McGill

Winter 2019
Midterm Examination 2

INTRODUCTION TO COMPUTER SCIENCE

COMP 250

Version A

Wednesday March 20th 18:30-20:00

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Signature:	____________________________	Signature:	________________________

Student Name:		**McGill ID:**									

INSTRUCTIONS:

- This is a CLOSED BOOK examination
- Answer ON THE SCORE SHEET
- **Ensure that the version number on your score sheet matches the version number of this exam questionnaire.**

1. **Consider the following declarations in Java. Which methods must class `Neighbour` implement to make the code compile**

```
interface DrivewayClearer { void clearDriveway(); }
interface WalkwayClearer extends DrivewayClearer { void clearWalkway(); }
class Neighbour extends WalkwayClearer { }
```

A. None, this code already compiles;
B. Only `clearDriveway()` is sufficient;
C. Only `clearWalkway()` is sufficient;
D. Both `clearDriveway()` and `clearWalkway()` are necessary; (ANSWER)
E. Inapplicable (an interface cannot extend an interface);

2. **You have a stack of letters A, B, C, D, E where E is on the top of the stack. What is the minimum number of operations (push, pop) that are required to change the stack to A, B, D, E?**

A. 1
B. 3
C. 5 (ANSWER)
D. 9
E. None of the above

3. **Consider a type Deque implemented in Java, with the operations isEmpty(), void addFirst(String), void addLast(String), String removeFirst(), and String removeLast(). Consider that one instance of Deque is initialized with, from last to first, the letters D, C, B, A. Chose the statements that will create a new Deque that is a reversed version of d1, namely, that would hold the letters A, B, C, D.**

```
Deque d1 = new Deque();
d1.addLast("A"); d1.addLast("B"); d1.addLast("C"); d1.addLast("D");

Deque d2 = new Deque();
while( !d1.isEmpty()  )
{
  /* X */ ( /* Y */ );
}
```

A. X: d2.addLast Y: d1.removeLast() (ANSWER)
B. X: d2.addLast Y: d1.removeFirst()
C. X: d2.addFirst Y: d1.removeLast()
D. All of the above
E. None of the above

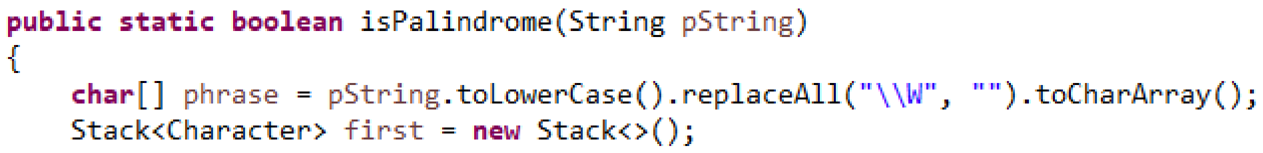
4. **In the code of a method, what does the keyword `this` refer to?**

A. An object that represents the method itself;
B. The object that is implicitly passed as argument to the method; (ANSWER)
C. An instance of the Java Virtual Machine
D. An array of arguments to the method;
E. None of the above

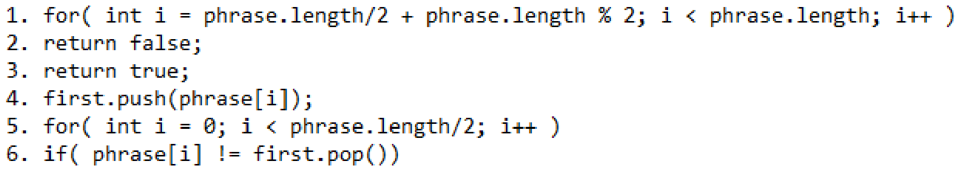
5. **We want to prove by induction that for n >= 0, 0 < a < 1, then $(1 - a)^n$ >= 1 – na. What is the base clause?**

A. There is no base clause;
B. a ≠ 0
C. n >= 0
D. 0 = 0
E. 1 >= 1 (ANSWER)

6. Order the statements to complete a valid implementation of a palindrome verifier. Remember that a palindrome is a string that can be read the same forward and backwards. Assume that all necessary closing braces will be added.



```java
public static boolean isPalindrome(String pString)
{
    char[] phrase = pString.toLowerCase().replaceAll("\\W", "").toCharArray();
    Stack<Character> first = new Stack<>();
```



```
1. for( int i = phrase.length/2 + phrase.length % 2; i < phrase.length; i++ )
2. return false;
3. return true;
4. first.push(phrase[i]);
5. for( int i = 0; i < phrase.length/2; i++ )
6. if( phrase[i] != first.pop())
```

A. 1,5,6,4,2,3

B. 5,6,1,2,4,3

C. 1,4,5,6,3,2

D. 5,4,1,6,2,3 (ANSWER)

E. 1,5,4,6,3,2

7. What is the most efficient way to compute a Fibonacci Sequence F(0)=1; F(1)=1; F(n)=F(n-1)+F(n-2) if n >=2 ?

A. A recursive algorithm that directly implements the formula

B. An iterative algorithm that stores intermediate Fibonacci values (ANSWER)

C. A combination of A and B that uses the recursive implementation for even numbers

D. An iterative algorithm that uses binary search

E. None of the above is a good way to compute Fibonacci sequences.

8. One can prove by induction that $\sum_{i=1}^{n} Q(i) = n^2(n+1)$. For which choice of $Q(i)$ will this be true?

A. $3i^2 - 2$

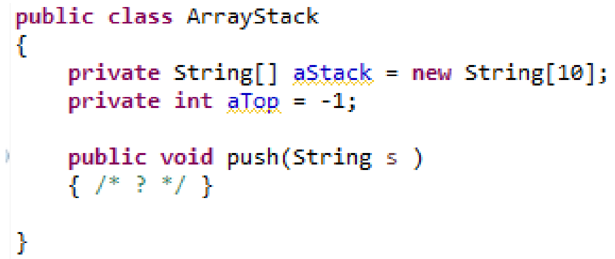
B. $2i^2$

C. $i(3i - 1)$ (ANSWER)

D. All of the above

E. None of the above

9. Given the following partial implementation for a Stack ADT supported by an array, how do you implement the `push(String)` operation?



```java
public class ArrayStack
{
    private String[] aStack = new String[10];
    private int aTop = -1;

    public void push(String s )
    { /* ? */ }

}
```

```
A. aTop++; aStack[aTop] = s; (ANSWER)
B. aStack = new String[1]; aStack[0] = s;
C. if( aTop < 0 ) aTop = 0; aTop++; aStack[aTop] = s;
D. while( aStack[aTop] != null ) aTop++; aStack[aTop] = s;
```

E. None of the above.

10. How do you implement a Queue ADT using two stacks S1 and S2?

A. Enqueue by pushing on S1, dequeue by popping all of S1 into S2, popping the top of S2, then pushing all of S2 into S1.
B. Enqueue by popping all of S1 into S2, pushing into S1, then popping all of S2 into S1, dequeue by popping the top of S1
C. Enqueue by popping all of S1 into S2, pushing into S2, then popping all of S2 into S1, dequeue by popping the top of S1
D. All of the above (ANSWER)
E. None of the above

11. Select the statements that will correctly implement the toString(String[]) method that returns a string with the element of the array in order. For example, [“A”, “B”, “C”] should be returned as “A, “B”, “C”. Remember that Arrays.copyOf(a,n) returns a copy of the array a that only includes the first n elements. Elements in brackets (e.g., <A>) are to be replaced by code.

```
public static String toString(String[] pElements)
{
  if( <W>  ) { return <X>; }
  else { return toString( <Y> ) + ", " + <Z>; }
}
```

A. W: pElements.length == 1 X: return pElements[0] Y: Arrays.copyOf(pElements, pElements.length-1)) Z: pElements[pElements.length-1] (ANSWER)
B. W: pElements.length == 0 X: return “” Y: Arrays.copyOf(pElements, pElements.length)) Z: pElements[pElements.length]
C. W: pElements.length == 0 X: return “” Y: Arrays.copyOf(pElements, pElements.length-1)) Z: pElements[pElements.length-1]
D. W: pElements.length == 1 X: return pElements[0] Y: Arrays.copyOf(pElements, pElements.length-2)) Z: pElements[pElements.length-1]
E. None of the above

12. What term describes the outcome of the following two statements:

```
List<Integer> list = new ArrayList<>(); list.add(250);
```

A. Compilation error;
B. Run-time ClassCastException
C. Run-time NumberFormatException
D. Integer overflow
E. Autoboxing (ANSWER)

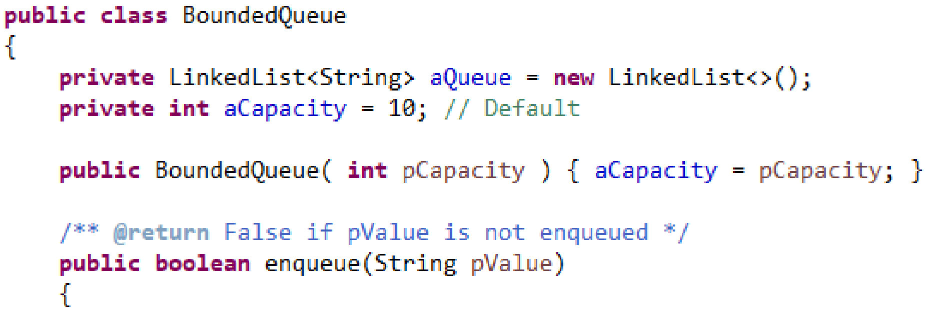
13. How do you make a class C iterable through the `Iterable` interface? You declare the class to implement the interface `Iterable` and…

A. That’s it.
B. Add an implementation for method iterator() in class C; (ANSWER)
C. Add implementations for methods hasNext() and next() in class C;
D. Add implementations for methods iterator(), hasNext(), and next() in class C;
E. Make class C also implement the Iterator interface;
F. None of the above

14. What is a PriorityQueue ADT?

A. A queue that keeps its components ordered according to some specified priority order. (ANSWER)
B. A synonym for deque, namely a queue that allows insertion of priority elements at the front.
C. A queue that implements the FIFO (first-in, first out) priority scheme.
D. A queue implementation that should be the first choice when selecting an ADT
E. None of the above

15. Implement the enqueue operation of a this bounded queue of strings by ordering the statements. Assume that all necessary closing braces will be added.



```
public class BoundedQueue
{
    private LinkedList<String> aQueue = new LinkedList<>();
    private int aCapacity = 10; // Default

    public BoundedQueue( int pCapacity ) { aCapacity = pCapacity; }

    /** @return False if pValue is not enqueued */
    public boolean enqueue(String pValue)
    {
```

```
1. return true;
2. return false;
3. aQueue.add(pValue);
4. if( aQueue.size() == aCapacity )
```

A. 3, 4, 1, 2

B. 3, 4, 2, 1

C. 4, 2, 3, 1 (ANSWER)

D. 4, 1, 3, 2

E. None of the above

16. Consider an array with n elements. What is the maximum number of comparisons that can take place when a bubble sort is executed?

A. $(n - 1)/2$

B. $(n + 1)/2$

C. $n(n - 1)/2$ (ANSWER)

D. $n(n - 1)/4$

E. $n(n + 1)/2$

17. Consider the following snippet of code.

```
MyDataStructure<MyE> m = new MyDataStructure<MyE>();
for(int i=0; i<5; i++) {
      m.add(new MyE());
}
for(MyE e : m) {
      System.out.println(e);
}
```

Assuming the code compiles and runs. Which of the following statements *must* be true?

A. MyE is an inner class of `MyDataStructure`

B. `MyDataStructure` is a linear data structure.

C. MyE implements `Iterator`

D. `MyDataStructure` is a subtype of `Iterable` (ANSWER)

E. None of the above

18. Consider the problem of sorting a list of 10 elements from smallest to largest. Which of the following statements is *always* (no matter the input list) true of the state of the list after *five* passes of `insertionsort`?

A. The first five elements are the smallest in the list.
B. The last five elements are sorted, but in reversed order.
C. The first five elements are sorted. (ANSWER)
D. The list is sorted.
E. None of the above.

19. Consider the problem of sorting a list from smallest to largest. For the following input list,

$$(\mathbf{7}, \mathbf{6}, \mathbf{1}, \mathbf{8}, \mathbf{4}, \mathbf{5}, \mathbf{3}, \mathbf{2})$$

what is the state of the list after *three* passes of `selectionsort`?

A. $(1, 2, 3, 8, 4, 5, 7, 6)$ (ANSWER)
B. $(1, 4, 5, 3, 2, 6, 7, 8)$
C. $(1, 6, 7, 8, 4, 5, 3, 2)$
D. $(1, 2, 3, 7, 6, 4, 8, 5)$
E. None of the above.

20. Suppose you were to sort a list of n values using `mergesort`. Which of the following statements is true?

A. The algorithm takes longer if the input list is already sorted, but in reversed order.
B. No matter the input list, there's always going to be $O(\log_2 n)$ calls to `merge`.
C. There are always going to be more calls to `merge` than to `mergesort`.
D. The number of calls to `mergesort` is always going to be $O(n)$. (ANSWER)
E. None of the above.

21. Consider an implementation of quicksort done "in place" (i.e. as seen in class) where the pivot is chosen as the first element of the list. For the input list,

$$(\mathbf{7}, \mathbf{3}, \mathbf{2}, \mathbf{8}, \mathbf{4}, \mathbf{6}, \mathbf{5}, \mathbf{1})$$

what is the state of the list after the first *three* calls to quicksort?

A. $(1, 3, 2, 4, 5, 7, 8, 6)$
B. $(1, 2, 3, 4, 6, 5, 7, 8)$ (ANSWER)
C. $(2, 1, 3, 4, 6, 5, 7, 8)$
D. $(1, 2, 3, 4, 5, 6, 7, 8)$
E. None of the above.

22. Recall the recursive algorithm to compute x^n.

```
power(x, n) {
     if (n==0)
          return 1;
     else if (n==1)
          return x;
     else {
          tmp = power(x, n/2);
          if(n%2==0)
               return tmp*tmp;
          else
               return tmp*tmp*x
     }
}
```

How many multiplications do we need to compute x^{167}?

A. 10
B. 11 (ANSWER)
C. 12
D. 13
E. 14

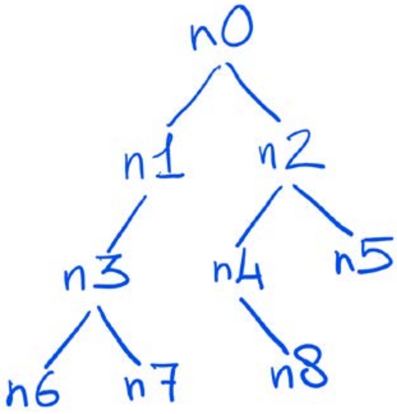
23. Write the following expression in prefix, assuming the usual operator precedence:

$$\mathbf{6 + (2 - 3) * 4 + 1/5}$$

(**Hint**: **you might find it useful to first build the corresponding expression tree**)

A. $6\ 2\ 3 - 4 * + 1\ 5 / +$
B. $+ + 6 * - 2\ 3\ 4\ /\ 1\ 5$ (ANSWER)
C. $6 + 2 - 3 * 4 + 1\ /\ 5$
D. $+ + / \ 6 * 1\ 5 - 4\ 2\ 3$
E. $+ + 6\ /\ 5 * -2\ 1\ 4\ 3$

24. Consider the following binary tree with labels $n0, n1, n2, n3, n4, n5, n6, n7, n8$:



What is the list of nodes visited in a post-order traversal?

A. $n0\ \ n1\ \ n3\ \ n6\ \ n7\ \ n2\ \ n4\ \ n8\ \ n5$
B. $n6\ \ n3\ \ n7\ \ n1\ \ n0\ \ n4\ \ n8\ \ n2\ \ n5$
C. $n1\ \ n3\ \ n6\ \ n7\ \ n2\ \ n8\ \ n4\ \ n5\ \ n0$
D. $n0\ \ n1\ \ n6\ \ n7\ \ n3\ \ n2\ \ n8\ \ n4\ \ n5$
E. $n6\ \ n7\ \ n3\ \ n1\ \ n8\ \ n4\ \ n5\ \ n2\ \ n0$ (ANSWER)

25. For the same tree as above, suppose it is a binary search tree. Which elements come between $n7$ and $n4$ (inclusive) in the natural ordering of the tree?

A. $n7\ \ n1\ \ n0\ \ n4$ (ANSWER)
B. $n7\ \ n3\ \ n1\ \ n0\ \ n2\ \ n4$
C. $n7\ \ n0\ \ n2\ \ n8\ \ n4$
D. $n7\ \ n1\ \ n0\ \ n2\ \ n4$
E. $n7\ \ n3\ \ n1\ \ n0\ \ n8\ \ n4$

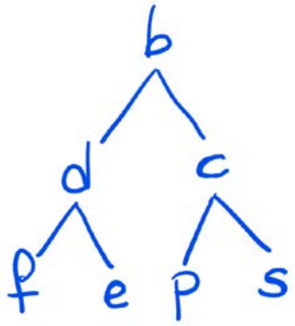
26. For the same tree as above, suppose it is a binary search tree. What is the list of nodes visited in an in-order traversal after `remove(n0)` is executed?

A. $n6\ \ n3\ \ n7\ \ n1\ \ n8\ \ n4\ \ n2\ \ n5$
B. $n6\ \ n3\ \ n7\ \ n1\ \ n5\ \ n4\ \ n8\ \ n2$
C. $n6\ \ n3\ \ n7\ \ n1\ \ n2\ \ n4\ \ n8\ \ n5$
D. $n6\ \ n3\ \ n1\ \ n7\ \ n4\ \ n8\ \ n2\ \ n5$
E. $n6\ \ n3\ \ n7\ \ n1\ \ n4\ \ n8\ \ n2\ \ n5$ (ANSWER)

27. A ternary tree is a tree where each node has up to three children. What is the maximum number of nodes in a ternary tree of depth h?

A. $\frac{3^h-1}{2}$
B. $3^{h+1}-1$
C. 3^h
D. $\frac{3^{h+1}-1}{2}$ (ANSWER)
E. None of the above.

28. Consider the following heap which is defined by the usual dictionary ordering for strings.



Suppose you were to call removeMin() twice followed by add(k). What would be the array representing the heap after the three operations?

A. $d\ e\ k\ f\ s\ p$ (ANSWER)
B. $p\ d\ k\ f\ e\ s$
C. $d\ e\ f\ s\ k\ p$
D. $p\ d\ f\ e\ k\ s$
E. $f\ s\ e\ p\ k\ d$

29. How many leaves does a complete binary tree with n nodes have? In the expressions below, assume integer division.

A. $\frac{n}{2}$
B. $\frac{n+1}{2}$ (ANSWER)
C. $\frac{n-1}{2}$
D. $\frac{n}{2}+1$
E. It depends.

30. What is the height of the root node of a complete binary tree with 16 elements?

A. 0
B. 2
C. 3
D. 4 (ANSWER)
E. 5