



1. Create two integer arrays **A** and **B**. The two arrays must contain **at least** 256 elements but must be of **unequal** size. Populate both arrays with randomly generated integers between 0 and 1024. Sort array **A** using **Shell Sort** and array **B** using **Quick Sort**.
2. Take the two **sorted** arrays **A** and **B** from Question 1 above and merge into a new array **C**. You must do this in linear time. Note that the size of **C** must be size of **A** plus size of **B**.
3. Let **A** be an array of **n** elements (that is, the elements of **A** are  $A[0], \dots, A[n-1]$ ). An element  $A[i]$  is called **extreme** if the following conditions hold regarding  $A[i]$ .
  - $A[i]$  is not the first nor the last element of **A**. That is,  $0 < i < n - 1$  and either  $A[i - 1] < A[i] > A[i + 1]$  or  $A[i - 1] > A[i] < A[i + 1]$ . For example, the extreme points of an array  $[0, 5, 3, 6, 8, 7, 15, 9]$  are 5, 3, 8, 7, 15.

Write an algorithm that prints the extreme points of the given array. If there are no extreme points, the algorithm prints "**SORTED**". Do you agree that an array has no extreme points if and only if it is sorted? Explain your answer.

4. Write a program that, given a list of integers, finds all **2-pairs** of integers that have the same product. A 2-pair is 2 distinct pairs of integers  $((a,b),(c,d))$  where  $a \times b = c \times d$  and  $a \neq b \neq c \neq d$ . The range of integers in the list should be from **1** to **1024**.
5. Write a program that uses an **ADT Stack** to evaluate arithmetic expressions in **RPN** format. The contents of the stack should be displayed on the screen during evaluation. The allowed arithmetic operators are +, -, x, and /.
6. Write a Boolean function that checks if a number is **prime**. Also implement the Sieve of Eratosthenes algorithm – two separate algorithms. Explain any optimizations made.
7. Write a program that generates the **Collatz sequence** of all the integers in the range 2 to 512. The program will store the generated sequences in a CSV file.  
See [The Simplest Math Problem No One Can Solve - Collatz Conjecture - YouTube](#)
8. Write a program that finds an approximation to the **square root** of a given number **n** using an iterative numerical method such as the **Newton-Raphson Method**.
9. Write a program that, given an array of integers, finds all integers in the array that are repeated more than once. Try to find a fast and memory-efficient way of doing this.

10. Write a **recursive** function that finds the largest number in a given list of integers.
11. Write a function that computes **cosine** or **sine** by taking the first ***n*** terms of the appropriate (Maclaurin?) series expansion. Be careful with computing large factorials.
12. Write a function that returns the sum of the first ***n*** numbers of the ***Fibonacci sequence*** (Wikipedia). The first 2 numbers in the sequence are 1,1, ...

**Deadline is *Friday 31<sup>st</sup> May, 2024 at Midnight (23:59).***

**You must upload the coursework, as a *single PDF file*, to Turnitin on the VLE. You must also upload all the code, in a *single ZIP or RAR file*, to a designated area on the VLE (so I can test it).**

**Allowed programming languages are those in the slide deck introducing the study unit. Python is recommended.**

***You cannot mix languages!***

**The PDF document must include the source code, sample screen dumps, statement of completion, and explanation of how each program was tested. The Plagiarism Declaration and the Statement of Completion must be included in the PDF document.**

**You do not have to print the documentation. All submissions are digital.**

**The Statement of Completion is a list of which questions were attempted, which work, and which have bugs. For example:**

- Question 1 – Attempted and works well.
- Question 2 – Not attempted.
- Question 3 – Attempted but does not work.
- Question 4 – Attempted but has the following bug...
- Etc.

**The Statement of Completion, like the Plagiarism Declaration, must be signed and included in the single PDF document uploaded to the VLE.**

**Including images of the code is a no-no. You will get a 0 mark.**

**You must state if (and how) you used a Generative AI tools such as ChatGPT. ChatGPT is a very useful learning tool and can really improve your coding skills. You are not prohibited from using ChatGPT or any other Generative AI tool.**