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No books ; No calculator ; No computer ; No email ; No internet ; No notes ; No phone. Neatness counts ! Do your scratch work elsewhere and enter only your final answer into the spaces provided. This test is shorter than the usual final exam because summer session does not have an exam week. The time limit is 100 minutes, rather than the usual 180 minutes given in the other quarters.

1. Write a complete program (everything that needs to be placed in the source file) in C++ to print the message "Hello, World!". **[1✔]**

2. Write a template function to reverse a sequence, given a pair of bidirectional iterators. Its template argument is any iterator type and its two function arguments are a begin and end iterator. Assume the iterators have `operator++`, `operator--`, unary `operator*`, and `operator!=`. The iterators are passed by value, so you may modify them. Use the STL function whose prototype is `template <class T> void swap (T& a, T& b);` **[2✔]**

3. Write a template function to print out a sequence, given a pair of forward iterators. Assume an appropriate `operator<<`, and print one space between each element, but not on the front or end. **[2✔]**

4. Define a template function called `swap` which exchanges two variables passed in by non-constant reference. (Hint : see above.) Use mover, not copier, operations. **[2✔]**

5. Define a template function `copy`. Its first template argument is an input iterator from which copying is done. Its second template argument is an output iterator. Its first two function arguments are begin and end iterators describing the input sequence. Its third function argument is a begin iterator pointing at the output sequence. It is assumed that there is enough space in the output container. **[3✔]**

6. Define a `struct accumulator` which acts as a function object to accumulate the sum of a sequence of `int`s. For example, after the declaration `accumulator acc`, the call `for_each(v.begin(),v.end(),acc)` will cause the sum of all elements in `v` to be in `acc.sum`. The function `for_each` applies the function to each element in the range. **[1✔]**

7. Provide a partial interface and implementation of class `complex`. Each object has a real and an imaginary field of type `double`. Show only the following three function members :
   (i) Show one constructor which takes zero, one or two arguments, and may be used to implicitly convert a `double` to a complex. The constructor has two arguments, both of which default to 0.
   (ii) Show `operator<<`, which may be used to print a complex number. It prints a left parenthesis, followed by the real part, followed by a comma, followed by the imaginary part, followed by a right parenthesis.
   (iii) Show binary `operator+`, which is a member, which adds two complex numbers using the formula $(a, b) + (c, d) = (a + c, b + d)$.

   Given the description above, answer the following questions :

   (a) Based on that description and showing only what is asked, what would go in the header file `complex.h` ? Make sure members have correct protection. Show how to declare the data fields given above. Do not put anything in the header file that can go into the implementation file. **[2✔]**

   (b) Show what would go in the implementation file `complex.cpp` :

      (i) For the constructor described above. **[1✔]**

      (ii) For `operator+`. **[1✔]**

      (iii) For `operator<<`. **[1✔]**

8. Write a program in Java. Define a class `say` whose constructor argument is a string, and which, when run as a thread, prints that string to the standard output then quits. Write a main program which starts up that class as a thread twice, once with the argument "Hello", and once with the argument "World".

   (a) Show the code for class `say`. **[2✔]**

   (b) Show the code for the `main` function . **[2✔]**

The following table contains examples of various kinds of polymorphism. For each one, identify the classification as ***universal*** or ***ad hoc***. Also identify the specific kind as one of ***conversion***, ***inheritance***, ***overloading***, or ***generic***. **[2✔]**

`class foo { virtual void f(); }`
`class bar: public foo { virtual void f(); }`

`template <typename T>`
`class c { void f (T&); }`

`void f (int x);`
`void f (double x);`

`void f (double x);`
`f (6);`

Multiple choice. To the ***left*** of each question, write the letter that indicates your answer. Write ***Z*** if you don't want to risk a wrong answer. Wrong answers are worth negative points. **[10✔]**

number of correct answers		× 1 =	$= a$
number of wrong answers		× ½ =	$= b$
number of missing answers		× 0 =	0
column total $c = \max(a - b, 0)$	10		$= c$

1. The acronym RAII means :
   (A) Random Access Inhibits Implementation
   (B) Reading An Iterator Incrementally
   (C) Resource Acquisition Is Initialization
   (D) Restoring Allocators Initially Inverted

2. Reference counting for storage management fails with what kind of data structure ?
   (A) binary tree
   (B) cyclic graph
   (C) hash table
   (D) linked list

3. Even though all run in $O(n)$ time, given the following loop :
   `for (i=v.begin(); i!=v.end(); *i++=0);`
   For which declaration of `v` will the code run fastest ?
   (A) `list<int> v;`
   (B) `map<int,int> v;`
   (C) `unordered_map<int,int> v;`
   (D) `vector<int> v;`

4. Which statement causes the pointer `p` to become dangling ?
   (A) `delete p;`
   (B) `free p;`
   (C) `malloc p;`
   (D) `new p;`

5. What keyword introduces a function that is selected at run-time and dynamically dispatched based on a pointer ?
   (A) `friend`
   (B) `static`
   (C) `template`
   (D) `virtual`

6. If a virtual function in a base class has the same signature as one in a derived class, we say that the function in the derived class ____ the one in the base class.
   (A) overflows
   (B) overloads
   (C) overrides
   (D) overwrites

7. In the bigint project, multiplying an m-digit number by an n-digit number should take how long ?
   (A) $O(m+n)$
   (B) $O(m10^n)$
   (C) $O(m \log n)$
   (D) $O(mn)$

8. A non-static variable declared inside a function is bound to a particular address at :
   (A) compile time.
   (B) link time.
   (C) program load time.
   (D) the time the function is called.

9. In class `vector<T>`, which operator necessarily returns a `T*` ?
   (A) `operator*`
   (B) `operator++`
   (C) `operator->`
   (D) `operator[]`

10. A thread that sits in the background waiting for another thread to make a request of it, then which performs the request, then waits again, is called a ____ thread.
    (A) daemon
    (B) vampire
    (C) werewolf
    (D) zombie

Write out the ***C++11*** prototypes of all members of class `foo` as they would appear in a header file without implementations. **[2✔]**

```
class foo {









};
```

Multiple choice. To the ***left*** of each question, write the letter that indicates your answer. Write ***Z*** if you don't want to risk a wrong answer. Wrong answers are worth negative points. **[10✔]**

number of correct answers		× 1 =	= *a*
number of wrong answers		× ½ =	= *b*
number of missing answers		× 0 =	0
column total $c = \max(a - b, 0)$	10		= *c*

1. For some `vector v`, what is the same as `v.begin()` ?
   (A) `v[0]`
   (B) `!v[0]`
   (C) `&v[0]`
   (D) `*v[0]`

2. For class `foo`, what should the parameter list look like for the non-member declaration
   `ostream& operator<< ( ____);`
   (A) `const ostream&, const foo&`
   (B) `const ostream&, foo&`
   (C) `ostream&, const foo&`
   (D) `ostream&, foo&`

3. In a systems programming application, where we need to make an unsigned integer from a pointer, what cast would be used ?
   (A) `const_cast`
   (B) `dynamic_cast`
   (C) `reinterpret_cast`
   (D) `static_cast`

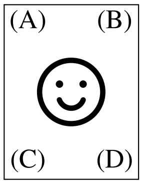
4. A virtual function table exists as a __(x)__ table for each __(y)__ in a program.
   (A) (x) = dynamic ; (y) = class
   (B) (x) = dynamic ; (y) = object
   (C) (x) = static ; (y) = class
   (D) (x) = static ; (y) = object

5. A Java class that implements `Runnable` must have a method named :
   (A) `run`
   (B) `start`
   (C) `synchronized`
   (D) `wait`

6. A web server written in Java, having opened a `ServerSocket`, allows a client to connect by calling what method ?
   (A) `accept`
   (B) `getInputStream`
   (C) `start`
   (D) `wait`

7. If two or more threads access the same variable without synchronization, what results ?
   (A) deadlock
   (B) livelock
   (C) race condition
   (D) segmentation fault

8. In this picture of a page, in which corner is the Postscript page coordinate (0,0) ?
   (A) upper left
   (B) upper right
   (C) lower left
   (D) lower right



9. An abstract class in C++ :
   (A) can not be instantiated.
   (B) can not be used like a Java interface.
   (C) has no virtual functions.
   (D) must be a derived class.

10. `vector<T>::push_back` has an amortized time complexity of :
   (A) $O(1)$
   (B) $O(\log_2 n)$
   (C) $O(n)$
   (D) $O(n \log_2 n)$

The following refers to which of Shakespeare's plays ? `2BORD4`