CONFIDENTIAL

FINAL EXAMINATION SEMESTER I
SESSION 2022/2023

COURSE CODE	:	**SEEM/SKEM 4173**
COURSE	:	**ARTIFICIAL INTELLIGENCE**
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PROGRAMME	:	**SKEE/SEEE/SKEL/SEEL/SKEM/SEEM/ SEELH/SEEEH**
SECTION	:	**01/ 02/ 03/ 04**
TIME	:	**2 HOURS 30 MINUTES**
DATE	:	

INSTRUCTION TO CANDIDATE	:	ANSWER ALL QUESTIONS WITHIN THE ALLOCATED TIME.

THIS EXAMINATION BOOKLET CONSISTS OF **10** PAGES INCLUDING THE FRONT COVER

Q.1 (a) Artificial intelligence (AI) is a tool developed to imitate human intelligence and decision-making, providing basic reasoning and other human characteristics. Many techniques have emerged till now.

(i) List four examples of AI techniques (exclude fuzzy logic).

(4 marks)

(ii) Discuss two occasions where AI should not be applied.

(4 marks)

(iii) Discuss how fuzzy logic resembles human intelligence.

(4 marks)

(b) A fuzzy set uses a common function called the membership function to support the membership value of its element. The vertical axis represents the membership value, while the horizontal axis represents the universe of discourse. Equations 1 and Equation 2 are the membership functions for fuzzy sets A and B, respectively.

(i) Discuss what the **universe of discourse** is.

(4 marks)

(ii) Sketch the membership functions of Equation 1 and Equation 2 on the same graph.

(4 marks)

(iii) Shade the areas in Q.1(b(ii) for $(\bar{A} \cap B)$ and $\overline{(A \cup B)}$. Show your answer in two separate graphs.

(5 marks)

$$\mu_A(u) = \begin{cases} 1 \ for \ u \leq 30 \\ \frac{50-u}{20} \ for \ 30 < u < 50 \\ 0 \ for \ u \geq 50 \end{cases} \qquad \text{Equation 1}$$

$$\mu_B(u) = \begin{cases} 0 \ for \ u \leq 30 \\ \frac{u-30}{30} \ for \ 30 < u \leq 60 \\ \frac{90-u}{30} \ for \ 60 < u < 90 \\ 0 \ for \ u \geq 90 \end{cases} \qquad \text{Equation 2}$$

Q.2 (a) Describe the goal of machine learning.

(2 marks)

(b) Compare between unsupervised learning and semi-supervised learning.

(2 marks)

(c) Determine three factors that must be considered in designing an ANN.

(3 marks)

(d) The OR problem is shown in Table Q2(d).

Table Q2(d): OR problem.

x_1	x_2	T
1	1	1
1	0	1
0	1	1
0	0	0

(i) By using Hebb network, solve the problem above by filling up the following table for **2 EPOCHS**. Set all initial weight and b = 0.

EPOCH 1

x_1	x_2	t	y	w_1	w_2	b
1	1		1		1	
1	0		1		1	
0	1		1		2	
0	0		0		2	

EPOCH 2

x_1	x_2	t	y	w_1	w_2	b
1	1	1		3		
1	0	1		4		
0	1	1		4		
0	0	0		4		

(6 marks)

(ii) Then, by using the Perceptron network, solve the same problem by filling up the following table for **2 EPOCHS**. Set all initial weights and b = 0, α = 0.5 and θ = 0.5.

EPOCH 1

x_1	x_2	s	y	t	w_1	w_2	b
1		0	0			0.5	
1		1	0			0.5	
0		1.5	1			1	
0		1.5	1			1	

EPOCH 2

x_1	x_2	s	y	t	w_1	w_2	b
1	1			1	0.5		
1	0			1	0.5		
0	1			1	0.5		
0	0			0	0.5		

(8 marks)

(iii) Based on i) and ii), justify TWO differences between Hebb and Perceptron.

(4 marks)

Q.3 A food processing factory wants to develop a fuzzy logic controller to control one of the processes they have in their factory. The process uses two inputs (*a* and *b*) and one output (*du*). A senior supervisor has been interviewed to get information on controlling the process. The rule base to control the process is developed based on the interview result. Table Q.3 shows the results of the interview. As an AI engineer, you are assigned to design the fuzzy logic controller for the process.

(a) Draw the architecture of the fuzzy logic controller. Label the diagram.

(5 marks)

(b) Write all the rules from Table Q.3.

E.g., "If *a* is aaa AND *b* is yyy, THEN *du* is uuu" or "If *a* is aaa OR b is bbb, THEN *du* is uuu".

(5 marks)

(c) Create the fuzzy rule matrix to control the process.

(5 marks)

(d) The membership functions for the three variables (*a*, *b*, and *du*) are given in Figure Q.3(d)(i) ~ Figure Q.3(d)(iii). Given that $a = -2$ and $b = 25$.

(i) Write down all the rules that are fired. E.g., (P, N; N).

(2 marks)

(ii) Estimate the values of all outputs (*du*) for all fired rules.

(4 marks)

(iii) Sketch the output waveform of the resultant *du* by using a suitable aggregation method.

(4 marks)

Table Q.3

No.	Interview answer
1	Set *du* to zero when both inputs are zero
2	*du* is set to positive when either of the inputs is negative
3	*du* is set to positive when *a* is negative and *b* is zero
4	Set *du* to positive if *a* is negative or *b* is zero
5	Set *du* to zero when *a* is zero or *b* is negative
6	*du* is set to zero if *a* is zero and *b* is positive
7	*du* is set to negative if *a* is positive and *b* is negative
8	Set *du* to negative when *a* is positive, and *b* is negative
9	*du* is set to negative if both inputs are positive

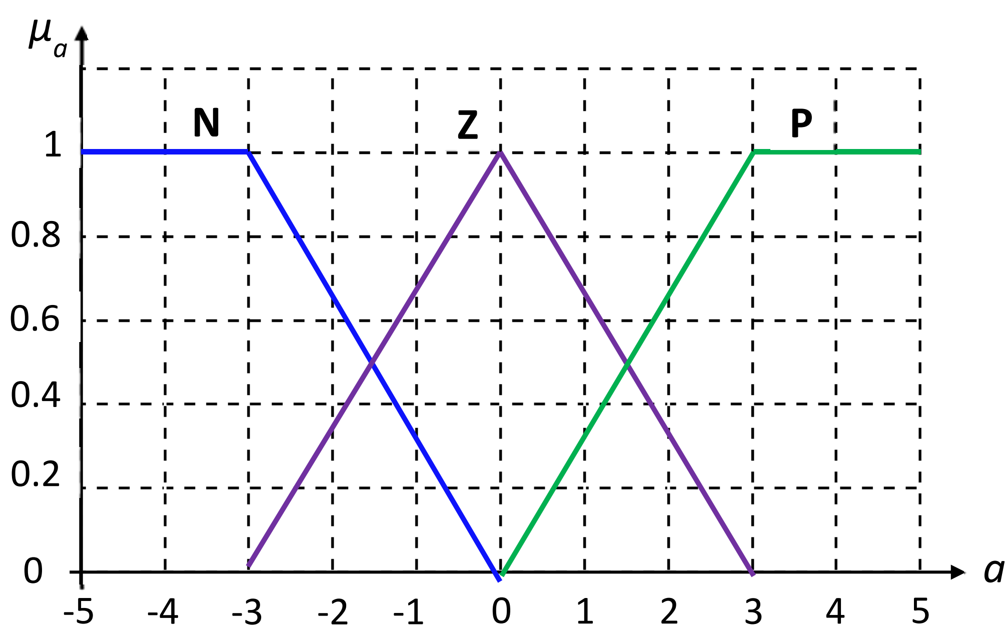

Figure Q.3(d)(i)

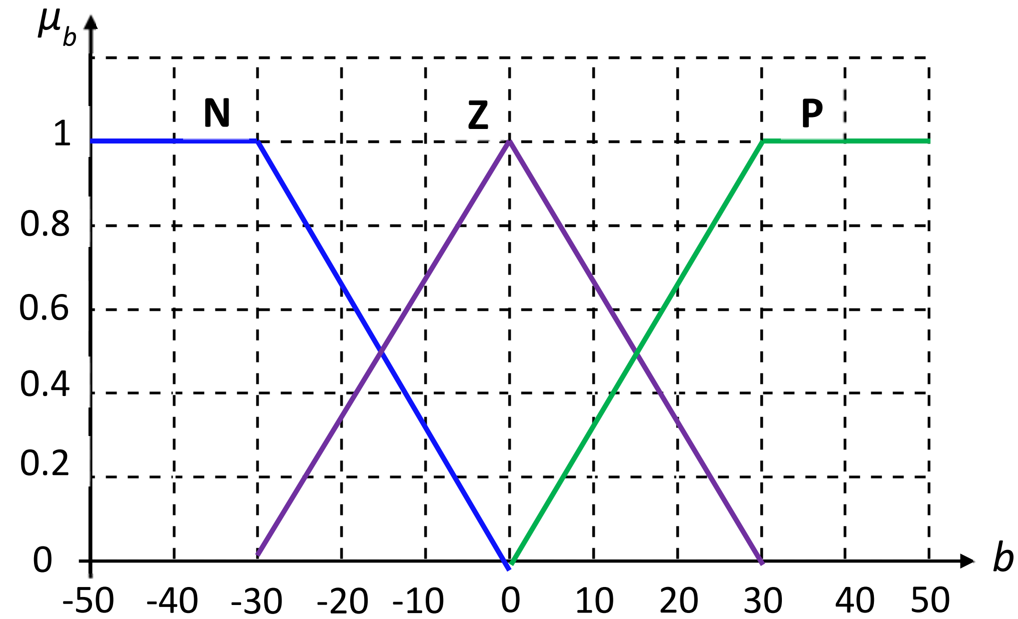

Figure Q.3(d)(ii)

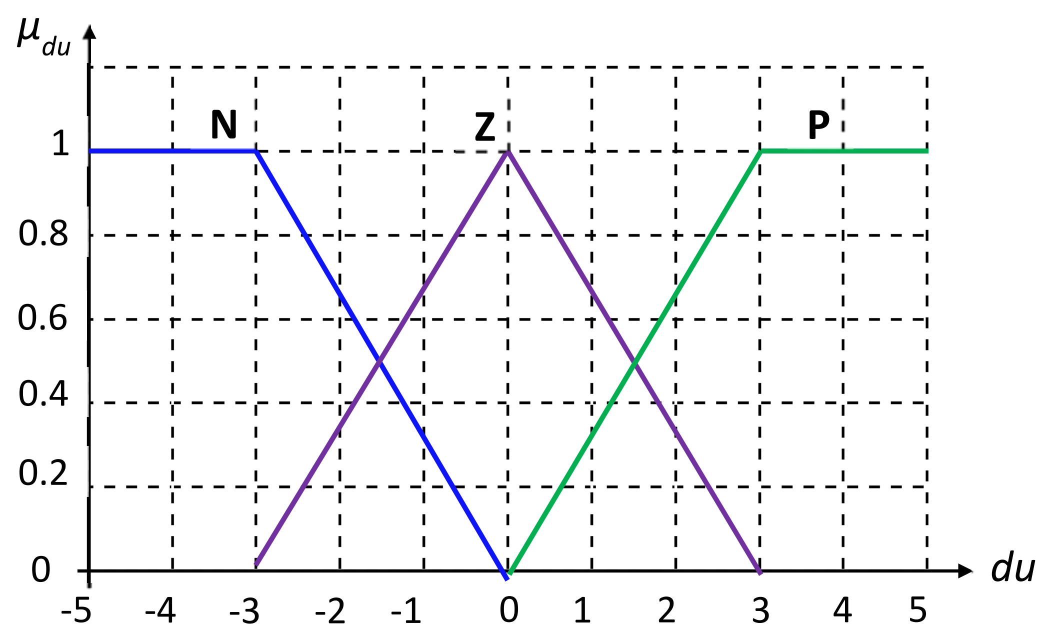

Figure Q.3(d)(iii)

Q.4 (a) In radial basis function neural networks (RBFNN), the centers C_k are defined as points that are assumed to perform an adequate sampling of the input space. The selection of appropriate centers is crucial as it will affect the overall performance of the training phase.

(i) Describe two common practices in the selection of RBFNN centers and the advantages of those methods.

(3 marks)

(ii) *K*-means clustering is a more systematic way to find the centers of RBFNN. Given a set of input-output training data as listed in Table Q.4a. Use ***K*- means clustering** to determine the two RBFNN centers, for *K*=2.

(8 marks)

Table Q.4a

Input, x	5	7	1	3	10	11	5	8	12
Target output, t	15	13	19	17	10	9	15	16	7

(b) Three data points have been collected from an experiment of a black-box system, as listed in Table Q.4b(i). A nonlinear function of the system is going to be formulated using a simple neuron as shown in Figure Q.4b. The neuron uses sigmoid activation function given by $z = \frac{1}{1+e^{-a}}$. The square error function, $E = \sum_{i=1}^{N}(\eta(x_i, w) - t_i)^2$ and the steepest descent training rule are used to train the neuron.

Table Q.4b(i)

x, input data	2	1	4
t, measured output data	4	1	2

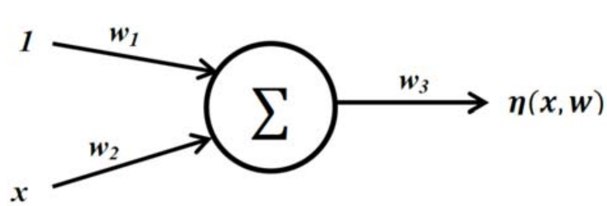

Figure Q.4b

(i) Determine the update rule for w_k, the error function $E(w)$ and the change of error function $\left(\frac{\partial E}{\partial w_k}\right)$ if the steepest descent learning rule and the square error are used. Use the variable α to indicate the learning rate.

(5 marks)

(ii) Determine w_1, w_2 and w_3 as shown in Table Q.4b(ii) if the learning rate used is $\alpha = 0.1$. Show all related calculations which involve the numerical computations of the neuron output, y, the activation function output, z, the summation output, a, the change of error function, $\left(\frac{\partial E}{\partial w_k}\right)$, and the updated weights of w_1, w_2 and w_3.

Table Q.4b(ii)

Iteration	w_1	w_2	w_3
0	1	-1	2
1			

(9 marks)

APPENDIX

Table of Summary of Fuzzy Set Operators

Fuzzy set operations	Operator expressions	
Equality	$\mu_A(u) = \mu_B(u)$	$u \in U$
Union	$\mu_{A \cap B}(u) = \max\{\mu_A(u), \mu_B(u)\}$	$for \mathrm{all u} \in \mathrm{U}$
Intersection	$\mu_{A \cap B}(u) = \min\{\mu_A(u), \mu_B(u)\}$	$for \mathrm{all u} \in \mathrm{U}$
Complement	$\mu_A(u) = 1 - \mu_A(u)$	$u \in U$
Normalization	$\mu_{NORM(A)}(u) = \mu_A(u) / \max(\mu_A(u))$	$u \in U$
Concentration	$\mu_{CON(A)}(u) = (\mu_A(u))^2$	$u \in U$
Dilation	$\mu_{DIL(A)}(u) = (\mu_A(u))^{0.5}$	$u \in U$
Intensification	$u_{INT(A)}(u) = \begin{matrix} 2(u_A(u))^2 & for\, 0 \le \mu_A(u) \le 0.5 \\ 1 - 2(1 - u_A(u))^2 & for\, 0.5 \le u_A(u) \le 1 \end{matrix}$	
Algebraic product	$u_{A \bullet B}(u) = u_A(u)_{\bullet \cdot UB}(u)\}$	$for \mathrm{all u} \in \mathrm{U}$
Bounded sum	$u_{A \oplus B}(u) = \min\{1, u_A(u) + u_B(u)\}$	$for \mathrm{all u} \in \mathrm{U}$
Bounded product	$u_{AB}\ (u) = \max\{0, u_A(u) + u_B(u) - 1\}$	$for \mathrm{all u} \in \mathrm{U}$
Drastic product	$u_{A \otimes B}(u) = \begin{cases} u_A(u) & for\ u_B(u) = 1 \\ u_B(u) & for\ u_A(u) = 1 \\ 0 & for\ u_A(u),\ u_B(u) < 1 \end{cases}$	
Algebraic Sum	$\mu_{A \hat{+} B}(u) = \mu_A(u) + \mu_B(u) - \mu_A(u)\mu_B(u)$	$\forall u \in U$

******End of SKEM4173 Examination Questions******