Introduction to Fortran: Problem Sheet

Chris Cooling

May 19, 2021

1 Compilation

- Obtain the code examples for this session
    - Download from github: https://github.com/coolernato/Intro-to-Fortran.git
- Find the "Compilation" directory
- Source.f90 should be compiled as a single file
- Source1.f90 and Source2.f90 should be compiled together
- Compile and run the files by either:
    - Compile it on your own computer and run it
    - Copy and paste it into https://www.onlinegdb.com , select "Fortran" in the top right and click "Run"

2 My First Code

- Find the "My_First_Program" directory
- Compile and run "my_first_program.f90"
- Experiment with:
    - Changing the words in quotation marks following the print statement
    - Adding more print statements
- You will need to recompile between making a change and running your program

3 Variables

3.1 Mathematical Operators

There are 5 identical cubes, each with a side length of 3.2m. Calculate and print:

- The volume of one cube
- The area of all faces of one cube
- The volume of all cubes
- The area of all cubes
- The surface area to volume ratio of the cubes

3.2 Order of Operations

- Find the "Variables" directory
- Compile the "order_of_operations" file
- Write down what you expect the value of the different cases to be
- Run the file
- Check the results are what you expect

3.3 Arrays

A location in 3d Cartesian space may be represented by (x,y,z) coordinates. This may be represented by a dimension 1 array with size 3.

- Create a 1d array with three elements to represent Position A, which is at (1,2,1)

- Calculate the location of Position B, which has a displacement of (3,-4,1) from Position A

- Calculate the location of Position C, which is twice as far from the origin as Position B

- Calculate the location of Position D, which is found by rotating position C 45° around the z axis (clockwise when viewed from above). To rotate a location around the z axis in this manner by an angle θ, it may be multiplied by the matrix:

$$\begin{pmatrix} \cos(\theta) & -\sin(\theta) & 0 \\ \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{1}$$

- Calculate the straight line distance between Position D and the origin

Extension:

- Repeat the above, but with three points, all contained in a single two-dimensional array

- Initial points to use are (1,2,1), (-1,0,1) and (-3, -2, -2.5)

4 Conditionals

- In the Conditionals directory open the exercise_conditionals.f90 file

- Write down what you think will be printed for each case

- Compile and run the file and check the results are what you expected

5 Loops

For each of the following tasks, write a piece of code using "do" or "do while" loops to achieve the following effects:

- Print the numbers 1-20.

  - If a number is a multiple of 3, print "Fizz" instead
  - If a number is a multiple of 5, print "Buzz" instead
  - If a number is a multiple of 3 and 5, print "FizzBuzz" instead

- Calculate the value of the expression $\sum_{n=1}^{\infty} 0.5^n = 0.5 + 0.25 + 0.125 + 0.0625 + \dots$

  - Use a variable to keep track of the increasing sum
  - Each iteration of your loop should add a new value to the increasing sum
  - When the difference between the increasing sum in one iteration of your loop and the previous is less than 0.0001, the loop should stop
  - Print the final value

6   Subroutines

Create a subroutine named "swap". It should:

- Take three arguments:

  - A one-dimensional array of 5 reals
  - Two integers

- Swap the values of the entries in the array with the indices of the two provided integers

Check the subroutine works with a couple of values.

What happens if you provide a value for one of the integers which is greater than 5 or less than 1? Would you prefer something else to happen instead?

7   Functions

Write a function:

- Named "cuboid_volume"

- Takes the real arguments "height", "width", "length"

- Returns the product of these values

Call this function with the following values and verify it produces the correct answers:

- Height=2.0, width=3.0, length=1.5

- Height=3.0, width=10.0, length=4.0

8   Modules

Computer codes can be very useful for calculating statistics of a dataset. The mean $\bar{x}$ and standard deviation σ of a dataset containing N entries x_i are defined as:

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N} \tag{2}$$

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

Create two modules:

- Named "statistical_moments", containing:

  - mean: A function which returns the mean of a 1D array with a deferred size
  - standard_deviation: A function which returns the standard deviation of a 1D array with a deferred size

- Named "analysis", containing:

  - stats_analyser: A subroutine which takes in a 1D array of deferred size and prints a message to the screen giving the mean and standard deviation of the array

Call stats_analyser from a main program named "stats_example" with the following datasets and ensure the resultant mean and standard deviation are correct:

- (1, 2, 3, 4, 5, 6, 7, 8, 9, 10) should give a mean of 5.5 and a standard deviation of 2.87

- (1.01, 1.00, 0.99, 1.02, 0.98) should give a mean of 1.0 and a standard deviation of 0.0141

9   Errors

Make a copy of the source file "compilation_errors_exercise.f90". It contains many errors for a very simple program. Try to compile the code and use the errors the compiler gives you to work out what's wrong with it and fix it.