Math Modeling and Consulting (553.600)
Homework 2 (Due Friday, February 09, 2024 11:59pm ET)

General Directions: You must show all work and document any assumptions to receive full credit. All problems are to be done without the use of any software unless otherwise stated. When formulating models, make sure you define your symbols and provide brief labels for the objective function and constraints.

Your assignment should be scanned into a single PDF document and uploaded to GRADE-SCOPE by the due date above. Make sure to adhere to the homework submission guidelines and JHU academic integrity policies when completing this assignment. **REMINDER:** You may work in a group of size 3 or less on homework. If you do so, pick one of your group members to submit a single assignment for your group. Make sure the name of all group members is on the front page of the submission.

If using Matlab (or other software), make sure to submit a hard copy any user created functions and your output with your assignment.

The state of Washimore has plans to develop a 400-acre parcel of land into a wild animal park. The park will be divided into seven general areas:

- habitat attractions

- show areas where animal shows will be seen throughout the day

- restaurant areas

- retail establishments

- maintenance areas

- "green" areas consisting of parks and other required green spaces

- walkways and service roads that intermingle throughout the park

The following is a list of constraints and other information that can be used to develop the park:

- Each acre devoted to habitat areas is expected to generate $1000 per hour in gross profit to the park and is to be surrounded by 0.03 acre of green area. At least 40% of the park will consist of habitat areas (not including the required green areas).

- Each acre devoted to show areas is expected to generate $900 per hour in gross profit to the park and is to be surrounded by 0.40 acre of green areas. At least 5% of the park will consist of show areas (not including the required green areas).

- Combined, the habitat and show areas (excluding corresponding green areas) should not account for more than 70% of the park. Also, the show areas (including corresponding green areas) should not represent more than 20% of the combined acreage for habitat and show areas (including their corresponding green areas).

- At least 25% of the park that is not dedicated to habitat and show areas (not including their required green areas) should be green areas.

- Maintenance facility space is required as follows: 0.01 acre for each acre of habitat, 0.10 acre for every acre of shows, 0.08 acre for every acre of restaurants, 0.06 acre for every acre of retail establishments, 0.02 acre for every acre of green space, and 0.04 acre for every acre of walkways/roads.

- Restaurants will average 0.25 acre. Each restaurant must be surrounded by 0.15 acre of green space. It is estimated that each restaurant will generate $800 per hour in gross profit. The park should contain between 20 and 30 restaurants.

- Retail stores will average 0.20 acre and will be surrounded by 0.10 acre of green areas. Each store will generate approximately $750 per hour in gross profit. The park should contain between 15 and 25 stores, but there should be at least as many restaurants as retail stores.

- At least 10 acres of the park should be walkways and service roads. Adjoining each walkway and service road must be green areas equal to 25% of the corresponding walkway/service area.

- At least 100 acres of the animal park should be park areas, which are green areas not required by the habitat and show areas, restaurant and retail establishments, and walkways/pathways.

- The park will be open 12 hours per day 350 days per year. It has fixed daily operating expenses of $2,000,000.

1. Formulate a linear program that will determine a design for the park that will maximize total hourly gross profit. The design should indicate the number of acres devoted to zoo habitat, show attractions, maintenance, walkways, and park areas. It should also detail the number and acreage required for restaurant and retail store areas and summarize the total green space in the animal park.

2. Solve your model from part (a) using Matlab or other software.

3. Typically clients wish to choose among several good alternatives rather than being presented with one "optimal solution." By varying some of the problem data and/or adding or removing variables and/or constraints, it may be possible to come up with a solution to the modified problem that is worth further identification.

   Develop two alternative zoo designs for Washimore. Explain how you came up with these alternatives and why you think they are worth further investigation.