Data Structures
Homework #4

Due: December 2, 2025 (Before class)

1. Describe a generalization of the Euler tour traversal to trees such that each internal node has three children. Describe how you could use this traversal to compute the height of each node in such a tree.

2. Draw the binary tree representation of the following arithmetic expression:
   `(((5+2)*(2-1))/((2+9)+((7-2)-1))*8)`.
   and compute the value of this expression step by step (Please drawing the intermediate steps with trees).

3. A *k-ary* tree is a tree of which each node has at most k children. What is the maximum number of nodes in a k-ary tree of height h? Prove your answer.

4. The *balance factor* of an internal node v of a proper binary tree is the difference between the heights of the right and left subtrees of v. Show how to specialize the Euler tour traversal to print the balance factors of all the internal nodes of a proper binary tree.

5. (50 pts) (**Programming Exercise**)
   Univariate polynomial of degree d has the form

   $$c_d x^d + c_{d-1} x^{d-1} + \cdots + c_2 x^2 + c_1 x + c_0,$$

   where $c_d \neq 0$. The c_i's are the *coefficients*, and $d, d-1, \cdots$ are the *exponents*. By definition, d is a nonnegative integer. In this exercise, we assume that all c_is are integers. We represent each polynomial as a linear list of coefficients and would like to have some operations (functions) on the polynomials. The first node in the list represents the first terms in the polynomial, the second node represents the second terms, and so forth.

   Each node contains three fields: the term's coefficient, the term's power, and a pointer to the next term. Write a Python program, that first reads the input file, `inFile.txt`, which has three lines and then performs the indicated operation. The first line is an integer representing the operation defined as below. The second line is the first polynomial and the next line is the second polynomial. The input polynomial, say $4x^3 - 2x + 1$, will be represented as `4x^3-2x+1`. The functions include the following operations:

   (1) `add`: Add two input polynomials.

   (2) `subtract`: Subtract the second polynomial from the first one.

   (3) `multiply`: Multiply two polynomials.

   (4) `divide`: Divide the first polynomial by the second one and return the quotient.

   The input file thus may be
   ```
   2
   4x^3-2x+1
   3x^2+x+4
   ```
   Your output will be `4x^3-3x^2-3x-3`.

About submitting this homework

1. For problem 1, 2, 3 and 4, Please

   (1) **write by hand** all of your solutions on the **papers of size A4**,

   (2) leave you name and student ID on the first page, and

   (3) hand in your solutions for problem 1, 2, 3 and 4 to me in class

2. For problem 5, things to be submitted include:

   (1) please finish each problem right after the problem description in the `HW4.ipynb` file provided on the **i-school(Plus)** (`https://istudy.ntut.edu.tw/learn/index.php`) platform with sample given input file; and

   (2) please upload the completed `.ipynb` file with the filename as `HW4_studentID.ipynb` to **i-school(Plus)**

3. **Late work** is not acceptable. Remember, the **deadline** is the midnight of **December 2**, 2025.

4. Honest Policy: We encourage students to discuss their work with the peer. However, each student should write the program or the problem solutions on her/his own. Those who copy others work will get 0 on the homework grade.