Answer 1(a)

Fuzzy Inference Systems are used in real life to solve decision making problems when input/output or both are not exact. There is (a) impreciseness while acquiring data, (ii) vagueness while representing human perception and (iii) uncertainty to represent the knowledge.

(i) We may use small interval $(a_1\text{-}a_2)$ instead of an exact value because data when measured from instruments/sensors is not precise due to calibration etc.

(ii) Seeing a person, it is difficult to say whether the person is Tall or Short, because human perception varies regarding tallness or shortness. Therefore, representation based on human perception is vague.

(iii) Rule is used to represent the knowledge about the problem domain by an expert who gives information based on his/her experiences, therefore not certain always. Uncertainty in Rules may appear both in antecedent and consequent to deal with such situation.

Answer 1(b)

Fuzziness of input, output linguistic variables used in the rule base,

Inference engine to execute the rules using Mamdani or Sugeno method,

Aggregation for combining the rules outcomes,

Defuzzification to obtain the crisp value of the fuzzified output variable.

Answer 1(c)

Main difference: Mamdani FIS evaluates the rules using T-norm or AND operation applied on the input/output variables, while Sugeno evaluates the rule using linear combination of input variables.

Mamdani FIS requires defuzzification, Sugeno generates output which is already in crisp, so defuzzification not required.

Answer 1(d): Given in PPT.

Answer 2(a)

First write what is linearly separable problem using plot.

Two input X-OR gate is not a linearly separable problem. Show it with truth table and plot.

Multilayer NN can transfer a linearly inseparable problem to linearly separable problem by adding hidden layer. Therefore, Multilayer NN can solve X-OR gate problem.

Answer 2(b) Sigmoidal activation function has two main contributions in Backpropagation algorithm.

(i) Maintaining hidden layer output within [0-1], therefore computation is efficient. Show using equation and plot.

(ii) Introduce nonlinearity in the NN and so differentiable. Therefore, used in calculating gradient vector, which is used to updating the weights of the connections.

Answer 2(c): Algorithm to state with example of each step.

Answer 3(a): Number of hidden layers and number of nodes in Encoder/Decoder, Code size, Learning rate in Loss function.

Number of hidden layers in Encoder/Decoder to compress/decompress the input.

Number of nodes reduces/increases in Encoder/decoder with number of hidden layers.

Learning rate for tradeoff between fast convergence and minimization of error.

Answer 3(b): Term set of Speed with membership plots.

Answer 3©: (i) Handling overlapping clusters where one object may belong to multiple clusters due to similarity of objects in different clusters. Membership value of each object belong to different clusters are used to decide which cluster the object belongs. Give example with plot, using at least two clusters.

(ii) During initialization each object must belong to every cluster with a membership value other than 0 and 1. $0 < u_{ij} < 1$, where i is the number of clusters (> 1) and true for each j-th object.

(iii) summation of membership values of each object belong to different cluster is one. $\sum_i u_{ij} = 1$