CS2030 Programming Methodology
Semester 2 2021/2022

9 & 10 March 2022
Problem Set #6 Suggested Guidance

1. For each of the questions below, suppose the following is invoked:

```
B b = new B();
b.f();
```

Sketch the content of the stack, heap and metaspace *immediately after* the line

```
A a = new A();
```

is executed. Label the values and variables/fields clearly. You can assume `b` is already on the heap and you can ignore all other content of the stack and the heap before `b.f()` is called.

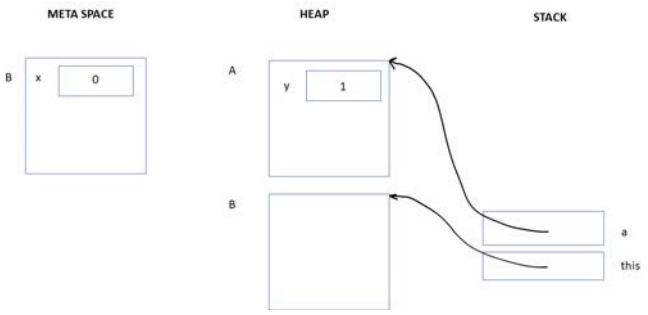
(a)

```
class B {
    static int x = 0;

    void f() {
        A a = new A();
    }

    static class A {
        int y = 0;

        A() {
            y = x + 1;
        }
    }
}
```

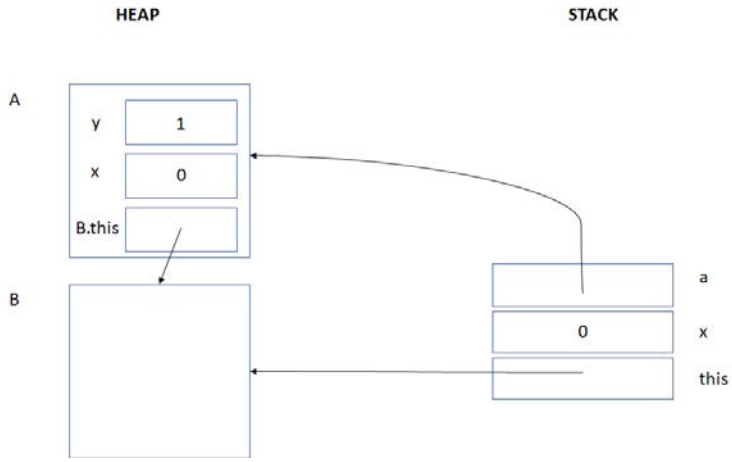


(b)

```
class B {
    void f() {
        int x = 0;

        class A {
            int y = 0;
            A() {
                y = x + 1;
            }
        }

        A a = new A();
    }
}
```



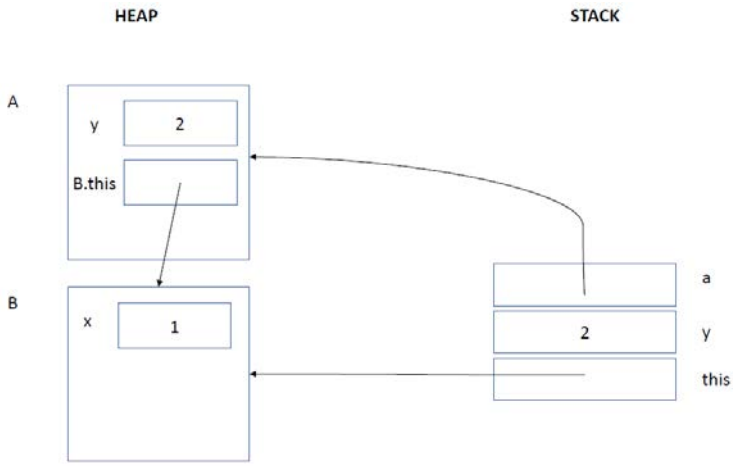
(c)

```
class B {
    int x = 1;

    void f() {
        int y = 2;

        class A {
            void g() {
                x = y;
            }
        }

        A a = new A();
        a.g();
    }
}
```



2. Consider the following Stack implementation.

```
public class Stack<T> {
    private T head;
    private Stack<T> tail;
    private static Stack<?> EMPTYSTACK = new Stack<>(null, null);

    private Stack(T head, Stack<T> tail){
        this.head = head;
        this.tail = tail;
    }

    public void push(T t){
        this.tail = new Stack<T>(this.head, this.tail);
        this.head = t;
    }

    public void pop(){
        if (this.head == null) {
            throw new RuntimeException("Stack is empty");
        }
        this.head = this.tail.head;
        this.tail = this.tail.tail;
    }

    public T head(){
        if (this.head == null) {
            throw new RuntimeException("Stack is empty");
        }
        return head;
    }

    public boolean isEmpty(){
        if (this.head == null) {
            return true;
        } else {
            return false;
        }
    }

    public static <T> Stack<T> getEmptyStack(){
        @SuppressWarnings("unchecked")
        Stack<T> emptyStack = (Stack<T>) EMPTYSTACK;
        return emptyStack;
    }
}
```

```
Stack<Integer> s = Stack.getEmptyStack();
s.push(1);
s.push(2);
s.push(3);
s.head();
s.pop();
s.head();
s.pop();
s.head();
s.pop();
```

Lets change the implementation of Stack to make it immutable. Create a new class ImmutableStack.

```
public class ImmutableStack<T> {
    private final T head;
    private final ImmutableStack<T> tail;
    private final static ImmutableStack<?> EMPTYSTACK =
                                    new ImmutableStack<>(null,null);

    private ImmutableStack(T head, ImmutableStack<T> tail){
        this.head = head;
        this.tail = tail;
    }

    public final ImmutableStack<T> push(T t){
        return new ImmutableStack<T>(t, this);
    }

    public final ImmutableStack<T> pop(){
        if (this.head == null) {
            throw new RuntimeException("Stack is empty");
        }
        return tail;
    }

    public final T head(){
        if (this.head == null) {
            throw new RuntimeException("Stack is empty");
        }
        return head;
    }

    public final boolean isEmpty(){
        if (this.head == null) {
            return true;
```

```
        } else {
            return false;
        }
    }

    public final static <T> ImmutableStack<T> getEmptyStack(){
        @SuppressWarnings("unchecked")
        ImmutableStack<T> emptyStack = (ImmutableStack<T>) EMPTYSTACK;
        return emptyStack;
    }
}
```

```
ImmutableStack<Integer> s = ImmutableStack.getEmptyStack();
s = s.push(1).push(2).push(3);
s.head();
s.pop().head();
s.pop().pop().head();
s.head();
```