SOLUTION KEY

This is the midterm examination for
CSC212: Data Structures
as taught by Pablo Frank and Nicholas Howe in Fall 2022.

The following materials are **permitted** while taking this examination:

- a single 8.5x11 sheet of paper (double-sided) containing your own handwritten or typed notes
- a blank exam booklet (provided)

Honor code: no other resources are permitted during this exam.
This includes (but is not limited to): textbooks, online materials, tutors, teaching assistants, and other students.

YOUR NAME:

Total points: _____ / 82

Vocabulary (16 points)

Define the following terms:

Interface: acts as a contract that a newly defined class must fulfill, describing methods that must be implemented

Child Class: a class that is derived from a specified parent class, and inherits all of the fields and methods of that parent.

Generic Data Structure: a data structure that is defined with an unspecified storage type, to be filled in later when the class is put to use.

Exception: an object that may be thrown by the program to indicate some unexpected or erroneous condition.

Tail Recursion: a style of recursion where the return value is simply the result of a recursive call, without any modification.

Iterative Method: a method that employs iteration (while or for loops) to accomplish its goals.

Sequence: a data structure that stores elements in a specified order, from first to last.

Declaration: a place in a program where a new variable is introduced and associated with a particular type.

Java (4 points)

If we compiled the following Code snippet, there would be an error. Indicate the line number and explain the cause of the error.

```
1  public class Context {
2      public static void staticMethod() {
3          nonstaticMethod();
4          Context c = new Context();
5          c.nonstaticMethod();
6      }
7
8      public void nonstaticMethod() {
9          staticMethod();
10         Context c = new Context();
11         c.staticMethod();
12     }
13
14
15     public static void main(String[] args) {
16         staticMethod();
17         nonstaticMethod();
18     }
19 }
```

Line number: 17

Explanation: The main method is static, meaning there is no 'this' object. It is an error to call nonstaticMethod directly, without creating an instance of class Context to call it upon.
There is a second error in line 3, where a non static method is called in the context of a static one.

Line number: 3

Explanation: This method is also static, and thus we cannot call nonstaticMethod directly. (The call on line 5 is acceptable because it is called on a specific object, c.)

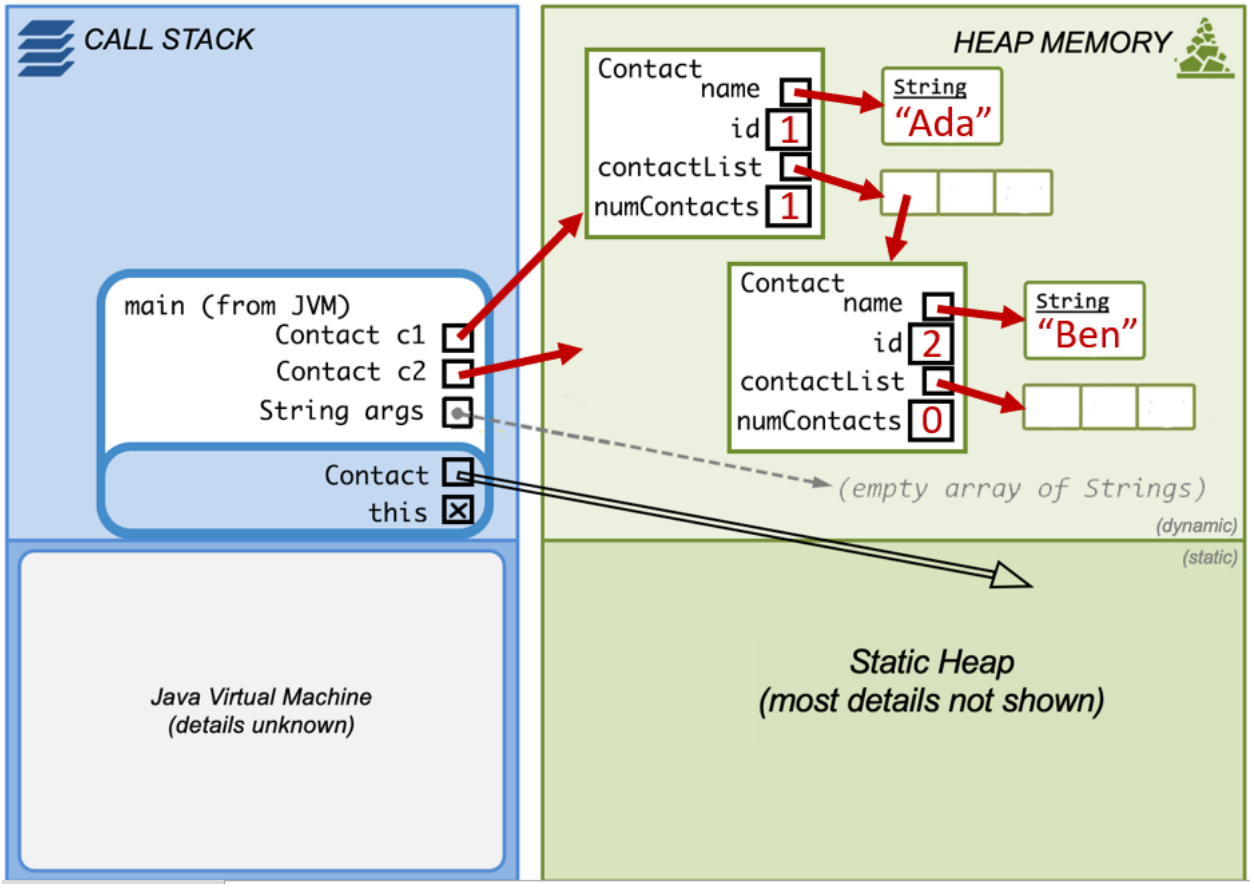
Code Analysis (12 points)

The class `Contact` is shown below.
Using the provided memory map on the next page, complete the diagram showing the state of the dynamic memory at the moment line 38 is executed. (You don't need to do anything with the static memory section.)

```
1  public class Contact {
2
3      public String name;
4      private int id;
5      private Contact[] contactList;
6      private int numContacts = 0;
7
8      public Contact() {
9          this.name = "";
10         this.id = -1;
11         this.contactList = new Contact[3];
12     }
13
14     public Contact(String name, int id) {
15         this.name = name;
16         this.id = id;
17         this.contactList = new Contact[3];
18     }
19
20     public void addContact(Contact other){
21         if (this.numContacts < 10){
22             this.contactList[this.numContacts++] = other;
23         }
24     }
25
26     public String getContactName(int i){
27         if (i>=0 && i < 10){
28             return this.contactList[i].name;
29         }
30         return "No such index";
31     }
32
33     public static void main(String[] args) {
34         Contact c1 = new Contact("Ada", 1);
35         Contact c2 = new Contact("Ben", 2);
36         c1.addContact(c2);
37         // What is the memory like at this point?
38         System.out.println(c1.getContactName(0));
39     }
40 }
```

Code Analysis continued**:**

Memory Map Template: fill in values in the empty boxes as appropriate to show the state of the dynamic memory when the program above reaches line 38.



Classes, Interfaces, and Inheritance (10 points)

Given the class Mammal and the Animal interface shown below:

```java
public class Canine {
  public void numLegs(){
    System.out.println("4 legs ");
  }
  public void cover(){
    System.out.println("hair");
  }
  public void movement(){
    System.out.println("runs and leaps");
  }
}
```

```java
interface Animal {
  //prints an animal sound (oink, miau, etc)
  public void animalSound();
  //prints a movement type (fly, run, etc)
  public void movement();
}
```

Answer the following questions:

(a) If we want to create a new class called Dog that extends Canine and implements the Animal interface, which methods besides the constructor **must** be written explicitly inside the Dog class?

animalSound, because the interface requires it.

(b) If we write the class Dog correctly, which methods will be available for an object of type Dog?

numLegs, cover, movement, animalSound (at minimum)

(c) How could we ensure that objects of the Dog class print something other than 'runs and leaps' when the 'movement' method is called?

We would define a new version of the ‘movement’ method inside class Dog, to override the old behavior.

(d) Can we add new methods to Dog if it extends Canine and implements Animal?

Yes, we can always add additional methods.

(e) If we create a Dog object, and store it within an array of Animal objects, which methods can we access directly via the array?

Only animalSound and movement will be directly accessible via the array. We would have to cast the array element to type Canine or type Dog if we wanted to use the other methods.

Recursion (16 points)

Consider the recursive method shown below. For each item, predict (i) the return value for the call shown, and (ii) the total number of times the method is called, including the call shown.

```
public static int recursive(int x) {
    if (x == 0) {
        return 0;
    } else if (x < 0) {
        return recursive(-x);
    } else {
        int half_x = x/2;
        if (x==half_x*2) {
            return recursive(half_x);
        } else {
            return 1+recursive(half_x);
        }
    }
}
```

(a) `recursive(2);`

Return value: 1

Number of calls: 3

(b) `recursive(5);`

Return value: 2

Number of calls: 4

(c) `recursive(32);`

Return value: 1

Number of calls: 7

(d) `recursive(-1);`

Return value: 1

Number of calls: 3

Hash Tables (16 points)

Consider the hash table shown below, which uses open addressing with linear probing. For each question part, determine (i) which line(s) of the table would **be examined** in order to fulfill the operation shown, (ii) which line(s) of the table would **change** after the operation shown. If the table contents would remain unchanged following the operation, then indicate <None>. Note: each subpart is independent of the others; you should assume that you always start in the configuration shown.

Row	Key	Value
0		
1	50	“Banana”
2	22	“Elderberry”
3	73	“Cherry”
4	9	“Durian”
5		
6	48	“Apple”

(a) `lookup(9);`

Examined: 2, 3, 4

Changed: <none>

(b) `lookup(57);`

Examined: 1, 2, 3, 4, 5

Changed: <none>

(c) `lookup(19);`

Examined: 5

Changed: <none>

(d) `store(19, "Fig");`

Examined: 5

Changed: 5

(e) `store(55, "Grapefruit");`

Examined: 6, 0

Changed: 0

(f) `delete(20);`

Examined: 6, 0

Changed: <none>

(g) `delete(50);`

Examined: 1, 2, 3, 4, 5

Changed: 1, 2, 4

(h) `delete(9);`

Examined: 2, 3, 4, 5

Changed: 4

Data Structure Identification (8 points)

Java's ArrayDeque class offers a large number of methods to choose from. By limiting ourselves to a subset of these, we can simulate the behavior of a different data structure such as a stack or queue. Of these options, which best describes the subset of methods shown for each question part? (You can also answer "neither".)

(a) `addFirst`, `removeFirst`: stack (add and remove from same place)

(b) `addLast`, `removeLast`: stack (add and remove from same place)

(c) `addFirst`, `removeLast`: queue (add at one end, remove from the other)

(d) `addLast`, `removeFirst`: queue (add at one end, remove from the other)

(e) `push`, `pop`: stack

(f) `add`, `remove`: queue

(g) `removeFirstOccurrence`, `removeLastOccurrence`: <neither>

(h) `peekFirst`, `peekLast`: <neither>