Computational Methods and Modelling

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Tutorial 2
Some basic python exercises
Approximation and errors

Exercise 1: Sum of the squares of the first 20 odd natural numbers

Sum of squares of first n integers

```
# Function that returns the sum of
# square of first n natural numbers
def squaresum(n) :
    # Initialise the sum to 0
    sm = 0
    # Iterate i from 1
    # to n finding
    # the square of i and
    # add to sum.
    for i in range(1, n+1) :
        sm = sm + (i * i)
    return sm

# Main Program
# Specify n
n = 20
# Call the function squaresum
sum_numbers = squaresum(n)
# Print result on screen
print(sum_numbers)
```

- Exercise question: Calculate the sum of the squares of the first 20 **odd** natural numbers.
- The code on the left can be used to perform this summation for **all** elements, even and odd.
- Adapt this code to sum the squares of the first n **odd numbers only**.

Note: To avoid indentation errors, do not copy and paste the code from this slide. It is available on Learn in the Week 2 folder, file "sqsum.py"

Exercise 2: Working with arrays

- Arrays in python:
  - Arrays are used to store multiple values in a single variable.
  - The different values can be accessed using an index.
  - For an array with N elements, the index is in the range $0 : N - 1$.
  - While there are many ways to create and manipulate arrays in python, for the mathematical tasks typical in this course, the library "numpy" provides the most convenient tools.
- Exercise
  - Create an array x with 20 elements; all the elements must be zeros.
  - Change the values of the elements in the array with random numbers in the range $(0, 10)$.
  - Print all the elements of the array on the console.
  - Find the index of the elements that are larger than 5 and smaller than 6 and print them on the console

Exercise 3: Plotting

- Create an array x of equispaced coordinates in the range $(0, 2\pi)$
- Create an array y, where the elements of y are the sine of the elements of x. $y = sin(x)$.
- Plot y vs x in a graph.

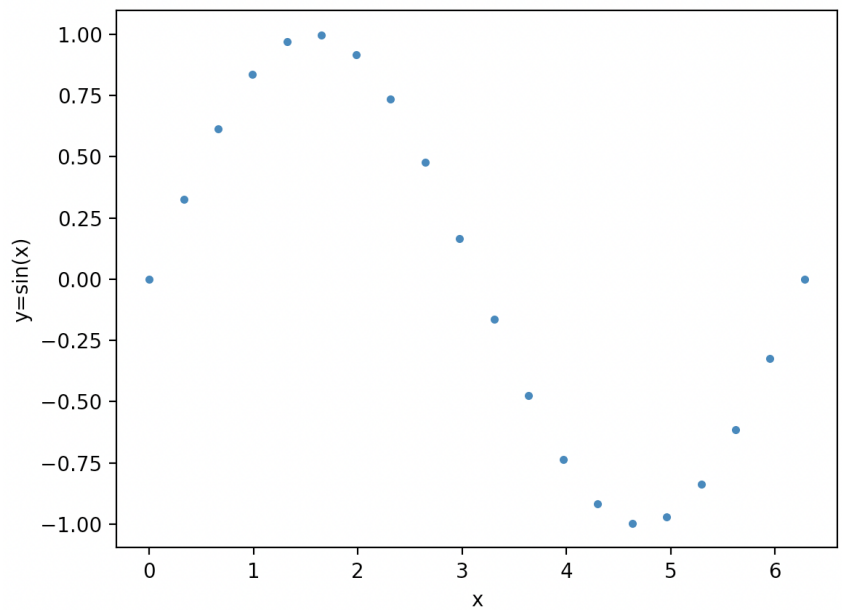

Figure: Plot of $y = sin(x)$.

Exercise 4: Error in a series approximation (exam-type question)

The following series converges to the well know mathematical constant π:

$$\sqrt{6\sum_{i=1}^{\infty}\frac{1}{i^2}} = \sqrt{6\left(\frac{1}{1}+\frac{1}{4}+\frac{1}{9}+\frac{1}{16}+\ldots\right)} = \pi \tag{1}$$

Therefore, if it is truncated to a certain specified number of terms N, it provides an approximation of π:

$$\sqrt{6\sum_{i=1}^{N}\frac{1}{i^2}} = \sqrt{6\left(\frac{1}{1}+\frac{1}{4}+\frac{1}{9}+\frac{1}{16}+\ldots+\frac{1}{N}\right)} \approx \pi \tag{2}$$

- Write python code to evaluate the truncated series in Equation 2 with a specified number of terms N. Compute and report the approximation of π obtained with exactly 10, 100, and 1000 terms ($N = 10$, $N = 100$ and $N = 1000$).
- For the same number of terms ($N = 10$, $N = 100$ and $N = 1000$), compute and report the error in the approximation of π using the two following definitions:
  - a true error, appropriately defined assuming that the true solution π is known.
  - an estimated error computed assuming that the true solution is not known.

  Provide an explanation of the definition you used for the true and estimated error.