Lab 1: Review

1 Pointer

Complete the following functions

1. Swap 2 given integers.

   ```
   void swap(int* a, int* b)
   ```

2. Calculate the total value of 2 integers.

   ```
   int* sum(int* a, int* b)
   ```

3. Input an array with an unknown size.

   ```
   void inputArray(int* &a, int &n)
   ```

4. Print a given array.

   ```
   void printArray(int* a, int n)
   ```

5. Find the largest value from a given array.

   ```
   int* findMax(int* arr, int n)
   ```

6. Find the longest ascending subarray from a given array.

   ```
   int* findLongestAscendingSubarray(int* a, int n, int &length)
   ```

7. Swap 2 given arrays.

   ```
   void swapArrays(int* &a, int* &b, int &na, int &nb)
   ```

8. Concatenate 2 given arrays.

   ```
   int* concatenate2Arrays(int* a, int* b, int na, int nb, int &nc)
   ```

9. Given 2 ascending arrays with distinguishing elements. Generate a new ascending array with all elements from the given arrays.

   ```
   int* merge2Arrays(int* a, int* b, int na, int nb, int &nc)
   ```

10. Generate a random matrix with keyboard input size.

```
void generateMatrix1(int** &a, int &length, int &width)
```

11. Given two 1D arrays `a` and `b`. Generate the matrix `c` that c[i][j] = a[i] * b[j].

```
int** generateMatrix2(int* a, int* b, int na, int nb, int &crow, &ccol)
```

12. Swap 2 columns/rows of a given matrix.

```
void swapRows(int** a, int length, int width, int ir1, int ir2)
```

```
void swapColumns(int** a, int length, int width, int ic1, int ic2)
```

13. Generate the transpose matrix of a given matrix.

```
int** transposeMatrix(int** a, int length, int width)
```

14. Concatenate 2 given size-equal matrices, horizontally / vertically.

```
int** concatenate2MatricesH(int** a, int** b,
                             int length, int width, int &lres, int &wres)
```

```
int** concatenate2MatricesV(int** a, int** b,
                             int length, int width, int &lres, int &wres)
```

15. Multiple 2 given matrices.

```
bool multiple2Matrices(int**& res, int** a, int **b, int& lengthr, int& widthr, int lengtha,
                       int widtha, int lengthb, int widthb)
```

16. Given a matrix a. Find the submatrix of a which satisfies keyboard input size and has the largest total value of its elements.

```
int** findSubmatrix(int** a, int length, int width, int &lres, int &wres)
```

From No. 17. *to No.* 20. *are Searching Algorithms. Return the first position found, else, return* -1.

17. Sequential Search.
    - `int LinearSearch(int* a, int n, int key)`
18. Sequential Search uses a flag.
    - `int SentinelLinearSearch(int* a, int n, int key)`
19. Binary Search in sorted array a.
    - `int BinarySearch(int* a, int n, int key)`
20. Binary Search in sorted array a uses recursion.
    - `int RecursiveBinarySearch(int* a, int left, int right, int key)`

2 Recursion

Complete the following functions using the Recursion technique (*you may declare some sub-functions*):

1. Calculate the sum of $S = 1 + 2 + 3 + ... + n$.
2. Calculate the factorial $n! = 1 * 2 * 3 * ... * n$.
3. Calculate x^n.
4. Count the number of digits of a given integer.
5. Verify if every digit of a given integer is even.
6. Count the number of common divisors of 2 given integers.
7. Calculate the Greatest common divisor and Least common multiple of 2 given integers.
8. Calculate the reverse value of a given integer.
9. Calculate the i^{th} Fibonacci number.
   - $F_0 = 0, F_1 = 1$
   - $F_n = F_{n-1} + F_{n-2}, (n \geq 2)$
10. * Given 4 single distinguish characters. Print out all possible permutations.
    - Example: ABCD, ABDC, ACBD, ...

3 File Handling

3.1 Data Description

This given data is the anonymized data of the results of the National High School Graduation Exam 2018 - 2019. The information is provided in the file *"data.txt"*, which has the first few lines as follows:

```
Số Báo Danh, Họ và Tên, Toán, Ngữ Văn, Vật Lý, Hóa Học, Sinh Học, Lịch Sử, Địa Lý, GDCD, KHTN, KHXH, Ngoại Ngữ, Ghi Chú, Tỉnh
BD1200000,,8.6,6.5,4.0,7.25,5.5,,,,,,8.4,N1,BinhDinh
BD1200001,,4.0,5.0,,,,4.25,7.0,7.75,,,2.0,N1,BinhDinh
BD1200002,,7.0,6.25,6.0,6.25,6.5,,,,,,5.2,N1,BinhDinh
BD1200003,,5.2,5.75,,,,5.75,7.25,9.25,,,4.6,N1,BinhDinh
BD1200004,,7.6,6.25,7.0,6.5,4.5,,,,,,6.2,N1,BinhDinh
BD1200005,,8.6,6.5,4.0,7.25,5.5,,,,,,8.4,N1,BinhDinh
```

in which:

- The first line provides the included information fields.
- For the next lines, each one is the information of 1 candidate, separated by a comma ",".
- The empty fields mean there is no information. If the empty field is a subject, that is equal to a 0.
- The scores in the fields of Natural Sciences (KHTN) and Social Sciences (KHXH) will be instructed in the next part.

3.2 Programming

Given the `Examinee` data structure definition:

```
// Examinee.h
struct Examinee
{
    string id;
    float maths, literature, physics, chemistry, biology, history, geography, civic_education, natural_science,
        social_science, foreign_language;
};
```

Fulfill the following requirements:

1. Read the information of one examinee:
   - `Examinee readExaminee(string line_info);`
   - **Input**: `line_info` - a line from *"data.txt"* which provides the information of 1 examinee.
   - **Output**: Return `Examinee` variable, which stores the info of the given examinee.
   - Note: The scores of Natural Sciences and Social Sciences column in *data.txt* is not available by default. Calculate the scores for each combination and store them into struct `Examinee`.
     - The score of Natural Sciences combination = physics + chemistry + biology.
     - The score of Social Sciences combination = history + geography + civic education.
2. Read the information of a list of examinees:
   - `vector<Examinee> readExamineeList(string file_name);`
   - **Input**: `file_name` - path to input file *"data.txt"*.
   - **Output**: `vector<Examinee>` variable, which stores the info of all examinees from the file.
3. Write scores of examinees to file:
   - `void writeScores(vector<Examinee> examinee_list, string out_file_name);`
   - **Input**: `examinee_list` - List of examinees.
     `out_file_name` - name of file to write.
   - **Output**: Write to output file Compulsory Scores (BB), Natural Sciences Scores (KHTN), and Social Sciences (KHXH) of each examinee using the following format:
     - The first line contains header information: "SBD BB KHTN KHXH".
     - Each next line contains info of only one examinee: ID, Compulsory Scores, Natural Sciences Scores, and Social Sciences Scores separated by a single space.
     - The Compulsory Scores = maths + literature + foreign language.
   - **Example**:

     SDB BB KHTN KHXH
     XX001 28.0 29.25 0.0
     ...
     XX999 20.0 0.0 28.75

4 Linkedlist

Given the following Linkedlist definition:

```
struct NODE {
    int key;
    NODE* pNext;
};
```

```
struct List {
    NODE* pHead;
    NODE* pTail;
};
```

Complete the following functions to fulfill the given requirements:

1. Initialize a `NODE` from a given integer:
   - `NODE* createNode(int data)`
2. Initialize a `List` from a give `NODE`:
   - `List createList(NODE* pNode)`
3. Insert an integer to the head of a given `List`:
   - `void addHead(List &L, int data)`
4. Insert an integer to the tail of a given `List`:
   - `void addTail(List &L, int data)`
5. Remove the first `NODE` of a given `List`:
   - `void removeHead(List &L)`
6. Remove the last `NODE` of a given `List`:
   - `void removeTail(List &L)`
7. Remove all `NODE` from a given `List`:
   - `void removeAll(List &L)`
8. Remove node before the node has `val` value in a given `List`:
   - `void removeBefore(List L, int val)`
9. Remove node after the node has `val` value in a given `List`:
   - `void removeAfter(List L, int val)`
10. Insert an integer at a position of a given `List`:
    - `void addPos(List &L, int data, int pos)`
11. Remove an integer at a position of a given `List`:
    - `void removePos(List &L, int pos)`
12. Insert an integer before a value of a given `List`:
    - `void addBefore(List L, int data, int val)`
13. Insert an integer after a value of a given `List`:
    - `void addAfter(List L, int data, int val)`
14. Print all elements of a given `List`:
    - `void printList(List L)`
15. Count the number of elements `List`:
    - `int countElements(List L)`
16. Create a new `List` by reverse a given `List`:
    - `List reverseList(List L)`
17. Remove all duplicates from a given `List`:
    - `void removeDuplicate(List &L)`
18. Remove all `key` value from a given `List`:
    - `bool removeElement(List &L, int key)`

5 Doubly Linkedlist

Following is the representation of a doubly linked list:

```
struct DNODE {
    int key;
    DNODE* pNext;
    DNODE* pPrev;
};
```

```
struct DList {
    DNODE* pHead;
    DNODE* pTail;

};
```

Implement functions to execute the operations from singly linkedlist section 4.

6 Stack - Queue

Following is the representation of a Singly linked list node:

```
struct NODE {
    int key;
    NODE* pNext;
};
```

Utilize the Linked list above, define the data structure of Stack and Queue, and then implement functions to execute the following operations:

1. Stack
   - **Initialize** a stack from a given key.
   - **Push** a key into a given stack.
   - **Pop** an element out of a given stack, the key's value will be returned.
   - **Count** the number of elements of a given stack.
   - Determine if a given stack **is empty**.
2. Queue
   - **Initialize** a queue from a given key.
   - **Enqueue** a key into a given queue.
   - **Dequeue** an element out of a given queue, the key's value will be returned.
   - **Count** the number of elements of a given queue.
   - Determine if a given queue **is empty**.