Exam Question Paper

College/ Institute	Engineering, Design and Physical Sciences		
Department	Computer Science		
Exam Author(s)	Dr Mahir Arzoky		
Module Code	CS2004		
Module Title	Algorithms and their Applications		
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Exam Type	Full	**Format**	WISEflow: FLOWmulti
Duration & Submission Instructions	3 Hours exam writing time. Uploads need to be COMPLETED before the end of the upload time. Late work will not be accepted. If you have any problems uploading work you must notify us that you are experiencing difficulties in uploading and/or submitting your work, using the contact details you have been given (in exam "Live Chat" or phone 01895 268860). Please do not contact academic staff directly. **Work sent via email will not be marked.** **Please ensure you click the green hand in button to submit your work as shown below, on the right** 		
Question Instructions	Answer all questions.		
Can students include drawings/ diagrams?	Yes		
Any permitted reference materials (including external websites)	None		
Contact for Academic Queries:	Use the chat tool that is embedded in WISEflow or use the following Collaborate session link: If you cannot access the Collaborate session, please email: mahir.arzoky@brunel.ac.uk		
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By continuing beyond this point, you confirm that you have read the information and instructions above, and understand the conditions of this examination.

Section A

[2 MARKS PER QUESTION]

A.1) Which of the following statements is NOT true about Pseudo-Code?

a) Pseudo-Code can only be used to represent certain types of algorithms.
b) Pseudo-Code is computer language independent.
c) Pseudo-Code is a mixture of structured English and formal notation.
d) Pseudo-Code can be used to compute the computational complexity of an algorithm.
e) All of the other statements are correct.

A.2) What is a primitive operation?

a) A set of steps for solving a problem.
b) Basic computation performed by an algorithm.
c) Any single line of code written in Java.
d) Anything that can be described by a flow chart.
e) All of the other statements are correct.

A.3) An algorithm has a primitive operator count of $T(n) = 13+55n^4+3n^2+7n$

What is the corresponding Big-O $O(n)$?
a) n.
b) n^7.
c) n^2.
d) 13.
e) None of the other statements are correct.

A.4) Which of the following sorting algorithms has a best case run time of $O(nLn(n))$?

a) Radix Sort.
b) Monkey Sort.
c) Quick Sort.
d) Bubble Sort.
e) None of the other statements are correct.

A.5) Which of the following algorithms have a worst case run time of $O(nLn(n))$?

a) Radix Sort.
b) Monkey Sort.
c) Quick Sort.
d) Bubble Sort.
e) None of the other statements are correct.

A.6) Which of the following aspects is NOT part of the Quick Sort algorithm?

a) A numeric input dataset.
b) Recursion.
c) The PivotTable algorithm.
d) The input graph.
e) All of the other statements are part of Quick Sort.

A.7) A QUEUE is a data structure that is often known as:

a) LIFO.
b) FIFO.
c) FIDO.
d) FILO.
e) None of the other statements are correct.

A.8) A Hash Table is a type of data structure that…

a) has ENQUEUE and DEQUEUE methods.
b) is used in almost all algorithms.
c) maps a key to a value.
d) is used in all sorting algorithms.
e) None of the other statements are correct.

Consider the following weights for the Scales Problem:

[1, 2, 3, 6, 8, 17, 24, 34]

A.9) What is the Scales fitness of the following solution: 11000011

a) 8.
b) 27.
c) 95.
d) 4.
e) None of the other statements are correct.

A.10) What is the OneMax fitness of the same solution?

a) 8.
b) 27.
c) 95.
d) 4.
e) None of the other statements are correct.

A.11) If we apply the Random Mutation Hill Climbing Algorithm's small change operator to the same solution which of the following new solutions could we get?

a) 11000010.
b) 11000000.
c) 10000001.
d) 11111111.
e) None of the other statements are correct.

A.12) Which of the following is a problem that is often encountered with the Tabu-Search algorithm?

a) The Tabu list can grow out of control.
b) There are many run time parameters to determine.
c) The number of iterations could be very large.
d) It is not guaranteed to find the global optimum.
e) All of the other statements are correct.

A.13) Which of the following search techniques take their inspiration from nature?

a) Particle Swarm Optimisation.
b) Evolutionary Programming.

c) Genetic Algorithms.
d) Particle Swarm Optimisation.
e) They were all inspired by observing nature.

A.14) Which Heuristic is normally associated with Genetic Algorithms?

a) Stigmergy.
b) Cooling rate.
c) Climbing a hill.
d) Crossover.
e) None of the other statements are correct.

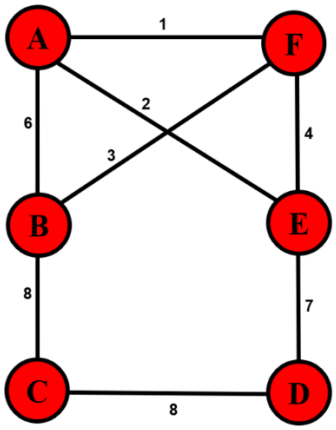
A.15) Iterated local search (ILS) is a stochastic local search method building a sequence of locally optimal solutions by…

a) maintaining a population of solutions and using the combination of selection, crossover and mutation to evolve the solutions.
b) simulating social behaviours of insects and moving around in the search space as a group.
c) using memory structures to forbid or penalise moves to certain points in the solution space previously visited.
d) incrementally changing a single element until no further improvements can be found.
e) perturbing the current local minimum and applying local search after starting from the modified solution.

A.16) Which one of the following is NOT a parameter for a Genetic Algorithm?

a) The number of bits.
b) Number of generations.
c) Population size.
d) Mutation probability.
e) All of the other statements are correct.

Consider the following graph:



A.17) What is the shortest path between nodes A and D?

a) AED.
b) AD.
c) ABCD.
d) ABFED.
e) None of the other statements are correct.

A.18) What is the length of the path ABFE?

a) 12.
b) 19.
c) 6.
d) 13.
e) None of the other statements are correct.

A.19) Which of the following statements is TRUE regarding the graph above?

a) The graph is a directed graph.
b) The graph has 6 edges.
c) The graph is a minimum spanning tree.
c) The graph is a complete graph.
e) None of the other statements are correct.

A.20) Which of the following techniques is NOT a graph-based technique?

a) A* Search.
b) Breath-First Search.
c) Minimum Spanning Trees.
d) Ant Colony Optimisation.
e) They all are graph-based techniques.

Section B

B1) Computational Complexity [15 marks]

B1.1) Define an algorithm. **[1 mark]**

B1.2) Define Big-T. **[1 mark]**

B1.3) Define Big-O. **[1 mark]**

Consider the following algorithm:

```
Algorithm 1. ALGORITHM(M,X,Y)
Input: M, an n by n real valued matrix
       X,Y, real number
1) For i = 1 to n
2)    For j = 1 to n
3)       Let S = Mij
4)       If S > X Then
5)          Let Mij = X
6)       End If
7)       If S < Y Then
8)          Let Mij = Y
9)      End If
10)   End For
11) End For
Output: The contents of M
```

Within the algorithm the notation M_{ij} is used to indicate the element at the *i*th row and *j*th column of matrix *M*.

B1.4) Compute the operator count T(*n*) for the algorithm. Show all of your working out. Only do calculations for the numbered lines. **[7 marks]**

B1.5) Derive the Big-O for Algorithm 1. **[1 mark]**

B1.6) What's the difference between P and NP classes of problems? [**2 marks**]

B1.7) What type of algorithms are used to solve NP-Complete problems and why? Give an example of such a problem. **[2 marks]**

B2) Heuristic Search Methods [15 marks]

B2.1) What is a Heuristic and give an example. **[2 marks]**

B2.2) In the context of search problems, define the following terms: local minimum, search method, search space, fitness function and invalid solution. [**5 marks**]

B2.3) What is the main difference between local search and global search methods? [**2 marks**]

B2.4) Describe the main similarities and differences between a Genetic Algorithm and an Evolutionary Program. **[3 marks]**

B2.5) Describe in words Particle Swarm Optimisation (PSO). [**3 marks**]

B3) Applications [15 marks]

The Knapsack problem is a combinatorial optimisation problem that has a wide-ranging number of applications. The idea is that there are *n* objects (each object has a weight which is a real number $w_i > 0$) that need to be put into a Knapsack that has a finite capacity *C*. Thus the sum of the weights of all of the objects put in the Knapsack cannot exceed *C*. The aim is to select which objects best fill the Knapsack without exceeding the capacity limit *C*.

Given that there are *n* weights there are 2^n-1 possible combinations, i.e. the number of possible subsets of objects that can be placed into the bag. We need the combination that is the best, i.e. the one that fills the Knapsack as close to capacity as possible without exceeding limit C.

We wish to solve the Knapsack problem using a Hill Climbing algorithm.

B3.1) Describe in words the representation you would use and give a small example using 8 weights. [**3 marks**]

B3.2) How would you create the initial starting point? [**2 marks**]

B3.3) Describe in words the fitness function you would use and state whether it is a minimisation or maximisation problem. [**3 marks**]

B3.4) Describe in words the small change operator you would use. [**2 marks**]

B3.5) Give the Pseudo-Code for the Hill Climbing algorithm applied to the Knapsack problem. [**5 marks**]

B4) Data Clustering and TSP [15 marks]

B4.1) Describe in words the Travelling Salesperson Problem (TSP) and give an example application. **[3 marks]**

B4.2) Draw a 4 city distance matrix for the TSP, give an example tour and evaluate its fitness. **[4 marks]**

B4.3) An Ant Colony Optimisation (ACO) can used to solve the TSP. What is the process and purpose of Stigmergy within ACO? **[2 marks]**

B4.4) Draw any clustering arrangement of nine (9) variables/objects contained in four (4) non-empty clusters and give the 1-dimensional vector/array representation. **[3 marks]**

B4.5) Describe in words the technique of data clustering and list a few examples of how it differs to the Bin Packing problem? **[3 marks]**