In run, write what gets printed next to each line.

\(x.a()\) will call the \(a()\) according to the variable’s dynamic type.

\(x.b()\), because \(b()\) is not overridden, will use the \(b()\) in \(Q\). Then, \(b()\) selects which \(a()\) to run based on the variable’s dynamic type.

\(x.c()\) runs \(Q.c()\), which runs \(Q.e()\). Note that \(e()\) is a static method, so it uses the static type to look up which function to call.

\(((R)x).c()\) makes the same series of calls. Again, \(e()\) is a static method, so it uses the static type to look up which function to call.

\(x.d()\) runs \(R.d()\), which runs \(this.e()\), this has a static type of \(R\) in \(R.d()\) so \(R.e()\) is run.

\(((R)x).d()\) makes the same series of calls.
2 Reduce

We’d like to write a method `reduce`, which uses a `BinaryFunction` interface to accumulate the values of a `List` of integers into a single value. `BinaryFunction` can operate (through the `apply` method) on two integer arguments and return a single integer. Note that `reduce` can now work with a range of binary functions (for example, addition and multiplication). Write two classes `Adder` and `Multiplier` that implement `BinaryFunction`. Then, fill in `reduce` and `main`, and define types for `add` and `mult` in the space provided.

```java
import java.util.ArrayList;
import java.util.List;
public class ListUtils {
    /** If the list is empty, return 0.
     * If it has one element, return that element.
     * Otherwise, apply a function of two arguments cumulatively to the
     * elements of list and return a single accumulated value.
     * Does not modify the list. */
    public static int reduce(BinaryFunction func, List<Integer> list) {
        if (list.size() == 0) { return 0; }
        int soFar = list.get(0);
        for (int i = 1; i < list.size(); i++) {
            soFar = func.apply(soFar, list.get(i));
        }
        return soFar;
    }

    public static void main(String[] args) {
        ArrayList<Integer> integers = new ArrayList<>();
        integers.add(2); integers.add(3); integers.add(4);
        Adder add = new Adder();
        Multiplier mult = new Multiplier();
        reduce(add, integers); //Should evaluate to 9
        reduce(mult, integers); //Should evaluate to 24
    }
}

interface BinaryFunction {
    int apply(int x, int y);
}

public class Adder implements BinaryFunction {
    public int apply(int x, int y) {
        return x + y;
    }
}

public class Multiplier implements BinaryFunction {
    public int apply(int x, int y) {
        return x * y;
    }
}

We declare an interface `BinaryFunction` which our `Adder` and `Multiplier` classes can implement. Writing a common interface is important, because it allows us to write a `reduce` function that is capable of accepting many kinds of functions. Note that interface methods are public by default, so `apply` must be public in `Adder` and `Multiplier`.

CS 61B, Spring 2020, Discussion 6: Test Review
3 Interleaving IntLists

Implement `interleave(IntList A, IntList B)` so that it returns an IntList whose contents are the result of interleaving IntLists A and B, beginning with the first item in A if possible. This method should interleave the items in-place and should therefore be destructive. For example, if A is (1 -> 3 -> 5 -> 7) and B is (2 -> 4), then calling `interleave(A, B)` should return the list (1 -> 2 -> 3 -> 4 -> 5 -> 7). Because this process is destructive, both A and B may become modified in the process. A and B are not guaranteed to be the same length and may be null.

```java
public IntList interleave(IntList A, IntList B) {
    if (A == null) {
        return B;
    } else if (B == null) {
        return A;
    }

    IntList curr = A;
    IntList other = B;
    IntList save;
    while (other != null) {
        save = curr.tail;
        curr.tail = other;
        curr = other;
        other = save;
    }

    return A;
}
```

Here is the recursive solution.

```java
public static IntList interleave(IntList A, IntList B) {
    if (A == null) {
        return B;
    } else if (B == null) {
        return A;
    }
    A.tail = interleave(B, A.tail);
    return A;
}
```
4 Inheritance Infiltration

Access modifiers are critical when it comes to security. Look at the `PasswordChecker` and `User` classes below.

```java
public class PasswordChecker {
    /** Returns true if the provided login and password are correct. */
    public boolean authenticate(String login, String password) {
        // Does some secret authentication stuff...
    }
}

public class User {
    private String username;
    private String password;

    public void login(PasswordChecker p) {
        p.authenticate(username, password);
    }
}
```

Even though the `username` and `password` variables are private, the `login` and `authenticate` methods are both public. We can use inheritance to take advantage of this and extract the password of any given `User` object. Complete the `PasswordExtractor` class below so that calling `extractPassword` returns the password of a given `User`. You may not modify the provided classes (i.e. you may not change the implementations of `PasswordChecker` or `User`).

```java
public class PasswordExtractor extends PasswordChecker {
    String extractedPassword;

    public String extractPassword(User u) {
        u.login(this);
        return extractedPassword;
    }

    @Override
    public boolean authenticate(String login, String password) {
        extractedPassword = password; // Victory is mine >:)
        return true; // or false. Needs to return something to compile.
    }
}
```

_Hint:_ The `login` method of `User` passes in the `username` and `password` fields as parameters to the `authenticate` method of a given `PasswordChecker`. Think about how we can take advantage of method overriding to gain access to the password.

By letting us subclass `PasswordChecker`, we can overwrite the `authenticate` method to capture the password in a local variable. By calling a user’s `login` method and passing ourselves in, we can force the user to provide its password. Finally, we can return the extracted password. We could fix this security hole by making `PasswordChecker` no longer a public class.