IE375 Spring 2020 Case Set II

Note: These cases do not have a solution. You have to think these cases as real problems and hence try to find an approach rather than actually solving it. The expectation is simple: you learn the material while coming up with different, possible approaches which will make sense for the given description. Learning the material includes:

1) **Going over the assumptions of the methods we covered in class.**
2) **Understand the need for additional reading/learning (starting with the text book and then others)**
3) **Additional information you need to have a better understanding.**

Russell, Roberta S., and Bernard W. Taylor-III. Operations management along the supply chain. 7th ed. John Wiley & Sons, 2011.

1) Disney's Magic Numbers, page 611.

2) Problem 14.1, page 672,

3) Problem 14.2, page 673,

4) Problem 14.3, page 674,

5) Problem 14.4, page 674,

6) Problem 14.5, page 675,

7) Problem 14.6, page 676,

ALONG THE SUPPLY CHAIN

Disney's Magic Numbers

Sales and operations planning at Disney World is all about people—how many people visit the parks and what they do while there. The Disney property in Florida includes 4 parks, 20 hotels, 27,500 rooms, 160 miles of roads, and 56,000 employees. Forecasting attendance and guest behavior helps plan for more than 1 billion customer interactions per year, and the purchase of 9 million hamburgers, 50 million Cokes, and tons of "tangible memories."

Planning begins with a five-year forecast of attendance based on a combination of econometric models, experience-based models, extensive research, and a magic mirror. The econometric model examines the international economies of seven key countries, their GDP growth, foreign exchange rate, and consumer confidence. The experience-based model looks at demographics, planned product introductions, capacity expansions, and marketing strategies. Extensive research is conducted by 35 analysts and 70 field personnel year round. Over 1 million surveys are administered to key household segments, current guests, cast members, and travel industry personnel. The magic mirror is the patented part of the forecasting procedure that, in part, accounts for the mere 5% error in the five-year attendance forecast and the 0% error in annual forecasts.

Disney's five-year plan is converted to an annual operating plan (AOP) for each park. Demand is highly seasonal and varies by month and day of the week. Economic conditions affect annual plans, as do history and holidays, school calendars, societal behavior, and sales promotions. The AOP is updated monthly with information from airline specials, hotel bookings, recent forecast accuracies, Web site monitoring, and competitive influences. A daily forecast of attendance is made by tweaking the AOP and adjusting for monthly variations, weather forecasts, and the previous day's crowds. Attendance drives all other decisions.

Disney is a master at adjusting its capacity and managing its demand. Capacity can be increased by lengthening park hours, opening more rides or shows, adding roving food and beverage carts, and deploying more "cast members." Demand is managed by limiting access to the park, shifting crowds to street activities, and taking reservations for attractions (*ever used a fast pass?*). Operating standards strictly regulate when these actions are taken. Obsessive collection of data ensures the response is timely.

Parks generally open at 9:00 A.M. each day, but an unusually high count of 7:30 A.M. breakfast patrons at on-property hotels will prompt early openings at select locations. By 11:00 A.M. the day's attendance forecast is updated based on traffic, the weather, entry patterns, and crowds at key attractions. The daily operating plan is continually updated every 20 minutes throughout the day from data collected by cast members using handheld computers. To maintain flexibility, cast members are scheduled in 15-minute intervals at various jobs throughout the park.

For Disney, pleasing the customer *and* making a profit takes careful planning. What other types of industries could benefit from a flexible planning process such as Disney's?

Source: Joni Newkirk and Mark Haskell, "Forecasting in the Service Sector," Presented at the Twelfth Annual Meeting of the Production Operations Management Society, Orlando, FL, April 1, 2001.

Alamy

Disney is a master at forecasting aggregate demand for its theme parks, as well as adjusting capacity in time increments as small as 15 minutes.

Facility	Annual Usage (people)	Acres	Cost ($)	Priority
Rugby fields	4700	7	75,000	3
Football fields	12,500	12	180,000	2
Soccer fields	32,000	20	350,000	1
Dog park	7500	6	45,000	3
Playground	41,000	3	120,000	2
Walking/Running trails	47,000	25	80,000	1
Softball fields	23,000	5	115,000	2
Baseball fields	16,000	8	210,000	3

S14-46. In the event of a disaster situation at State University from weather, an accident, or terrorism, victims will be transported by emergency vehicles to three area hospitals: County General, Memorial, and All Souls. County General is (on average) 10 minutes away from State, Memorial is 20 minutes away, and All Souls is 35 minutes away. State wants to analyze a hypothetical disaster situation in which there are 15 victims with different types of injuries. The emergency facilities at County General can accommodate, at most, 8 victims; Memorial can handle 10 victims; and All Souls can admit 7 victims. A priority has been assigned for each victim according to the hospital that would best treat that victim's type of injury, as shown in the following table (where 1 reflects the best treatment).

	Patient						
Hospital	1	2	3	4	5	6	7
County General	1	1	2	2	2	1	3
Memorial	2	2	3	3	1	3	3
All Souls	3	3	1	1	3	2	1

	Patient							
Hospital	8	9	10	11	12	13	14	15
County General	3	3	1	3	3	2	1	3
Memorial	1	1	1	3	3	2	2	3
All Souls	2	2	2	1	1	1	2	1

For example, for victim 1's type of injury, the best hospital is County General, the next best is Memorial, and All Souls is third best.

a. Formulate and solve a linear programming model that will send the victims to the hospital best suited to administer to their specific injuries while keeping the average transport time to 22 minutes or less.
b. Formulate and solve a linear programming model that will minimize the average transport time for victims while achieving an average hospital priority of at least 1.50.

CASE PROBLEM S14.1

Mosaic Tile Company

Gilbert Moss and Angela Pasaic spent several summers during their college years working at archaeological sites in the Southwest. While at these digs they learned from local artisans how to make ceramic tiles. After college they started a tile manufacturing firm called Mosaic Tiles, Ltd. They opened their plant in New Mexico, where they would have convenient access to a special clay to make a clay derivative for their tiles. Their manufacturing operation consists of a few simple but precarious steps, including molding the tiles, baking, and glazing.

Gilbert and Angela plan to produce two basic types of tile for use in home bathrooms, kitchens, sunrooms, and laundry rooms: a larger single-colored tile; and a smaller patterned tile. In the manufacturing process the color or pattern is added before a tile is glazed. Either a single color is sprayed over the top of a newly baked set of tiles, or a stenciled pattern is sprayed on the top of a baked set of tiles.

The tiles are produced in batches of 100. The first step is to pour the clay derivative into specially constructed molds. It takes 18 minutes to mold a batch of 100 larger tiles and 15 minutes to prepare a mold for a batch of 100 smaller tiles. The company has 60 hours available each week for molding. After the tiles are molded, they are baked in a kiln: 0.27 hour for a batch of 100 larger tiles and 0.58 hour for a batch of 100 smaller tiles. The company has 105 hours available each week for baking. After baking, the tiles are either colored or patterned and glazed. This process takes 0.16 hour for a batch of 100 larger tiles and 0.20 hour for a batch of 100 smaller tiles. Forty hours are available each week for the "glazing" process. Each batch of 100 large tiles requires 32.8 pounds of the clay derivative to produce, while each batch of smaller tiles requires 20 pounds. The company has 6000 pounds of the clay derivative available each week.

Mosaic Tile earns a profit of $190 for each batch of 100 of the larger tiles and $240 for each batch of 100 smaller

patterned tiles. Angela and Gilbert want to know how many batches of each type of tile to produce each week in order to maximize profit. They also have some questions about resource usage they would like to answer.

a. Formulate a linear programming model for the Mosaic Tile Company to determine the mix of the tiles it should manufacture each week.
b. Transform the model into standard form.
c. Solve the linear programming model graphically.
d. Determine the resources left over and not used at the optimal solution point.
e. For artistic reasons Gilbert and Angela like to produce the smaller patterned tiles best. They also believe in the long run the smaller tiles will be a more successful product. What must be the profit for the smaller tiles in order for the company to produce only the smaller tiles?
f. Solve the linear programming model using Excel.
g. Mosaic believes that it may be able to reduce the time required for molding to 16 minutes for a batch of larger tiles and 12 minutes for a batch of the smaller tiles. How will this affect the solution?
h. The company that provides Mosaic with clay has indicated that it can deliver an additional 100 pounds of clay each week. Should Mosaic agree to this offer?
i. Mosaic is considering adding capacity to one of its kilns to provide 20 additional glazing hours per week at a cost of $90,000. Should it make the investment?
j. The kiln for glazing had to be shut down for three hours, reducing the available kiln hours from 40 to 37. What effect will this have on the solution?

CASE PROBLEM S14.2

Summer Sports Camp at State University

Mary Kelly is a scholarship soccer player at State University. During the summer she works at a youth all-sports camp that several of the university's coaches operate. The sports camp runs for eight weeks during July and August. Campers come for a one-week period, during which time they live in the State dormitories and use the State athletic fields and facilities. At the end of a week a new group of kids comes in. Mary serves primarily as one of the camp soccer instructors. However, she has also been placed in charge of arranging for sheets for the beds the campers will sleep on in the dormitories. Mary has been instructed to develop a plan for purchasing and cleaning sheets each week of camp at the lowest possible cost.

Clean sheets are needed at the beginning of each week, and the campers use the sheets all week. At the end of the week the campers strip their beds and place the sheets in large bins. Mary must arrange either to purchase new sheets or clean old sheets. A set of new sheets costs $10. A local laundry has indicated that it will clean a set of sheets for $4. Also, a couple of Mary's friends have asked her to let them clean some of the sheets. They have told her they will charge only $2 for each set of sheets. However, while the laundry will provide cleaned sheets in a week, Mary's friends can only deliver cleaned sheets in two weeks. They are going to summer school and plan to launder the sheets at night at a neighborhood laundromat.

The following number of campers have registered during each of the eight weeks the camp will operate:

Week	Registered Campers
1	115
2	210
3	250
4	230
5	260
6	300
7	250
8	190

Based on discussions with camp administrators from previous summers and on some old camp records and receipts, Mary estimates that each week about 20% of the cleaned sheets that are returned will have to be discarded and replaced. The campers spill food and drinks on the sheets, and sometimes the stains will not come out during cleaning. Also, the campers occasionally tear the sheets or the sheets can get torn at the cleaners. In either case, when the sheets come back from the cleaners and are put on the beds, 20% are taken off and thrown away.

At the beginning of the summer, the camp has no sheets available, so initially sheets must be purchased. Sheets are thrown away at the end of the summer.

Mary's major at State is operations management, and she wants to develop a plan for purchasing and cleaning sheets using linear programming. Help Mary formulate a linear programming model for this problem, and solve it using Excel.

(*Continued*)

CASE PROBLEM S14.3

Spring Garden Tools

The Spring family has owned and operated a garden tool and implements manufacturing company since 1952. The company sells garden tools to distributors and also directly to hardware stores and home improvement discount chains. The Spring Company's four most popular small garden tools are a trowel, a hoe, a rake, and a shovel. Each of these tools is made from durable steel and has a wooden handle. The Spring family prides itself on its high-quality tools.

The manufacturing process encompasses two stages. The first stage includes two operations—stamping out the metal tool heads and drilling screw holes in them. The completed tool heads then flow to the second stage. The second stage includes an assembly operation, in which the handles are attached to the tool heads, a finishing step, and finally packaging. The processing times per tool for each operation are provided in the following table:

	Tool (Hours/Unit)				Total Hours Available
Operation	Trowel	Hoe	Rake	Shovel	Per Month
Stamping	0.04	0.17	0.06	0.12	500
Drilling	0.05	0.14	—	0.14	400
Assembly	0.06	0.13	0.05	0.10	600
Finishing	0.05	0.21	0.02	0.10	550
Packaging	0.03	0.15	0.04	0.15	500

The steel the company uses is ordered from an iron and steel works in Japan. The company has 10,000 square feet of sheet steel available each month. The metal required for each tool and the monthly contracted production volume per tool are provided in the following table:

	Sheet Metal (FT2)	Monthly Contracted Sales
Trowel	1.2	1800
Hoe	1.6	1400
Rake	2.1	1600
Shovel	2.4	1800

The reasons the company has prospered are its ability to meet customer demand on time and its high quality. As a result, the Spring Company will produce on an overtime basis in order to meet its sales requirements, and it also has a longstanding arrangement with a local tool and die company to manufacture its tool heads. The Spring Company feels comfortable subcontracting the first-stage operations, since it is easier to detect defects prior to assembly and finishing. For the same reason, the company will not subcontract for the entire tool, since defects would be particularly hard to detect after the tool is finished and packaged. However, the company does have 100 hours of overtime available each month for each operation in both stages. The regular production and overtime costs per tool for both stages are provided in the following table:

	Stage 1		Stage 2	
	Regular Cost ($)	Overtime Cost ($)	Regular Cost ($)	Overtime Cost ($)
Trowel	6.00	6.20	3.00	3.10
Hoe	10.00	10.70	5.00	5.40
Rake	8.00	8.50	4.00	4.30
Shovel	10.00	10.70	5.00	5.40

The cost of subcontracting in stage 1 adds 20% to the regular production cost.

The Spring Company wants to establish a production schedule for regular and overtime production in each stage and for the number of tool heads subcontracted, at the minimum cost. Formulate a linear programming model for this problem and solve the model using Excel. Which resources appear to be most critical in the production process?

CASE PROBLEM 14.4

Walsh's Juice Company

Walsh's Juice Company produces three products from unprocessed grape juice—bottled juice, frozen juice concentrate, and jelly. It purchases grape juice from three vineyards near the Great Lakes. The climate in this area is good for growing the concord grapes necessary to produce grape juice products. The grapes are harvested at

the vineyards and immediately converted into juice at plants at the vineyard sites and stored in refrigerated tanks. The juice is then transported to four different plants in Virginia, Michigan, Tennessee, and Indiana, where it is processed into bottled grape juice, frozen concentrated juice, and jelly. Vineyard output typically differs each month in the harvesting season and the plants have different processing capacity.

In a particular month the vineyard in New York has 1400 tons of unprocessed grape juice available, while the vineyard in Ohio has 1700 tons and the vineyard in Pennsylvania has 1100 tons. The processing capacity per month is 1200 tons of unprocessed juice at the plant in Virginia, 1100 tons of juice at the plant in Michigan, 1400 tons at the plant in Tennessee, and 1400 tons at the plant in Indiana. The cost per ton of transporting unprocessed juice from the vineyards to the plant is as follows:

	Plant			
Vineyard	Virginia	Michigan	Tennessee	Indiana
New York	$850	720	910	750
Pennsylvania	970	790	1050	880
Ohio	900	830	780	820

The plants are different ages, have different equipment, and have different wage rates; thus, the cost of processing each product at each plant ($/ton) differs as follows:

	Plant			
Vineyard	Virginia	Michigan	Tennessee	Indiana
Juice	$2100	2350	2200	1900
Concentrate	4100	4300	3950	3900
Jelly	2600	2300	2500	2800

This month the company needs to process a total of 1200 tons of bottled juice, 900 tons of frozen concentrate, and 700 tons of jelly at the four plants combined. However, the production process for frozen concentrate results in some juice dehydration, and the process for jelly includes a cooking stage that evaporates water content. To process 1 ton of frozen concentrate requires 2 tons of unprocessed juice; a ton of jelly requires 1.5 tons of unprocessed juice; and a ton of bottled juice requires 1 ton of unprocessed juice.

Walsh's management wants to determine how many tons of grape juice to ship from each of the vineyards to each of the plants, and the number of tons of each product to process at each plant. Thus, management needs a model that includes both the logistical aspects of this problem and the production processing aspects. It wants a solution that will minimize total costs, including the cost of transporting grape juice from the vineyards to the plants and the product processing costs. Help Walsh's solve this problem by formulating a linear programming model and solve it using Excel.

CASE PROBLEM S14.5

Julia's Food Booth

Julia Robertson is a senior at Tech, and she's investigating different ways to finance her final year at school. In her first three years at school she worked a part-time job at a local bar, but she wants more free time during the week in her senior year to interview for jobs after she graduates, to work on some senior projects, and to have some fun with her friends. She is considering leasing a food booth outside the stadium at the Tech home football games which Tech allows for selected students and student groups. Tech sells out every home game, and she knows from going to the games herself that everyone eats a lot of food. She has to pay $1000 per game for a booth and the booths are not very large. Vendors can sell only food or drinks on Tech property but not both. Only the Tech athletic department concession stands can sell both inside the stadium. She thinks slices of cheese pizza, hot dogs, and barbecue sandwiches are the most popular food items among fans, so these are the items she would sell.

Most food items are sold during the hour before the game starts and during half time; thus, it will not be possible for Julia to prepare the food while she is selling it. She must prepare the food ahead of time and then store it in a warming oven. She can lease a warming oven for the home season, which includes six games, for $600. The oven has 16 shelves, and each shelf is 3 ft by 4 ft. She plans to fill the oven with the three food items before the game and before half time.

Julia has negotiated with a local pizza delivery company to deliver 14-inch cheese pizzas twice each game; two hours before the game and right after the opening kickoff. Each pizza will cost her $6 and will include eight slices. She estimates it will cost her $0.45 for each hot dog and $0.90 for each barbecue sandwich if she makes the barbecue herself the night before. She measured a hot dog and

(*Continued*)

found it takes up about 16 in.^{2} of space, while a barbecue sandwich takes up about 25 in.^{2} She plans to sell a slice of pizza and a hot dog for $1.50 apiece and a barbecue sandwich for $2.25. She has $1500 in cash available to purchase and prepare the food items for the first home game; for the remaining five games she will purchase her ingredients with money she has made from the previous game.

Julia has talked to some students and vendors who have sold food at previous football games at Tech as well as at other universities. From this she has discovered that she can expect to sell at least as many slices of pizza as hot dogs and barbecue sandwiches combined. She also anticipates that she will probably sell at least twice as many hot dogs as barbecue sandwiches. She believes that she will sell everything she can stock and develop a customer base for the season if she follows these general guidelines for demand.

If Julia clears at least $1000 in profit for each game after paying all her expenses, she believes it will be worth leasing the booth.

a. Formulate and solve a linear programming model for Julia that will help you advise her if she should lease the booth.

b. If Julia can borrow some more money from a friend before the first game to purchase more ingredients, could she increase her profit? If so, how much should she borrow and how much additional profit would she make? What factor constrains her from borrowing even more money than this amount (indicated in your answer to the previous question)?

c. When Julia looked at the solution in (a), she realized that it would be physically difficult for her to prepare all the hot dogs and barbecue sandwiches indicated in this solution. She believes she can hire a friend of hers to help her for $100 per game. Based on the results in (a) and (b), is this something you think she could reasonably do and should do?

d. Julia seems to be basing her analysis on "certain" assumptions that everything will go as she plans. What are some of the uncertain factors in the model that could go wrong and adversely affect Julia's analysis? Given these uncertainties and the results in (a), (b), and (c), what do you recommend that Julia do?

CASE PROBLEM S14.6

The Sea Village Amusement Park

Sea Village is a large amusement and water park located on the coast of South Carolina. The park hires high school and college students to work during the summer months of May, June, July, August, and September. The student employees operate virtually all of the highly mechanized, computerized rides; perform as entertainers; perform most of the custodial work during park hours; make up the work force for restaurants, food services, retail shops, and stores; drive trams; and park cars. Park management has assessed their monthly needs based on previous summers' attendance at the park, and the expected available work force. Park attendance is relatively low in May until public schools are out, then it increases through June, July, and August, and decreases dramatically in September when schools reopen after Labor Day. The park is open seven days a week through the summer until September when it cuts back to weekends only. Management estimates that it will require 21,000 hours of labor in each of the first two weeks of May, 26,000 hours during the third week of May, and 32,000 hours during the last week in May. During the first two weeks of June, it will require at least 36,000 hours of labor and 41,000 hours during the last two weeks in June. In July, 46,000 hours will be required each week, and in August 47,000 hours will be needed each week. In September, they will only need 14,000 hours in the first week, 12,000 hours in each of the second and third weeks, and 9,000 hours the last week of September.

The park hires new employees each week from the first week in May through August. A new employee mostly trains the first week by observing and helping more experienced employees; however, they do work approximately 10 hours under the supervision of an experienced employee. An employee is considered experienced after completing one week on the job. Experienced employees are considered part-time and are scheduled to work 30 hours per week in order to eliminate overtime and reduce the cost of benefits, and to give more students the opportunity to work. However, no one is ever laid off or will be scheduled for less (or more) than 30 hours, even if more employees are available than needed. Management believes this is a necessary condition of employment because so many of the student employees move to the area during the summer just to work in the park and live near the beach nearby. If these employees were sporadically laid off and were stuck with lease payments and other expenses, it would be bad public relations and hurt employment efforts

in future summers. Although no one is laid off, 15% of all experienced employees quit each week for a variety of reasons, including homesickness, illness, and other personal reasons, plus some are asked to leave because of very poor job performance.

Park management is able to start the first week in May with 800 experienced employees who worked in the Park in previous summers and live in the area. They are generally able to work a lot of hours on the weekends and then some during the week; however, in May, attendance is much heavier on the weekend so most of the labor hours are needed then. The park expects to have a pool of 1,600 available applicants to hire for the first week in May. After the first week, the pool is diminished by the number of new employees hired the previous week, but each week through June the park gets 210 new job applicants, which decreases to 120 new applicants each week for the rest of the summer. For example, the available applicant pool in the second week in May would be the previous week's pool, which in week 1 is 1,600, minus the number of new employees hired in week 1, plus 210 new applicants. At the end of the last week in August, 75% of all the experienced employees will quit to go back to school and the park will not hire any new employees in September. The park must operate in September using experienced employees who live in the area, but the weekly attrition rate for these employees in September drops to 12%.

Formulate and solve a linear programming model to assist the park's management to plan and schedule the number of new employees it hires each week that will minimize the total number of new employees it must hire during the summer.

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