

**Assignment # 2**  
**Linear Programming Formulation and Sensitivity Analysis**

ADM2302 students are reminded that submitted assignments must be neat, readable, and well-organized. Assignment marks will be adjusted for sloppiness, poor grammar and spelling, as well as for technical errors. This assignment can be done in a group of one, two, three or four students. Plagiarism on assignments will not be accepted, *each student must sign the statement of integrity*. Solutions to the Case Study are to be prepared using the **Report to Management format provided in the ADM2302 Course Outline**.

This assignment can NOT be hand written.

The assignment is to be submitted electronically as a single PDF file via blackboard learn by Sunday February 26<sup>th</sup> prior to 23:59. Front page of the PDF document has to include title of the assignment, course code and section, student name and student number. Second page is *the statement of integrity that must be signed*.

**E-mail questions related to the assignment should be sent to the Teaching Assistant or posted on the Blackboard Learn course website “Discussion Area” (viewed by all).**

**Problem 1 (18 points)**

RJCK Inc. produces two steak sauces, Spicy Diablo and Mild Red Baron. These sauces are both made by blending two ingredients, A and B. A certain level of flexibility is permitted in the formulas for these products. The allowable percentages, along with the revenue and cost data, are given the table below.

SAUCE	INGREDIENT		SALES PRICE PER LITER \$
	A	B	
Spicy Diablo	a least 25%	at least 50%	5.35
Mild Red Baron	at most 75%	*	4.85
Cost per liter	\$1.50	\$2.00	

\*No explicit maximum or minimum percentage.

Up to 50 liters of A and 40 liters of B could be purchased. RJCK can sell as much of these sauces as it produces. The objective is to maximize the net revenue from the sale of the sauces.

- a. Formulate the algebraic LP formulation (13 points)
- b. Find the optimal solution using Solver. (Provide a printout of the corresponding “Excel Spreadsheet” and the “Answer Report”). Include “managerial statements” that communicate the results of the analyses (i.e. describe verbally the results). (5 points)

**Problem 2 (22 points)**

Professional traders can find investment opportunities from day-to-day financial markets. Very often an investment strategy is required that determines how the investment should be planned across different days so that it can eventually lead to some profits. After months of study on the daily stock market, the traders of the international firm QuantTradeX have identified which stocks they should invest into so that they can receive almost-predictable returns. In particular, by investing in these stocks they have the following proprietary trading strategy. At the start of every day of the week (Monday through Friday), they can decide how much to invest on that day, say,  $X$  dollars. If in the next day they are able to match that initial investment (the  $X$  dollars) with another investment of half of that amount, i.e.  $X/2$  dollars, then they can expect to receive a total return on the third day that doubles the initial amount of the investment, i.e. a total return of  $2X$  dollars. For example, if the trader invests  $X$  dollars on Monday and another  $X/2$  dollars on Tuesday, which in total is  $1.5X$  dollars, they can expect to receive  $2X$  dollars on Wednesday, which gives them a gain of  $0.5X$  dollars in two days.

However, any initial investment that is not matched on the subsequent day will lose its whole value. Thus, considering any investment without a subsequent fund to match might not be meaningful.

Besides the stock market, Foreign Exchange (FX) market is another popular financial market that daily traders actively participate. Although the firm QuantTradeX used to invest mostly in the stock market, they cannot let go any good investment opportunity even if it is in the FX market. The firm has recently noticed that whenever the number of travelers increases during the weekend, the FX rate tends to increase also in the following few days and go back to normal by the end of the week. They believe that in this case if they are able to invest  $Y$  dollars in the FX market on the Monday that follows right after the weekend, they can receive its doubled amount, i.e.  $2Y$  dollars next day (Tuesday). If the investment is made on Tuesday, they can receive  $1.5Y$  dollars next day (Wednesday). However, if the investment is made on Wednesday, they only receive  $1.2Y$  dollars in two days, i.e. Friday. No investment in FX markets will be considered for the days after Wednesday.

On any given day of a week, the traders of the firm can re-invest any return they receive from the previous investments made in the same week. If there is any amount in the firm's account that is not invested in any of the financial markets, that amount can accrue 1% of daily interest through money markets.

Every Sunday night, the traders of the firm need to determine an investment plan for the following weekdays, i.e. how money in their account should be invested in each day. The plan is considered successful if it maximizes the amount of money they can have in their account by the end of the coming Saturday. It is assumed that on Saturday they can still receive returns from earlier investments in the same week.

Today is another Sunday and the firm needs to make its weekly investment plan. It has been just confirmed that the number of travelers has increased significantly this weekend. The firm currently has 1 million in its account.

You have been hired fairly recently and assigned to help the traders determine a successful investment plan for the coming week.

Report how you would solve this problem by formulating the **algebraic formulation** of the Linear Programming (LP) model. You should provide all the details, which includes but are not limited to the LP model, i.e. decision variables, constraints, and objective function, with detailed explanations, the Excel sheets including your LP model, and answer Report. Include “managerial statements” that communicate the results of the analyses (i.e. describe verbally the results).

### **Case Study: Staffing Nurse Personnel (60 points)**

The dermatology clinic at the Ontario Women’s College Hospital offers a wide variety of services and treatments to the community. Some of these include the removal of unwanted marks such as skin lesions or moles, the treatment of general dermatitis, acne, blistering diseases, and alopecia. Patients arrive at the clinic on an appointed schedule and as walk-in-patients. Five registered nurses (RNs), three senior registered practical nurses (SRPNs), and five junior registered practical nurses (JRPNs) work in the clinic to move patients through the process in a timely way, as well as to administer care in the form of delivering services and providing instructions. *The clinic’s administrators are wondering whether they can still provide a high quality service to patients with a lower staffing level.* The clinic serves about 100 to 150 patients per year and growth is expected in the foreseeable future. JRPNs are paid \$23,000 per year, SRPNs are paid \$28,000 per year and RNs are paid \$45,000 per year.

To cover the responsibilities of the floor on weekly basis, it was determined that the clinic required 134 hours of JRPNs’ time, 88 hours of SRPNs’ time, and 138 hours of RNs’ time. Each nurse works 40 hours per week and is paid for 52 weeks per year. For efficient operations, the clinic has determined that the minimum amount of total nurse time to be covered in a week is 360 hours. Because no other nurse can do an RN’s work, the minimum amount of RNs’ work per week has been set at 138 hours. It was also determined that the maximum amount of work that RNs can do is 360 hours per week, which is theoretically covers all the nursing work. The maximum amount of work time for JRPNs is 134 hours, because JRPNs cannot do any other nursing duties; and the maximum amount of work time per week for SRPNs, is 222 hours, which is the time it takes to theoretically cover weekly SRPN tasks as well as JRPN tasks.

1. Prepare a report for the senior administrators that would indicate the effective combination of nurses that would allow for all weekly clinic tasks to be covered while providing the lowest possible cost and meeting the operating constraints. Provide your algebraic linear programming (LP) model and indicate how many nurses the clinic should staff in each category (i.e. Find the optimal solution using Solver, provide the Excel spreadsheet formulation and Sensitivity Report). Provide a cost analysis of your LP model solution on an hourly, weekly, and yearly basis. What will be the annual savings (or additional cost) in personal cost if the solution from your model is implemented?

2. Perform a sensitivity analysis to answer the following questions, taken independently.
  - a. If one additional SRPN is hired at a salary of \$28,000 would the clinic still save money annually?
  - b. What saving will result if one RN staff is removed from the payroll?
  - c. What saving will result if one SRPN staff is removed from the payroll?
  - d. What saving will result if one JRPN staff is added to the payroll?
  
3. If one wanted to perform such a study in a real-life setting, discuss some of the challenges that might be involved to develop the LP model included in your report and some limitations to account for in the study.