NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2020-2021

EE6204 – SYSTEMS ANALYSIS

April / May 2021 Time Allowed: 3 hours

INSTRUCTIONS

1. This paper contains 5 questions and comprises 5 pages.
2. Answer all 5 questions.
3. All questions carry equal marks.
4. This is a closed book examination.
5. Unless specifically stated, all symbols have their usual meanings.

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1. A small food-processing factory has been producing three products, namely, *PA*, *PB* and *PC* that are well-liked by the public. Due to rising material costs, lack of capital and intense competition, the management would like to re-plan the production by keeping the operating costs low while maximizing the overall profit from selling these products. The material requirements and the costs to produce these products as well as the associated packing costs are given in Table 1 (data for the production of *PA*, *PB* and *PC*).

Table 1

Product (per package)	Materials needed (kg) (per package)	Cost to produce a package ($)	Packing cost ($) (per package)
PA	0.2	1.50	0.50
PB	0.18	1.70	0.35
PC	0.16	1.80	0.60

Note: Question No. 1 continues on Page 2.

The factory also faces material and financial constraints on a daily basis. It can use no more than 10 kg of materials and spend no more than \$100.00 a day to produce these products. In addition, the total packing costs cannot be more than \$30.00 a day. The estimated profits from selling each package of *PA*, *PB* and *PC* are \$2.50, \$2.20 and \$2.10, respectively.

(a) Formulate a programming problem that maximizes the overall profit that can be obtained from selling these products.

(5 Marks)

(b) Determine how many packages of each of these products should be produced a day in order to obtain the maximum overall profit.

(12 Marks)

(c) Suppose that the management wants to decrease the cost further by cutting the budget for packing. You should advice if it is possible while ensuring the current solution that you obtained in part (b) is still feasible. Provide your justification.

(3 Marks)

2. You are asked to design sealed cylindrical cans. The cans are to be made using a material costing \$$C$/m^2 ($C > 0$). The volume of a can is fixed at V m^3 ($V > 0$). You are to ensure that the material cost is minimized while all the other requirements are met.

(a) Formulate the above-mentioned problem as an optimization program. You may let the radius and height of the cylinder be x_1 m and x_2 m, respectively. Then the volume of the sealed cylinder is given by $\pi x_1^2 x_2$ m^3 and the overall surface area is $2\pi x_1^2 + 2\pi x_1 x_2$ m^2.

(4 Marks)

(b) Use the method of Lagrange multiplier to determine the dimensions of the can so that the material cost is minimized. Show all your calculations.

(12 Marks)

(c) Determine the approximate change in the cost you found in part (b) if the volume of the can is to be reduced by 5%.

(4 Marks)

3. A real estate company is about to launch its new condominium for sale. The weekly sales of the new condominium can be classified as "Low" or "High". The company's advertising strategy will be based on the weekly sales level. Since the company's advertising budget cannot afford advertising all the time, the company is considering the following two advertising strategies:

(A) advertise when sales are low; do not advertise when sales are high;

(B) advertise when sales are high; do not advertise when sales are low.

Running advertisements in any week will have primary positive impact on sales in the following week. So, at the beginning of each week, the company will forecast as best as it could whether sales will be low or high that week. Based on the forecast, the company will decide whether to run advertisements that week. When advertising is done during a week, the probability of having low sales the following week is 1/5 or 1/10, depending on whether the current week's sales are low or high respectively. These probabilities are increased to 1/2 or 1/3, depending on whether the current week's sales are low or high respectively, when advertising is not done during the current week.

The cost of advertising for an entire week depends on the current week's sales - advertising costs $200,000 if the current week's sales are low (more advertisements) while the cost is $100,000 if the current week's sales are high (less advertisements). Before deducting advertising cost, the company's weekly profits are $2,000,000 when sales are high but only $500,000 when sales are low.

Let state 0 indicate the "Low" level of sales and state 1 indicate the "High" level of sales during a week, where each transition of the process goes from one week to the next.

(a) For each of the two advertising strategies (A) and (B), construct the (one-step) transition probability matrix.

(4 Marks)

(b) For each of the two advertising strategies (A) and (B), find the mean sojourn times for state 0 and state 1. Which strategy is better if the company wants to have short low sales period on the average? Which strategy is better if the company wants to have long high sales period on the average?

(6 Marks)

(c) Calculate the steady-state probabilities for each of the two advertising strategies (A) and (B).

(5 Marks)

(d) Find the long run expected weekly profit (after a deduction for advertising costs) for each of the two advertising strategies (A) and (B). Which strategy is better according to this measure of performance?

(5 Marks)

4. Jack is a bachelor and he knows two nice ladies, Jane and Anne, for some time. He is seriously considering to advance his friendship with one of them to that of courtship, i.e., he is considering to pursue one of the ladies as his 'girlfriend' and eventually he would like to marry his girlfriend and start a family. Jack is not sure which lady is the better 'girlfriend' as each of them has her merits. Jack has three criteria for a perfect girlfriend - (i) she is his Soul Mate (*S*); (ii) she has good Earning Power and as a wife can strengthen the family's finance (*E*); (iii) she is well liked by Jack's parents (*P*).

Jack has set up the following pair-wise comparison matrices:

Criterion

	S	*E*	*P*
S	1	5	6
E	1/5	1	2
P	1/6	1/2	1

Soul mate (*S*)

	Jane	Anne
Jane	1	4
Anne	1/4	1

Earning power (*E*)

	Jane	Anne
Jane	1	1/6
Anne	6	1

Liked by parents (*P*)

	Jane	Anne
Jane	1	1/7
Anne	7	1

Note: Question No. 4 continues on page 5.

(a) Compute the priority of each criterion (*S*, *E*, *P*) in terms of its contribution to the overall goal. State the most important criterion, the next important criterion and the least important criterion.

(5 Marks)

(b) Compute the Consistency Ratio (CR) and comment on its acceptability. For three criteria, the consistency index of a randomly generated pair-wise comparison matrix is 0.58.

(6 Marks)

(c) Determine the overall priority for each lady and give your recommendation to Jack.

(9 Marks)

5. An international fashion house of men's wear has just completed the design of the spring/summer collection for year 2021. Before moving the new collection to mass production stage, the company is considering to appoint JJ, the famous Hollywood actor who starred in the latest star war movie, to be the ambassador of the new collection. The appointment of JJ has to be negotiated through an agent. If the negotiation is successful, i.e., JJ becomes the ambassador of the new collection, the company will pay $1 million to JJ and $100,000 to the agent. If the negotiation fails, the company will still have to pay the agent $50,000 for his efforts.

Without JJ as the ambassador, there is a 51% chance that the new collection will be a hit, and a 49% chance that it will be a bomb. In the case of a hit, the company will make a profit of $20 million. In the case of a bomb, the company will suffer a loss of $10 million. There is no gain or loss if the company does not mass produce the new collection.

If JJ becomes the ambassador of the new collection, there is a 75% chance that the new collection will be a hit. Based on the negotiating agent's estimation, there is a 55% chance that JJ will agree to become the ambassador.

In the event that a deal cannot be struck with JJ, the company's next plan is to decide whether to engage a handsome model to appear in all the advertisements of the new collection. The model will cost $300,000. With the model appearing in the advertisements, there is a 60% chance that the new collection will be a hit.

(a) Use a decision tree to represent the above problem.

(12 Marks)

(b) Recommend a strategy for the company to adopt so that its expected final profit is maximized. What is the maximum expected final profit? What are the possible actual profits/losses of your recommended strategy?

(8 Marks)

END OF PAPER

EE6204 SYSTEMS ANALYSIS

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.