
Question 1:

Graffeo Coffee Roasting Company is one of North America's oldest artisan coffee roasters and sells the best coffee in San Francisco. Graffeo blends four beans into three final blends of coffee: one is sold to luxury hotels, another to restaurants, and the third to supermarkets for store-label brands. The company has four reliable bean supplies: Robusta, Javan Arabica, Liberica, and Brazilian Arabica. The table below summarizes the precise recipes for the final coffee blends, the costs and the availability information for the four components, and the wholesale price per pound of the final blends. The percentages indicate the fraction of each bean to be used in each blend. The roasting plant of the company can handle no more than 100,000 pounds per week. The minimum production levels for the hotel, restaurant, and supermarket blends are 15,000, 25,000 and 30,000 pounds. Please assume that there is plenty of demand for each blend, i.e. there are no demand constraints.

Beans	Luxury Hotels	Restaurants	Supermarkets	Cost per lb	Maximum Weekly Availability (lbs)
Robusta	20%	35%	10%	\$0.65	22,500
Javan Arabica	40%	15%	35%	\$0.80	25,000
Liberica	15%	20%	40%	\$0.60	20,000
Brazilian Arabica	25%	30%	15%	\$0.70	45,000
Wholesale Price (per lb)	\$1.25	\$1.50	\$1.40		

- a. Develop a linear optimization model to help Graffeo Coffee decide how many pounds of each blend to produce to maximize its total profit. In doing so, assume that fractional values are acceptable. Write down your decision variables and formulas for the objective function and constraints below.

- [0.5 point] Decision variables (A):

- [0.5 point] Objective Function (B):

- [1 point] Constraints (C):

- b.** [1 point] Use the sheet named “Q1” in the solution template and setup your model in Excel Solver. Then solve it using Excel Solver to find the optimal production plan. Write down your optimal solution below.

Optimal value for each of your decision variables:

Maximum Profit: \$ _____

In answering the following questions, use Solver's sensitivity report to give exact numerical answers whenever possible without rerunning the Solver. Include the sensitivity report sheet in your submission. If it is not possible to answer the question without rerunning Solver, please do so and report the answer and provide the excel model you ran in a separate sheet.

- c. [0.5 point] By how much will the profit of Graffeo increase if the capacity of the roasting plant increases by an additional pound? Justify your answer.

- d. [0.5 point] Suppose that Graffeo can purchase an additional 3000 lbs. of Liberica for \$4.00/lb. Should Graffeo make this purchase? What is the impact on the profit? Justify your answer.

- e. [0.5 point] Suppose that Graffeo has the option to decrease the minimum production level for one of the three blends by 5000 lbs per week. For which blend should Graffeo consider decreasing the production? If this reduction is made, what will be the new total profit? Justify your answer.

- f. [0.5 point] How much can Graffeo increase the wholesale price for the supermarket blend without changing the current optimal solution? What will be the new total profit? Justify your answer.

Question 2:

Paul Bergey is in charge of loading cargo ships for International Cargo Company (ICC) at the port in Newport News, Virginia. Paul is preparing a loading plan for an ICC freighter destined for Ghana. An agricultural commodities dealer would like to transport the following products aboard the ship:

Commodity	Amount Available (tons)	Volume per Ton (cubic feet)	Profit per Ton (\$)
1	4,800	40	70
2	2,500	25	50
3	1,200	60	60
4	1,700	55	80

Paul can select any combination of available commodities, and can choose to carry any amount of the selected commodities. However, the ship has three cargo holds with the following capacity restrictions:

Cargo Hold	Weight Capacity (tons)	Volume Capacity (cubic feet)
Forward	3,000	145,000
Center	6,000	180,000
Rear	4,000	155,000

Only one type of commodity can be placed into any cargo hold. However, because of balance considerations, the weight in the forward cargo hold must be within 10% (that is, between 90% and 110%) of the weight in the rear cargo hold, and the center cargo hold must be between 40% and 60% of the total weight on board.

- a. Develop a linear optimization model to determine the optimal loading plan. Write down your decision variables and formulas for the objective function and constraints below.

- [0.5 point] Decision variables (A):

- [0.5 point] Objective Function (B):

- [3 points] Constraints (C):

- b.** [1 point] Use the sheet named “Q2” in the solution template and setup your model in Excel Solver. Then, solve it using Excel Solver to find the optimal landing plan. Write down your optimal solution below.

Optimal value for each of your decision variables:

Maximum Profit: \$ _____

- c. [1 point] Suppose Paul wants to enforce the constraint that he will only carry at most two distinct commodities. Describe the new decision variables needed (if any) and the additional modeling constraints (in terms of your decision variable symbols). You do not have to implement this new constraint in Solver.

- d. [1 point] Suppose the dealer requires that if Paul ships any amount of commodity 1, he must ship the entire 4,800 tons. Describe the new decision variables needed (if any) and the additional modeling constraints (in terms of your decision variable symbols). You do not have to implement this new constraint in Solver.

Question 3:

Royal Conch Oil (RCO) is an oil company that bids for the rights to drill in offshore areas. RCO is trying to determine a profit-maximizing bid for the right to drill on an offshore oil site. The actual value of the right to drill is unknown, but it is equally likely to be any value between \$10 million and \$110 million. Three competitors will bid against RCO. Each bidder (including RCO's) estimates the value of the drilling rights independently. Each bidder's estimate is equally likely to be any number between 50% and 150% of the actual value. Based on past history, RCO believes that each competitor is equally likely to bid between 40% and 60% of its own value estimate. Assume that the auction mechanism is a simple first price auction: The drilling rights are awarded to the highest bidder, the winner pays his bid amount, and losing parties do not pay anything. Also assume that the actual value of the oil field and the competitors' bids are uniformly distributed.

- a. [3 points] Assume that RCO bids 95% of its estimated value. Build a model to simulate the bidding process, determine the winner, and the payoff of RCO. Use the sheet named "Q3" in the solution template and setup your simulation model in Excel.
- b. [1 point] Run the simulation for 1000 times. What is the average Profit of RCO?

- c. [2 point] RCO wants to find the profit maximizing bid. Run simulations using different percentages of RCO's estimated value as the bid. Please search within multiples of 5%. What is the profit maximizing bid for RCO?

- d. [1 point] What fraction of time does RCO win when it uses the profit maximizing bid percentage?

Question 4:

S&C company signs a contract with a retailer and can sell up to 8000 ounces of shampoo to the retailer. S&C outsources the production to a factory. This product is manufactured in batches that take 5 to 11 days according to the following distribution.

Time to make a batch (days)	5	6	7	8	9	10	11
Probability	0.05	0.10	0.20	0.30	0.20	0.10	0.05

Only one batch can be made at a time. Each batch yields an uncertain amount of product, ranging between a minimum of 600 ounces and a maximum of 1100 ounces, with a most likely value of 1000 ounces. Data from past production cycles show that a triangular distribution fits the batch yields fairly well. Finally, 20% of the time a batch fails inspection and the entire batch must be discarded. S&C needs to decide the profit maximizing number of batches to order. The cost to produce one batch is \$90.00. The selling price of the shampoo to the retailer is \$0.15.

- a. [2 point] Suppose S&C decides to order 10 batches from the factory. Build a model to simulate total profit of S&C and the number of days to finish this production plan. Use the sheet named “Q4” in the solution template and setup your simulation model in Excel.
- b. Answer the following questions based on your simulation model.
 - [0.5 point] What is the mean profit of S&C?

- [0.5 point] What is the mean number of days that will be required?

- [0.5 point] What is the probability that the number of days required to finish the current production plan will exceed 85?

- c. [2.5 points] Assume that the retailer does not accept the order after 85 days. In other words, S&C can only sell shampoo (up to 8000 ounces) produced before day 85 (day 85 included) to the retailer. All shampoo produced afterwards will be discarded. Modify the simulation in part a., and find profit maximizing number of batches S&C should order to produce. What is the profit maximizing number of batches and what is the expected profit at this batch size?

Question 5:

A product manager at Clean & Brite (C&B) needs to determine whether her company should market a new product. If this new product succeeds in the marketplace, C&B estimates that it could earn \$1,600,000 in future profits from the sale of the new product. However, if this new product fails, the company expects that it could lose approximately \$850,000. If C&B chooses not to market this new product, the product manager believes there will be no impact on the profits earned through sales of C&B's other products. The manager has estimated that the new product will succeed with probability 0.55.

a. [1 point] Build a decision tree to determine the best course of action to maximize the expected profit of C&B. Use the sheet named "Q5" in the solution template and setup your decision tree in Excel.

b. Answer the following questions based on your decision tree built in part a.

- [0.5 point] What are the optimal decisions (best course of action) for the C&B product manager?

- [0.5 point] What is the maximum expected profit?

c. [2 points] Before making her decision regarding this product, the manager can hire a market research study at the cost of \$80,000. Such a study of consumer preferences will yield either a positive recommendation with probability 0.6 or a negative recommendation with probability 0.4. Given a positive recommendation, the new product will eventually succeed in the marketplace with probability 0.75. Given a negative recommendation, the new product will eventually succeed in the market place with probability 0.25. Build a decision tree to determine the best course of action to maximize the expected profit of C&B.

d. Answer the following questions based on your decision tree built in part c.

- [0.5 point] Should C&B hire the study or not?

- [0.5 point] What is the maximum expected profit?

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1a	1b	1c-1f	2a	2b	2c-d
2 pts	1 pts	2 pts	4 pts	1 pts	2pt
3a-3b	3c-3d	4a-4b	4c	5a-5b	5c-5d
4 pts	3 pts	3.5 pts	2.5 pts	2 pts	3 pts