GX657

OLLSCOIL NA hÉIREANN
The National University of Ireland

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Trinity Examinations, 1998/99

First Year Mechanical & Biomedical Engineering Examination

COMPUTER PROGRAMMING & ORGANISATION

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Attempt Five Questions
Attempt at least one question from Section A AND one question from Section B.
Use a Separate Answer Book for each section.
Time Allowed : 3 Hours

A list of Fortran 90 intrinsic procedures is attached.

Section A

1. (a) What is the difference between static and dynamic storage allocation ? Under what circumstances is dynamic allocation for arrays an advantage ? Which statements are used in Fortran 90 to handle assignment and release of storage for dynamic arrays ? Use sketches and code samples, as appropriate, to illustrate your answers. (5)

(b) Explain the following Fortran 90 intrinsic procedures for arrays: SIZE, SHAPE, SECTION, MATMUL. Use sketches and code samples, as appropriate, to illustrate your answers. (5)

(c) Matrix multiplication is defined by the product $[C] = [A][B]$, where $[A]$, $[B]$ and $[C]$ have dimensions M x L, L x N, and M x N, respectively, and the elements of $[C]$ are given by

$$C_{ij} = \sum A_{ik} B_{kj}, \text{ with summation limits from } k = 1 \text{ to } k = L.$$

Making use of a subroutine construction and dynamic array allocation, draw a flowchart and write a Fortran 90 programme to perform matrix multiplication. (10)

2. (a) Outline the use of CHARACTER variables and arrays in Fortran 90 under the headings : declaration, I/O format specifications, comparisons and modifications. Provide simple examples to illustrate your answers. (8)

(b) Draw a flowchart and write a Fortran 90 programme to count the number of occurrences of a particular letter in a word. Such a programme might be used to decode an encrypted message. Enable the word and the letter to be input by the user from the terminal, and store the inputs in CHARACTER variables called TEXT and LETTER, of lengths 20 and 1, respectively. (12)

cont/...

3. (a) Derive the formulae for approximating the roots of $f(x) = 0$ by the methods of Newton-Raphson and of false position. (8)

(b) Draw a flowchart and write a Fortran 90 programme to evaluate a root of the following equation, accurate to four decimal places, using the method of false position:

$$x^3 = \pi(e^x - \sqrt{x}\, e^{-x})$$

The programme should request all necessary parameters from the user. (12)

4. A procedure for calculating the temperature distribution in a rectangular, flat metal plate is defined as follows: the top, bottom, left and right edges of the plate are maintained at uniform temperatures Tt, Tb, Tl and Tr, respectively (***Figure 4a***). The temperature of an interior point on the plate depends on the temperature of the surrounding material. The plate is assumed to be divided into cells, each with its own temperature. Temperatures in the outer (edge) cells are fixed by the prescribed edge values (***Figure 4b***). Interior cell temperatures, which are the unknowns, are determined by iteration. Initially, all interior temperatures are set to zero. During an iteration the new temperature of each interior cell is calculated as the average of its four immediate neighbours (above, below, left, right). The change in temperature for every cell is checked, and iteration ceases when all changes are less than a defined tolerance. Draw a flowchart and write a Fortran 90 programme to perform the above procedure for an arbitrary set of cells. The programme should read from an input file the numbers of cells in the horizontal direction (Nh) and in the vertical direction (Nv), the values of Tt, Tb, Tl and Tr and of the tolerance. The final temperature distribution should be written to an output file. (20)

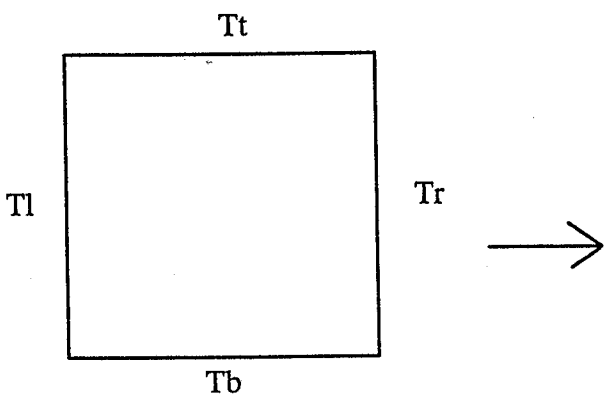

Figure 4a

Tt	Tt	Tt	Tt
Tl			Tr
Tl			Tr
Tb	Tb	Tb	Tb

Figure 4b

5. (a) Describe the possible uses of the MODULE facility in Fortran 90. Use sketches and code samples, as appropriate, to illustrate your answers. (5)

(b) Draw a flowchart and write a Fortran 90 programme that approximates the following integral using the trapezoidal rule:

$$\int_A^B \frac{x^2 - 1}{x + 3} dx$$

The programme should comprise three units: a main programme, a subroutine for performing the trapezoidal calculation, and a function for the integrand. The programme should request the limits of integration A and B, also the number of segments N, from the user, and should offer a repeat option. (15)

Section B

6. Some mechanical engineering problems require the solution of a quadratic equation. The solution can yield three possible types of results, namely, repeated real roots, two separate real roots or complex roots.

Write a program in C to determine the roots of a quadratic equation. In this program, the *if....else* statement should be used to determine if the roots are real, complex or singular. The value passed to the square-root function (*sqrt ()*) should be checked to determine if it is negative (avoid attempting to calculate the square root of a negative number). If it is, it may cause the program to terminate as the square root of a negative number cannot be calculated (it is numerically invalid). The program may also terminate if the coefficient of x^2 is zero as this causes a divide by zero error. The inputs (a, b, c) shall be read from the keyboard and the output shall be printed to the screen and also written to a text file. Illustrate your program with a flowchart.

The following notation shall be used in the program:

a, b, c :	constants in quadratic equation
real1, real2 :	real roots of quadratic
imag :	imaginary roots of quadratic

(20)

7. The resistance of a cylindrical conductor is a function of its resistivity, cross-sectional area and length.

Write a program to determine the resistance of a cylindrical conductor made from either silver, manganese, aluminium or copper. The resistivities of these materials are 17×10^{-9}, 25.4×10^{-9}, 16×10^{-9}, 1400×10^{-9} $\Omega\ m^{-1}$ and shall be defined at the beginning of the program. The user shall enter the conductor type as a character ('*s*', '*m*', '*a*', '*c*') from the keyboard. When an invalid character is entered, a default condition shall be executed and the text *invalid option* displayed. The output shall be displayed on the screen and also written to a text file in scientific format as values are typically much less than 1 ohm. Illustrate your program with a flow chart.

The following notation shall be used in the program:

RHO_COPPER :	Resistivity of Copper
RHO_AL :	Resistivity of Aluminium
RHO_SILVER :	Resistivity of Silver
RHO_MANGANESE :	Resistivity of Manganese
radius :	radius of conductor
length :	length of conductor
area :	area of conductor
rho :	resistivity of conductor
resistance :	resistance of conductor

(20)