Homework Assignment 1

Due Wednesday September 14, 9:00 am

Do the following problems from Chapter 3 in the Hillier and Lieberman text (10th Edition). Please follow the detailed instructions and guidelines under "Homework Assignments" in the course outline. An older version of Chapter 3 is available from the text website, at URL:

http://www.mhhe.com/engcs/industrial/hillier/etext/PDF/chap03.pdf

1. Problem 3.5-4. This is Problem 3.6-3 in the older version available on the web. Answer questions (a) to (e).

2. Problem 3.4-11 (The Medequip Company). This is Problem 3.4-11 in the older version on the web. Answer question (a) and then use GAMS and its default Solver to solve your model.

3. Case 3.2 (Cutting Cafeteria Costs). This is Case 3.2 in the older version on the web. Answer all questions (a) to (g). Make sure to formulate and use Linear Programming models (in particular, ensure that all constraints and the objective are linear, e.g. by checking the "Assume Linear Model" Option if you use Excel Solver). Solve the relevant LP models and present your work as a Case Report following the guidelines given in the course outline.

3.6-3. You are given the following data for a linear programming problem where the objective is to minimize the cost of conducting two nonnegative activities so as to achieve three benefits that do not fall below their minimum levels.

Benefit	Benefit Contribution per Unit of Each Activity		Minimum Acceptable Level
	Activity 1	Activity 2	
1	5	3	60
2	2	2	30
3	7	9	126
Unit cost	$60	$50	

(a) Formulate a linear programming model for this problem.
D **(b)** Use the graphical method to solve this model.
(c) Display the model on an Excel spreadsheet.
(d) Use the spreadsheet to check the following solutions: $(x_1, x_2) = (7, 7), (7, 8), (8, 7), (8, 8), (8, 9), (9, 8)$. Which of these solutions are feasible? Which of these feasible solutions has the best value of the objective function?
C **(e)** Use the Excel Solver to solve this model by the simplex method.

3.4-11.* The Medequip Company produces precision medical diagnostic equipment at two factories. Three medical centers have placed orders for this month's production output. The table to the right shows what the cost would be for shipping each unit from each factory to each of these customers. Also shown are the number of units that will be produced at each factory and the number of units ordered by each customer. (Go to the next column.)

From \ To	Unit Shipping Cost			Output
	Customer 1	Customer 2	Customer 3	
Factory 1	$600	$800	$700	400 units
Factory 2	$400	$900	$600	500 units
Order size	300 units	200 units	400 units	

A decision now needs to be made about the shipping plan for how many units to ship from each factory to each customer.
(a) Formulate a linear programming model for this problem.
C **(b)** Solve this model by the simplex method.

CASE 3.2 CUTTING CAFETERIA COSTS

A cafeteria at All-State University has one special dish it serves like clockwork every Thursday at noon. This supposedly tasty dish is a casserole that contains sautéed onions, boiled sliced potatoes, green beans, and cream of mushroom soup. Unfortunately, students fail to see the special quality of this dish, and they loathingly refer to it as the Killer Casserole. The students reluctantly eat the casserole, however, because the cafeteria provides only a limited selection of dishes for Thursday's lunch (namely, the casserole).

Maria Gonzalez, the cafeteria manager, is looking to cut costs for the coming year, and she believes that one sure way to cut costs is to buy less expensive and perhaps lower-quality ingredients. Because the casserole is a weekly staple of the cafeteria menu, she concludes that if she can cut costs on the ingredients purchased for the casserole, she can significantly reduce overall cafeteria operating costs. She therefore decides to invest time in determining how to minimize the costs of the casserole while maintaining nutritional and taste requirements.

Maria focuses on reducing the costs of the two main ingredients in the casserole, the potatoes and green beans. These two ingredients are responsible for the greatest costs, nutritional content, and taste of the dish.

Maria buys the potatoes and green beans from a wholesaler each week. Potatoes cost $0.40 per pound, and green beans cost $1.00 per pound.

All-State University has established nutritional requirements that each main dish of the cafeteria must meet. Specifically, the total amount of the dish prepared for all the students for one meal must contain 180 grams (g) of protein, 80 milligrams (mg) of iron, and 1,050 mg of vitamin C. (There are 453.6 g in 1 lb and 1,000 mg in 1 g.) For simplicity when planning, Maria assumes that only the potatoes and green beans contribute to the nutritional content of the casserole.

Because Maria works at a cutting-edge technological university, she has been exposed to the numerous resources on the World Wide Web. She decides to surf the Web to find the nutritional content of potatoes and green beans. Her research yields the following nutritional information about the two ingredients:

	Potatoes	Green Beans
Protein	1.5 g per 100 g	5.67 g per 10 ounces
Iron	0.3 mg per 100 g	3.402 mg per 10 ounces
Vitamin C	12 mg per 100 g	28.35 mg per 10 ounces

(There are 28.35 g in 1 ounce.)

Edson Branner, the cafeteria cook who is surprisingly concerned about taste, informs Maria that an edible casserole must contain at least a six to five ratio in the weight of potatoes to green beans.

Given the number of students who eat in the cafeteria, Maria knows that she must purchase enough potatoes and green beans to prepare a minimum of 10 kilograms (kg) of casserole each week. (There are 1,000 g in 1 kg.) Again for simplicity in planning, she assumes that only the potatoes and green beans determine the amount of casserole that can be prepared. Maria does not establish an upper limit on the amount of casserole to prepare, since she knows all leftovers can be served for many days thereafter or can be used creatively in preparing other dishes.

(a) Determine the amount of potatoes and green beans Maria should purchase each week for the casserole to minimize the ingredient costs while meeting nutritional, taste, and demand requirements.

Before she makes her final decision, Maria plans to explore the following questions independently except where otherwise indicated.

(b) Maria is not very concerned about the taste of the casserole; she is only concerned about meeting nutritional requirements and cutting costs. She therefore forces Edson to change the recipe to allow for only at least a one to two ratio in the weight of potatoes to green beans. Given the new recipe, determine the amount of potatoes and green beans Maria should purchase each week.

(c) Maria decides to lower the iron requirement to 65 mg since she determines that the other ingredients, such as the onions and cream of mushroom soup, also provide iron. Determine the amount of potatoes and green beans Maria should purchase each week given this new iron requirement.

(d) Maria learns that the wholesaler has a surplus of green beans and is therefore selling the green beans for a lower price of \$0.50 per lb. Using the same iron requirement from part (*c*) and the new price of green beans, determine the amount of potatoes and green beans Maria should purchase each week.

(e) Maria decides that she wants to purchase lima beans instead of green beans since lima beans are less expensive and provide a greater amount of protein and iron than green beans. Maria again wields her absolute power and forces Edson to change the recipe to include lima beans instead of green beans. Maria knows she can purchase lima beans for \$0.60 per lb from the wholesaler. She also knows that lima beans contain 22.68 g of protein per 10 ounces of lima beans, 6.804 mg of iron per 10 ounces of lima beans, and no vitamin C. Using the new cost and nutritional content of lima beans, determine the amount of potatoes and lima beans Maria should purchase each week to minimize the ingredient costs while meeting nutritional, taste, and demand requirements. The nutritional requirements include the reduced iron requirement from part (*c*).

(f) Will Edson be happy with the solution in part (*e*)? Why or why not?

(g) An All-State student task force meets during Body Awareness Week and determines that All-State University's nutritional requirements for iron are too lax and that those for vitamin C are too stringent. The task force urges the university to adopt a policy that requires each serving of an entrée to contain at least 120 mg of iron and at least 500 mg of vitamin C. Using potatoes and lima beans as the ingredients for the dish and using the new nutritional requirements, determine the amount of potatoes and lima beans Maria should purchase each week.