Question 1 [6 points]

Can2Oil, a global company specializing in canola oil refinement, is in the process of restructuring its operations. The company sources canola oil from numerous producers worldwide. However, for strategic reasons, Can2Oil plans to simplify its operations. Specifically, the company aims to reduce the amount of canola oil that is transshipped without compromising its ability to meet global demand. This restructuring should also align with the capacity limitations of its refinement centers.

Can2Oil sources canola oil from 40 different production facilities in Canada (5), United States (5), Mexico (5), China (5), France (5), India (5), Ukraine (5), Germany (5). While canola oil from Canada, US, Mexico, China, and France (i.e., facilities indexed from $i = 1, ..., 25$) can be shipped directly to its refinement centers, canola oil from India, Ukraine, and Germany (facilities indexed from $i = 26, ..., 40$) need to be transshipped through an intermediary that operates two large distribution centers in Italy ($j = 1$) and Greece ($j = 2$). Note that Can2Oil owns five refinement centers in North America.

To determine the optimal sourcing plan that minimizes total costs, the company has provided data on transportation costs per million pound, production and distribution capacities (in millions of pounds), and demand (in millions of pounds). Formulate and solve a linear program using this data.

(a) After solving the linear program, what is the optimal transportation cost?

(b) In the optimal solution, what proportion of canola oil is transshipped?

(c) The model does not currently limit that amount of canola oil that is transshipped. How would you modify the objective function to account for this? Formulate and solve this model.

(d) Instead of modifying the objective function, how would you modify the constraint set to reduce the proportion of canola oil that is transshipped? Formulate and solve this model.

(e) Which of the two modeling approaches would you recommend the company take to determine a transportation plan that reduces the amount of canola oil that is transshipped?

(f) Re-shoring is the practice of transferring overseas business operations closer to the home country. Given its prevalence in today's economy, how would you alter the original model to favor producers closer to North America? Formulate and solve this model.

(g) Do you expect the optimal solution to the re-shoring model to be similar to the optimal solution of the model that attempts to reduce transshipment? Why or why not?

Question 2 [6 points]

Sunnyshore Bay is a charming, privately-owned waterpark located near the serene Blue Lake, operating from May to September. Given the seasonal nature of the business, several significant expenses must be covered at the start of the waterpark season, ahead of achieving a stable cash flow. Over the four months of the season, Sunnyshore Bay expects the following revenues and expenses.

	May	June	July	August
Revenues	$180,000	$260,000	$420,000	$580,000
Expenses	$300,000	$400,000	$350,000	$200,000

Sunnyshore Bay starts the season with an initial cash balance of $140,000. Additionally, the company can opt to borrow money from a local bank at the following rates and term structures:

	1-month	2-months	3-months
Interest Rate	1.75%	2.25%	2.75%

Money is borrowed at the end of a month and repaid, with interest, at the end of the month in which the obligation is due. For example, if the company borrows $10,000 at a 3-month rate in May, they must pay back $10,275 at the end of August (the rate is not annualized). Sunnyshore Bay is not allowed to borrow money that cannot be paid back in this period (e.g., money cannot be borrowed at the 3-month rate in July). In addition, the following financial restrictions must be satisfied.

- The company must maintain a cash balance of at least $25,000 in May, $20,000 in June, $35,000 in July, and $18,000 in August, which is verified at the end of each month.

- The total amount borrowed in a month, i.e. taking into account any term/rate structures for that month, cannot exceed $250,000 in May, $150,000 in June, and $350,000 in July.

- The cash balance at the end of July (after accounting for all loans) must be at least 65% of the combined total cash balances from May and June.

Formulate and solve a linear program that minimizes the total amount that Sunnyshore Bay has to repay to the bank over the summer months. Answer the following questions along the way:

(a) How many different investments can be made over the 4-month period?

(b) Write down the cash balance constraint for money on-hand at the end of June.

(c) Write down the linear ratio constraint associated with the cash balance at the end of July.

(d) What is the total amount that Sunnyshore Bay has to repay to the bank over the entire season?

(e) How much money does Sunnyshore Bay withdraw in May from all loans?

(f) What is the cash balance at the end of August?

(g) Due to potential unexpected repairs, one of the managers has suggested increasing the minimum cash balance for June to $27,500. How much will now have to be repaid if this change is approved?

(h) Formulate and solve the dual linear program demonstrating that the model you create is, indeed, the correct dual problem of the primal formulation.

(i) Which formulation, the primal or the dual model, do you think is easier to solve?