

CS 14 – Midterm
100 points possible

For all questions, $\lg N$ or $\log N$ is the log base 2 of N .

For all questions, assume all ADT implementations and algorithms are good implementations.

Do NOT make any stray marks on your answer sheet. You may use pen or pencil, but if you want to change an answer, you MUST either erase completely or mark an “X” through your incorrect answer.

True/False questions. Please mark A for True and B for False on the answer sheet provided: (2 point each – 16 points total)

For the following two questions, suppose $f(N) = O(h(N))$ and $g(N) = O(h(N))$.

1. Is $f(N) + g(N) = O(h(N))$?

2. Is $f(N) * g(N) = O(h(N))$?

3. If x and y are real numbers such that $0 < x < y$ then n^x is $O(n^y)$ but n^y is not $O(n^x)$

4. A stack is a FIFO structure.

5. Assume you have a queue implemented with a singly linked list with head and tail pointers. Performing enqueue operations at the head and dequeue operations at the tail is more efficient than performing enqueue operations at the tail and dequeue operations at the head.

6. You can only write an iterator for a linked list.

7. Binary search has the same runtime on a sorted array as on a sorted linked list.)

8. $O(\max\{f(n), g(n)\}) = O(f(n) + g(n))$

Multiple choice questions. Please mark the answer on the answer sheet provided:
(3 pts each) – 45 points total

9. Put the following in order of **increasing** growth rate:

n, 2^n , $n \log n$, n^n , $n - n^3 + 7n^5$, $n^2 + \log n$, n^2 , $\log n$, $n!$

- A. n, $n^2 + \log n$, $\log n$, n^2 , $n \log n$, $n - n^3 + 7n^5$, $n!$, 2^n , n^n
- B. $n \log n$, n, $\log n$, n^2 , $n^2 + \log n$, n^2 , $n - n^3 + 7n^5$, 2^n , n^n , $n!$
- C. $n \log n$, $\log n$, n, $n - n^3 + 7n^5$, $n^2 + \log n$, n^2 , 2^n , $n!$, n^n
- D. 2^n , $n!$, n^n , $\log n$, n, $n \log n$, $n - n^3 + 7n^5$, $n^2 + \log n$, n^2
- E. $\log n$, n, $n \log n$, $n^2 + \log n$, n^2 , $n - n^3 + 7n^5$, 2^n , $n!$, n^n

10. In C++, the protected modifier for members of a class C means:

- A. The exact same as private
- B. The same as private except when C inherits from another class
- C. The same as private except when another class derives from C
- D. There may only be one copy of the class in memory at a time
- E. All of the above
- F. None of the above

11. If the definition of class *Dog* contains the line “*friend class Cat*” then

- A. Instances of type *Dog* can access private members of instances of type *Cat*
- B. Instances of type *Cat* can access private members of instances of type *Dog*
- C. Instances of type *Dog* can access friend members of instances of type *Cat*
- D. Instances of type *Cat* can access friend members of instances of type *Dog*
- E. All of the above
- F. None of the above

12. Suppose you have a sorted array of 1000 elements. Using the most efficient search method possible, what is the maximum number of elements you will have to examine to determine if some value *v* is in the array?

- A. 1
- B. 9
- C. 10
- D. 250
- E. 500
- F. 1000

For the questions on this page, use the following answer choices:

- | | | | |
|----|-------------|----|-------------------|
| A. | $O(1)$ | B. | $O(N)$ |
| C. | $O(N^2)$ | D. | $O(N \log N)$ |
| E. | $O(\log N)$ | F. | None of the above |

Give the Big-Oh runtime for the following snippets of code:

13.

```
void Ex2(int n)
    int a;
    for ( int x = 0; x < n; x+=2 ) a = x;
```
14.

```
void Ex3(int n)
    int a;
    for ( int x = 0; x < n*n; ++x ) a = x;
```
15.

```
void Ex5(int n)
    int a;
    for ( int x = 0; x < n*n; ++x )
        for ( int y = 0; y < x; ++y ) a = x;
```
16.

```
void Ex6(int n)
    int a;
    for (int x = 0; x < n; x++ )
        for (int y = 1; y < n; y *= 2) a = x;

    for (int x = 0; x < 3*n; x++ ) a = x;
```

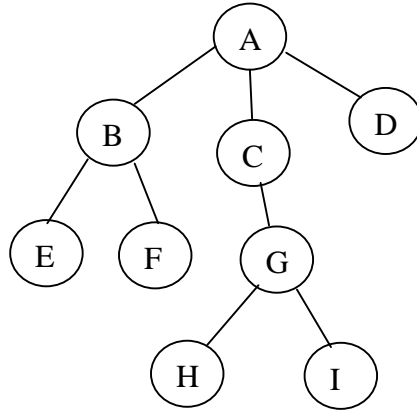
17. Which of the above best represents the Big-Oh runtime for push into an array implemented stack?

18. Which of the above best represents the Big-Oh runtime for enqueue into a linked list implemented queue?

19. Which of the above best represents the Big-Oh runtime for replaceAtRank for an array implemented sequence?

20. Which of the above best represents the Big-Oh runtime for replaceAtRank for a linked list implemented sequence?

For the next 5 questions, use the following tree:



21. Which node/nodes is/are descendant(s) of C (Mark only one answer)

- | | | | |
|----|------------------|----|-------------------|
| A. | A | B. | E |
| C. | G | D. | D |
| E. | All of the above | F. | None of the above |

22. What is the path length of the path from A to I

- | | | | |
|----|---|----|-------------------|
| A. | 1 | B. | 2 |
| C. | 3 | D. | 4 |
| E. | 5 | F. | None of the above |

23. What is the height of node D

- | | | | |
|----|---|----|-------------------|
| A. | 1 | B. | 2 |
| C. | 3 | D. | 4 |
| E. | 5 | F. | None of the above |

Briefly define the following:

24. (3 pts) Virtual Function

25. (3 pts) Static/early binding

26. (2 pts) Abstract Data Type

27. (7 pts) It is possible to implement two stacks using a single array. Describe how to do the push and pop operations for both stacks and give the big-oh runtimes of the operations. You may draw a picture to show the operations if that is easier.

27. (8 pts) Given the following snippet of code:

```
int* x = new int;  
int y = *x;  
int* z = &y;  
y = 10;  
int a = *z;  
(*x) ++;  
(*z) --;  
int* b = 0;
```

Describe what the following statements will produce (either what will be printed or what will happen). If a memory address is printed, be as specific as you can by telling me what variable/value the memory address is associated with.

a) `cout << *b << endl;`

b) `cout << y << endl;`

c) `cout << *z << endl;`

d) `cout << a << endl;`

e) `cout << *x << endl;`

f) `cout << &y << endl;`

g) `cout << z << endl;`

h) `cout << x << endl;`

28. (6 pts) Write a recursive function to print the elements of a linked list **backwards** (print last element first and first element last).

29. (12 pts) Given an n-element unsorted linked list and a value k , write a *recursive* function to find and return a pointer to the node containing the **smallest value greater** than k . If no such value exists, return NULL.