eC Academy

Realize Your Dreams

AP Computer Science A Review

Week 11: Algorithm IV Control Structure

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SECTION 1

Algorithms

Algorithm

- The word algorithm can be simply defined as “a process to be followed to solve a problem.”
- The number of algorithms to learn is infinite, so rather than attempting to learn all possible algorithms, our goal will be to learn how to develop an algorithm.
- In fact, most FRQ problems in AP Computer Science is targeted at demonstration of problem solving capability which is actually writing algorithms.

Study of Algorithm and Coding

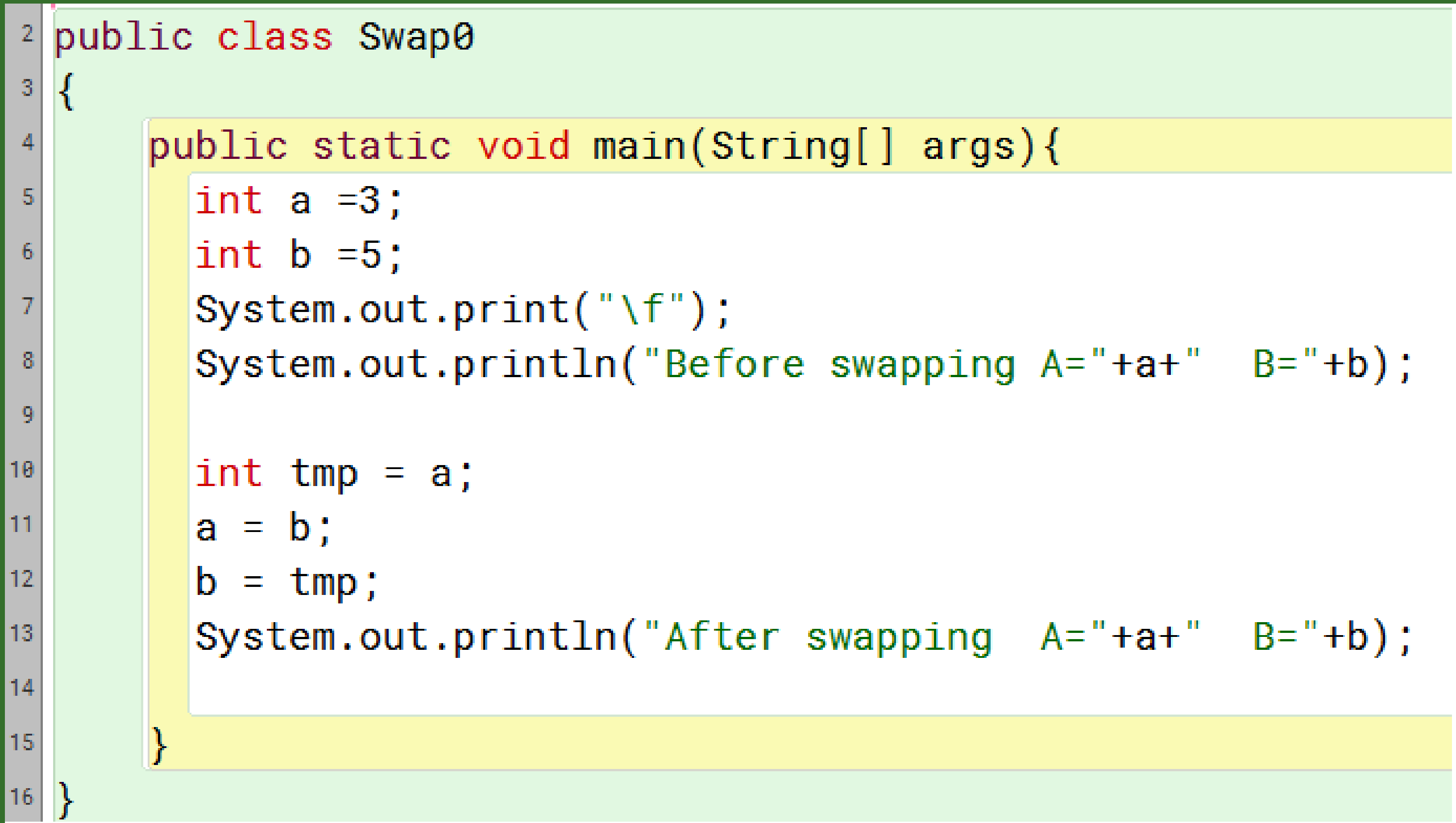
1. Basic design patterns.
2. Program control structure.
3. Development of algorithms from scratch.

SECTION 2

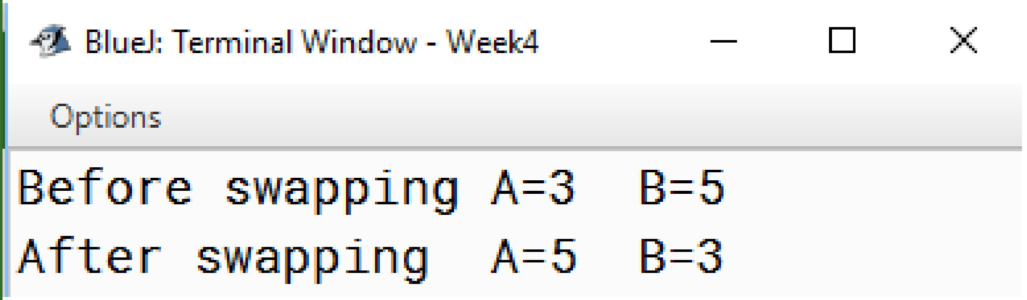
Basic Design Patterns

Swap Algorithm

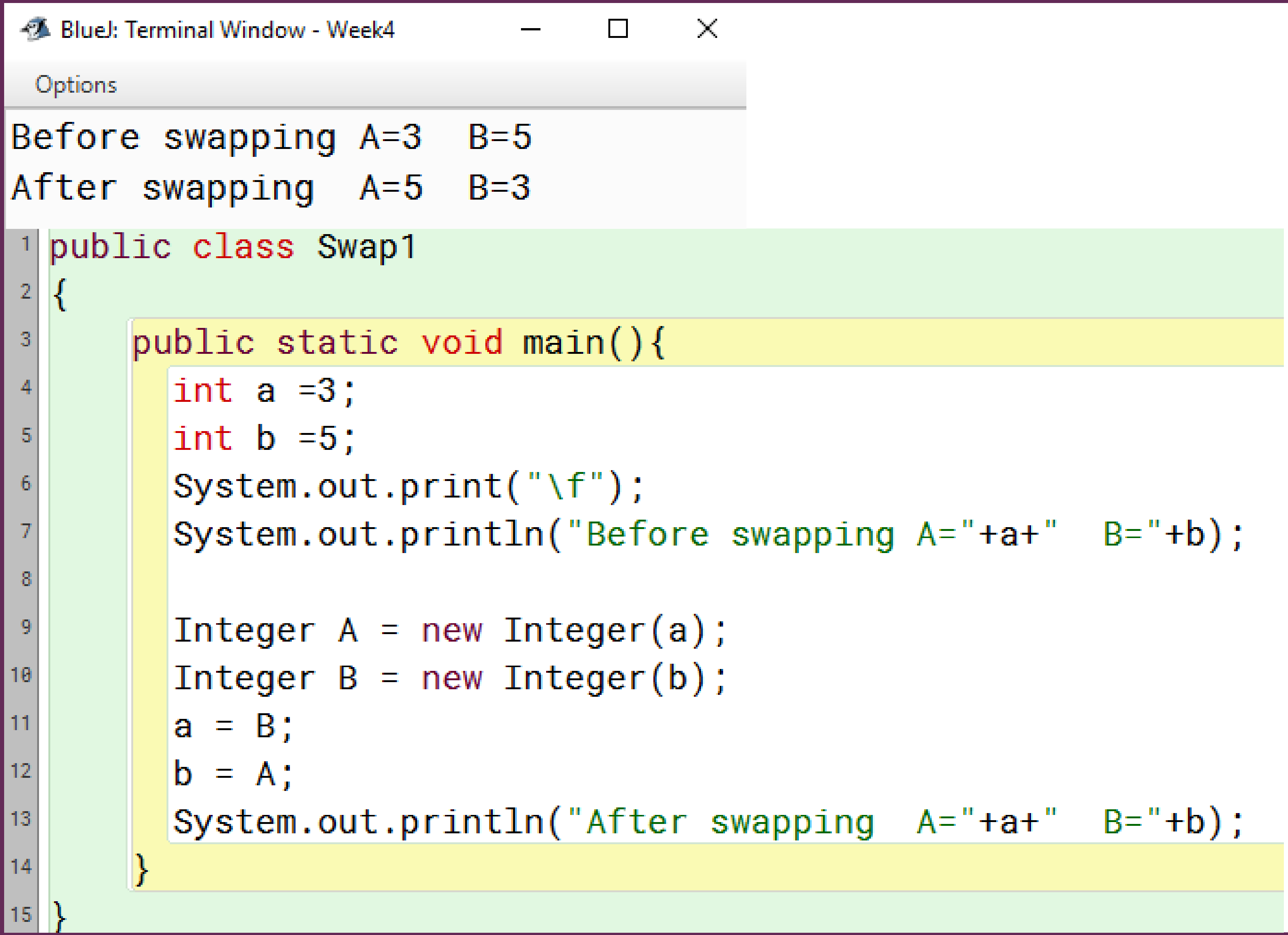
```
int a = 3;
 int b = 5;


 /* swap pattern */
  int tmp = a;
  a = b;
  b = tmp;
```



```
public class Swap0
{
    public static void main(String[] args){
      int a =3;
      int b =5;
      System.out.print("\f");
      System.out.println("Before swapping A="+a+"  B="+b);

      int tmp = a;
      a = b;
      b = tmp;
      System.out.println("After swapping  A="+a+"  B="+b);

    }
}
```

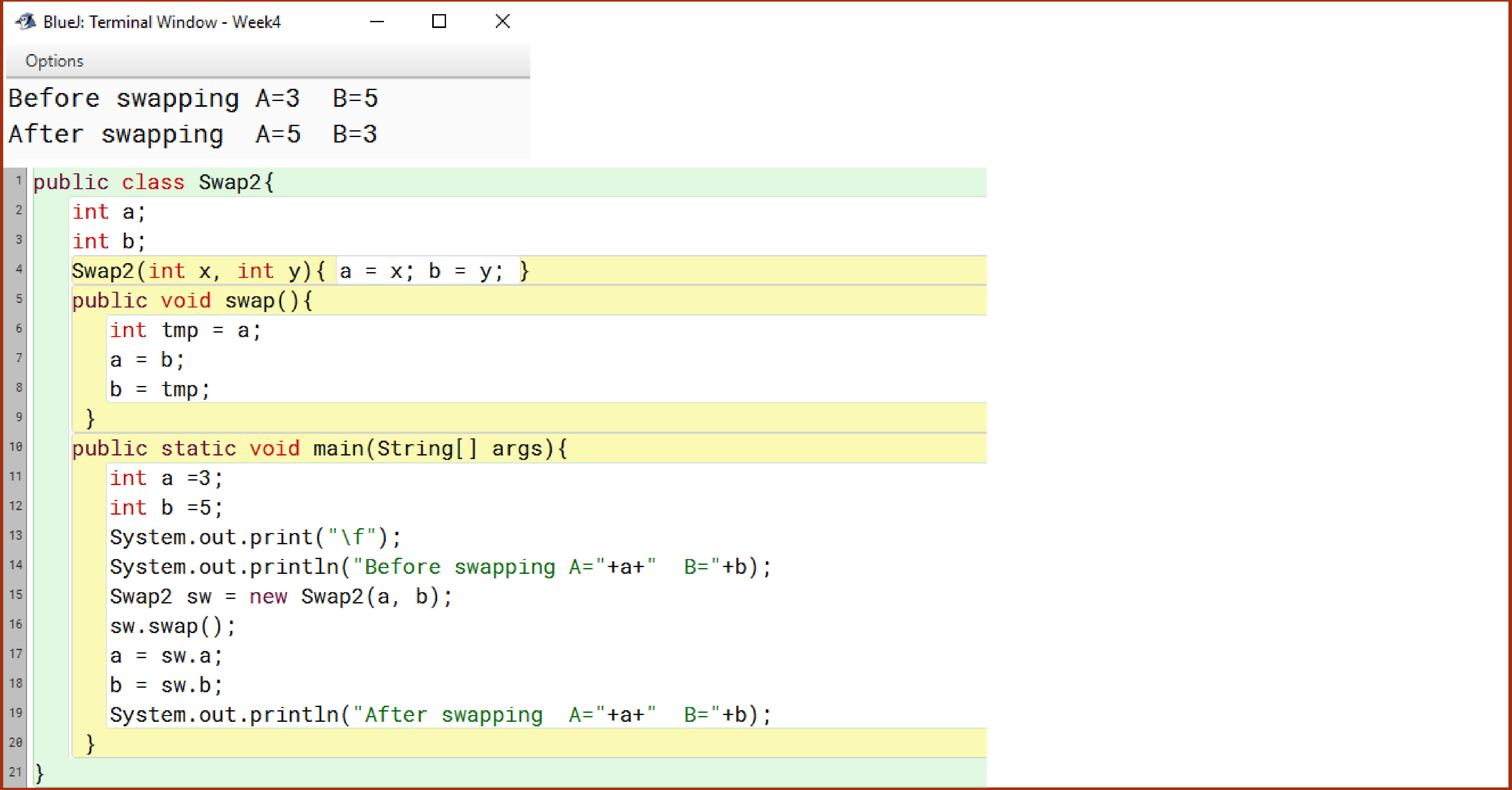


```
Before swapping A=3  B=5
After swapping  A=5  B=3
```



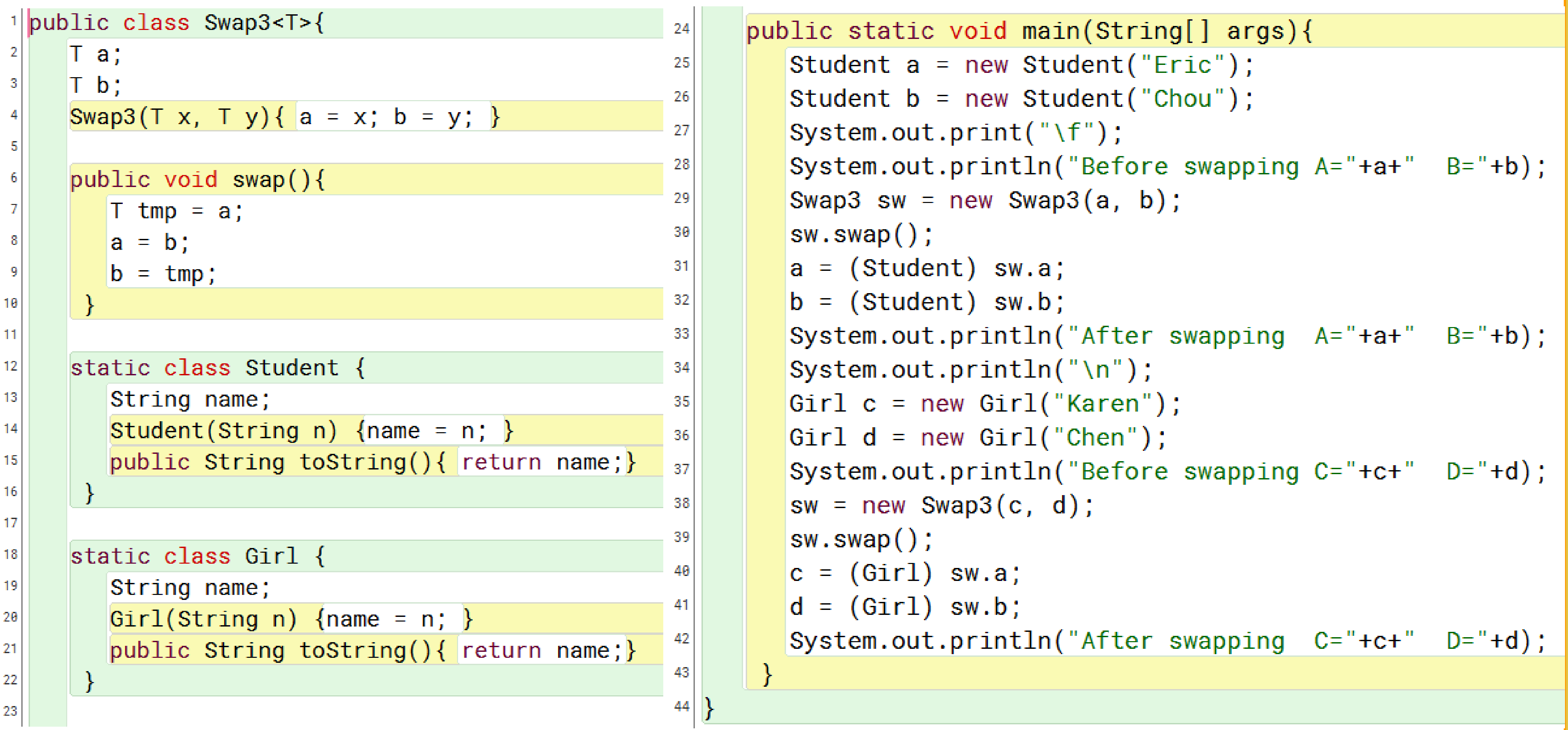
```
Before swapping A=3  B=5
After swapping  A=5  B=3
```

```java
public class Swap1
{
    public static void main(){
        int a =3;
        int b =5;
        System.out.print("\f");
        System.out.println("Before swapping A="+a+"  B="+b);

        Integer A = new Integer(a);
        Integer B = new Integer(b);
        a = B;
        b = A;
        System.out.println("After swapping  A="+a+"  B="+b);
    }
}
```

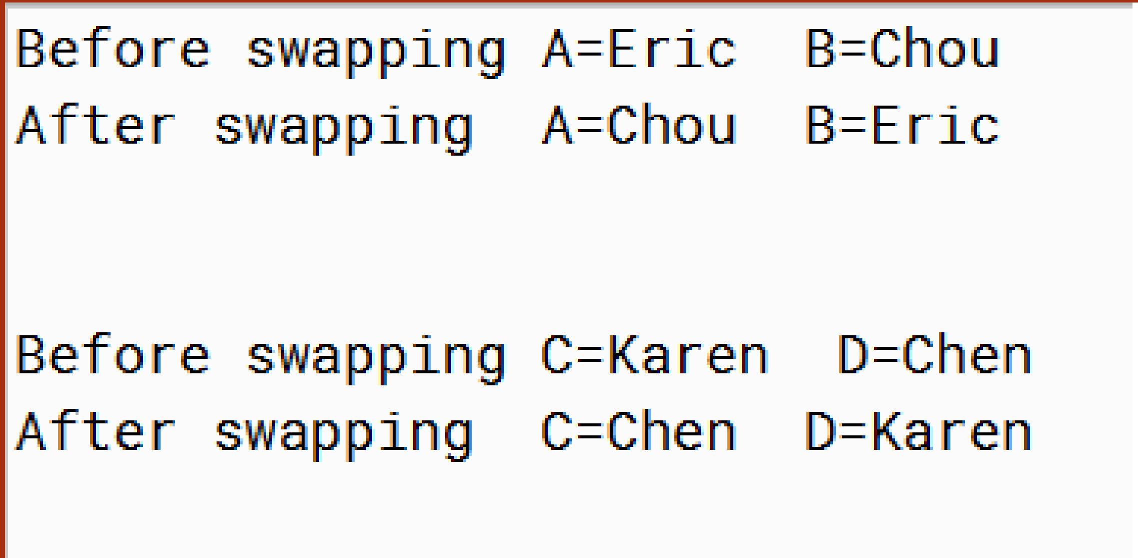


```
Before swapping A=3  B=5
After swapping  A=5  B=3
```

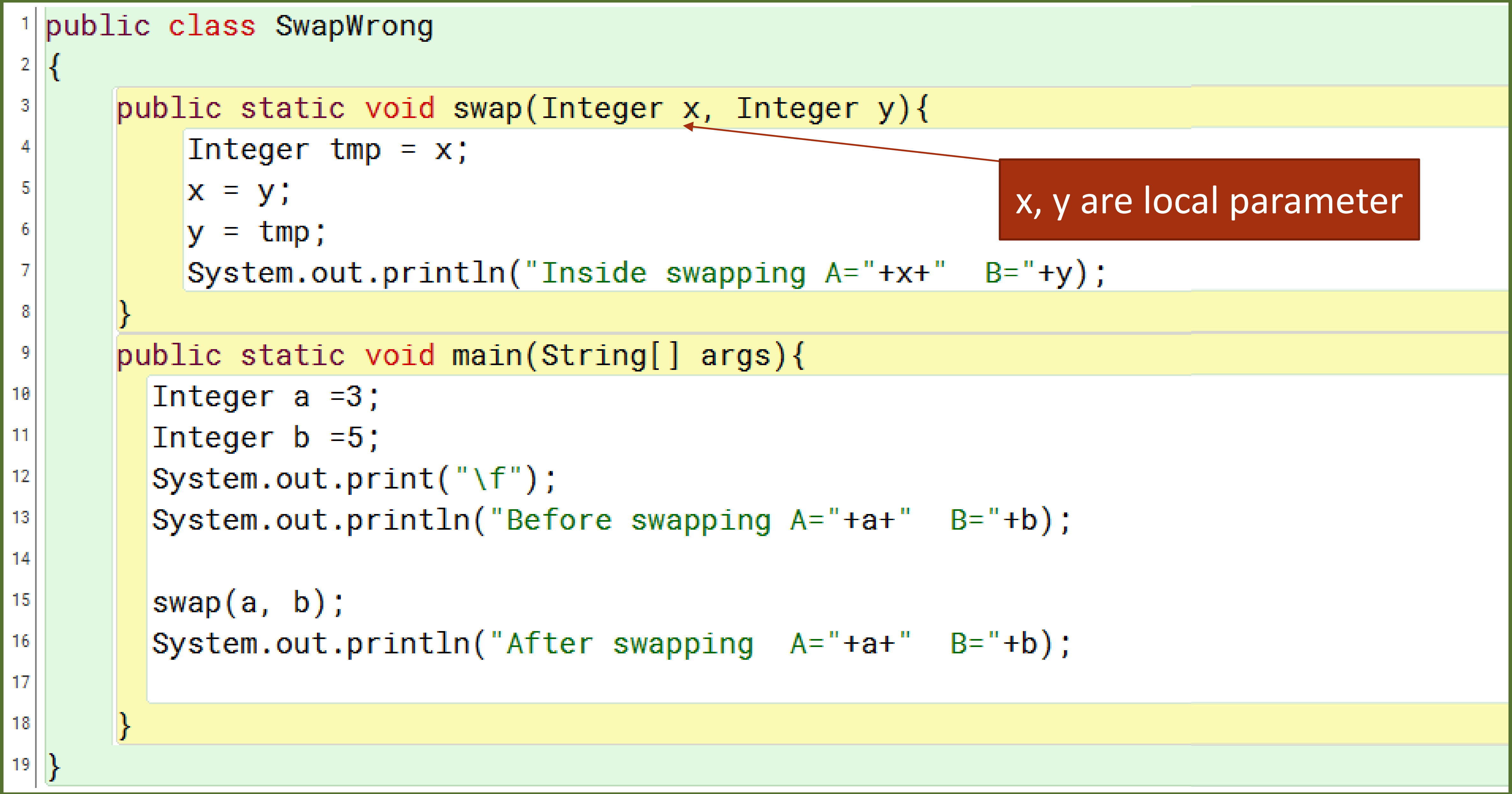
```java
public class Swap2{
   int a;
   int b;
   Swap2(int x, int y){ a = x; b = y; }
   public void swap(){
      int tmp = a;
      a = b;
      b = tmp;
    }
   public static void main(String[] args){
      int a =3;
      int b =5;
      System.out.print("\f");
      System.out.println("Before swapping A="+a+"  B="+b);
      Swap2 sw = new Swap2(a, b);
      sw.swap();
      a = sw.a;
      b = sw.b;
      System.out.println("After swapping  A="+a+"  B="+b);
    }
}
```



```java
public class Swap3<T>{
    T a;
    T b;
    Swap3(T x, T y){ a = x; b = y; }

    public void swap(){
        T tmp = a;
        a = b;
        b = tmp;
    }

    static class Student {
        String name;
        Student(String n) {name = n; }
        public String toString(){ return name;}
    }

    static class Girl {
        String name;
        Girl(String n) {name = n; }
        public String toString(){ return name;}
    }

    public static void main(String[] args){
        Student a = new Student("Eric");
        Student b = new Student("Chou");
        System.out.print("\f");
        System.out.println("Before swapping A="+a+"  B="+b);
        Swap3 sw = new Swap3(a, b);
        sw.swap();
        a = (Student) sw.a;
        b = (Student) sw.b;
        System.out.println("After swapping  A="+a+"  B="+b);
        System.out.println("\n");
        Girl c = new Girl("Karen");
        Girl d = new Girl("Chen");
        System.out.println("Before swapping C="+c+"  D="+d);
        sw = new Swap3(c, d);
        sw.swap();
        c = (Girl) sw.a;
        d = (Girl) sw.b;
        System.out.println("After swapping  C="+c+"  D="+d);
    }
}
```



```
Before swapping A=Eric  B=Chou
After swapping  A=Chou  B=Eric


Before swapping C=Karen  D=Chen
After swapping  C=Chen  D=Karen
```



```java
public class SwapWrong
{
    public static void swap(Integer x, Integer y){
        Integer tmp = x;
        x = y;
        y = tmp;
        System.out.println("Inside swapping A="+x+"  B="+y);
    }
    public static void main(String[] args){
        Integer a =3;
        Integer b =5;
        System.out.print("\f");
        System.out.println("Before swapping A="+a+"  B="+b);

        swap(a, b);
        System.out.println("After swapping  A="+a+"  B="+b);

    }
}
```

x, y are local parameter

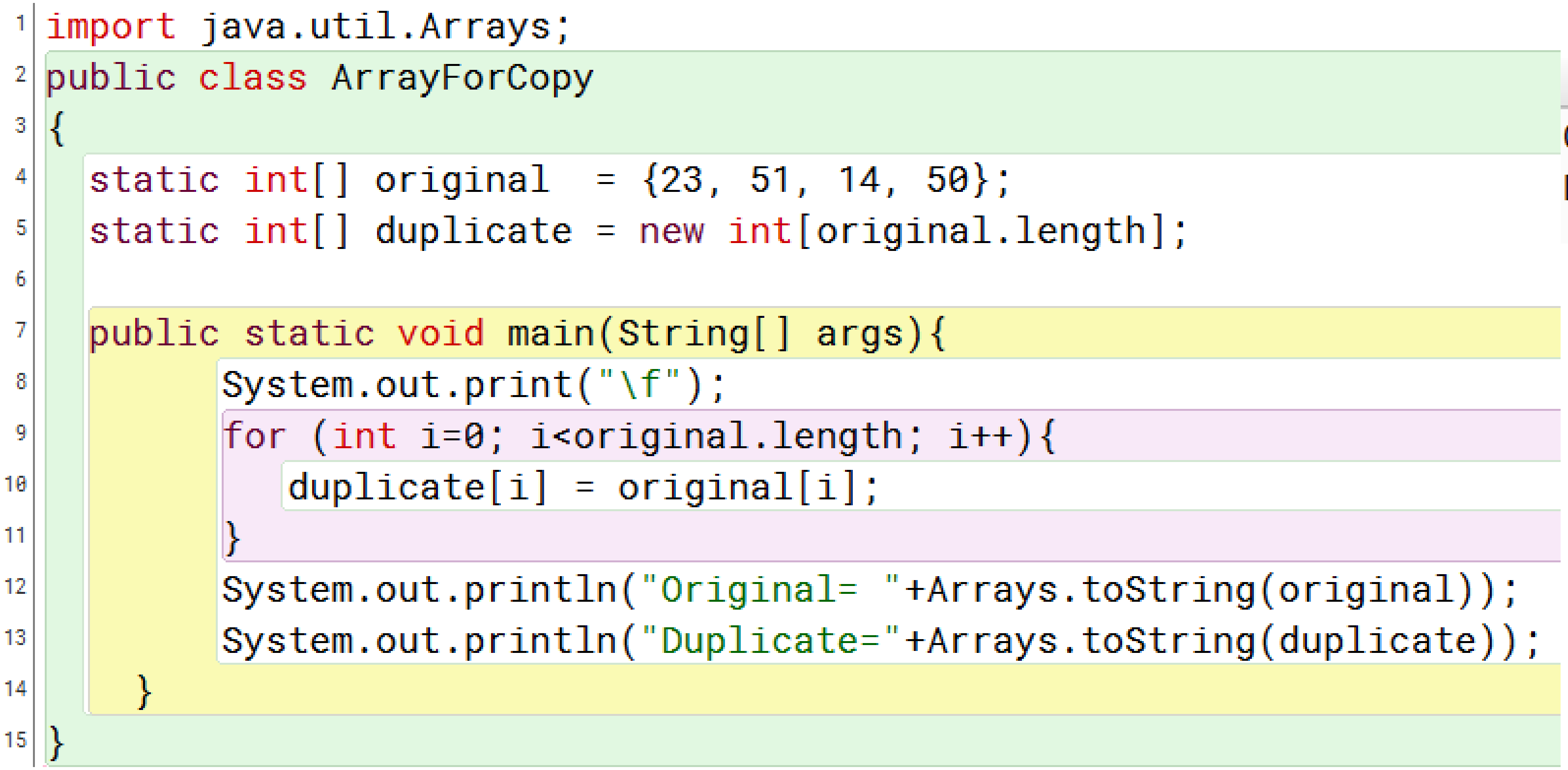
SECTION 3

Copy Algorithms

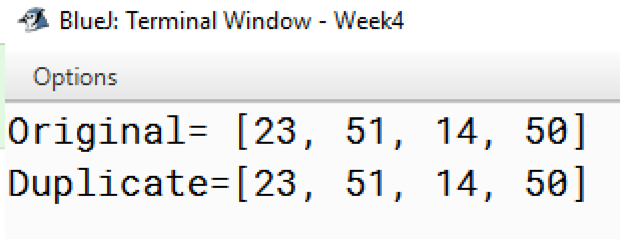
Copy algorithm for the Array and ArrayList

- Array copy (for-loop)
- Array copy (for-each loop)
- ArrayList copy (for-loop)
- ArrayList copy (for-each loop)
- 1 D Array copied to 2D Array
- 2 D Array copied to 1D Array

Array copy (for-loop)

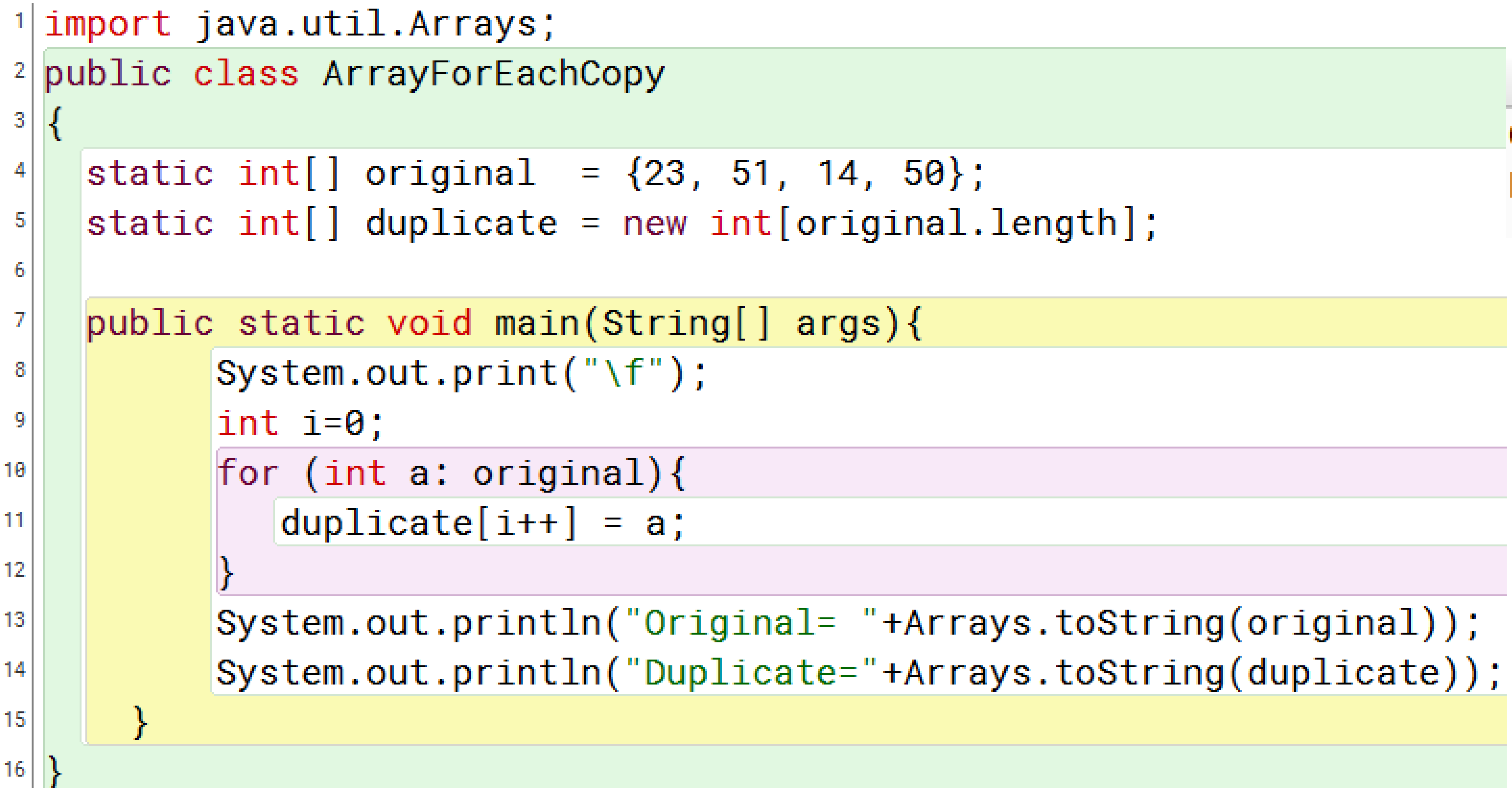


```java
import java.util.Arrays;
public class ArrayForCopy
{
    static int[] original  = {23, 51, 14, 50};
    static int[] duplicate = new int[original.length];

    public static void main(String[] args){
        System.out.print("\f");
        for (int i=0; i<original.length; i++){
            duplicate[i] = original[i];
        }
        System.out.println("Original= "+Arrays.toString(original));
        System.out.println("Duplicate="+Arrays.toString(duplicate));
    }
}
```

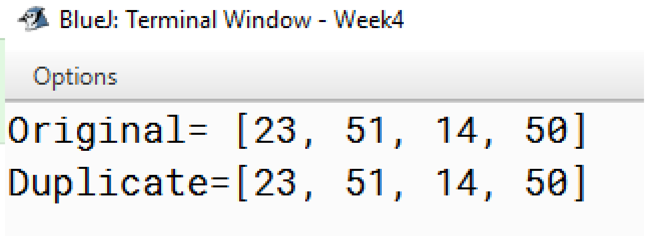


```
Original= [23, 51, 14, 50]
Duplicate=[23, 51, 14, 50]
```

Array copy (for-each loop)

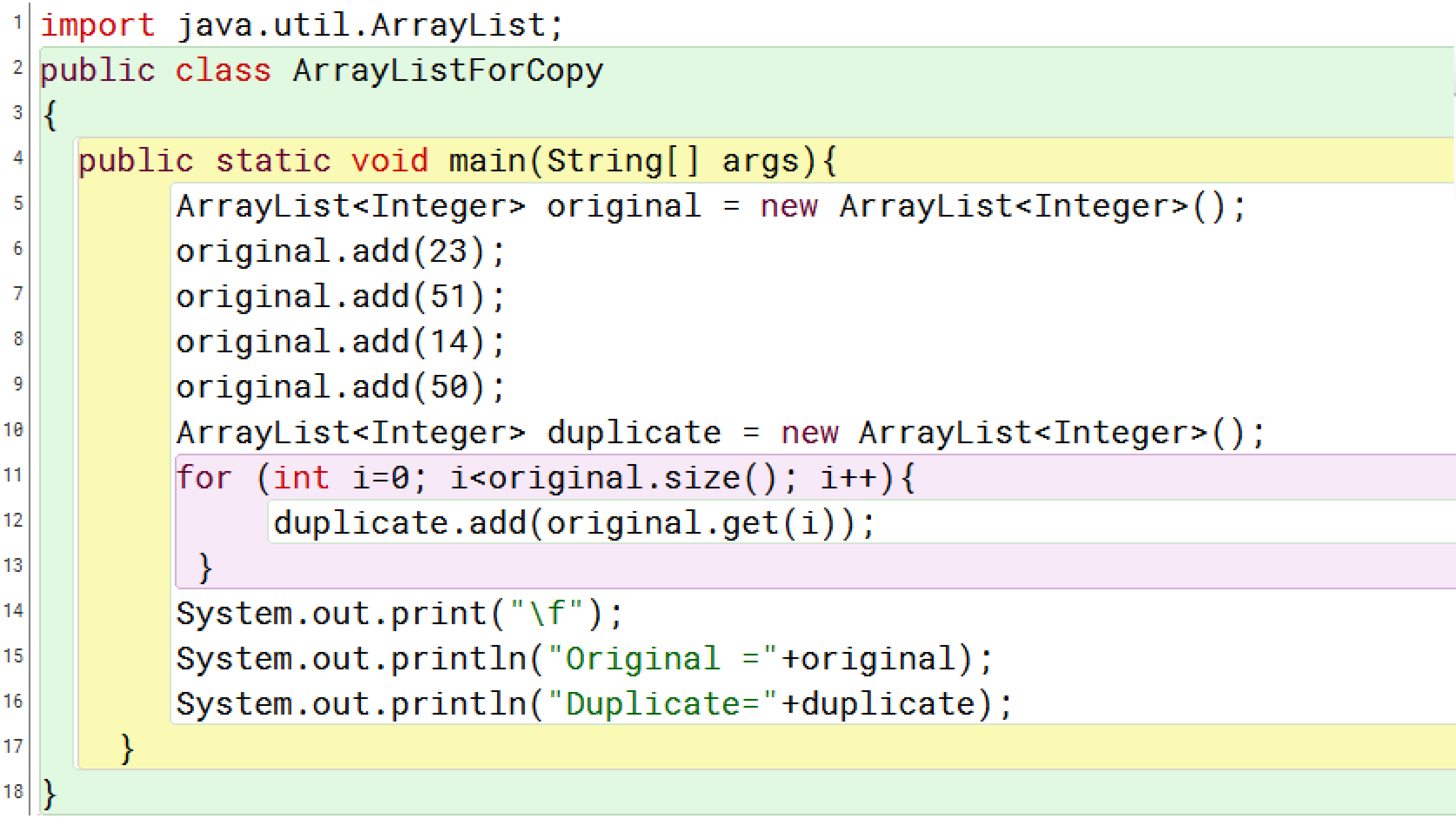


```java
import java.util.Arrays;
public class ArrayForEachCopy
{
  static int[] original  = {23, 51, 14, 50};
  static int[] duplicate = new int[original.length];

  public static void main(String[] args){
        System.out.print("\f");
        int i=0;
        for (int a: original){
           duplicate[i++] = a;
        }
        System.out.println("Original= "+Arrays.toString(original));
        System.out.println("Duplicate="+Arrays.toString(duplicate));
    }
}
```

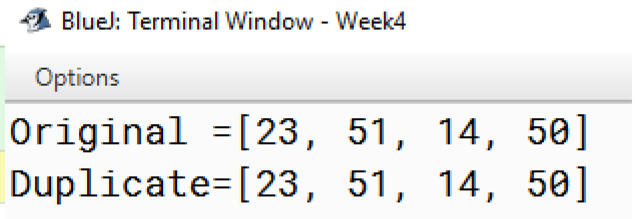


```
Original= [23, 51, 14, 50]
Duplicate=[23, 51, 14, 50]
```

ArrayList copy (for-loop)

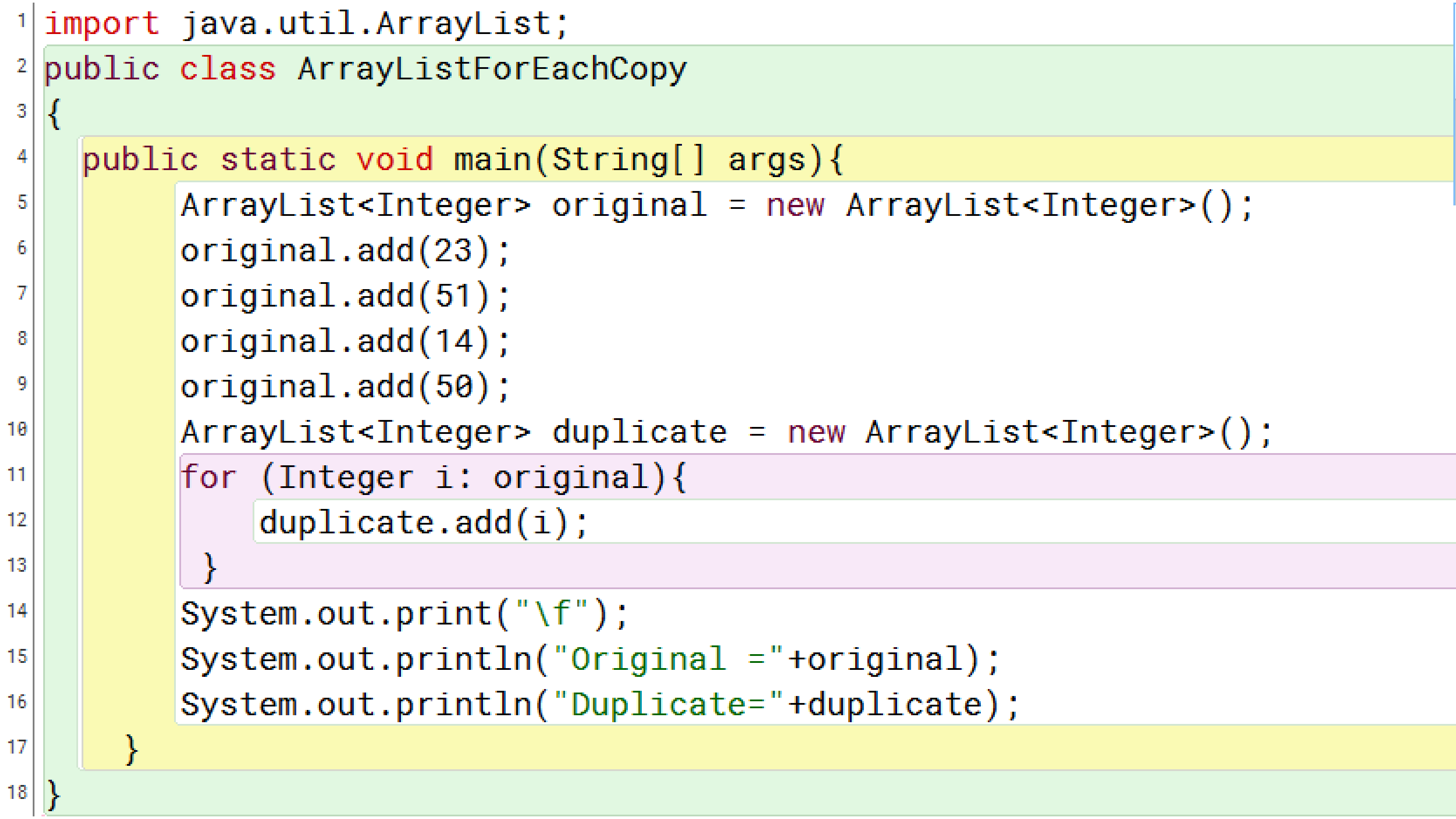


```java
import java.util.ArrayList;
public class ArrayListForCopy
{
  public static void main(String[] args){
        ArrayList<Integer> original = new ArrayList<Integer>();
        original.add(23);
        original.add(51);
        original.add(14);
        original.add(50);
        ArrayList<Integer> duplicate = new ArrayList<Integer>();
        for (int i=0; i<original.size(); i++){
             duplicate.add(original.get(i));
         }
        System.out.print("\f");
        System.out.println("Original ="+original);
        System.out.println("Duplicate="+duplicate);
    }
}
```

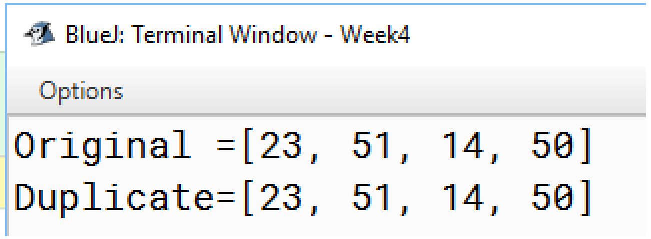


```
Original =[23, 51, 14, 50]
Duplicate=[23, 51, 14, 50]
```

ArrayList copy (for-each loop)



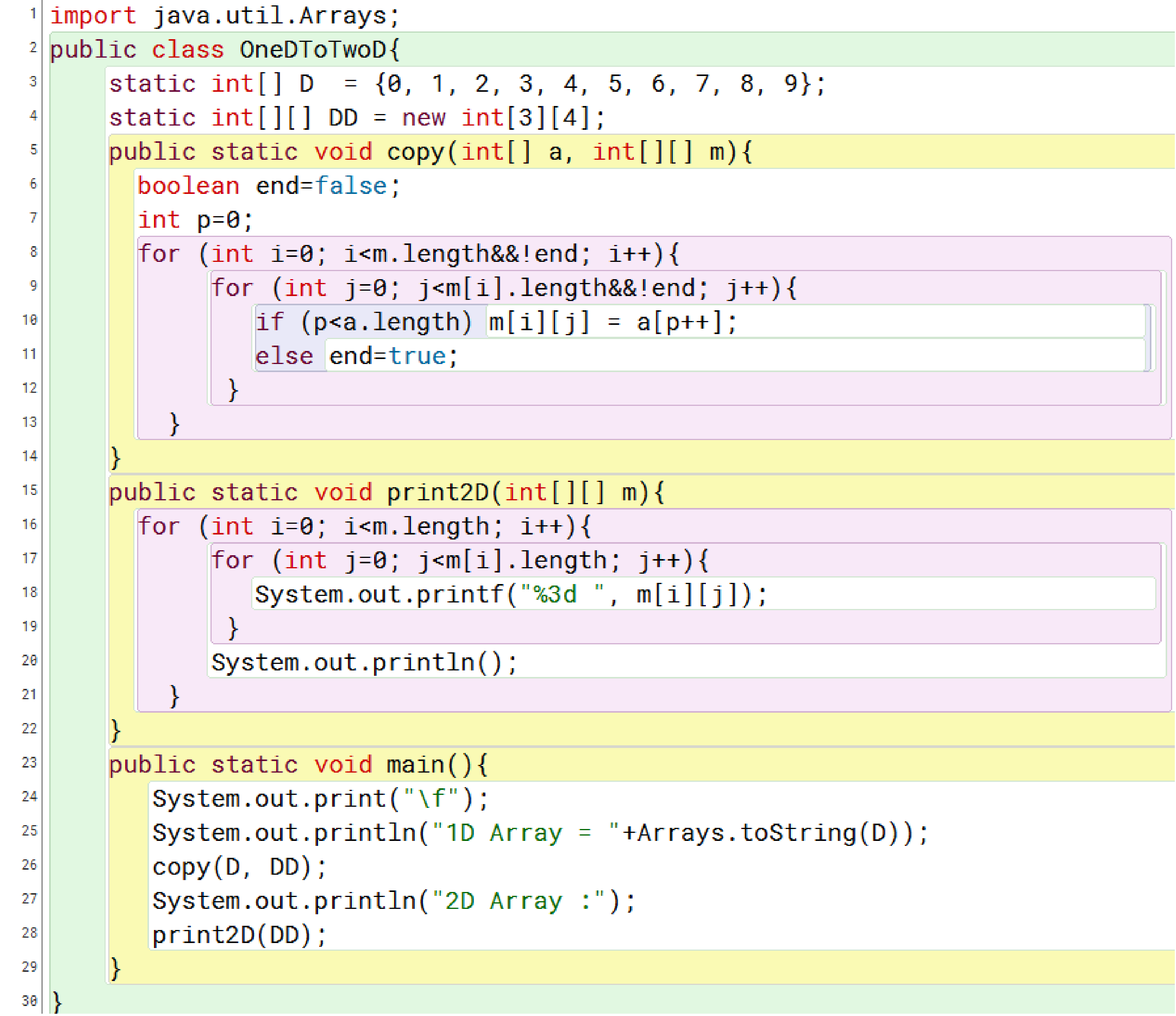
```
import java.util.ArrayList;
public class ArrayListForEachCopy
{
   public static void main(String[] args){
          ArrayList<Integer> original = new ArrayList<Integer>();
          original.add(23);
          original.add(51);
          original.add(14);
          original.add(50);
          ArrayList<Integer> duplicate = new ArrayList<Integer>();
          for (Integer i: original){
              duplicate.add(i);
           }
          System.out.print("\f");
          System.out.println("Original ="+original);
          System.out.println("Duplicate="+duplicate);
      }
}
```



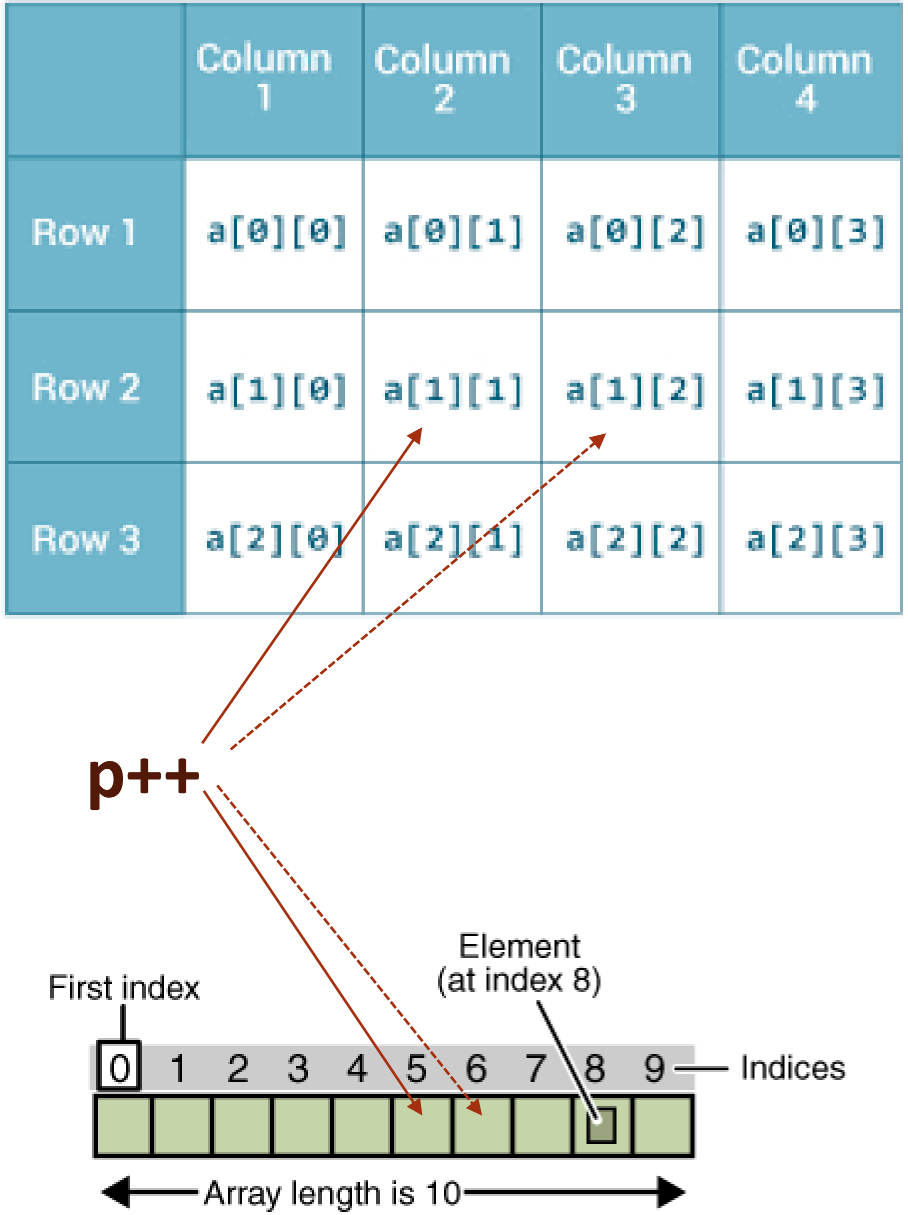
```
Original =[23, 51, 14, 50]
Duplicate=[23, 51, 14, 50]
```

Array copy from 1D to 2D

- The 2D use normal traversal.
- The 1D use a index pointer to traverse
  - If the 2D array has more elements, then ends the traversal when the 1D array is all copied.
  - If the 1D has more elements, ends the traversal when the 2D traversal is done.

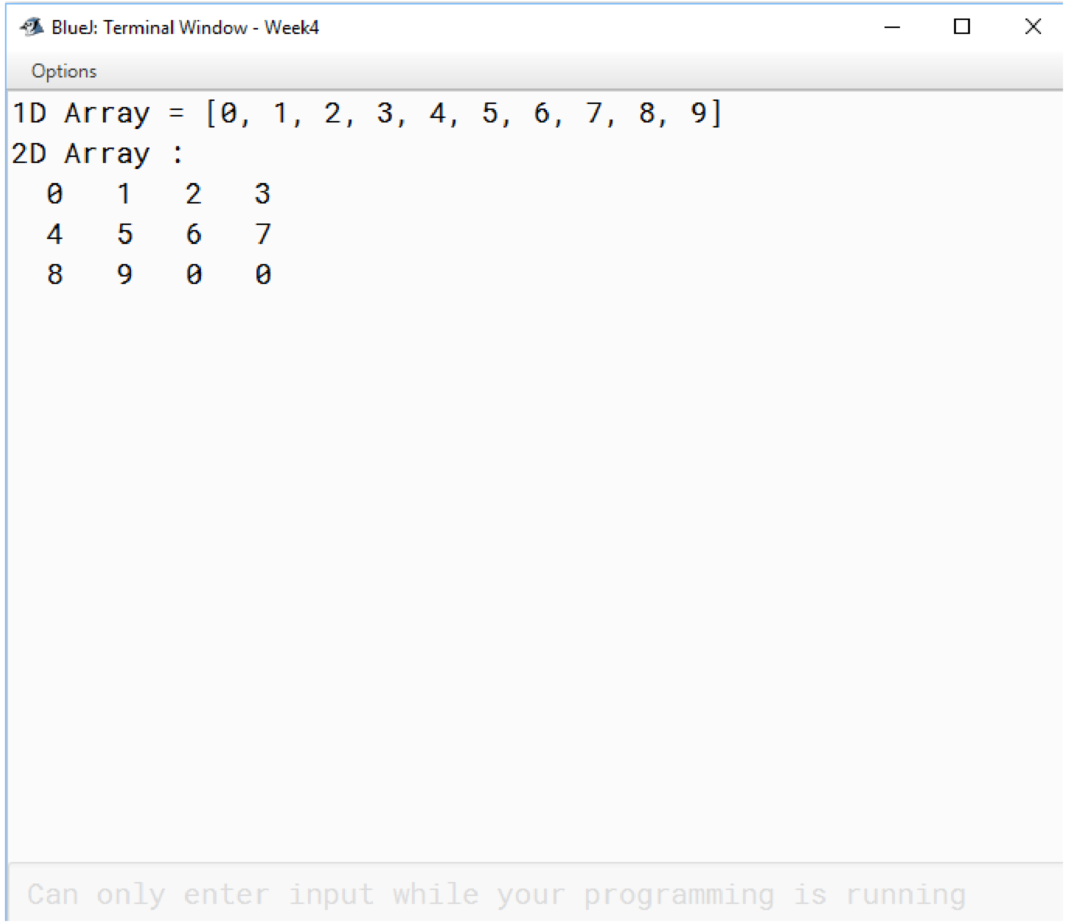


```
import java.util.Arrays;
public class OneDToTwoD{
    static int[] D  = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9};
    static int[][] DD = new int[3][4];
    public static void copy(int[] a, int[][] m){
      boolean end=false;
      int p=0;
      for (int i=0; i<m.length&&!end; i++){
            for (int j=0; j<m[i].length&&!end; j++){
               if (p<a.length) m[i][j] = a[p++];
               else end=true;
            }
        }
    }
    public static void print2D(int[][] m){
      for (int i=0; i<m.length; i++){
            for (int j=0; j<m[i].length; j++){
               System.out.printf("%3d ", m[i][j]);
            }
            System.out.println();
        }
    }
    public static void main(){
        System.out.print("\f");
        System.out.println("1D Array = "+Arrays.toString(D));
        copy(D, DD);
        System.out.println("2D Array :");
        print2D(DD);
    }
}
```



	Column 1	Column 2	Column 3	Column 4
Row 1	a[0][0]	a[0][1]	a[0][2]	a[0][3]
Row 2	a[1][0]	a[1][1]	a[1][2]	a[1][3]
Row 3	a[2][0]	a[2][1]	a[2][2]	a[2][3]

Result

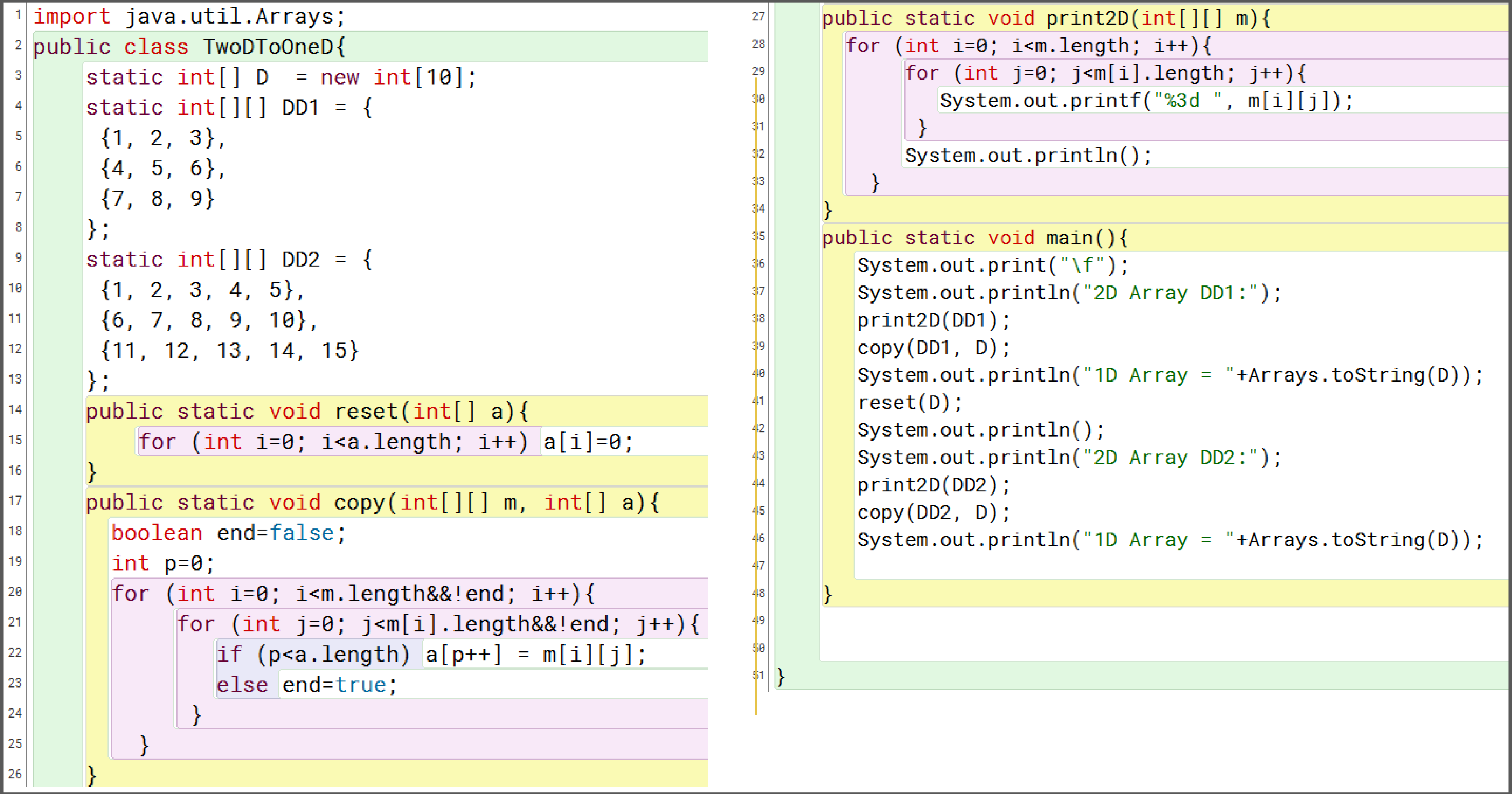

BlueJ: Terminal Window - Week4
Options

```
1D Array = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
2D Array :
  0   1   2   3
  4   5   6   7
  8   9   0   0
```

Can only enter input while your programming is running

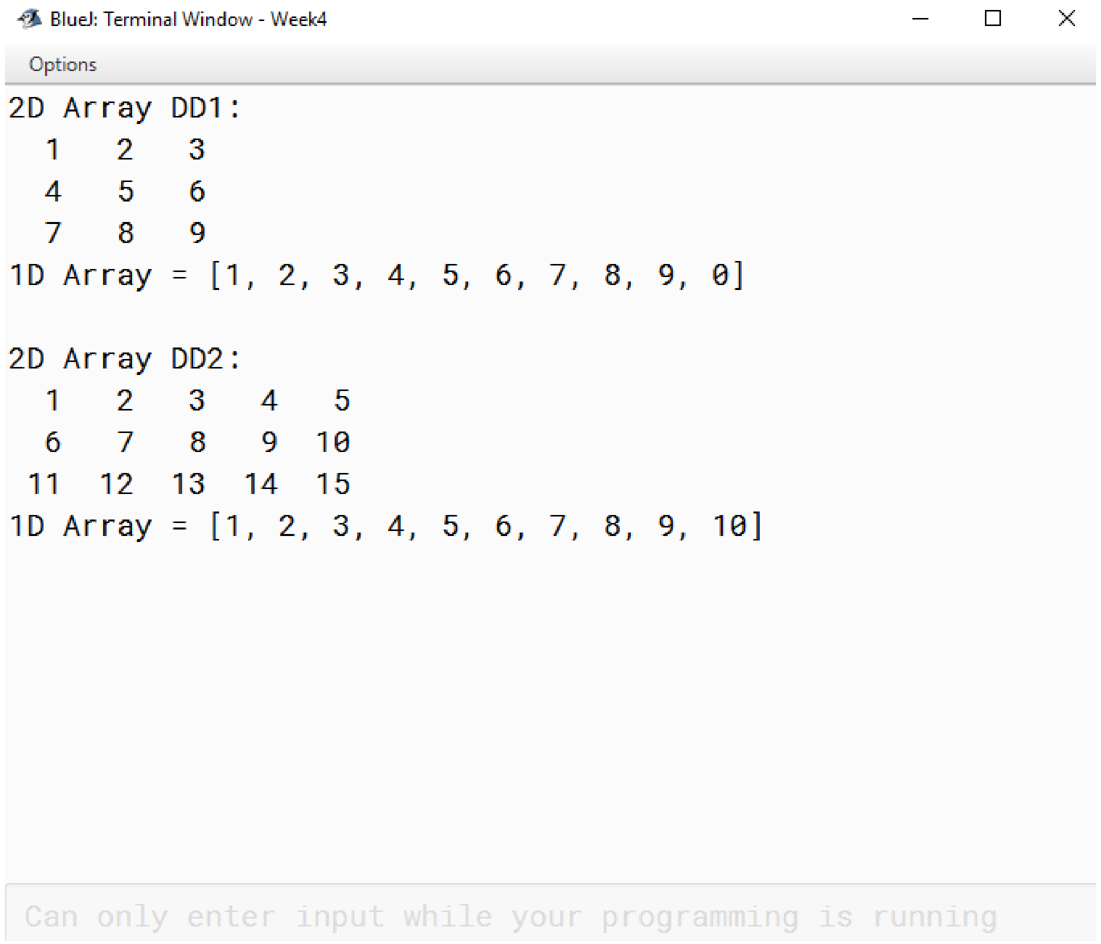
Array copy from 2D to 1D

- The 2D use normal traversal.
- The 1D use a index pointer to traverse
  - Assign value to 1D array only when the array is not all traversed through.



```java
import java.util.Arrays;
public class TwoDToOneD{
    static int[] D  = new int[10];
    static int[][] DD1 = {
     {1, 2, 3},
     {4, 5, 6},
     {7, 8, 9}
    };
    static int[][] DD2 = {
     {1, 2, 3, 4, 5},
     {6, 7, 8, 9, 10},
     {11, 12, 13, 14, 15}
    };
    public static void reset(int[] a){
        for (int i=0; i<a.length; i++) a[i]=0;
    }
    public static void copy(int[][] m, int[] a){
      boolean end=false;
      int p=0;
      for (int i=0; i<m.length&&!end; i++){
           for (int j=0; j<m[i].length&&!end; j++){
              if (p<a.length) a[p++] = m[i][j];
              else end=true;
            }
        }
    }
    public static void print2D(int[][] m){
      for (int i=0; i<m.length; i++){
          for (int j=0; j<m[i].length; j++){
             System.out.printf("%3d ", m[i][j]);
           }
          System.out.println();
       }
    }
    public static void main(){
       System.out.print("\f");
       System.out.println("2D Array DD1:");
       print2D(DD1);
       copy(DD1, D);
       System.out.println("1D Array = "+Arrays.toString(D));
       reset(D);
       System.out.println();
       System.out.println("2D Array DD2:");
       print2D(DD2);
       copy(DD2, D);
       System.out.println("1D Array = "+Arrays.toString(D));

    }

}
```

Result



BlueJ: Terminal Window - Week4
Options

```
2D Array DD1:
  1   2   3
  4   5   6
  7   8   9
1D Array = [1, 2, 3, 4, 5, 6, 7, 8, 9, 0]

2D Array DD2:
  1   2   3   4   5
  6   7   8   9  10
 11  12  13  14  15
1D Array = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

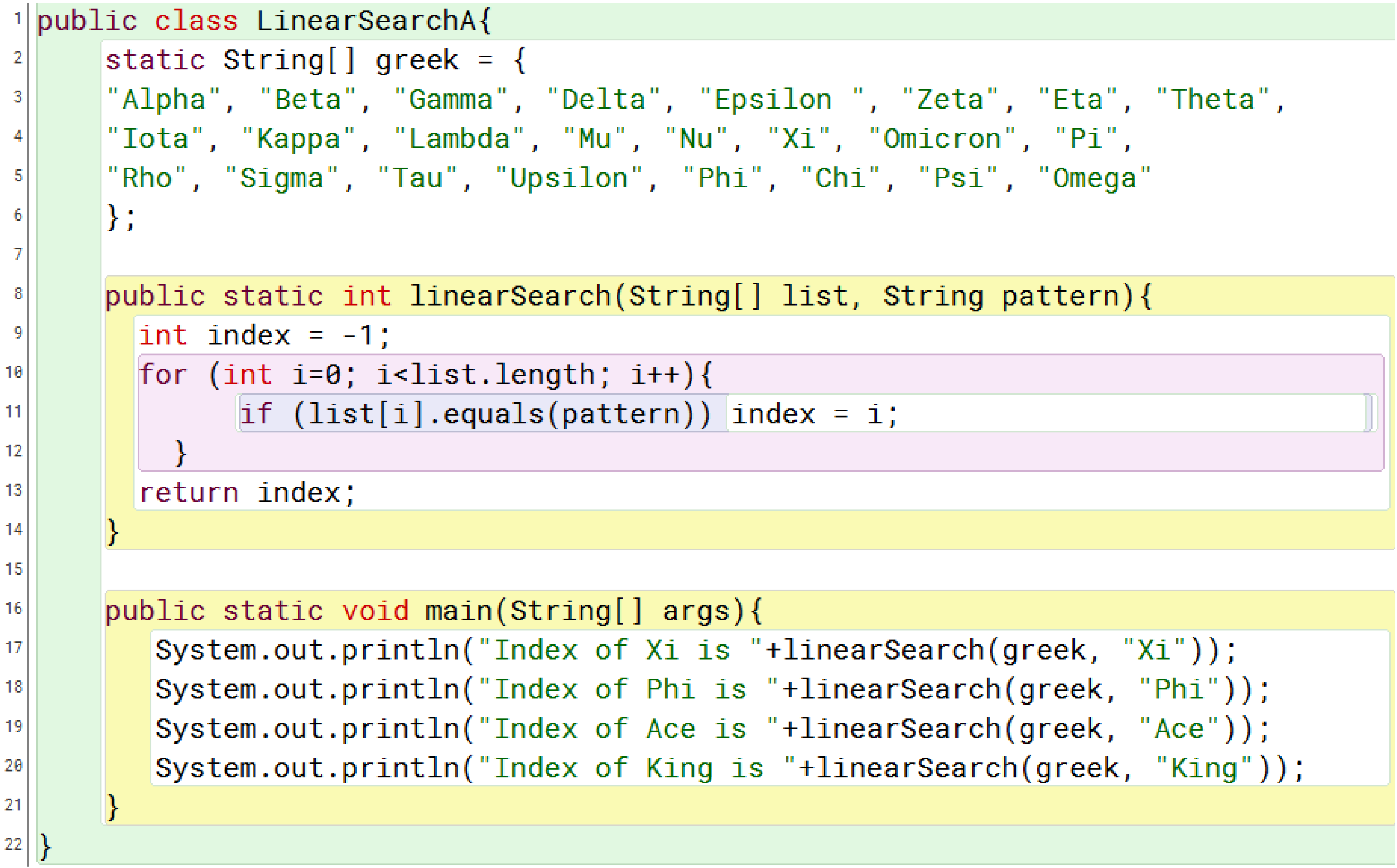
Can only enter input while your programming is running

SECTION 4

Sequential Algorithms

Look at every item in the list

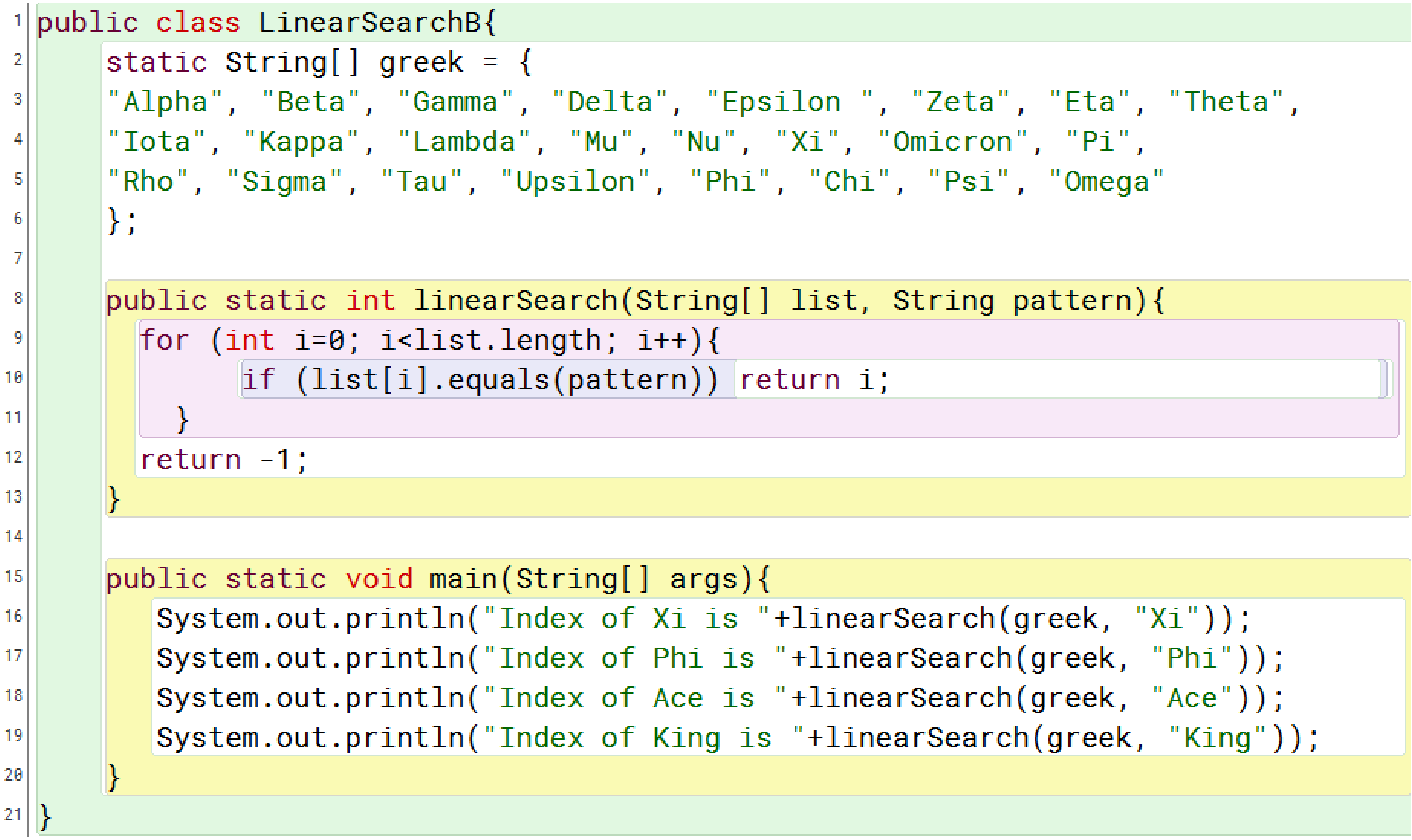
Demo Program: LinearSearchA.java



```java
public class LinearSearchA{
    static String[] greek = {
    "Alpha", "Beta", "Gamma", "Delta", "Epsilon ", "Zeta", "Eta", "Theta",
    "Iota", "Kappa", "Lambda", "Mu", "Nu", "Xi", "Omicron", "Pi",
    "Rho", "Sigma", "Tau", "Upsilon", "Phi", "Chi", "Psi", "Omega"
    };

    public static int linearSearch(String[] list, String pattern){
      int index = -1;
      for (int i=0; i<list.length; i++){
            if (list[i].equals(pattern)) index = i;
        }
      return index;
    }

    public static void main(String[] args){
       System.out.println("Index of Xi is "+linearSearch(greek, "Xi"));
       System.out.println("Index of Phi is "+linearSearch(greek, "Phi"));
       System.out.println("Index of Ace is "+linearSearch(greek, "Ace"));
       System.out.println("Index of King is "+linearSearch(greek, "King"));
    }
}
```

Stop looking if you find the search target

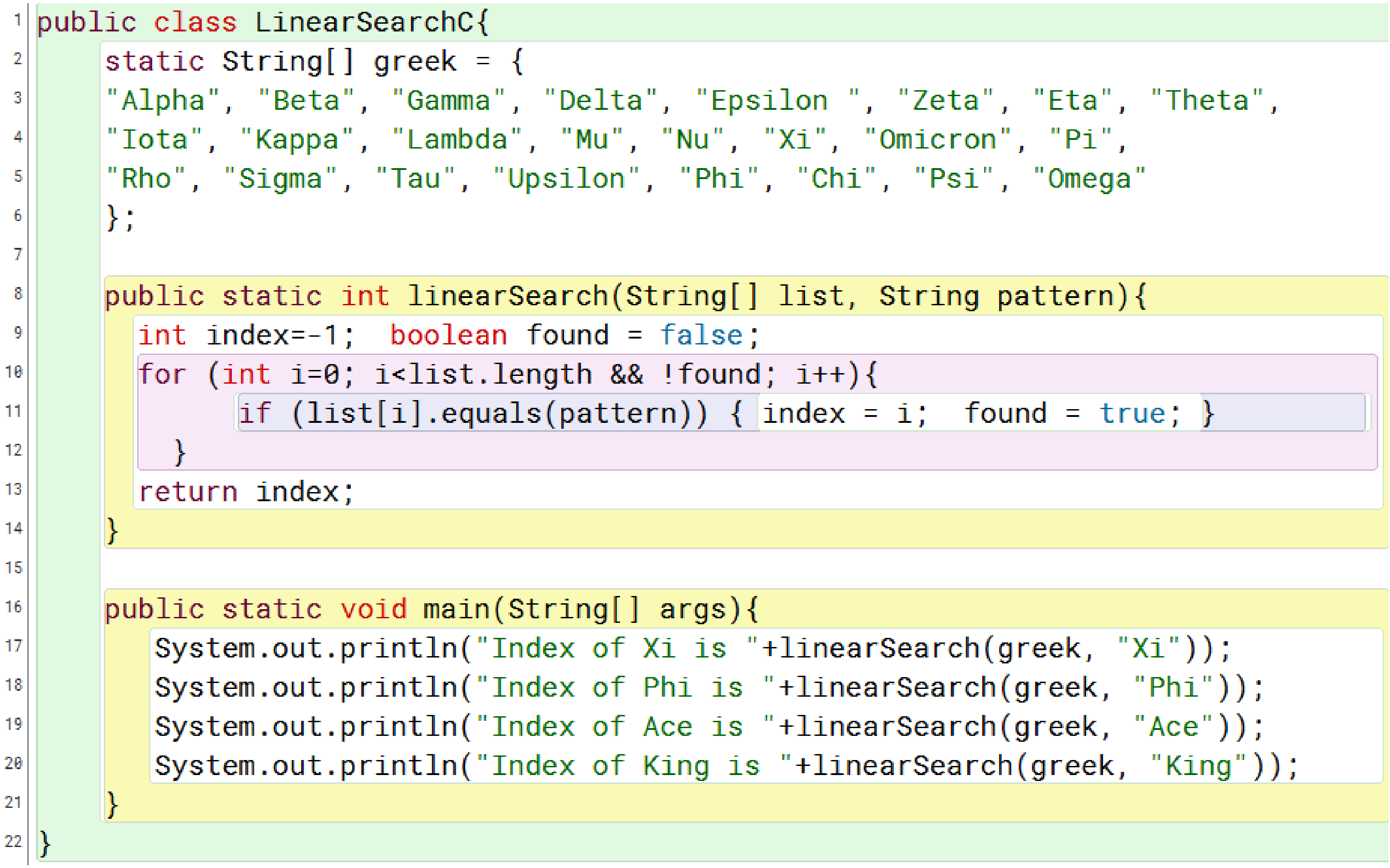
(Solution 1)



```
public class LinearSearchB{
    static String[] greek = {
    "Alpha", "Beta", "Gamma", "Delta", "Epsilon ", "Zeta", "Eta", "Theta",
    "Iota", "Kappa", "Lambda", "Mu", "Nu", "Xi", "Omicron", "Pi",
    "Rho", "Sigma", "Tau", "Upsilon", "Phi", "Chi", "Psi", "Omega"
    };

    public static int linearSearch(String[] list, String pattern){
      for (int i=0; i<list.length; i++){
            if (list[i].equals(pattern)) return i;
        }
      return -1;
    }

    public static void main(String[] args){
       System.out.println("Index of Xi is "+linearSearch(greek, "Xi"));
       System.out.println("Index of Phi is "+linearSearch(greek, "Phi"));
       System.out.println("Index of Ace is "+linearSearch(greek, "Ace"));
       System.out.println("Index of King is "+linearSearch(greek, "King"));
    }
}
```

Stop looking if you find the search target

(Solution 2)



```java
public class LinearSearchC{
    static String[] greek = {
    "Alpha", "Beta", "Gamma", "Delta", "Epsilon ", "Zeta", "Eta", "Theta",
    "Iota", "Kappa", "Lambda", "Mu", "Nu", "Xi", "Omicron", "Pi",
    "Rho", "Sigma", "Tau", "Upsilon", "Phi", "Chi", "Psi", "Omega"
    };

    public static int linearSearch(String[] list, String pattern){
      int index=-1;  boolean found = false;
      for (int i=0; i<list.length && !found; i++){
            if (list[i].equals(pattern)) { index = i;  found = true; }
        }
      return index;
    }

    public static void main(String[] args){
       System.out.println("Index of Xi is "+linearSearch(greek, "Xi"));
       System.out.println("Index of Phi is "+linearSearch(greek, "Phi"));
       System.out.println("Index of Ace is "+linearSearch(greek, "Ace"));
       System.out.println("Index of King is "+linearSearch(greek, "King"));
    }
}
```

SECTION 5

Accumulate Algorithms

Accumulator

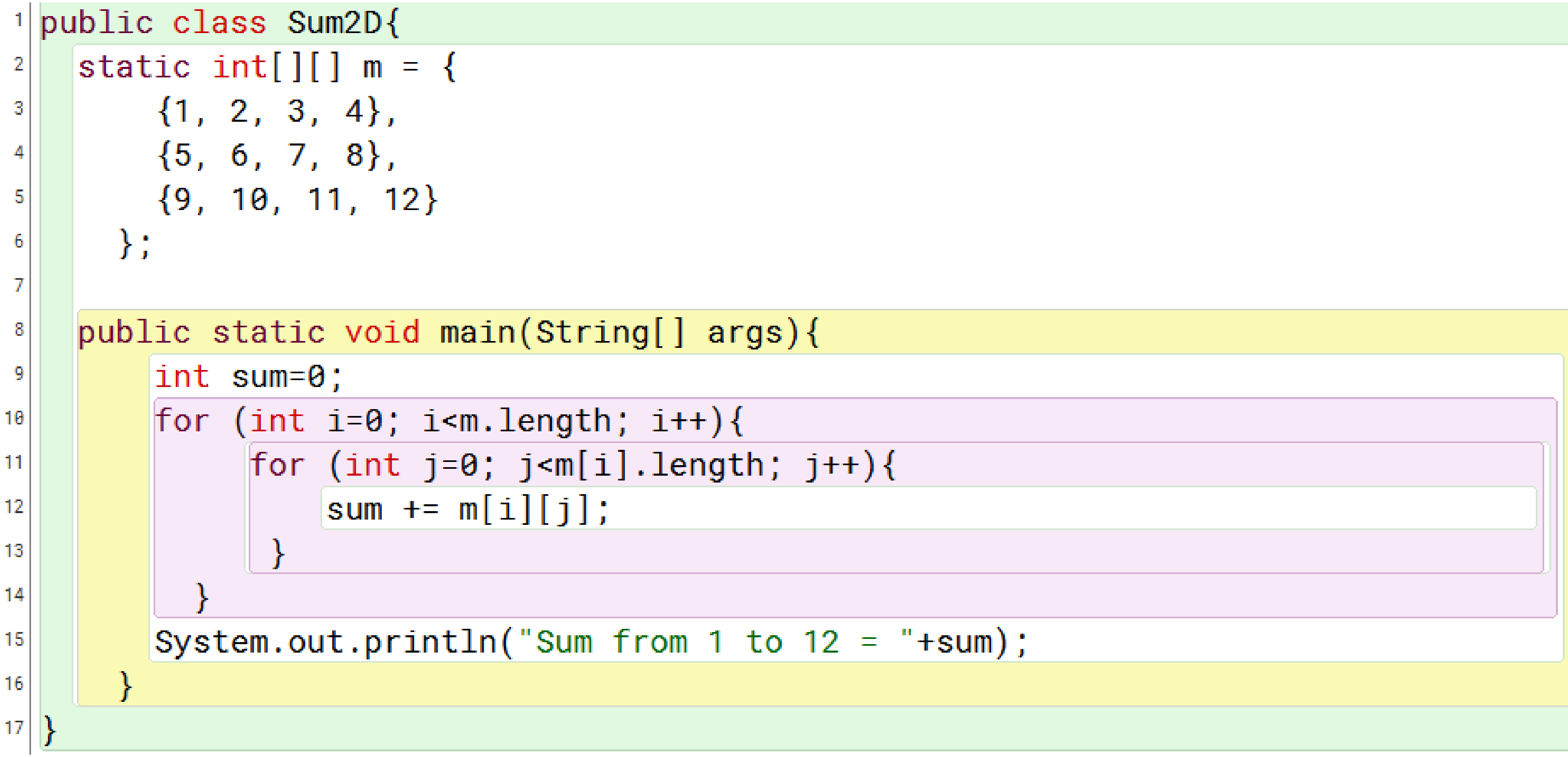
1. Traverse through an array and add(multiply) all elements of a list (array or arraylist) to a sum value (accumulator)

Application:

1. Sum or average value of a list.

2. Product of a list (n!, C(m, n))

Sum of 2D Array



```
public class Sum2D{
 static int[][] m = {
    {1, 2, 3, 4},
    {5, 6, 7, 8},
    {9, 10, 11, 12}
  };

 public static void main(String[] args){
    int sum=0;
    for (int i=0; i<m.length; i++){
         for (int j=0; j<m[i].length; j++){
             sum += m[i][j];
          }
      }
    System.out.println("Sum from 1 to 12 = "+sum);
  }
}
```

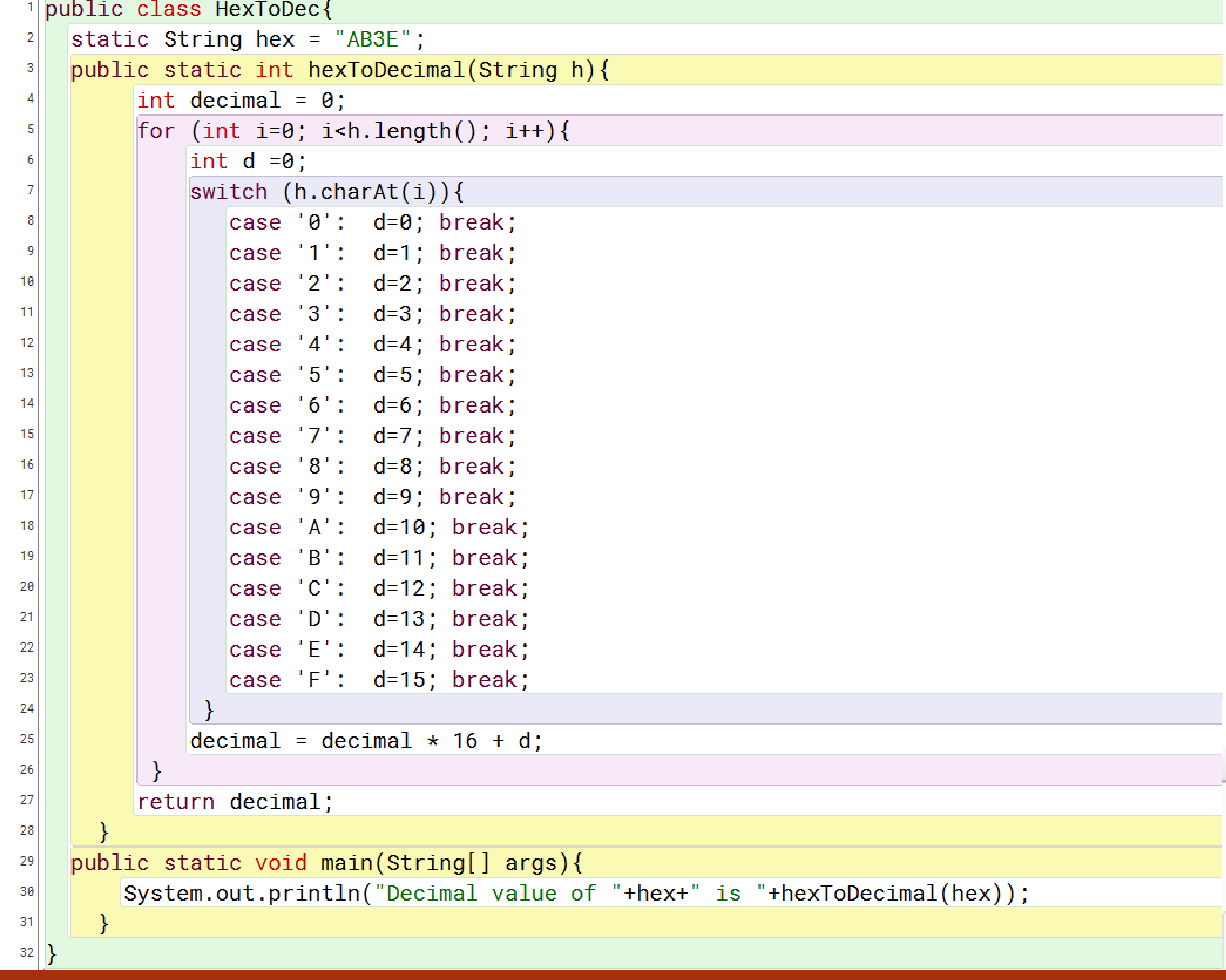
Accumulator with Shift and Add

Multiply and Add

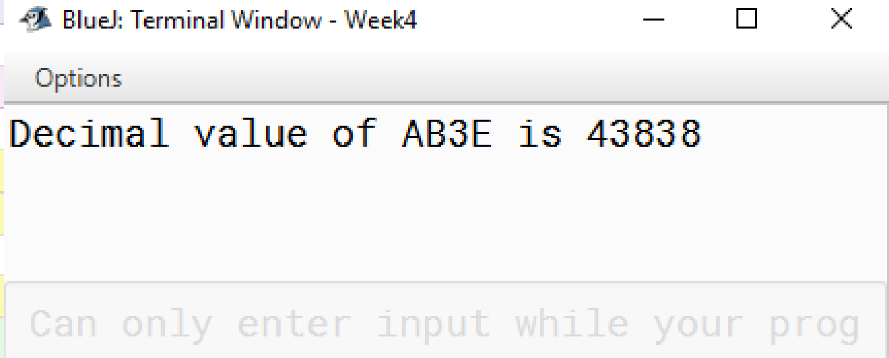
Shift a value to the left(or right) and then add an new element to the right (or left)

Application:

1. Encoder
2. Hexadecimal to decimal
3. Reverse of decimal value



```
public class HexToDec{
 static String hex = "AB3E";
 public static int hexToDecimal(String h){
     int decimal = 0;
     for (int i=0; i<h.length(); i++){
         int d =0;
         switch (h.charAt(i)){
             case '0':  d=0; break;
             case '1':  d=1; break;
             case '2':  d=2; break;
             case '3':  d=3; break;
             case '4':  d=4; break;
             case '5':  d=5; break;
             case '6':  d=6; break;
             case '7':  d=7; break;
             case '8':  d=8; break;
             case '9':  d=9; break;
             case 'A':  d=10; break;
             case 'B':  d=11; break;
             case 'C':  d=12; break;
             case 'D':  d=13; break;
             case 'E':  d=14; break;
             case 'F':  d=15; break;
          }
         decimal = decimal * 16 + d;
      }
     return decimal;
  }
 public static void main(String[] args){
    System.out.println("Decimal value of "+hex+" is "+hexToDecimal(hex));
  }
}
```



BlueJ: Terminal Window - Week4
Options
Can only enter input while your prog

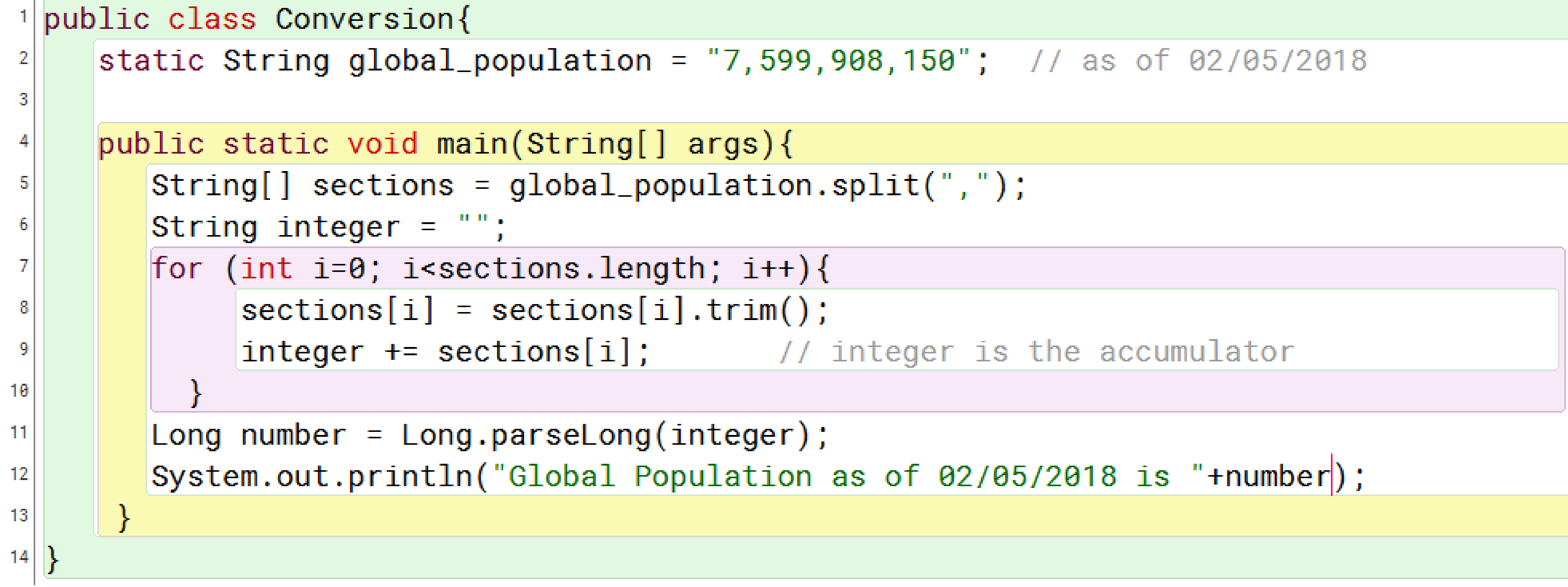
```
Decimal value of AB3E is 43838
```

Accumulator by Appending

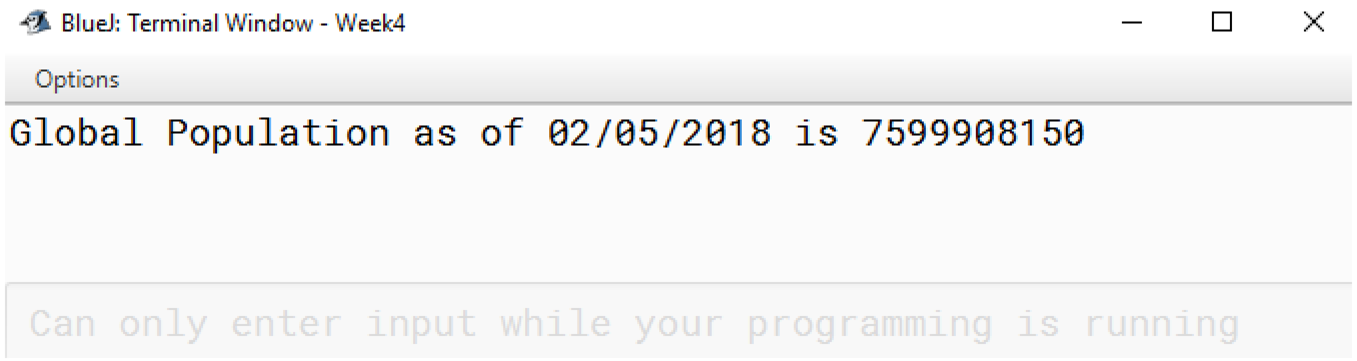
Accumulator using string

Application:

1. Reverse of String
2. Conversion of a number with "," to integer



```java
public class Conversion{
    static String global_population = "7,599,908,150";  // as of 02/05/2018

    public static void main(String[] args){
        String[] sections = global_population.split(",");
        String integer = "";
        for (int i=0; i<sections.length; i++){
            sections[i] = sections[i].trim();
            integer += sections[i];        // integer is the accumulator
        }
        Long number = Long.parseLong(integer);
        System.out.println("Global Population as of 02/05/2018 is "+number);
    }
}
```



```
Global Population as of 02/05/2018 is 7599908150
```

```
Can only enter input while your programming is running
```

SECTION 6

Min/Max

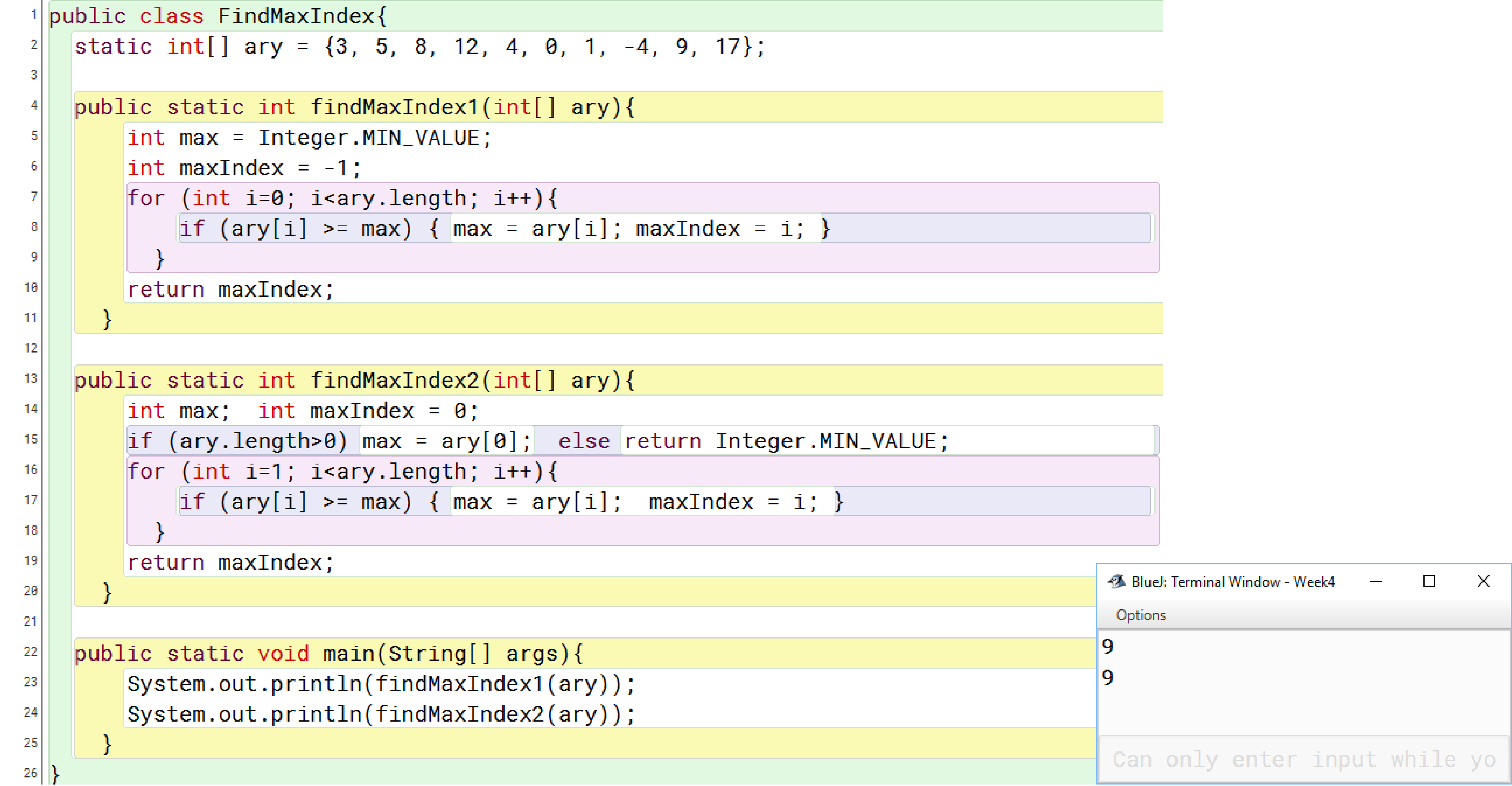
Two ways of Finding Maximum

- Using the low value (Integer.MIN_VALUE, Integer.MAX_VALUE)
- Using the first element of the list.

See Week 2 Program FindMax.java

Finding the MaxIndex

- Just keep track of another integer for the index of the maximum value.



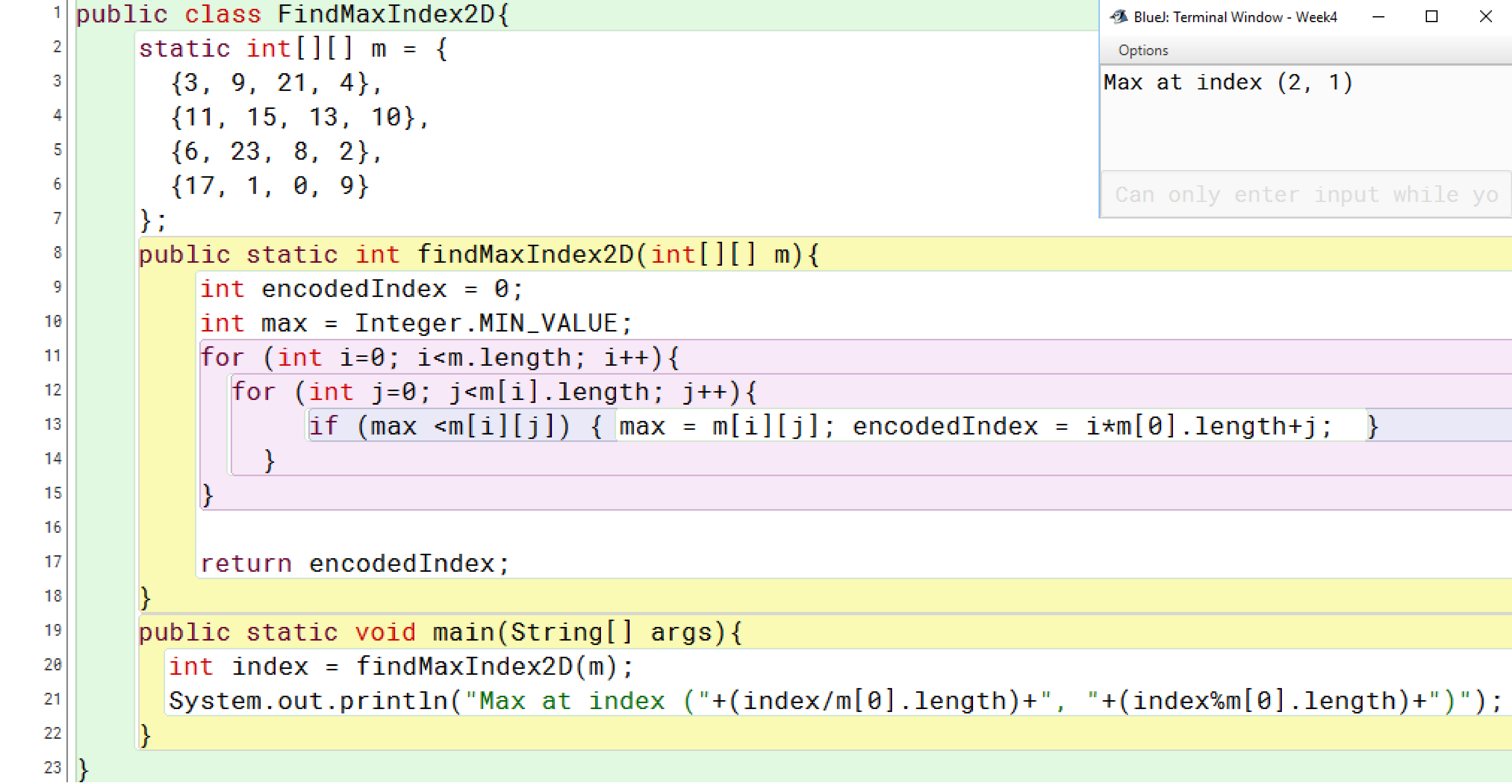
```java
public class FindMaxIndex{
   static int[] ary = {3, 5, 8, 12, 4, 0, 1, -4, 9, 17};

   public static int findMaxIndex1(int[] ary){
       int max = Integer.MIN_VALUE;
       int maxIndex = -1;
       for (int i=0; i<ary.length; i++){
           if (ary[i] >= max) { max = ary[i]; maxIndex = i; }
         }
       return maxIndex;
    }

   public static int findMaxIndex2(int[] ary){
       int max;  int maxIndex = 0;
       if (ary.length>0) max = ary[0];  else return Integer.MIN_VALUE;
       for (int i=1; i<ary.length; i++){
           if (ary[i] >= max) { max = ary[i];  maxIndex = i; }
         }
       return maxIndex;
    }

   public static void main(String[] args){
       System.out.println(findMaxIndex1(ary));
       System.out.println(findMaxIndex2(ary));
    }
}
```

```
9
9
```

Finding the Encoded 2D Index for the Maximum Value

- The encoded 2D index

```
encodedIndex = i * number_of_cols + j;
```

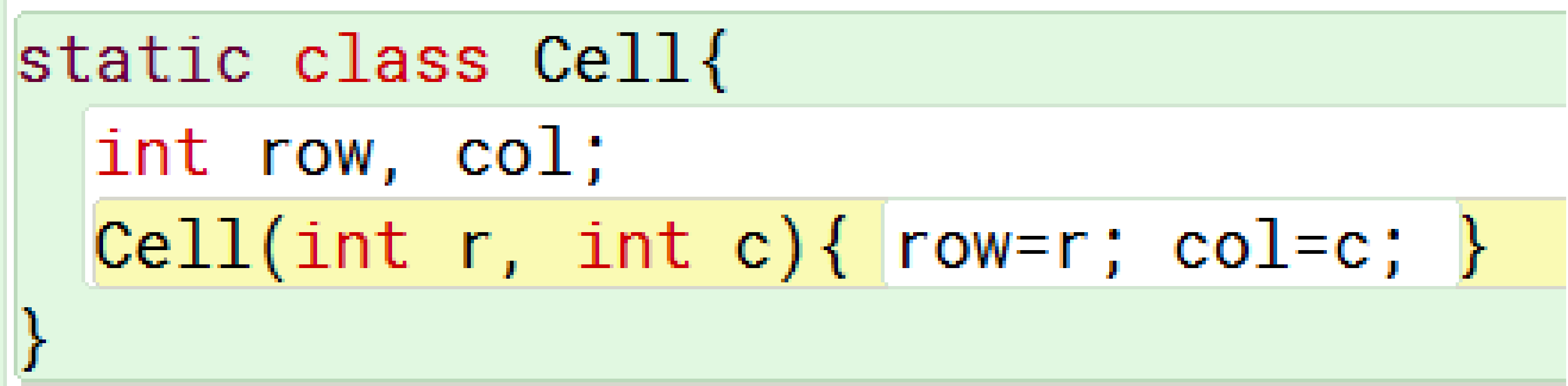


```java
public class FindMaxIndex2D{
    static int[][] m = {
      {3, 9, 21, 4},
      {11, 15, 13, 10},
      {6, 23, 8, 2},
      {17, 1, 0, 9}
    };
    public static int findMaxIndex2D(int[][] m){
        int encodedIndex = 0;
        int max = Integer.MIN_VALUE;
        for (int i=0; i<m.length; i++){
          for (int j=0; j<m[i].length; j++){
               if (max <m[i][j]) { max = m[i][j]; encodedIndex = i*m[0].length+j;  }
            }
        }

        return encodedIndex;
    }
    public static void main(String[] args){
      int index = findMaxIndex2D(m);
      System.out.println("Max at index ("+(index/m[0].length)+", "+(index%m[0].length)+")");
    }
}
```

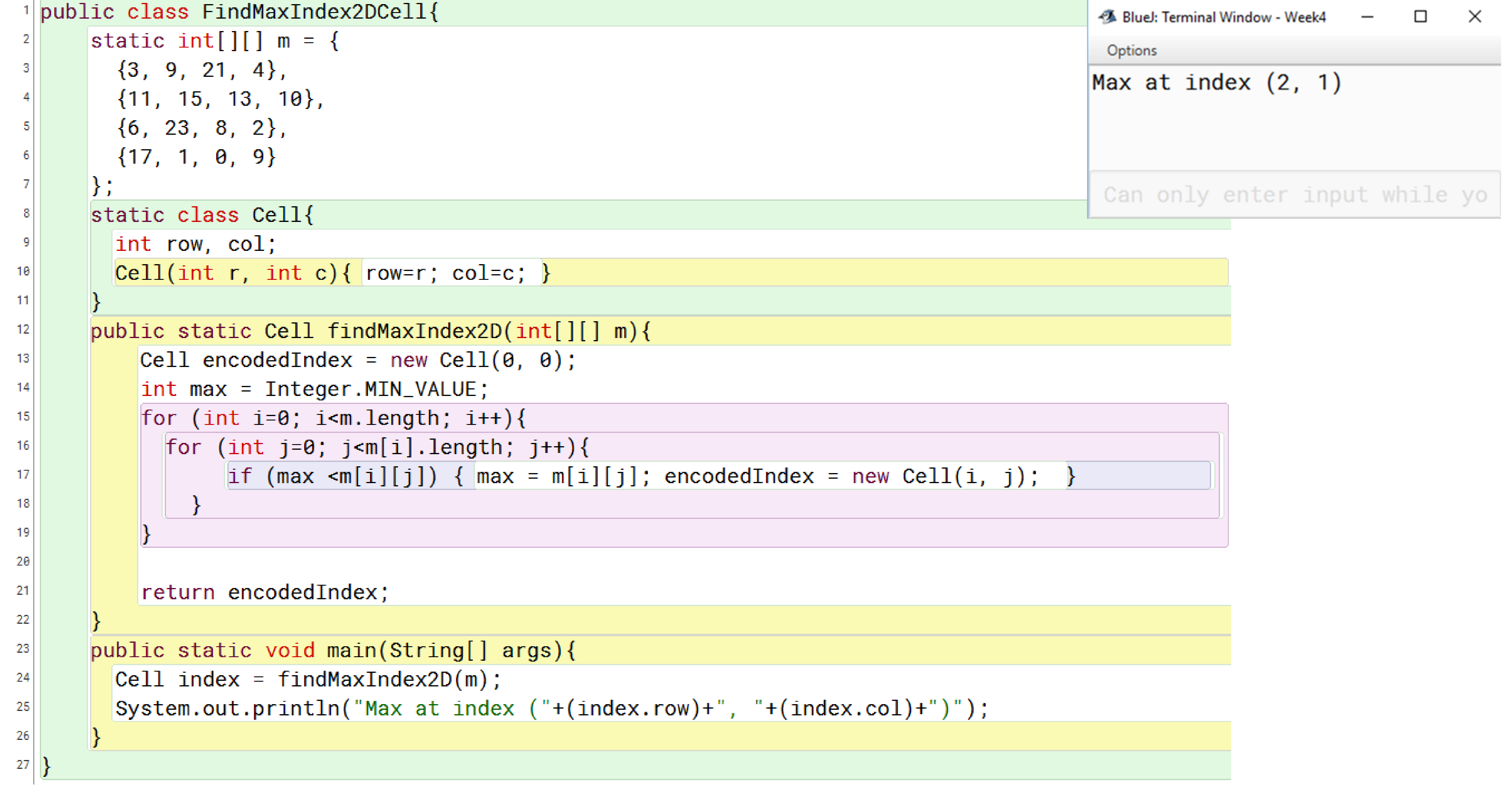
```
Max at index (2, 1)
```

Finding the 2D Cell Object with Maximum Value

- Create an easy 2D (row, col) object as a structure (record) as return data type.



```
static class Cell{
   int row, col;
   Cell(int r, int c){ row=r; col=c; }
}
```



```java
public class FindMaxIndex2DCell{
    static int[][] m = {
      {3, 9, 21, 4},
      {11, 15, 13, 10},
      {6, 23, 8, 2},
      {17, 1, 0, 9}
    };
    static class Cell{
      int row, col;
      Cell(int r, int c){ row=r; col=c; }
    }
    public static Cell findMaxIndex2D(int[][] m){
        Cell encodedIndex = new Cell(0, 0);
        int max = Integer.MIN_VALUE;
        for (int i=0; i<m.length; i++){
          for (int j=0; j<m[i].length; j++){
               if (max <m[i][j]) { max = m[i][j]; encodedIndex = new Cell(i, j);  }
            }
        }

        return encodedIndex;
    }
    public static void main(String[] args){
      Cell index = findMaxIndex2D(m);
      System.out.println("Max at index ("+(index.row)+", "+(index.col)+")");
    }
}
```

```
Max at index (2, 1)
```