ISE 4623/5023: Deterministic Systems Models / Systems Optimization

University of Oklahoma
College of Engineering
School of Industrial and Systems Engineering
Fall 2021

Individual Assignment 2 (100 points)

Name: **Student ID:**

Problem 1 - (50 points)

Seeds Inc. is a company that produces and exports bags of corn seeds. For this purpose, the company has a production plant in the state of Oklahoma, in which the company processes corn of two varieties: Hard and Serrated. To make the seed bags, the plant uses three resources: water, electricity, and gas. The following table provides the basic data of the problem:

Resource	Hard (units of resources per bag of seeds)	Serrated (units of raw resources per bag of seeds)	Maximum monthly availability (units of Liters, kWh, and cm^3, respectively)
Water	100.05	60.75	810.50
Electricity	5.50	10.25	655.80
Gas	75.30	24.84	520.75
Profit per seed bag	\$275.75	\$120.50	

In this way, Seeds Inc. produces bags of seeds for both varieties of corn that it processes (i.e., hard corn seeds and serrated corn seeds). Given that Seeds Inc. is so famous and respected, the demand for her seed bags is always very high, so they always sell all the seed bags they produce, and they cand produce fractional numbers of seed bags (i.e., 7.22 bag of hard corn seed bags). You want to determine the production plan that retrieves the greatest profit to Seeds Inc.'s profit. To do this, first you decide to formulate this problem as an LP model. In particular:

a. (5 points) Define the decision variables for this problem. What is its gradient?

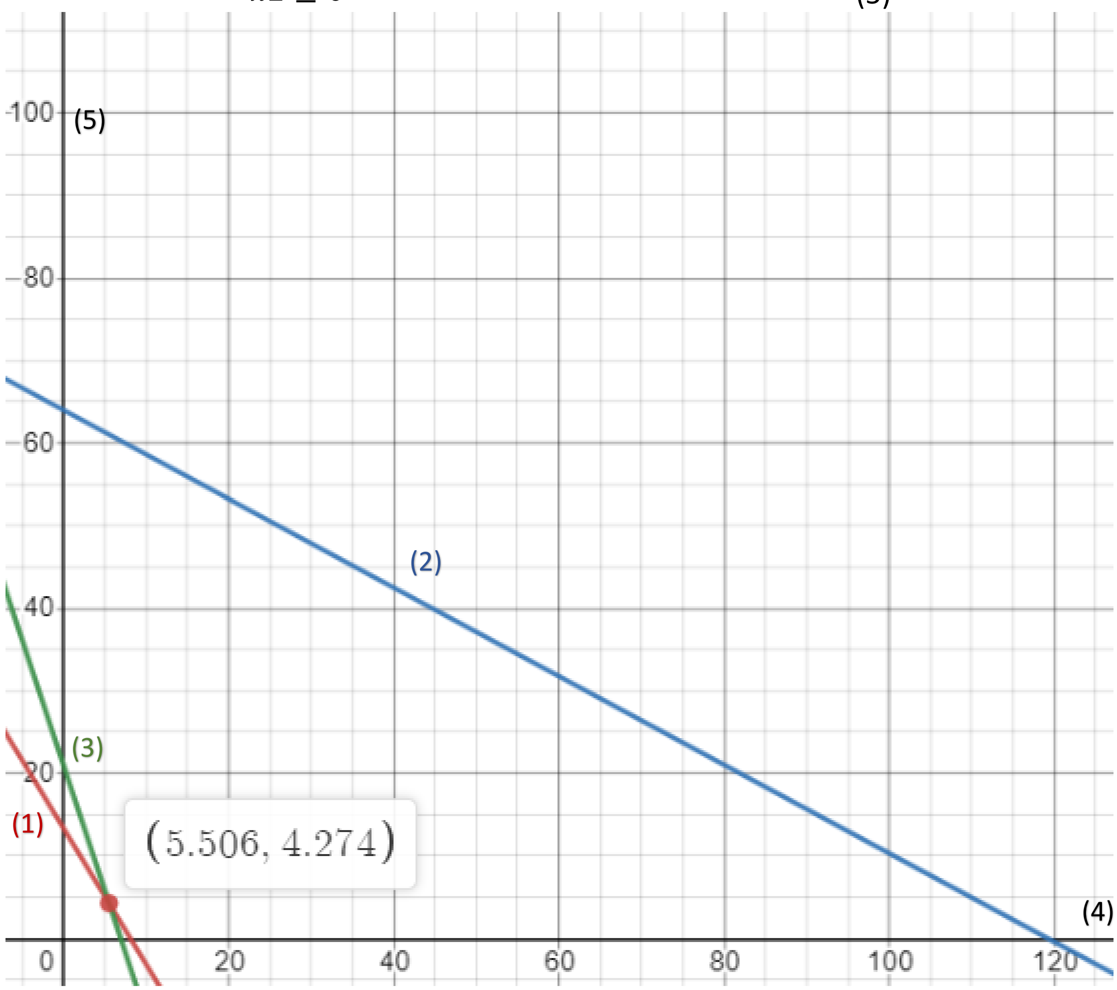
Decision variables:
x_1: Number of Hard seed bags produced.
x_2: Number of Serrated seed bags produced.

Objective function:
$z = 275.75 \cdot x_1 + 120.5 \cdot x_2$

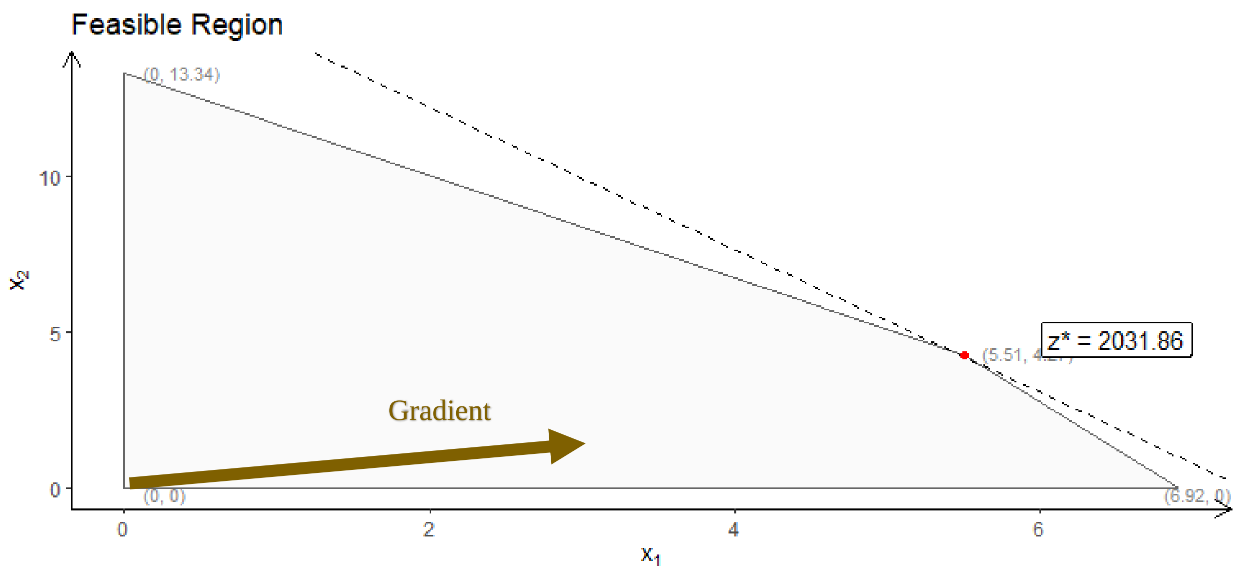
Gradient:
$\nabla z = \begin{bmatrix} 275.75 \\ 120.5 \end{bmatrix}$

b. (15 points) Plot the gradient and the feasible region (clearly indicating all the constraints and "shading" the feasible region).

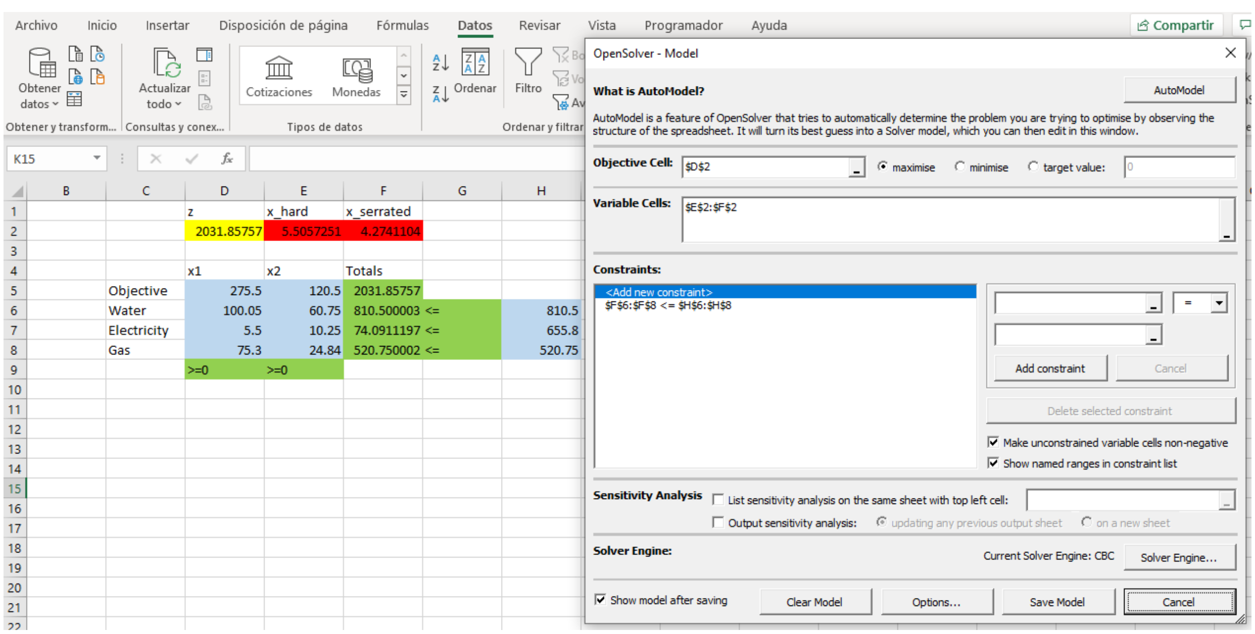
$$\max 275.75x1 + 120.5x2$$
s.t.,
$$100.05x1 + 60.75x2 \leq 810.50 \quad (1)$$
$$5.50x1 + 10.25x2 \leq 655.80 \quad (2)$$
$$75.30x1 + 24.84x2 \leq 520.75 \quad (3)$$
$$x1 \geq 0 \quad (4)$$
$$x2 \geq 0 \quad (5)$$



c. (5 points) Solve this problem using the graphical method. Indicate the values of all the variables and the objective function associated with the optimal solution.



d. (10 points) Solve the problem using Excel Solver and indicate the values of all the variables and the objective function associated with the optimal solution. Compare your results with part c. Include a snapshot of your Excel model (Excel cells and the Solver window).



e. (15 points) Solve the problem using Gurobi/Python. Compare your results with parts c and d. Include a snapshot of your Gurobi/Python code and obtained results.

```
In [1]:
from gurobipy import *
import numpy as np
import matplotlib.pyplot as plt
import random

def Seeds():
    #Follower
    m = Model('seeds')

    m.setParam(GRB.Param.OutputFlag, 0)
    m.setParam(GRB.Param.DualReductions, 0)

    x_hard = m.addVar(vtype=GRB.CONTINUOUS, name = 'hard_seeds')
    x_serrated = m.addVar(vtype=GRB.CONTINUOUS, name = 'serrated_seeds')

    m.setObjective(275.5*x_hard + 120.50*x_serrated, GRB.MAXIMIZE)

    c1_1 = m.addConstr(x_hard*100.05 + x_serrated*60.75 <= 810.50, name = 'water')
    c2_1 = m.addConstr(x_hard*5.50 + x_serrated*10.25 <= 655.80, name ='electricity')
    c3_1 = m.addConstr(x_hard*75.30 + x_serrated*24.84 <= 520.75, name = 'gas')

    m.update()

    return m

m1 = Seeds()

m1.optimize()

for v in m1.getVars():
    if v.varName == 'hard_seeds':
        print(f'Hard seed bags produced: {v.x}')
    else:
        print(f'Serratred seed bags produced: {v.x}')
print(f'Total profit: {m1.objVal}')
```

```
Academic license - for non-commercial use only - expires 2022-08-12
Using license file C:\Users\samue\gurobi.lic
Hard seed bags produced: 5.505725067524782
Serratred seed bags produced: 4.274110403195811
Total profit: 2031.8575596881726
```

Problem 2 (50 points)

Andes Inc. is an oil company that has a refinery on the Texas coast. The refinery processes crude oil from Saudi Arabia and Venezuela, producing gasoline, diesel, and lubricants. The two crude oils differ in their chemical composition, which is why they produce different amounts of each product. A barrel of crude from Saudi Arabia produces 0.3 barrels of gasoline, 0.4 barrels of diesel, and 0.2 barrels of lubricants. On the other hand, a barrel from Venezuela produces 0.4 barrels of gasoline, 0.2 barrels of diesel, and 0.3 barrels of lubricants. The remaining 10% of the crude is lost in the refining process.

Crudes also differ in price and availability. Andes Inc. can buy up to 9,000 barrels per day from Saudi Arabia at a price of $20 per barrel. You can buy from Venezuela up to 6,000 barrels per day at a price of $ 15 per barrel.

The contracts established by Andes Inc. forces them to produce 2,000 barrels per day of gasoline, 1,500 barrels per day of diesel, and 500 barrels per day of lubricants.

You want to determine the supply plan for the crude oil that results in the least cost for Andes Inc. To do this, first you decide to formulate this problem as an LP model. In particular:

f. (5 points) Define the decision variables for this problem. What is its gradient?

Decision variables:
x_a: Number of barrels bought from Saudi Arabia.
x_v: Number of barrels bought from Venezuela.

Objective function

$$z = 20 \cdot x_a + 15 \cdot x_v$$

Gradient
$\nabla z = \begin{bmatrix} 20 \\ 15 \end{bmatrix}$

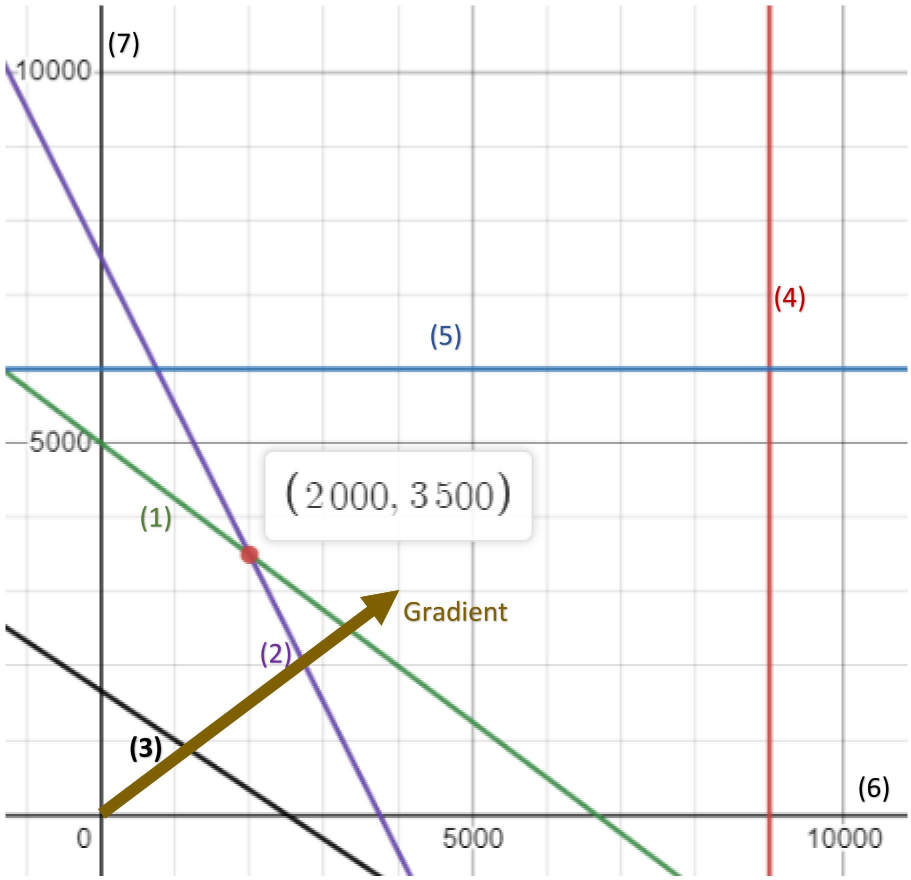
g. (15 points) Plot the gradient and the feasible region (clearly indicating all the constraints and "shading" the feasible region).

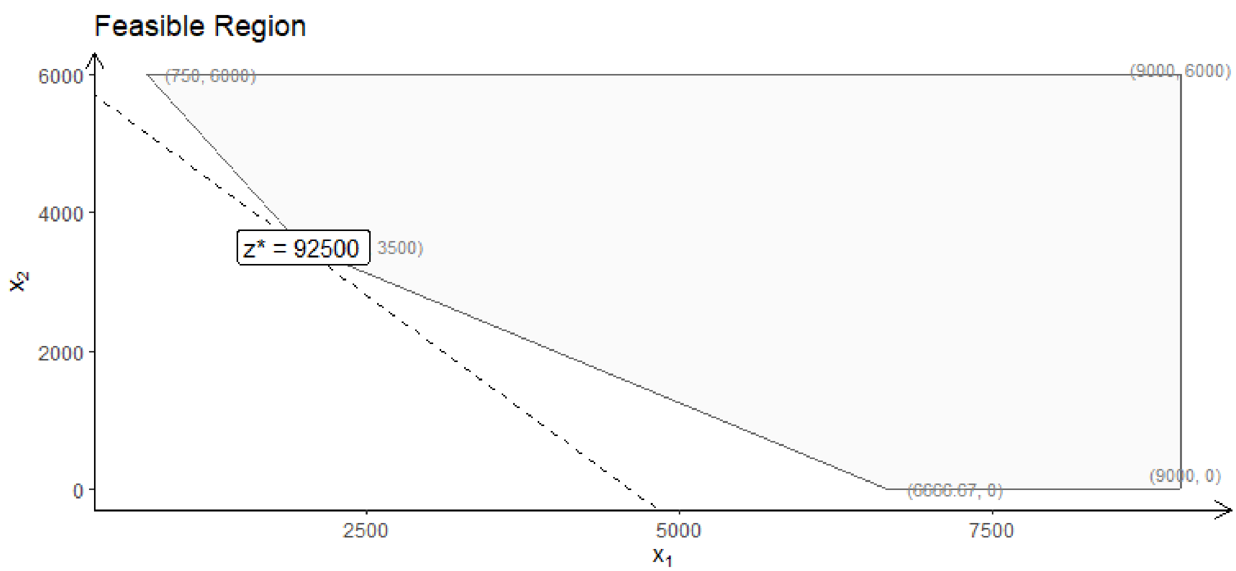
$$\min 20x_a + 15x_v$$

s.t.,

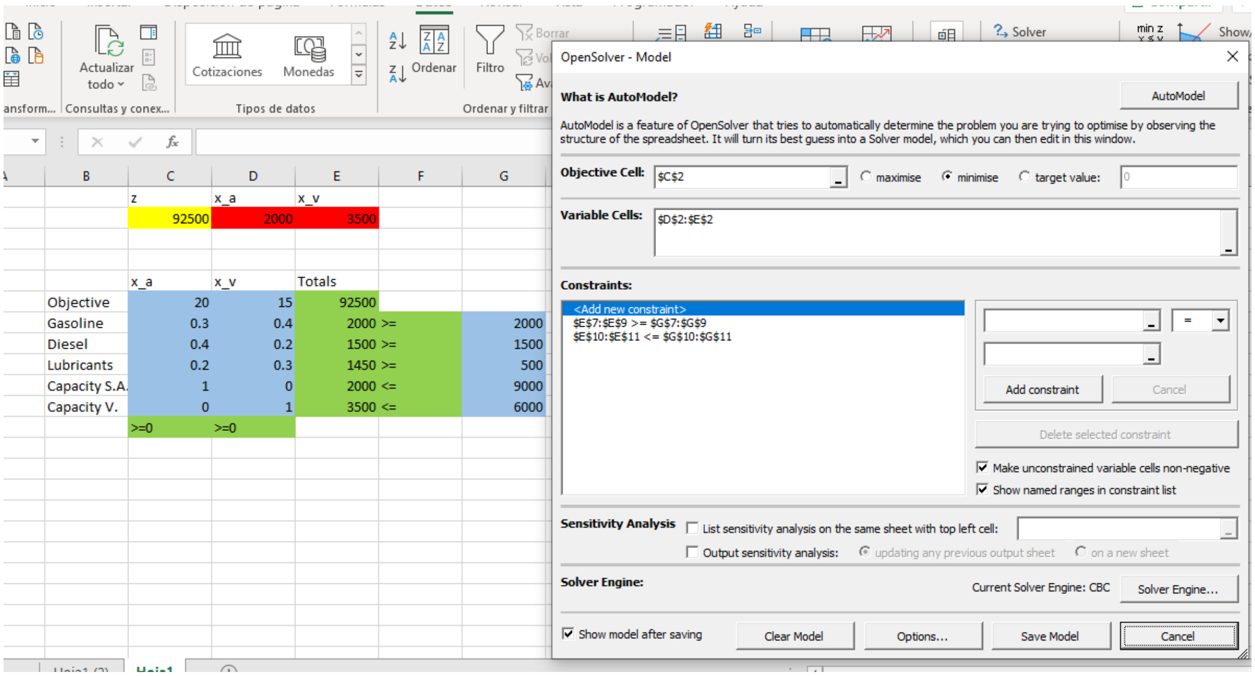
$$0.3x_a + 0.4x_v \geq 2000 \quad (1)$$
$$0.4x_a + 0.2x_v \geq 1500 \quad (2)$$
$$0.2x_a + 0.3x_v \geq 500 \quad (3)$$
$$x_a \leq 9000 \quad (4)$$
$$x_v \leq 6000 \quad (5)$$
$$x1 \geq 0 \quad (6)$$
$$x2 \geq 0 \quad (7)$$

h. (5 points) Solve this problem using the graphical method. Indicate the values of all the variables and the objective function associated with the optimal solution.





i. (10 points) Solve the problem using Excel Solver and indicate the values of all the variables and the objective function associated with the optimal solution. Compare your results with part c. Include a snapshot of your Excel model (Excel cells and the Solver window).



j. (15 points) Solve the problem using Gurobi/Python. Compare your results with parts c and d. Include a snapshot of your Gurobi/Python code and obtained results.

```
In [2]:
def Andes():
    #Follower
    m = Model('Andes')

    m.setParam(GRB.Param.OutputFlag, 0)
    m.setParam(GRB.Param.DualReductions, 0)

    x_a = m.addVar(vtype=GRB.CONTINUOUS, name = 'saudi_arabia')
    x_v = m.addVar(vtype=GRB.CONTINUOUS, name = 'venezuela')

    m.setObjective(20*x_a + 15*x_v, GRB.MINIMIZE)

    c1_1 = m.addConstr(0.3*x_a + 0.4*x_v >= 2000, name = 'gasoline_production')
    c2_1 = m.addConstr(0.4*x_a + 0.2*x_v >= 1500, name ='diesel_production')
    c3_1 = m.addConstr(0.2*x_a + 0.3*x_v >= 500, name = 'lubricant_production')
    c4_1 = m.addConstr(x_a <= 9000, name = 'saudi_arabia_capacity')
    c5_1 = m.addConstr(x_v <= 6000, name = 'venezuela_capacity')
```



```
    m.update()

    return m


m = Andes()

m.optimize()

for v in m.getVars():
    if v.varName == 'saudi_arabia':
        print(f'Barrels bought to Saudi Arabia: {v.x}')
    else:
        print(f'Barrels bought to Saudi Venezuela: {v.x}')
print(f'Total cost: {m.objVal}')
```

```
Barrels bought to Saudi Arabia: 2000.0
Barrels bought to Saudi Venezuela: 3500.0
Total cost: 92500.0
```