U20688/M352 – Advanced Decision Modelling

Coursework

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Hand in date: 05 May 2021 before 16:00 online

This assignment is worth 40% of the total unit mark. It is an individual assessment. Group work and/or copying of work or reports are not permitted and will be dealt with under the University rules on plagiarism. This work is marked out of 100.

What you need to submit

Submit ONE ".doc" or ".pdf" file, ONE Excel file and ONE Simul8 file online to Moodle.port.ac.uk -> Advanced Decision Modelling -> Coursework Submission -> Final Submission -> Confirm Submission (Press the Button to Confirm)

In this coursework:

a = The fourth digit of your Student ID number
b= The fifth digit of your Student ID number
c = The last digit of your Student ID number

(e.g. Student ID number 456713 gives a=7, b=1, c=3)

Problem 1: Product Mix Problem

A company produces three types of products, which are Product A, B and C. These products are processed in four departments: Assemble, Edit the steel, Chemical process and Forge Welding. All three products are produced from Stainless Steel and need Rust protection. The manager of the company needs to determine the product mix for the next month in order to maximize the total profit of the company for the next month. The availability and the unit costs of the resources and activities, and the specific requirements for each product are given in Table 1.

Table 1. The availability and the unit costs of the resources and activities, and the specific requirements for each product

	Total Available in next Month	Unit Cost of the Resource/ Activity	Requirements		
			Required per product A	Required per product B	Required per product C
Raw Material					
Stainless Steel	150,000 Kg.	£200/Kg.	7 Kg.	23 Kg.	3.5 Kg.
Rust protection	23,000 gram	£20 per gram	5 gram	2.5 gram	7.5 gram
Activity					
Assemble	3000 hours	£30/hour	10 minutes	20 minutes	15 minutes
Edit the steel	5,000 hours	£25/hour	20 minutes	35 minutes	25 minutes
Chemical process	8,000 hours	£37/hour	45 minutes	60 minutes	20 minutes
Forge Welding	3,000 hours	£25/hour	30 minutes	10 minutes	20 minutes

All products produced in next month are made available for meeting the demand in the same month. The manager estimates that

- All satisfied demand can be sold at the estimated sale price.

- All made in excess of demand can be sold at the discount price, which equals 80% of the original sale price.
- If the demand for a certain product is not satisfied. A penalty cost of £1,000/product will be incurred.
- Also the manager needs to guarantee that at least 90% of the demand for each product is satisfied.

The estimated sale price of each product and estimated demand in one month are shown in Table 2:

Table 2. The sale price and estimated demand of each product

	Product A	Product B	Product C
Demand	1,650	3,068	700
Sale price (£/product)	2,655	6,890	1,510

The manager of the company needs to determine the product mix for the next month in order to maximize the total profit of the company for the next month.

a) Formulate an Integer Programming model for this product mix problem so that the **Total Profit** of the company in the next month is maximized (**Total Profit** = **Total Revenue – Raw Material Cost – Labour Cost**). Describe clearly each of the following parts of your mathematical model with ONE or TWO sentences: objective function, decision variables, constraints and decision variable domain.
[17 marks]

b) Model this problem in Excel and use Solver to find the optimal solution. Provide a description of the optimal solution found in the context of the application with ONE or TWO sentences. A hard copy screenshot of your Excel model should accompany your description.
[15 marks]

c) Generate the Answer Report and Sensitivity Analysis Report **by dropping the integer requirement on decision variables** in a). Use the Answer Report and Sensitivity Analysis Report to find out the most limiting resource or activity to the furniture company. Analyse what if the availability of the most limiting resource changes. Are the Total Profit and/or production plan going to change? How are they going to change and why? [Maximum 200 words]
[8 marks]

d) Model the following situations by adding extra variables and revising objectives and constraints of the Integer programme model in a). Each question is independent of the others. **No Excel implementation is needed**.

i) All production of Products A, B, and C needs to be made in 1000's. For example, the production of Product A needs to be 1000, 2000, 3000 etc.
[5 marks]

ii) Production of Product A and production of Product B cannot exceed the estimated demand at the same time.
[5 marks]

iii) If Product A is made more than 20% in excess of the estimated demand, Product B must be made no more than 20% in excess of the estimated demand.
[5 marks]

iv) If a third party offers to produce product A for the company with a fixed charge of £500,000 and they also charge £1000 per Product A. Should the company manufacture Product A on them own or the company should buy it from the third party? Or should the company do both?
[10 marks]

[65 marks in total]

Problem 2: Simulation

In a restaurant kitchen, orders arrive randomly from 9am – 10pm; the time between two consecutive orders arriving follows an exponential distribution with an average of 10 minutes between 9-12am, 5 minutes between 12-2pm, 20 minutes between 2-5pm, and 8 minutes between 5-10pm. 15 percent of

all orders are cold meals, 60 percent are hot meals, and 25 percent are fish meals; these percentages do not significantly change during the day.

- In a first operation, the ingredients for the order are prepared; preparation time is exponentially distributed with an average of 5 minutes for a cold plate, 10 minutes for a hot meal, and 15 minutes for a fish dish.
- In a second operation, the meal is cooked; the time of this operation is exponentially distributed with an average of 4 minutes for a cold plate, 12 minutes for a hot meal, and 23 minutes for a fish dish.
- In a third operation, the orders are arranged; the time is exponentially distributed with an average of 4 minutes for a cold plate, 6 minutes for a hot meal, and 9 minutes for a fish dish.

The restaurant opens 7 days a week. Build a simulation model that can test the following two queue priority rules: First-In-First-Out, Shortest Expected Processing Time First. **The objective is to find the processing rule that will minimise the average throughput time of an order**. Let the model report the throughput time of each order.

a) Conceptual Model. Develop a conceptual model for the problem, by describing the objectives, inputs, outputs, content (including a logic flow diagram) assumptions and simplifications of the model, in approximately 500 words.

[10 marks]

b) Computer Model. Build a simulation computer model in SIMUL8 to model the problem with First-In-First-Out priority rule only. A hard copy screenshot of your simulation model should be provided in your report.
   i) Set Result Collection Period = 2000 weeks. Set number of runs in trial = 5. Halt the simulation at limit: 1000, 5000, 11,000, 12,000, and 13,000 orders leaving the system. Create a table and a graph to observe if the system reaches steady state with the increasing limit of the number of orders leaving the system. Explain with a couple of sentences.
   ii) Select **ONE of the limits from i) to halt the simulation** so that the system reaches steady state. Start with "number of runs in trial = 5". **Calculate** the number of runs for a trial, so that 95% confidence interval of **the average throughput time of an order** is reduced to ±10 minutes?
   iii) Use the parameter settings in ii), change the number of runs in trial to the value calculated in ii). Run the trial to determine the following:
      - Average throughput time of an order of all three types.
      - Average throughput time of an order for cold plates.
      - Average throughput time of an order for hot meals.
      - Average throughput time of an order for fish dishes.

[15 marks]

c) Experimentation. Experiment with the simulation model you built in b) iii) to find average throughput time of **an order for a cold meal**. Make a comparison of the system following two queue priority rules: First-In-First-Out, Shortest Expected Processing Time First. Provide **detailed calculation** and your conclusions and recommendations based on your statistical analysis.

[10 marks]

[35 marks in total]