

Due date is **March 26th 09:00!**

## Homework Policy

- Use comments whenever necessary to explain your code. Also, **write your name on top of each file you are sending in comment!**
- Do not forget to handle exceptions and print error messages!
- Your program should be compiled and run using g++ compiler. ITU servers provide g++ compiler, you can test your program by connecting to the servers using ssh(If you don't know how to do it, [click here](#)).
- IMPORTANT: This is an individual assignment! You are expected to act according to [Student Code of Conduct](#), which forbids all ways of cheating and plagiarism. It is okay to discuss the homework with others, but it is strictly forbidden to use all or parts of code from other students' codes or online sources and let others do all or part of your homework. **Your codes will be checked using plagiarism detection software. In case of cheating occurs, you will be subject to disciplinary actions.**
- If you have any questions, you can contact me at kamard@itu.edu.tr. Do NOT hesitate to send an e-mail if you are confused, in fact I encourage you to ask questions!

## Problem Description

In this assignment, you are going to implement classes for two mathematical expressions: **Polynomials** and **Vectors**(do not confuse this with `std::vector`). These classes will hold necessary information to represent the data, and will also support some of the mathematical operations of these expressions: In **Polynomial** class, you will implement polynomial addition and multiplication and in **Vector** class, you will implement vector addition, scalar multiplication and dot product. You will also implement a user interface for users to perform operations with **Polynomials** and **Vectors**. More details are given below.

As a reminder, following section gives basic explanations of **polynomials** and **vectors**, and how to perform the operations.

## Polynomials and Vectors

A **polynomial** is an expression in the form of

$$a_n x^n + a_{n-1} x^{n-1} + \dots a_2 x^2 + a_1 x^1 + a_0 \quad (1)$$

where  $x$  is a variable and  $a_k$  is a real number and called the coefficient of  $x^k$ . Such polynomial is called " $n$ -th" degree polynomial. For example:  $2x^3 + x^2 + 5x + 12$  is a third degree polynomial. Coefficients can be zero, so  $x^4 + 2x$  is also a polynomial and degree of it is four.

**Polynomial addition** is an operation between two polynomials and is performed by adding the coefficients of the variables with the same exponent. An example:  $(x^3 + 2x^2 + 3x + 4) + (-2x^3 + 2x - 2) = -x^3 + 2x^2 + 5x + 2$

**Polynomial multiplication** is performed by multiplying every pair of terms between two polynomials, such that  $ax^k \cdot bx^l = (a \cdot b)x^{k+l}$ . An example:  $(x^2 + 2x + 3) \cdot (x - 1) = x^3 + x^2 + x - 3$ .

The definition of a **vector** is given as "an object that has a magnitude and direction". In this assignment, we are only working with real numbers, so in the sense of list representation, we can represent a vector in an  $n$ -dimensional vector space with  $n$  real numbers, each number showing the length of vector in one axis. For example, in a 4-dimensional vector space, a vector can be represented as  $(a_1, a_2, a_3, a_4)$ , where  $a_k$  is a real number.

**Vector Addition** can be performed with two vectors in a vector space. Since the vectors must be in the same vector space, we can not perform vector addition with different sized vectors (we can extend the vectors but we will assume that it can not be performed in this homework). For example:  $(2, 3, 1) + (1, 5, 11) = (3, 8, 12)$ .  $(3, 4, 2) + (1, 2, 3, 4)$  can not be performed, since their size is not equal.

**Scalar multiplication** of a vector and a scalar is performed by multiplying all elements of a vector with a scalar such that  $(a_1, a_2, \dots, a_n)xc = (ca_1, ca_2, \dots, ca_n)$  where  $c$  is a real number.

**Dot product** between two vectors is performed by multiplying the elements that represents the same dimension and summing them together such that  $(a_1, a_2, \dots, a_n) \cdot (b_1, b_2, \dots, b_n) = a_1b_1 + a_2b_2 + \dots + a_nb_n$ . For example:  $(1, 2, 3) \cdot (2, 1, 3) = 2 + 2 + 9 = 13$ .

You can find more sources on the internet if you are not familiar with concepts above.

## Implementation Details

As explained, you will implement 2 classes and a user interface. First of all you should implement **Vector** and **Polynomial** classes in their respective header files, "**Vector.h**" and "**Polynomial.h**". In these 2 classes, following should be included:

- In the **Vector** class, size of the vector and the value array should be maintained. Similarly in **Polynomial** class, degree and values should be maintained.
- Both of the classes should have a constructor that initializes objects with given values. They should also have a copy constructor. If your class uses arrays, your copy constructor should allocate new memory for arrays in the new objects.
- You need to use operator overloading feature to implement the operations.  $+$  operation should perform vector addition in **Vector** class and polynomial addition in **Polynomial** class, while  $*$  operation should perform multiplication operations. Note that **Vector** has two forms of multiplication: scalar multiplication and dot product. You need to overload  $*$  operation such that it performs scalar multiplication when given input is integer, and dot product when given input is a **Vector**. Also do not forget that, for dot product and vector addition operations, size of the vectors must be the same!
- To print both classes, use operator overloading to overload " $<<$ " operator. Make sure to print the object in a suitable format(Example is given in the "Screen Outputs" section). Make sure that terms with higher degrees are printed out first and the terms with zero coefficient are not printed when printing **Polynomial** objects. If a term has a coefficient of 1, in that case coefficient should not be printed(Not  $1x^2$  but  $x^2$ ).
- For both of the classes, you should also implement necessary getter methods as well. You should not need setter methods for this assignment, but if you find them necessary for your implementation, you can implement them as well (However, you can NOT use setter methods to initialize values, that is constructor's job).

In your main program, you will maintain an array for **Polynomial** objects and an array for **Vector** objects, both of which will be initialized with the values read from files. You will

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be given 2 text files, one is called **Polynomial.txt** and the other one is called **Vector.txt**. Both of these files' first line indicate the number of objects they consist. Following lines give the attributes of the objects. For polynomials, in each line, first number specifies degree of polynomial, and the following numbers specify the coefficients in decreasing order. Similarly, in vector file, first number specifies size of vector, and the following numbers specify the elements of vector. For example, for polynomials, the line 3 2 3 1 4 represents the polynomial:  $2x^3 + 3x^2 + x + 4$ , and for vectors, the line 3 1 10 2 represents the vector: (1, 10, 2). Here is a screenshot of **Polynomial** textfile similar to the one you will receive:

```
5
3 1 2 4 1
3 4 10 2 7
2 2 3 1
5 1 9 13 13 8 1
1 20 40
```

Indicates there is 5 polynomials!

First line: Polynomial has a degree of "3", and coefficients are 1, 2, 4, 1. In that case, polynomials is:  $x^3 + 2x^2 + 4x + 1$

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You also need to implement a user interface that will be displayed on the terminal. The interface should provide the user possible options to perform. Each option should be assigned a number, so the user enters the corresponding number to perform the desired action. Check Screen Outputs section for clarity. Following options should be provided to user:

- Print the list of vectors and polynomials. List index should start from 1. You will
- Do a vector operation and print the result. Vectors in the operation are given with their

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index.  $1 + 2$  should perform addition with first and second vectors in the list. There will be 3 operation options here:  $+$ ,  $*$ , and  $..$

- Do a polynomial operation and print the result. Similarly, polynomials are given with their index. With polynomials, there will be 2 operation options:  $+$  and  $*$ .
- Exit the program

For both vector and polynomial operation, user should enter the operation **in a single line**. For example, when user is asked a vector operation,  $1 + 2$  should print the result of addition of vectors1 and vector2 in the list.  $1.2$  should print dot product of vectors1 and vector2, while  $1 * 2$  should print scalar multiplication of vector1 with integer 2.

## Submission

Submit your homework files through Ninova. Please zip and upload all your files using filename BLG252E\_HW\_1\_STUDENTID.zip. You are going to submit the following files:

1. Polynomial.h
2. Vector.h
3. main.cpp

In addition, you can submit any other files if you found it necessary, but above should be sufficient.

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## Screen Outputs

After you are through with everything, your program should look like below. It would be better if it looks exactly like the screenshots, but printing parts might differ and they will not affect your grade negatively. However, **in your program, user should be able to give inputs as in the screenshot!**

```
dogaykamari $ ./list
Polynomial and Vector List Program!
Polynomials and Vectors are read from text files!

Possible Actions:
1. Print Polynomial and Vector lists
2. Do a polynomial operation
3. Do a vector operation
4. Help: Print possible actions
0. Exit the program

Enter an option: 1
Vectors:
1. (1, 5, 12)
2. (6, 12, 7)
3. (1, 2, 5, 3, 2)
4. (1, 5, 12, 2, 4, 13, 2, 2)
5. (7, 102, 3, 3)
6. (10)
7. (3, 4)
8. (5, 7)

Polynomials:
1. x^3 + 3x^2 + 3x + 2
2. x^7 + 4x^6 + 7x^5 + 10x^4 + 12x^3 + 3x^2 + 8x + 1
3. x^4 + 4x^3 + 6x^2 + 17x + 81
4. x^2 + 2x + 1
5. x^4 + 5x^3 + 6x^2 + 2x + 3
6. x^5 + 2x^4 + 9x^3 + x^2 + 2x + 1
7. 10x + 1
8. 3x^2 + 12x + 2

Enter an option: 2
Which polynomial operation would you like to do?(+:addition, *:multiplication):
1+4
(x^3 + 3x^2 + 3x + 2) + (x^2 + 2x + 1) = x^3 + 4x^2 + 5x + 3

Enter an option: 2
Which polynomial operation would you like to do?(+:addition, *:multiplication):
7*8
(10x + 1) * (3x^2 + 12x + 2) = 30x^3 + 123x^2 + 32x + 2

Enter an option: 3
Which vector operation would you like to do?(+:addition, *:scalar multiplication, .:dot product):
1+2
(1, 5, 12) + (6, 12, 7) = (7, 17, 19)

Enter an option: 3
Which vector operation would you like to do?(+:addition, *:scalar multiplication, .:dot product):
5*7
(7, 102, 3, 3) * 7 = (49, 714, 21, 21)

Enter an option: 3
Which vector operation would you like to do?(+:addition, *:scalar multiplication, .:dot product):
7.8
(3, 4) . (5, 7) = 43

Enter an option: 0
dogaykamari $
```