INSTRUCTIONS:

Answer all questions. The marks for the paper total 100.

Most questions require only brief answers – point form answers are fine.

PLEASE NOTE

Examination candidates may only bring authorised materials into the examination room. If a supervisor finds, during the examination, that you have unauthorised material, in whatever form, in the vicinity of your desk or on your person, whether in the examination room or the toilets or en route to/from the toilets, the matter will be reported to the head of school and disciplinary action will normally be taken against you. This action may result in your being deprived of any credit for this examination or even, in some cases, for the whole unit. This will apply regardless of whether the material has been used at the time it is found.

Therefore, any candidate who has brought any unauthorised material whatsoever into the examination room should declare it to the supervisor immediately. Candidates who are uncertain whether any material is authorised should ask the supervisor for clarification.
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Q1. **Search algorithms**

(a) Define *completeness* and *optimality* as they apply to search algorithms in AI.  
2 marks

(b) Describe the operation of *depth-limited search*.  
3 marks

(c) How is depth-limited search extended to *iterative deepening*?  
2 marks

(d) Describe the operation and problems of *bidirectional search*.  
3 marks

Q2. **Informed search algorithms**

(a) What is the role of a *heuristic* in an informed search algorithm?  
2 marks

(b) Describe how the algorithm $A^*$ ranks nodes for expansion.  
3 marks

(c) Describe what it means for a heuristic to be *admissible*.  
2 marks

(d) Describe with an example how using an inadmissible heuristic in $A^*$ can cause a sub-optimal goal to be chosen.  
3 marks

Q3. **Game-playing algorithms**

(a) Describe the two principal sources of *incompleteness* in AI problems.  
2 marks

(b) Describe the three usual approaches for dealing with incompleteness.  
3 marks

(c) Describe the operation of the *minimax* algorithm.  
3 marks

(d) Describe how $\alpha-\beta$ pruning improves the performance of minimax.  
2 marks

Q4. **Learning agents**

(a) Describe the four basic components of a *learning AI agent*, and their roles.  
4 marks

(b) Describe the general operation of *inductive learning*.  
3 marks

(c) Given a large set of examples for an AI problem, how are they best deployed for developing a learning agent?  
3 marks
Q5. **Sequential decision problems**

(a) Describe what is meant by a *sequential decision problem* (SDP).  
2 marks

(b) What is a *policy* in the context of an SDP?  
3 marks

(c) What is the *transition model* in the context of an SDP?  
2 marks

(d) Describe generally how the transition model and the step cost of an SDP are likely to affect the optimal policy.  
3 marks

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Q6. **Reinforcement learning**

(a) What is the principal difference between *reinforcement learning* and *supervised learning*?  
2 marks

(b) Describe the operation of *temporal difference learning*.  
4 marks

(c) What is an *optimistic prior* in the context of reinforcement learning?  
2 marks

(d) How does an optimistic prior encourage exploration by an agent?  
2 marks

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Q7. **Planning**

(a) What is meant by *subgoaling* in a planning algorithm?  
2 marks

(b) What is the principal advantage of subgoaling?  
2 marks

(c) What is the *qualification problem* for a planning algorithm?  
2 marks

(d) What is the principal problem with using *conditional planning*?  
2 marks

(e) What is the main alternative to conditional planning?  
2 marks
Q8. **Logical agents**

(a) What does it mean if a knowledge base entails a logical sentence?  
2 marks

(b) What is the usual way of checking entailment?  
2 marks

(c) Define with an example the resolution rule for performing inference.  
3 marks

(d) Argue informally that resolution is sound.  
3 marks

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Q9. **First-order logic**

(a) Describe the two principal enhancements in first-order logic (FOL) relative to propositional logic.  
2 marks

(b) Give an example of an English statement that can be captured in FOL but that is difficult to say in propositional logic.  
2 marks

(c) Describe with an example what it means to unify two FOL sentences.  
4 marks

(d) What inference rule is used in the Prolog programming language?  
2 marks

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Q10. **Knowledge engineering**

(a) What is the fundamental trade-off in the use of logics in AI?  
4 marks

(b) How is the trade-off resolved in the design of temporal logics?  
3 marks

(c) How is the trade-off resolved in the design of description logics?  
3 marks

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END OF PAPER