Data Structures and Object-Oriented Programming

110 Spring

National Yang Ming Chiao Tung University

Time: 110 minutes

Instructions:

A. There are FIVE pages.

B. There are TEN questions. You must answer all of them.

C. Write your answers ONLY on the answer sheets. You must sign your name and student ID on each answer sheet. Scan or take photos of the answer sheets. Upload all the scanned images or photos to E3 before deadline. The signed name and ID must be shown clearly on each scanned image or photo.

D. You should assume that all the libraries are included properly for each question.

E. CHEATING IS A SERIOUS MATTER. YOU WILL RECEIVE A SCORE OF ZERO and SERIOUS PENALTY IF YOU CHEAT.

Student Name: _____

Student ID: _____

1. Given the program, answer the following questions

```
class OOP {
  private: int a;
  protected: int b;
  public: int c;
  OOP( ) { a = b = c = 1;}
};
```

```
class CPP : protected OOP
{
public: int c; static int d;
   CPP( ) { c = 5; }
   void f( ) { .... // L1 }
};
```

```
...          // L2
OOP x;       // L3
OOP y( );    // L4
OOP *z;      // L5
CPP e;
```

```
void main( ) {
   OOP *w = new CPP( ); // L6
   x.a = 1;             // L7
   e.b = 2;             // L8
   e.c = 3;             // L9
   CPP s; s.CPP::c = 7;    // L10
}
```

1(a) [1%] Write an instruction to set the data member c of OOP to **10** at line L1.
1(b) [1%] Write an instruction to initialize the static data member d of CPP to **−1** at line L2.
1(c) [1%x4] Write down the purpose of each of the following lines L3, L4, and L5.
1(d) [1%x4] For each of the instructions at lines L6, L7, L8, L9, and L10, write down **Yes** if the instruction can be compiled successfully; and otherwise write down **No** and **explain why the line cannot be compiled.**

2(a)[(0.5+0.5+1+1%)x2] After L1 is executed, what are the values of x.a, y.b, z.a, w.b? Explain clearly how each of the values is obtained step by step.
If a value is uncertain, write down **Uncertain**.

```
class X {
   public:      X( ) { a = -1; b = 1; }
   X( int a, int b = 3 ) { this->a =a; (*this).b = b; }
   int a, b;
};
```

```
class Y: public X {
   public: Y( ): X( 5 ) {   }
   Y( int a, int b ) { this->b = b; b++; }
};
```

```
void main( ) {
      X x, y(7);    Y z, w(2,1);
      z.a++;                        // L1
}
```

2(b) Given the following code fragment:

```
class W { public: const W *n; int v;
   W( ) { v = 0; n = 0; }
   W( const W &w ) { v = w.v; v++; n = &w; }
};
```

```
void f( ) {
   W a; W b(a); W c(b);
   W* d = new W(c);
   W e(*d);                    // L2
}
```

2(b) Invoke f( ). After L2 is executed, answer the following questions.
2(b1) [1+1+1%] What are the values of b.v, d->v, and e.v?
2(b2) [1%] What does the pointer c.n point to?

3(a) [1%x4] Describe at least four major steps of quicksort. The input are an array of numbers and its size. Use 1, 2, 3, …, to label the steps.

3(b) [1+1%] Write down in big-O notation for each of the following expressions:
i) $\log(n^3) + k^k$ and ii) $n^2/k + 1000k$. Here, n is the input size and $k = 100^{2021}$.

3(c) [1%x4] Write down four properties of a red back tree. Use the colored node definition.

3(d) [1%x4] Describe how to use the maximum priority heap to sort a set of numbers in ascending order. The numbers are stored in an array. There should be four or more steps. The steps are performed one by one. Write down the assumption(s). Use 1, 2, 3, …, to label the steps.

4. Given the following code fragment:

```
int s = 0;
int f( int a, int n ) {
   if (a > 2*n) {
      cout << s << endl;
      return s;
   }
   s = f(a+2, n);
   return s;
}
```

```
int h( int a, int n, int &s ) {
   if (a > 2*n) {
      cout << s << endl;
      return s;
   }
   s += 2*n - a;
   h(a+1, n, s);
   return s;
}
```

```
int k( int a, int b, int n, int s ) {
    if (s==1) {
      cout << a%n << endl;
      return a%n;
    }
    return k(a*b, b, n, s – 1);
}
```

Mark the new line correctly in the answer(s).

4(a) [1%] Invoke f(-1, 1). What are/is the output? Assume s = 0 initially.

4(b) [1+1.5%] Invoke h(0, 1, s). What are/is the output? Assume s = 0 initially. Show step-by-step the parameter values (a and n) except for s when the function h(…) is invoked each time. Label the steps.

4(c) [1+1.5%] Invoke k(3, 3, 7, 12). What are/is the output? Assume s = 0 initially. Show step-by-step the parameter values when the function k(…) is invoked each time. Label the steps.

.

5. Given the following code fragment:

```
class X {
   public: int x; string n;
   X( ) { n = "z"; x = 0; }
   X( string n, int x )   {   this->n = n, this->x = x; }
   X( const X &a ) {
      this->n = "copy of\t" + (&a)->n;
      this->x = a.x;
   }
   ~X( ) { cout << n << endl; }
   X &operator=( const X &a ) {
      this->n = "assign\t" + a.n + "\tto\t" + this->n;
      return *this;
   }
   void p( ) const {
      cout << "X:" << "\t" << n << "\t"   << x << endl;
   }
};
```

```
void q03_1( X x ) {
      x.p( );
}
void q03_2( const X &x ) {
      x.p( );
}
void q03( ) {
   X x1; x1.p( );                    // L1
   X x2 = x1; x2.p( );               // L2
   X x3("x3", 2); x3.p( );           // L3
   (x3 = x1).p( );                   // L4
   q03_1(x2);                        // L5
   q03_1(X("good", 5));              // L6
   q03_2(*(new X("hello", 6)));      // L7
   …// other bug free instructions
}
```

If there is no output, write down **No output**. If the line has error(s), write down **Error** and skip the line. The output order and format must be correct, e.g., including new lines, tab, etc. **Mark each invisible output.** Function q03( ) is invoked. Answer the following questions.

5(a) [2+2+1+1+1%] For each of the following lines L1, L2, L3, L4, and L5, after the line is executed, what is/are the output?

5(b) [(1+0.5)%x2] For each of the following lines L6 and L7, after the line is executed, what is/are the output? Explain how the output(s) is/are obtained for each line.

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

```
ad 80 12 34 11 00 00 00 3f
```

The following code fragment is executed:

```
char a; short b; int c;
fstream input;
input.open( "dat.txt", ios::in|ios::binary );
cout << input.tellg( ) << endl;                                          // L1
input.read( reinterpret_cast<char*>(&a), sizeof(a) );
cout << input.tellg( ) << endl;          input.seekg(3, ios::cur);       // L2
input.read( reinterpret_cast<char*>(&b), sizeof(b) );
cout << input.tellg( ) << endl;          input.seekg(-2, ios::cur);      // L3
input.read( reinterpret_cast<char*>(&c), sizeof(c) );
```

6(a) [1%x3] What is/are the output at each line, L1, L2, and L3?

6(b) [1%x3] What are the values of a, b, c? Write each answer in the hexadecimal format. Assume that little endian is adopted for storing a number.

6(c) [2+2%] What is the decimal value of b and c? If a value is negative, put down the minus sign properly. Assume that little endian is adopted for storing a number.

7. Given the following source code, answer the questions.

```
template <typename T> void h( int m ) {
   int index = -1;
   const int n = 10; T a[n];
   for ( int i = 0; i < n; ++i ) a[ i ] = (i+1)%m+0.5;
   int j =0; int c   = 0;
   while ( j < n – 1 ) {
      if ( a[ j ] < a[ j+1 ] ) {
         index = j;
         ++c;
      }
      ++j;
   }
   cout << index << "\t" << c << endl;
}
```

```
void u( int m ) {
   int index = -1;
   const int n = 100; int a[n];
   for ( int i = 0; i < n; ++i ) a[ i ] = (i+1)%m;
   int j =0; static int c = 0;
   while ( j < n – 1 ) {
      if ( a[ j ] > a[ j+1 ] ) ++c;
      ++j;
   }
   cout << j << "\t" << c << endl;
}
```

7(a) [2%] Invoke h<double>(2), what is/are the output? If there is an error, write down **error**.

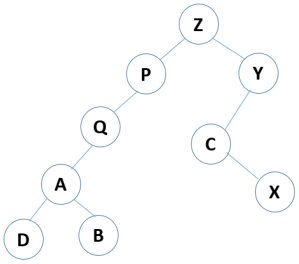
7(b) [1%] Invoke h<int>(5), what is/are the output? If there is an error, write down **error**.

7(c) [1+1%] What is the purpose of c in function h? What is the purpose of index in function h?

7(d) [2+2%] Invoke u(1), what is/are the output? After that, invoke u(2), what is/are the output? If there is an error, write down **error**.

7(e) [1%] What is the purpose of c in function u?

8. Given a binary tree on the right side, answer the following questions:



8(a) [2%] What is the level-order traversal output?

8(b) [2%] What is the post-order traversal output?

8(c) [2%] What is the in-order traversal output?

8(d) [2%] What is the pre-order traversal output?

8(e) [5%] The preorder traversal result is BCDALHFEG and the inorder traversal result is CBALDEFGH. Construct the binary tree.

9. Given the program fragment, answer the following questions. main( ) is invoked.

```
void pp( const string &s, int v) {
   cout << s << "\t"
        << v << endl;
}
class X {
public:
  X( ) { a =1; pp("CX", a); }
  X(int b) { a =b; pp("CXb", a);}
  virtual void h( ) = 0;
  void k( ) const { pp("X:", a); }
  void p( ) { pp("p:", a);}
  int a;
};
```

```
class Y: public X {
public:
   Y( ) { pp("CY", a);}
   Y(int b) { a = b+1; pp("CYb", a);}
   void h( ) { a = a + 1; }
   void k () { a = a + 3; }
};
class W: public Y {
public:
   W( ) { pp("CW", a);}
   W(int b) { a = b + b; pp("CWb", a);}
   virtual void h( ) { a = a + 5; }
   virtual void k () { a = a +7; }
};
```

```
void main( ) {
   Y y;              //L1
   W a;
   W b(2);           //L2
   a.p( );           // L3
   X *q = &y;
   y.h( );
   q->p( );          // L4
   q = &b;
   q->p( );          // L5
}
```

If there is no output, write down **no output**. The output order and format must be correct, e.g., including new lines, tab, etc. **Mark each invisible output.**

9(a) [2%x3] Write down the output for each line of L1, L2, and L3 after the line is executed.

9(b) [3%x2] Write down the output for each line of L4 and L5 after the line is executed.

10. The numbers are stored in the little endian format.

```
unsigned short a[ ] = {0x4321, 0x5678, 0xcdef, 0x89ab};
unsigned char *r = (unsigned char*) a;
unsigned short *p = a; unsigned int *q = (unsigned int*) a;
```

Write each answer in hexadecimal format. Write down **uncertain** if a value is uncertain.

10(a) [1%x4] What are the values of a[3], (r+2)[2], (p+1)[2], and q[1]?

10(b) [1%] Write down one instruction to assign 0x56 to the second element of r. Treat r as an array.

;END EXAM