King's College London

UNIVERSITY OF LONDON

This paper is part of an examination of the College counting towards the award of a degree. Examinations are governed by the College Regulations under the Authority of the Academic Board.

B.Sc. EXAMINATION

CP/1710 COMPUTING FOR PHYSICAL SCIENCES

JANUARY 1999

Time allowed: **THREE HOURS**

Candidates must answer any SIX questions from 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.

Good answers to the questions in Section B will consist of plans or explanations in addition to Fortran 90 code. You can gain marks for later sections of a question even if you cannot do the earlier sections.

TURN OVER WHEN INSTRUCTED

SECTION A – Answer SIX parts of this section

1.1) Write down the lines of Fortran 90 code which specify that variable `x` is an integer with a value of zero, `y` is a real number with a value of 10^{-6} and `z` is a character string containing the text:

```
CP1710 examination
```

How much memory (in a 32 bit workstation such as GUM at King's College) is used for each of these variables?

[7 marks]

1.2) What is a module in Fortran 90? When would you use it?

[7 marks]

1.3) Write down the lines of Fortran 90 code which would write the values stored in the integer array `a(10)` to a file called `output.d`.

Write the lines of code that would read the values from this file into an array in another program.

[7 marks]

1.4) What does the following section of code print out?

```
do first=1,5
     do second=1,5
          if (first > second)print*,first,second
     enddo
enddo
```

Rewrite the code without the `if(...)` such that the same numbers are printed out.

[7 marks]

1.5) Write a short program in Fortran 90 which prints out the 17 times table (up to 12 ×17). The output should be formatted as follows:

```
1 * 17 = 17
2 * 17 = 34
...
```

[7 marks]

SEE NEXT PAGE

1.6) Write the lines of Fortran 90 code which read the co-ordinates of ten points (x, y) into a 2-D array called `points(10,2)`, and print out the one which is nearest to the origin.

[7 marks]

1.7) The following section of code is found towards the beginning of a program:

```
interface
     real function integral(n,a,int_a)
     integer, intent(in):: n
     real, dimension(n,n), intent(in) :: a
     real, intent(out) :: int_a
     end function integral
end interface
```

What is its purpose? What does it tell you about the function it refers to?

[7 marks]

1.8) If the integer `i=3` and the real constant `a=4.0`, what are the values of the real variable `x` after the following sections of code?

a)
```
x=i/2+a
```
b)
```
x=i/(2+a)
```
c)
```
x=i/2.+a
```
d)
```
x=i**2/a
```
e)
```
x=2.
if(i==3)x=a
```
f)
```
x=0.
do i=1,3
   x=x+i
enddo
```
g)
```
x=mod(5,i)
```

[7 marks]

SEE NEXT PAGE

SECTION B – Answer TWO questions

2) Write a function in Fortran 90 that takes as its argument a value of *n* (an integer) and returns the value of *n*!.

[10 marks]

Explain why you chose to use an integer or a real type for this function.

[5 marks]

You could use your function for *n*! in the evaluation of the series:

$$\exp(x) = \sum_{n=0}^{\infty} x^n \Big/ n!$$

Explain why this would cause problems for certain values of *x*. What would be a better way of programming it (without using the intrinsic function `exp(x)`)?

[15 marks]

3) Write a short program which reads in, from the keyboard, ten values of a real quantity *x*, measured in an experiment, and calculates their mean, $\bar{x}$, and standard deviation, σ.

[10 marks]

Adapt this program so that it reads in an arbitrary number of data values (less than 1000) from a file called `data.d`, and writes all those values which lie within 3 standard deviations of the mean to another data file called `new_data.d`.

[20 marks]

For *N* measurements of *x*, each denoted x_n, $\bar{x} = \frac{1}{N}\sum_{n=1}^{N} x_n$, $\sigma = \frac{1}{N}\sqrt{\sum_{n=1}^{N}(x_n - \bar{x})^2}$.

SEE NEXT PAGE

4) The method of bisection is used to find a real root of an equation, $f(x) = 0$. If there are two values of x, x_1 and x_2, such that $f(x_1)$ and $f(x_2)$ have different signs, then there must be a root between x_1 and x_2. Hence if you guess a new value, $x_3 = \frac{1}{2}(x_1 + x_2)$, $f(x_3)$ must have a different sign to either $f(x_1)$ or $f(x_2)$, and the whole procedure can be repeated, until the separation of subsequent guesses is smaller than the accuracy required.

Write a program to use the method of bisection to find the values of the two non-zero roots of the equation:

$$f(x) = \sin(x) - x/2$$

to 5 significant figures.

[25 marks]

Describe (without writing any further code) why this method may not be suitable to use to find the roots of a general equation.

[5 marks]

5) Write a short program which calculates, numerically, the value of:

$$\int_0^{\pi} \sqrt{x}\sin(x)\,dx$$

[20 marks]

Explain how you would adapt your program so that it calculates the value of a general integral, $\int_a^b f(x)\,dx$ where the value of $f(x)$ is provided in the form of a function `f(x)`, which returns the value of $f(x)$, given x as an argument.

[10 marks]

FINAL PAGE