HERIOT-WATT UNIVERSITY

SCHOOL OF MATHEMATICAL
AND COMPUTER SCIENCES

COMPUTER
SCIENCE

F21BC

BIOLOGICALLY INSPIRED COMPUTATION

Semester 2 Exam Diet 2012

Answer **THREE** questions
Please use a separate script book for each question

Candidates may only use a University approved calculator

Q1

(a) Name and briefly explain the three types of Neighbourhood that can be used with Particle Swarm Optimization; also explain the parameters C1 and C2 and indicate the commonly used settings for these parameters.

[7 marks]

(b) Describe the PCR (polymerase chain reaction) process and explain what PCR is used for. If PCR begins with m copies of DNA and is repeated n times, how many copies of DNA are present at the end of the process? Briefly explain your answer.

[8 marks]

(c) Define "associative memory" and briefly explain how it is related to feedback mechanisms. Name an example of an artificial neural network that is considered an associative memory device.

[5 marks]

Q2

(a) Using examples to illustrate, describe k-gene Position-Based Crossover and k-gene Order-Based Crossover.

[6 marks]

(b)

(i) Describe k-gene Inversion Mutation.

[2 marks]

(ii) Comment on the relative suitability of using Inversion Mutation and using Single-Gene random-allele Mutation, when using the standard direct encoding for timetabling problems;

[2 marks]

(iii) Comment on the relative suitability of using Inversion Mutation and using Single-Gene random-allele Mutation, when usingb the standard permutation-based encoding for the travelling salesperson problem.

[2 marks]

(c) Suppose you need to design the cheapest possible new cycle-route network, which links all of the 10,000 largest villages in Europe. You have a matrix that shows the cost of each direct link between any two villages. The completed network must connect all the villages (that is, for any pair of villages A and B it must be possible to get from A to B, possibly via other villages). However, each village may be directly connected to no more than three others.

(i) Describe an encoding and a suitable crossover operator for an Evolutionary Algorithm to solve this problem;

[4 marks]

(ii) Indicate how you would apply Ant Colony Optimization to this problem.

[4 marks]

Q3

(a) Show the full process of training and execution, step by step of a Hopfield neural network designed to learn the pattern "0111" (draw all the matrices involved during the execution of the pseudocode both during training and execution).

[10 marks]

(b) Execute the trained network in part (a) to recall the pattern "1000". Could this network recall the pattern "1000" correctly? Explain why or why not.

[5 marks]

(c) Define the GasNet artificial neural network. Highlight the main differences between the original GasNet model and standard artificial neural networks, in terms of type of connections between neurons, weight values and training algorithm.

[5 marks]

Q4

(a) Briefly answer each of the following questions about DNA:

i) What is DNA?
ii) What is DNA made of?
iii) What is meant by 'Watson-Crick complementarity'?
iv) Why can DNA be modelled with a single sequence of letters, despite the fact it is double stranded?

[4 marks]

(b) Consider the Turing machine having instructions:

(s1, 0, s1, 1, R)
(s1, b, s2, b, L)
(s2, 1, s2, 1, L)
(s2, 0, s3, 0, L)

and having as initial configuration:

```
bb000bb
  ^
  s1
```

that is, the head reads the middle 0 and the machine is in state s1.

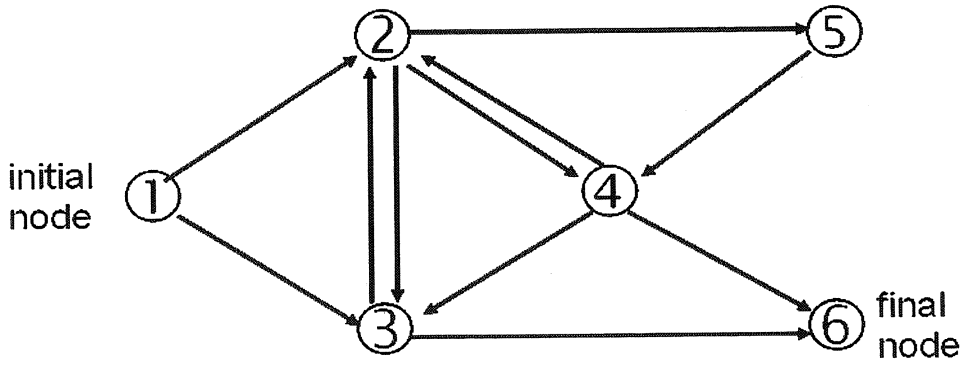
(i) Write down the set of DNA tiles (not the DNA strands, just show the tiles with indications of the attachment points) needed to implement this Turing machine.

[5 marks]

(ii) Using these tiles and other tiles encoding the initial configuration, run the Turing machine on the given input.

[5 marks]

(c) Consider the following graph:



where ① is the initial node and ⑥ is the final node.

Write down a set of DNA strands needed to implement Adleman's solution of the Hamiltonian path problem on this graph.

Considering your set of DNA strands, write down the molecule encoding a Hamiltonian path in this graph and at least two molecules encoding paths which are not Hamiltonian in this graph.

[6 marks]

END OF PAPER