Answer:

Final Exam S25 Final V1

CSCI 13500: Software Analysis and Design 1

Hunter College, City University of New York

May 21, 2025, 11:30 AM - 1:30 PM, N118

Exam Rules

- Show all your work. Your grade will be based on the work shown.
- The exam is closed book and closed notes with the exception of a provided cheat sheet.
- When taking the exam, you may bring pens and pencils.
- Scratch paper is provided. For your convenience, you may take the scratch paper and cheat sheet off. But make sure **not** to put solutions to the scratch paper.
- You may not use a computer, calculator, tablet, phone, earbuds, or other electronic device.
- Unless the problem explicitly requests, no need to include libraries and using namespace std.
- **Do not open this exam until instructed to do so.**

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1 (30 points) Answer the following questions.

(1) Given `string groceries[] = {"cake mix", "grape juice", "apple pie"}`, what is the value of groceries[1].substr(4, 3)?

Answer: groceries[1].substr(4, 3) is "e j". Explanation: groceries[1] is the second element of array of strings, which is "grape juice". Expression groceries[1].substr(4, 3) is the substring from the fifth letter – index 4 – of this string spanning with 3 letters, which is substring "e j".

(2) Given a declaration `std::vector<int> v(3, 1); v.push_back(2);`, what is the value of v.size()?

Answer: 4

explanation: `vector<int> v(3);` creates a vector of integers with 3 elements. After push one more element to it, v has one more element. Hence, `v.size()` returns the number of elements of v, which is 4 in this example.

(3) What is the **maximum** integer that expression rand() % 5 -2 can generate?

Answer: 2

`rand() % 5` generates a random int in [0, 4].

`rand() % 5 - 2` generates a random int in [-2, 2].

The maximum random int generated is 2.

(4) Given Given int `num = std::to_string(15).size() + 3;`, where `to_string` converts an integer to a string and `size` method returns the number of characters of a string. What is the value for num?

Answer: 5

```
std::to_string(15) converts integer 15 to string "15".

std::to_string(15).size() is 2, the number of characters in string "15".

std::to_string(15).size() + 3 is 2 + 3, which returns 5.
```

(5) What is the value of `5 - 4 / (8 % 5)` in C++?

Answer: 4

Explanation: (1) expression in parentheses runs first. Run 8 % 5 and get 3. It is like to divide 8 pens among 5 persons, each person get 1 pens, three pens left. (3) Operator / has higher precedence than operator -. Run 4 / 3 and get 1. (4) 5 - 1 returns 4.

(6) Write **header** of a function called hasPositive, given an array *arr* of double type with *size* many elements, return whether the array has at least a positive number or not. If yes, return true, otherwise, return false.

Answer: `bool hasPositive(double* arr, int size);` or `bool hasPositive(double arr[], int size`

(7) Declare class Time as follows.

```
class Time {
public:
    int hour;
    int minute;
};
```

Declare a Time object `curr` and initialize its hour as 10 and minute as 25.

Answer:

```
Time curr = {10, 25};
```

or

```
Time curr{10, 25};
```

or

```
Time curr;
curr.hour = 10;
curr.minute = 25;
```

(8) Given `int grades[] = {73, 92, 62};` What is the value of `*(grades + 1)`?

Answer: 92

grades is name of array grades, which is also the initial address of grades, aka, the address of the first element of the array.

grades + 1 is the address of the second element of the array.

*(grades + 1) is the element residing in the address of the second element of the array. In short, *(grades + 1) is the second element of the array, which is 92 in this example.

(9) Given the following code segment.

```
//foo works with array pf of double type with size many elements
void foo(double *pf, int size);

int main() {
    double *arr = new double[10];

    //TODO: write a statement to call foo for dynamically allocated array arr and
       its size.
    //WRITE YOUR ANSWER IN THE FOLLOWING BOX.

    %

    Answer: penalize(arr, 170);
```

```
13
14      delete[] arr;
15      arr = nullptr;
16
17      return 0;
18  }
```

Answer: `foo(arr, 10);`

(10) Suppose we have main function defined as follows.

```
1  int main() {
2     int a = 1;
3     int b = foo(&a, "hello");
4     return 0;
5  }
```

What is the **header** of function foo?

Answer: `int foo(int* a, string str);`

(11) What is output for the following code?

```
1  string s = "abc";
2  string *p = &s;
3  *p += "123";
4  cout << s << endl;
```

Answer: abc123

Explanation: after `string* p = &a`, which saves a's address to pointer p, then $*p$ represents the guy who lives in the address of variable a. Note that no two variables can reside in the same address, so *p is an alias of variable a.

*p += "123"; is the same as $*p = *p +$ "123";; which concatenate "123" to the end of *p. Thus, $*p$ changes from the initital value "abc" to "abc123". Then s is "abc123".

(12) What is the output for the following code?

```
1  vector<int> nums = {2, 0, -2, 5};
2
3  int count = 0;
4  for (int i = 0; i < nums.size(); i++)
5      if (nums[i] > 0)
6         count++;
7
8  cout << count << endl;
```

Answer: 2

Find out all positive integers in nums.

(13) What the output of the following code?

```
#include <iostream>
#include <string>
using namespace std;

int main() {
    for (int row = 0; row < 3; row++) {
        for (int col = 0; col < 4; col++) {
            if (col % 2 == 0)
               cout << "*";
            else cout << "#";
        }
        cout << endl;
    }
    return 0;
}
```

Answer:

```
*#*#
*#*#
*#*#
```

(14) What is the output of the following code? Assume that libraries and standard namespace are set up.

```
void foo(vector<string>& v);

int main() {
    vector<string> v = {"hello", "hi", "great", "hey"};
    foo(v);

    for (int i = 0; i < v.size(); i++)
        cout << v[i] << " ";
    cout << endl;

    return 0;
}

void foo(vector<string>& v) {
    int i = 0;
    int j = v.size() - 1;
    while (i < j) {
        swap(v[i], v[j]);
```

```
        i++;
        j--;
    }
}
```

Answer: ”hey great hi hello ” (without double quotes) and followed by a return key.

(15) Given the following code, fill in the TODO part.

```
class Coord2D {
public:
    double x; //x-coordinate
    double y; //y-coordinate
};

double foo(Coor2D point) {
    //TODO: return the sum of x- and y-coordinates of point
    //WRITE YOUR CODE IN THE FOLLOWING BOX.

}
```

Answer:

```
#include <iostream>
#include <string>
using namespace std;

class Coord2D {
public:
    double x;
    double y;
};

double foo(Coord2D point);

int main() {
    Coord2D point = {3, 5};
    cout << foo(point) << endl;
    return 0;
}

double foo(Coord2D point) {
    return point.x + point.y;
}
```

2 (15 points) Answer the following questions.

(1) Define a function, `alpha_space_only`, for a given string s, if it is **non-empty** and contains **only** alpha and spaces, return true, otherwise, return false.

For example, `alpha_space_only("")` returns false since it is an empty string.

`alpha_space_only("Abc efg")` returns true.

`alpha_space_only("A! b")` returns false since symbol ! is not an alpha or a space.

Hint: you might use the following functions from `cctype` library.

int isalpha (int c); Check if character is alphabetic or not

int isspace (int c); Check if character is a whitespace or not

Answer:

```cpp
//Define a function, alpha_space_only, for a given string s,
//if it is non-empty and contains only alpha and spaces, return true, otherwise,
   return false.
#include <iostream>
#include <string>
using namespace std;

bool alpha_space_only(string s);

int main() {
    cout << boolalpha << alpha_space_only("") << endl; //false
    cout << boolalpha << alpha_space_only("abc") << endl; //true
    cout << boolalpha << alpha_space_only("Abc Efg") << endl; //true
    cout << boolalpha << alpha_space_only("Efg") << endl; //true
    cout << boolalpha << alpha_space_only("Efg#") << endl; //false

    return 0;
}

bool alpha_space_only(string s) {
    if (s == "")
       return false;

    for (int i = 0; i < s.size(); i++)
        if (!isalpha(s[i]) && !isspace(s[i]))
           return false;

    return true;
}
```

(2) Write a function `pointerToMax` that returns a **pointer** to the **first** occurrence (if there are more than one occurrence) of the maximum value of an array of double type with *size* many elements.

If size is 0, return nullptr.

For example, suppose an array has elements 1.1, 3.3, 2.2, 3.3, 1.1, then the return of the function is a pointer to the second element.

Hint: you may use an index to the maximum element. Then use index and array name to get the pointer.

Answer:

```
double* pointerToMax(double* arr, int size) {
    if (size == 0)
       return nullptr;

    int maxIdx = 0;
    for (int i = 0; i < size; i++)
        if (arr[i] > arr[maxIdx])
           maxIdx = i;

    return maxIdx + arr;
}
```

A complete code is as follows.

```
#include <iostream>
#include <string>
using namespace std;

double* pointerToMax(double* arr, int size);

int main() {
    double arr[] = {1.1, 3.3, 2.2, 3.3};
    int size = sizeof(arr) / sizeof(arr[0]);

    cout << pointerToMax(arr, size) << endl; //a pointer to the second element
    cout << pointerToMax(arr, size) - arr << endl;
        //show offset of maximum element to the initial address of array

    return 0;
}

double* pointerToMax(double* arr, int size) {
    if (size == 0)
       return nullptr;

    int maxIdx = 0;
    for (int i = 0; i < size; i++)
        if (arr[i] > arr[maxIdx])
           maxIdx = i;
```

```
26
27      return maxIdx + arr;
28  }
```

3 (10 points) Programming exercise on class

1. Define class for representing length in feet and inches. It is reasonable to define it to have two integer fields:

   `foot` for the number of feet, and

   `inch` for the number of inches. Note that a foot has 12 inches, so we need to make sure that inch is in [0, 11].

   Declare class `Length` with public data members `foot` and `inch`, both of `int` type.

   Define non-member function `add`, given Length objects len and len2, the function should create and return a length object that is the sum of `len` and `len2`. Example:

   ```
   add({2, 8}, {3, 9}) // should return {6, 5}
   ```

   Reason: 2 feet 8 inches is 2 * 12 + 8 = 32 inches. Also, 3 feet and 9 inches is 3 * 12 + 9 = 45 inches. Then 32 + 45 = 77 inches, which equals 6 feet and 5 inches.

   Answer:

```
1  class Length {
2  public:
3      int foot;
4      int inch; //value in [0, 11]
5  };
```

   Answer:

```
1  #include <iostream>
2  #include <string>
3  using namespace std;
4
5  class Length {
6  public:
7      int foot;
8      int inch; //value in [0, 11]
9  };
10
11 Length add(Length len, Length len2);
12
13 int main() {
14     Length len = {2, 8};
15     Length len2 = {3, 9};
```

```
16
17      Length total = add(len, len2);
18      cout << total.foot << " " << total.inch << endl; //6 5
19
20      return 0;
21  }
22
23  Length add(Length len, Length len2) {
24      int total_inches = len.foot * 12 + len.inch;
25      int total_inches2 = len2.foot * 12 + len2.inch;
26
27      int sum = total_inches + total_inches2;
28      return {sum / 12, sum % 12};
29  }
```

4 (10 points) Write codes of vector

Define a function called `choose`, for a vector `v` of strings and a character (type char) `ch`, return a vector with all the elements from `v` whose strings **starting** from ch, in the same order. String `s` **starts** with character `ch` means `ch` is the **first** character of `s`.

For example, given a vector of strings with elements `"apple", "banana", "", "ABC", "almond"` and character 'a', the return is a vector with elements `"apple", "almond"`. Note that C++ is a case sensitive language, so 'a' is different from 'A'.

Hint: you may need to consider the case when a string is empty.

Answer:

```
1  vector<string> choose(vector<string> v, char ch) {
2      vector<string> result;
3
4      for (int i = 0; i < v.size(); i++)
5          if (v[i].size() > 0 && v[i][0] == ch)
6              result.push_back(v[i]);
7
8      return result;
9  }
```

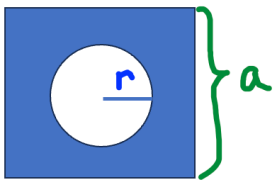
A complete code is shown as follows.

```
1  #include <iostream>
2  #include <string>
3  #include <vector>
4  using namespace std;
5
6  //sample output:
7  //apple
8  //almond
```

```cpp
vector<string> choose(vector<string> v, char ch);

int main() {
    vector<string> v = {"apple", "", "banana", "ABC", "almond"};
    vector<string> result = choose(v, 'a');

    for (string elm: result)
        cout << elm << endl;

    return 0;
}

vector<string> choose(vector<string> v, char ch) {
    vector<string> result;

    for (int i = 0; i < v.size(); i++)
        if (v[i].size() > 0 && v[i][0] == ch)
          result.push_back(v[i]);

    return result;
}
```

5 (15 points) Define class.

1. Define a CirSq as the region between a circle nested into a square. The shapes are concentric (share the same center). It has two parameters:



   (a) radius of the circle **r**

   (b) edge of the square **a**

2. **Assume that CirSq.hpp is provided** where data members **r** and **a** are declared as double types. **Your job** is to define **CirSq.cpp** with the following requirement.

3. Define a default constructor, set data members **r** to be 1 and **a** to be 2.5.

Answer:

```cpp
CirSq::CirSq() {
    r = 1;
```

```
    a = 2.5;
}
```

4. Define a non-default constructor, which takes formal parameters r and a, both are double types.

   (a) If both r and a are positive and a is at least twice of r, set data member **r** by given parameter r and set data member **a** by given parameter a.

   (b) otherwise, set data members **r** to be 1 and **a** to be 2.5.

Answer:

```
CirSq::CirSq(double r, double a) {
    if (r > 0 && a > 0 && a >= 2*r) {
       this->r = r;
       this->a = a;
    }
    else {
        this->r = 1;
        this->a = 2.5;
    }
}
```

5. Define method **getArea**, return the value of $a^2 - \pi r^2$, where π is defined as `M_PI` in `cmath` library. Note that a and r are data members.

Answer:

```
double CirSq::getArea() const {
    return a * a - M_PI * r * r;
}
```

6. Define method **getPerimeter**, which returns $4a + 2\pi r$. Note that a and r are data members.

Answer:

```
double CirSq::getPerimeter() const {
    return 4 * a + 2 * M_PI * r;
}
```

Define **CirSqTest.cpp**, do the following:

7. Create a CirSq object named **shape** from its non-default constructor with the radius of the circle as 1 and the edge of the square as 3.

Answer:

```
    CirSq shape(1, 3);
```

8. Find out and print the area of **shape**.

Answer:

```
    cout << "area: " << shape.getArea() << endl;
```

9. Find out and print the perimeter of **shape**.

Answer:

```
    cout << "perimeter: " << shape.getPerimeter() << endl;
```

Answer: A complete code is as follows.
code of CirSq.hpp

```
#ifndef CIR_SQ_H
#define CIR_SQ_H
class CirSq {
public:
    CirSq();
    CirSq(double r, double a);
    double getArea() const;
    double getPerimeter() const;

private:
    double r; //radius of the circle
    double a; //edge of the square
};
#endif
```

Code of CirSq.cpp

```
#include "CirSq.hpp"
#include <cmath>

CirSq::CirSq() {
    r = 1;
    a = 2.5;
}

CirSq::CirSq(double r, double a) {
    if (r > 0 && a > 0 && a >= 2 * r) {
       this->r = r;
       this->a = a;
    }
    else {
        this->r = 1;
```

```
        this->a = 2.5;
    }
}

double CirSq::getArea() const {
    return a * a - M_PI * r * r;
}

double CirSq::getPerimeter() const {
    return 4 * a + 2 * M_PI * r;
}
```

code of CirSqTest.cpp

```
#include <iostream>
#include <string>
#include "CirSq.hpp"
using namespace std;

//sample output:
//area: 3.10841
//perimeter: 16.2832
int main() {
    CirSq shape;
    cout << "area: " << shape.getArea() << endl;
    cout << "perimeter: " << shape.getPerimeter() << endl;

    return 0;
}
```

6 (10 points) function on vectors

Define a function called `fourOrMoreSucc`, given a vector of integers `v` and an integer `toAdd`, do the following:

(1) Push `toAdd` to the back of `v` using `push_back` method of vector.

(2) Test whether there were 4 or more **consecutive** items in the **back** of the vector. If so, return true, otherwise, return false.

For example, if the vector has elements {3, 2, 3}, and the element to add is 3, then the return is false. Reason: after pushing 3 to the back of the vector, the elements change to {3, 2, 3, 3}, but there are only two **consecutive** 3's in the **back** of the vector.

If the vector has elements {1, 2, 3, 3, 3}, and the element to add is 3, then the return is true. Reason: after pushing 3 to the back of the vector, the elements change to {1, 2, 3, 3, 3, 3}, and there are four **consecutive** 3's in the **back** of the vector.

Answer: function compare is defined as follows.

```
bool fourOrMoreSucc(vector<int> v, int toAdd) {
    v.push_back(toAdd);

    int count = 0;
    for (int i = v.size() - 1; i >= 0 && v[i] == toAdd; i--)
        count++;

    return (count >= 4);
}
```

A complete code is as follows.

```
#include <iostream>
#include <string>
#include <vector>
using namespace std;

bool fourOrMoreSucc(vector<int> v, int toAdd);

int main() {
    vector<int> v = {3, 1, 3};
    cout << boolalpha << fourOrMoreSucc(v, 3) << endl; //false

    vector<int> v2 = {3, 1, 3, 3, 3};
    cout << boolalpha << fourOrMoreSucc(v2, 3) << endl; //true

    return 0;
}

bool fourOrMoreSucc(vector<int> v, int toAdd) {
    v.push_back(toAdd);

    int count = 0;
    for (int i = v.size() - 1; i >= 0 && v[i] == toAdd; i--)
        count++;

    return (count >= 4);
}
```

7 (10 points) Define recursive function

Define a recursive function `reverse`, given an array of int with size many elements, reverse its elements. That is, swap the first and the last elements, swap the second and second to last elements, and so on. The return type is `void`.

For example, if an array with elements 1, 2, and 3, after the reverse, the array becomes

3, 2, 1

Warning: If you do not use recursion, you will not get any point.
No repetition statement, global or static variables are allowed in this function.
Use array, not vector.

Answer: Code of function is as follows.

```
void reverse(int arr[], int size) {
    if (size <= 1)
       return;

    //size >= 2
    swap(arr[0], arr[size-1]);
    reverse(arr+1, size-2);
}
```

A complete code is as follows.

```
#include <iostream>
#include <string>
using namespace std;

void reverse(int arr[], int size);

int main() {
    int arr[] = {1, 2, 3};
    int size = sizeof(arr) / sizeof(arr[0]);

    reverse(arr, size);

    for (int i = 0; i < size; i++)
        cout << arr[i] << " ";

    cout << endl;

    return 0;
}

void reverse(int arr[], int size) {
    if (size <= 1)
       return;

    //size >= 2
    swap(arr[0], arr[size-1]);
    reverse(arr+1, size-2);
}
```