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.

M.Sci. EXAMINATION

CP/4731 C and C++ programming for physicists

Summer 2001

Time allowed: THREE Hours

Candidates must answer any THREE questions. No credit will be given for attempting a further question.

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

Good answers to questions will include plans and explanations in addition to sections of C or C++ code.

Some questions specify C or C++. Marks will be lost if you use C++ syntax in the solutions to questions that specify C.

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

TURN OVER WHEN INSTRUCTED

Answer THREE questions

1) Write a short program in C, which reads in an arbitrary integer and finds all of its prime factors, including repeated factors.

[20 marks]

2) Write a function in C, called `double Bessel(int n, double x)`, which calculates the Bessel function of the first kind, $J_n(x)$, using the following series:

$$J_n(x) = \left(\frac{x}{2}\right)^n \sum_{k=0}^{\infty} \frac{\left(-\frac{1}{4}x^2\right)^k}{k!(k+n)!}$$

Note that this series converges very slowly for $x \gg 1$ (where other methods of evaluation are more appropriate), so your function should print a warning if convergence is likely to be slow.

[20 marks]

3) Explain the differences between pointers (in C or C++) and references (in C++).

[2 marks]

Show how the elements of one- and two-dimensional arrays can be manipulated by means of pointer variables, or, interchangeably, by using the index (or indices).

[8 marks]

Write a short function in C or C++ which, given two 3×3 float arrays representing matrices as arguments, calculates their matrix product.

[10 marks]

4) Define a class in C++ called `complex` which manipulates complex numbers. It should include the overloaded operators +, – and the function `conjugate`, which calculates the complex conjugate of the complex number.

[10 marks]

Define another class of lines in the complex plane, using the class `complex` in a suitable way. It should include a function which returns the length of the line.

[6 marks]

Write a short main function to show how these classes would be used.

[4 marks]

SEE NEXT PAGE

5) Write a program in C or C++ which reads in a list, of unknown length, of real numbers from a file. It should allocate just sufficient space for an array to store the values. The program should then calculate the mean, standard deviation and the skewness of the distribution of the numbers. The allocated space should be freed at the end of the program.

[20 marks]

Note that: If the real numbers are denoted as x_i, $i=1...N$, then the mean, $\bar{x}$, is given by:

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

The standard deviation, σ, is given by:

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

and the skewness, s, is given by:

$$s = \frac{N}{(N-1)(N-2)}\sum_{i=1}^{N}\left(\frac{x_i - \bar{x}}{\sigma}\right)^3 .$$

FINAL PAGE