# NSYSU – Data Structure – Spring 2026

## Homework 1

## Design: Designing a Polynomial Class

### Data Preparation

For this assignment, you will find a zip file named `HW1.zip` containing template files and public test data. Your task is to implement a `Polynomial` class in either Python or C++. The directory structure and contents are as follows:

1. Python Implementation (`Py/` directory):
   - ✓ `Polynomial.py`: Implement your `Polynomial` class here.
   - ✓ `test.py`: Contains public test cases for your implementation.
   - ✓ `benchmark.py`: A template for conducting benchmark analysis.
2. C++ Implementation (`Cpp/` directory):
   - ✓ `Polynomial.cpp`: Implement your `Polynomial` class here.
   - ✓ `Polynomial.h`: The header file for your `Polynomial` class.
   - ✓ `main.cpp`: Contains public test cases for your implementation.
   - ✓ `benchmark.cpp`: A template for conducting benchmark analysis.

### Description

This assignment is divided into three main parts:

1. Environment Setup:
   - ✓ Choose either C++ or Python as your programming language.
   - ✓ Set up your programming environment accordingly.
2. Class Implementation:
   - ✓ Implement a new class named `Polynomial` in the provided template file. For Python, use `Polynomial.py`. For C++, use `Polynomial.cpp`.
   - ✓ The specifications for the `Polynomial` class will be provided in the subsequent sections.
3. Time Complexity Analysis:
   - ✓ Analyze the time complexity for the following operations in your `Polynomial` class: **Addition, Subtraction and Multiplication**. Report the worst-case time complexity using Big O notation.
   - ✓ Use the benchmarking method introduced in class to validate your analysis. Implement your analysis in the provided template (`benchmark.py` for Python or `benchmark.cpp` for C++).

- ✓ Benchmark Requirements:
  - Test at least 4 different input sizes n.
  - The input sizes must grow geometrically (e.g., ×2 or ×10).
  - Measure once per n for each operation (addition, subtraction, multiplication).

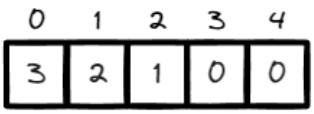
Note: You may assume that all basic operations on `lists` (or `vectors` in C++) have constant time complexity for the purpose of this analysis.

## ADT

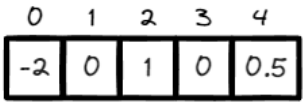
| **`Polynomial` ADT** |
|---|
| **Data:** A list (vector) that stores coefficients in **descending order** from left to right. An integer that records the degree of the polynomial. |
| **Operation:**<br>1. **Initialize:** Creates a new polynomial that is constructed using the given coefficients. It needs a list of coefficients as input and returns the polynomial.<br>2. **Addition:** Add two polynomials and return the resulting polynomial: $(\boldsymbol{x^2 + 3x + 2}) + (\boldsymbol{x + 2}) = \boldsymbol{x^2 + 4x + 4}$<br>3. **Subtraction:** Subtract one polynomial from the other and return the resulting polynomial: $(\boldsymbol{x^2 + 3x + 2}) - (\boldsymbol{x + 2}) = \boldsymbol{x^2 + 2x}$<br>4. **Multiplication:** Multiply two polynomials and return the resulting polynomial: $(\boldsymbol{x^2 + 3x + 2}) \times (\boldsymbol{x + 2}) = \boldsymbol{2x^3 + 5x^2 + 8x + 4}$<br>5. **Negation:** Negate the coefficient of a polynomial: $-(\boldsymbol{x^2 + 3x + 2}) = \boldsymbol{-x^2 - 3x - 2}$ |

## Specifications

1. Class name: `Polynomial`
2. Attribute name: `_degree, _coeff` (They should be private)
3. Method: Constructor (list of coefficients), $+$, $-$, $\times$ and negation. You should implement them using operator overloading. Note a custom `print`() method for the class is already implemented. Do not modify this method.
4. **Use a `list` (in Python) or a `vector` (in C++) to store the coefficients.**
5. **Coefficients should be stored in descending order of power (from left to right). For a polynomial with highest power $x^n$ it will contain $n + 1$ terms (Input sequences may contain leading zeros; these should be removed).**
   **Ex: $3x^4 + 2x^3 + x^2$ (Input will be [3,2,1,0,0] or [0,3,2,1,0,0] …)**



$$-2x^4 + x^2 + 0.5$$




$$x + 1$$


6. The input coefficients can be integers or floating-point numbers.
7. If all coefficients are zero, the polynomial should be represented as "0".
8. You can only use standard Python or C++ library and do not use `reverse()` or `[::-1]` method for `list` and `vector`.

## Deliverables

1. Deadline: 2026/3/20 (Fri.), 11:59 PM. Submit in the following two items to the cyber universities.
2. Report:
   - ✓ Describe your programming environment and provide instructions on how to set it up.
   - ✓ Explain the design of your program and the data structures used. Discuss what you have learned from completing this homework.
   - ✓ Provide a detailed analysis of the time complexity (Big O notation) and benchmark results for the Addition, Subtraction, and Multiplication operations in your implementation**.**
3. Program Source Files:
   - ✓ Submit your source files in a zip file. **Ensure that you follow the provided template files**.
   - ✓ Source File Comments: Each file must begin with three lines of comments indicating the Author, Date, and Purpose of the program. Include appropriate comments throughout your code for clarity.

## Grading Policy

- Function Correctness: 60% (45% for public test cases and 15% for hidden test cases).
- Report: 40%( Program design explanation and discuss:20%, Big O and Benchmark Analysis: 20%)

## Reference


1. https://python-course.eu/oop/polynomial-class.php
2. https://hplgit.github.io/primer.html/doc/pub/class/._class-readable003.html
3. https://web.ntnu.edu.tw/~algo/Polynomial.html
4. https://gist.github.com/birshert/8965693055464cb8b4e4cb16d6306fc8