UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING	
MODULE	**IT00187** NEW SYSTEMS DEVELOPMENT PARADIGMS
CAMPUS	**APK**
SSA EXAMINATION	**DECEMBER, 2014**

DATE 3 DECEMBER 2014	**SESSION** 8:30 – 10:30
ASSESSOR(S)	DR. GJ VAN NIEKERK
INTERNAL MODERATOR	NONE
EXTERNAL MODERATOR	DR. MC DU PLESSIS (NMMU)
DURATION 2 HOURS	**MARKS** 100

NUMBER OF PAGES: 4 (cover page included)

INSTRUCTIONS

ANSWER ALL THE QUESTIONS
WRITE NEATLY AND LEGIBLY
NUMBER IN SEQUENCE

REQUIREMENTS

NONE

Section A: Evolutionary Algorithms

1. (3 marks) Give a definition of Evolutionary Computation.

2. (4 marks) Discuss the importance of the fitness function in Evolutionary Algorithms (EAs) and the properties of a well defined fitness function.

3. (4 marks) The initial EA population is usually generated randomly. Discuss **TWO** scenarios where a random population is not necessarily the best strategy to follow (also discuss why a random strategy is not necessarily the best approach).

4. (4 marks) Discuss the importance of correctly balancing exploration and exploitation during algorithm execution. Explain the dangers of over-exploration as well as premature exploitation.

5. (10 marks) Design a competitive co-evolution strategy for finding the coefficients of a function of the form $f(x) = c_0x^3 + c_1x^2 + c_2x + c_3$ to fit some objective function $g(x)$ as closely as possible. (In other words, determine the values for c_0, c_1, c_2 and c_3, such that $f(x) - g(x) \approx 0 \quad \forall x$ within some domain.

6. (5 marks) A specific Genetic Algorithm (GA) implementation starts with a very high mutation rate. After each iteration the mutation rate is increased by 15% if the iteration improves on the current best and is decreased by 15% if the iteration does not provide any improvement. Discuss whether this approach is viable or not.

7. An EA can be terminated in a number of ways. Two such ways is to terminate after a set number of iterations or after a given time period has elapsed.
   (a) (3 marks) Briefly explain the problem behind both these approaches.
   (b) (3 marks) Suggest an EA stopping condition that is an improvement on both these techniques. Motivate your answer clearly.

8. (1 marks) Briefly explain the concept of a *meme* in terms of Cultural Algorithms.

9. Consider the problem of evolving a program using any EA to guide a robot though a static maze (i.e. the maze does not change). The **robot is reset when it runs into a wall** and cannot sense its environment (i.e. no sensors). Furthermore, it can execute the commands forward, left and right (turns are always 90 degrees). You can assume that corrections are made automatically to counteract any accumulated errors resulting from imprecise turns and motion. Without the aid of a Neural Network (i.e. training the weights), answer the following:
   (a) (5 marks) Explain how this problem can be solved using a GA.
   (b) (1 marks) What disadvantage does this technique will have if the maze becomes dynamic (i.e. constantly changing).

(c) (5 marks) The robot is enhanced and now features a sensor that can sense the presence of a wall directly in front of it. Using a Genetic Programming (GP) algorithm, design an algorithm to solve this problem. Pay careful attention to the representation of a solution (and provide an example of a probable solution).

(d) (2 marks) Compare the adaptiveness of the sensor-based GP solution with the GA solution.

Section B: Particle Swarm Optimisation

1. (2 marks) Give two reasons why particle indices are often used to form neighbourhoods as oppose to Euclidean distances.

2. (12 marks) Briefly explain how the Cooperative Split PSO (CPSO) algorithm works by giving the algorithm and discussing the important parts.

3. (3 marks) It can be shown that a particle will converge somewhere between its personal best and the global best. Name the algorithm which exploits this property and the manner in which it is exploited.

4. (2 marks) Briefly explain the main problem that the Guaranteed Convergence PSO attempts to address and how this is achieved.

5. (3 marks) Briefly explain the possible reasons why an atomic swarm tends to perform better than a charged and a neutral swarm.

Section C: Ant Algorithms

1. (3 marks) In a bridge experiment with two paths of equal lengths from the source to destination, real (and virtual!) ants will eventually converge to one of the paths. Explain why.

2. (3 marks) Briefly explain the concept of "emergent behaviour" in the context of any ant algorithm of your choice.

3. (4 marks) The Ant Systems (AS) uses the following probability to govern the movement of ants between nodes:

$$p_{ij}^k(t) = \begin{cases} \frac{\tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)}{\sum_{u \in N_i^k} \tau_{iu}^{\alpha}(t)\eta_{iu}^{\beta}(t)} & \text{if } j \in N_i^k \\ 0 & \text{if } j \notin N_i^k \end{cases}$$

...where $\tau_{ij}^{\alpha}(t)$ and $\eta_{ij}^{\beta}(t)$ refers to the two components that drive the AS. Explain the effect that the constants α and β will have on the algorithm. (Also discuss the effect when either is set to 0 as well.)

4. For the ant clustering algorithm, explain why
   (a) (2 marks) there should be fewer ants than data clusters;
   (b) (2 marks) there should be more sites than data vectors.

5. (14 marks) You are provided by a number of $n \times m$ black and white bitmaps representing alphanumeric characters of different fonts. If a bitmap position is '1', that position in the bitmap is filled, while 0 indicates an unfilled position.

   Briefly explain how the Lumer-Faieta clustering algorithm can be used to cluster all the symbols of the same type together (i.e. all the As, all the Bs, etc.). Place special emphasis on this specific problem, rather than elaborating on the theoretical aspects of the theoretical algorithm.