Answer THREE questions, at least ONE from EACH of Sections A and B.

SECTION A

1. a. Give your answers to (i)-(iv) briefly.

   i. Define the property of monotoncity for a consequence relation.

   ii. Why does an intelligent agent need to suspend monotonicity?

   iii. What is the ramification problem and why is it a difficult problem in artificial intelligence?

   [9 marks]

   b. i. Give a default theory with three extensions.

   ii. Give a default theory with no extensions.

   [12 marks]

   c. Consider the following default theories. Give the extensions with explanation, if there are any, otherwise explain fully why no extension exists.

   i. Let $W = \emptyset$ and D contain just the following two defaults.

$$\frac{\top : \alpha}{\neg\beta} \qquad \frac{\top : \beta}{\neg\alpha}$$

   ii. Let $W = \emptyset$ and D contain just the following three defaults.

$$\frac{\top : \alpha}{\neg\beta} \qquad \frac{\top : \beta}{\neg\gamma} \qquad \frac{\top : \neg\alpha}{\neg\gamma}$$

   iii. Let $W = \{\alpha \rightarrow \neg\alpha, \beta \rightarrow \beta\}$ and D contain just the following two defaults.

$$\frac{\neg\alpha : \gamma}{\gamma} \qquad \frac{\beta : \delta}{\delta}$$

   [12 marks]

   [Total 33 marks]

2. a. Give a semantic network for each of the following sets of concepts. Define the arcs that you use in each network, and explain the design choices made.

   i. Fish, Swim, Dogs, Cats, Walk, Fur, Scales, Legs, Trees, Living-things, Things, Minerals, Coal, Limestone, Whales, Sharks, Fins, Ferns, Plants, Animals, Mammals

   ii. Uncertainty, Ignorance, Incompleteness, Inconsistency, Vagueness, Probability, Fuzziness, Underspecificity, Prototypicality, Normality,

   [10 marks]

   b. Consider the following set of classical formulae:

$$\{\beta, \gamma, \beta \rightarrow \alpha, \gamma \rightarrow \alpha, (\beta \wedge \neg\gamma) \vee (\gamma \wedge \neg\beta)\}$$

   i. For this set, give all the maximally consistent subsets.

   ii. For this set, give all the minimally inconsistent subsets.

   [10 marks]

   c. Let Δ be a set of classical formulae, let $MaxCon(\Delta)$ be the set of all maximally consistent subsets of Δ, and let $MinIncon(\Delta)$ be the set of all minimally inconsistent subsets of Δ. How can $\bigcup MinIncon(\Delta)$ be formed from just the set $MaxCon(\Delta)$? Give a proof with your answer.

   [13 marks]

[Total 33 marks]

3. a. For Dempster-Shafer theory, define the following concepts:

   i. A frame of discernment

   ii. A basic probability assignment

   iii. A belief function

   iv. A plausibility function

[10 marks]

b. The following two basic probabilities assignments are defined for the frame of discernment = $\{\alpha, \beta, \gamma\}$:

$$
\begin{array}{ll}
m_1(\{\alpha\}) = 0.8 & m_2(\{\alpha\}) = 0.5 \\
m_1(\{\beta\}) = 0.0 & m_2(\{\beta\}) = 0.2 \\
m_1(\{\gamma\}) = 0.0 & m_2(\{\gamma\}) = 0.0 \\
m_1(\{\alpha, \beta\}) = 0.1 & m_2(\{\alpha, \beta\}) = 0.1 \\
m_1(\{\alpha, \gamma\}) = 0.0 & m_2(\{\alpha, \gamma\}) = 0.0 \\
m_1(\{\beta, \gamma\}) = 0.0 & m_2(\{\beta, \gamma\}) = 0.0 \\
m_1(\{\alpha, \beta, \gamma\}) = 0.1 & m_2(\{\alpha, \beta, \gamma\}) = 0.2
\end{array}
$$

Give the combined basic probability assignment, the resulting belief function, and the resulting plausibility function. Explain your calculations.

[10 marks]

c. Assume that you have been asked to advise two detectives in an inquiry into the murder of Dr Yellow in his house. The detectives have now narrowed consideration to three suspects: Mr Blue, Ms Red, and Prof Green.

   i. Suppose Detective White usually assumes a confession from a suspect is adequate for identifying the murderer. Prof Green has confessed. Also Prof. Green was heard arguing with Dr Yellow at his house on the day of the murder. However, Prof Green does have a medical history of pathological lying. Also all the suspects had something to gain by the death of Dr Yellow. Give a belief probability assignment that reflects Detective White's beliefs.

ii. Suppose Detective Black prefers to use forsenic evidence. Both Mr Blue and Ms Red have fingerprints on the murder weapon. But, Prof Green is a retired forensic scientist. There are fingerprints of all the suspects in Dr Yellow's house, but all were friends of Dr Yellow. Give a belief probability assignment that reflects Detective Black's beliefs.

iii. Give the combined basic probability assignment, and then the belief and possibility in each of the suspects having committed the murder.

[13 marks]

[Total 33 marks]

SECTION B

4. a. Explain the basic details of the operation of a genetic algorithm, and how such algorithms can be applied to supervised learning.

[15 marks]

b. Compare genetic algorithms with decision trees as techniques for supervised learning. You do not have to describe in detail any specific algorithm for constructing a decision tree.

[10 marks]

c. Give a critical assessment of how you might assess the performance of the hypothesis produced by a GA-based supervised learner.

[8 marks]

[Total 33 marks]

5. a. Give a detailed definition of a *Probably Approximately Correct (PAC) learning algorithm*, and the *growth function*, and *Vapnik-Chervonenkis (VC) dimension* of a hypothesis space.

[15 marks]

b. State Sauer's lemma and explain in detail why it is significant in PAC learning when considering hypothesis spaces of finite VC dimension.

[13 marks]

c. Explain the advantages and disadvantages of the PAC framework as a theoretical model of supervised learning. From what improvements do you think it would benefit?

[5 marks]

[Total 33 marks]

6. Write an essay on the subject of supervised learning using a *Version Space*, with particular reference to the *Candidate-Elimination* algorithm.

[Total 33 marks]

END OF PAPER