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Important Instructions: (a) Attempt **ALL FIVE** questions (b) **Assume data** wherever necessary and mention in your answer script. (c) Clean writing will be given credit.

Question 1:
(6 Marks)

In risk assessment, we deal with characterizing uncertainty in assessing the hazard to human health posed by various toxic chemicals. Because the pharmacokinetics of the human body are very difficult to explain for long-term chemical hazards, such as chronic exposure to lead or to cigarette smoke, hazards can sometimes be uncertain because of scarce data or uncertainty in the exposure patterns. Let us characterize hazard linguistically with two terms: "low" hazard and "high" hazard:

$$\text{"Low" Hazard} = \{0/1 + 0.3/2 + 0.8/3 + 0.1/4 + 0/5\}$$
$$\text{"High" Hazard} = \{0/1 + 0.1/2 + 0.2/3 + 0.8/4 + 0/1\}$$

Find the membership functions for the following linguistic expressions:
(a) low hazard and not high hazard (b) high hazard and not low hazard (c) low hazard or high hazard.

Question 2:
(8 Marks)

Consider the fuzzy sets A, B and C whose membership functions are defined by formulas

$$A(x) = \frac{x}{(x+2)}, \qquad B(x) = \frac{1}{1+10(x-2)^2}, \qquad C(x) = 2 \quad \text{for all } x \in \{0,1,2,....,10\} = X$$

Let $f(x) = x^2$ for all $x \in X$. Use the extension principle to derive $f(A)$, $f(B)$ and $f(C)$. Given a fuzzy set D defined on $\{0,1,4,9,16,....,100\}$ by $D = 0.5/4 + 0.6/16 + 0.7/25 + 1/100$. Find $f^{-1}(D)$.

Question 3:
(10 Marks)

Design a circular tank closed at both ends to have volume of 250 m^3. The fabrication cost is proportional to the surface area of the sheet metal and is Rs. 2000/m^2. The tank is housed in a shed with sloping roof. Therefore, height H of the tank is limited by the relation $H \leq 10 - 0.5D$, where D is the diameter of the tank. Formulate this as an optimization problem. Carry out step-by-step calculations for this problem using Genetic Algorithm assuming initial population size of four. Accuracy of the variable is expected to be up to one decimal point. Restrict your demonstration for two iterations only. Explain the importance of crossover probability and mutation probability.

Question 4:
(6 Marks)

Explain in detail about the scheme of machine learning modeling.

Question 5:
(10 Marks)

The ductility of a long slender steel rod under tension may be characterized by a decrease in diameter, d, together with a significant increase in elongation, L. Let $x = d/L$, where x is dimensionless. As x approaches zero the elongation is maximized and the subsequent failure of the member in tension will occur. However, before the member will fail, it will first go from an elastic state, to a plastic state. Failure can be defined as exceeding the elastic limit, or in breaking apart in the plastic state. We define two failure states as a function of x: state (1) is where the member exceeds the elastic limit, but can still support further tension; state (2) where the member exceeds the onset of plastic deformation and will break if further tension is applied. The following table defines tests on 12 slender rods, whose final state is shown.

$x = d/L$	0.11	0.10	0.08	0.06	0.04	0.03	0.01	0.009	0.007	0.005	0.003	0
State	1	1	1	1	1	1	1	2	2	2	2	2

Carry out step-by-step calculations demonstrating Perceptron Learning for three examples. Assume required data.

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