$Id: cmps109-2015q3-exam3.mm,v 1.89 2015-08-13 18:43:14-07 - - $

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Code only in C++11. 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.
For all answers, assume : `using namespace std;`

1. Write the prototypes for the implicitly generated members of class `foo`. **[2✔]**

Available in C++98.	Available in C++11 but not C++98.
`class foo {`	`class foo{`

2. Each of the boxes here represents one kind of polymorphism. In each, write ***universal*** or ***ad hoc*** to indicate which category. Also, write one of the following terms to indicate the more specific form : ***conversion***, ***overloading***, ***parametric***, ***inclusion***. **[2✔]**

`void foo (int);` `void foo (double);`	`void bar (double);` `bar (3);`
`class qux: public baz {` `};`	`template <typename T>` `T sum (T*);`

3. Code a template function `find` which performs a linear search. Its two template arguments are : an iterator type, a function type. Its function arguments are : a begin iterator, an end iterator, a function returning a `bool` to indicate found or not found. **[2✔]**

4. Write a function to compute the inner product of two `vector<double>`. If the vectors are of different lengths, throw a `domain_error`. The formula for inner product of vectors u and v of size n is given at the left. **[2✔]**
$p = \sum_{i=0}^{n-1} u_i v_i$

5. Code a template function `monotonic` which takes a pair of iterators and returns `true` if the sequence thus indicated is monotonically increasing, and `false` otherwise. Assume `operator<` exists for the elements pointed at by the iterators. Monotonically increasing means that each element is larger than the preceding one. A sequence of fewer than two elements is by definition monotonically increasing. Example : $\{1,3,5,11,15\}$. **[2✔]**

6. Given the template class **fixvec** partially shown here :

   (a) Code the functions **begin**, **end**, and **size** as inline functions. Code the destructor. Code both the constant and non-constant **operator[]** as inline functions. **[3✔]**

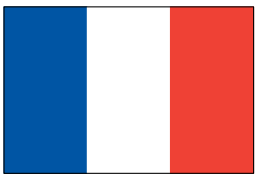
```
template <typename T>
class fixvec {
   private:
      size_t size_;
      T* data_;
   public:
      class iterator;
```

   (b) Code the class **iterator** as it would be defined outside of the class **fixvec**. Show all functions as inline, and code : **operator!=**, **operator++** (prefix), **operator++** (postfix), **operator*** (unary), and **operator->**. Code the default ctor, which initializes the pointer to **nullptr**, and another ctor callable from **begin** and **end**. **[4✔]**

7. Assume the following global declarations, and a suitable reshaping function :

```
struct { size_t width; size_t height; } window;
const GLubyte BLEU[] {0, 85, 164};
const GLubyte BLANC[] {255, 255, 255};
const GLubyte ROUGE[] {239, 65, 53};
vector<const GLubyte*> colors {BLEU, BLANC, ROUGE};
```

   Write a function **draw_french_flag** which will fill the entire window with a French flag, assuming proper window proportions. The flag consists of three rectangles : the left third is *bleu*, the middle third is *blanc*, and the right third is *rouge*. Each rectangle is the entire height of the window. Assume that coördinate $(0, 0)$ is at the lower left corner of the window, and that the given width and height are pixel coördinates of the upper right. An example is shown here. **[3✔]**



bleu *blanc* *rouge*

8. Consider an expression tree where interior nodes are operations and leaf nodes are numbers. Define a class hierarchy :
   (a) An abstract base class is called `arith`, and is extended by the others.
   (b) Derived class `number` contains a single `double` value.
   (c) Derived class `add` has raw pointers to two `arith` objects.
   (d) Derived class `mul` has raw pointers to two `arith` objects.

   The function members do the following :
   (a) Method `double eval()` returns the value of a `number`. For the others, it returns the sum and product (respectively) of the values of the two children.
   (b) Method `void print()` prints to `cout` the parenthesized value of the expression. Numbers are not parenthesized. Each `add` and `mul` is printed as an inorder expression, bounded with a pair of parentheses, with the operator in the middle. The operator is not part of the `struct`. Example output : `((3+4)*(5+67))`.
   (c) Code the destructors as well.

   For each class, show the member fields, functions `eval` and `print`, and the destructor. Use the keyword `struct` to avoid any use of `private`, etc. Do not show constructors. For simplicity, code all functions inline. Traversals are all encoded in the inheritance hierarchy. Do not code any depth-first traversals directly, as would be done in a data structures course.

   (a) Code for : **[2✔]**
   ```
   struct arith {
   ```

   (b) Code for : **[2✔]**
   ```
   struct number {
   ```

   (c) Code for : **[3✔]**
   ```
   struct add {
   ```

   (d) Code for : **[3✔]**
   ```
   struct mul {
   ```

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. **[12✔]**

number of correct answers		× 1 =	$= a$
number of wrong answers		× ½ =	$= b$
number of missing answers		× 0 =	0
column total $c = \max(a - b, 0)$	12		$= c$

1. Given a variable declared as a pointer to a base class, what cast would be used to assign it to a pointer to a derived class ?
   (A) `const_cast`
   (B) `dynamic_cast`
   (C) `reinterpret_cast`
   (D) `static_cast`

2. Which of the following declarations has an erroneous narrowing conversion ?
   (A) `int a {'b'};`
   (B) `double b {456};`
   (C) `long c {a};`
   (D) `char d {4589};`

3. In the following, when is the variable `x` assigned to a particular memory address ?
   `int f() { int x = 3; return x; }`
   (A) at compile time
   (B) at link time
   (C) when the program is loaded
   (D) when the function is called

4. If an object is to be called as if it were a function, what operator must it have defined ?
   (A) `operator""`
   (B) `operator()`
   (C) `operator<>`
   (D) `operator[]`

5. Given the following declaration, which answer is equivalent to type `int` ?
   `using m = map<string,int>;`
   (A) `m::key_type`
   (B) `m::mapped_type`
   (C) `m::size_type`
   (D) `m::value_type`

6. Which of the following `g++` options is used during compilation to an object file, but which suppresses linking ?
   (A) `-c`
   (B) `-g`
   (C) `-o`
   (D) `-S`

7. An iterator is based on the half-open interval $[a, b)$. This is the set :
   (A) $\{x \mid a < x < b\}$
   (B) $\{x \mid a < x \leq b\}$
   (C) $\{x \mid a \leq x < b\}$
   (D) $\{x \mid a \leq x \leq b\}$

8. The return value from `main` is an `int`, which is likely a 32-bit number. The parent process will thus receive an exit status in what range ?
   (A) 0 to 255
   (B) 0 to 65536
   (C) −128 to +127
   (D) −2147483648 to +2147483647

9. A destructor for a derived class destroys in what order ?
   (A) base class first, then fields in declaration order.
   (B) base class first, then fields in reverse declaration order.
   (C) fields in declaration order, then base class.
   (D) fields in reverse declaration order, then base class.

10. What kind of cast is used (usually implicitly) to convert an `int` to a `double` ?
    (A) `const_cast`
    (B) `dynamic_cast`
    (C) `reinterpret_cast`
    (D) `static_cast`

11. Which data structure guarantees at all elements are held in a single block of contiguous storage on the heap ?
    (A) `deque`
    (B) `list`
    (C) `map`
    (D) `vector`

12. A function which is a member of a class, but does not modify `*this`, is properly declared as :
    (A) `const void foo ();`
    (B) `void foo () const;`
    (C) `void foo (const&);`
    (D) `void foo const ();`

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. **[12✔]**

number of correct answers		× 1 =	$= a$
number of wrong answers		× ½ =	$= b$
number of missing answers		× 0 =	0
column total $c = \max(a - b, 0)$	12		$= c$

1. To define a C++ class that is equivalent to an interface in Java, all functions in the class must be declared :
   (A) abstract
   (B) private
   (C) static
   (D) virtual

2. Which of the following declarations would one expect for the following declaration (fill in the blank) ?
   `ostream& operator<< ( _____);`
   (A) `const ostream&, const foo&`
   (B) `const ostream&, foo&`
   (C) `ostream&, const foo&`
   (D) `ostream&, foo&`

3. Given the boundary tag method of managing heap storage, and that the `sizeof` a pointer is 8, what is the minimum distance in bytes returned by successive calls to `new` ?
   (A) 0x0008
   (B) 0x0020
   (C) 0x0100
   (D) 0x4000

4. What is the appropriate way to free data allocated by the following statement ?
   `int* p = new int[20];`
   (A) `delete[] p;`
   (B) `delete p;`
   (C) `delete p[20];`
   (D) `free (p);`

5. Primary colors as displayed on a computer monitor are :
   (A) cyan, magenta, yellow
   (B) orange, green, violet
   (C) red, green, blue
   (D) red, yellow, blue

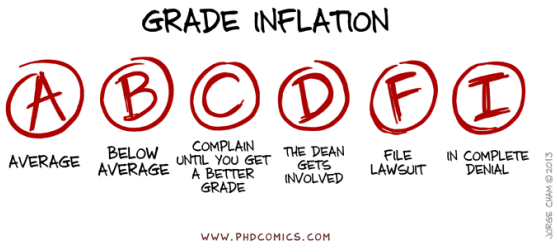
6. What is the correct way to declare a function as abstract ?
   (A) `abstract virtual void f();`
   (B) `virtual void f() = 0;`
   (C) `virtual void f() = default;`
   (D) `void f() virtual abstract;`

7. Which of the following lacks `operator[]` ?
   (A) `deque`
   (B) `list`
   (C) `map`
   (D) `vector`

8. An `unordered_map` is implemented as a :
   (A) balanced binary search tree
   (B) doubly linked list
   (C) hash table
   (D) singly linked list

9. Which of the following is a syntactically valid way to initialize a single `int` called `a`, but which will error out on a narrowing conversion ?
   (A) `int a (4.8);`
   (B) `int a <4.8>;`
   (C) `int a [4.8];`
   (D) `int a {4.8};`

10. If `i` is of type `vector<string*>::iterator`, what will print the string itself ?
    (A) `cout << ***i;`
    (B) `cout << **i;`
    (C) `cout << *i;`
    (D) `cout << i;`

11. A class hierarchy whose functions are chosen dynamically at run-time will declare functions using what keyword to indicate this ?
    (A) `const`
    (B) `friend`
    (C) `static`
    (D) `virtual`

12. Edsger Dijkstra wrote a paper claiming that the _____ statement was harmful to code.
    (A) `break`
    (B) `goto`
    (C) `throw`
    (D) `while`