COMP 333 Practice Exam #1

This is representative of the kinds of topics and kind of questions you may be asked on the midterm. This practice exam, along with assignment 1 and the 3-4 in-class handouts, are intended to be comprehensive of everything on the exam. That is, I will not ask anything that's not somehow covered by those sources. (I will announce the exact cutoff for the handouts and other material on Wednesday.)

You are permitted to bring two 8.5 x 11 sheets of paper into the exam with you, as long as they have handwritten notes on them. Both sides of both sheets can be used. To be clear, these must be entirely handwritten.

Virtual Dispatch - Conceptual Understanding

1.) Name one reason why someone might want to use virtual dispatch.

2.) Name one reason why someone might **not** want to use virtual dispatch.

Virtual Dispatch in Java

3.) Consider the following Java code:

```
public interface I1 {
  public void doThing();
}
public class C1 implements I1 {
  public void doThing() { System.out.println("c1"); }
}
public class C2 implements I1 {
  public void doThing() { System.out.println("c2"); }
}
public class Main {
  public void makeCall(I1 value) {
    value.doThing();
  }
  public static void main(String[] args) {
    I1 t1 = new C1();
    I1 t2 = new C2();
    makeCall(t1);
    makeCall(t2);
  }
}
```

What is the output of the `main` method above?

4.) Consider the following code snippet:

```
public class Main {
  public static void main(String[] args) {
    Operation op1 = new AddOperation();      // line 3
    Operation op2 = new SubtractOperation(); // line 4
    int res1 = op1.doOp(5, 3);               // line 5
    int res2 = op2.doOp(5, 3);               // line 6
    System.out.println(res1); // line 7; should print 8
    System.out.pritnln(res2); // line 8; should print 2
  }
}
```

Define any interfaces and/or classes necessary to make this snippet print 8, followed by 2.

5.) Consider the following incomplete Java code and output:

```
public class Incomplete {
  public static void printResult(final Runner r, final int i) {
    boolean result = r.someMethod(i);
    System.out.println(result);
  }
  public static void main(final String[] args) {
    final IsEven even = new IsEven();
    printResult(even, 3); // prints false
    printResult(even, 4); // prints true
    final IsLessThan ltFive = new IsLessThan(5);
    printResult(ltFive, 4); // prints true
    printResult(ltFive, 6); // prints false
    final IsLessThan ltZero = new IsLessThan(0);
    printResult(ltZero, -1); // prints true
    printResult(ltZero, 1); // prints false
  }
}
```

Define any interfaces and/or classes necessary to make the output in the comments work. You should not have to modify any code here. Multiple answers are possible.

6.) Consider the following Java code, which simulates a lock which can be either locked or unlocked. The lock is an immutable data structure, so locking or unlocking returns a new lock in an appropriate state.

```
public class Lock {
    private final boolean locked;

    public Lock(final boolean locked) {
        this.locked = locked;
    }

    public Lock unlock() {
        if (locked) {
            System.out.println("lock unlocked");
            return new Lock(false);
        } else {
            System.out.println("lock already unlocked");
            return this;
        }
    }

    public Lock lock() {
        if (!locked) {
            System.out.println("lock locked");
            return new Lock(true);
        } else {
            System.out.println("lock already locked");
            return this;
        }
    }

    public boolean isLocked() {
        return locked;
    }
}
```

Refactor this code to use virtual dispatch, instead of using if/else. As a hint, you should have a base class/interface for Lock, and subclasses for locked and unlocked locks. Lock itself doesn't need a constructor, and you do not need to worry about maintaining compatibility with existing code that uses Lock. (Continued on to next page)

Types

7.) The code below does not compile. Why?

```
public interface MyInterface {
  public void foo();
}

public class MyClass implements MyInterface {
  public void foo() {}
  public void bar() {}

  public static void main(String[] args) {
    MyInterface a = new MyClass();
    a.bar();
  }
}
```

8.) Java supports subtyping. Write a Java code snippet that compiles and uses subtyping.

9.) Name one reason why someone might prefer static typing over dynamic typing.

10.) Name one reason why someone might prefer dynamic typing over static typing.

11.) Name one reason why someone might prefer strong typing over weak typing.

12.) Name one reason why someone might prefer weak typing over strong typing.

13.) Consider the following code, written in some unknown language:

```
define myFunc(x, y) {
  return x + y;
}

a = 1
b = 2
myFunc(a, b)
```

Provide an argument why this language might be statically-typed, OR why it might be dynamically-typed. Both are possible; the explanation why is the only important part.

14.) Consider the following code snippet which accesses (what is hopefully) an array at some unknown position:

```
hopefullyArray[unknownPosition]
```

Say what this code will do for each of the following scenarios. Your answers only need to be a few words, perhaps 2 sentences at most. As a hint, all your answers are likely to be different for each scenario.

14.a.) Assume this is written in a statically typed, strongly typed language. What sort of checks (if any) will likely be done at compile time? What sort of checks (if any) will likely be done at runtime?

14.b.) Assume we are in a statically typed, weakly typed language. What sort of checks (if any) will likely be done at compile time? What sort of checks (if any) will likely be done at runtime?

14.c.) Assume we are in a dynamically typed, strongly typed language. What sort of checks (if any) will likely be done at compile time? What sort of checks (if any) will likely be done at runtime?

14.c.) Assume we are in a dynamically typed, weakly typed language. What sort of checks (if any) will likely be done at compile time? What sort of checks (if any) will likely be done at runtime?

Higher-Order Functions in JavaScript

15.) Write the output of the following JavaScript code:

```
function foo(fooParam) {
  return function (innerParam) {
    return fooParam - innerParam;
  }
}

let f1 = foo(7);
let f2 = foo(10);
console.log(f1(2));
console.log(f2(3));
console.log(f1(4));
console.log(f2(5));
```

16.) Write the output of the following JavaScript code:

```
// Representing lists as higher-order functions.
// The function returns true if the given element exists in the list,
// else false (e.g., contains).  The weird part is that the list
// _is_ the function.

function nil() {
    // nil doesn't contain any elements, so it definitely doesn't
    // contain searchKey, either
    return function (searchKey) {
        return false;
    };
}

function cons(head, tail) {
    // cons contains the given element searchKey, if either the
    // head of the list is searchKey, or if the tail of the list
    // contains searchKey
    return function (searchKey) {
        if (searchKey === head) {
            return true;
        } else {
            return tail(searchKey);
        }
    }
}

let emptyList = nil();
let one = cons(1, nil());
let oneTwo = cons(1, cons(2, nil()));

console.log(emptyList(1));
console.log(one(1));
console.log(oneTwo(1));

console.log();

console.log(emptyList(2));
console.log(one(2));
console.log(oneTwo(2));
```

17.) Consider the following JavaScript code with corresponding output, which calls an unseen function called `mystery`:

```
function output() {
    console.log("foo");
}

let f1 = mystery(output);
f1();
console.log();

let f2 = mystery(f1);
f2();
console.log();

let f3 = mystery(f2);
f3();
console.log();
```

Output:

```
foo
foo

foo
foo
foo
foo

foo
foo
foo
foo
foo
foo
foo
foo
```

Define the `mystery` function below.

18.) Write the output of the following JavaScript code:

```
function cap(min, max, wrapped) {
  return function (param) {
    let temp = wrapped(param);
    if (temp < min) {
      return min;
    } else if (temp > max) {
      return max;
    } else {
      return temp;
    }
  };
}

function addTen(param) {
  return param + 10;
}

function subTen(param) {
  return param - 10;
}

let f1 = cap(0, 10, addTen);
let f2 = cap(0, 100, addTen);
let f3 = cap(0, 10, subTen);
let f4 = cap(0, 100, subTen);

console.log(f1(0));
console.log(f1(5));
console.log(); // prints an empty line

console.log(f2(0));
console.log(f2(5));
console.log(); // prints an empty line

console.log(f3(0));
console.log(f3(5));
console.log(); // prints an empty line

console.log(f4(0));
console.log(f4(5));
console.log(); // prints an empty line
```

19.) Consider the following incomplete JavaScript code and output, which calls an unprovided function named `invert`:

```
function greaterThanFive(input) {
  return input > 5;
}

let notGreaterThanFive = invert(greaterThanFive);
let notEqualsFoo = invert(function (e) { return e === "foo"; });

console.log(notGreaterThanFive(3));
console.log(notGreaterThanFive(7));
console.log(notEqualsFoo("foo"));
console.log(notEqualsFoo("bar"));


---OUTPUT---
true
false
false
true
```

`invert` should return a new function that effectively inverts the behavior of the provided function. `invert` should work for any function taking one parameter and returning a boolean, not just the calls shown here. Implement `invert` below.

20.) Consider the following JavaScript code and output:

```
console.log(
    ifNotNull(1 + 1,
              a => ifNotNull(2 + 2,
                             b => a + b)));
console.log(
    ifNotNull(7,
              function (e) {
                  console.log(e);
                  return ifNotNull(null,
                                   function (f) {
                                       console.log(f);
                                       return 8;
                                   })
              }));
```

Output:

```
6
7
null
```

`ifNotNull` takes two parameters:

1. Some arbitrary value, which might be `null`
2. A function. This function is called with the arbitrary value if the value is not `null`, and the result of the function is returned. If the value is `null`, this function isn't called, and `null` is returned instead.

Define the `ifNotNull` function below, so that the output above is produced.

21.) Consider the following array definition in JavaScript:

```
let arr = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

21.a) Use `filter` to get an array of all even elements in `arr`.

21.b) Use `map` to get an array of strings, where each string represents a number in `arr`. As a hint, you can call the `toString()` method on a number (e.g., `5.toString()`) in JavaScript to get its string representation.

21.c) Use `reduce` to get the last element in `arr`.

21.d) Use a combination of `filter` and `reduce` to get the sum of all elements in `arr` which are greater than `5`.

Prototype-Based Inheritance in JavaScript (Depends on Wednesday)

22.a.) Define a constructor for Dog objects, where each Dog object has a name. An example code snippet is below, illustrating usage:

```
let d = new Dog("Rover"); // line 1
console.log(d.name);      // line 2; prints Rover
```

22.b.) Define a different constructor for `Dog`, which puts a `bark` method **directly** on the `Dog` objects. The `bark` method should print "Woof!" when called. Example usage is below:

```
let d = new Dog("Sparky");
d.bark(); // prints Woof!
```

22.c.) Define a method named growl for Dog objects, which prints "[dog name] growls" when called. Use Dog's **prototype**, instead of putting the method directly on Dog objects themselves. Example usage is below:

```
let d = new Dog("Rocky");
d.growl(); // prints Rocky growls
```

23.) Consider the JavaScript code below:

```
function Animal(name) { this.name = name; }
Animal.prototype.getName = function() { return this.name; }
function Bird(name) { this.name = name; }
Bird.prototype = { '__proto__': Animal.prototype };
Bird.prototype.fly = function() {
  console.log(this.getName() + " flies");
}
function Mouse(name) {
  this.name = name;
  this.squeak = function() {
    console.log(this.name + " squeaks");
  }
}
Mouse.prototype = { '__proto__': Animal.prototype };
Mouse.prototype.fly = Bird.prototype.fly;
let b1 = new Bird("Coco"); let b2 = new Bird("Sunny");
let m1 = new Mouse("Pip"); let m2 = new Mouse("Ruby");
```

Write a memory diagram which shows how memory looks after this program executes. Your diagram should include the objects and fields associated with `b1`, `b2`, `m1`, `m2`, `Mouse.prototype`, and `Bird.prototype`, `Animal.prototype`. You do not need to show what `Animal`, `Mouse`, and `Bird` refer to.

24.) Consider the JavaScript code below, adapted from the second assignment:

```
function List() {}
List.prototype.isList = function() { return true; }
function Cons(head, tail) {
  this.head = head;
  this.tail = tail;
}
Cons.prototype = new List();
Cons.prototype.isEmpty = function() { return false; }
function Nil() {}
Nil.prototype = new List();
Nil.prototype.isEmpty = function() { return true; }
let list1 = new Nil();
let list2 = new Cons("hi", list1);
```

Write a memory diagram which shows how memory looks after this program executes. Your diagram should include the objects and fields associated with `List`, `Cons`, `Nil`, `list1`, and `list2`.