IEOR 240: Optimization Analytics   Fall 2022

Final Project – Instructions

General :

The first task is to formulate, solve, and analyze the problem as described in the **Problem Statement** as an LP model (**not** a Mixed Integer LP model). The second task is to do the same for the **Modified Problem Statement**. Here you will need to define some of the variables as integers (and thus use a Mixed Integer LP model).

Report :

- The report (for the original problem, as well as for the modified one) should contain sections on formulation, solution and analysis.

- In your formulations, define all variable clearly, state the units that you use, and justify briefly all constraints and the objective function. Make reasonable assumptions wherever necessary, but be sure to state them clearly and discuss their justifications.

- After solving the problem(s), present the optimal solution(s) clearly in non-technical terms. It is advisable to use tables, summaries and graphs when applicable. It should be presented in a way that is understandable to management personnel that have no training in Operations Research. It is ok to present the solution(s) with round numbers if you chose to do that. The output from the solver should be included in an appendix with brief explanations.

- Treat the modified problem as a situation where two months after providing the first report you were informed about the modifications described in the **Modified Problem Statement**. Thus your report for the modified problem should discuss and analyze the changes in the optimal solution as related to the original problem. You may also discuss such relations in the sensitivity analysis section.

- You should present sensitivity analysis of the LP model in the original problem, by analyzing how the solution changes when you change **three** different parameter values or assumptions. Each chosen parameter should be of a different type (e.g. do not change two right hand size values). A very rigorous or exhaustive analysis is not required. However, you should present a variety of detailed examples, like what happens if some of the data is changed, based on the sensitivity and one/two ways reports. While the presentation should be clear and non-technical, you are required to include the technical details (with explanations) in an appendix.

Groups :

The groups should be the same as Case Study 1. The project and its reports can be a joint work of a team of up to five members from both sections. Every member of a team is required to understand every part of the project. It is the responsibility of the members of a team to ascertain that everybody in the team does a fair share of the work and understands every part of the project.

Submission of Report :

- The due date for the final project is Friday, December 16, 2022 at 11:59pm. No Exceptions.
- Each group should submit one report through bCourses.

Problem Statement

Lake Saddleback Development Corporation (LSDC) is developing a planned community of homes and condominiums around a section of Lake Saddleback, Texas. The idea is to develop 300 acres of land it owns on and near the lake in such a way that it maximizes its profits from the development while offering an appropriate variety of different home plans in different products.

LSDC is building four products: (1) the Grand Estate Series; (2) the Glen Wood Collection; (3) the Lakeview Patio Homes; and (4) the Country Condominiums. Within each product are three to four floor plans of various styles, as described in the following list.

Plan	Selling Price	Size (sq. ft.)	Bedrooms	Bathrooms	Stories	Garage Size
Grand Estates						
The Trump	$700,000	4000	5+den	4	2	3 car
The Vanderbilt	$680,000	3600	4+den	3	2	3 car
The Hughes	$650,000	3000	4	3	1	3 car
The Jackson	$590,000	2600	3	3	1	3 car
Glen Wood Collection						
Grand Cypress	$420,000	2800	4+den	3	2	3 car
Lazy Oak	$380,000	2400	4	3	2	2 car
Wind Row	$320,000	2200	3	3	2	2 car
Orangewood	$280,000	1800	3	$2\frac{1}{2}$	1	2 car
Lakeview Patio Homes						
Bayview	$300,000	2000	4	$2\frac{1}{2}$	2	2 car
Storeline	$270,000	1800	3+den	$2\frac{1}{2}$	2	2 car
Docks Edge	$240,000	1500	3	$2\frac{1}{2}$	1	2 car
Golden Pier	$200,000	1200	2	2	1	2 car
Country Condominiums						
Country Stream	$220,000	1600	3	2	2	-
Weeping Willow	$160,000	1200	2	2	1	-
Picket Fence	$140,000	1000	2	$1\frac{1}{2}$	1	-

Lot Sizes

Lots for all models include the land on which the house resides, the garage (which is not considered part of the advertised square footage of the house), and yard space. It excludes outside parking and space for parks, roads, undeveloped landscape, and so on.

All models in the Grand Estate series are built on one-half acre lots, and 50 half-acre lots on the lake are to be used exclusively by the Grand Estate Series homes. The selling price of

these exclusive homes will be an additional 30% plus $50,000 more than the models not on the lake. (For example, the $700,000 Trump model would sell for $960,000 if on the lake.) Each of the Grand Estate series plans must have at least eight units on the lake.

Some Grand Cypress models (in the Glen Wood Homes series) may be built on "premium" quarter-acre lots. These homes sell for $40,000 more than similar models on standard lots. In addition, some Bayview models (in the Lakeview Patio Home series) may be built on "premium" one-sixth acre lots, which sell for $30,000 more than models built on standard lot sizes. No more than 25% of the total Grand Cypress models and 25% of the total Bayview models may be built on the premium lots.

Lot sizes for the Country Condominiums are fixed at 1500 square feet.

The minimum standard lot for homes in the Glen Wood and Lakeview series homes (except for the premium models) is $\frac{1}{10}$ of an acre. Lot sizes for certain models can be higher if the following calculation exceeds $\frac{1}{10}$ acre.

$$\text{Lot size} = (\text{Ground Area of House}) + (\text{Yard Size}) + (\text{Garage Size}).$$

Ground Area The ground area of any single-story house is the advertised square footage of the house. The ground area for two-story homes is 75% of the advertised square footage.

Yard Size For homes in the Glen Wood series, yard sizes 1200 square feet for single-story homes, and the same as the ground area of the house for two-story homes. For homes in the Lakeview Patio Home series, yard sizes are 900 square feet for single-story homes. For two-story homes in this series, the yard size is 600 square feet + 50% of the ground area of the house.

Garage Size Two-car garages occupy 500 square feet of the ground area, and three-car garages occupy 750 square feet of ground area space. Note that there are no garages for the Country Condominium models.

Parking

Current code requires one parking space per bedroom for each unit built. For example, outside parking space for two cars would be required for a four-bedroom house with a two-car garage. Each outside parking space will occupy 200 square feet of space. No more than 15 acres of the project may be used for outside parking. All parking for the Country Condominiums is outside.

Roads/Greenbelts, Etc.

A total of 1000 square feet per house is to be set aside for the building of roads, greenbelts, and small parks to add both to the aesthetics and necessities of the project.

Variety

Throughout the entire project, the following maximum and minimum percentages have been established by the marketing department. (Note: Condominiums are included in the following figures.)

	Maximum	Minimum
Tow-bedroom homes	25%	15%
Three-bedroom homes	40%	25%
Four-bedroom homes	40%	25%
Five-bedroom homes	15%	5%

In addition, none of the four products is to make up more than 35% or less than 15% of the units built in the development. Furthermore, within each product, each plan must occupy between 20% and 35% of the total units of that products. For appearance's sake, no more than 70% of the single-family homes (all homes except the Country Condominiums) may be two-story homes.

Affordable Housing

In the affluent Lake Saddleback area, any house priced at $200,000 or below is considered "affordable" housing. The federal government requires at least 15% of the project to be designated affordable housing.

Profit

LSDC has determined the following percentages of the sales prices to be net profits:

Grand Estates	22%
Glen Wood	18%
Lakeview	20%
Country Condominiums	25%

Modified Problem Statement

Consider the original problem of Saddleback Development Corporation but with the following modifications:

1. In the **Variety** section, ignore the table of the maximum and minimum percentages. Keep all the other requirements in this section.

2. Ignore the requirement in the **Affordable Housing** section. Instead, the county government imposes a "Luxury Tax" on each unit sold of 8% of the selling price per unit. However, based on the number of *Country Condominiums* sold, the Saddleback Development Corporation will have to pay the following Luxury Tax on each unit sold of the *Country Condominiums*:

   Let i be the position of the number of *Country Condominiums* units sold compared to the other three types (e.g, if the number of *Country Condominiums* sold is the highest among all four types then $i = 1$, if the number of *Country Condominiums* sold is the second highest among all four types, then $i = 2$, etc.) Then, the Luxury Tax paid on each unit of the *Country Condominiums* type is $2i\%$.

3. Modify the requirement in the **Lot Sizing** section that

   "Each of the Grand Estate series plans must have at least eight units on the lake."

   to

   "At least three of the Grand Estate series plan must have at least eight units on the lake."

4. The LSDC can build a 10-acre sports/recreational complex on the property, this would reduce the usable land by 10 acres and cost \$8 million to build. However, LSDC can then raise the cost of the homes as follows:

Grand Estates	5%
Glen Wood	3%
Lakeview	2%
Country Condominiums	3%

   All these increases can be considered additional profit to the net profit figures determined in the original problem.