CSCI 160 Final Exam – Dec 16, 2021
Out of XX marks NAME:____________________________________

# 1 While and For loop code fragments

1. Write a for-loop that sums the first ten floats in array `arr` and stores the result in a variable called `sum10`. You do not have to declare `arr`, but you should declare `sum10`.

2. Write a while-loop that searches int array `arr` for the first occurence that is greater than or equal to 100. `arr` is of size `size`, and both `arr` and `size` are already declared and have values. If there exists such an element in the array, print out the message "Contains value ¿= 100"; otherwise print out "Does not contain value ¿= 100".

# 2 If and Switch statements, structs plus loops

3. (a) Declare a struct to store courses, each course having a four-character department (like CSCI) and an integer (like 160), and a term ('F', 'S', 'I'), and a section number (an int).

   (b) `Course courseOfferings[MAXNUMCOURSES];` Suppose the above is an array of all the courses. Declare sufficiently large arrays fallCourses, springCourses, intersessionCourses, and copy the courses from courseOfferings into these three arrays, such that 'F' courses are copied into fallCourses, 'S' courses into springCourses, and 'I' courses into intersessionCourses.

# 3 Recursion

4. Write in C++ a **recursive** function called `max` that takes as input an array `arr` of non-negative float values, and the `int size` of the array `arr`, and returns the maximum value in the array `arr`. The returned value will be of type `float`. Use a for-loop to conduct the search for the maximum value.

5. Consider starting with any number, call it $n$. If $n$ if 1, halt; if $n$ is even divide $n$ by 2. If it is odd, multiply it by 3 and add 1. Now you have a new $n$, and repeat. A sequence results, depending on where you start. For example, if you start with 3, the sequence is 3, 10, 5, 16, 8, 4, 2, 1. We call that the Collatz sequence for 3.

   The Collatz Conjecture states that for every positive integer $n$, the sequence will eventually end in the value 1. Quadrillions of integers have been tested and they all to eventually converge to 1 – in fact, they've checked all integers up to $2.95 * 10^{20}$. The question we want answered is, how long is the Collatz sequence for a given integer $n$?

   Write a recursive function `collatz` that takes an integer $n$ and returns the length of $n$'s collatz sequence. Note: it might run forever if the Collatz Conjecture is false and you happen to enter a value for which Collatz sequence does not converge – we'll take that risk!

6. How many $n$-bit strings are there containing $k$ 1's? For example, there are three 3-bit strings containing one 1: 001, 010, 100. There is a formula for this value, but let's compute it recursively just for fun. Write a recursive function

   ```
   int numBitStrings(int n, int k)};
   ```

   that computes the number of bitstrings of length $n$ containing $k$ 1's.

7. (8 marks) Write a function called `fib` that recursively computes the $n^{\text{th}}$ Fibonacci number. The input parameter is an integer $n$. The output is also of type `int`. When $n$ is 0, the returned value should be 0. When $n$ is 1, the returned value should be 1. For larger $n$, the value returned should accord with the formula $fib(n) = fib(n-1) + fib(n-2)$.

## 4 Structs, and sorting

8. Given the definitions below, write the function called insertStud as per the prototype. Assume that the array students is **sorted**, and your insertStudent must leave the array sorted, with the new student added, and with numstudents increased.

```
struct Student {
   int studentNo;
   string fname;
   string lname;
};

const max=10000;
Student students[max];
int numstudents;

void swap(Student &x, Student &y) {
   float temp = x;
   x = y;
   y = temp;
}

void insertStudent(Student stud);
```

## 5 Binary Search, and BubbleSort

9. Binary Search takes a sorted array `arr` of values and a target value $t$ and returns the index $i$ such that `arr[i]` $= t$.
Suppose `arr = [8 9 12 14 17 33 38 40 41 59 101 108 173 188 217 ]`
and suppose $t = 8$. Exactly what values and will Binary Search compare to $t$ in the course of searching for $t$, and what is the index of each value? What if $t = 38$? $t = 108$?

10. Adapt BubbleSort so that it will find the tenth-smallest and the tenth-largest integers $x$ and $y$, and will use no more than 20 passes. Here is the prototype:

```
// x will be the 10th smallest, i.e., there are nine values smaller
// than it in arr, and y will be the tenth largest, in arr, after
// calling the following function.
void xAndY(float arr[], int size, float &x, float &y);
```

and here is the original code for bubblesort:

```
void bubblesort( float arr[], int size) {
for (int pass=0; pass < size-1; pass++) {
for (int pair=1; pair<size; pair++) {
if (arr[pair-1] > arr[pair] {
swap(arr[pair-1], arr[pair]);
}
}
}
}
```

Provide the code for `xAndy`. Then write a code fragment that finds the tenth smallest value and the tenth largest value in an array `rr` and prints out the result to cout.

# 6 Pointers and Dynamic Data Structures

Assume the following struct is defined, as well as the following pointers.

```
struct Node {
string name;
int customNo;
Node* next;
};

// These pointers define our list.  They are initially NULL.
Node* head=NULL;
Node* tail=NULL;
```

11. Give a function that takes a string and an int as parameters, creates a new Node, stores the string as name and the int as customNo, and returns a pointer to that Node.

12. Give a function that takes a pointer to a Node and inserts that at the tail of the list.

13. Give a function that prints out all the customNo values, separated by " ", to cout, in the order they occur in the list, starting at head.

Challenge! Give a *recursive* function that sorts the linked list, pointed to by head, in order of customNo. At the end, head should point to the first element of the sorted list.