

OLLSCOIL NA hÉIREANN

The National University of Ireland

National University of Ireland, Galway

Michaelmas Examinations, 2002/2003

First University Examination in Engineering

Mechanical, Biomedical & Undenominated

ENGINEERING COMPUTING I (FORTRAN)

*Professor P. Mallon**Professor J.F. McNamara**Dr. J.A. Eaton***Attempt Three Questions****Time Allowed: 2 Hours***A list of Fortran intrinsic procedures is attached.*

1. The boiling temperature (T) of a liquid has been measured for a range of pressures (P), and the data pairs (P_i, T_i) have been stored in a sequential formatted file called TEMP.DAT. Draw a flowchart and write a Fortran 95 program that applies the Method of Least Squares to calculate the best fit straight line representing the data. Use arrays and dynamic dimensioning. Output the results to a file and include a repeat option. The Least Squares formulae are as follows: (20 points)

$$T = aP + b, \quad a = \frac{N \sum P_i T_i - \sum P_i \sum T_i}{N \sum P_i^2 - (\sum P_i)^2}, \quad b = \frac{\sum T_i - a \sum P_i}{N}$$

2. (a) Describe the possible uses of the MODULE facility in Fortran 95. Use sketches and code samples, as appropriate, to illustrate your answers. (6 points)
- (b) Draw a flowchart and write a Fortran 95 programme to compute the integral

$$\int_a^b \left(f_1 - f_3 e^{-\frac{f_3}{f_2} x} \right) dx$$

using the trapezoidal rule (*i.e.* approximating the function by linearly varying small steps). Read in the parameters f_1, f_2, f_3, a, b and n , the number of subdivisions of the range a to b and output the value of the integral. Your programme should compare the approximate result with the exact analytic result given in the formula below. Output the exact result and the normalized error.

$$\left(f_1 b + f_2 e^{-\frac{f_3}{f_2} b} \right) - \left(f_1 a + f_2 e^{-\frac{f_3}{f_2} a} \right) \quad (14 \text{ points})$$

3. (a) Briefly explain logical variables, logical operators and logical expressions. Use Fortran 95 statements to illustrate your answers. (5 points)
- (b) Draw a flowchart and write a programme in Fortran 95 to sort a list of student names in descending order based on overall marks. The input data consists of a list of 150 names and their corresponding laboratory and examination marks. The output should be the ordered list of names and the corresponding overall mark. Use files for input and results. (15 points)

4. (a) Briefly explain what a recurrence relation is. Use Fortran 95 statements to illustrate. (5 points)

- (b) The sine of an angle x , in *radians*, is the result of the summation of the infinite series:

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \frac{x^9}{9!} \dots$$

Draw a flowchart and write a Fortran 95 programme to read in a number of angles in units of *degrees*, and for each of them to sum the first 50 terms of the series. At the end, compare your summations with the intrinsic procedure value $\text{SIN}(X)$.

(15 points)

5. (a) Derive the formula for approximating the roots of $f(x) = 0$ by the method of Newton-Raphson. (5 points)

- (b) Draw a flowchart and write a Fortran 95 programme to calculate to six decimal places, using the Newton-Raphson method, the roots of the following cubic equation:

$$y = x^3 - 5x^2 + 6x$$

The programme should request all necessary parameters from the user.

(15 points)