

Western University  
Department of Computer Science  
CS1027B Foundations of Computer Science II  
Midterm Exam  
October 26, 2024

Last Name: \_\_\_\_\_

First Name: \_\_\_\_\_

Student Number: \_\_\_\_\_

Section Number (1-Ibrahim, 2-Solis-Oba): \_\_\_\_\_

**Instructions**

- Fill in your name, student number, and section.
- The exam is 2 hours long and it has a total of 106 marks.
- The first part of the exam consist of multiple choice questions. For each question **CIRCLE ONLY ONE ANSWER.**
- For the second part of the exam, answer each question **ONLY IN THE SPACE PROVIDED.**
- When you are done, raise your hand and one of the TA's will collect your exam.
- **YOU CANNOT LEAVE** the examination room in the last 10 minutes of the exam.

**Note.** In all questions that refer to singly linked lists or doubly linked lists methods `getNext`, `getPrevious` (for doubly-linked lists only), `setNext` and `setPrevious` (for doubly-linked lists only) are getter and setter methods to obtain and to set the next or previous node in the list.

### Part I. Multiple Choice Questions

For each multiple choice question circle **ONLY ONE** answer.

1. (2 marks) Which of the following statements are true:

(A) A java compiler executes a java program  
(B) A java compiler detects runtime errors  
(C) A runtime error would be caused if a variable is not declared before being used

☐ Only A    ☐ Only B    ☐ Only C    ☐ Only A and B    ☐ Only A and C  
☐ Only B and C    ☐ All    ☐ None

2. (2 mark) Which of the following statements are true:

(A) Casting transforms an object from one type to a different type  
(B) In statement `int[] a;` `a` is a variable of a primitive type  
(C) In statement `String[] s;` `s` is a variable of a non-primitive type

☐ Only A    ☐ Only B    ☐ Only C    ☐ Only A and B    ☐ Only A and C  
☐ Only B and C    ☐ All    ☐ None

3. (2 mark) Consider the following Java statement

```
Object p = new String("hi");
```

Which of the following statements is true:

☐ The above statement will cause a compiler error  
☐ The above statement will cause a runtime error  
☐ The above statement will cause no error

4. (2 marks) Consider the following Java code:

```
int c = 0;
String s1 = new String("string");
String s2 = "string";
String s3 = "string";
if (s1 == s2) ++c;
if (s1 == s3) ++c;
if (s2 == s3) ++c;
if (s1.equals(s2)) ++c;
if (s3.equals(s1)) ++c;
System.out.println(c);
```

If this code is executed, which value will be printed?

☐ 0    ☐ 1    ☐ 2    ☐ 3    ☐ 4    ☐ 5

5. (2 marks) Consider the following java statement

```
int[] arr = new int[1];
```

What value is stored in variable `arr`?

☐ An array of size 1, whose only entry stores the value zero  
☐ An array of size 1, whose only entry stores the value null  
☐ The address of an array large enough to store one integer value  
☐ An integer value

6. (2 marks) Let class `ClassA` be a parent class of `ClassB`. The constructors for the classes are `ClassA()` and `ClassB()`. Consider the following java code

```
ClassA varA;  
ClassB varB = new ClassB();  
varA = varB;           // Line A  
varB = new ClassA();    // Line B
```

Which line(s) generate compilation error(s)?

- ☐ Line A      ☐ Line B      ☐ Lines A and B      ☐ None

7. (2 mark) Consider the following Java code

```
int c = 3;  
String[] list = new String[3];  
for (int i = 0; i < 3; ++i)  
    if (list[i].length() == 0) c = c - 1;
```

Which of the following statements are true?

- (A) After executing this code variable `list` will store the address of an array in which every entry stores the empty string ""  
(B) After executing this code variable `c` will have value 0  
(C) The code will crash with a run time error

- ☐ Only A      ☐ Only B      ☐ Only C      ☐ Only A and B      ☐ Only A and C  
☐ Only B and C      ☐ All      ☐ None

8. (2 mark) Consider the following code

```
Object[] arr = new Object[4];  
for (int i = 0; i < 4; ++i)  
    if (i < 2) arr[i] = new String("java"); else arr[i] = new Square(i);
```

Class `Square` is the class with the same name discussed in class. Which of the following statements is true?

- ☐ This code produces compilation errors  
☐ The execution of this code produces run time errors  
☐ This code does not produce any errors

9. (3 marks) Consider the following java class

```
public class Class1 {  
    private int i;  
    public Class1() {i = 0;}  
    public void m() {++i;}  
    public void m(int inc){i = i + inc;}  
}
```

Which of the following statements is true?

- ☐ The code produces compilation errors because a class cannot have two methods with the same name.  
☐ The code when executed will produce a run time error, because two methods in a class cannot have the same name.  
☐ The code does not have compilation or run time errors.

10. (3 mark) Consider the following java classes

```
public class ClassA {
    private int a;
    public ClassA() {a = 0;}
    public void m() {System.out.println("ClassA");}
}
public class ClassB extends ClassA {
    public ClassB() {super();}
    public void m() {System.out.println("ClassB");}
}
```

Consider the following code

```
ClassA var1 = new ClassB();
var1.m();
```

Which of the following statements is true?

- ☐ The above code produces a compilation error.  
☐ There are no errors and the code prints "ClassA".  
☐ There are no errors and the code prints "ClassB".

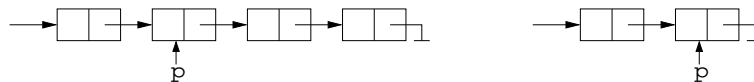
11. (3 marks) Consider the following Java code. Method `length` of class `String` returns the length of a string; variable `length` in an array is the array's length.

```
int k = 0;
int[] arr = null;
String s = "";
try {
    for (int j = 0; j <= arr.length; j = j+1) {
        arr[j] = j;
        k = k+j;
    }
    k = k + s.length();
}
catch (NullPointerException e) {k = k - 1;}
catch (ArrayIndexOutOfBoundsException e) {k = 10;}
catch (Exception e) {k = k+1;}
```

Which value will `k` have after executing the above code?

- ☐ -1    ☐ 0    ☐ 1    ☐ 10    ☐ 11

12. (2 marks) Consider a singly linked list of node objects of class `LinearNode`. Class `LinearNode` has methods `setNext` and `getNext` to set and to access the next node in the list, respectively. Let `p` be a variable referencing a node in the list. See two example lists in this figure.



Which of the following code correctly removes from a list the node that appears after the node referenced by `p` (if any)? No other node must be deleted.

- ☐ `p.setNext(p.getNext());`  
☐ `p = p.getNext(); p = null;`  
☐ `if (p.getNext() != null) p.setNext(p.getNext());`  
☐ `if (p.getNext() != null) p.setNext((p.getNext()).getNext());`  
☐ `if (p.getNext() != null) {p = p.getNext(); p.setNext(p.getNext());}`

Consider the following classes for the next three questions:

```
public class A {...}
public class B extends A {...}
public class C extends B {...}
public class D extends C {...}
```

---

14. (2 marks) Consider the following statements

- (i) `A var1 = new C();`
- (ii) `A var2 = new B();`
- (iii) `B var3 = new A();`
- (iv) `B var4 = new D();`
- (v) `D var5 = new B();`

Which statements are incorrect?

- ☐ (iv) and (v)    ☐ (i) and (ii)    ☐ (i), (ii), and (iii)    ☐ (iii) and (v)  
☐ Only (v)    ☐ All of them    ☐ None

15. (2 marks) Consider this code fragment:

```
B var1 = new B();
D var2 = (D) var1;
```

Casting `var1` in the second line transforms the object referenced by `var1` to an object of class `D` that contains all methods and instance variables of class `D`

- ☐ True    ☐ False

16. (3 marks) Assume that class `C` has a method

```
public void m() {...}
```

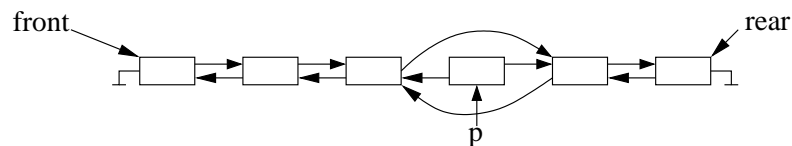
that is not in class `B`. Consider this code fragment:

```
C var1 = new C();
B var2 = var1;
var2.m();
```

Which of the following statements is correct?

- ☐ The above code fragment will not cause any errors  
☐ The above code fragment causes compile-time errors  
☐ The above code fragment will cause a run-time error

17. (3 marks) An algorithm `delete(p)` has been invoked to remove the node referenced by variable `p` from a doubly linked list. The list produced by the algorithm is as follows:



Which of the following statements is correct?

- ☐ The algorithm correctly deleted the node referenced by `p` from the linked list  
☐ The algorithm is incorrect because the node referenced by `p` is still pointing to the other nodes in the list  
☐ The algorithm is incorrect because `p` should have been set to null to release the memory used by the removed node  
☐ The algorithm is incorrect because we should first execute these two statements `p.setNext(null);` and `p.setPrevious(null);`

18. (2 marks) Consider the following java code.

```
public class Class1 {
    private String s;
    public int b;
    public Class1() {
        s = "empty";
        b = 2;
    }
}

public class Class2 {
    public Class2() {
        Class1 var1 = new Class1();
        String s1 = var1.s;           // Line A
        int b = var1.b + s1.length(); // Line B
    }
}
```

Which line(s) will cause compilation error(s)?

☐ Line A    ☐ Line B    ☐ Lines A and B    ☐ None

19. (3 marks) What would be printed by the following code?

```
public class Variables {
    private int a = 0;
    private static int b = 0;
    public Variables () {
        a = 5;
        b = 8;
    }
    public int m1 (int a) {
        b = a;
        return b + 3;
    }
    public void m2 (int b) {
        int a = m1(b);
        b = a + b;
    }
    public static void main (String[] args) {
        Variables var = new Variables();
        b = 1;
        int a = var.m1(5);
        var.m2(a);
        System.out.println(a);
    }
}
```

☐ 0    ☐ 1    ☐ 5    ☐ 8    ☐ 11    ☐ 20    ☐ 21

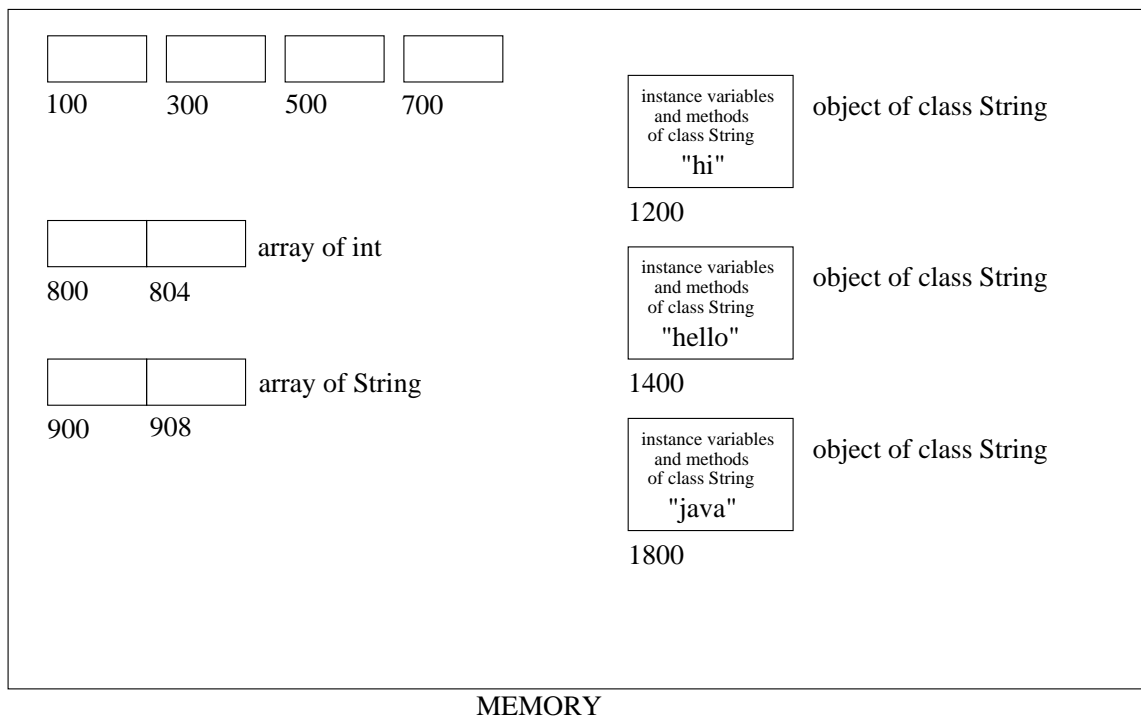
## Part II. Written Answers

20. (8 marks) Consider the following code.

```
int a = 1;
String b;
int[] arr = new int[2];
String[] s = new String[2];
b = new String("hello");
arr[0] = 3; arr[1] = 5;
if (a < arr[0]) {
    a = 7;
    s[0] = "hello";
    s[1] = "java";
}
if (a > arr[1]) arr[0] = arr[1] + 1;
```

We show the symbol table below. The big box represents the memory of the computer. Complete the symbol table and show in the memory diagram the values of all the variables when the code finishes execution.

Symbol Table		
Variable	Type	Address
a		100
b		
arr		
s		



21. (8 marks) Consider the following class `ExceptionTest`. Hand-trace through the code and write out what would be printed if the code was executed. Note that `Exception1` and `Exception2` are not parent/child classes of each other and they both inherit from the Java `Exception` class.

```
public class ExceptionTest {
    private static int k = 1;
    public static void m2 (int z) throws Exception2 {
        if (z < k) {
            k = 5;
            throw new Exception2("z is small");
        }
        k = 0;
    }
    public static void m1 (int z) throws Exception2 {
        try {
            m2(z);
            if (k == 0) throw new Exception1("Divide by 0");
            k = z / k;
            System.out.println("k = " + k);
        } catch (Exception2 e) {
            System.out.println("Caught Exception1");
        } finally {
            System.out.println("Leaving m1");
        }
    }
    public static void main (String[] args) {
        try {
            m1(-1);
            m1(5);
            System.out.println("k = " + k);
        } catch (Exception1 e) {
            System.out.println("Caught exception in main");
        } finally {
            System.out.println("Final value of k is "+k);
        }
    }
}
```

Write in the box what the algorithm prints, in the correct order.



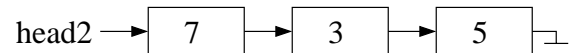
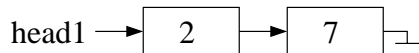
22. Consider the following algorithm, `modList(front)` that manipulates a given singly-linked list, where `front` is a reference to the first node of the list and each node stores an integer value. For each one of the questions (a), (b) you need to

- show what the resulting linked list would look like when the algorithm is executed (you must show all the nodes and the variables `head1`, for (a), and `head2`, for (b)) , and
- indicate whether the algorithm would either (i) terminate correctly, (ii) crash, or (iii) get caught in an infinite loop.

```

Algorithm modList(front) {
    p = front
    q = p.getNext()
    while q ≠ null do {
        if q.getDataItem() < p.getDataItem() do {
            q = q.getNext();
            p.setNext(front);
            p = q.getNext();
        }
        else q = p
    }
}

```



(a) (5 marks) Show the linked list and indicate whether the algorithm would terminate, crash, or get in an infinite loop when algorithm `modList(head1)` is invoked.

(b) (5 marks) Show the linked list and indicate whether the algorithm would terminate, crash, or get in an infinite loop when algorithm `modList(head2)` is invoked.

23. (16 marks) Complete in Java or in **detailed pseudocode** like the one used in the lecture notes the following algorithm `move(front)` that receives as parameter a reference `front` to the first node of a singly linked list storing integer values and it moves the last node of the list to the second position of the list (so after executing the algorithm the node that was last will be the second node in the list). **Assume that the list has at least 3 nodes.** For example, for the singly linked list shown on the left side of the following figure the algorithm must produce the list shown on the right side of the figure.



The **ONLY** methods that you can use in your algorithm are `getNext()` that returns a reference to the next node in the list and `setNext()` that changes the reference to the next node.

- (i) **You CANNOT** change the data stored in the nodes; so **you CANNOT** use `getDataItem()`, `setDataItem()`, `getElement()`, or `setElement()`; **you must modify the node links.**
- (ii) **You CANNOT** use any auxiliary data structures (you cannot use an array, stack, queue, another list, and so on).
- (iii) You **CANNOT** create a second linked list and copy the values from the first list to the second one. You **CANNOT** create new nodes.

If you do any of the above (i), (ii), or (iii), you will receive ZERO marks.

**Hint.** Complete the **while** loop of the algorithm so that variable `last` points to the last node of the list and `prev` points to the second last node. After the **while** loop finishes only 3 pointers need to be changed. Which ones?

**Algorithm** `move(front)`

**In:** Reference to the first node of a singly linked list with at least 3 nodes

**Out:** Nothing, but modify list links so that the last node will move to the second position of the list

```

prev = front
last = front.getNext()
while _____ do {

}

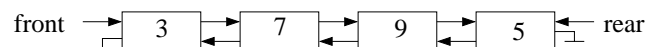
```

24. (4 marks) Complete the following code to swap the first and last nodes of the following doubly linked list. You need to write only four statements. You can use methods `getNext`, `getPrevious`, `setNext`, and `setPrevious`.

```

front._____
front._____
rear._____
rear._____
tmp = front; front = rear; rear = tmp;

```



25. (16 marks) Consider an array **A** storing  $n > 1$  **different** integer values sorted in increasing order. At least one value in **A** is negative and at least one of them is positive. Array **A** does not store the value zero. Write in Java or in **detailed pseudocode** like the one used in the lecture notes an algorithm **invertPositive(A,n)** that changes the positions of the **positive** values stored in **A** so the positive values appear in decreasing order. So, for example, if the array **A** is as in the figure on the left, the modified array must be as in the figure on the right.



- You **CANNOT** use any auxiliary data structures (you cannot use another array, a linked list, an ArrayList, and so on).
- You **CANNOT** use made-up array operations, like **A.remove(value)** or **A.add(value)**. If you want to store a value in an index **i** of the array you must write **A[i] = value**. If you want to read the value stored in index **i** you must use **value = A[i]**.

If you use auxiliary data structures or use made-up array operations, you will receive ZERO marks.

**Hint.** Scan the array until you find the first positive value. Use a variable **first** for the index of this value and a second variable **last** for the index of the last value in the array. Use a while loop to continue scanning the array and swapping the values in **first** and **last**. How are **first** and **last** updated? When does the loop end?

**Algorithm invertPositive(A,n)**

**In:** Array **A** storing **n** integer values as specified above

**Out:** Nothing, but sort the positive values so they appear in decreasing order without changing the positions of the negative values.