UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2001

MSc in Computing Science
for Internal Students of the Imperial College of Science, Technology and Medicine

PAPER M231

ARTIFICIAL INTELLIGENCE I

Friday 11 May 2001, 14:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators not required

1a   Specify the two components of a Constraint Satisfaction problem (CSP) and give three specific examples of such CSPs.

b   The Magic Crown Puzzle has eight counters numbered from 1 to 8 which must be placed on the circles of the Crown shaped network, shown below, so that each row adds up to 16. We wish to investigate the different solutions possible.

Counters   **Crown Configuration**
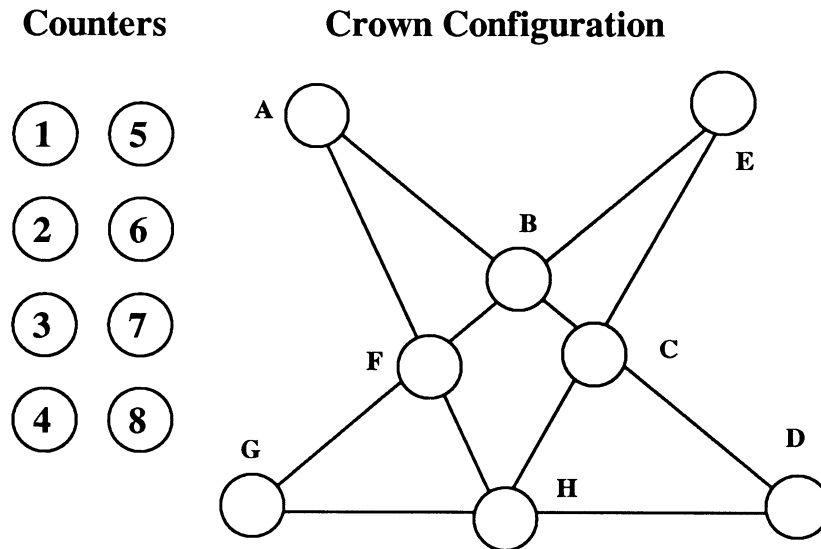
State the three stages you have to go through when finding a solution to a CSP. Perform the first two of these stages for the task of solving the Magic Crown puzzle described above.

(In your specification consider the nodes in alphabetical order A, B ... H)

c   Show how you can use your initial **naive** specification to find a solution to the Magic Crown Puzzle above. Now explain carefully why this specification is inefficient and demonstrate how it can be changed to find solutions much more effectively.

d   Briefly describe, with an example, an alternative approach to the "generate and test" method of solving CSPs.

Each part carries approximately equal marks.

2   A possible definition of learning is "The ability to do things better a second time as the result of practical personal experience."

a   Explain the principles of Rote Learning and describe two distinct applications of the technique (one to a game playing and the second to a non game playing situation).

Briefly outline Rote Learning's benefits and limitations suggesting ways of minimising the latter.

b   Describe carefully a second method of learning applicable to a game such as Othello (sometimes called Reversi).

Explain the Credit Assignment problem in this context and suggest how this might be overcome.

c   One difficulty for a beginner is how to decide what moves are good. Suggest ways in which a novice human chess player could learn good play and briefly discuss machine analogues of two of these (including at least one not mentioned in section b).

In what way might the above definition of learning have to be modified in the light of this?

d   Give an example of the Genetic Algorithm (GA) approach to learning and contrast it with other approaches.

What factors affect the effectivness of GA learning?

*Each part carries approximately equal marks.*

3a State two important characteristics of an expert system and explain with an example of each why they are desirable.

b A blind student needs braille versions of her textbooks. Grade 1 Braille - the simplest form - has a sign for each letter of the alphabet and punctuation character. The digits 1, 2 .. 0 are represented by the signs for a to j prefixed by a Number-shift sign. Capital letters are prefixed by a Capitals sign. A number shift sign affects all following characters up to a space or non numeric character. The Capitals shift however only changes the immediately following letter.

   i) Outline the design of a rule based system for translating machine readable text into grade 1 braille.

   ii) Suggest how the necessary information for performing the translation could be represented and show with examples how it would be used during the translation process.

c Grade 2 braille is a contracted form of braille where common words or letter combinations (such as **and, for, the, sh, er, ea**) are represented by single braille signs. Certain other economies such as omitting spaces between words are allowed provided there is no ambiguity created. Contractions like **ea** cannot be used where the **e** and **a** belong to different syllables as in the word **react**.

   Show how to extend your system to take account of these contractions and constraints. Briefly discuss the advantages an expert system approach has over more conventional approaches for developing such a system.

d Given the Expert System design suggest how the system could be used for more than just text to Braille translation.

   If the textbook information were available on a CD Rom outline an alternative approach to providing hard-copy braille in a book which would allow a blind person to quickly locate, access and "read" required items of information. Indicate briefly possible solutions to any problems.

Each part carries approximately equal marks.

4a Carefully explain the terms *Best First Search, Heuristic cost function* and *Admissible search algorithm.*

b The **Four Puzzle** is played with four numbered counters on the following board.

Counters
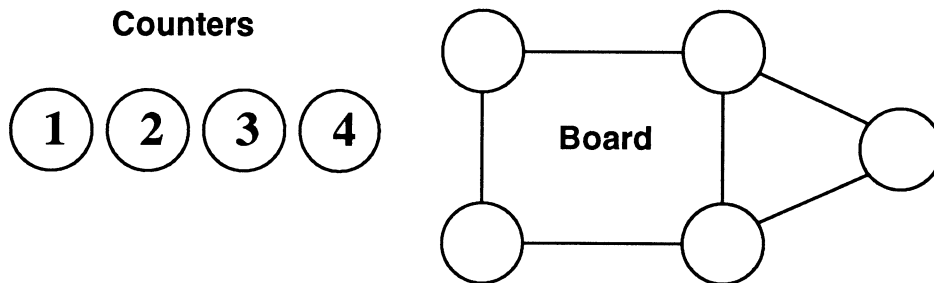
The aim of the puzzle is to move the four numbered pieces from the start position to the goal position. A piece may be moved along a line into a vacant circle but **not** over or onto another piece.

Start Position   Goal Position
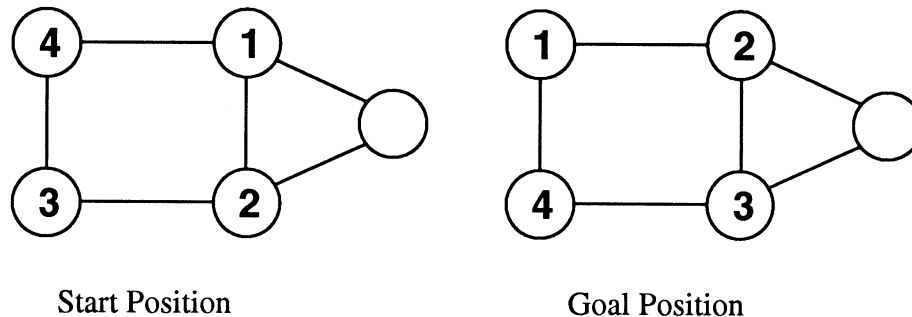
Describe carefully the requirements and operation of the A^* search algorithm, on the Four puzzle using the *Number of pieces out of place (POOP)* as the h' function. When growing the search tree, select move directions in the order:

$$\downarrow, \searrow, \rightarrow, \nearrow, \uparrow, \nwarrow, \leftarrow \text{ and } \swarrow$$

c Without generating the search space, prove breadth first search is admissible and also that POOP is an admissible heuristic function for the Four Puzzle. Suggest another admissible heuristic function indicating how it and POOP might be "discovered" from the rules of the puzzle.

d Use Penetrance to compare the effectiveness of the A* search using POOP as the heuristic function h' with A* using a perfect heuristic function.

How does A* search differ from Hill Climbing search?

Each part carries approximately equal marks.