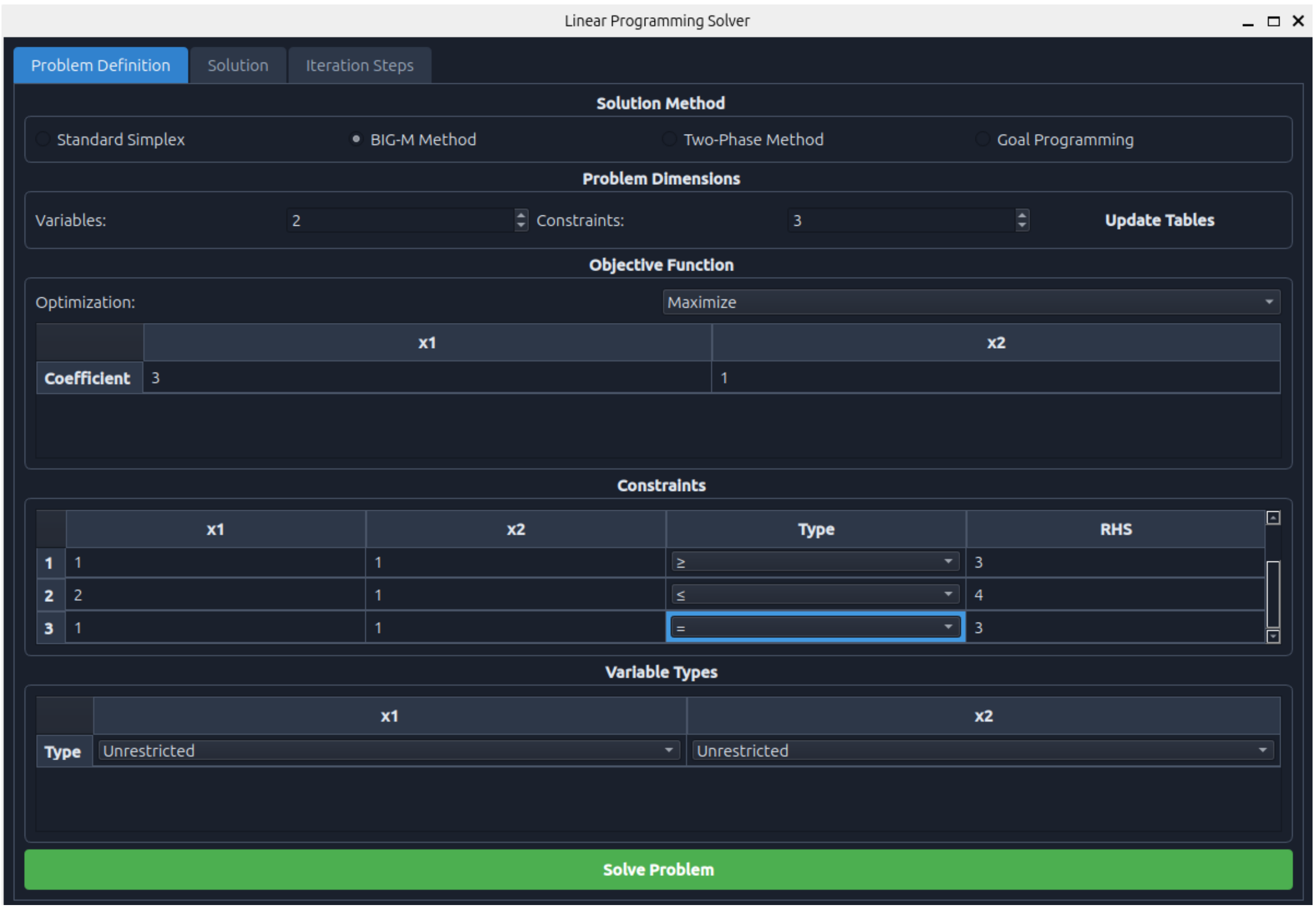
| | x1 | x2 | d1- | d1+ | d2- | d2+ | d3- | d3+ | s1 | Solution |
|---|---|---|---|---|---|---|---|---|---|---|
| Z1 | 0 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Z2 | 0 | 0 | 0 | 0 | -2 | 0 | 0 | 0 | 0 | 0 |
| Z3 | 0 | 0 | 0.6250 | -0.6250 | 0 | 0 | 0 | -1 | -0.0833 | 175 |
| x1 | 1 | 0 | 0.0050 | -0.0050 | 0 | 0 | 0 | 0 | 0 | 5 |
| x2 | 0 | 1 | -0.0025 | 0.0025 | 0 | 0 | 0 | 0 | 0.0003 | 2.5000 |
| d3- | 0 | 0 | 0.6250 | -0.6250 | 0 | 0 | 1 | -1 | -0.0833 | 175 |
| d2+ | 0 | 0 | -0.5000 | 0.5000 | -1 | 1 | 0 | 0 | 0.1333 | 300 |

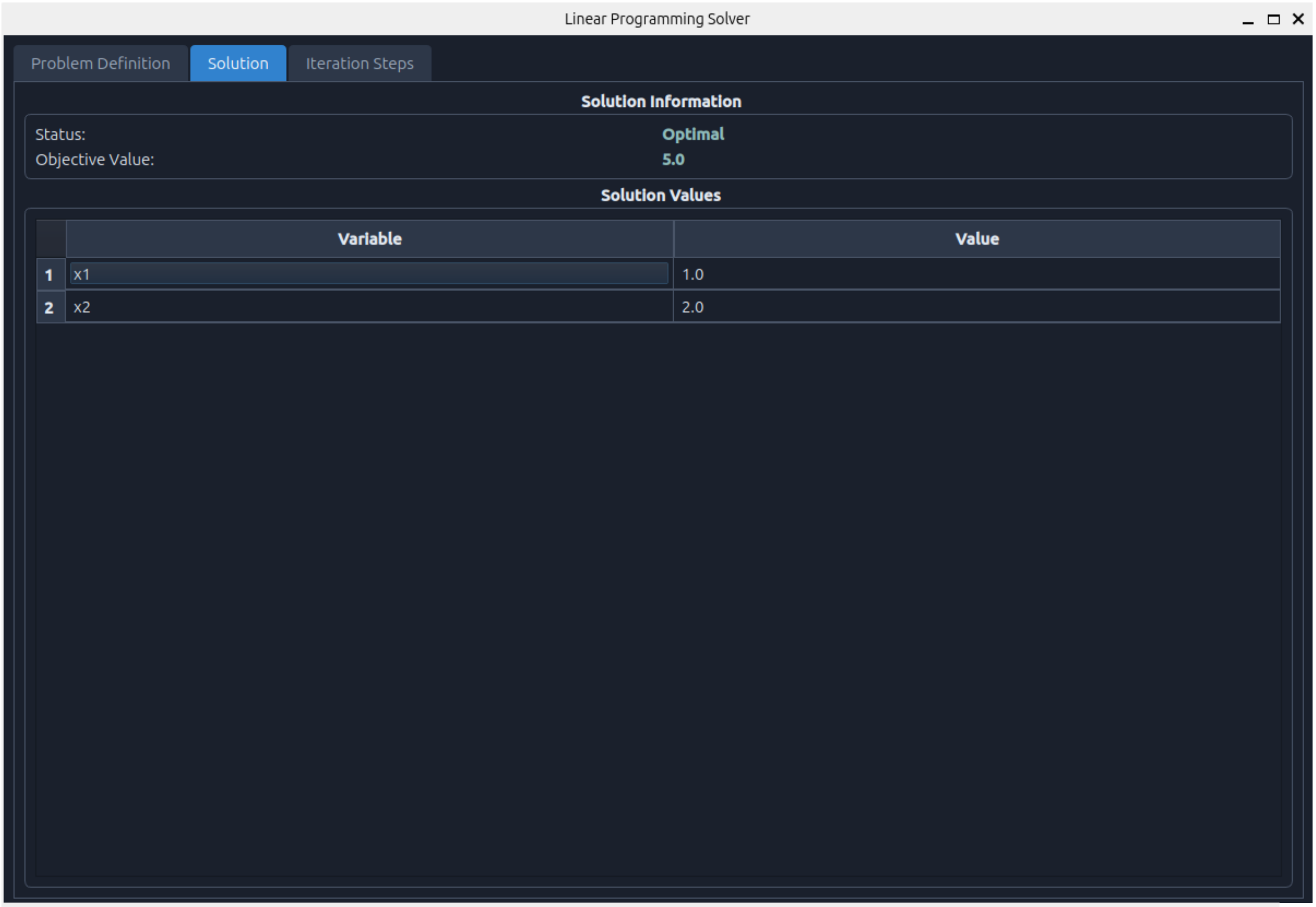
**Output:**

- Optimal Solution: x1 = 5, x2 = 2.5

## 4.4 Example 4 – Unrestricted variables

Maximize Z =3 x1 +x2
x1 + x2 ≥7
2x1 + x2 <= 4
x1 + x2 =3





Linear Programming Solver

Problem Definition | Solution | Iteration Steps

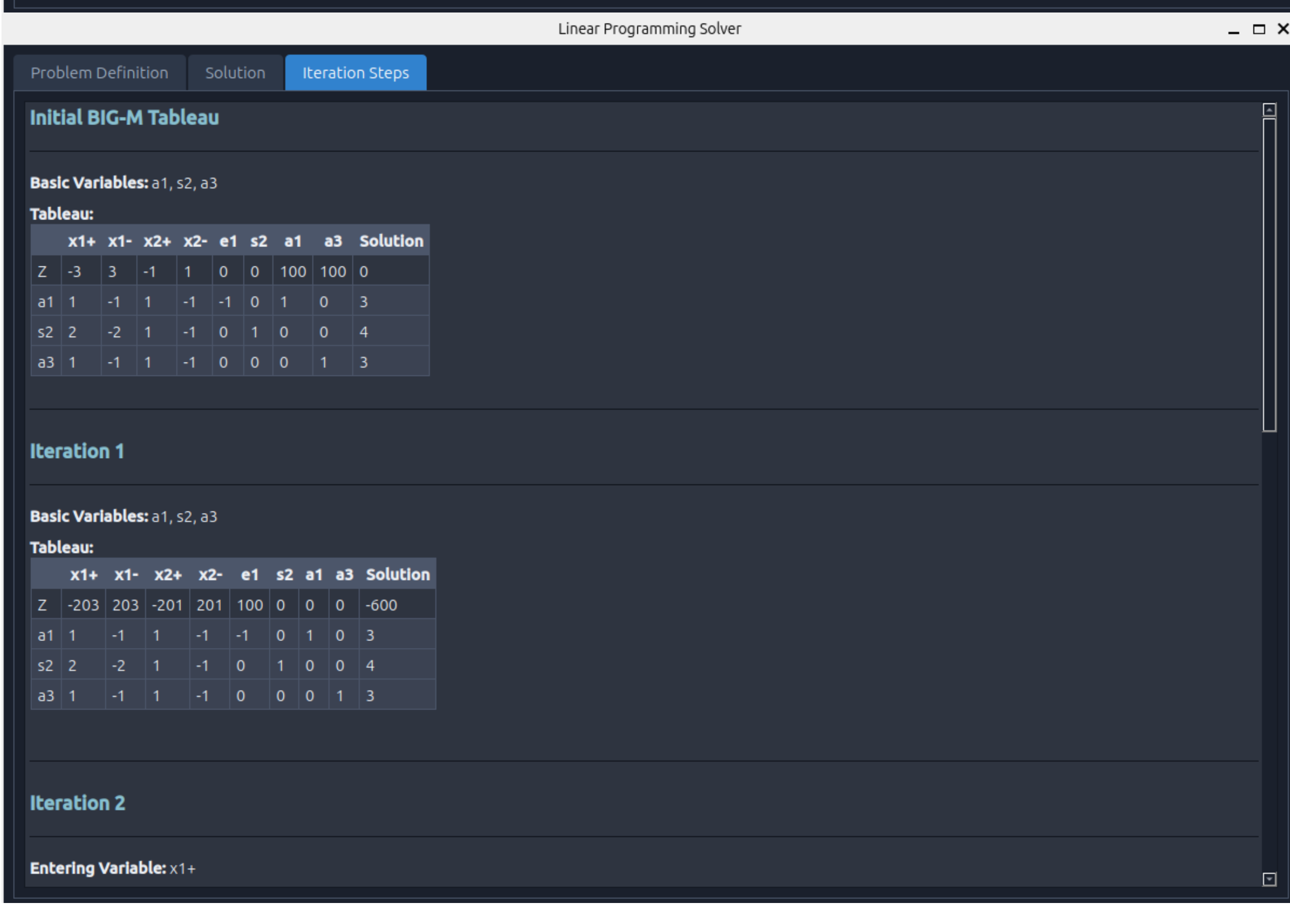
**Solution Information**

Status: **Optimal**

Objective Value: **5.0**

**Solution Values**

| | Variable | Value |
|---|---|---|
| 1 | x1 | 1.0 |
| 2 | x2 | 2.0 |



Linear Programming Solver

Problem Definition | Solution | Iteration Steps

## Initial BIG-M Tableau

**Basic Variables:** a1, s2, a3

**Tableau:**

| | x1+ | x1- | x2+ | x2- | e1 | s2 | a1 | a3 | Solution |
|---|---|---|---|---|---|---|---|---|---|
| Z | -3 | 3 | -1 | 1 | 0 | 0 | 100 | 100 | 0 |
| a1 | 1 | -1 | 1 | -1 | -1 | 0 | 1 | 0 | 3 |
| s2 | 2 | -2 | 1 | -1 | 0 | 1 | 0 | 0 | 4 |
| a3 | 1 | -1 | 1 | -1 | 0 | 0 | 0 | 1 | 3 |

## Iteration 1

**Basic Variables:** a1, s2, a3

**Tableau:**

| | x1+ | x1- | x2+ | x2- | e1 | s2 | a1 | a3 | Solution |
|---|---|---|---|---|---|---|---|---|---|
| Z | -203 | 203 | -201 | 201 | 100 | 0 | 0 | 0 | -600 |
| a1 | 1 | -1 | 1 | -1 | -1 | 0 | 1 | 0 | 3 |
| s2 | 2 | -2 | 1 | -1 | 0 | 1 | 0 | 0 | 4 |
| a3 | 1 | -1 | 1 | -1 | 0 | 0 | 0 | 1 | 3 |

## Iteration 2

**Entering Variable:** x1+

Linear Programming Solver

Problem Definition | Solution | Iteration Steps

### Iteration 2

**Entering Variable:** x1+

**Leaving Variable:** s2

**Basic Variables:** a1, x1+, a3

**Tableau:**

| | x1+ | x1- | x2+ | x2- | e1 | s2 | a1 | a3 | Solution |
|---|---|---|---|---|---|---|---|---|---|
| Z | 0 | 0 | -99.5000 | 99.5000 | 100 | 101.5000 | 0 | 0 | -194 |
| a1 | 0 | 0 | 0.5000 | -0.5000 | -1 | -0.5000 | 1 | 0 | 1 |
| x1+ | 1 | -1 | 0.5000 | -0.5000 | 0 | 0.5000 | 0 | 0 | 2 |
| a3 | 0 | 0 | 0.5000 | -0.5000 | 0 | -0.5000 | 0 | 1 | 1 |

### Iteration 3

**Entering Variable:** x2+

**Leaving Variable:** a1

**Basic Variables:** x2+, x1+, a3

**Tableau:**

| | x1+ | x1- | x2+ | x2- | e1 | s2 | a1 | a3 | Solution |
|---|---|---|---|---|---|---|---|---|---|
| Z | 0 | 0 | 0 | 0 | -99 | 2 | 199 | 0 | 5 |
| x2+ | 0 | 0 | 1 | -1 | -2 | -1 | 2 | 0 | 2 |
| x1+ | 1 | -1 | 0 | 0 | 1 | 1 | -1 | 0 | 1 |
| a3 | 0 | 0 | 0 | 0 | 1 | 0 | -1 | 1 | 0 |

Linear Programming Solver

Problem Definition | Solution | Iteration Steps

### Iteration 3

**Entering Variable:** x2+

**Leaving Variable:** a1

**Basic Variables:** x2+, x1+, a3

**Tableau:**

| | x1+ | x1- | x2+ | x2- | e1 | s2 | a1 | a3 | Solution |
|---|---|---|---|---|---|---|---|---|---|
| Z | 0 | 0 | 0 | 0 | -99 | 2 | 199 | 0 | 5 |
| x2+ | 0 | 0 | 1 | -1 | -2 | -1 | 2 | 0 | 2 |
| x1+ | 1 | -1 | 0 | 0 | 1 | 1 | -1 | 0 | 1 |
| a3 | 0 | 0 | 0 | 0 | 1 | 0 | -1 | 1 | 0 |

### Iteration 4

**Entering Variable:** e1

**Leaving Variable:** a3

**Basic Variables:** x2+, x1+, e1

**Tableau:**

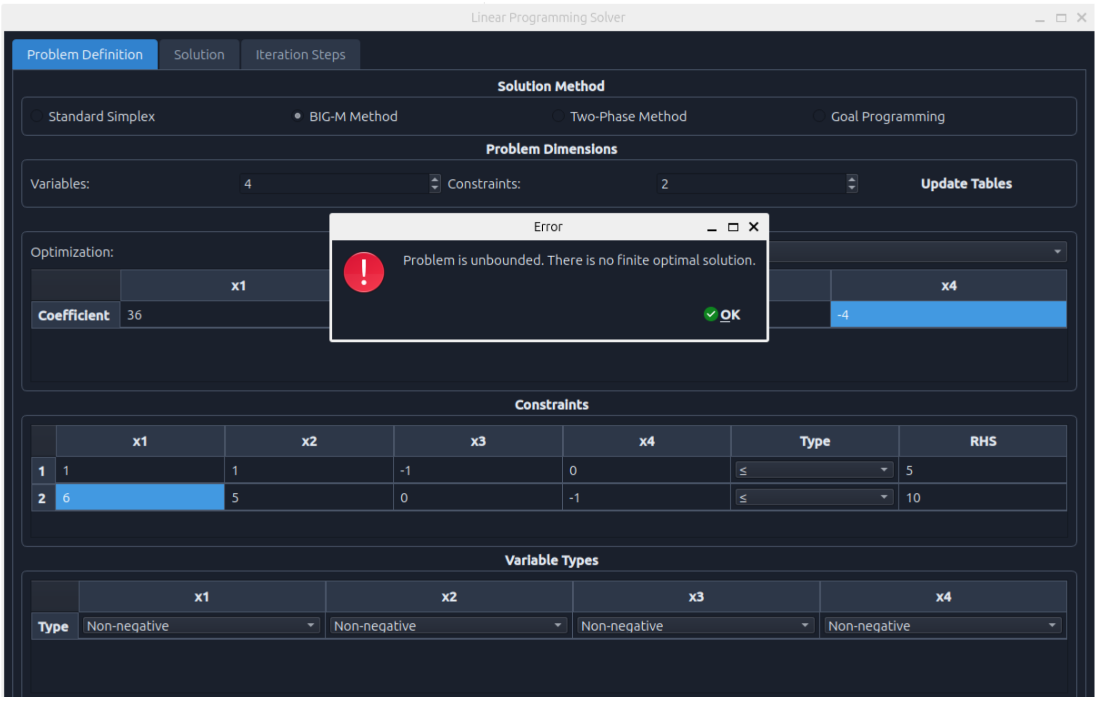
| | x1+ | x1- | x2+ | x2- | e1 | s2 | a1 | a3 | Solution |
|---|---|---|---|---|---|---|---|---|---|
| Z | 0 | 0 | 0 | 0 | 0 | 2 | 100 | 99 | 5 |
| x2+ | 0 | 0 | 1 | -1 | 0 | -1 | 0 | 2 | 2 |
| x1+ | 1 | -1 | 0 | 0 | 0 | 1 | 0 | -1 | 1 |
| e1 | 0 | 0 | 0 | 0 | 1 | 0 | -1 | 1 | 0 |

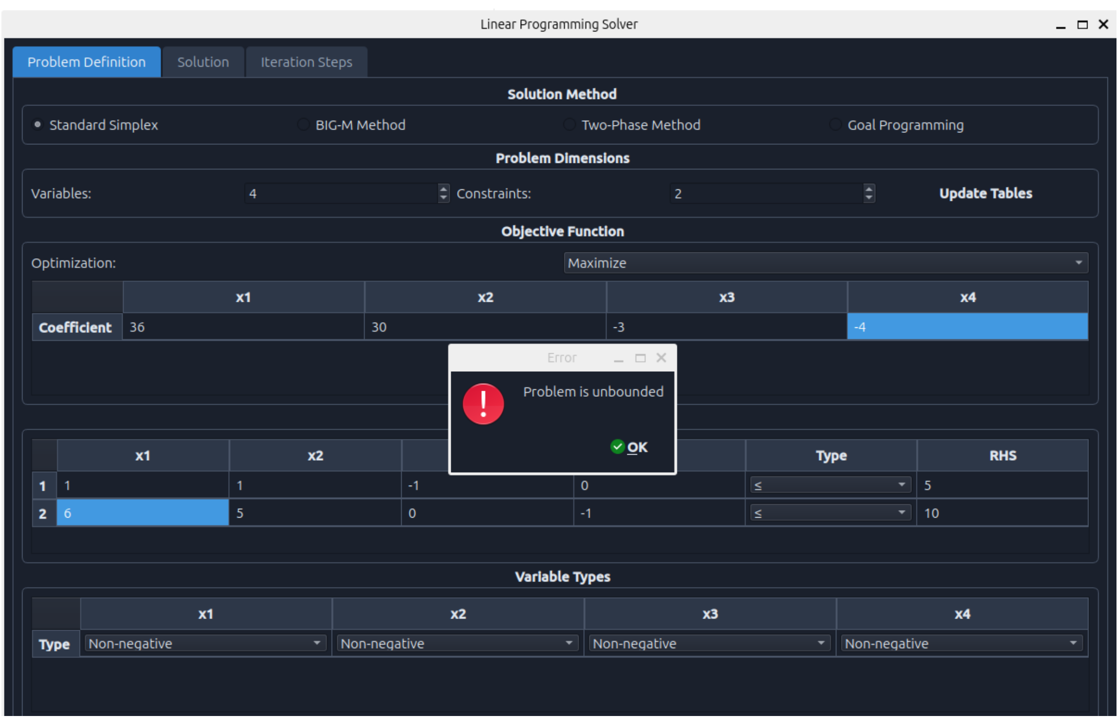
## 4.5 Example 5 – unbounded solution

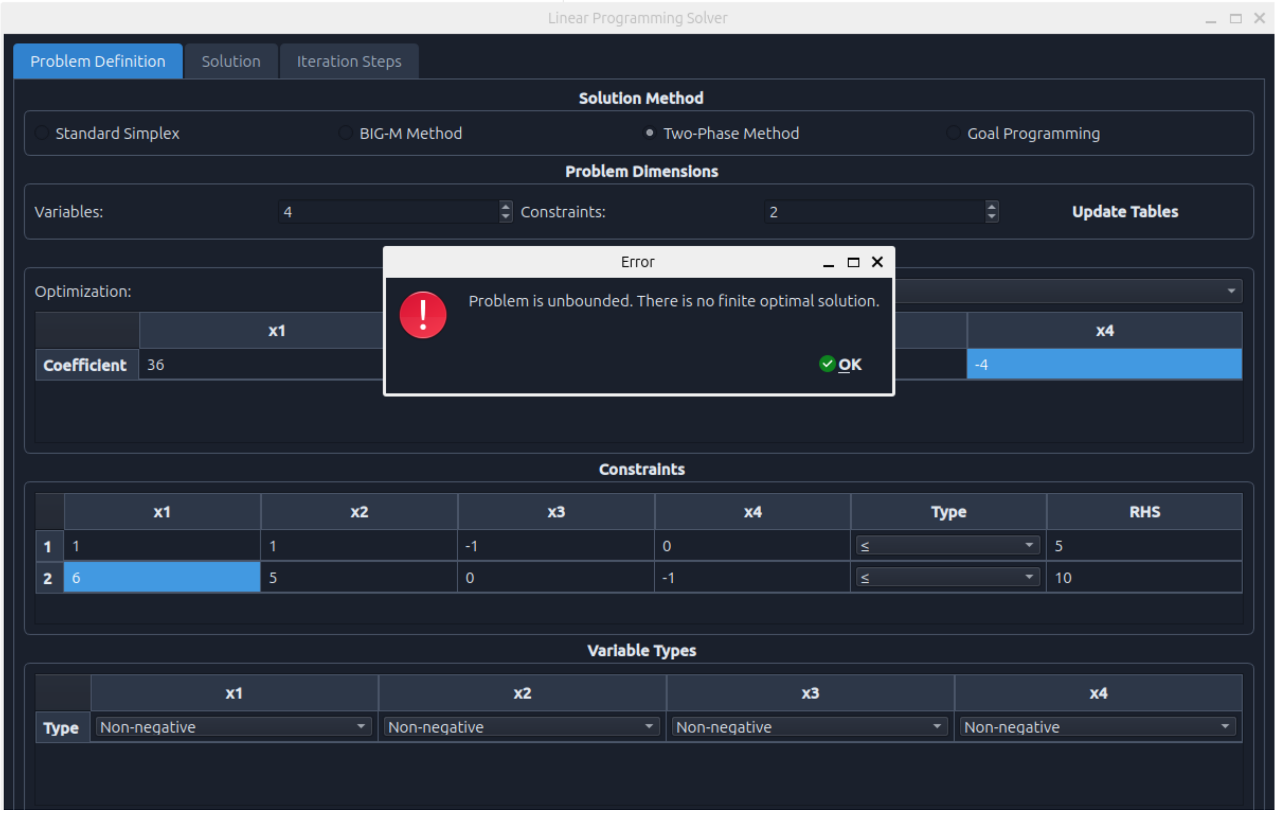
Maximize Z =36 x1 +30x2 -3 x3 -4x4

x1 + x2-x3 <= 5

6x1 + 5x2-x4 <=10





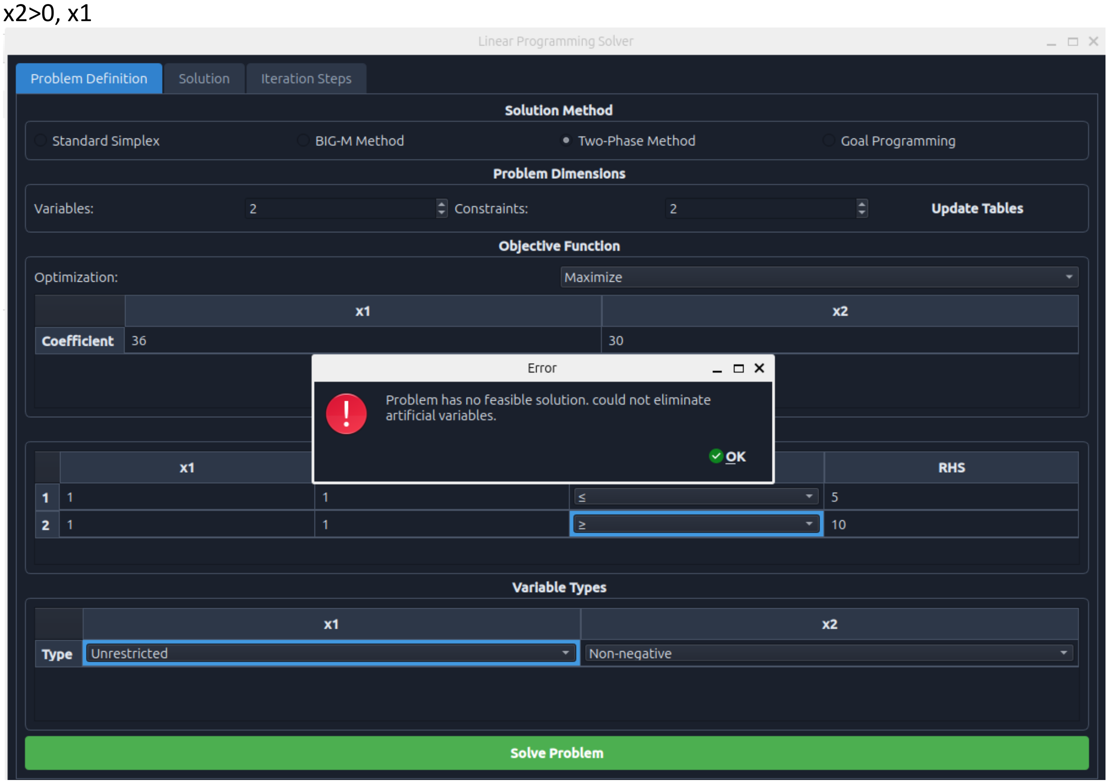

## 4.6 Example 6 – infeasible solution

Maximize Z =36 x1 +30 x2

x1 + x2 ≥10

x1 + x2 <= 5

x2>0, x1



## 5. Bonus Feature

We developed a **user-friendly interface** by pyQt5 in python that allows users to input LP problems easily and view the solution process interactively.

## 6. Conclusion

This project provided hands-on experience in solving LP problems using different methods. The solver successfully handles various constraints and outputs detailed step-by-step solutions. Future improvements include extending support for additional optimization techniques and graphical visualization of results.