CSD1/3

DIPLOMA IN COMPUTER SCIENCE

Friday 3 June 1977. 1.30 to 4.30

PAPER 3

Answer five questions including at least one from Section A and at least three from Section B.

SECTION A

1. Investigate the following grammar:

$$\begin{aligned} S &\to A\ B\ d \\ A &\to A\ a\ B \mid a \\ B &\to B\ b\ C \mid b \\ C &\to C\ c \mid c \end{aligned}$$

Show how to write a program that tests whether a given string belongs to this grammar.

2. Describe how character stream documents might be represented in a computer system. Discuss the inconsistencies that may arise when documents are copied from one medium to another and then back again.

3. Discuss the detailed implementation of binary semaphores in a multiprocessor computer system. What higher-level synchronisation facilities would you build using these semaphores? Are there differences between the facilities needed by system and user programs?

4. Describe how display registers can be used in the implementation of a block structured programming language paying particular attention to the way in which they are set and restored during a procedure call.

SECTION B

5. Describe Jacobi's method for finding the eigenvalues of a real symmetric matrix and explain how it is modified in practice to provide an efficient general purpose subroutine.

6. Describe both an *explicit* and an *implicit* method of improving the performance of a computer by the use of extra registers or small fast stores, and give details of the action of the implicit method.

7. Write a LISP function, together with any necessary subsidiary functions, that will create a list of all the atoms that are in a piece of LISP data structure. Modify the program so that it can cope with re-entrant structures, and, with the aid of a suitable small example, show how it works.

8. Describe the way in which eigenfunctions and eigenvalues may be used to discuss the convergence of an iterative method for solving elliptic partial differential equations. Illustrate these ideas by discussing the optimum value of α in the method based on the use of $1+\alpha L$ when L is the Laplacian operator. Explain in what way the nature of residual error after a large number of iterations differs according as to whether α is greater than or less than the optimum. For some iterative methods the eigenfunctions and eigenvalues are complex. How does this affect the argument?

9. Describe the operation of a rasterscan VDU and explain in detail how character formation is achieved. How could such a display be enhanced to provide simple graphics facilities, such as the display of graphs and bar charts?

TURN OVER

10. There are many computational problems that are referred to as being NP-complete. What does this mean, and why would it be important if an efficient method for solving one of these problems was found?

A travelling salesman plans a round trip journey in which he will move from one city to the next by always chosing as his next stop the closest city not previously visited. Show by giving sample routemaps that this does not necessarily produce an optimal solution.

11. What are the properties of the data transmission code whose codewords are 1011, 0110, 1101? Describe the use of Slepian's Standard Array and show what may be done to decode long codes more efficiently.

12. Discuss the importance of the Chinese Remainder theorem in algebraic manipulation.

13. Define a sequence of functions $[f_n]$ as follows:

$$f_0(x) = x + 1 \quad , \quad \text{and recursively}$$

$$f_n(x) = (f_{n-1})^{x+1}(1) \quad \text{for all } n \geq 1.$$

Prove that for each fixed value of n, the function $f_n(x)$ is primitive recursive. Outline a design for a Minsky register machine to compute the function g of two arguments defined by

$$g(n,x) = f_n(x) \ .$$

(Note. The notation $(f_{n-1})^{x+1}(1)$ means that the function f_{n-1} is applied $(x+1)$ times, i.e. $h^{x+1}(y) = h[h^{x}(y)]$.)

14. Explain the purposes of *index sequential* and *inverted* file structures. Describe how one of these structures may be implemented defining clearly:

(a) how an access is made,

(b) how a new record is added to the structure, and

(c) how a record is deleted from the structure.

(Details of operations to maintain a sequential file need not be specified.)

If the records of the structure have varying size components, what modifications would be required to permit reasonably efficient updating of records?