UNIVERSITY OF LONDON

IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 1996

BEng Honours Degree in Computing Part I
MEng Honours Degrees in Computing Part I
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute

PAPER 1.7

TURING PROGRAMMING AND DATA STRUCTURES

Wednesday, May 8th 1996, 10.00 - 12.00

Answer FOUR questions

For admin. only: paper contains
6 questions
5 pages (excluding cover page)

Section A *(Use a separate answer book for this Section)*

1a Write in Turing a function called `Hash` that takes string `s`, and a non-negative integer `n` as parameters and returns a number that is obtained by adding up the ordinal values of the characters in the string `s` modulo `n`. You may use the inbuilt function `length` in your function.

b i) Declare a data type `Student` suitable for holding a name, an email address, and a student number (non-negative integer).

ii) Declare a data structure `Class` suitable for holding `n Students`.

iii) Write a function `InitClass` that returns a `Class` where each entry has been set to

```
email = "xx"

name = "xx"

student number = 0
```

c Write a procedure `Include` that takes a `Student` and a `Class` and puts the `Student` into the `Class` at the position determined by the `Hash` function produced in part a of this question when applied to the `Student`'s name. If this space is already occupied then put the student in the next free space in `Class`. The pre-condition for `Include` is that there is at least one free place.

d Write a procedure `Email` that takes a `Student`'s name and a `Class` and prints on the screen the `Student`'s email address. If the `Student` is not in the `Class` the procedure should print a message to say this.

Make sure you include pre conditions in your code. They may be written in Turing or logic.

The four parts carry, respectively, 20%, 25%, 25%, and 30% of the marks.

2 A three-dimensional vector **v** has components v_x, v_y, and v_z .We can represent vectors in Turing programs using declarations such as

```
type Coord:enum(x,y,z)

type Vector : array Coord of real
```

Using these declarations, write functions corresponding to each of the following vector calculations.

a The *magnitude* of a vector **v** is $|\mathbf{v}| = \sqrt{\ (v_x^2 + v_y^2 + v_z^2)}$.

b The *dot product* of two vectors **u** and **v** is the real number

$$\mathbf{u} \bullet \mathbf{v} = u_x v_x + u_y v_y + u_z v_z .$$

c The *cross product* of two vectors **u** and **v** is a vector $\mathbf{w} = \mathbf{u} \times \mathbf{v}$ with components

$$w_x = u_y v_z - u_z v_y$$

$$w_y = u_z v_x - u_x v_z$$

$$w_z = u_x v_y - u_y v_x .$$

d The *triple product* of three vectors **u**, **v** and **w** is the real number $\mathbf{u} \bullet (\mathbf{v} \times \mathbf{w})$ in which $\bullet$ is the dot product and $\times$ is the cross product defined above.

e Declare a data structure suitable for holding `n Vectors`. Write a function that searches this data structure and returns the `Vector` with the smallest magnitude. If more than one `Vector` has this magnitude then return any of the `Vectors` with this magnitude.

The five parts carry equal marks.

Section B *(Use a separate answer book for this Section)*

3a Define a *binary search tree.* Draw an example.

List the *access procedures* for the abstract data type binary search tree.

Write *data declarations* and *code* for a dynamic implementation of the binary search tree in Turing.

b Write the following function in Turing:

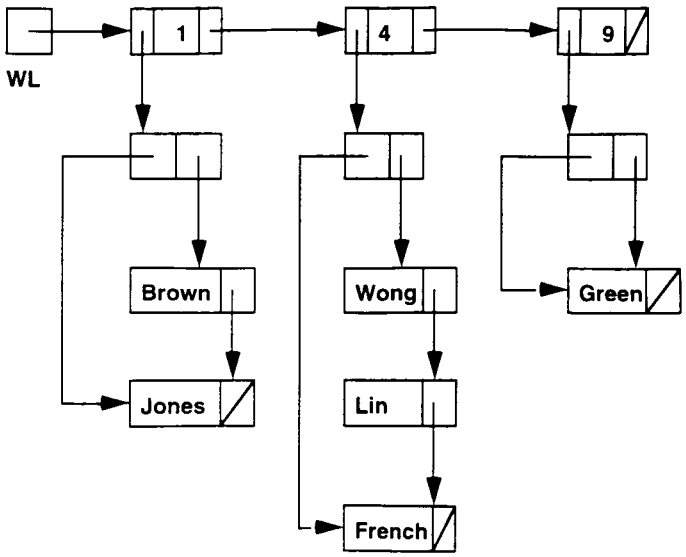
```
function TreetoList (T:Tree) : List
% pre :  takes a binary search tree with integer data items.
% past : returns a list containing the item values in the tree
%        in descending order.
```

You may assume the availability of the ADT List with access procedures Empty, IsEmpty, Head, Tail, Cons, and also Append.

The two parts carry, respectively, 80%, 20% of the marks.

4. This question is about an Abstract Data Type WaitingList.

The diagram is of a dynamic implementation of a hospital waiting list data structure in which patients are grouped according to a priority rating from 1 (highest) to 10. Patients with the same priority wait on a first come, first served basis. The next patient to be taken from the waiting list for treatment is the one of the highest priority rating who has been waiting the longest. The diagram shows the structure with patients Brown and Jones having priority 1; Wong, Lin and French with priority 4 and Green with priority 9.



a Give type declarations in Turing for this dynamic implementation of the ADT WaitingList.

b Write Turing code for the following access procedures:

function NextPatient (WL : WaitingList) : Name
% post : returns name of next patient to be treated

procedure Remove Patient (var : WL : WaitingList)
% post : removes from waiting list next patient to be treated.

c Suppose standard ADTs List and Queue were available

Describe how you could use these to construct the ADT WaitingList.

The three parts carry, respectively, 40%, 40%, 20% of the marks.

Turn over ...

5 a Describe the *Replacement Selection Sort* algorithm, and show its operation by means of an example.

b Explain why the replacement selection sort is particularly suited to the preparation of initial runs for an external sort/merge.

c Show the detailed operation of a *Balanced Merge* for a system with a maximum of 8 files available, where the data has been sorted into 300 initial runs.
Explain any notation you use.

d Describe how you could modify the algorithm given in your answer to part a to give an n-way merge algorithm and illustrate your answer with an example.

6 a Define the *stack* data structure.

List the *access procedures* for the abstract data type *stack* and describe briefly the action of each.

List the formal axioms specifying the behaviour of the access procedures.

b Give the *data definitions* for a dynamic implementation of the ADT stack in Turing.

The following two additional access procedures are required, in addition to those you have given in your answer to part a, for an Extended Stack ADT. Write them both in full in Turing :

```
function Depth (S : Stack) : int
% post : return the number of items in the stack S
%      : S is not changed

function Retrieve (I : int, S : stack) : InfoType
% pre  : I >= 1
% post : returns the Ith most recently-added item
%      : in the stack S. S is not changed.
```

End of paper