

Data Structures and Object-Oriented Programming

111 Spring
Final Written Exam

National Yang Ming Chiao Tung University

Time: 110 minutes

Instructions:

- A. There are FIVE pages.
- B. There are NINE questions. You must answer all of them.
- C. Write your answers ONLY on the answer book.
- D. DO NOT TURN OVER the cover page until you are told to do so.
- E. You should assume that all the libraries are included properly for each question.
- F. **Output format:** If a question is about the output of a function call or an instruction, the output format must be correct, e.g., including new lines, tab, etc. Indicate clearly the invisible characters, such as white space character, tabs, new lines, and etc. You must mark clearly those invisible characters, e.g., “tab”, “white space character”, and etc. If the value of a variable cannot be determined, write down “arbitrary” for the value of the variable, e.g., “the value of u is arbitrary”.
- G. **Error(s) at a line:** If a line of a given code fragment has a **syntax** error, write down “error” for the line, indicating clearly the line number. And the line is removed. Do not consider that line for the rest of the given code fragment. For example, if L1 has a syntax error, write down “L1: error”.
- H. CHEATING IS A SERIOUS MATTER. YOU WILL RECEIVE A SCORE OF ZERO and SERIOUS PENALTY IF YOU CHEAT.

1.a [1% \times 5] The following code fragment **1.A** has three classes X, Y, and Z. For each line of L1, L2, L3, L4, and L5, is there any error at the line? If there is no error at the line, write down “no”. If there is an error at the line, write down “error”.

1.b [1%] If line LL is removed, what problem will be encountered? Hint: Consider to create an object of Z.

Code fragment 1.A

<pre>class X { private: int a; protected: int b; public: char c; X() { a = 1; b = -1; c = 'x'; } };</pre>	<pre>class Y : private X { public: // LL Y() { a = 12; // L1 b = 13; // L2 c = 'z'; // L3 } };</pre>	<pre>class Z : public Y { public: Z() { a = 3; // L4 c = 'k'; // L5 } };</pre>
---	--	---

1.c [1% \times 4] Code fragment **1.C** is shown below. After executing test(), what output is(are) produced at each line of L1, L2, L3, and L4? If the value of a variable cannot be determined, write down “arbitrary” for the value, e.g., the value of u is arbitrary.

Code fragment 1.C

<pre>class R { public: int w; R() { w = 1; } virtual void p() { cout << "Rp:" << w << endl; } void q() { cout << "Rq:" << w << endl; } };</pre>	<pre>class T : public R { public: T() { w = 2; } void p() { cout << "Tp:" << w << endl; } virtual void q() { cout << "Tq:" << w << endl; } };</pre>	<pre>void test() { R a; T b; R *ap = new R; R *bp = new T; a.p(); // L1 b.q(); // L2 (*ap).p(); // L3 bp->q(); // L4 }</pre>
---	---	--

2. [10%]

<p>Given the right code fragment, fix errors. The class has one constructor. There are at least 10 (syntax or semantics) errors. Fix all the errors. You must fix the errors with the minimum changes of the code fragment.</p> <p>Penalty: Reduce 1 point for an extra change of the fragment.</p>	<pre>template < classname T ==int, typename D > class A { public: T &v; D *u; static int c; void A(const T &v) const { this.v = v; u = new *D; } }; int A.c = 0; A(int, vector(vector<string>)) this_A;</pre>
---	---

3. (a) [1.5%x6] Given the following code fragment **3.A**, execute q03(). What output is(are) produced at each line of L1, L2, L3, L4, L5, and L6?

Code fragment 3.A

<pre> class A { public: int x, y; A(int x, int y) { this->x = x; y = this->y; cout << (x != 2) << endl; this->y = (y==y); } A& operator=(int v) { cout << "=" << endl; y = v; return *this; } int getX() { return x; } int &getY() { cout << y << endl; return y; } }; </pre>	<pre> void p() { A c(2, 4); // L1 cout << c.x << "\t" << c.y << endl; // L2 c = 3; // L3 (++c.getY())++; // L4 int y = c.getY() + c.getX(); // L5 cout << "c.y:" << c.y << endl; // L6 } </pre>	<pre> void q03() { p(); } </pre>
--	---	---------------------------------------

3.(b) [3%x4] Given the following code fragment **3.B**, main() is invoked. After invoking q04(), what output is(are) produced at each line of L1, L2, L3, and L4?

Code fragment 3.B

<pre> class X { protected: public: string n; int a, b; X(); X(int x, const string &u); ~X() { cout << "~X()" << endl; } X(const X &h) { cout << "X(const X&)" << endl; a = h.b; b = h.a; // no error } X &operator=(const X &j) { //no error cout << "X operator =" << endl; a = j.a; b = j.b; n = n + ":" + "copy of\t" + j.n; p(); } void p() { cout << n << "\t" << a << "\t" << b << endl; } }; </pre>	<pre> X::X() { n = "def"; a = 1, b = 2; cout << "X():" << n << endl; } X::X(int x, const string &u) { a = x; b = a + 1; n = u; cout << "X(const string &):" << n << endl; } void t () { X a; X b = a; } </pre>	<pre> void h () { X d(3, "D"); X e; e = d; } X * g () { return new X(2, "newX"); } void k() { delete g(); } void q04() { t(); // L1 h(); // L2 k(); // L3 X(); // L4 } </pre>
---	--	--

4.a [3%] Write down three properties of red-black trees.

4.b [2%] Write down two properties of a singly linked list.

4.c [1+0.5+0.5%] Write down the three major steps of quick sort.

5 [10%] A min heap is empty initially. The following 5 numbers are inserted to the heap one by one: 5, 3, 2, 7, and 9. Draw a figure for the heap after each number is added to it. There must be at least 5 figures.

6. [8%] Answer the questions based on the following code fragment. The file content of oop.txt is as follows (in hexadecimal format; the memory address is increasing from left to right):

e0 12 01 81 12 68 90 01 02 fe ff 20

6.a [2%x2] The right fragment is executed. What are the values of u and w? Write the answers in the hexadecimal format. Little endian is adopted for storing integers. If the program has an error, write down “error”.

6.b [2%x2] What output is(are) produced at each line of L1 and L2, respectively?

```
unsigned int w; char u;
fstream input;
input.open("oop.txt", ios::in | ios::binary );
input.seekg( 5, ios::beg );
cout << input.tellg() << endl; // L1
input.read( reinterpret_cast<char*>( &u ), sizeof( char ) );
cout << input.tellg() << endl; // L2
input.seekg( -2, ios::cur );
input.read( reinterpret_cast<char*>( &w ), sizeof( unsigned int ) );
```

7.a Given the right binary tree, answer the following questions.

7.a1 [2%] What is the pre-order traversal output?

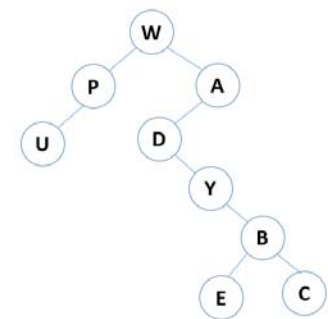
7.a2 [2%] What is the in-order traversal output?

7.a3 [2%] What is the post-order traversal output?

7.a4 [2%] What is the level-order traversal output?

7.a5 [2%] What is the post-order traversal output for the subtree rooted at D?

7.b [5%] The level and inorder traversal results are CFHXALW and CXLAWHF for a binary tree, respectively. Construct the binary tree.



8. In code fragment 8.A, function q08() is invoked with appropriate parameters for nodeArr and M.

8.a [2%] Assume that an integer has 4 bytes. If the output value at L1 is FB001000, what output value is produced at L2?

8.b [1x2%] What output values are produced at L3 and L4, respectively?

8.c [2%] What is the smallest upper bound of the running time complexity of the for-loop structure in the code fragment q()? Write down in big-O notation. M is the number of elements of nodeArr.

Code fragment 8.A

<pre>class NODE { public: int a, b; union { int x; int w; }; NODE () { a = 10; b = 5; x = 4; w = 3; } };</pre>	<pre>int q(const NODE nodeArr[], int M) { int s = 0; // for-loop structure for (int i = 0; i < M; ++i) { if (nodeArr[i].a == 1) s += nodeArr[i].a; } return s; }</pre>	<pre>int q08(const NODE nodeArr[], int M) { NODE n; cout << &n.x << endl; // L1 cout << &n.w << endl; // L2 cout << * (& * (&n.b)) << endl; // L3 cout << n.x << endl; // L4 return q(nodeArr, M) + n.a; }</pre>
---	--	--

9. Given the following three code fragments, answer the questions. These three code fragments are independent from each other.

Fragment A	Fragment B	Fragment C
<pre> class A { virtual void f() { } }; class B : public A { }; class C : public A { }; void B01() { A a; B b; C c; A* p = &a; B* q = &b; C* w = &c; A* u = dynamic_cast<B*>(w); // A1 p = dynamic_cast<A*>(q); // A2 } </pre>	<p>Assume that X is a class.</p> <pre> X a(); // B1 X b; // B2 X(); // B3 X &u = b; // B4 int h[] = {1, 2, 4, 8}; // B5 int k = sizeof(h)/sizeof(int); // B6 </pre>	<pre> int f(int n, int j) { int s; switch(j) { case 0: if (n<=0) s = 1; else s = 2 + f(n-1, j); break; case 1: if (n<=0) s = 1; else s = (n-1)*f(n-1, j); break; } return s; } void q09(int n) { cout << f(2, 0) << endl; // C1 cout << f(3, 1) << endl; // C2 int s = f(n, 0) + f(n, 1); // C3 } </pre>

9.a [1% \times 2] In **Fragment A**, invoke B01(). After A1 and A2 are executed, what are the values of u and p, respectively? You can use the addresses of the objects (e.g., a, b, and c) as values.

9.b [1% \times 6] In **Fragment B**, what is the meaning of the instruction at each line of B1, B2, B3, B4, B5, and B6?

9.c [2% \times 2] In **Fragment C**, invoke q09() with a valid parameter n. What is the output at line C1 and C2, respectively?

9.d [1%] In **Fragment C**, use an mathematics expression to express the value of s in terms of n in line C3. Simplify the expression.

; END EXAM