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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.

1. Write the template function `find` which takes a key and a pair of ***forward*** iterators and returns the iterator which indicates the first item in the container that is `==` to the key. **[2✔]**

```
template <typename Keytype, typename Itertype>
Itertype find (Itertype begin, Itertype end, const Keytype& key) {
```

2. Write the template function `find` which takes a pair of ***forward*** iterators and a predicate and which returns the iterator indicating the first item in the container for which the predicate is true. Hint: the predicate takes a `const Keytype&` and returns a `bool`. **[2✔]**

```
template <typename Keytype, typename Itertype>
Itertype find (Itertype begin, Itertype end, bool (*pred) (const Keytype& key) {
```

3. Write the function `circle` in OpenGL, which draws a circle with the center at the coordinates (x, y) given to it. The radius and color are also given. **[3✔]**

```
void draw_circle (float xcenter, float ycenter, float radius, const GLubyte* color) {
   glBegin (GL_POLYGON);
```

4. Assuming the `sockets` library from project 5, and assuming that a date server exists that sends a single message back to the client then quits, write a function `date_client`, which when called from `main`, will contact the server for the date and print it. **[3✔]**

```
void date_client (string host, in_port_t port) {
```

5. In the multiprecision project, it was necessary to add two vectors of digits, each digit being represented in a byte. Write a function which takes to such vectors (signs are ignored here, only absolute values are used) and adds them together. **[4✔]**

```
typedef unsigned char byte;
typedef vector<byte> unumber;
unumber absadd (const unumber& u1, const unumber& u2) {
```

6. Define an object-oriented hierarchy as shown in the three parts described here. Show all code as it would appear in a header file so that no implementation file is needed. All classes have the virtual functions `area` and `circumference` as well as suitable constructors. Make sure the constructors can not be used in implicit conversions.

   (a) Class `shape` is the base class with abstract functions, and a suitably protected constructor. **[2✔]**

   (b) Class `circle`[1] has a single radius field which is initialized by the constructor. **[2✔]**

   (c) Class `square` has a single edge field (the length of one edge) initialized by the constructor and also the two other functions. **[2✔]**

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1. For the mathematically challenged: $A = \pi r^2$ and $C = 2\pi r$.
   And `<cmath>` defines `M_PI`: `# define M_PI 3.14159265358979323846 /* pi */`

7. Referring to the question on the previous page, write a function that will take a pair of iterators pointing into a container, and print two numbers: the sum of the areas and the sum of the circumferences. **[3✔]**

```
typedef vector<shared_ptr<shape>>::const_iterator vec_iterator;
void print_data (vec_iterator begin, vec_iterator end) {
```

8. Define a template class `queue` with a single typename parameter `T`. Show only what should be in `queue.h`, not anything from `queue.cpp`, except for when an inline is explicitly requred.
   (i) Declare the private node which contains a T and a link to the next node in the list. **[1✔]**
   (ii) Declare the head and tail pointers to be automatically initiallized to the null pointer. **[1✔]**
   (iii) Disable the copy constructor and copy `operator=`. **[1✔]**
   (iv) Declare a `front` function which is a constant function returning a constant reference to the data in the first node. **[1✔]**
   (v) Declare a non-constant `front` function which returns a non-constant reference to the data in the first node. **[1✔]**
   (vi) Declare `pop_front` in the way consistent with other containers. Do not show the implementation. **[1✔]**
   (vii) Declare `push_back`. Do not show the implementation. **[1✔]**

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, which count 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. A process which stays in the background doing nothing until it accepts a request from a client is called a :
   (A) daemon
   (B) vampire
   (C) werewolf
   (D) zombie

2. The value of a `constexpr` identifier is computed at :
   (A) compile time.
   (B) link time.
   (C) program load time.
   (D) funcation call time.

3. Which of the following makes use of the least amount of heap space ?
   (A) `deque<T>`
   (B) `list<T>`
   (C) `map<T>`
   (D) `vector<T>`

4. Two processes communicate via a socket, but each does only writing to the socket, never reading. This results in a :
   (A) deadlock
   (B) livelock
   (C) memory leak
   (D) race condition

5. The declaration `int x;` inside a function results in `x` being allocated in what memory segment ?
   (A) data
   (B) heap
   (C) stack
   (D) text

6. To prevent a constructor from being used implicitly in a conversion operation, precede its declaration by what keyword ?
   (A) `const`
   (B) `explicit`
   (C) `inline`
   (D) `private`

7. If an object is to be used as if it were a function, it must have what operator defined ?
   (A) `operator()`
   (B) `operator*`
   (C) `operator->`
   (D) `operator[]`

8. If `i` is an iterator pointing into a `map`, then the value associated with a given key is accessed via :
   (A) `i->first`
   (B) `i->second`
   (C) `i.first`
   (D) `i.second`

9. What are the maximum and minimum values of the exit status value returned by a program ?
   (A) –1 for error and 0 for success.
   (B) –128 to 127.
   (C) 0 to 255.
   (D) 0 to 65535.

10. In a client/server application, the client indicates a need to talk to a server via what system call ?
    (A) `accept`(2)
    (B) `bind`(2)
    (C) `connect`(2)
    (D) `socket`(2)

11. What is a possible way to implement `map` in C++ so that performance is acceptable ?
    (A) double-ended queue
    (B) hash table
    (C) linear linked list
    (D) red-black tree

12. What class performs storage management by reference counting ?
    (A) `auto_ptr<T>`
    (B) `counted_ptr<T>`
    (C) `shared_ptr<T>`
    (D) `unique_ptr<T>`

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, which count 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. After a process exits but before its parent waits for it, it is a :
   (A) daemon
   (B) vampire
   (C) werewolf
   (D) zombie

2. In OpenGL without transformations on a 2D plane, the x-axis increases ____-ward and the y-axis increases ____-ward.
   (A) x leftward and y downward.
   (B) x leftward and y upward.
   (C) x rightward, and y downward.
   (D) x rightward, and y upward.

3. To register an interrupt handler, such as, for example, to catch a `SIGINT` without having the program crash, what function is used ?
   (A) `accept`(2)
   (B) `listen`(2)
   (C) `sigaction`(2)
   (D) `socket`(2)

4. When a `runtime_exception` is caught, how is the specific message found ?
   (A) `e.getMessage()`
   (B) `e.strerror()`
   (C) `e.to_string()`
   (D) `e.what()`

5. Which of the following will be flagged (the compiler issues a warning) as a narrowing conversion ?
   (A) `int a (4.8);`
   (B) `int a = 4.8;`
   (C) `int a = {int(4.8)};`
   (D) `int a {4.8};`

6. If we have a class `T` and a variable `T x;`, Then normally we would expect `operator<<` that allows `cout<<x;` to be :
   (A) a member of class `T`.
   (B) a member of class `ostream`.
   (C) a virtual function dispatched on `x`.
   (D) not a member of any class.

7. For class `T`, in order to ensure that there is no copy constructor for itself nor for any derived classes, it should be declared as :
   (A) `T (const T&) = 0;`
   (B) `T (const T&) = delete;`
   (C) `T (const T&) = void;`
   (D) `T (const T&) {}`

8. What would one expect to be the first non-comment line in `foo.h` ?
   (A) `#define __FOO_H__`
   (B) `#ifdef __FOO_H__`
   (C) `#ifndef __FOO_H__`
   (D) `#include "foo.h"`

9. Which of the following will generate a compile time error message ?
   (A) `"a" + "b"`
   (B) `"a" + string("b")`
   (C) `string("a") + "b"`
   (D) `string("a") + string("b")`

10. Which system call when executed by a server causes it to block until another process tries to connect to it or until an interrupt occurs ?
    (A) `accept`(2)
    (B) `listen`(2)
    (C) `sigaction`(2)
    (D) `socket`(2)

11. What is the preferred way of referring to the null pointer in C++11 ?
    (A) `0`
    (B) `NULL`
    (C) `null`
    (D) `nullptr`

12. A move constructor for class `T` would be declared as :
    (A) `T (T&&);`
    (B) `T (T**);`
    (C) `T (const T&);`
    (D) `T (const T*);`