Individual Assignment 2 (90 points)

Blue Ribbon Foods

On Monday, September 12, 2012, Ms. Cora Ophoven, Vice President of Operations, asked the Controller Koichi Haneda, the Sales Manager Ricardo Reynoso, and Allie Allen the Production Manager to meet with her to discuss the amount of tomato products to pack that season. The tomato crop, which had been purchased at planting, was beginning to arrive at the cannery, and packing operations would have to be started by the following Monday. Blue Ribbon Foods (BRF) was a medium-size company that canned and distributed a variety of fruit and vegetable products under private brands in the western states.

Haneda and Reynoso were the first to arrive in Ms. Ophoven's office. The production manager came in a few minutes later and said that he had picked up produce inspection's latest estimate of the quality of the incoming tomatoes. According to their report, about 20% of the crop was grade 'A' quality and the remaining portion of the 3 million kg crop was grade 'B'.

Ophoven asked Reynoso about the demand for tomato products for the coming year. Reynoso replied that they could sell all of the whole canned tomatoes they could produce. The expected demand for tomato juice and tomato paste, on the other hand, was limited. The sales manager then passed around the latest demand forecasts, which is shown in Exhibit 1. He reminded the group that the selling price has been set in light of the long-term marketing strategy of the company, and potential sales have been forecasted at these prices.

Exhibit 1: Demand forecasts and usage

Product	Demand Forecast	Kilograms per case
Whole Tomato (cases)	700,000	18
Tomato Juice (cases)	60,000	20
Tomato Paste (cases)	75,000	25

Koichi Haneda, after looking at Reynoso's estimates of demand said that it looked like the company "should do quite well on the tomato crop this year." In May, after BRF had signed contracts agreeing to purchase the grower's production at an average delivered price of £0.18 per kg. The marginal profits of each product are as follows:

Product	Whole Tomatoes	Tomato Juice	Tomato Paste
Selling Price per Case	£ 12.20	£ 13.60	£ 11.40
Variable cost	£ 7.30	£ 8.50	£ 5.50
Contribution Margin	£ 4.90	£ 5.10	£ 5.90

Allie Allen brought to Haneda's attention that although there was ample production capacity, it was impossible to produce all whole tomatoes because too small a portion of the tomato crop was 'A' quality. BRF used a numerical scaling to record the quality of both raw produce and prepared products. This scale ran from 0 to 10, with the higher number representing better quality. Rating tomatoes according to this scale, grade 'A' tomatoes averaged 9 points per kg and grade B tomatoes averaged 5 points per kg. Allen noted that the minimum average input quality for canned whole tomatoes was 8 and for juice it was 6 points per kg.

Assignment Questions

Set up a linear programming model and solve it with Solver. Answer the following sensitivity analysis questions:

1. Formulate as an LP the problem of determining the optimal production policy. Write down the decision variables, the objective function and the constraints. (10 pts)

2. Answer the following questions about the optimal solution: (13 pts)
    a. Formulate the linear program in Excel and solve it and do sensitivity analysis. Attach the answer report and sensitivity report here. (5 points)

    b. How much of each tomato grade will be used for the production of each product? (3 pts)

    c. What is the actual average quality per kg of the whole tomato and the juice? (2 pts)

    d. What is the net profit obtained after netting out the cost of the crop? (3 pts)

3. Following sensitivity analysis questions: (17 pts)
    a. Should additional purchase of up to 100,000 kg of grade 'A' be undertaken at a price of £0.25? Can you tell exactly how much should be purchased? (3 pts)

    b. Suppose the Market Research Department feels that it can increase demand for the juice product by 40,000 cases by starting an advertising campaign. How much should BRF be willing to pay for such a campaign? (3 pts)

    c. Suppose an additional lot of 500,000 kg of grade 'B' tomatoes becomes available. BRF can buy either all or none. What is the highest price BRF be willing to pay? (3 pts)

    d. Suppose the price of juice decreased 15 pennies per case. What will happen to the optimal solution? Note that sensitivity analysis cannot be used when you have more than one change on coefficients. (3 pts)

e. Given all the other parameters unchanged, what is the range of price of juice such that the optimal solution is the same as the current one. (Hint: If you cannot use sensitivity analysis for question (d) or this question, could you find another way to formulate the problem so you can use sensitivity analysis report? How about adding several decisions variables and constraints?) (5 pts)

4. By now, the cost of purchasing grade A and B tomatoes is sunk. Next we assume the purchase contract is not signed yet. We assume the total available tomatoes are still 3 million kg and the proportion of grade A is still 20%. Assuming the prices of three products and customer demands are unchanged. BRF needs to make decisions on how many grade A and B tomatoes to purchase and how to produce the mix of the three products. Differently, suppose that grade A tomatoes charge £0.23 per kg, and grade B tomatoes charge £0.17 per kg. Answer the following questions. (20 pts)
   a. Formulate a linear program for the problem: write down the decision variables, objective function and the constraints. (10 pts)

   b. Formulate the linear program in Excel and solve it and do sensitivity analysis. Attach the answer report and sensitivity report here. (5 points)

c. Similar to question 3(e), given all the other parameters unchanged, what is the range of price of Grade A tomatoes such that the optimal solution is the same as the current optimal solution when that price 0.23 per kg? You can formulate the problem in a way such that sensitivity analysis can be used to find the answer. (5 pts)

5. (40 pts) This problem is based on the Shelter Case we discussed in class. In class, we try to miminize the number of shelters. The constraints are to make sure each location can find a shelter within 2 miles. We transform the distance maxtrix into a 0-1 maxtrix D where $D_{ij} = 1$ means location i is within 2 miles distance of loaction j, and $D_{ij} = 0$ otherwise. We fomulate an Integer programm:
   Binary decision variables: $x_j = 1$ if location j has a shelter, $x_j = 0$ otherwise.
   The objective: $\min \sum_j x_j$
   Constraints: for each location i, $\sum_j D_{ij} x_j \geq 1$.
   Using Excel solver, we obtain one optimal solution (building shelters at locations 3,6,19,22,25,29,30,32 and 34). The total number of shelters is 9. Note that we may have multiple optimal solutions.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S				
1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0			0	**1**
3	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0			1	**3**
4	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0	**4**
6	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0			1	**6**
9	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1			0	**9**
10	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1			0	**10**
12	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1			0	**12**
15	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0			0	**15**
17	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0			0	**17**
19	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0			1	**19**
20	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0			0	**20**
22	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0			1	**22**
23	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0			0	**23**
25	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0			1	**25**
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0			1	**29**
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0			1	**30**
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0			1	**32**
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0			0	**33**
34	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1			1	**34**
	2	1	1	1	0	1	1	2	1	1	1	1	1	1	1	1	1	1	1			9	
	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=	>=				
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				

Objective Function

Constraints

Constraints

a. If the project head Christina realize that 2-mile range is not enough to move people to shelters during earthquakes. She wants to decrease the range to 1.5 miles. That is, she wants to make sure each location can find a shelter within 1.5 miles. The objective is still to minimize the total number of shelters. Formulate the IP in Excel. List your steps and attach your Excel solution here. (10 pts)

b. Compared the solution of (a) and the original solution with 2-mile constraints, you may realize that we need to build more shelters to satisfy the harsher 1.5-mile constraints. However, the government cannot fund so many shelters. The government only affords to build at most 11 shelters. Christina has to lower her aspiration and change her objective to maximize the number of locations that are within 1.5-mile range of a shelter. Still, Christina would like to satisfy the original constraints: make sure each location can find a shelter within 2 miles. Using Integer programming to formulate this problem. List all your decision variables, the objective function and the constraints. Note that your objective and constraints should all be **linear** functions of your decision variables. (20 pts)

c. Solve the IP in (b) in Excel attach your Excel solution here. (10 pts)