COMPUTER SCIENCE TRIPOS

Saturday 4 June 1977. 9 to 12

PAPER 4

Candidates should answer five questions

1. Obtain a second-order iteration to solve the equation

$$\tan(x) = x + \tfrac{1}{2}$$

Show how you would choose a starting value and an end criterion to obtain the smallest positive solution to the maximum precision of your computer.

2. The following events consist of strings s in the alphabet $(0,1)$:

$E_1 = \{s : s$ contains more 0's than 1's$\}$

$E_2 = \{s : 0$ and 1 alternate in $s\}$

$E_3 = \{s : s$ contains the same number of 0's and 1's$\}$

$E_4 = \{s : s$ does not contain the substring $'1101'\}$

Which of the above events are regular? Where possible design a finite state automaton that accepts the event E_i.

3. Show that the Jacobi iteration will not converge for the set of equations

$$\begin{aligned} 10x - 6y - 5z &= 100 \\ -6x + 10y - 7z &= 100 \\ -5x - 7y + 10z &= 200 \end{aligned}$$

Determine a suitable over-relaxation parameter to ensure that the extrapolated Jacobi scheme converges.

TURN OVER

4. Describe the characteristics and mode of action of disc storage devices. What factors have led to their large scale use?

5. SNOBOL4 is one of a line of programming languages derived originally from Markov algorithms. Define a Markov algorithm, explaining why substantial modification was inevitable when the idea was incorporated into a practical programming language.

What features of SNOBOL4 make it convenient for text processing? Illustrate your answer with a simple program.

6. Explain the mathematical basis of the finite element method for solving elliptic partial differential equations. What are the advantages of finite element methods over finite difference methods? State the circumstances in which the two methods are equivalent.

7. Propose a set of subroutines for building a display file for a steered beam refreshed display and describe the action of the more important subroutines. How might they be used in the construction of a picture compiler?

8. Show how to obtain recurrence formulae that define coefficients in power series solutions to:

$$(dy/dt)^2 - exp(t+dy/dt) = 0$$

9. Describe a modular gcd algorithm. If A and B are the two polynomials

$$A = x^4 + 4x + 4$$

$$B = x^4 + 2x^3 + 3x^2 + 2x + 1$$

calculate the gcd of A and B

(a) modulo 3,

(b) modulo 5.

What can you deduce about the (non-modular) gcd of A and B?

10. Among the principles of the Younger Committee concerning data protection are the following:

(a) Information may be held only for the specific purpose for which it was collected.

(b) Any subject has the right to be told about the information concerning him.

It is assumed that within a short time data protection legislation will be enacted which enshrines in law the above principles. Discuss the technical and political impact of the legislation in the following situations:

(i) a batch payroll system in a large multi-national company;

(ii) an on-line system for recording details of new policies in a life-assurance company;

(iii) a hospital system for the storage of patients' medical records.

11. In a general-purpose filing system a directory must contain some information about where each file is stored. Describe *two* methods of recording and checking the physical allocation of disc space to files, giving the advantages and disadvantages of each.

12. *either*

Describe the routing algorithm used in the ARPAnet.

Discuss the problem of avoiding congestion in a computer network in relation to *routing*, *virtual calls*, and *flow control*.

or

Describe *three* signalling methods suitable for serial data transmission by wire. The ASCII code includes control characters, many of which are concerned with the control of such transmissions. Show how these characters may be used in the transfer of fixed-length blocks of data in synchronous mode.

13. In Algol W the expression S(P) could be a reference to an element of an array, a reference to a field within a record, or a procedure call, depending on the declarations of the variables involved. Other languages sometimes distinguish these three cases syntactically. Discuss the relative merits of these two approaches.