

NWEN 241 SYSTEMS PROGRAMMING FINAL TEST

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FINAL TEST – 2021

TRIMESTER 1

NWEN 241
SYSTEMS PROGRAMMING

Time Allowed: TWO HOURS

CLOSED BOOK

Permitted materials: Only silent non-programmable calculators or silent programmable calculators with their memories cleared are permitted in this test.
No electronic dictionaries are allowed.
Paper foreign to English language dictionaries are allowed.

Instructions: Attempt ALL TEN (10) questions:

1. C Fundamentals. [10 marks]
2. Arrays, Strings and Pointers. [20 marks]
3. User-Defined Types and Linked Lists. [12 marks]
4. Storage Classes and Dynamic Memory. [13 marks]
5. C File Stream I/O. [5 marks]
6. Process Management and Socket Programming. [10 marks]
7. C++ Classes. [24 marks]
8. Dynamic Memory in C++. [6 marks]
9. Templates and Containers. [15 marks]
10. File I/O in C++. [5 marks]

The test consists of 120 marks in total.

1. C Fundamentals. (10 marks)

- (a) Declare a macro symbolic constant SPEED with a single-precision floating point value 3.25×10^{-26} . (2 marks)

- (b) A C program contains the following declarations: (2 marks)

```
int i, j;  
long ix;  
short s;  
float x;
```

What is the resulting **data type** of the expression

(int) ix / s - 2.5 * 'Z' + x * i / j ?

- (c) Consider the following C program: (2 marks)

```
#include <stdio.h>  
  
int func(int a, int b)  
{  
    return a * --b;  
}  
  
int main(void)  
{  
    int i = 5;  
    int j = 2 * func(1+2, i+1);  
    printf("%d %d", i, j);  
    return 0;  
}
```

What is the output of the program?

- (d) Re-write `func(int a, int b)` in program in (c) into a function-like macro `FUNC(A, B)`, such that when the call to `func(1+2, i+1)` in the program is replaced with `FUNC(1+2, i+1)`, the outputs will remain the same.

(2 marks)

- (e) What is the output of the following C program?

(2 marks)

```
#include <stdio.h>

int main(void)
{
    for (int i = 0; i < 10; i++)
        if (i % 3)
            printf("%d ", i);
    return 0;
}
```

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Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

2. Arrays, Strings and Pointers. **(20 marks)**

- (a) Using only one C statement, declare an array which can hold 100 integers with initial values 1, 2, 3 and 4 for the first four elements, and 0 for the remaining elements. Name this array `iarray`. **(2 marks)**

- (b) Declare a C string symbolic constant named `STRING` using macro with value `"Hello, world"` **(2 marks)**

- (c) Consider the following C program: **(2 marks)**

```
#include <stdio.h>

#define S1 "ABCD"
#define S2 "1234"

int main(void)
{
    char *str = S1 S2;
    printf("%s", str);
    return 0;
}
```

Will the program compile? Briefly explain your answer.

(d) Consider the following C code snippet:

```
char carray[] = "ABCD\0WXYZ";
```

i. What is the value of the expression `sizeof(carray)`? **(2 marks)**

ii. What is the value of the expression `strlen(carray)`? **(2 marks)**

(e) Given the following array and pointer declarations:

```
short sarray[] = {1,2,4,8,16};  
short *sp = array;  
short **spp = &sp;
```

Suppose that a `short` occupies 2 bytes. The address of `sarray` is 100, while `sp` and `spp` are at addresses 200 and 204, respectively (all addresses are expressed in decimal form).

i. What is the numeric value of the expression `sarray`? **(2 marks)**

ii. What is the numeric value of the expression `sp + 2`? **(2 marks)**

iii. What is the numeric value of the expression $*(sp + 2)$? **(2 marks)**

iv. What is the numeric value of the expression $*sp + 2$? **(2 marks)**

v. What is the numeric value of the expression $*spp + 3$? **(2 marks)**

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3. User-Defined Types and Linked Lists. (12 marks)

(a) Consider the following C code snippet:

```
enum maker { toyota, honda, mercedes = 10, audi };

union info {
    int year;
    char age;
};

struct car {
    enum maker maker;
    char model[10];
    union info info;
};
```

i. What is the value of the symbolic constant `honda`? (2 marks)

ii. Using only one C statement, declare a variable named `c1` which is of type `struct car`, and initialize the members `maker` and `model` to `audi` and `"a4"`, respectively. (2 marks)

iii. Suppose that for the variable `c1` declared in the (ii), the following assignment statement is given: (2 marks)

```
c1.info.year = 2017;
```

What will be the value of `c1.info.age`? Briefly explain your answer.

- iv. Assuming that an `int` occupies 32 bits, what is the size (in bytes) of the variable `c1` declared in (ii)? Provide a brief explanation of your answer. **(2 marks)**

- (b) Consider a singly-linked list which contains a list of integers. A node in this list is defined as follows: **(4 marks)**

```
struct node {  
    int data;  
    struct node *next;  
};
```

Suppose that `head` points to the head of the list.

Write the necessary C code to print all the elements of the list, beginning at the head.

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Cross out rough working that you do not want marked.
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4. Storage Classes and Dynamic Memory. **(13 marks)**

- (a) Briefly describe what memory leak is and its effect on the memory usage of a program. **(3 marks)**

- (b) Consider the following C code snippet: **(2 marks)**

```
int *mem = (int *)calloc(10, sizeof(int));
for(int i=0; i<10; i++) {
    /* Do something with mem[i] */
}

realloc(mem, 20*sizeof(int));
for(int i=0; i<20; i++) {
    /* Do something with mem[i] */
}
```

Briefly describe one problem (if there is any) with the above code, and how you should fix it. Assume that the call to `realloc()` is successful.

(c) Given the following C program:

```
#include <stdio.h>

int func (int x)
{
    static int y;

    if (x == 0)
        y += 5;
    else if (x == 1)
        y += 10;
    else
        y++;

    return y;
}

int z;

int main (void)
{
    int w;

    func(1);
    func(2);
    w = func(z);
    printf("%d", w);

    return 0;
}
```

i. What is the initial value of y? **(2 marks)**

ii. In which memory segment is z stored? **(2 marks)**

iii. What is the storage class of w? **(2 marks)**

iv. What is the output of the program?

(2 marks)

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Cross out rough working that you do not want marked.
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5. C File I/O. (5 marks)

Suppose you are given a text file named `input.txt` which contains two decimal numbers per row:

```
1 6
12 9
3 15
30 17
```

Complete the following C program (by filling in the blanks beside comments L1, L2, L3, L4 and L5) which is supposed to add the numbers in every row and output the numbers, together with the sum to a text file named `output.txt`. The contents of `output.txt` should look like this:

```
1 6 7
12 9 21
3 15 18
30 17 47
```

```
#include <stdio.h>
```

```
int main(void)
```

```
{
```

```
    FILE *in, *out;
```

```
    /* Open input.txt for reading */
```

```
    in = _____; /* L1 */
```

```
    if (in == NULL) {
        printf("Failed to open input file.\n");
        return 0;
    }
```

```
    /* Open output.txt for writing (overwrite existing contents) */
```

```
    out = _____; /* L2 */
```

```
    if (out == NULL) {
        printf("Failed to open output file.\n");
        return 0;
    }
```

```
    while( !feof(_____ /* L3 */) ) {
```

```
        int a, b;
```

```
        /* Use a and b to store decimal numbers in a row */
```

```
        int ret = fscanf(in, "%d %d", &a, &b);
```

```
        if(_____ /* L4 */) {
```

```
            int sum = a + b;
```

```
            fprintf(_____ /* L5 */);
```

```
        }
```

```
    }
```

```
    fclose(in);  
    fclose(out);  
    return 0;  
}
```

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Cross out rough working that you do not want marked.
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6. Process Management and Socket Programming. **(10 marks)**

- (a) Name the family of system calls that does not return control back to the calling point on termination. **(1 mark)**

- (b) What are the two types of sockets supported by the socket system call? **(2 marks)**

- (c) How many times will the following C program print Hi? **(2 marks)**

```
#include<stdio.h>
#include <sys/types.h>
#include <unistd.h>

int main()
{
    fork() && fork();
    fork();
    fork() && fork();
    printf("Hi\n");
}
```

(d) You are given the following C program:

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <sys/wait.h>

int gvar = 20;

int main(void)
{
    int lvar = 40;
    pid_t pid;

    if ((pid = fork()) < 0) {
        printf("fork error\n");
    } else if (pid == 0) {
        gvar++;
        lvar++;
    } else {
        wait(NULL);
    }

    printf("%ld %d %d\n", (long) getpid(), gvar, lvar);
    exit(0);
}
```

Answer the following TWO (2) questions:

- i. Explain how the `fork()` function executes and how and when the variables `gvar` and `lvar` change. **(3 marks)**

- ii. Assume that the `fork()` is successful and that the parent process ID is 16232 while the child process ID is 16233. What is the output of the program? **(2 marks)**

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Cross out rough working that you do not want marked.
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7. C++ Classes. (24 marks)

(a) Define a class `rational` with the following members:

- two private integer data members: `numerator` and `denominator`.
- a public constructor that takes in two integers and assigns to the members `numerator` and `denominator` using an initializer list.
- a public member function `getFloat` with no arguments that returns a floating point number which is the quotient of `numerator` and `denominator`.

(5 marks)

(b) Consider the following C++ class declaration.

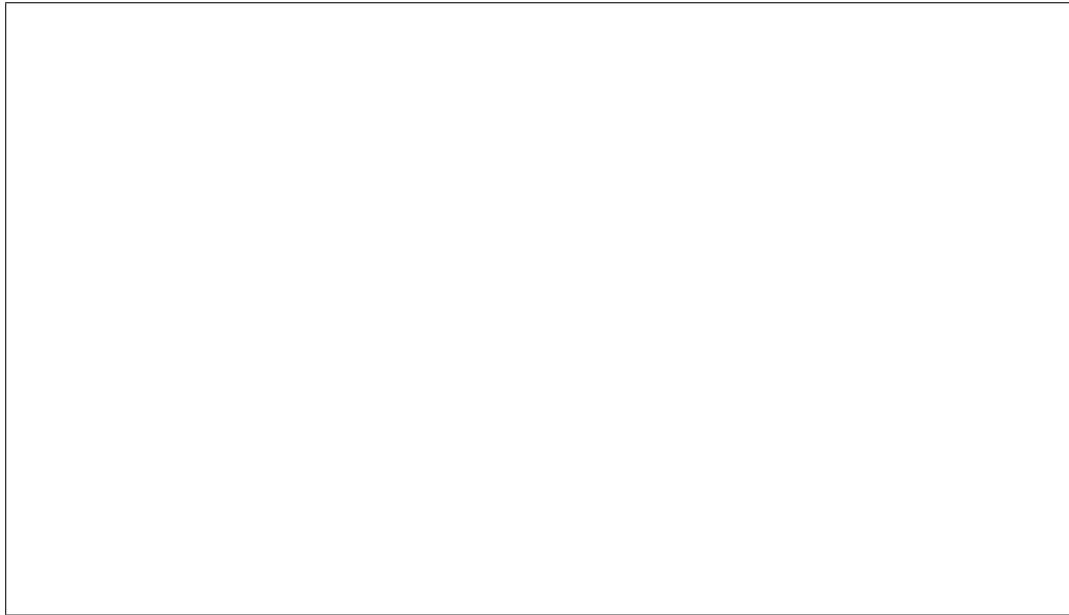
(5 marks)

```
namespace nsA {  
    class classA {  
    public:  
        virtual void disp() const = 0;  
        virtual int get (void) = 0;  
        classA (int x) : a(x) {}  
    protected:  
        int a;  
    };  
}
```

Declare a class `classB` that extends `classA` but in a different namespace named `nsB`. Class `classB` should:

- preserve the access specifier of the inheritable members of `classA`.
- not be abstract.
- have an inline default constructor that initializes the member variable `a` to 100.

You do not need to show function implementations, just give the function prototype declarations.



(c) What is the output of the following C++ program? **(3 marks)**

```
#include<iostream>

void Execute(int &x, int y = 50)
{
    int TEMP = x + y;
    x += TEMP;
    if (y != 200)
        std::cout<<TEMP<<" "<<x<<" "<<y<<std::endl;
}

int main()
{
    int A = 10, B = 20;
    std::cout<<A<<" "<<B<<std::endl;
    Execute(A, B);
    std::cout<<A<<" "<<B<<std::endl;
    return 0;
}
```



(d) What is the output of the following C++ program? **(4 marks)**

```
#include<iostream>

using namespace std;

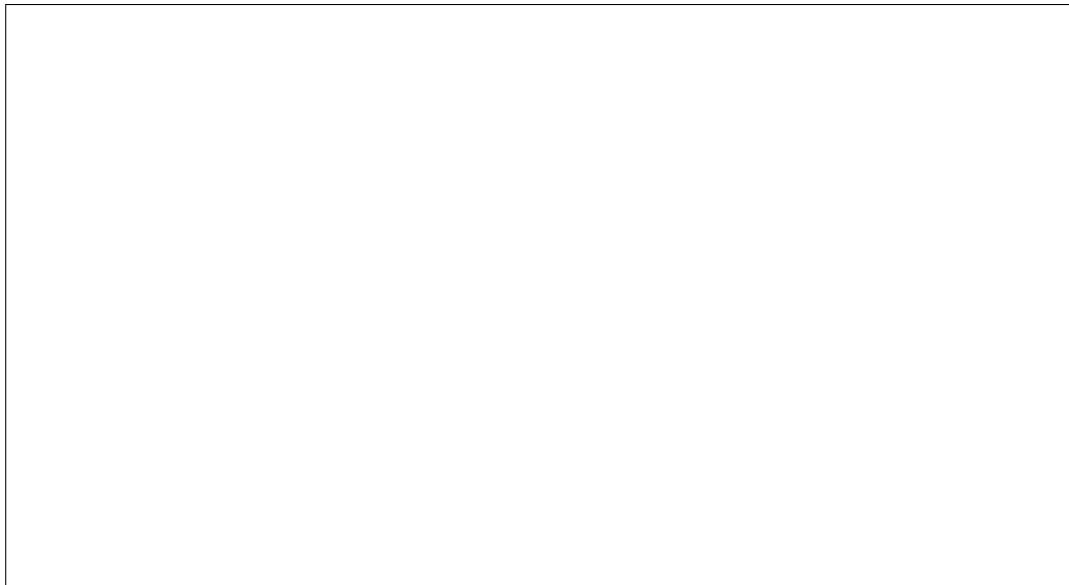
class base {
public:
    base() { cout<<"BCon"<<endl; }
    ~base() { cout<<"BDest"<<endl; }
};

class derived: public base {
public:
    derived() { cout<<"DCon"<<endl; }
    ~derived() { cout<<"DDest"<<endl; }
};

int main()
{
    derived obj;
    return 0;
}
```



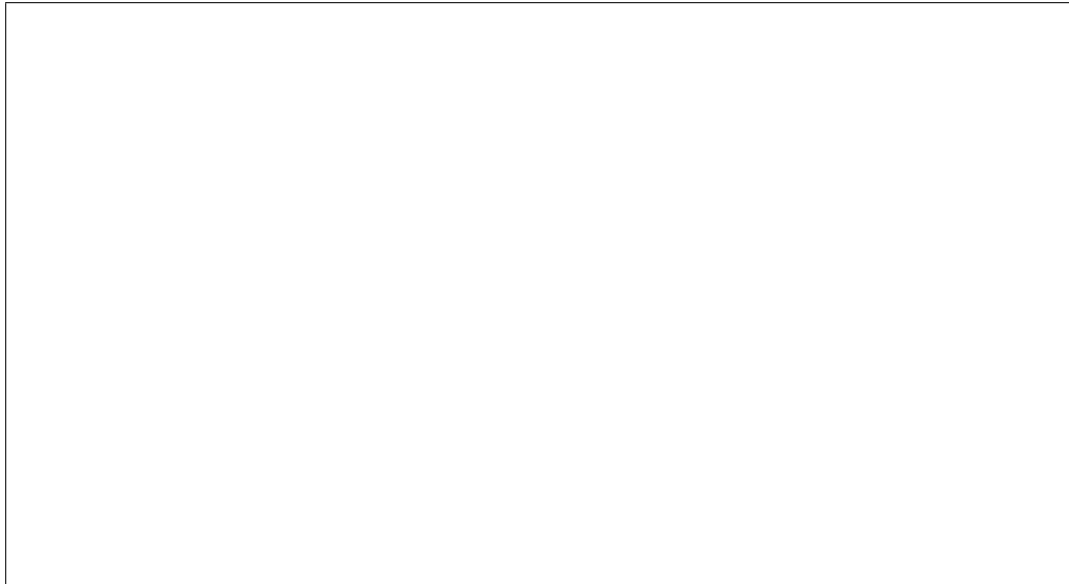
- (e) List one difference between a friend function of a class and a member function of a class. **(2 marks)**



- (f) Given the following definition of a class `Distance`, write a definition of the friend function `sumDistance()` that finds sum of two `Distance` objects. (One Feet = 12 inches) **(5 marks)**

```
class Distance //English Distance class
{
private:
    int feet;
    float inches;
public:
    Distance(int f, float i) : feet(f), inches(i) {}
    Distance() {}
    void showdist() //display distance
    { std::cout << feet << "\'-" << inches << '\\"'; }

    friend Distance sumDistance(Distance d1, Distance d2);
};
```



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8. Dynamic Memory in C++ (6 marks)

- (a) Give two reasons why `new` and `delete` are the preferred methods for managing dynamic memory in C++. (4 marks)

- (b) Give a C++ statement which uses the `delete` operator to deallocate memory allocated by the following statement ? (2 marks)

```
employee *elist = new employee[10];
```

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9. Templates and Containers. (15 marks)

- (a) In C++, Standard Template Library (STL) has container classes to implement two types of lists. What are the names of these container classes? (2 marks)

- (b) What will be the output of the following C++ program? (4 marks)

```
#include <iostream>
#include <list>
#include <iterator>

using namespace std;

// Print the elements in a list
void showlist(list <int> l)
{
    list <int> :: iterator it;
    for(it = l.begin(); it != l.end(); ++it)
        cout << *it<<" ";
    cout <<"\n";
}

int main()
{
    list <int> list1;
    for (int i = 1; i < 10; ++i) {
        list1.push_back(i);
    }
    list1.pop_front();
    list1.reverse();
    showlist(list1);
    return 0;
}
```


(c) In C++, what does the Standard Template Library (STL) define? **(3 marks)**

(d) Give three advantages of using the generic vector class over a C-style array. **(3 marks)**

(e) Write a generic function to return the minimum of two parameters/arguments. **(3 marks)**

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10. File I/O in C++. **(5 marks)**

- (a) Write a C++ code that will declare and open a binary file `picture.gif` for input. **(2 marks)**

- (b) In C++, what is the command to clear an output stream buffer? **(1 mark)**

- (c) Write a statement in C++ that will read an entire line from keyboard until a `newline` character is entered and store it in a `std::string` variable `str`. **(2 marks)**

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Specify the question number for work that you do want marked.

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