**Section: A**

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| **Q1:** | **Question 1 (12 marks)**  AdvTech is planning to set up a new manufacturing department to meet the increasing customer demands for special purpose sensors used in industries.  1.a) State the two factors AdvTech needs to consider when selecting the right type of manufacturing process structure for the new department. (2 marks) | **Mark (2)** |
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|  | Word Count: 12 | Max Words: 100 |

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| **Q2:** | 1.b) After analyzing the potential customer demands, AdvTech decided to produce only a few types of highly demanded sensors at high quantities to lower cost and ensure quality.  1.b)i) What is the process structure AdvTech should use? In terms of resource flexibility, what kind of equipment (general purpose or specialized) is more suitable for the process structure identified? (2 marks)  The process structure AdvTech should use:   The kind of equipment more suitable for the process structure: | **Mark (2)** |

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| **Q3:** | 1.b)ii) Identify two competitive priorities that AdvTech wants to leverage for the production of the sensors. (2 marks) | **Mark (2)** |
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|  | Word Count: 23 | Max Words: 100 |

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| **Q4:** | 1.c) A process map was plotted for the sensor production process as shown in Figure 1a.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_1210708245_1553143137.png  1.c)i) State the cycle time of the sensor production process and calculate the number of sensors produced in a shift of 8 hours. (3 marks) | **Mark (3)** |
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|  | Word Count: 30 | Max Words: 100 |

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| **Q5:** | 1.c)ii) Assume that the manufacturing department at AdvTech is able to produce 600 sensors monthly. If 540 sensors were produced in May, determine the capacity utilization of the process and state the type of measure of capacity used. (3 marks) | **Mark (3)** |
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|  | Word Count: 23 | Max Words: 100 |

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**Section: B**

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| **Q6:** | **Question 2 (16 marks)**  ACE Pte Ltd is considering three alternatives to expand its production capacity for a newly developed product: 1) Building a large plant, 2) Building a small plant, or 3) Upgrading the existing plant. The potential annual payoffs resulting from these alternatives depend on the market response as shown in Table 2a. The company wants to select only one of the three alternatives.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_224356542_-1383578758.png  2.a) Assume that the probability of each market response is not known to ACE Pte Ltd.    2.a)i) The management of ACE Pte Ltd wants to regret the least if the worst case scenario happens. Which criterion (Maximax, Maximin, Minimax Regret, Equal Likelihood, Hurwicz) would ACE Pte Ltd use to select the alternative? (1 mark)  Your answer: | **Mark (1)** |

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| **Q7:** | 2.a)ii) Assume that ACE Pte Ltd decides to apply the Hurwicz criterion to make the decision. If alpha (coefficient of realism) is set to be 0.85 in the calculations, is the decision maker an optimist or a pessimist? Explain. (2 marks) | **Mark (2)** |
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|  | Word Count: 34 | Max Words: 100 |

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| **Q8:** | 2.b) ACE Pte Ltd managed to obtain the probability of each market response as shown in Table 2b below.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_328830336_-323553744.png  2.b)i) Which alternative should ACE Pte Ltd select based on the Expected Monetary Value (EMV) method? Explain and show your workings clearly. (8 marks) | **Mark (8)** |
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|  | Word Count: 59 | Max Words: 200 |

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| **Q9:** | 2.b)ii) A consultancy company specialized in market research can forecast the market responses with 100% accuracy. Determine the maximum amount ACE Pte Ltd should pay the consultancy company to gain the perfect information. Show your workings clearly. (5 marks) | **Mark (5)** |
|  |  | |
|  | Word Count: 40 | Max Words: 200 |

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**Section: C**

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| **Q10:** | **Question 3 (9 marks)**  A manufacturer of household appliances is required to distribute vacuum cleaners from two warehouses (A and B) to three retail shops (1, 2 and 3). The problem has been represented as a transportation model and shown in Table 3a. The unit shipping cost, demand and supply information are also compiled in Table 3a.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_818148669_-912663577.png  To determine the shipping plan with the minimum cost, you are required to formulate a Linear Programing (LP) model based on the decision variables defined below:  Xij: The number of vacuum cleaners to be shipped from warehouse i (i = A and B) to retail shop j (j = 1, 2, and 3). For example, XA2 represents the number of vacuum cleaners to be shipped from Warehouse A to Retail Shop 2.    3.a) Construct the objective function. (2 marks) | **Mark (2)** |
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|  | Word Count: 15 | Max Words: 100 |

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| **Q11:** | 3.b) Formulate the supply constraint for Warehouse A. State the total number of supply constraints you have in the LP model. (2 marks) | **Mark (2)** |
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|  | Word Count: 9 | Max Words: 100 |

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| **Q12:** | 3.c) Formulate the demand constraint for Retail Shop 3. State the total number of demand constraints you have in the LP model. (2 marks) | **Mark (2)** |
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|  | Word Count: 9 | Max Words: 100 |

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| **Q13:** | 3.d) If the available supply of Warehouse B is changed from 50 to 40 units and all the other demand and supply remain unchanged, formulate the constraints for Warehouse B and Retail Shop 2.  3.d)i) The constraint for Warehouse B. (1 mark)  Your answer: | **Mark (1)** |

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| **Q14:** | 3.d)ii) The constraint for Retail Shop 2. (2 marks) | **Mark (2)** |
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|  | Word Count: 9 | Max Words: 100 |

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**Section: D**

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| **Q15:** | **Question 4 (9 marks)**  a) In a Department X, five new machines were installed and used to produce 10 types of products. Some of these products can be produced by a single machine while others need to be processed through more than one machine. As an example, Table 4a shows the products produced/processed on machines A and B.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_-2113221654_1395012618.png  Table 4b shows the dissimilarity indices among the five machines in Department X based on the products they produce or process.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_-2113221654_-2143377617.png  4.a)i) Based on the information given, work out the dissimilarity index, ***dAB***, between Machine A and Machine B based on the products processed on the machines. (2 marks) | **Mark (2)** |
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|  | Word Count: 13 | Max Words: 100 |

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| **Q16:** | 4.a)ii) Suggest one criterion which can be used to group the machines into cells.    (1 mark)  Your answer: | **Mark (1)** |

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| **Q17:** | 4.b) Your friend Adam is given a network diagram as shown in Figure 4a below.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_365997267_1834367701.png  4.b)i) Adam thinks that Node A and Node F are not connected. Explain why you disagree with him. (1 mark)  Your answer: | **Mark (1)** |

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| **Q18:** | 4.b)ii) Adam wants to construct a spanning tree for the network diagram in Figure 4a. The result is shown in Figure 4b. Explain with two reasons why it is not a spanning tree. (2 marks)  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_-869758987_430147507.png | **Mark (2)** |
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|  | Word Count: 76 | Max Words: 100 |

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| **Q19:** | 4.b)iii) Adam needs to construct a minimum spanning tree for the network diagram in Figure 4a using the Kruskal’s algorithm. List the first three pairs of nodes to be connected in the right sequence. (3 marks) | **Mark (3)** |
|  |  | |
|  | Word Count: 18 | Max Words: 100 |

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**Section: E**

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| **Q20:** | **Question 5 (11 marks)**  Ashly needs to assign five tour guides to two tourist attractions. Table 5a shows the distance each tour guide needs to travel (from home) to the tourist attractions, the number of tour guides required at each tourist attraction and the language skills of the tour guides.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_-736046571_1462649248.png  Let Xij represent the decision whether tour guide i (i = 1, 2, 3, 4 and 5) is to be assigned to attraction j (j=A and B). For example, X3B represents whether Tour Guide ‘3’ is to be assigned to Attraction ‘B’.  5.a) What values can the decision variables take? What do you call this type of decision variables? (2 marks)  Your answer:  The values that the decision variables can take:   You call this type of decision variables:  5.b) State clearly what you should optimize in the objective function. (1 mark)  Your answer:  5.c) Formulate the following constraints using the decision variables defined in the question.        5.c)i) Each tour guide must be assigned to one of the two tourist attractions. Use Tour Guide ‘3’ as an example to formulate this constraint. (1 mark)  Your answer:  5.c)ii) Two tour guides are required to be assigned to Tourist Attraction ‘B’. (1 mark)  Your answer: | **Mark (5)** |

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| **Q21:** | 5.c)iii) Tourist Attraction ‘A’ requires to have at least one tour guide proficient in Malay. (2 marks) | **Mark (2)** |
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|  | Word Count: 3 | Max Words: 100 |

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| **Q22:** | 5.c)iv)  Tour Guide ‘2’ and Tour Guide ‘4’ cannot be both assigned to Tourist Attraction ‘B’.  (2 marks) | **Mark (2)** |
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|  | Word Count: 3 | Max Words: 100 |

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| **Q23:** | 5.d) List two characteristics of a service scheduling problem. (2 marks) | **Mark (2)** |
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|  | Word Count: 10 | Max Words: 100 |

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**Section: F**

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| **Q24:** | **Question 6 (13 marks)**  Haydon owns a logistics company providing warehousing and storage services to customers. Recently, Haydon is planning to include the delivery function into his business. He is choosing between buying a new truck or renting a truck to provide the delivery service. The decision is highly dependent on the customer demand. Haydon can improve his estimation of the customer demand by obtaining information from economic forecast done by a consultancy at the cost of $10,000. A decision tree generated from DPL software is illustrated in Figure 6a below. (Note: the economic forecast cost of $10,000 is not considered in the decision tree).  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_1379335110_1508727670.png  6.a) Give one example of a decision node in the decision tree. What do branches from a decision node represent? (2 marks)  Your answer:  Example of a decision node:  Branches from a decision node represent:  6.b) Give one example of an event node in the decision tree. What do branches from an event node represent? (2 marks)  Your answer:  Example of an event node:  Branches from an event node represent: | **Mark (4)** |

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| **Q25:** | 6.c) What is the “decision value” associated with the “Rent or Buy” decision when ‘Economic Forecast Outcome’ is ‘Poor’ (labeled ‘1’ in Figure 6a)? Show your workings clearly. (2 marks) | **Mark (2)** |
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|  | Word Count: 46 | Max Words: 100 |

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| **Q26:** | 6.d) Calculate the Expected Value of Sample Information (EVSI). Do you recommend using the “Economic Forecast” information from the consultancy if it costs $10,000? Explain and show your workings clearly. (4 marks) | **Mark (4)** |
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|  | Word Count: 16 | Max Words: 200 |

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| **Q27:** | 6.e) Based on the decision tree given in Figure 6a, state the overall best course of action for the decision making problem. (3 marks) | **Mark (3)** |
|  |  | |
|  | Word Count: 47 | Max Words: 100 |

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**Section: G**

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| **Q28:** | **Question 7 (19 marks)**                    Wince works in a department that manufactures two models of a product: A and B. The following Table 7a shows the resources (Labour Time, Machine Time and Raw Material) required by each model, daily available amount, and the unit profit from selling each product model.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_-1073311012_532295817.png  Wince wants to apply Linear Programming (LP) to determine the number of each model to produce each day to maximize the total daily profit. The decision variables are defined as:  X1: Number of units of Model A to produce daily; X2: Number of units of Model B to produce daily.  7.a) Construct the objective function for the LP model using the decision variables defined above. (2 marks) | **Mark (2)** |
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|  | Word Count: 5 | Max Words: 100 |

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| **Q29:** | 7.b) Formulate the constraint, ‘the total raw material consumed cannot exceed the amount available’. (1 mark)  Your answer: | **Mark (1)** |

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| **Q30:** | 7.c) Figure 7a below shows the graph plotted to find the optimal solution for the LP model.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_-1505460721_948201112.png  7.c)i) State the optimal solution and work out the corresponding maximum daily profit. Show your workings clearly. (4 marks) | **Mark (4)** |
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|  | Word Count: 25 | Max Words: 100 |

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| **Q31:** | 7.c)ii) If Wince plans to produce the products according to the current optimal solution, which resource (Labour Time, Machine Time and Raw Material) is not used up? Calculate the remaining amount of this resource after the production. Show your workings clearly. (3 marks) | **Mark (3)** |
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|  | Word Count: 31 | Max Words: 100 |

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| **Q32:** | 7.c)iii) The marketing department requested to produce 18 Model A and 10 Model B to fulfill a customer order. Help Wince identify the resource that is insufficient (Labour Time, Machine Time and Raw Material) to fulfil this order. (1 mark)  Your answer: | **Mark (1)** |

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| **Q33:** | 7.d) A new constraint line is added into the graph as shown in Figure 7b to represent the available machine time being reduced to 300 minutes. With this reduction, the total daily profit is also reduced by $540.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_2122990380_-2125456371.png  7.d)i) Verify the shadow price for Machine Time is $3.6. (2 marks) | **Mark (2)** |
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|  | Word Count: 24 | Max Words: 100 |

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| **Q34:** | 7.d)ii) Determine the allowable decrease in the right-hand side value of Machine Time constraint for the shadow price of $3.6 to be valid. Justify your answer. (2 marks) | **Mark (2)** |
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|  | Word Count: 30 | Max Words: 100 |

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| **Q35:** | 7.e) With the current optimal solution, the shadow price for Labour Time is $4 and the shadow price for Machine Time is $3.6. Determine the required machine time to produce each unit of Model B. Show your workings clearly. (4 marks) | **Mark (4)** |
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|  | Word Count: 0 | Max Words: 200 |

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**Section: H**

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| **Q36:** | **Question 8 (11 marks)**  *Show your workings clearly and round off your answers to 2 decimal places when necessary.*  8.a) Steven received a year-end bonus recently. He has the following two investment plans in mind:  **Plan 1:** Invest the bonus in his friend’s business. Annually he will obtain $7,000 when the market condition is good with probability p and obtain $2,000 when the market condition is poor with probability (1-p).  **Plan 2:** Put the bonus in a bank and earn an annual interest of $5,000.  8.a)i) Steven is indifferent between the two plans when p = 0.4 based on his utility function. Calculate Steven’s risk premium and determine his risk attitude (risk-averse, risk-neutral or risk-seeking). (4 marks) | **Mark (4)** |
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|  | Word Count: 162 | Max Words: 200 |

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| **Q37:** | 8.a)ii) Assume that Steven’s wife, Nancy, is **indifferent** between the two plans based on a utility function U(Z) = 10 + (Z/1000)2. Determine the value of p for Nancy. (3 marks) | **Mark (3)** |
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|  | Word Count: 6 | Max Words: 200 |

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| **Q38:** | 8.b) Steven has two daughters, Jenny and Penny. Figure 8a below shows their utility curves. It is known that their utility curves can be described by exponential functions.  C:\Users\17046589\AppData\Roaming\Republic Poly\eQuest\_assessmentimages\_assessmentimg_1631042083_-2140787991.png  8.b)i) State Jenny’s risk attitude. Explain why Jenny has a positive risk premium. (2 marks) | **Mark (2)** |
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|  | Word Count: 35 | Max Words: 100 |

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| **Q39:** | 8.b)ii) It is known that the two utility curves in Figure 8a were plotted based on risk tolerance values of $5,000 and $10,000. Determine Jenny’s risk tolerance. Who is more risk averse? (2 marks)  Your answer:  Jenny’s risk tolerance:  Who is more risk averse? | **Mark (2)** |

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