COMPUTER SCIENCE TRIPOS Part II (General)
DIPLOMA IN COMPUTER SCIENCE

Wednesday 2 June 1993 1.30 to 4.30

Paper 12 (Paper 3 of Diploma in Computer Science)

Answer **five** *questions.*
Submit the answers in five **separate** *bundles each with its own cover sheet.*
Write on **one** *side of the paper only.*

1 Digital Electronics and Computer Design

Describe the operation and gate-level circuit of a multiplexer. [6+6 marks]

How may it be used in conjunction with a de-multiplexer to establish alternative connections across a unidirectional path between two modules? [2 marks]

What is involved in extending the method to allow a bidirectional path between two (or more) modules? [3 marks]

What do you understand by the terms *bus*, *master* and *slave* in connection with your circuit? [3 marks]

2 Computer Structures

Sketch the basic hardware components of a personal computer (PC). [4 marks]

Describe how these components operate to maximise the performance of the machine. [10 marks]

How would you expect the design to change as the CPU power, the memory size and the input/output bandwidth increase over the next few years? [6 marks]

3 Digital Communication I

Describe briefly both Synchronous and Asynchronous Time Division Multiplexing (TDM). [4 marks]

Describe four solutions to the problem of contention resolution in Asynchronous TDM. [12 marks]

Which solution is adopted by Ethernet and what measures are taken to ensure stability in circumstances of high load? [4 marks]

4 Graphics I

A certain image contains a number Q of differently coloured pixels. There are not enough different pixel values available to represent these and so a method of approximation is needed.

Describe an approach and comment on its performance. [15+5 marks]

5 Programming in C

You have a C compiler which is ANSI conforming in all respects except that it has no facility for the definition, declaration or use of standard C structures. Outline a set of routines written in this language to provide a mechanism for handling structures.

Your solution should contain the following:

(a) function prototypes for each of the routines [10 marks]

(b) a few sentences describing the behaviour of each function [10 marks]

Note: no code other than the prototypes is required.

6 Programming Language Compilation

Discuss the issues that must be considered when designing the calling sequence to be used for recursive procedures on a machine with several general-purpose central registers. Assume that the language allows procedures to be declared within other procedures and that procedures may be passed as arguments in calls. Pay particular attention to how arguments, local variables and free variables are accessed.
[20 marks]

7 Artificial Intelligence I

A sliding-tile puzzle consists of three black tiles, three white tiles and an empty space, thus:

B_1	B_2	B_3		W_1	W_2	W_3

There are three legal ways of moving a tile, each with an associated cost:

slide into the adjacent empty location — cost 1

jump over one tile into the empty location — cost 1

jump over two tiles into the empty location — cost 2

The goal is to have all the white tiles to the left of all the black tiles and to achieve this at minimum cost. The final position of the empty space is not important.

(*a*) Represent the problem using the following knowledge representation schemes:

(*i*) production system rules [5 marks]

(*ii*) a semantic network [5 marks]

In one sentence, describe the different emphases of these two schemes. [1 mark]

(*b*) State two possible heuristics to help solve this problem. [2 marks]

(*c*) For a planner to solve this puzzle, what operators (i.e. planning actions) would be needed? [7 marks]

8 Databases

Describe the relational model of data. [4 marks]

What is meant by a *candidate key*? [2 marks]

Explain what it means for a relational data model to be presented in

(*a*) *Third Normal Form* (3NF) [5 marks]

(*b*) *Fourth Normal Form* (4NF) [5 marks]

in each case illustrating your answer with a suitable example data model.

In what circumstances might it not be sensible to hold relational data according to these normal forms? [4 marks]

9 Introduction to Functional Programming

Consider the ML definitions

```
fun N f x = x;
fun P a k f x = f a (k f x);
fun Q k l f x = k f (l f x);
fun W a k = Q k (P a N);
fun R k = k W N;
```

Suppose further that `K` and `L` have ML definitions of the form

```
val K = P a1 (P a2 ... (P ai N) ...);
val L = P b1 (P b2 ... (P bj N) ...);
```

In parts (*b*) to (*d*) below, assume that `f` and `x` are arbitrary ML identifiers of suitable type for the expression containing them.

(*a*) State the ML types of `N` and `P`. [3 marks]

(*b*) What does the expression `K f x` evaluate to? [3 marks]

(*c*) What does the expression `Q K L f x` evaluate to? [4 marks]

(*d*) What does the expression `R K f x` evaluate to? [10 marks]

10 Computation Theory

Show that there is no way of deciding by algorithms whether a general register machine program with code p will terminate when started with initial data of 0 in every register. [10 marks]

Show that there is no way of deciding by algorithm whether the blank character will be printed during the course of a general Turing machine computation. [10 marks]

Note: any standard form of the undecidability result for the general halting problem may be assumed, but should be stated clearly.

11 Complexity Theory

Explain how to measure the size of a problem in complexity theory. [3 marks]

What is meant by reducing one problem to another? [4 marks]

Given that the Boolean Satisfiability Problem is NP-complete, show that the Hamiltonian Circuit Problem for undirected graphs is also NP-complete. [13 marks]

12 Professional Practice and Ethics

How should privacy be distinguished from (*a*) secrecy, (*b*) confidentiality, and (*c*) anonymity? Is there a right to privacy? [20 marks]