HOMEWORK PROBLEMS 16

1) What is the difference between an abstract class and an interface?

2) Why can an `Object` reference point to any object?

3) Write the statement that calls the `f` method in the object to which `r` points. Assume `f` takes no arguments, `r` is type `A`, and the object to which `r` points is type `B`. Assume the `B` class has an `f` method but the class `A` does not. `B` is a subclass of `A`.

4) Can an abstract class be extended?

5) Define a class that implements the following interface:

```
interface Wisp
{
    public void f();
}
```

6) Comment out the `xDisplay` methods in the `P` and `Q` classes in `C16h6.java` (copy of `Generic2.java` in Fig. 16.4). Compile and run. What happens?

7) Comment out the `xDisplay` methods in the `P` and `Q` classes in `C16h7.java` (copy of `Generic3.java` in Fig. 16.5). Compile and run. What happens?

8) Comment out the `xDisplay` methods in the `P` and `Q` classes in `C16h8.java` (copy of `Generic4.java` in Fig. 16.6). Compile and run. What happens?

9) Write a program that consists of an interface `Kons`, and two classes `C16h9` and `Cusp`, both of which implement `Kons`. The interface should contain the constants `KON1` and `KON2` equal to `1.3` and `5.5` respectively. `main` should display the values of `KON1` and `KON2`. It should also create a `Cusp` object and call its `display` method. The `Cusp` class should contain a `display` method that displays the `KON1` and `KON2` constants. Use the file named `C16h9.java`.

10) Is the following code legal. If so, what happens when it is executed?

```
Object obj = "hello";
System.out.println(obj);
```

11) Does the following program compile and run? If not, fix it so that it does.

```
class C16h11
{
   public static void main(String[] args)
   {
      Vincent v = new Vincent();
      v.f();
      v.g();
      v.display();
   }
}
//===============================================
abstract class Dali
{
    private int x = 1;
```

```
    private static int y = 3;
    public abstract void f();
    public void g()
    {
       System.out.println("in g");
    }
}
//================================================
class Vincent extents Dali
{
   public void f()
   {
      Sytem.out.println("in f");
   }
   public void display()
   {
      System.out.println(x + " " + y);
   }
}
```

12) Create a class `Objects` that contains the following fields:

```
private Object[] oa = new Object[2];
private int nextIndex = 0;
```

`Objects` should also contain the following methods:

`public void add(Object obj)`

Assigns `obj` to the next available slot in the `oa` array, and increments `nextIndex`. If there are no more available slots, `add` creates a new array with 10 more slots than the current `oa` array. It then copies the contents of the current `oa` to the new array. It finally assigns to `oa` the reference to the new array.

`public Object get(int i)`

Returns `oa[i]`.

`public void display()`

Displays all the objects in `oa` by calling `println` for each object stored in the `oa` array.

`public int size()`

Returns `nextIndex`, whose value equals the number of occupied slots in `oa`.

Write a complete program in which `main` creates an `Objects` object to which it adds ten strings and ten `Integer` objects. `main` then calls the `display` method. Use the file `C16h12.Java`.

13) Create an interface named `Shape` that has two methods: `public double getArea()` and `public void display()`. Also create three classes that implement `Shape`: `Circle`, `Square`, and `Rectangle`. Each class should have a `getArea` method that returns the area of the object, and a `display` method that displays the dimensions of the object. In `main`, create an `Object` array with 12 slots to which you assign `Circle`, `Square`, and `Rectangle` objects whose dimensions are initialized with random numbers. Then execute a `for` loop that processes each reference in the `Object` array, displaying the dimension and area of each object. Use the file named `C16h13.java`.

14) Same as homework problem 13 except use a `Shape` array in place of the `Object` array. Use the file named `C16h14.java`.

15) Same as homework problem 13 except use an abstract class in place of an interface. Use the file named `C16h15.java`

16) Same as homework problem 13 except make `Square` a subclass of `Rectangle`. Use the file named `C16h16.java`

17) It makes sense for the `String` class have a `toString` method. Why?

18) Implement the `toString` method as it would appear in the `String` class.

19) Can a generic class have more than one type parameter. For example, is the following class legal? Use it in a program to see if it works.

```
class TwoParms<T, U>
{
   T x;
   U y;
   //---------------------------------
   public TwoParms(T xx, U yy)
   {
      x = xx;
      y = yy;
   }
   //---------------------------------
   public T xGet()
   {
      return x;
   }
   //---------------------------------
   public U yGet()
   {
      return y;
   }
}
```

20) The method below is a **generic method**. Use it in a program that calls it several times, passing it arrays of different types (`Integer`, `Double`, `String`, and `int`). Does it work for all types?

```
public static <T> void display(T[] a)
{
   for (int i = 0; i < a.length; i++)
      System.out.println(a[i]);
}
```

21) Add the `clear` method to `MyArrayList` in `C16h21.java`. Your `clear` method should work like the `clear` method in the `ArrayList` class (see Section 9.12). Add code to the `main` method that tests your `clear` method.

22) Add the `indexOf(Object obj)` method to `MyArrayList` in `C16h22.java`. Your `indexOf` method should work like the `indexOf(Object obj)` method in the `ArrayList` class (see Section 9.12). Add code to the `main` method that tests your `indexOf` method.

23) Add the `remove(int index)` method to `MyArrayList` in `C16h23.java`. Your `remove` method should work like the `remove(int index)` method in the `ArrayList` class (see Section 9.12). Add code to the `main` method that tests your `remove` method.

24) Create a generic class `MyQueue` that creates a FIFO (First In First Out) data structure. Use a field `qal` with type `ArrayList` within your `Queue` class to hold your data. Your `MyQueue` class should have the following methods:

`public boolean isEmpty()`

Returns `true` if the size of the the `ArrayList` is 0. Otherwise, it returns `false`.

`public int size()`

Returns the current size of the `ArrayList`.

`void enqueue(T x)`

Adds `x` to the end of the `ArrayList`.

`T dequeue()`

Removes and returns the item at index 0 in the `ArrayList`.

Test your class with

```
class C16h24
{
   public static void main(String[] args)
   {
      MyQueue<String> q = new MyQueue<String>();
      q.enqueue("hello");
      q.enqueue("goodbye");
      q.enqueue("last one");
      while (!q.isEmpty())
      {
         System.out.println(q.size());
         System.out.println(r.dequeue());
      }
   }
}
```

25) Add a selection sort method (see Section 9.9) to the `MyArrayList` in `C16h25.java`. Test your class with

```
class C16h25
{
   public static void main(String[] args)
   {
      MyArrayList<Integer> mal = new MyArrayList<Integer>();
      mal.add(3);
      mal.add(1);
      mal.add(2);
      mal.selectionSort();
      for (int i = 0; i < mal.size(); i++)
         System.out.println(mal.get(i));
   }
}
```

26) Is the following statement legal if the `OneThing` class is defined as in Fig. 17.2:

```
OneThing<double> p = new OneThing<double>(3.0);
```

27) Write a generic class with two members: a private instance variable whose type is parameterized and a constructor that initializes this variable to the parameter the constructor is passed.

28) Why is the following statement illegal in a generic class, where `T` is the type parameter:

```
T r = new T()
```

29) Compile the program below. What error message does the compiler produce? What is the problem with this program?

```
class Gosh<T>
{
   T x;
}
//================================================
class C17h29
{
   public static void main(String[] args)
   {
      Gosh<int> r = Gosh<int>();
   }
}
```

30) Can a generic class with type parameter `T` contain fields whose types are not `T`? For example, would a generic class with the following fields be legal?

```
T x;
String y;
int z;
```

Create a program and compile such a class to see if it is legal.

31) Modify `MyArrayList.java` in `C16h31.java` so that you can pass an initial capacity to its constructor. Also add the `set` method. Your `set` method should work like the `set` method in the `ArrayList` class (see Section 9.12). Add code to the `main` method that tests your enhancement.

32) Create a generic class `Yi` with type parameter `T` in `C16h32.java` that contains

```
T x;
public Yi(T xx)
{
   x = xx;
}
 public void display()
{
   System.out.println(x);
}
```

Test your `Yi` class with

```
class C16h32
{
   public static void main(String[] args)
   {
      Yi<Integer> y1 = new Yi<Integer>(20);
      y1.display();
      Er e = new Er();
      Yi<Er> y2 = new Yi<Er>(e);
      y2.display();
   }
}
```

`Er` is defined as follows:

```
 class Er
 {
    private int n = 2;
 }
```

What is displayed when `C16h32` runs? Why is the value in `y1` displayed but not the value in `y2`?

33) Why is line 18 in Fig. 16.9 not illegal (it is a downcast).

34) Can a generic class with type parameter `T` contain fields whose types are also generic classes with type parameter `T`? For example, is the `MyStack` class below legal? Use it in a program that reads in the numbers in the `t1.txt` file and displays them in reverse order. `MyStack` is in `C16h34.java`.

```
import java.util.ArrayList;
 class MyStack<T>
{
   private ArrayList<T> s = new ArrayList<T>();
   //---------------------------------
   public void push(T x)
   {
      s.add(x);
   }
   //---------------------------------
   public T pop()
   {
      return s.remove(s.size() - 1);
   }
   //---------------------------------
   public boolean isEmpty()
   {
      return s.size() == 0;
   }
}
```

The class that is passed to the `MyStack` class is, in turn, passed to the `ArrayList` class within `MyStack`. Thus, if we execute

```
MyStack<Integer> s = new MyStack<Integer>();
```

the object constructed would contain an object of type `ArrayList<Integer>`. But if we execute

```
MyStack<String> s = new MyStack<String>();
```

then the object constructed would contain an object of type `ArrayList<String>`. The `MyStack` class implements a **stack**—a **last-in-first-out** (LIFO) data structure.

35) Same as homework problem 34 but use the predefined generic `Stack` class in `java.util`.

36) Delete all the angle brackets and the types they enclose in the `main` method in `C17h36.java` (a copy of `TestOneThing.java` in Fig. 16.7). Do *not* modify the `OneThing` class. Does the modified program compile without any errors? Does it run correctly? If you do not pass a type to a generic class, the type `Object` is passed by default. Add the following line at the end of `main`:

```
Integer i = p1.get();
```

Does it compile without error? Now try

```
Integer j = (Integer)p1.get();
```

Why does the statement above with a cast work but not the statement without the cast? If the `OneThing` class were not generic, but its base type were `Object`, in what way would it be less versatile than the original `OneThing` class?

37) Convert the `MyLinkedList` in `C16h37.java` to a generic class. Test your new clas

Intersession assignment

This problem set provides a good review for a final exam on the more difficult concepts in Chapters 1 to 16. It also is excellent preparation for the next course on Java programming, typically called "data structures". If you do not continue to work with Java between courses, you will probably forget a lot. You will then start the next course without the proper preparation. But if you do at least some of the problems below between your first and second courses in Java, you will start the next course "ahead" in which case you will do well, learn more, and be rightfully proud of your accomplishment.

38) Add to `C16h38.java` (a copy of `TestMyTree.java`) a method that determines if the tree has the property below. It should return true or false accordingly.

> Property: The data in each node is greater than or equal to the data in its tow subtrees. A null tree (i.e., a tree with no nodes) automatically satisfies this property.

Use recursion. *Hint*: Suppose the left and right subtrees off the root has this property. Then what test(s) must you make to determine if the entire tree has the property. What can you say about the data in the root node for a tree with this property? If the root node is removed, what must be done with its two subtrees to form a tree with the property above?

39) Eliminate recursion in the following programming:

```
class C16h39
{
   public static void main(String[] args)
   {
      f(5);
   }
   public static void f(int x)
   {
      if(x >= 0)
      {
         System.out.println(x);
         f(x-1);                // tail recursive
      }
      else
         System.out.println("bottom");
   }
}
```

40) Eliminate recursion in the following program. Use the `MyStack` class (see homework problem 34).

```
class C16h40
{
   public static void main(String[] args)
   {
      f(5);
   }
   public static void f(int x)
   {
      if(x >= 0)
      {
          f(x-1); // save current x on a stack (see homework problem 34)
         System.out.println(x);
      }
```

```
            else
               System.out.println("bottom");
         }
      }
```

41) In `C16h41.java` (a copy of `TestMyLinkedList.java`), add a method `loopReverse` that traverses the list in reverse order. Do not use recursion (i.e., use a loop instead). *Hint*: As you move down to the end of the list using a loop, save each pointer on a stack. Then pop and use these saved pointers to go backwards in the list. Use the `MyStack` class in homework problem 34 to save (with `push`) and retrieve (with `pop`) the node pointers.

42) Write a program that prompts the user to enter two integers. Your program should display their sum. If the user enters a non-integer for either the first or second integer, your program should not terminate, but prompt the user again. Use `try` and `catch` blocks.

43) Implement a stack class with `push`, `pop`, and `isEmpty` methods, but use an array instead of an `ArrayList` (see homework problem 34). Redo homework problem 41 using your new stack class.

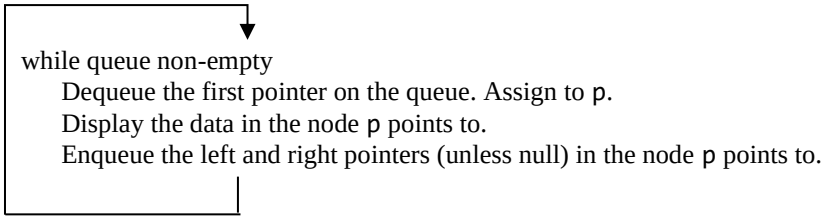
44) A **stack** is a data structure in which adds and removals are from one side only (the "top" of the stack). The last item added is the first item removed. Thus, a stack is an example of a LIFO (last-in-first-out) structure. A **queue** (see homework problem 24) is a data structure in which adds are to one side and removals are from the other side. It works like the line in front of a movie theater—people get on the end of the line, the person at the head of the line gets served next. Thus, a queue is a FIFO (first-in-first-out) structure.

    Redo homework problem 24, but use an array in place of an `ArrayList`. Use variables `first` and `last` to keep track of the first and last items on the queue. Use the file name `C16h44.java`.

45) Redo homework problem 24, but use a linked list in place of an `ArrayList`. Use variables `first` and `last` to keep track of the first and last items on the queue. Use the file name `C16h45.java`.

46) The tree traversal performed by the program in `TestMyTree.java` is an example of a **depth-first traversal** because each recursive call goes down to a lower node. Another type of traversal is a **breadth-first traversal**. In a breadth-first traversal, each level is traversed before the next lower level is traversed.

    A good way to implement a breadth-first traversal is with a queue. The queue is initialized with the pointer to the root node. Then the following loop is executed while the queue is non-empty:

    Add to `C16h46.java` a `bftraverse` (breadth-first) traversal method using a queue implemented with an `ArrayList` (see homework problem 24).

47) Add to `C16h47.java` (a copy of `TestMyTree.java`) a method that returns the **height** of the tree. The height is the number of nodes in the longest path from the root to a leaf node (i.e., a node in which both pointers are null). Thus, a null tree has height 0. A tree with just the root node has height 1.

48) What is the advantage of the tree data structure compared with the singly-linked list data structure? *Hint*: Why it may be safter to walk a group of kids across a busy street in the formation of a tree rather than in the formation of a linked list?

49) What is the least number of nodes in the tree in `TestMyTree.java` if the tree has height 5? If the tree has the height 30.

50) What is the maximum number of nodes in the tree in `TestMyTree.java` if the tree has height 5? If the tree has the height 30?