Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

GX ______

Semester II Examinations, 2004/2005

Exam Code(s)	1IF1
Exam(s)	IF1 B.Sc. (Information Technology)
Module Code(s)	CT102
Module(s)	Algorithms & Information Systems
Paper No.	1
Repeat Paper	______ Special Paper ______
External Examiner(s)	Professor P. Nixon
Internal Examiner(s)	Professor G. Lyons
	Dr. M. Mc Gettrick

Instructions Answer 5 questions.
All questions will be marked equally.

Duration	3hrs
No. of Answer Books	1

Requirements

Handout ______
MCQ ______
Statistical Tables ______
Graph Paper ______
Log Graph Paper ______
Other Material ______

No. of Pages ______
Department(s) ______

1. Using each of the following methods, write down (step by step) the position of each letter in the string "verona" when sorted alphabetically using

   (a) quick sort

   (b) merge sort

   (c) selection sort

2. (a) "Big Oh" notation allows us to write equations such as $3n^2 - \log_2(n) = \mathbf{O}(n^2)$. Write each of the following functions in their simplest possible "Big Oh" notation:

      (i) $7n! + 3^n - n^5$

      (ii) $5n^3 \log_2(n)$

      (iii) $(n^4 - 1)/(n^2 + 1)$

      (iv) $(5 + 3n^4)(n + 2\log_2(n))$

   (b) Explain the difference between the best case and worst case behaviour of the quicksort algorithm, in both cases stating the complexity in "Big Oh" notation. For a quicksort of a million items, how much slower would you expect the worst case behaviour to be compared to the best case behaviour?

3. (a) Calculate `f(5)` where `f` is the recursive function defined by the following pseudocode.

```
f(i)
IF (i<3) THEN
f ← i
ELSE
f ← f(i-1) + f(i-2) + f(i-3)
```

   (b) How many times was the function `f` called in the calculation of `f(5)`?

   (c) Given two positive integers x, y with $y \geq x$, write an algorithm using either iteration or recursion to calculate how many times x goes into y and the integer remainder (i.e. find q and r where $y = qx + r$ and $r < x$).

4. (a) Draw an example of

      (i) A cyclic disconnected graph

      (ii) A ternary forest

      (iii) A unary tree

      (iv) A binary tree of depth 4

   (b) Describe any three operations associated with the **(ordered) list** Abstract Data Type (ADT). For this ADT, explain how it can be implemented using

      (i) an array

      (ii) a linked list

   and state an advantage of each implementation.

5. (a) Five (5) cities are connected by a road system, with distances in km given by the following matrix:

$$\begin{pmatrix} \infty & 31 & 77 & 21 & 143 \\ 31 & \infty & 191 & 52 & 110 \\ 77 & 191 & \infty & 99 & 82 \\ 21 & 52 & 99 & \infty & 44 \\ 143 & 110 & 82 & 44 & \infty \end{pmatrix}$$

(So, for example, city 2 is connected to city 4 by an arc/road/edge of length 52 km. An infinity (∞) in the matrix indicates the two cities are not (directly) connected.)

   (i) Draw the graph corresponding to the matrix.

   (ii) Starting from city 4, calculate the route proposed by the *greedy* strategy which makes a tour of all the cities, visiting each exactly once and then returning to base. State the length of this tour.

   (b) State in "Big Oh" notation the complexity of the greedy approach to solving the travelling salesperson problem described in the previous section. If a greedy algorithm for such a problem with $n = 100$ cities takes 1.7 seconds to run, estimate the time it will take to run if we double the number of cities.

6. Explain each of the following terms:

   (a) Database.

   (b) The 3-schema architecture.

   (c) Logical and Physical Data Independence.

   (d) Entity-Relationship Diagrams.

7. Describe the components of an Expert System. Explain the difference between Bottom-Up (Forward Chaining) and Top-Down (Backward Chaining) Inference, giving an example of each.

8. In different countries, records are kept on the car colours that are most popular. For countries C_1 to C_4 the most popular colours are given below.

C_1 : {blue, red, black, brown}
C_2 : {red, yellow, brown}
C_3 : {black, white, red}
C_4 : {red, green, black, brown}

Calculate the support and the confidence of each of the following Association Rules, and state which are valid if we set our threshold at 70%.

   (a) {brown, red} $\rightarrow$ {blue}

   (b) {green} $\rightarrow$ {red}

   (c) {red} $\rightarrow$ {black}