Public-Service Announcement

“CodeBase is a student organization that does technical consulting for startups. It is an opportunity for students to design, develop, and consult on real world technical challenges that companies face as well as build an impressive portfolio and resume. We are looking for talented developers and designers to work with us on industry projects. If you’re interested come learn more at our infosession! [Thursday at 7PM in Anna Head Alumnae Hall]

See http://info.codebase.club.

Learn more about us at: http://www.codebase.club

Apply at: http://www.codebase.club/students/"
Labs: We are forgiving during the first week or so, but try to get your lab1 submitted properly. DBC: Let us know if you can't get something to work!

There are 50-100 people who do not yet have Git repositories (which you need to complete the lab). Do you this done!

If you are on the waiting list, you will not be admitted until you find an open lab (or a space opens up in the one you are waiting on). Remove yourself from the one you are waiting on and enroll for an open one, or risk not getting in.

Tests weeks of Sept 28 and Oct 26. We'll be more specific when we get rooms.
More Iteration: Sort an Array

Problem. Print out the command-line arguments in order:

% java sort the quick brown fox jumped over the lazy dog
brown dog fox jumped lazy over quick the the

Plan.

```java
public class Sort {
    /** Sort and print WORDS lexicographically. */
    public static void main(String[] words) {
        sort(words, 0, words.length-1);
        print(words);
    }

    /** Sort items A[L..U], with all others unchanged. */
    static void sort(String[] A, int L, int U) {
        /* "TOMORROW" */
    }

    /** Print A on one line, separated by blanks. */
    static void print(String[] A) {
        /* "TOMORROW" */
    }
}
```

How do We Know If It Works?

- **Unit testing** refers to the testing of individual units (methods, classes) within a program, rather than the whole program.

- In this class, we mainly use the JUnit tool for unit testing.

- Example: AGTestYear.java in lab #1.

- **Integration testing** refers to the testing of entire (integrated) set of modules—the whole program.

- In this course, we’ll look at various ways to run the program against prepared inputs and checking the output.

- **Regression testing** refers to testing with the specific goal of checking that fixes, enhancements, or other changes have not introduced faults (regressions).
Test-Driven Development

• Idea: write tests first.
• Implement unit at a time, run tests, fix and refactor until it works.
• We’re not really going to push it in this course, but it is useful and has quite a following.
Testing sort

● This is pretty easy: just give a bunch of arrays to sort and then make sure they each get sorted properly.

● Have to make sure we cover the necessary cases:
  - *Corner cases.* E.g., empty array, one-element, all elements the same.
  - *Representative “middle” cases.* E.g., elements reversed, elements in order, one pair of elements reversed, ....
Simple JUnit

• The JUnit package provides some handy tools for unit testing.
• The Java annotation @Test on a method tells the JUnit machinery to call that method.
• (An annotation in Java provides information about a method, class, etc., that can be examined within Java itself.)
• A collection of methods with names beginning with assert then allow your test cases to check conditions and report failures.
• [See example.]
Selection Sort

/** Sort items A[L..U], with all others unchanged. */
static void sort(String[] A, int L, int U) {
    if (L < U) {
        int k = /*( Index s.t. A[k] is largest in A[L],...,A[U] )*/;
        /*{ Sort items L to U-1 of A. }*/;
    }
}

And we're done! Well, OK, not quite.
Selection Sort

/** Sort items A[L..U], with all others unchanged. */
static void sort(String[] A, int L, int U) {
    if (L < U) {
        int k = indexOfLargest(A, L, U);
        /*{ Sort items L to U-1 of A. }*/
    }
}
Selection Sort

/** Sort items A[L..U], with all others unchanged. */
static void sort(String[] A, int L, int U) {
    if (L < U) {
        int k = indexOfLargest(A, L, U);
        sort(A, L, U-1);  // Sort items L to U-1 of A
    }
}

Last modified: Mon Aug 29 14:41:43 2016
Selection Sort

/** Sort items A[L..U], with all others unchanged. */
static void sort(String[] A, int L, int U) {
    if (L < U) {
        int k = indexOfLargest(A, L, U);
        sort(A, L, U-1); // Sort items L to U-1 of A
    }
}
Selection Sort

/** Sort items A[L..U], with all others unchanged. */
static void sort(String[] A, int L, int U) {
    if (L < U) {
        int k = indexOfLargest(A, L, U);
        sort(A, L, U-1);  // Sort items L to U-1 of A
    }
}

What would an iterative version look like?

    while (?) {
        ?
    }
Selection Sort

/** Sort items A[L..U], with all others unchanged. */
static void sort(String[] A, int L, int U) {
    if (L < U) {
        int k = indexOfLargest(A, L, U);
        sort(A, L, U-1); // Sort items L to U-1 of A
    }
}

Iterative version:

while (L < U) {
    int k = indexOfLargest(A, L, U);
    U -= 1;
}
Find Largest

/** Index k, I0<=k<=I1, such that V[k] is largest element among * V[I0], ... V[I1]. Requires I0<=I1. */
static int indexOfLargest(String[] V, int i0, int i1) {
    if (?)
        return i1;
    else {

    }
}


/** Index k, I0<=k<=I1, such that V[k] is largest element among * V[I0], ... V[I1]. Requires I0<=I1. */
static int indexOfLargest(String[] V, int i0, int i1) {
    if (i0 >= i1)
        return i1;
    else /* if (i0 < i1) */ {

    }
}

Find Largest

/** Index k, I0<=k<=I1, such that V[k] is largest element among * V[I0], ... V[I1]. Requires I0<=I1. */
static int indexOfLargest(String[] V, int i0, int i1) {
    if (i0 >= i1)
        return i1;
    else /* if (i0 < i1) */ {
        int k = /*( index of largest value in V[i0 + 1..i1] )*/;
        return /*( whichever of i0 and k has larger value )*/
    }
}
Find Largest

/** Index k, I0<=k<=I1, such that V[k] is largest element among * V[I0], ... V[I1]. Requires I0<=I1. */
static int indexOfLargest(String[] V, int i0, int i1) {
    if (i0 >= i1)
        return i1;
    else /* if (i0 < i1) */ {
        int k = indexOfLargest(V, i0 + 1, i1);
        return /*( whichever of i0 and k has larger value )*/
    }
}
/** Index k, I0<=k<=I1, such that V[k] is largest element among * V[I0], ... V[I1]. Requires I0<=I1. */
static int indexOfLargest(String[] V, int i0, int i1) {
    if (i0 >= i1)
        return i1;
    else /* if (i0 < i1) */ {
        int k = indexOfLargest(V, i0 + 1, i1);
        return (V[i0].compareTo(V[k]) > 0) ? i0 : k;
        // if (V[i0].compareTo(V[k]) > 0) return i0; else return k;
    }
}

- Turning this into an iterative version is tricky: not tail recursive.
- What are the arguments to compareTo the first time it's called?
Iteratively Find Largest

/** Value k, I0<=k<=I1, such that V[k] is largest element among
 *  V[I0], ... V[I1]. Requires I0<=I1. */
static int indexOfLargest(String[] V, int i0, int i1) {
  if (i0 >= i1)
    return i1;
  else /* if (i0 < i1) */ {
    int k = indexOfLargest(V, i0 + 1, i1);
    return (V[i0].compareTo(V[k]) > 0) ? i0 : k;
  }
}

Iterative:

int i, k;

k = ?;  // Deepest iteration
for (i = ?; ...?; i ...?)
  k = ?;
return k;
Iteratively Find Largest

/** Value k, I0<=k<=I1, such that V[k] is largest element among * V[I0], ... V[I1]. Requires I0<=I1. */

```java
static int indexOfLargest(String[] V, int i0, int i1) {
    if (i0 >= i1)
        return i1;
    else /* if (i0 < i1) */ {
        int k = indexOfLargest(V, i0 + 1, i1);
        return (V[i0].compareTo(V[k]) > 0) ? i0 : k;
    }
}
```

Iterative:

```java
int i, k;

k = i1;  // Deepest iteration
for (i = ?; ...?; i ...?)
    k = ?;
return k;
```
Iteratively Find Largest

/** Value k, I0<=k<=I1, such that V[k] is largest element among *  V[I0], ... V[I1]. Requires I0<=I1. */
static int indexOfLargest(String[] V, int i0, int i1) {
    if (i0 >= i1)
        return i1;
    else /* if (i0 < i1) */ {
        int k = indexOfLargest(V, i0 + 1, i1);
        return (V[i0].compareTo(V[k]) > 0) ? i0 : k;
    // if (V[i0].compareTo(V[k]) > 0) return i0; else return k;
    }
}

Iterative:

int i, k;

k = i1;    // Deepest iteration
for (i = i1 - 1; i >= i0; i -= 1)
    k = ?;
return k;
Iteratively Find Largest

/** Value k, I0<=k<=I1, such that V[k] is largest element among
 * V[I0], ... V[I1]. Requires I0<=I1. */

static int indexOfLargest(String[] V, int i0, int i1) {
    if (i0 >= i1)
        return i1;
    else /* if (i0 < i1) */ {
        int k = indexOfLargest(V, i0 + 1, i1);
        return (V[i0].compareTo(V[k]) > 0) ? i0 : k;
    }
}

Iterative:

int i, k;

k = i1; // Deepest iteration

for (i = i1 - 1; i >= i0; i -= 1)
    k = (V[i].compareTo(V[k]) > 0) ? i : k;

return k;
Finally, Printing

/** Print A on one line, separated by blanks. */
static void print(String[] A) {
    for (int i = 0; i < A.length; i += 1)
        System.out.print(A[i] + " ");
    System.out.println();
}

/* J2SE 5 introduced a new syntax for the \{\bf for\} * loop here: */
for (String s : A)
    System.out.print(s + " ");
/* Use it if you like, but let’s not stress over it yet! */
Another Problem

Given an array of integers, \( A \), move its last element, \( A[A.length-1] \), to just after nearest previous item that is \( \leq \) to it (shoving other elements to the right). For example, if \( A \) starts out as

\[
\{ 1, 9, 4, 3, 0, 12, 11, 9, 15, 22, 12 \}
\]

then it ends up as

\[
\{ 1, 9, 4, 3, 0, 12, 11, 9, 12, 15, 22 \}
\]

If there is no such previous item, move \( A[A.length-1] \) to the beginning of \( A \) (i.e., to \( A[0] \)). So

\[
\{ 1, 9, 4, 3, 0, 12, 11, 9, 15, 22, -2 \}
\]

would become

\[
\{ -2, 1, 9, 4, 3, 0, 12, 11, 9, 15, 22 \}
\]

(Preliminary question: How can I state this without making this last case special?)
public class Shove {

    /** Move A[A.length-1] so that it is just after the nearest
     * previous item that is <= A[A.length-1], or to A[0] if
     * there isn’t such an item. Move all succeeding items
     * to the right (i.e., up one index). */
    static void moveOver(int[] A) {
        // FILL IN
    }

}