

Fortran90 Course, Examples A1

- 1) Using your favourite editor, write a program which prints out your name.
- 2) The following program contains a number of errors. Identify them and produce a corrected version. The code may be obtained via

`ftp://ftp.ma.man.ac.uk/pub/gajjar/f90`

with the file name `expl.f90` .

```
PROGRAM test
  IMPLICIT NONE
  REAL : number
  ! This program contains a number of errors &
  ! is not a good example of Fortran 90 at all!
  PRINT *, 'This &      ! trailing
           & is a silly  ! comments!
           & program
  PRINT *, 'Type a number''
  READ *, 'number''
  PRINT 'Thank you. &
  Your number was '' number
END test
```

- 3) Enter the following program exactly as shown:

```
PROGRAM new
  ! this program contains four major errors &
  & and three examples of bad programming style
  PRINT *, Please type a number
  READ *, numbr
  PRINT *, 'The number you typed was ', number
END
```

The program contains several errors, only some of which will be picked up by the compiler. There are also three additional mistakes in the program, which although not errors, are very poor programming practice. Can you find all the mistakes. Now compile the program, correct only those mistakes detected by the compiler, and run it again, typing the value 321 when requested. Was the answer that was printed correct? If not why not?

How would you improve the program so that the compiler found more of the errors?

4) Write a program that expects three numbers to be entered, but only uses one READ statement, and the prints them out so that you can check that they have been input correctly.

When typing the numbers at the keyboard try typing them all on one line.

- (a) separated by spaces,
- (b) separated by commas,
- (c) separated by semicolons.

Then run the program again, but type each of the numbers on a separate line, followed by RETURN.

5) Write and run a program which will read in 10 numbers and find their sum. Test the program with several sets of data. Were the answers what you expected?

[Sample data: 1, 5 , 17.3, 9, -23.714, 12.9647, 0.0005, -297, 3951.44899, -1000]

6) The following program is intended to swap the values of x1 and x2.

```
PROGRAM swap
IMPLICIT NONE
REAL :: x1=111.11 ,x2= 222.22

! Exchange values
x1=x2
x2=x1
!print values
PRINT *, x1,x2

END PROGRAM swap
```

Obtain the program as in example 2, this time the file is exp3.f90. Compile and run the program. What is wrong with the program. Correct and check that it works properly.

7) Write a program that reads a six word sentence, one word at a time, into six variables, and then prints the sentence formed by concatenating the six variables.

8) Write a subroutine which, when supplied with the coordinates of two points (x_1, y_1) and (x_2, y_2) , calculates the distance of each point from the origin and the distance between the two points. Test your program using sample data and check that it works correctly

9) Write a program to solve the quadratic equation

$$ax^2 + bx + c = 0.$$

The user should be asked to input the coefficients of the quadratic and the programme should calculate the roots (real or complex) and print them out.

10) Write a subroutine that calculates the position r , velocity v , and acceleration a of a body undergoing simple harmonic motion using the equations given below.

$$r = b \sin(nt + \epsilon), \quad v = nb \cos(nt + \epsilon), \quad a = -n^2 r.$$

Use the starting values $n = 3.14159265$, $\epsilon = 0$, $b = 2.5$. Test by specifying your values of t .

11) Write the following using Fortran syntax. In all cases the end result is to be stored in the variable y .

a)

$$y = 2 \tan^{-1} \left(\left(\frac{1 + \gamma}{1 - \gamma} \right)^{\frac{1}{2}} \sin \gamma \right).$$

b) $y = \frac{1}{\sqrt{2\pi}} \ln(x^3 + 1) e^{-x^{1.5}/3}$.

12) Write a program that accepts a positive integer as its input and informs the user of all the following:

1. whether the number is odd or even,
2. whether it is divisible by seven,
3. whether it is a perfect square.

Modify your program to find the first even number that is divisible by 7 and is a perfect square.

13) The Fibonacci Sequence is one in which each number is the sum of the previous two. The starting values are 0,1. Write a program to calculate the first 26 numbers of the sequence. The ratio of successive terms x_n/x_{n+1} tends to a limit called the Golden Ratio:

$$\frac{\sqrt{5} - 1}{2}.$$

Modify your program to determine how far along the sequence you have to go until the difference between the Golden Ratio and that of consecutive numbers is less than 10^{-6} .

14) Write a program which uses the Maclaurin series for $\sin(x)$ to calculate $\sin(x)$ to an accuracy that is provided by an argument to the function.

Modify the program so that you calculate the value of $\sin(x)$ from a value input at the keyboard. Also modify the program so that it produces a table showing the value of $\sin(x)$ for x taking the values from 0° to 90° in steps of 1. Each line should show the angle (in degrees) and the value of $\sin(x)$ calculated by your program and the value as calculated by the intrinsic function SIN.

15) Store twelve 5 digit numbers in an array. Purely by changing the output format, print the numbers as

- a single column of numbers,
- four rows of three numbers,
- a single line of numbers.

16) Write a program that has an explicit-shape rank-two integer array of shape (4,5) with default index bounds. Fill the array so that the (i, j) th element has the value $10i + j$. Print out all the array element values in a rectangular pattern that reflects the array structure. Now modify your program so that the printed pattern is rotated through 90° ; that is, as if the original version treated the first subscript as the row number and the second subscript as the column, then this version should treat the subscript as the column number and the second as the row number.

17) Write a function returns the infinity norm (defined as the largest of the absolute values of the elements of the vector) of a vector whose elements are stored in a rank-one assumed-shape real array which is the only argument to the function. Test that this function works correcting by using some sample data.

The L_2 norm of a matrix whose elements are a_{ij} is defined to be

$$\sqrt{\sum_{i=1}^m \sum_{j=1}^n a_{ij}^2}.$$

Modify the function written so that it calculates the two-norm of a matrix, and test it with several matrices of different sizes.

18) Write a program to calculate the values of y , where $y = e^x \sin x$, for x varying from 0 to 20 in steps of 0.5. The sets of values of x and y should be written to an unformatted file, and should also be printed using list directed printing.

Now write a second program which reads the result produced by the first program and prints them in the form of a table containing the values of x and y . The program should print this table several times using different formats for both x and y as follows:

- Both in **F** format.
- x in **F** format and y in **E** format.
- Both in **E** format.

Try different **E** and **F** formats and compare the output.

19) Use Newton's method to find roots of $f(x) = 0$ where

$$f(x) = 9x^4 - 42x^3 - 1040x^2 + 5082x - 5929.$$

Repeat the exercise using the Secant method.

[In Newton's method one uses the sequence

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)},$$

and in the Secant method

$$x_n = x_{n-1} - \frac{f(x_{n-1})(x_{n-1} - x_{n-2})}{f(x_{n-1}) - f(x_{n-2})}.$$

]

20) A popular method for integrating an ODE

$$dy/dx = f(x, y), \quad y(x_0) = y_0$$

is the 4th order Runge-Kutta method. This is described by the following algorithm.

$$y_{n+1} = y_n + \frac{h}{6} [k_1 + 2k_2 + 2k_3 + k_4],$$

where

$$k_1 = f(x_n, y_n), \quad k_2 = f\left(x_n + \frac{h}{2}, y_n + \frac{hk_1}{2}\right),$$
$$k_3 = f\left(x_n + \frac{h}{2}, y_n + \frac{hk_2}{2}\right), \quad k_4 = f(x_n + h, y_n + hk_3),$$

where h is the step size, and $y_{n+1} = y(x_n + h)$. Write a function to implement the above algorithm for the two equations below.

a)

$$\frac{dy}{dx} = \frac{y}{4}\left(1 - \frac{y}{20}\right), \quad y(0) = 1,$$

[The exact solution is

$$y(x) = \frac{20}{(1 + 19e^{-\frac{x}{4}})}.$$

Here use stepsizes $h = 0.1, 0.01, 0.001$, and tabulate your results in steps of $x = 1$ up to $x = 20.0$. Compare with the exact solution and also tabulate the error.

b)

$$\frac{d\mathbf{y}}{dx} = \mathbf{f},$$

where

$$\mathbf{y} = (y_1, y_2, y_3)^T, \quad \mathbf{f} = (y_2, y_3, -y_1 y_3)^T, \quad \mathbf{y}(0) = (0, 0, a).$$

Here choose a step size $h = 0.1, 0.01$ and values of $a = 1, 0.3$. Tabulate your results in steps of $x = 0.5$, up to $x = 10$, printing out x, y_1, y_2, y_3 in 4 columns using the format 4(F12.5,1x).

Modify your code so that the value of a is adjusted so that $y_2(10)$ is equal to 1 ± 10^{-8} .