Note: Some comments in code may be incorrect. This is to simulate an employee who thinks the code does X, but it does Y.

Note: Unless specified, there may be more than one correct answer

You will have two hours to complete this exam.

1. Suppose we implement a queue.
    a. What is the worst-case time to dequeue?
        i. $O(n^2)$
        ii. $O(n)$
        iii. $O(1)$
        iv. $O(2^n)$
    b. What is the worst-case time to enqueue?
        i. $O(n^2)$
        ii. $O(n)$
        iii. $O(1)$
        iv. $O(2^n)$
    c. What is the worst-case time to peek?
        i. $O(n^2)$
        ii. $O(n)$
        iii. $O(1)$
        iv. $O(2^n)$
    d. What is the worst-case time of isEmpty?
        i. $O(n^2)$
        ii. $O(n)$
        iii. $O(1)$
        iv. $O(2^n)$
2. Suppose we implement a Stack.
    a. What is the worst-case time to dequeue?
        i. $O(n^2)$
        ii. $O(n)$
        iii. $O(1)$
        iv. $O(2^n)$
    b. What is the worst-case time to enqueue?
        i. $O(n^2)$
        ii. $O(n)$
        iii. $O(1)$
        iv. $O(2^n)$
    c. What is the worst-case time to peek?
        i. $O(n^2)$

ii. O(n)
iii. O(1)
iv. O(2^n)

d. What is the worst-case time of isEmpty?
   i. O(n^2)
   ii. O(n)
   iii. O(1)
   iv. O(2^n)

3. Suppose we have a word W and the length L. We want to see if W is a palindrome (radar backwards is radar). Which of the following is the correct implementation?
   a. A
   b. B
   c. C

A)

```
bool isPalindromeA(string word){
  queue<char> q;

  // Put all of the word in the queue, reversed
  for (char& c : word){
    q.push(c);
  }

  char checkC;

  // Check the reversed word agaist the orig
word
  for (char& c : word){
    checkC = q.front();
    q.pop();

    if (c != checkC){
      return false;
    }
  }


  return true;
}
```

B)

```
bool isPalindromeB(string word){
  // Go through the word, in linear time
  for (size_t i = word.size() - 1, j = 0;
     i >= j;
     i--, j++){
    if (word[i] != word[j]){
      return false;
    }
  }

  return true;
}
```

C)

```
bool isPalindromeC(string word) {
    stack<char> s;
    for (int i = word.size()/2;
         i >= 0;
         i--) {
        s.push(word[i]);
    }

    for (auto i = word.size() - 1;
         i >= word.size()/2;
         i--) {
        if (s.top() != word[i]) {
            return false;
        }
        s.pop();
    }
    return true;
}
```

4. What is wrong with the following tree?

Here is a binary search tree (BST) that can be constructed with the input numbers 12, 5, 3, 85, 39, and 90:

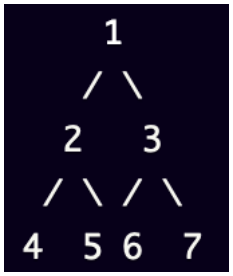
```
Code                                                    Copy Code

        12
       /  \
      5    85
     /    /  \
    3    39   90
```

Credit: GPT-3.5 Turbo

a. Nothing
b. 85 and 90 should be swapped
c. The root is incorrect
d. Something else (describe below)

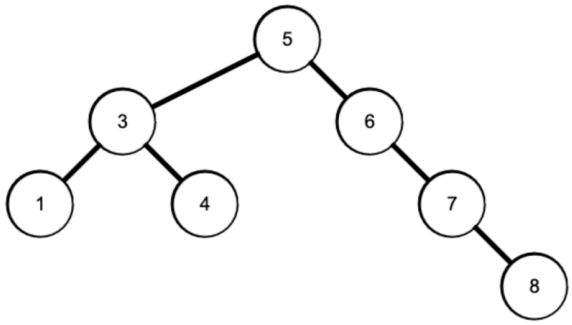
5. What input would produce the following tree?



Credit: CPT-3.5 Turbo

a. I cannot know without more details
b. 7 6 5 4 3 2 1
c. 1 2 3 4 5 6 7
d. 3 2 1 7 6 5 4
e. Something else (describe below)

Use the tree below for 6 & 7.



Credit: https://wintercore.github.io/bst-visualizer/

6. What is the insert order to obtain this tree?
    a. 8 7 4 1 3 6 5
    b. 5 3 6 1 4 7 8
    c. 5 6 3 7 4 1 8
    d. 6 5 7 8 4 3 1
    e. Something else (Describe to the right)
7. What insert order can we use to obtain a balanced tree?
    a. No such order exists
    b. The order:
8. Why would we want to write a private and public version of the same function?
    a. We do not, it wastes time
    b. If we are working with time-critical programs where 1ns is critical
    c. To increase security
    d. To hide pointer information
    e. To convert a const parameter to non-const parameter
    f. Because our boss tells us to
9. What should every class contain? [Select exactly 3]
    a. Constructor
    b. Setter
    c. Getter
    d. Destructor
    e. Overloaded stream operators (<< and/or >>)
    f. Overloaded assignment operator
    g. Inheritance
    h. Copy constructor
    i. Private members
    j. Virtual functions
    k. Virtual constructors

10. Suppose we have a queue with 100 elements.
    a. When we dequeue,
        i. Only the front changes
        ii. Only the rear changes
        iii. Nothing changes
        iv. Other/Conditionally I, II, III
    b. When we enqueue,
        i. Only the front changes
        ii. Only the rear changes
        iii. Nothing changes
        iv. Other/Conditionally I, II, III
    c. When we peek at the front or back,
        i. Only the front changes
        ii. Only the rear changes
        iii. Nothing changes
        iv. Other/Conditionally I, II, III
11. What is wrong with the following code?

```
// The base class with x, y, and z visible
class BaseClass {
protected:
    int x; int y; int z;
};

// The mid class with x, y, z, a, b, and c visible
class MidClass: BaseClass {
protected:
    int a; int b; int c;
};

// The upper class with x, y, z, a, b, c, d, f, and g visible
class UpperClass: MidClass {
    UpperClass() {
        x = d; y = f; z = g;
    }
protected:
    int d; int f; int g;
};
```

Write what is wrong with the code here (also provide solution):

12. Write the purpose of the following data structures:
    a. Tree
    b. Queue
    c. List
    d. Stack
13. Virtual functions must be pure virtual functions if there is at least one pure virtual function.
    a. True
    b. False
14. We use the @Override attribute to override (not overload) a function.
    a. True
    b. False
15. Inserting at the end of a singly linked list is *always* slower than inserting at the end of an array.
    a. True
    b. False
16. We use UML to graphically describe the functionality of a system.
    a. True
    b. False
17. UML can only describe logical, class, and other code-related relationships.
    a. True
    b. False
18. You attempt to allocate memory, but it fails. An exception (`std::bad_alloc`) is thrown. But you are a good programmer and anticipated this being thrown, write the code below. **You want to print out the debug info using .what().**

19. FIFO is the same as FILO
    a. True
    b. False
20. FIFO is comparable as FCFS
    a. True
    b. False
21. We can use a BST to sort, reverse, and maintain order of an input vector.
    a. We can only maintain the order
    b. We can only reverse it, the original order is lost
    c. We can only sort it, the original order is lost
    d. We can do all of them
22. FIFO is used in the following data structures:
    a. Tree
    b. Queue
    c. List
    d. Stack
23. FILO is used in the following data structures:
    a. Tree
    b. Queue
    c. List
    d. Stack
24. Find any issues with the enqueue code.

```
Queue enqueue(T value) {
     Node* newNode = new Node(value)
     if (rear == nullptr) {
          front = rear = newNode;
     } else {
          rear->next = newNode;
          rear = newNode;
     }
}
```

25. Find any issues with the dequeue code.

```
void dequeue(T out) {
     if (front == nullptr) {
          abort("front is null ptr");
     }

     out = front;
     front = front->next;
     delete temp;
```

```
    if (front == nullptr) {
        rear = nullptr;
    }
}
```

26. What is the proper way to cast an int to a double?
    a. int x = y;
    b. int x = (int)y;
    c. int x = static_cast<int>(y);
    d. int x = dynamic_cast<int>(y);
27. It is valid to use C code in C++
    a. True
    b. False
28. It is valid to use C++ code in C
    a. True
    b. False
29. Which line is correct to override a pure virtual function in C++?
    a. void f() override {}
    b. override void f() {}
    c. void override f() {}
    d. void f() {} override
    e. @Override void f() {}
30. What does delete do?
    a. Deallocate memory
    b. Allocate memory
    c. Call the constructor
    d. Call the destructor
    e. None of the above (describe correct answer)
31. What does new do?
    a. Deallocate memory
    b. Allocate memory
    c. Call the constructor
    d. Call the destructor
    e. None of the above (describe correct answer)
32. In C++, we can inherit from 500 base classes
    a. True
    b. False
33. In C++, what problems do we encounter with inheritance?
    a. None
    b. Tree Problem

c. Circular Problem
d. Diamond Problem
e. Ruby Problem

34. What is wrong with this BST's private insert function?

Specifications:

- There must be a public interface which the developer will call insert(50). The caller should expect a Boolean value which indicates if it failed to insert. It does not matter if it failed to allocate memory or if it already exists.
- Within the private function, we want to set the left and right. It should return the same value as the public interface.
- The node contains getters and setters for the left and right node. The function to get the value is value().

/// Note: The public function is good

```
Node* insertRec(Node* root, int value) {
     if (root == nullptr) {
          return new Node(value);
     }

     if (key < root->value()) {
          root->setLeft = insertRec(root->left, key);
     } else if (key > root->key) {
          root->setRight = insertRec(root->right, key);
     }

     return root == nullptr;
}
```

Describe here:

35. What is the correct order for in-order transversal?
    a. LEFT DATA RIGHT
    b. LEFT RIGHT DATA
    c. RIGHT LEFT DATA
    d. RIGHT DATA LEFT
    e. DATA LEFT RIGHT
    f. DATA RIGHT LEFT
36. What is the correct order for pre-order transversal?
    a. LEFT DATA RIGHT
    b. LEFT RIGHT DATA
    c. RIGHT LEFT DATA

    d. RIGHT DATA LEFT
    e. DATA LEFT RIGHT
    f. DATA RIGHT LEFT

37. What is the correct order for post-order transversal?
    a. LEFT DATA RIGHT
    b. LEFT RIGHT DATA
    c. RIGHT LEFT DATA
    d. RIGHT DATA LEFT
    e. DATA LEFT RIGHT
    f. DATA RIGHT LEFT
38. When do we use pre-order traversal?

39. When do we use post-order traversal?

40. When do we use in-order traversal?

41. We can use a queue to implement an array.
    a. True
    b. False
42. `this` keyword is an object.
    a. True
    b. False
43. When we overload an operator, we can provide the precedence.
    a. True
    b. False
44. Within an overloaded operator, say for `+`, we must use the `+` symbol within the body, otherwise we get a compiler error.
    a. True
    b. False
45. Suppose class A and B are defined. B inherits from A as such `class B : A {…};`. Now, we write `B newClass = A()`. This is valid.
    a. True
    b. False

46. Suppose class A and B are defined. B inherits from A as such `class B : A {…};`. Now, we write `A newClass = A()`. This is valid.
    a. True
    b. False
47. Suppose class A and B are defined. B inherits from A as such `class B : A {…};`. Now, we write `A newBClass = B()`. This is valid.
    a. True
    b. False
48. Suppose class M is fully functional and has a destructor. Within M, we allocate memory that needs to be destroyed. We declare it as `M* m = new M()`. Now, we are done with m and destroy it like `free(m)`. The following occurs:
    a. Compiler Error
    b. Runtime Error
    c. Memory Leak
    d. Dangling Pointer
    e. No Error
49. Suppose class M is fully functional and has a destructor. Within M, we allocate memory that needs to be destroyed. We declare it as `M* m = new M()`. Now, we are done with m and destroy it like `~(*m); free(m)`. The following occurs:
    a. Compiler Error
    b. Runtime Error
    c. Memory Leak
    d. Dangling Pointer
    e. No Error
50. Suppose class M is fully functional and has a destructor. Within M, we allocate memory that needs to be destroyed. We declare it as `M* m = new M()`. Now, we are done with m and destroy it like `m->~M(); free(m)`. The following occurs:
    a. Compiler Error
    b. Runtime Error
    c. Memory Leak
    d. Dangling Pointer
    e. No Error
51. All data structures are linear because non-linear structures are too complicated to program with efficiency.
    a. True
    b. False
52. Polymorphism is the same as inheritance.
    a. True
    b. False

53. What is required for a class to be considered abstract?
    a. It has at least one *virtual* function
    b. It has more than one *virtual* function
    c. It has all *pure virtual* functions
    d. It has at least one *pure virtual* function
    e. It has more than one *pure virtual* function
    f. It has *virtual* constructors
    g. It has *virtual* destructors

54. Is there anything wrong with these constructors? If so, what is wrong?

```
virtual MyClass() {
        cout << "Setting up…" << endl;
        … set all members …
}
virtual MyClass(MyClass* copy) {
        cout << "Copying class…" << endl;
        … copy over members …
}
```

55. What will be implicitly called when the operator is invoked?

```
operator<<(ostream& lhs, Data& rhs);
```

56. What is wrong with the implementation below?

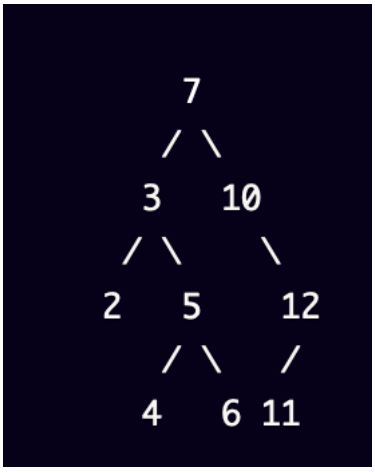
```
ostream operator<<(ostream& lhs, Data& rhs) {
     lhs << rhs.data() << endl;
}
```

57. What is wrong with the following reverse function (of a singly linked list)?

Note: The members of Node are public

```
Node* reverse(Node* cur) {
    Node * last = cur;
    if (cur != nullptr) {
        last->next = nullptr;
        cur = reverse(cur);
        cur->next = last;
    }
    return cur;
}
```

58. When would we want to use polymorphism?
    a. When we want to look fancy
    b. When we want to use more generic base classes
    c. When we want to use write less code to do more
59. When we inherit from multiple classes, how to we access a function in B1 instead of B2 from C `class C: B1, B2 {…};` (From the perspective of C)?
    a. dynamic_cast<B1>(this)->f1();
    b. ((B1)(this))->f1();
    c. __treat_as_base__((B1))
       this->f1();
    d. this->B1.f1();
    e. this->B1->f1();
    f. Something else
60. Who can access private members of class A?
    a. private, protected, public members of A
    b. private members of B (which inherits from A)
    c. private, protected, public members of B (which inherits from A)
    d. friends of A
    e. all classes which inherit via public or protected
61. Which of the following protection levels are valid in C++?
    a. private
    b. protected
    c. public
    d. fileprivate
    e. internal
62. What is the output of the code below?
    a. preOrderTraversal()
    b. postOrderTraversal()
    c. inOrderTraversal()



Credit: GPT-3.5 Turbo

63. What is the output of the following code?

```
/// Node has last, next, and data
void foo(Node * n) {
     for (;n != nullptr; n = n->next) {
          cout << n->data() << endl;
     }
}
```

64. What is happening in the following code?

```
/// Node has last, next, and data
void bar(Node * n) {
     Node * p = nullptr;
     for (;n != nullptr; n = n->next) {
          if (p) {
               barfoo(p,n); // Assuming we are never at list end
               p = nullptr;
          } else {
               p = n;
          }
     }
}
void barfoo(Node * p, Node * n) {
     Node * pL = p->last,
          * pN = p->next,
          * nL = n->last,
          * nN = n->next;
     if (pL) {
          pL->next = n;
     }
     if (pN) {
          pN->last = n;
     }
     if (nL) {
          nL->next = p;
     }
     if (nN) {
          nN->last = p;
     }
       n->last = p->last;
       n->next = p->next;
       p->last = nL;
       p->next = nN;
}
```