



Figure Q9.1

The fuzzy variable X is described by a set of fuzzy labels over the interval $[0, 24]$ as shown in the Figure Q9.1. Describe the fuzzy labels using the trapezoidal membership function denoted by: $\text{TPMF}[a, b, c, d]$ for each of the labels. State the type of fuzzy partitioning of the space provided by these four membership functions over the interval.

9.2 A set of fuzzy variables s-quality, f-quality and t-payment are defined by the respective set of membership functions:

s-quality:	fuzzy term/label "poor" μ_{sq1} :	$\text{tpmf}[0, 0, 4, 5]$
	fuzzy term/label "good" μ_{sq2} :	$\text{tpmf}[4, 5, 6, 7]$
	fuzzy term/label "excellent" μ_{sq3} :	$\text{tpmf}[6, 7, 10, 10]$
f-quality:	fuzzy term/label "lousy" μ_{fq1} :	$\text{tpmf}[0, 0, 2, 3]$
	fuzzy term/label "delicious" μ_{fq2} :	$\text{tpmf}[7, 8, 10, 10]$
t-quality:	fuzzy term/label "cheap" μ_{tq1} :	$\text{tpmf}[0, 2, 2, 3]$
	fuzzy term/label "average" μ_{tq2} :	$\text{tpmf}[3, 4, 4, 5]$
	fuzzy term/label "generous" μ_{tq3} :	$\text{tpmf}[4, 5, 5, 9]$

- (i) Draw the fuzzy partitions for each of the fuzzy variable over the domain $[0, 10]$. State the type of fuzzy partitioning for each of the dimensions.
- (ii) The above fuzzy labels are used in the formulation of an fuzzy expert rule system for tipping. The amount of tips (t-quality) derived from the fuzzy rules are based on the service quality (s-quality) and the food quality (f-quality). Here are 4 fuzzy rules:
 - R1. If service is poor then tip is cheap.
 - R2. If service is excellent and food is delicious then tip is generous.
 - R3. If food is lousy then tip cheap.
 - R4. If service is good and food is delicious then tip is average.

Determine the membership for the resultant tip if the scores for s-quality is 3 and f-quality is 7.

- (iii) Linguistic modifiers or hedges are used to change the semantics of the linguistic labels. What will the fuzzy memberships for s-quality and t-quality be like if a rule is given as:
 - R1'. If service is very poor then tip is very cheap.

9.3 The fuzzy rules can be implemented using neural networks.

- (i) Using the fuzzy rule base given in question Q9.2 draw the fuzzy neural network structure to construct the fuzzy rules: R1, R2, R3 and R4.
- (ii) State briefly the operation of each layer in performing the fuzzy inference based on the Mamdani fuzzy implication relation AND.
- (iii) Using a block diagram, briefly discuss how clustering and neural network learning can be used to automatically construct such a fuzzy rule base using data derived from the food and service qualities as well as the tipping by clients given the client scoring and tipping behaviours.