King's College London

UNIVERSITY OF LONDON

B.Sc. EXAMINATION

CP/1710 Computing for Physical Scientists

Summer 1997

Time allowed: THREE HOURS

Candidates must answer SIX parts of SECTION A, and TWO questions from SECTION B.

Separate answer books must be used for each Section of the paper.

The approximate mark for each part of a question is indicated in square brackets.

You must not use your own calculator for this paper.
Where necessary, a College Calculator will have been supplied.

TURN OVER WHEN INSTRUCTED

SECTION A – Answer SIX parts of this section

1.1) How much memory (in bytes) is allocated to the variables `a, b, c` and `d` by the following lines of Fortran 90 code?

```
real :: a
integer, dimension (4) :: b
character (len=5) :: c
logical :: d(10,4)
```

[7 marks]

1.2) What would the value of `x` in the following code be?

```
real :: x
integer :: a=5, b=3
x=a+3/b**2
```

Explain why.

[7 marks]

1.3) When the following code was run, the `print` statement was not executed. Why?

```
real :: degrees=90.0,radians,secant,pi=3.1415927
radians=pi*degrees/180.0
if(cos(radians) == 0.0)then
    print*,'The secant is infinite'
else
    secant=1./cos(radians)
endif
```

How would you rewrite it so that there is no risk of an overflow error?

[7 marks]

1.4) How are the values of variables passed between programs, subroutines and functions. What are the advantages and disadvantages of each method.

[7 marks]

1.5) What will be printed out by the following section of Fortran 90 code?

```
do i=1,5
    do j=i,5
        if(mod(i+j,3) == 0)print*,i,j
    enddo
enddo
```

[7 marks]

1.6) The following section of code reads in 10 integers and stores them in an array, while calculating their accumulated sum.

```
integer ::  x(10),i,sum=0
do i=1,10
     read*,x(i)
     sum=sum+x(i)
enddo
```

Rewrite it so that a list of any number (up to 200) of integers can be read in and summed.

[7 marks]

1.7) Explain what an array is and when it is better to use one instead of separate variables. Write the line (or lines) of Fortran 90 code which would set up an array of 10 integers, `arr` and initialise all the elements to zero.

[7 marks]

1.8) Write lines of code to print out the 10 real values in the array `x` (which all have values between -90 and +120) on one line of your screen (80 characters wide), to the highest number of decimal places that can be easily read.

[7 marks]

SECTION B – Answer TWO questions

2) Write a subroutine which is passed two 3×3 matrices as arguments and calculates their matrix product, passing it back to the calling subprogram.

In general, for two matrices A and B, the matrix product C is given by:

$$C_{ik} = \sum_{j=1}^{3} A_{ij} B_{jk}$$

[20 marks]

How could this subroutine be modified to find the product of square matrices of other sizes?

[10 marks]

3) Write a short program which reads in an integer and finds **all** of its factors and prints them out. If it is prime a message to that effect should be printed.

For example if the integer were `10`, the output could be:

```
The factors of 10 are:
1
2
5
10
```

(or something similar.)

[22 marks]

Explain how the program could be changed to find only prime factors. You do not need to write code for this modified program.

[8 marks]

4) Write a Fortran 90 function, `area`, which calculates the area under a curve defined by a set of 1000 points (x_i, y_i), for $i = 1$ to 1000, which are stored in the arrays (of length 1000) called `x` and `y`. The function call has this form:

```
areacurve = area(x,y)
```

You may assume that the values of x_i are monotonically increasing (i.e. $x_i < x_{i+1}$ for all i) but not neccessarily equally spaced. The curve is defined between each pair of adjacent points by the straight line between them.

[30 marks]

5) Write a short Fortran 90 function, with an integer argument `n` and an integer value, which calculates $n!$.

[10 marks]

Why will this fail to give the correct answer if n is greater than about 12?

[5 marks]

How could it be changed to manage rather larger values?

[5 marks]

This function is to be used in the calculation of the series:

$$\sum_{n=1}^{\infty} \frac{x^n}{n!}$$

Explain, without programming it, how you could formulate the sum to avoid this problem altogether.

[10 marks]