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Introduction to Industrial Engineering: Theme Park Design and Layout

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Plant layout and design is one of the key areas of industrial engineering. There are numerous issues that must be accounted for. A subset include: machine utilization, queueing space, and flow of materials.

To provide you with an introduction to plant layout and design, let's consider designing a theme park. As we will see, many of the concepts will be the same. To give you some background, here are some facts about Disneyland in Anaheim California

- Disneyland occupies 85 acres of land
- 33 million visitors per year visit the park (approximately 90,400 per day)
- Has parking for 15,167 vehicles on 100 acres of land
- Disneyland currently has 60 major attractions
- There are about 10,000 Disneyland cast/workers each day
- There are more than 100,000 light bulbs used in Disneyland
- Disneyland uses 26 million hand towels in its restrooms each year
- 1000 brooms, 500 dust pans, and 3000 mops are used each year
- Approximately 12 millions pounds of trash is collected in a year
- In one year, guests buy 4 million hamburgers, 1.6 million hot dogs, 3.4 million orders of fries, 3.2 million boxes of popcorn, 3.2 million servings of ice cream, and 1.2 million gallons of soft drinks.

Group Task 1

[1] What type of theme park does your team want to design (*e.g.,* waterpark, Disneyland, Magic Mountain, Dollywood)? *Why?* Assume that the theme park will be open all days of the year.

[2] How many acres of land should you purchase for building the current theme park. Do not worry about future expansion. Land prices are $9000 an acre.

[3] How many major rides (*e.g.,* Jurassic Park ride, Back to the Future ride) and exhibits (*e.g.,* World's largest fruit display) do you want in your theme park? It will cost you $50 million to build each ride and $5 million for each exhibit. Though you choice will greatly impact your potential attendance.

[4] What is your total cost to purchase the land and build the major rides and exhibits?

Group Task 2

For what hours of the day will your theme park be open?

What is the anticipated daily attendance at your theme park?

Group Task 3

What does your team want to charge for admittance to your theme park?

What is your estimated daily and yearly gross revenue from people entering the park?

Group Task 4

To purchase the land, pave it, and clean and maintain it, it will cost $2000 for each parking space you decide to build.

How many parking spaces do you want to build? To answer this question, you might want to make some estimates:

[1] Average number of people per vehicles?

[2] Average length of time a group stays in the theme park (*i.e.,* a vehicle stays in the lot)?

Next, you will want to do some simple calculations:

[1] Number of cars per day that need parking in the lot? (assume there is no where else for vehicles to park and all people come to the park in their own vehicle).

[2] Number of times a space can be used per day?

Finally, how many parking spaces does your team want to build?

Group Task 5

What are you going to charge for parking? *You do not have to charge anything if you do not want to.*

Given what you are charging for parking, the number of spaces you decided to build, and the cost of $2000 for building a parking space, how long will it be before your theme park starts to make a profit on parking?

Group Task 6

The only place for patrons to purchase admittance tickets to the park is from one of the ticket windows outside the park. Hence, patrons stand single file in a line to purchase their tickets from one of an available number of windows.

How many ticket windows should your theme park have?   There is a formula from queueing theory (an area of operations research) which states that the utilization of a server (*i.e.*, ticket window) is equal to the arrival rate divided by the service rate multiplied by the number of servers. Mathematically, this is:

$$\rho = \frac{\text{arrival rate}}{\#\text{ of servers} \times \text{service rate}} = \frac{\text{average time between arrivals}}{\#\text{ servers} \times \text{average service time}}$$

Obviously, one does not want a server to be in use more than 100%. Such a situation would indicate that people are arriving faster than they are getting served. As a result, a huge line will form and continue to grow.

Given this formula and the number of people you estimated that will arrive daily to your park (assume arrivals are constant throughout all hours of operation), how many windows should you have open?

There above several problems with the above estimate. Can you team guess two of them and decide if they would impact your result?

[1]

[2]

Group Task 7

Let's total some of your expenses…

[1] Estimate the one time expense of building paths, restrooms, signs, and snack stations. Let's estimate this as 1/4 of the total purchase and major ride and exhibit cost (Task 1-Number 4). Your cost is:

[2] Cost of windows workers for one year. Assume their salary and benefits works out to $12 per hour.

[3] Cost of other park workers (actors, maintenance, custodian, etc.). Let's assume there is 1 worker for 20 visitors. Assume salary and benefits cost $20 per hour for each worker. What is the cost per day for these other workers? What is the cost per year?

[4] Cost of park supplies (brooms, paint, plants, paper towels). Assume that the park yearly spends 1/10th of the total purchase and major ride and exhibit cost (Task 2 - Number 4).

[5] Insurance cost. Assume the park spends $1/20^{th}$ of the total purchase cost and major ride and exhibit cost (Task 2 - Number 4).

[6] Trash disposal cost. Assume your theme park spends $250 per ton to dispose of trash (remember, Disneyland has 12 million pounds of trash per year). What is your yearly disposal cost

[7] Are there any other major costs not accounted for? If yes, specify them and estimate their yearly cost.

Let's look at some of the profits you make…

[1] What is the average amount a person will spend on food while in the park? What is your estimated yearly gross profit from food sales?

[2] What is the average amount a person will spend on souvenirs while in the park? What is your yearly estimated gross profit from souvenir sales?

[3] Are there any other profits that have not been accounted for (earlier we took care of parking and admittance to the park)? If yes, specify them and estimate your yearly gross profit.

A typical payback period for huge projects such as this is 20 years. Hence, we would like to be making a profit within 20 years. Let's see how your theme park does…

Expenses	Amount over 20 years
Land purchase and building of major rides and exhibits	
Cost of building paths, signs, etc.	
Cost of building parking	
Cost of window workers	
Cost of other workers	
Cost of park supplies	
Cost of insurance	
Cost of trash disposal	
Other costs	
Total expenses over 20 years =	

Income	Amount over 20 years
Admittance income	
Parking Income	
Food Income. Assume profit is 1/3 of the gross income.	
Souvenir Income. Assume profit is 1/2 of the gross income.	
Souvenir Income. Adjust the gross income to account for the expense of the activity.	
Total gross income over 20 years =	
Corporate Taxes (assume a rate of 20%)	
Total net (after tax) income over 20 years	

Even though we have made some HUGE simplifying assumptions to get the above numbers (*i.e.*, no interest on the building load) we could guess that they are in the right ballpark (give or take $10 million). Using these ballpark estimated, does your park make money by the 20 year point?

Sketch out a map of your theme park? Be sure to indicate the parking lot, the entrance, the major rides and exhibits, the food court area, and the restrooms.

Are there reasons you placed certain facilities where they are?

Think about one of your major rides or events (the most popular one at the theme park). How do people wait in line for this ride? Describe or sketch out how they wait in line. Why did you design the line like this?