1 Fill Grid

Given two one-dimensional arrays LL and UR, fill in the program on the next page to insert the elements of LL into the lower-left triangle of a square two-dimensional array S and UR into the upper-right triangle of S, without modifying elements along the main diagonal of S. You can assume LL and UR both contain at least enough elements to fill their respective triangles. (Spring 2020 MT1)

For example, consider

```c
int[] LL = { 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 0, 0 };
int[] UR = { 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 };
int[][ ] S = {
    { 0, 0, 0, 0, 0 },
    { 0, 0, 0, 0, 0 },
    { 0, 0, 0, 0, 0 },
    { 0, 0, 0, 0, 0 },
    { 0, 0, 0, 0, 0 }
};
```

After calling `fillGrid(LL, UR, S)`, S should contain

```c
{
    { 0, 11, 12, 13, 14 },
    { 1, 0, 15, 16, 17 },
    { 2, 3, 0, 18, 19 },
    { 4, 5, 6, 0, 20 },
    { 7, 8, 9, 10, 0 }
}
```

(The last two elements of LL are excess and therefore ignored.)
/** Fill the lower-left triangle of S with elements of LL and the 
 * upper-right triangle of S with elements of UR (from left-to 
 * right, top-to-bottom in each case). Assumes that S is square and 
 * LL and UR have at least sufficient elements. */

public static void fillGrid(int[] LL, int[] UR, int[][] S) {
    int N = S.length;
    int kL, kR;
    kL = kR = 0;
    for (int i = 0; i < N; i += 1) {
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    }
}
Solution:

```java
public static void fillGrid(int[] LL, int[] UR, int[][] S) {
    int N = S.length;
    int kL, kR;
    kL = kR = 0;
    for (int i = 0; i < N; i += 1) {
        for (int j = 0; j < N; j += 1) {
            if (i < j) {
                S[i][j] = UR[kR];
                kR += 1;
            } else if (i > j) {
                S[i][j] = LL[kL];
                kL += 1;
            }
        }
    }
}
```

Alternate Solutions:

```java
public static void fillGrid(int[] LL, int[] UR, int[][] S) {
    int N = S.length;
    int kL, kR;
    kL = kR = 0;
    for (int i = 0; i < N; i += 1) {
        for (int j = 0; j < i; j += 1) {
            S[i][j] = LL[kL];
            kL += 1;
        }
        for (int j = i + 1; j < N; j += 1) {
            S[i][j] = UR[kR];
            kR += 1;
        }
    }
}
```

```java
public static void fillGrid(int[] LL, int[] UR, int[][] S) {
    int N = S.length;
    int kL, kR;
    kL = kR = 0;
    for (int i = 0; i < N; i += 1) {
        System.arraycopy(LL, kL, S[i], 0, i);
        System.arraycopy(UR, kR, S[i], i + 1, N - i - 1);
        kL += i;
        kR += square.length - i - 1;  */
    }
}
```
2 Even Odd

Implement the method evenOdd by destructively changing the ordering of a given IntList so that even indexed links precede odd indexed links.

For instance, if lst is defined as IntList.list(0, 3, 1, 4, 2, 5), evenOdd(lst) would modify lst to be IntList.list(0, 1, 2, 3, 4, 5).

You may not need all the lines.

Hint: Make sure your solution works for lists of odd and even lengths.

```java
public class IntList {
    public int first;
    public IntList rest;
    public IntList (int f, IntList r) {
        this.first = f;
        this.rest = r;
    }

    public static void evenOdd(IntList lst) {
        if (__________________________________________) {
            return;
        }

        while (____________________________________________) {
            _________________________________________________
            _________________________________________________
            _________________________________________________
            _________________________________________________
            _________________________________________________
        }
    }
}
```
Solution:

```java
public static void evenOdd(IntList lst) {
    if (lst == null || lst.rest == null) {
        return;
    }
    IntList oddList = lst.rest;
    IntList second = lst.rest;
    while (lst.rest != null && oddList.rest != null) {
        lst.rest = lst.rest.rest;
        oddList.rest = oddList.rest.rest;
        lst = lst.rest;
        oddList = oddList.rest;
    }
    lst.rest = second;
}
```

Alternate Solution:

```java
public static void evenOdd(IntList lst) {
    if (lst == null || lst.rest == null || lst.rest.rest == null) {
        return;
    }
    IntList second = lst.rest;
    int index = 0;
    while (!(index % 2 == 0 && (lst.rest == null || lst.rest.rest == null))) {
        IntList temp = lst.rest;
        lst.rest = lst.rest.rest;
        lst = temp;
        index++;
    }
    lst.rest = second;
}
```

**Explanation:** For any linked list, observe that we simply want to change the rest attribute of each IntList instance to skip an IntList instance. Looking at lst, we want to link 0 to 1, 3 to 4, and so on. This will constitute the work of the body of the while loop, so we just need to figure out how to link the last even indexed IntList instance to the first odd indexed IntList instance. To keep track of the first odd indexed IntList instance, we can use second. Now, we just need to exit the while loop when we are at the last even indexed IntList instance. This occurs when the index is even and we are either at the second to last element (lst.rest. rest == null) or the last element (lst.rest == null).

3 Partition

Implement partition, which takes in an IntList lst and an integer k, and destructively partitions lst into k IntLists such that each list has the following
properties: Firstly, it is the same length as the other lists. If this is not possible, i.e., \texttt{lst} cannot be equally partitioned, then the later lists should be one element smaller. For example, partitioning an \texttt{IntList} of length 25 with \( k = 3 \) would result in partitioned lists of lengths 9, 8, and 8. Secondly, its ordering is consistent with the ordering of \texttt{lst}, i.e., items in earlier in \texttt{lst} must \texttt{precede} items that are later.

These lists should be put in an array of length \( k \), and this array should be returned. For instance, if \texttt{lst} contains the elements 5, 4, 3, 2, 1, and \( k = 2 \), then a possible partition (note that there are many possible partitions), is putting elements 5, 3, 2 at index 0, and elements 4, 1 at index 1.

You may assume you have the access to the method \texttt{reverse}, which destructively reverses the ordering of a given \texttt{IntList} and returns a pointer to the reversed \texttt{IntList}. You may not create any \texttt{IntList} instances. You may not need all the lines.

\textbf{Hint:} You may find the \% operator helpful.

```java
public static IntList[] partition(IntList lst, int k) {
    IntList[] array = new IntList[k];
    int index = 0;
    IntList L = ________________________________
    while (L != null) {
        ________________________________
        ________________________________
        ________________________________
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        return array;
    }
}
```

\textbf{Solution:} Here is a video walkthrough of the solution.

```java
public static IntList[] partition(IntList lst, int k) {
    IntList[] array = new IntList[k];
    int index = 0;
    IntList L = reverse(lst);
    while (L != null) {
        IntList prevAtIndex = array[index];
        IntList next = L.rest;
```
array[index] = L;
array[index].rest = prevAtIndex;
L = next;
index = (index + 1) % array.length;
}
return array;

**Explanation:** We reverse our `IntList` so that we can build up each element of the `IntList[]` array backwards—in general, it is much easier to build an `IntList` backward than forward.

The general idea is to initialize each element in the array to `null`, then put an element of `L` inside the correct index by assigning `array[index] = L`. Then, we get whatever we’ve built up so far (`prevAtIndex`) and add it to the end of our `rest` element so that we have the entire `IntList` again with one element at the front. Afterwards, we advance `L` to the next element and increment the index.