Exercise 2 – Finite differences

1. Last week you wrote a Fortran program that calculates the mean and standard deviation of a series of real numbers. Now edit the program to calculate these properties for an array. The program should:

   - Ask for the number of numbers
   - If the number entered is negative, ask repeatedly for a positive number
   - Allocate the array
   - Read the values into the array
   - Calculate the mean and standard deviation of the array
   - Display the result

   Use as many whole array operations and as few loops as possible.

2. Write a Fortran program that uses the sieve of Eratosthenes to find all prime numbers less than or equal to a given number.

3. Write a Fortran program that computes the second derivative of a 1D array using the finite difference method for a given number of grid points (n) and grid spacing (h):

$$\left(\frac{\partial^2 y}{\partial x^2}\right)_i \approx \frac{y_{i+1} - 2y_i + y_{i-1}}{h^2} \tag{1}$$

   - The second derivative is calculated at the points i = 2. . . n-1
   - At the boundaries (i=1 and n) the derivative is set to 0.
   - The result is another 1D array.

   Test the program for two idealized functions for which you know the result, e.g. sin(x) or x^2. Compare the result of your program with the correct result and calculate the error.

Deadline: Please hand in your solutions (`.f90` files and the results of the two tests) by **Tuesday, 19 March 2024, 23:59**.