Homework #3

Complete the following problems and be sure to show all of your work. Please type-up your solutions and submit as a PDF file. This homework assignment is worth 100 points in total.

Problem #1 (20 points)

A toy manufacturing company currently maintains plants in Atlanta and Tulsa that supply to retail centers in Los Angeles and New York. Because of expanding demand, the company has decided to build a third plant and has narrowed the choice to one of two cities, ***Seattle or Baltimore.*** The distribution costs, as well as plant capacity and retailer demand, are shown in the table:

Retail Stores	Manufacturing Plant				Demand
	Atlanta	Tulsa	Seattle	Baltimore	
Los Angeles	$ 8.00	$ 4.00	$ 5.00	$ 4.00	800
New York	$ 5.00	$ 7.00	$ 6.00	$ 6.00	1200
Capacity	600	900	500	500	

Formulate the given problem scenario as an integer linear program for the toy manufacturer by recommending the most suited new location to establish the plant. **Solve** the problem using Microsoft Excel with ASPE (and/or Gurobi Python). For the formulation, provide a complete description of the decision variables used along with their units and also label the constraints mentioned in the problem as completely as possible. Also, the **model setup** should provide clearly labeled values used for the decision variables, constraints, and objective function.

Problem #2 (20 points)

A meatpacking house is creating a new variety of hot dog for the low-calorie, low-fat, low-cholesterol market. This new hot dog will be made of beef and pork, plus either chicken, turkey, or both. It will be marketed as a 2-ounce all-meat hot dog, with no fillers. Also, it will have no more than 6 grams of fat, no more than 27 grams of cholesterol, and no more than 100 calories. The cost per pound for beef, pork, chicken, and turkey, plus their calorie, fat, and cholesterol counts, are shown in the following table.

	Cost/Pound	Calories/Pound	Fat (G/lb)	Cholesterol (G/lb)
Beef	$ 0.76	640	32.5	210
Pork	$ 0.82	1055	54	205
Chicken	$ 0.64	780	25.6	220
Turkey	$ 0.58	528	6.4	172

The packer would like each 2-ounce hot dog to be at least 25% beef and at least 25% pork.

Formulate the given problem scenario as a linear program (LP) for the meatpacking house by recommending the most economical combination of four meats to make this hot dog. **Solve** the problem using Microsoft Excel with ASPE (and/or Gurobi Python). For the formulation, provide a complete description of the decision variables used along with their units and also label the constraints mentioned in the problem as completely as possible. Also, the **model setup** should provide clearly labeled values used for the decision variables, constraints, and objective function.

Problem #3 (20 points)

Read the attached conference proceedings article by Bastian et al. (2015) titled, "Optimizing Forward Surgical Team Operating Room Scheduling for Mass Casualty Events."

In this problem, you will mimic the computational experiment using integer linear programming (ILP) to solve the *FST OR scheduling problem for MASCAL events* for the three problem instances: 5 patients, 10 patients, and 15 patients.

Using Microsoft Excel with ASPE, **setup** the spreadsheet model and **solve** the ILP for the three problem instances. You will need to use sub-schedule elimination constraints, as discussed in the article. Do not use the Evolutionary Solver. For each problem instance, report the optimal surgical schedule with minimal makespan (i.e., total surgical setup time). If you have variable/constraint limitations using ASPE, please use the OpenSolver Add-in for Excel (https://opensolver.org/).

Solve the three problem instances using Gurobi Python and compare/contrast with the ASPE results. To get started in Gurobi, see http://www.gurobi.com/documentation/8.0/examples/tsp_py.html.

Here are the problem instance data:

sij	**1**	**2**	**3**	**4**	**5**
1	0	20	15	8	6
2	15	0	18	9	28
3	24	23	0	13	13
4	15	27	8	0	14
5	8	17	24	15	0

sij	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	0	9	12	26	11	24	12	13	17	15
2	24	0	28	23	22	5	7	18	9	23
3	19	30	0	30	15	22	25	15	28	15
4	18	10	27	0	28	12	16	19	22	7
5	5	16	11	7	0	25	27	30	23	15
6	7	26	6	17	6	0	28	10	13	28
7	23	26	20	20	24	30	0	16	18	27
8	23	20	22	8	18	10	14	0	14	12

9	7	13	9	19	29	27	18	23	0	30
10	16	10	11	11	28	26	6	11	12	0

sij	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	0	15	27	7	19	7	22	26	29	6	5	18	30	11	25
2	24	0	9	23	21	15	25	8	8	9	16	26	22	8	16
3	22	5	0	28	14	22	30	7	22	26	8	5	25	22	14
4	6	20	13	0	23	17	5	17	11	15	30	30	26	21	26
5	27	18	19	17	0	29	18	26	12	22	16	17	14	24	10
6	8	29	21	8	14	0	6	27	25	14	22	13	14	7	9
7	24	24	5	25	16	27	0	24	8	24	12	15	26	29	28
8	16	23	10	13	6	9	15	0	14	12	9	21	14	17	23
9	5	23	26	18	21	12	28	29	0	8	6	27	23	11	10
10	18	18	17	7	7	8	12	13	28	0	20	5	27	25	29
11	10	18	28	26	24	15	17	21	25	25	0	30	16	15	20
12	28	15	17	6	28	30	17	23	14	22	6	0	27	19	28
13	10	19	27	25	17	28	18	25	8	25	13	17	0	7	28
14	12	10	25	26	22	7	20	18	16	25	19	24	19	0	16
15	11	28	13	22	10	21	23	24	19	23	19	16	19	19	0

Problem #4 (20 points)

The Tiny Toy Company makes three types of new toys: the tiny tank, the tiny truck, and the tiny turtle. Plastic used in one unit of each is 1.5, 2.0 and 1.0 pounds, respectively. Rubber for one unit of each toy is 0.5, 0.5, and 1.0 pounds, respectively. Also, each tank uses 0.3 pounds of metal and the truck uses 0.6 pounds of metal during production. The average weekly availability for plastic is 16,000 pounds, 9,000 pounds of metal, and 5,000 pounds of rubber. It takes two hours of labor to make one tank, two hours for one truck, and one hour for a turtle. The company allows no more than 40 hours a week for production (priority #1). Finally, the cost of manufacturing one tank is $7, 1 truck is $5 and 1 turtle is $4; a target budget of $164,000 is initially used as a guideline for the company to follow.

a) Minimize over-utilization of the weekly available supply of materials used in making the toys and place twice as much emphasis on the plastic (priority #2)

b) Minimize the under and over-utilization of the budget. Maximize available labor hour usage (priority #3).

Formulate the decision problem as a single linear goal programming model. Use a preemptive goal programming approach (i.e., hierarchy of priority levels for the goals) in your formulation's objective function. Do not solve.

Problem #5 (20 points)

XYZ Company is planning an advertising campaign for its new product. The media considered are television and radio. Rated exposures per thousand dollars of advertising expenditure are 10,000 for TV and 7,500 for radio. Management has agreed that the campaign cannot be judged successful if total exposures are under 750,000. The campaign would be viewed as superbly successful if 1 million exposures occurred. In addition, the company has realized that the two most important audiences for its product are persons 18 to 21 years of age and persons 25 to 30 years of age. The following table estimates the number of individuals in the two age groups expected to be exposed to advertisements per $ 1,000 of expenditures:

Exposures per $1000 Age	Television	Radio
18-21	2,500	3,000
25-30	3,000	1,500

Management has rank ordered five goals it wishes to achieve, arranged from highest to lowest priorities.

a) Achieve total exposures of at least 750,000 persons.

b) Avoid expenditures of more than $100,000.

c) Avoid expenditures of more than $70,000 for television advertisements.

d) Achieve at least 1 million total exposures.

e) Reach at least 250,000 persons in each of the two age groups, 18-21 and 25-30 years. In addition, management realizes and wishes to account for the fact that the purchasing power of the 25-30 age group is twice that of the 18-21 age group.

Formulate the above decision problem as a single linear goal program. Use a preemptive goal programming approach (i.e., hierarchy of priority levels for the goals) in your formulation's objective function. Do not solve.

Extra Credit Problem (10 points)

Suppose that a lumberyard has a supply of 10-ft boards, which are cut into 3-ft, 4-ft, and 5-ft boards according to customer demand. The 10-ft boards can be cut into several sensible patterns, each in such a way that there the leftover material is less than 3-ft. The lumberyard just received an order for 90 3-ft boards, 60 4-ft boards, and 60 5-ft boards.

a) Determine all sensible patterns the lumberyard may use to cut the 10-ft boards.

b) The lumberyard would like to use as few 10-ft boards as possible in meeting the demand. Write out a mathematical formulation for the problem as an integer linear program (ILP), and **setup/solve** this problem using Microsoft Excel with ASPE. What is the optimal number of

each pattern, and what is the minimum number of boards to cut?

c) Solve the ILP using Gurobi Python (for assistance, please refer to: http://www.gurobi.com/resources/seminars-and-videos/modeling-with-the-gurobi-python-interface).