STOR415: Introduction to Optimization

Department of Statistics and Operations Research

———————— Fall 2022 ————————

Instructor: Michael O'Neill

Homework 9: More Linear Programming Applications

Each problem should be solved in a separate Jupyter notebook.

- Create an ipynb with exactly the same name as is required in the problem. In the Julia code, declare variables with the name given in the problem. Then, after solving the problem, in the last cell of your notebook print (or use @show) all the values of all of the variables in your optimization problem as well as the value of the objective function.
- Please comment add comments to your code describing the variables, constraints and objective function of your model.
- The homework assignment will have two parts. For the first part (with this outline), you should submit a PDF of your Jupyter notebook for each homework problem (You should be able to submit multiple PDF's for the assignment. If you submit everything in a single pdf, please assign pages to make it easier to grade). For the second part, which is Homework 8 IPYNB, please submit your Jupyter notebook files (.ipynb's). We won't directly grade these, however they may be used if there are issues with your PDF submissions.
- Ensure that your notebook runs properly before submitting it. In the main bar, perform **Clear Outputs of All Cells** then **Run All** to ensure that there are no errors.
- To generate a PDF of your notebook:
  - In the main bar, click **Export** (may be hidden behind a 3 dots dropdown menu)
  - Choose Export as PDF (may require additional extensions).
  - If Export as PDF fails or does not give proper output, export the file as HTML, open this HTML file in a web browser and save the HTML file as a PDF.
  - If you cannot get exporting to work in VSCode, you may use a Jupyter Notebook to PDF converter online.
- Remember to submit the .pdf versions to the normal Homework 9 assignment and the .ipynb files to the Homework 8 IPYNB assignment.

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Question 1. (**30 points**): Paul Hollywood bakes two types of cakes: cheesecakes and black forest cakes. During any month, he can bake at most 65 cakes in total. The costs per cake and the demands for cakes, which must be met in time, are given in the following table.

	Month 1		Month 2		Month 3	
Item	Demand	Cost/cake($)	Demand	Cost/cake($)	Demand	Cost/cake($)
Cheesecake	40	3.00	30	3.40	20	3.80
Black Forest	20	2.50	30	2.80	10	3.40

We assume that cakes baked during a month can be used to meet demand for this month. At the end of each month (after all cakes have been baked and the current month's demand has been satisfied), a holding cost of 50 cents per cheesecake and 40 cents per black forest cake is incurred for cakes left in inventory. Those cakes can be used to satisfy future demand.

Formulate an LP to minimize the total cost of meeting the next three months' demands and solve it using JuMP. Create a Jupyter notebook named *cake.ipynb*. Declare two vectors in the Julia Code:

cakes = [:cheesecake, :blackforest]

months = 1:3

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Declare the holding costs as a Dictionary over *cakes* and the demands and production costs as NamedArrays over *(cakes,months)*. Then, declare positive variables *x[cakes,months]* and *h[cakes,months]*, to represent the number of each type of cakes to make each month and the number of each type of cakes left in inventory at the end of each month respectively. To check the correctness of your solution: the optimal value is $464.5.

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Question 2. (**30 points**): A shipping company supplies goods to three customers, who require 40, 50 and 40 units respectively. The company has three warehouses, each of which has 30 units available. The costs of shipping 1 unit from each warehouse to each customer are shown in the table below.

From/To	Customer 1	Customer 2	Customer 3
Warehouse 1	\$15	\$35	\$25
Warehouse 2	\$10	\$50	\$40
Warehouse 3	\$20	\$40	\$30

There is a penalty for unmet demand: With customer 1, a penalty cost of \$70 per unit is incurred; with customer 2, \$75 per unit; and with customer 3, \$65 per unit. The company's goal is to minimize the total cost.

Formulate the problem as a balanced transportation problem by adding a dummy warehouse. Create a Jupyter notebook named *company.ipynb* to solve the problem. Display values of all variables. (The optimal value is \$4,950.)

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Question 3. (**40 points**):

Oilco has oil fields in Los Angeles and San Diego. The Los Angeles field can produce 400,000 barrels per day and the San Diego field can produce 500,000 barrels per day.

Oil is sent from the fields to a refinery, in either Dallas or Houston (assume each refinery has unlimited capacity). To refine 100,000 barrels costs $700 at Dallas and $900 at Houston.

Refined oil is shipped to customers in New York and Chicago. New York customers require 300,000 barrels per day and Chicago customers require 400,000 barrels per day.

The costs of shipping 100,000 barrels of oil (refined or unrefined) between cities are shown below.

From/To($)	Dallas	Houston	New York	Chicago
Los Angels	300	110	-	-
San Diego	420	100	-	-
Dallas	-	-	450	550
Houston	-	-	470	530

Formulate a minimum-cost-network-flow-problem (MCNFP) to minimize the total cost of meeting all demands. Create a Jupyter notebook named *oilco.ipynb* to solve this problem. Display values of all variables. (The optimal value is $10,470.)

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