Introduction to Fortran: Problem Sheet

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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 Code” directory
- Compile and ”run my_first_code.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

100m3 of water is added to these cubes. One cube will be fully filled, before the next is filled and so on. Eventually there will be a number of completely filled cubes and a partially filled cube.

- How many cubes are completely or partially filled?
- What volume of the partially filled cube is unfilled?

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^o 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:

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

- Calcualte the straight line distance between Positions A and D

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 $\sum_{n=1}^{\infty} 0.5^n = 0.5 + 0.25 + 0.125 + 0.0625 + \ldots$
  - 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

Write a subroutine called “swap” which takes three arguments:

- A one dimensional array of deferred size of real numbers
- Two integers

The subroutine should modify the array by switching the values with the indices of the two integers. Test it with a few values.

Now, consider what happens if one or both of the integers is greater than the size of the array. How does you code behave? How would you like it to behave?

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:

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

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

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.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.