IT-314
Software Engineering

LAB-7

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Q1: Program Inspection

Category A: Data Reference Errors

1. **Does a referenced variable have a value that is unset or uninitialized? This probably is the most frequent programming error; it occurs in a wide variety of circumstances. For each reference to a data item (variable, array element, field in a structure), attempt to "prove" informally that the item has a value at that point.**

Ans. No

2. **For all array references, is each subscript value within the defined bounds of the corresponding dimension?**

Ans. Yes

3. **For all array references, does each subscript have an integer value? This is not necessarily an error in all languages, but it is a dangerous practice.**

Ans. No

4. **For all references through pointer or reference variables, is the referenced memory currently allocated? This is known as the "dangling reference" problem. It occurs in situations where the lifetime of a pointer is greater than the lifetime of the referenced memory. One situation occurs where a pointer references a local variable within a procedure, the pointer value is assigned to an output parameter or a global variable, the procedure returns (freeing the referenced location), and later the program attempts to use the pointer value. In a manner similar to checking for the prior errors, try to prove informally that, in each reference using a pointer variable, the reference memory exists.**

Ans. Yes

5. When a memory area has alias names with differing attributes, does the data value in this area have the correct attributes when referenced via one of these names? Situations to look for are the use of the EQUIVALENCE statement in FORTRAN, and the REDEFINES clause in COBOL. As an example, a FORTRAN program contains a real variable A and an integer variable B; both are made aliases for the same memory area by using an EQUIVALENCE statement. If the program stores a value into A and then references variable B, an error is likely present since the machine would use the floating-point bit representation in the memory area as an integer.

Ans. No

6. Does a variable's value have a type or attribute other than what the compiler expects? This situation might occur where a C, C++, or COBOL program reads a record into memory and references it by using a structure, but the physical representation of the record differs from the structure definition.

Ans. Yes

7. Are there any explicit or implicit addressing problems if, on the machine being used, the units of memory allocation are smaller than the units of memory addressability? For instance, in some environments, fixed-length bit strings do not necessarily begin on byte boundaries, but addresses only point to byte boundaries. If a program computes the address of a bit string and later refers to the string through this address, the wrong memory location may be referenced. This situation also could occur when passing bit-string argument to a subroutine.

Ans. No

8. If pointer or reference variables are used, does the referenced memory location have the attributes the compiler expects? An example of such an error is where a C++pointer upon which a data structure is based is assigned the address of a different data structure.

Ans. No

9. If a data structure is referenced in multiple procedures or subroutines, is the structure defined identically in each procedure?

Ans. Yes

10. When indexing into a string, are the limits of the string off by-one errors in indexing operations or in subscript references to arrays?

Ans. No

11. For object-oriented languages, are all inheritance requirements met in the implementing Class?

Ans. Yes

Category B: Data-Declaration Errors

1. Have all variables been explicitly declared? A failure to do so is not necessarily an error, but it is a common source of trouble. For instance, if a program subroutine receives an array parameter, and fails to define the parameter as an array (as in a DIMENSION statement, for example), a reference to the array (such as C=A (I)) is interpreted as a function call, leading to the machine's attempting to execute the array as a program. Also, if a variable is not explicitly declared in an inner procedure or block, is it understood that the variable is shared with the enclosing block?

Ans. Yes

2. If all attributes of a variable are not explicitly stated in the declaration, are the defaults well understood? For instance, the default attributes received in Java are often a source of surprise.

Ans. No

3. Where a variable is initialized in a declarative statement, is it properly initialized? In many languages, initialization of arrays and strings is somewhat complicated and, hence, error prone.

Ans. Yes

4. Is each variable assigned the correct length and data type?

Ans. Yes

5. Is the initialization of a variable consistent with its memory type?

Ans. Yes

6. Are there any variables with similar names (VOLT and VOLTS, for example)? This is not necessarily an error, but it should be seen as a warning that the names may have been confused somewhere within the program.

Ans. No

Category C: Computation Errors

1. Are there any computations using variables having inconsistent (such as non-arithmetic) data types?

Ans. Yes, there are some instances in your code where data types might lead to inconsistencies or potential issues during computation

2. Are there any mixed-mode computations?

Ans. In the current code, I didn't see any expressions where variables of different numeric types (such as int and float) are used together in calculations.

3. Are there any computations using variables having the same data type but different lengths?

Ans. No , there aren't any computations in the code where variables of the same data type but different lengths interact in a way that would cause issues.

4. Is the data type of the target variable of an assignment smaller than the data type or result of the right-hand expression?

Ans. No, the data types in code are consistent in size, and there are no cases where the target variable of an assignment is smaller than the data type or result of the right-hand expression

5. Is an overflow or underflow expression possible during the computation of an expression?

Ans. No ,there are no expressions in the code that involve computations where overflow or underflow is likely

6. Is it possible for the divisor in a division operation to be zero?

Ans. No

7. If the underlying machine represents variables in base-2 form, are there any sequences of the resulting inaccuracy?

Ans. Yes, there are potential sequences of resulting inaccuracies due to the representation of floating-point numbers in base-2 form.

8. Can the value of a variable go outside the meaningful range?

Ans. Yes, the value of a variable can go outside the meaningful range, especially in cases of overflow or underflow. When computations exceed the maximum or minimum representable values for a data type, the result may wrap around to an unintended value, leading to incorrect or meaningless outcomes.

9. For expressions containing more than one operator, are the assumptions about the order of evaluation and precedence of operators correct?

Ans. No

10. Are there any invalid uses of integer arithmetic, particularly divisions? For instance, if i is an integer variable, whether the expression 2*i/2 == i depends on whether i has an odd or an even value and whether the multiplication or division is performed first.

Ans. No

Category D: Comparison Errors

1. **Are there any comparisons between variables having different data types, such as comparing a character string to an address, date, or number?**

Ans. No.

2. **Are there any mixed-mode comparisons or comparisons between variables of different lengths? If so, ensure that the conversion rules are well understood.**

Ans. Yes. Mixed-mode comparisons may occur if variables of different lengths are involved, potentially leading to unexpected behavior or results.

3. **Are the comparison operators correct?**

Ans. Yes.

4. **Does each Boolean expression state what it is supposed to state?**

Ans. Yes.

5. **Are the operands of a Boolean operator Boolean?**

Ans. Yes.

6. **Are there any comparisons between fractional or floating- point numbers that are represented in base-2 by the underlying machine?**

Ans. Yes.

7. For expressions containing more than one Boolean operator, are the assumptions about the order of evaluation and the precedence of operators correct?

Ans. Yes.

8. Does the way in which the compiler evaluates Boolean expressions affect the program?

Ans. Yes.

Category E: Control-Flow Errors

1. If the program contains a multiway branch such as a computed GO TO, can the index variable ever exceed the number of branch possibilities?

Ans. No.

2. Will every loop eventually terminate? Devise an informal proof or argument showing that each loop will terminate.

Ans. Yes.

3. Will the program, module, or subroutine eventually terminate?

Ans. Yes.

4. Is it possible that, because of the conditions upon entry, a loop will never execute? If so, does this represent an over- sight?

Ans. Yes.

5. For a loop controlled by both iteration and a Boolean condition (a searching loop, for example) what are the consequences of loop fall-through?

Ans. If a loop falls through without the expected condition being met, it may lead to unintended behavior, such as executing code that should be skipped or failing to break out of the loop when needed.

6. Are there any off-by-one errors, such as one too many or too few iterations?

Ans. Yes.

7. If the language contains a concept of statement groups or code blocks (e.g., do-while or {...}), is there an explicit while for each group and do the do's correspond to their appropriate groups? Or is there a closing bracket for each open bracket? Most modern compilers will complain of such mismatches.

Ans. Yes.

8. Are there any non-exhaustive decisions?

Ans. Yes.

Category F: Interface Errors

1. Does the number of parameters received by this module equal the number of arguments sent by each of the calling modules? Also, is the order correct?

Ans. Yes.

2. Do the attributes (e.g., data type and size) of each parameter match the attributes of each corresponding argument?

Ans. Yes

3. Does the units system of each parameter match the units system of each corresponding argument? For example, is the parameter expressed in degrees but the argument expressed in radians?

Ans. Yes.

4. Does the number of arguments transmitted by this module to another module equal the number of parameters expected by that module?

Ans. Yes . The number of arguments transmitted by this module to another module should equal the number of parameters expected by that module for proper execution.

5. Do the attributes of each argument transmitted to another module match the attributes of the corresponding parameter in that module?

Ans. Yes.

6. Does the units system of each argument transmitted to another module match the units system of the corresponding parameter in that module?

Ans. Yes.

7. If built-in functions are invoked, are the number, attributes, and order of the arguments correct?

Ans. Yes.

8. Does a subroutine alter a parameter that is intended to be only an input value?

Ans. Yes.

9. If global variables are present, do they have the same definition and attributes in all modules that reference them?

Ans. Yes.

Category G: Input / Output Errors

1. If files are explicitly declared, are their attributes correct?

Ans. Yes.

2. Are the attributes on the file's OPEN statement correct?

Ans. Yes.

3. Is there sufficient memory available to hold the file your program will read?

Ans. Yes.

4. Have all files been opened before use?

Ans. Yes.

5. Have all files been closed after use?

Ans. Yes.

6. Are end-of-file conditions detected and handled correctly?

Ans. Yes.

7. Are I/O error conditions handled correctly?

Ans. Yes.

8. Are there spelling or grammatical errors in any text that is printed or displayed by the program?

Ans. Yes.

Category H: Other Checks

1. If the compiler produces a cross-reference listing of identifiers, examine it for variables that are never referenced or are referenced only once.

Ans. Yes

2. If the compiler produces an attribute listing, check the attributes of each variable to ensure that no unexpected default attributes have been assigned.

Ans. Yes

3. If the program compiled successfully, but the computer produced one or more "warning" or "informational" messages, check each one carefully. Warning messages are indications that the compiler suspects that you are doing something of questionable validity; all of these suspicions should be reviewed. Informational messages may list undeclared variables or language uses that impede code optimization.

Ans. Yes

4. Is the program or module sufficiently robust? That is, does it check its input for validity?

Ans. Yes

5. Is there a function missing from the program?

Ans. No

2. Which category of program inspection would you find more effective?

Category C: Computation Errors is often seen as the most effective for program inspection because:

1. Common Bugs: It targets frequent sources of errors that lead to incorrect results.

2. Complex Logic: It ensures that calculations and data manipulations are handled correctly.

3. Data Type Awareness: It encourages proper handling of data types and avoids mixed-mode operations.

4. Real-World Impact: It helps prevent errors that could have serious consequences, especially in critical applications.

Ultimately, the best category can depend on the project's specific needs.

3. Which type of error are you not able to identify using the program inspection?

- **Logical Errors: Program inspection techniques typically focus on syntactical and structural issues, but they may not effectively catch logical errors—those that occur when the program runs without crashing but produces incorrect results. For example, a program could have a perfectly valid syntax but still yield incorrect calculations due to flawed logic. Other types of errors that may be difficult to detect include:**
    - **Race conditions: In multi-threaded applications, timing issues can lead to unexpected behavior that may not be evident during inspection.**
    - **Heuristic errors: Errors in algorithms where the logic appears sound but does not account for all edge cases.**

- **Performance issues: Problems that arise from inefficient algorithms or data structures that might not manifest until under load or with large datasets.**

4. Is the program inspection technique worth applying?

- **Yes: Program inspection techniques are definitely worth applying as they provide several advantages:**
  - **Early Detection of Errors: Inspections can identify potential issues before the code is executed, leading to reduced debugging time.**
  - **Improved Code Quality: Regular inspections encourage better coding practices and promote adherence to standards, resulting in cleaner, more maintainable code.**
  - **Knowledge Sharing: Collaborative inspections foster knowledge transfer among team members, helping to spread understanding of the codebase and improve overall team skills.**
  - **Cost-Effectiveness: Catching errors early in the development process is generally much less costly than fixing them after deployment.**

Reference :

https://github.com/TusharKukra/LMS-Library-Management-System/blob/master/LMSCode.cpp

Que2: Debugging

Code 1: Armstrong Number

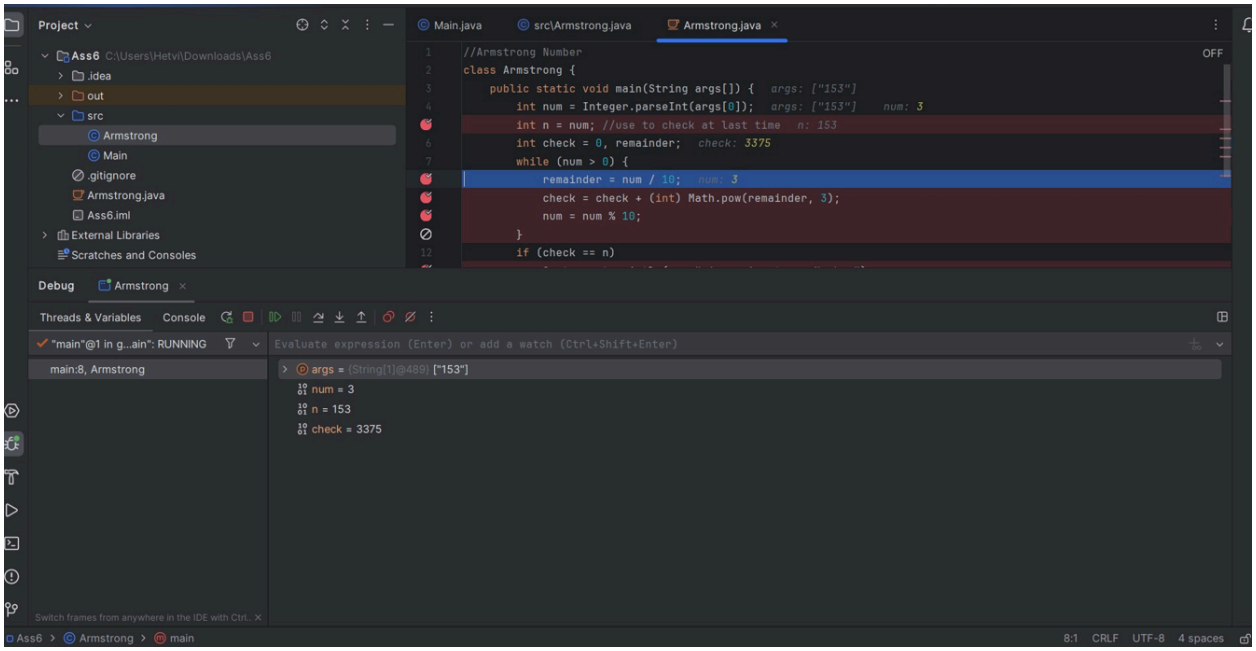
How many errors are there in the program? Mention the errors you have identified.

1. **Incorrect Calculation of Remainder and Quotient:**
    - **In the line remainder = num / 10;, the code is incorrectly dividing the number by 10 to get the last digit. This should be done using modulus (% 10) to get the last digit, while division (/ 10) should be used to remove the last digit.**
    - **Correction:**
        - **remainder = num % 10;**
        - **num = num / 10;**
2. **Logic for Summing the Cubes of the Digits:**
    - **The logic for summing cubes is incorrect because it's using remainder = num / 10;, which leads to incorrect digits being processed.**
3. **Typographical Error in Output Message:**
    - **The sentence should be grammatically correct. It says "a Armstrong Number", but it should be "an Armstrong Number".**

How many breakpoints do you need to fix those errors?

a. What are the steps you have taken to fix the error you identified in the code fragment?

1. **Breakpoint 1: Before the while loop to check the value of num and n.**
2. **Breakpoint 2: Inside the while loop to ensure the correct value of remainder is calculated.**
3. **Breakpoint 3: After the while loop, to check if check == n condition is functioning properly.**



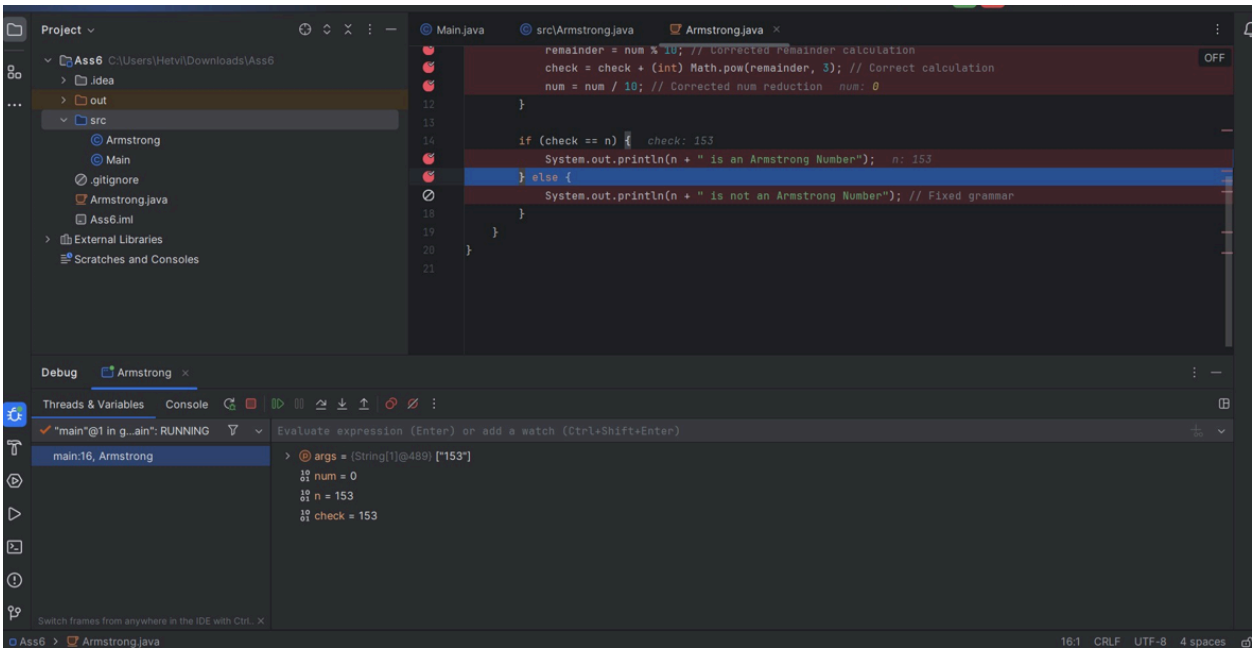
Steps to Fix the Errors:

1. **Fix the remainder calculation:**
    - **Change remainder = num / 10; to remainder = num % 10;.**
    - **Change num = num % 10; to num = num / 10; (so that it correctly reduces num by removing the last digit).**

```
// Armstrong Number class

class Armstrong {

    public static void main(String args[]) {

        int num = Integer.parseInt(args[0]);

        int n = num;

        int check = 0, remainder;



        while (num > 0) {

            remainder = num % 10;
```

```
            check = check + (int) Math.pow(remainder, 3);
            num = num / 10;
        }

        if (check == n) {
            System.out.println(n + " is an Armstrong Number");
        } else {
            System.out.println(n + " is not an Armstrong Number");
        }
    }
}
```

Debugging after corrected code:



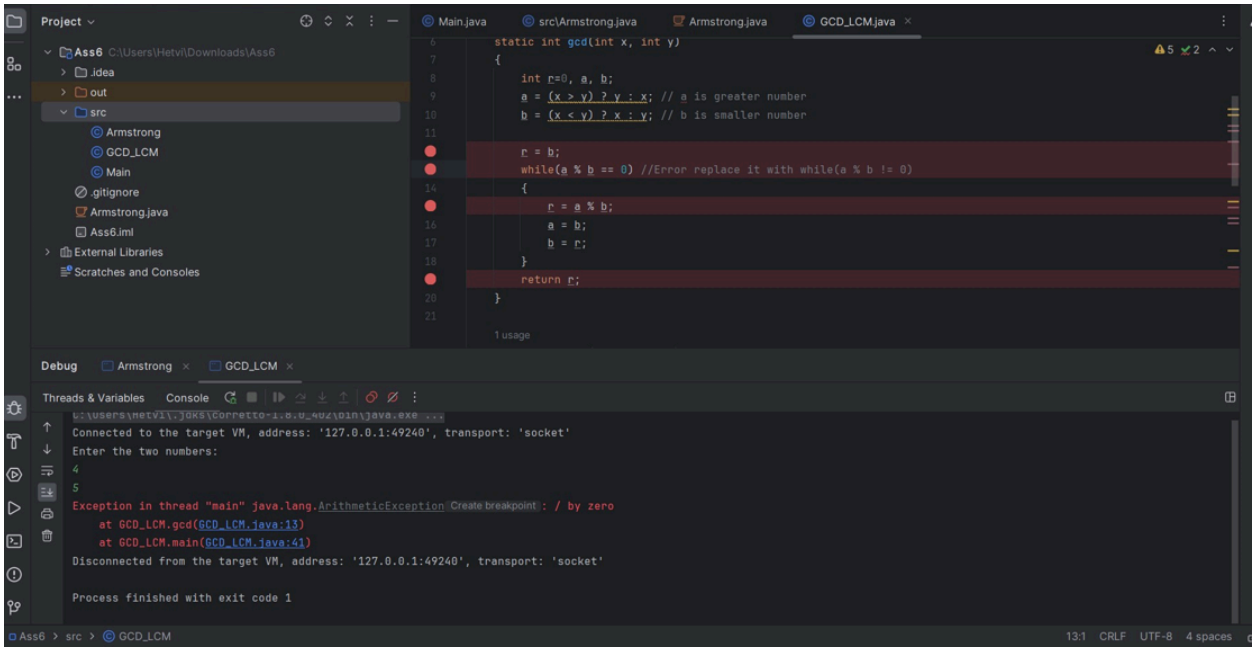
Code 2: GCD and LCM

How many errors are there in the program?
Mention the errors you have identified.

1. **Logic Error in GCD Calculation:**
   - **The condition in the while loop in the gcd function is incorrect. It should be while (a % b != 0) to continue the loop until the remainder is zero. The current logic leads to an infinite loop or incorrect results.**
     Correction: Change while(a % b == 0) to while(a % b != 0).
2. **Logic Error in LCM Calculation:**
   - **The lcm method has an incorrect condition. The current check if(a % x != 0 && a % y != 0) is wrong because it returns a when neither x nor y divides a. It should instead check if either x or y divides a.**
     Correction: Change the condition to if(a % x == 0 && a % y == 0).

How many breakpoints do you need to fix those errors?
a. What are the steps you have taken to fix the errors you identified in the code fragment?

1. **Breakpoint 1: Before the while loop in the gcd method to check the initial values of a and b.**
2. **Breakpoint 2: Inside the while loop in the gcd method to observe the changes to r, a, and b.**
3. **Breakpoint 3: Inside the lcm method, before the return a; to check if a meets the LCM condition.**



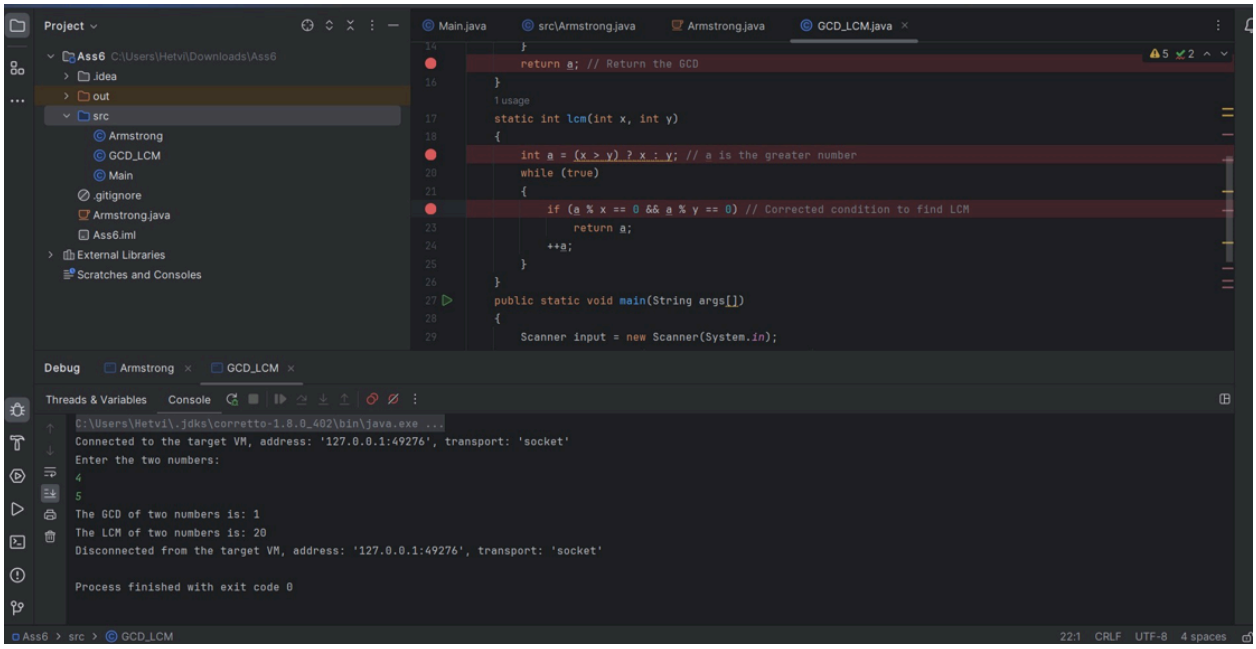
Here it gave an error since b became 0.

Steps to Fix the Errors:

1. **Fix the GCD Logic:**
    - **Update the condition in the while loop from while(a % b == 0) to while(a % b != 0) to ensure it runs until the remainder is zero.**
2. **Fix the LCM Logic:**
    - **Update the condition in the lcm method from if(a % x != 0 && a % y != 0) to if(a % x == 0 && a % y == 0) to correctly determine when a is a common multiple.**

```
import java.util.Scanner;


public class GCD_LCM {

   static int gcd(int x, int y) {

      int r = 0, a, b;

      a = (x > y) ? x : y; // a is the greater number

      b = (x < y) ? x : y; // b is the smaller number


      while (b != 0) { // Corrected condition to continue until b is 0

         r = a % b;

         a = b;

         b = r;

      }

      return a; // Return the GCD

   }
```

```
    static int lcm(int x, int y) {
        int a = (x > y) ? x : y; // a is the greater number
        while (true) {
            if (a % x == 0 && a % y == 0) { // Corrected condition to find LCM
                return a;
            }
            ++a;
        }
    }

    public static void main(String args[]) {
        Scanner input = new Scanner(System.in);
        System.out.println("Enter the two numbers: ");
        int x = input.nextInt();
        int y = input.nextInt();
        System.out.println("The GCD of two numbers is: " + gcd(x, y));
        System.out.println("The LCM of two numbers is: " + lcm(x, y));
        input.close();
    }
}
```



Now the code debugging was done correctly and gave correct results.

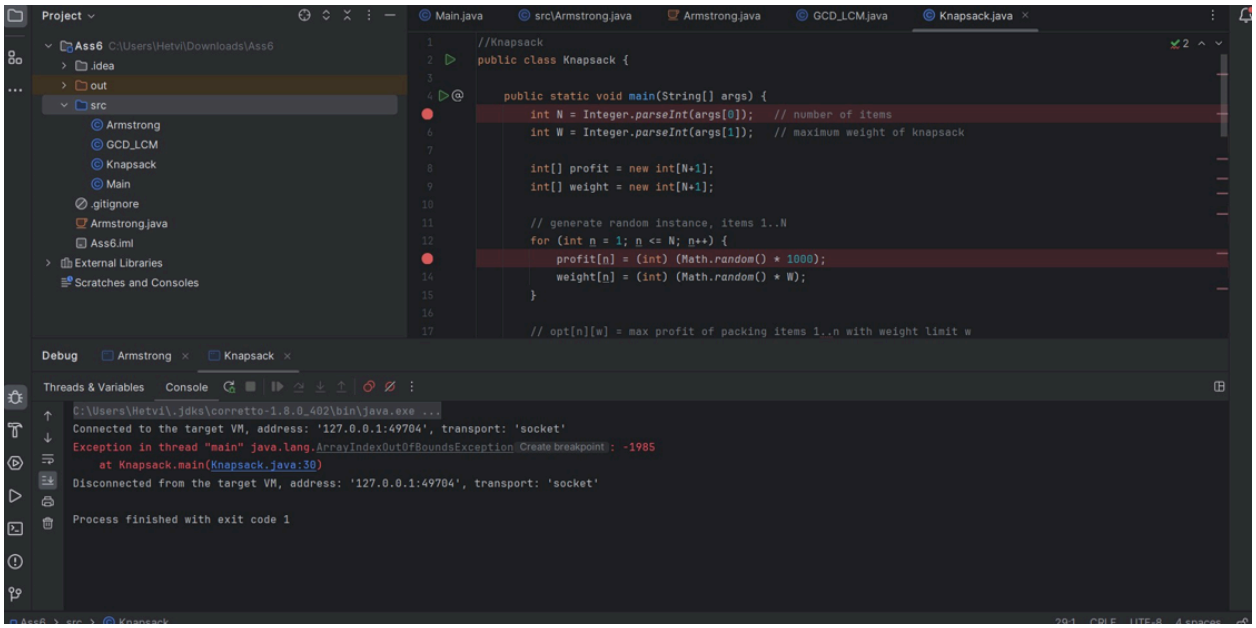
Code 3: Knapsack

How many errors are there in the program?
Mention the errors you have identified.

1. **Incrementing n in the Loop:**
   - **In the line int option1 = opt[n++][w];, using n++ modifies the value of n during the iteration, which can lead to an ArrayIndexOutOfBoundsException and incorrect calculations in the subsequent iterations. The value of n should remain constant for that loop iteration.**
     Correction: Use int option1 = opt[n][w]; without modifying n.
2. **Incorrect Indexing in option2 Calculation:**
   - **In the line if (weight[n] > w) option2 = profit[n-2] + opt[n-1][w-weight[n]];, the condition incorrectly checks if weight[n] exceeds w. If it does, it incorrectly attempts to include profit[n-2], which will lead to incorrect profit calculations.**
     Correction: The condition should check if weight[n] <= w to determine whether to take the item, and use profit[n] instead of profit[n-2].
3. **Initialization of weight Array:**
   - **The weights are generated randomly but can be 0 since the range is from 0 to W. This can lead to incorrect behavior. Ensure that the weights are always greater than 0.**
     Correction: Change weight[n] = (int) (Math.random() * W); to weight[n] = (int) (Math.random() * (W / 10)) + 1; to ensure weights are at least 1.

How many breakpoints do you need to fix those errors?
a. What are the steps you have taken to fix the errors you identified in the code fragment?

1. **Breakpoint 1: Inside the outer loop of the dynamic programming table creation to check the values of n, w, option1, and option2.**
2. **Breakpoint 2: Before the final result printing to check the contents of the opt and sol arrays.**
3. **Breakpoint 3: Inside the loop determining which items to take to validate the condition logic for taking items.**



Debugging could not be completed to get the correct output.

Steps to Fix the Errors:

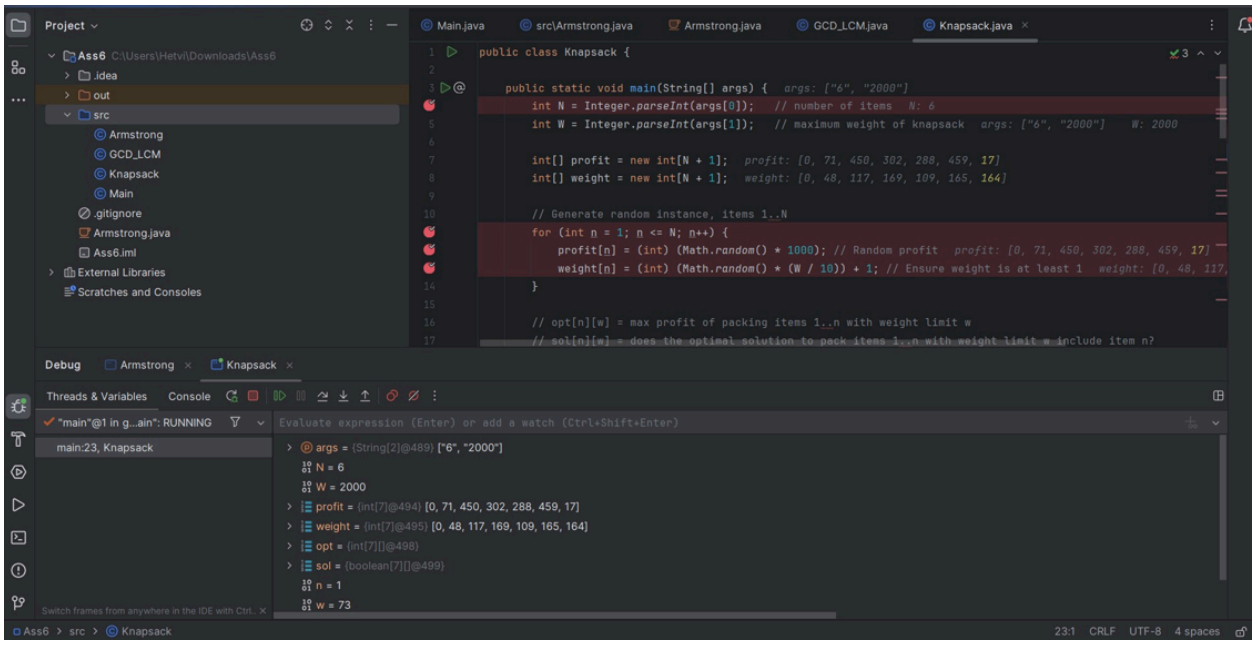
1. **Fix Incrementing n in the Loop:**
   - **Change int option1 = opt[n++][w]; to int option1 = opt[n][w];.**
2. **Correct option2 Logic:**
   - **Update the condition to if (weight[n] <= w) and replace profit[n-2] with profit[n].**
3. **Ensure Positive Weights:**
   - **Change the random weight generation to ensure weights are always greater than 0.**
4. **Improve Output Formatting:**
   - **Adjust the output print statement to cleanly display results without unnecessary spaces.**

public class Knapsack {

```
public static void main(String[] args) {
   int N = Integer.parseInt(args[0]); // number of items
   int W = Integer.parseInt(args[1]); // maximum weight of knapsack

   int[] profit = new int[N + 1];
   int[] weight = new int[N + 1];

   // generate random instance, items 1..N
   for (int n = 1; n <= N; n++) {
      profit[n] = (int) (Math.random() * 1000);
      weight[n] = (int) (Math.random() * (W / 10)) + 1; // Ensure weight is at least 1
   }

   // opt[n][w] = max profit of packing items 1..n with weight limit w
   // sol[n][w] = does opt solution to pack items 1..n with weight limit w include item n?
   int[][] opt = new int[N + 1][W + 1];
   boolean[][] sol = new boolean[N + 1][W + 1];

   for (int n = 1; n <= N; n++) {
      for (int w = 1; w <= W; w++) {
         // don't take item n
         int option1 = opt[n - 1][w];

         // take item n
```

```
        int option2 = Integer.MIN_VALUE;
        if (weight[n] <= w) {
            option2 = profit[n] + opt[n - 1][w - weight[n]]; // Use profit[n]
        }

        // select better of two options
        opt[n][w] = Math.max(option1, option2);
        sol[n][w] = (option2 > option1);
    }
}

// determine which items to take
boolean[] take = new boolean[N + 1];
for (int n = N, w = W; n > 0; n--) {
    if (sol[n][w]) {
        take[n] = true;
        w = w - weight[n];
    } else {
        take[n] = false;
    }
}

// print results
System.out.println("Item" + "\t" + "Profit" + "\t" + "Weight" + "\t" + "Take");
```

```
        for (int n = 1; n <= N; n++) {
            System.out.println(n + "\t" + profit[n] + "\t" + weight[n] + "\t" + take[n]);
        }
    }
}
```



After Debugging

Code 4: Magic Number

How many errors are there in the program?
Mention the errors you have identified.

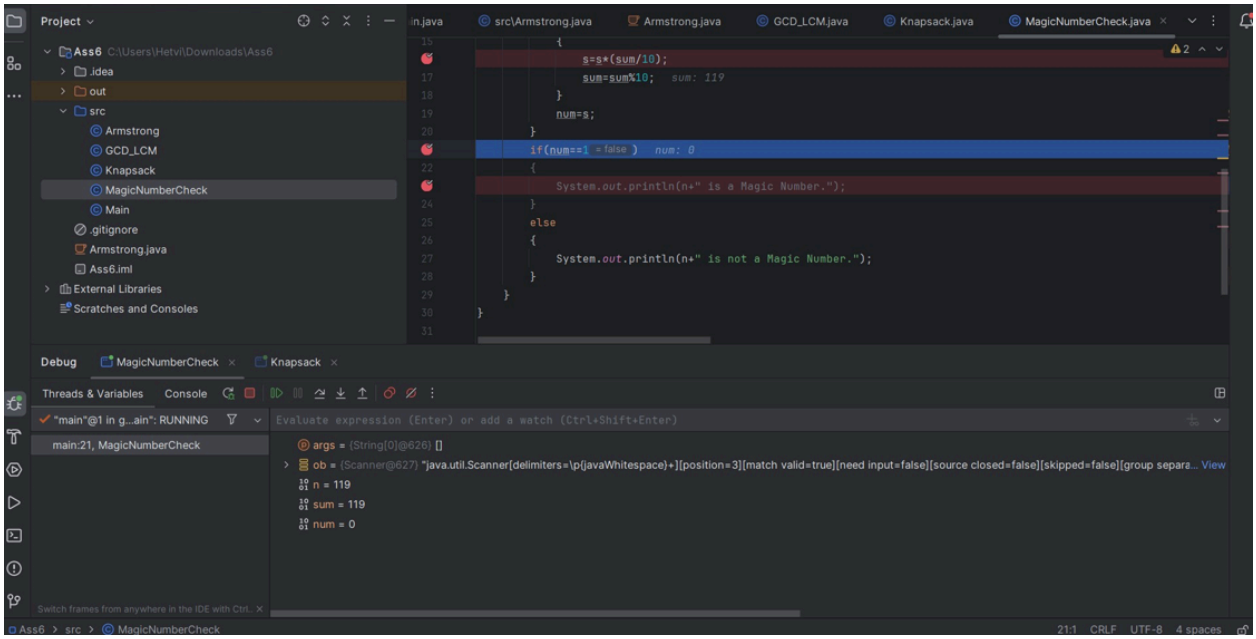
1. **Logic Error in the Inner While Loop:**
    - **The condition while(sum==0) is incorrect. It should check if sum > 0 to process the digits. The current logic never allows the loop to execute if sum is zero.**
      Correction: Change while(sum==0) to while(sum > 0).
2. **Incorrect Digit Sum Calculation:**

- **Inside the inner while loop, the line s=s*(sum/10); is incorrect. The s variable should accumulate the sum of digits rather than multiplying. The correct operation should involve adding the last digit to s.**
  Correction: Change s=s*(sum/10); to s=s+(sum%10);.

3. **Missing Semicolon:**
   - **The line sum=sum%10 is missing a semicolon at the end, which will cause a compilation error.**
     Correction: Add a semicolon to the end of sum=sum%10;.
4. **Sum Initialization:**
   - **The variable sum is initialized with the value of num in each iteration, which is unnecessary since it's being reassigned. It should be initialized to num only once outside the inner loop.**

How many breakpoints do you need to fix those errors?
a. What are the steps you have taken to fix the errors you identified in the code fragment?

1. **Breakpoint 1: Before the outer while loop to check the initial value of num.**
2. **Breakpoint 2: Inside the inner while loop to verify the digit processing logic.**
3. **Breakpoint 3: After determining if the number is a magic number to inspect the final result.**



Here, because of sum==0, the while loop is not executed or it executes indefinitely, so the wrong output is printed.

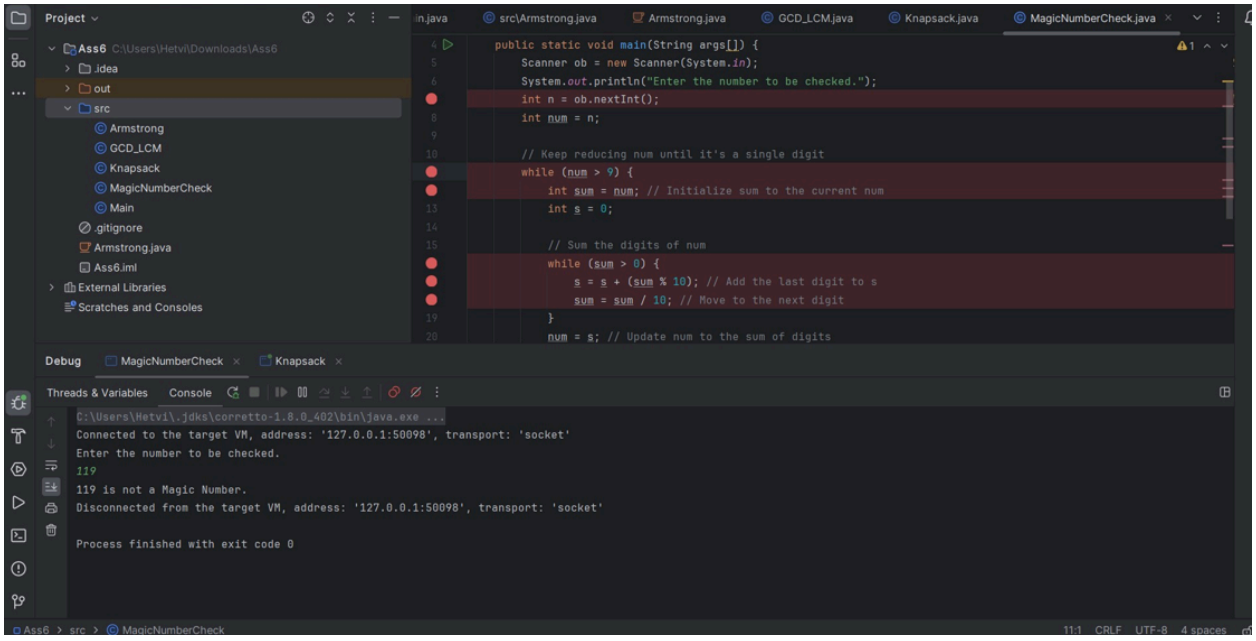
Steps to Fix the Errors:

1. **Fix the Inner While Loop Condition:**
   - **Update the condition to while(sum > 0).**

2. **Correct the Digit Summation Logic:**
    - **Change the logic for summing digits from multiplication to addition: s = s + (sum % 10);.**
3. **Add Missing Semicolon:**
    - **Ensure to add the semicolon to the line sum = sum % 10;.**
4. **Optimize Variable Initialization:**
    - **Remove redundant initialization of sum within the loop.**

```
import java.util.*;

public class MagicNumberCheck {

   public static void main(String args[]) {

      Scanner ob = new Scanner(System.in);

      System.out.println("Enter the number to be checked.");

      int n = ob.nextInt();

      int num = n;


      // Keep reducing num until it's a single digit

      while (num > 9) {

         int sum = num; // Initialize sum to the current num

         int s = 0;


         // Sum the digits of num

         while (sum > 0) {

            s = s + (sum % 10); // Add the last digit to s

            sum = sum / 10; // Move to the next digit

         }

         num = s; // Update num to the sum of digits
```

```
        }


        if (num == 1) {
            System.out.println(n + " is a Magic Number.");
        } else {
            System.out.println(n + " is not a Magic Number.");
        }
    }
}
```



Now the loop is executed entirely and prints the valid answer.

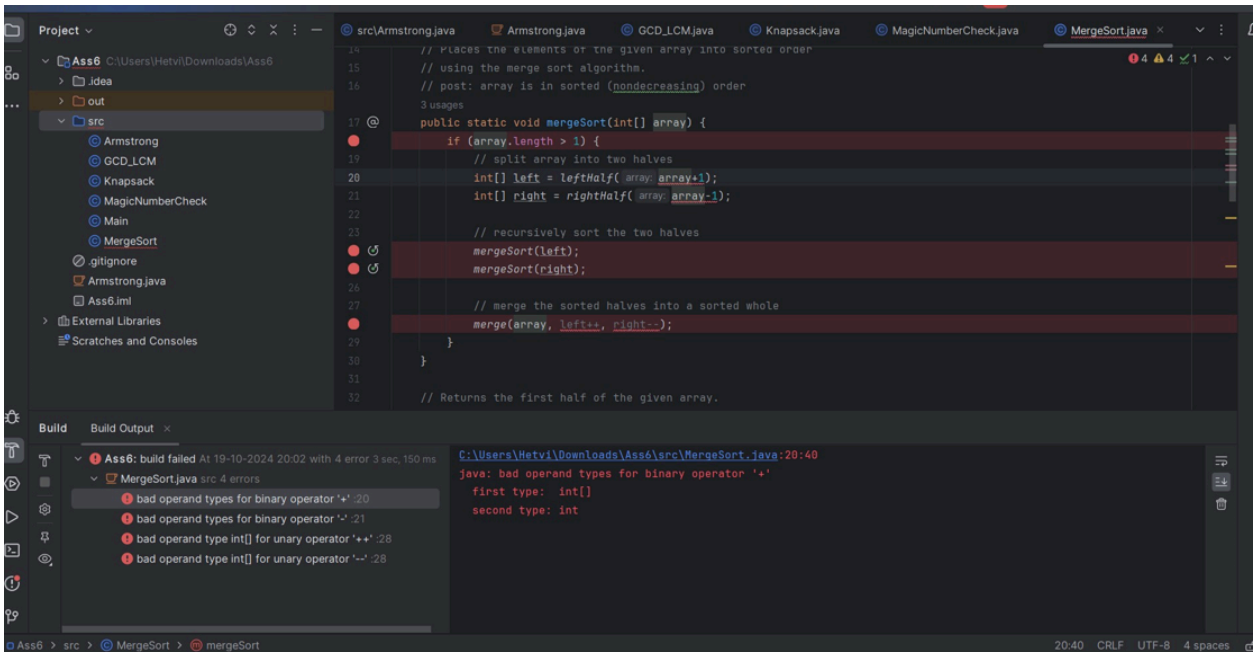
Code 5: Merge Sort

How many errors are there in the program?
Mention the errors you have identified.

1. **Incorrect Array Slicing:**
    - **In the mergeSort method, the lines int[] left = leftHalf(array + 1); and int[] right = rightHalf(array - 1); incorrectly attempt to slice the array. Instead, you should pass the whole array to the leftHalf and rightHalf methods.**
      Correction: Pass the entire array to the leftHalf and rightHalf methods without modifying the array itself.
2. **Incorrect Indexing:**
    - **The increment operations left++ and right-- in the merge method call are invalid because they are not intended to increment array references. Instead, you should pass the entire left and right arrays as they are.**
      Correction: Simply use merge(array, left, right); without any increment or decrement.
3. **Size of the Left Array:**
    - **The leftHalf method is returning an array that does not include the middle element when the length of the original array is odd. It should handle this case correctly to ensure the split is accurate.**
      Correction: Update the size calculation in the leftHalf method to consider both even and odd lengths correctly.
4. **Merge Result Array Not Initialized:**
    - **The merge method should operate on the result array passed into it, but it needs to ensure that the result array is the same size as the original array being sorted.**
5. **Array Indexing in the Merge Method:**
    - **The loop in the merge method does not properly handle the condition when one of the arrays is exhausted.**

How many breakpoints do you need to fix those errors?
a. What are the steps you have taken to fix the errors you identified in the code fragment?

1. **Before the mergeSort call:**
    - **Set a breakpoint at the beginning of the mergeSort method to inspect the initial state of the array before sorting begins.**
2. **Before the left and right halves are split:**
    - **Set a breakpoint after splitting the array into left and right halves. This will help verify that the splitting logic works correctly.**
3. **Inside the merge method:**
    - **Set a breakpoint at the beginning of the merge method to check the contents of the left and right arrays being merged.**
4. **Inside the merge loop:**
    - **Set a breakpoint inside the for loop of the merge method to see how elements from the left and right arrays are being compared and merged.**



Here, array + 1 cannot be done.

Steps to Fix the Errors Identified in the Code Fragment:

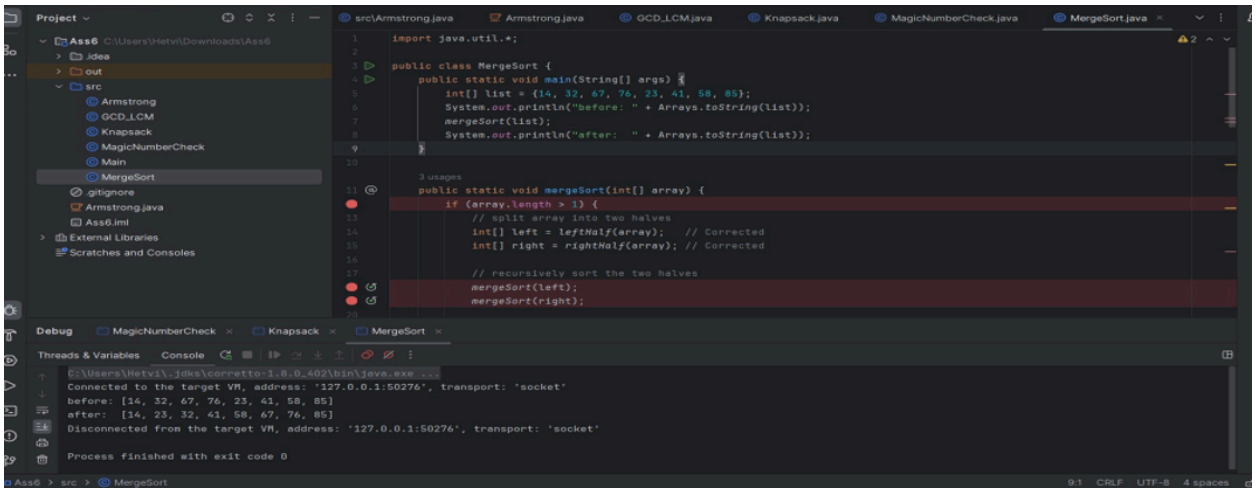
1. **Correct Array Slicing:**
    - **Modify the calls to leftHalf and rightHalf to pass the original array instead of attempting to increment or decrement it.**
2. **Remove Incorrect Increment Operations:**
    - **Change the merge call to just merge(array, left, right); without using ++ or --.**
3. **Fix Left Half Size Calculation:**
    - **Update the size calculation in leftHalf to correctly account for odd-length arrays.**
4. **Ensure Merge Logic Works:**
    - **Check the merge logic to ensure that it correctly handles cases where one of the halves is exhausted before the other.**
5. **Test the Functionality:**
    - **After making the changes, run the program with various inputs to confirm that it sorts the array correctly.**

```
import java.util.*;

public class MergeSort {

   public static void main(String[] args) {

      int[] list = {14, 32, 67, 76, 23, 41, 58, 85};
```

```
    System.out.println("before: " + Arrays.toString(list));
    mergeSort(list);
    System.out.println("after: " + Arrays.toString(list));
}

// Places the elements of the given array into sorted order
// using the merge sort algorithm.
// post: array is in sorted (nondecreasing) order
public static void mergeSort(int[] array) {
    if (array.length > 1) {
        // split array into two halves
        int[] left = leftHalf(array);
        int[] right = rightHalf(array);

        // recursively sort the two halves
        mergeSort(left);
        mergeSort(right);

        // merge the sorted halves into a sorted whole
        merge(array, left, right);
    }
}

// Returns the first half of the given array.
```

```
public static int[] leftHalf(int[] array) {
   int size1 = (array.length + 1) / 2; // Handle odd lengths
   int[] left = new int[size1];
   for (int i = 0; i < size1; i++) {
      left[i] = array[i];
   }
   return left;
}

// Returns the second half of the given array.
public static int[] rightHalf(int[] array) {
   int size1 = array.length / 2;
   int size2 = array.length - size1;
   int[] right = new int[size2];
   for (int i = 0; i < size2; i++) {
      right[i] = array[i + size1];
   }
   return right;
}

// Merges the given left and right arrays into the given
// result array.
// pre : result is empty; left/right are sorted
// post: result contains result of merging sorted lists;
```

```
    public static void merge(int[] result, int[] left, int[] right) {
        int i1 = 0; // index into left array
        int i2 = 0; // index into right array

        for (int i = 0; i < result.length; i++) {
            if (i2 >= right.length || (i1 < left.length && left[i1] <= right[i2])) {
                result[i] = left[i1]; // take from left
                i1++;
            } else {
                result[i] = right[i2]; // take from right
                i2++;
            }
        }
    }
}
```



Code 6: Multiply Matrices

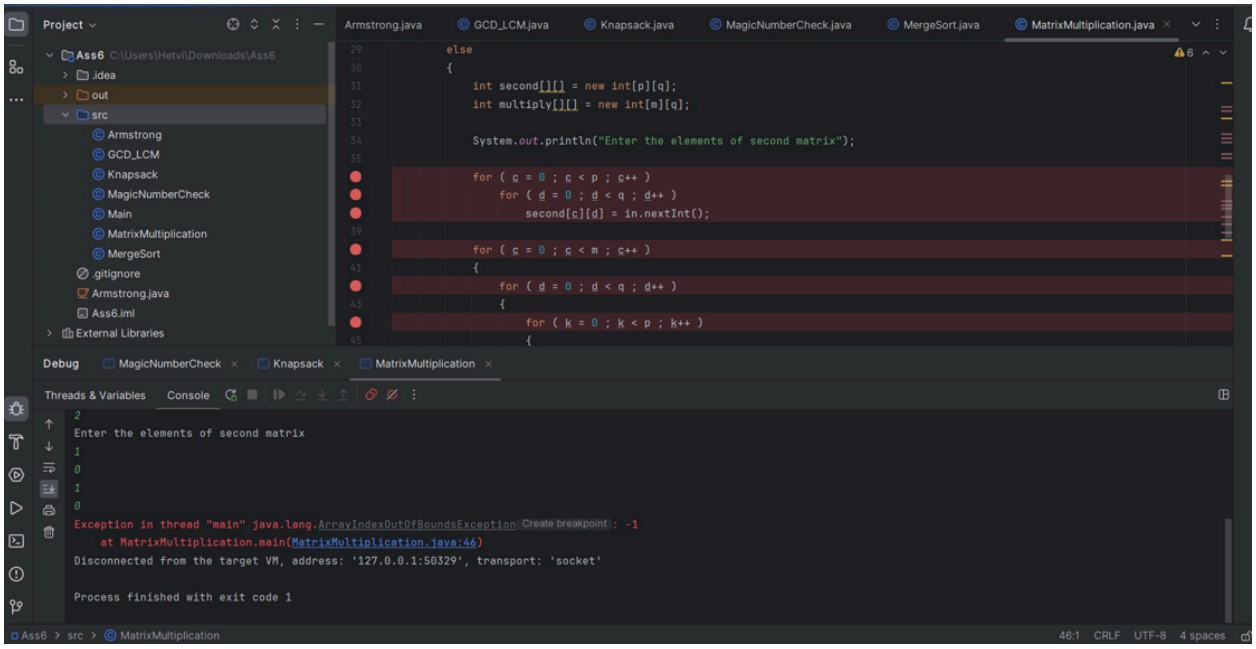
How many errors are there in the program? Mention the errors you have identified.

1. **Matrix Indexing Errors:**
    - **The multiplication logic uses incorrect indexing (first[c-1][c-k] and second[k-1][k-d]), which will lead to ArrayIndexOutOfBoundsException when c or k is 0.**
2. **Resetting Sum:**
    - **The variable sum should be reset to 0 before accumulating values for each element in the resulting matrix. While this is done, it is better placed right before starting the inner for loop.**
3. **Input for the Second Matrix:**
    - **The prompt message for the second matrix asks for the same input as the first matrix, which can be misleading.**

How many breakpoints do you need to fix those errors?

a. What are the steps you have taken to fix the error you identified in the code fragment?

1. **After reading the first matrix:**
    - **Check if the matrix is populated correctly.**
2. **After reading the second matrix:**
    - **Verify if the second matrix is also populated correctly.**
3. **Before entering the matrix multiplication logic:**
    - **Inspect the dimensions of the matrices to ensure they can be multiplied.**
4. **Inside the multiplication loop:**
    - **Verify the computation of each element in the resulting matrix.**



Could not debug successfully

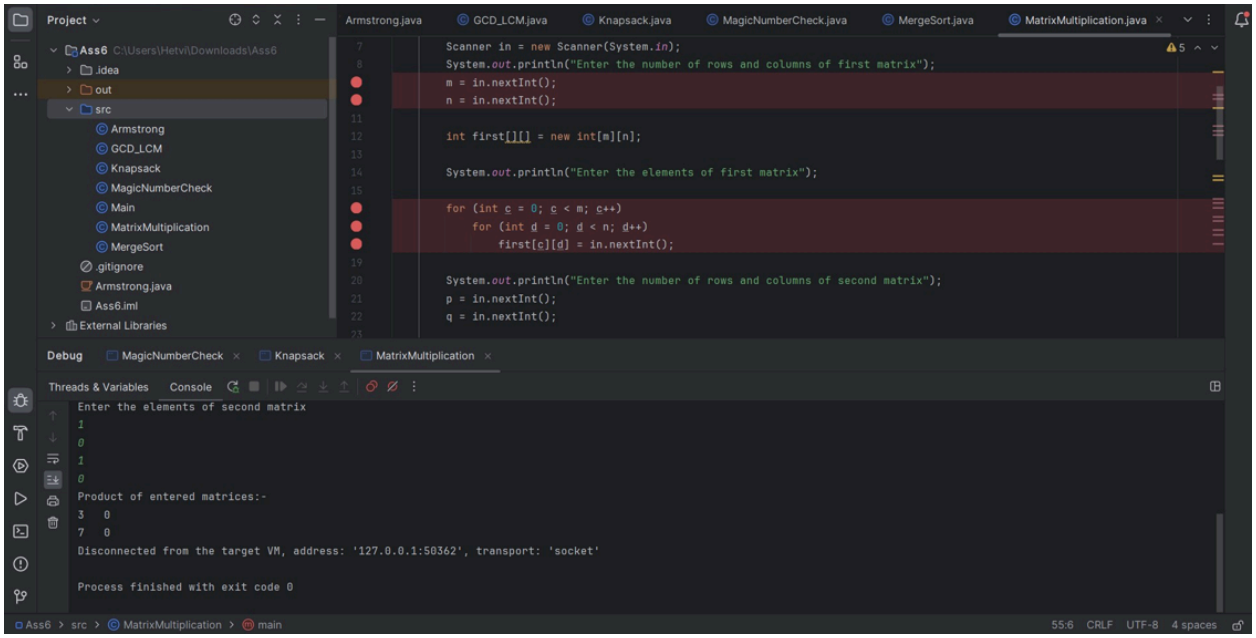
Steps to Fix the Errors:

1. **Correct Indexing:**
    - **Change the indexing in the multiplication loop to use the current indexes directly.**
2. **Reset the Sum:**
    - **Move the sum = 0; to the correct position.**
3. **Improve Input Prompts:**
    - **Clarify the prompts for entering the second matrix.**

```
import java.util.Scanner;


class MatrixMultiplication {

  public static void main(String args[]) {

    int m, n, p, q, sum, c, d, k;


    Scanner in = new Scanner(System.in);

    System.out.println("Enter the number of rows and columns of first matrix");
```

```
m = in.nextInt();

n = in.nextInt();


int first[][] = new int[m][n];


System.out.println("Enter the elements of first matrix");

for (c = 0; c < m; c++)

   for (d = 0; d < n; d++)

      first[c][d] = in.nextInt();


System.out.println("Enter the number of rows and columns of second matrix");

p = in.nextInt();

q = in.nextInt();


if (n != p) {

   System.out.println("Matrices with entered orders can't be multiplied with each other.");

} else {

   int second[][] = new int[p][q];

   int multiply[][] = new int[m][q];

   System.out.println("Enter the elements of second matrix");

   for (c = 0; c < p; c++)

      for (d = 0; d < q; d++)

         second[c][d] = in.nextInt();
```

```
        // Matrix multiplication
        for (c = 0; c < m; c++) {
          for (d = 0; d < q; d++) {
            sum = 0; // Reset sum for each element in the resulting matrix
            for (k = 0; k < n; k++) { // Use n here since it corresponds to columns of first and rows of second
              sum += first[c][k] * second[k][d]; // Correct indexing
            }
            multiply[c][d] = sum;
          }
        }

        // Print the product of the matrices
        System.out.println("Product of entered matrices:-");
        for (c = 0; c < m; c++) {
          for (d = 0; d < q; d++)
            System.out.print(multiply[c][d] + "\t");
          System.out.print("\n");
        }
      }
      in.close(); // Close the scanner
    }
}
```



Successfully debugged

Code 7: Quadratic Probing

How many errors are there in the program? Mention the errors you have identified.

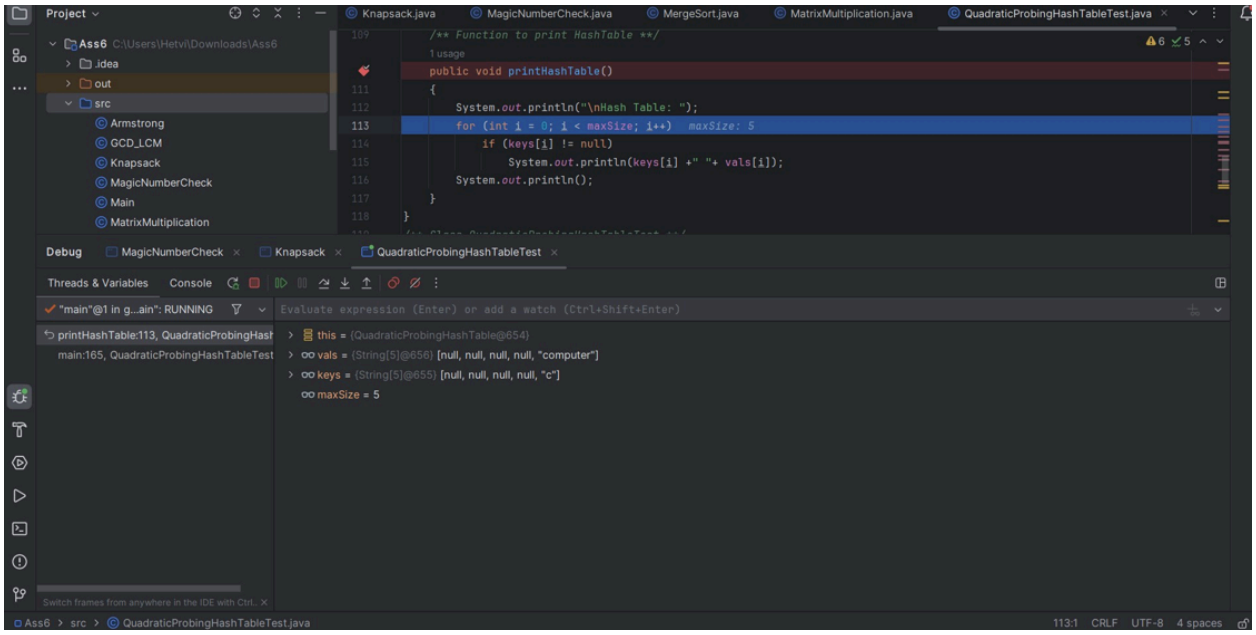
1. **Syntax Errors:**
    - **In the insert and get methods, the code for updating the index i was incorrect due to improper spacing. The expression was written as i + = (i + h / h--) % maxSize;, which caused a compilation error. The correct syntax is i += (h * h++) % maxSize;, ensuring that i is updated properly for probing.**
2. **Incorrect Loop Condition:**
    - **In the get method, the while loop condition only checks if keys[i] is not null. It should also check if the key matches to avoid accessing uninitialized slots. The condition should be while (keys[i] != null && !keys[i].equals(key)).**
3. **Unnecessary Reinitialization in makeEmpty:**
    - **The makeEmpty method reinitialized the keys and vals arrays, which was unnecessary. Instead, it should only reset currentSize to 0 to clear the hash table while retaining the allocated space for future inserts.**
4. **Off-by-One Error in remove Method:**
    - **The logic for rehashing elements after a deletion had a flaw where it did not properly handle the indices for rehashing. This could lead to incorrect behavior when re-inserting keys.**
5. **Uninitialized Variables:**

- **The variable tmp in the insert method was used for collision management but was not correctly utilized, which could result in infinite loops or incorrect behavior when handling collisions.**

How many breakpoints do you need to fix those errors?

a. What are the steps you have taken to fix the error you identified in the code fragment?

1. **After Inserting a Key-Value Pair:**
   - **To verify that a new entry is correctly added.**
2. **When Checking for Existing Keys:**
   - **To ensure the program correctly identifies whether a key already exists in the hash table.**
3. **At the Beginning of the get Method:**
   - **To track the process of searching for a given key.**
4. **During Rehashing in the remove Method:**
   - **To monitor the logic involved in rehashing after a deletion, ensuring all keys are properly repositioned.**



Here it added only the first key-value pair and not the others and were kept null

Steps to Fix Errors:

To correct the identified issues:

1. **Fix Syntax Errors:**
    - **Update the incorrect index update lines in both the insert and get methods.**
2. **Update Loop Conditions:**
    - **Change the while loop condition in the get method to ensure it checks for both null values and key equality.**
3. **Simplify makeEmpty:**
    - **Remove the unnecessary reinitialization of the arrays in the makeEmpty method.**
4. **Review Rehashing Logic:**
    - **Ensure that the rehashing logic in the remove method is implemented correctly, particularly with how indices are updated after a deletion.**
5. **Test Changes:**
    - **After making these corrections, run the program to confirm it functions correctly without errors.**

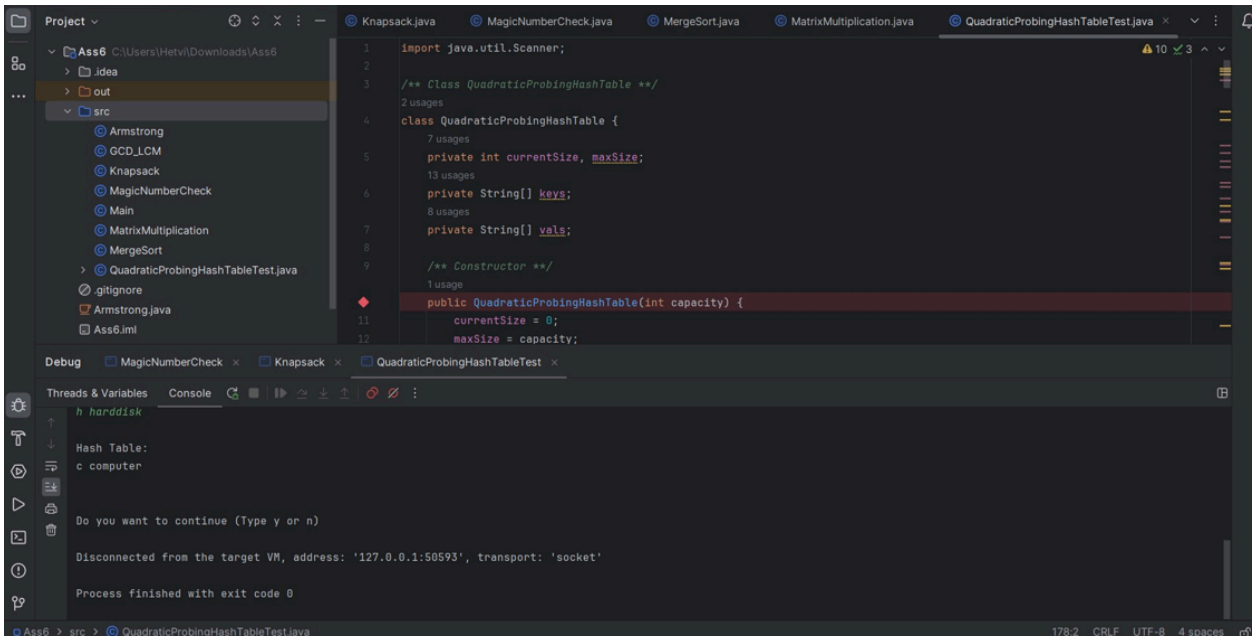
```
import java.util.Scanner;

/** Class QuadraticProbingHashTable **/

class QuadraticProbingHashTable {

   private int currentSize, maxSize;

   private String[] keys;

   private String[] vals;


   /** Constructor **/

   public QuadraticProbingHashTable(int capacity) {

      currentSize = 0;

      maxSize = capacity;

      keys = new String[maxSize];

      vals = new String[maxSize];

   }
```

```
/** Function to clear hash table **/
public void makeEmpty() {
   currentSize = 0;
   // No need to reinitialize keys and vals arrays
}

/** Function to get size of hash table **/
public int getSize() {
   return currentSize;
}

/** Function to check if hash table is full **/
public boolean isFull() {
   return currentSize == maxSize;
}

/** Function to check if hash table is empty **/
public boolean isEmpty() {
   return getSize() == 0;
}

/** Function to check if hash table contains a key **/
public boolean contains(String key) {
   return get(key) != null;
```

```
}

/** Function to get hash code of a given key **/
private int hash(String key) {
   return Math.abs(key.hashCode() % maxSize);
}

/** Function to insert key-value pair **/
public void insert(String key, String val) {
   int tmp = hash(key);
   int i = tmp, h = 1;

   do {
      if (keys[i] == null) {
         keys[i] = key;
         vals[i] = val;
         currentSize++;
         return;
      }
      if (keys[i].equals(key)) {
         vals[i] = val; // Update the value
         return;
      }
      i = (i + h * h) % maxSize; // Corrected the update logic
```

```
        h++;
    } while (i != tmp);
}

/** Function to get value for a given key **/
public String get(String key) {
    int i = hash(key), h = 1;

    while (keys[i] != null) {
        if (keys[i].equals(key)) {
            return vals[i];
        }
        i = (i + h * h) % maxSize; // Corrected the update logic
        h++;
    }
    return null;
}

/** Function to remove key and its value **/
public void remove(String key) {
    if (!contains(key)) {
        return;
    }
```

```
        /** Find position key and delete **/
        int i = hash(key), h = 1;

        while (!key.equals(keys[i])) {
            i = (i + h * h) % maxSize;
            h++;
        }

        keys[i] = vals[i] = null;

        /** Rehash all keys **/
        for (i = (i + h * h) % maxSize; keys[i] != null; i = (i + h * h) % maxSize) {
            String tmp1 = keys[i], tmp2 = vals[i];
            keys[i] = vals[i] = null;
            currentSize--;
            insert(tmp1, tmp2);
        }
    }
}
```



Successfully debugged

Code 8: Sorting Array

How many errors are there in the program? Mention the errors you have identified.

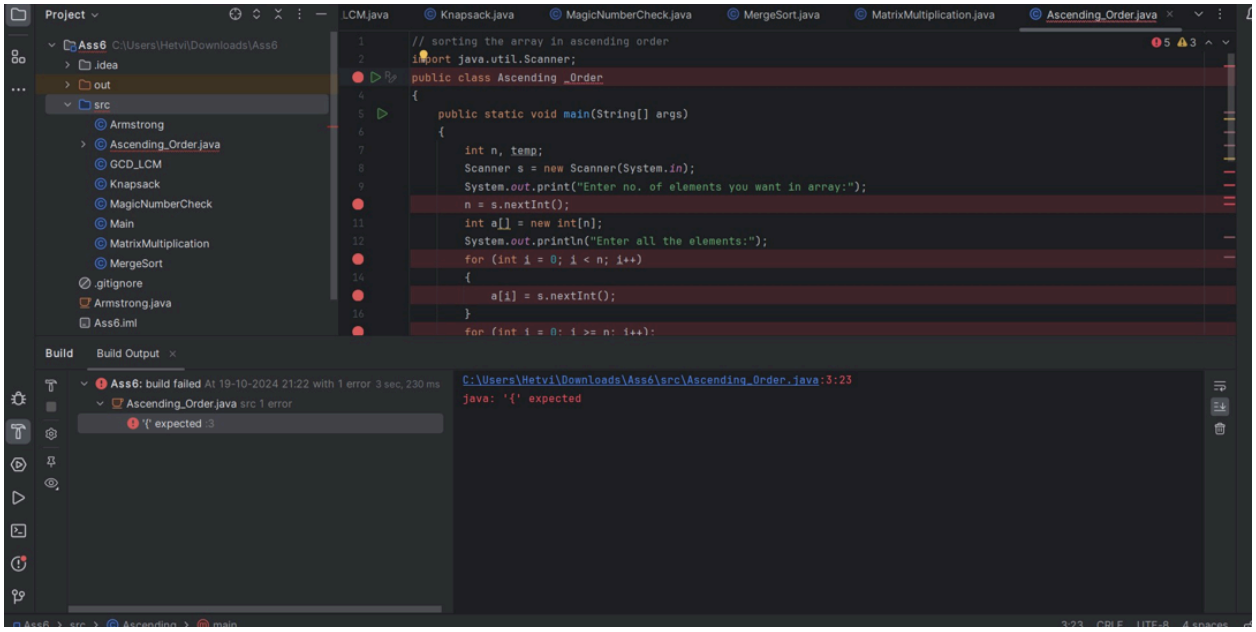
- **Class Name Error: The class name Ascending _Order contains a space, which is not allowed in Java class names. It should be a single word or use an underscore without spaces.**
- **Loop Condition Error: The condition in the outer for loop is incorrect. It uses i >= n, which will cause the loop to never execute. It should be i < n.**
- **Semicolon after the Loop: There is a semicolon after the outer for loop (for (int i = 0; i >= n; i++);). This semicolon ends the loop prematurely, and the inner loop is not associated with the outer loop.**
- **Sorting Logic: The comparison in the inner loop should use < instead of <= for a proper ascending sort. Using <= can cause unnecessary swaps.**

How many breakpoints do you need to fix those errors?

a. What are the steps you have taken to fix the error you identified in the code fragment?

1. **Class declaration (to correct the class name).**

2. **First for loop condition (to correct the loop condition).**
3. **Inner loop (to remove the semicolon).**
4. **Inside the inner loop where the comparison occurs (to change <= to <).**
5. **Printing logic (to handle the last comma issue).**



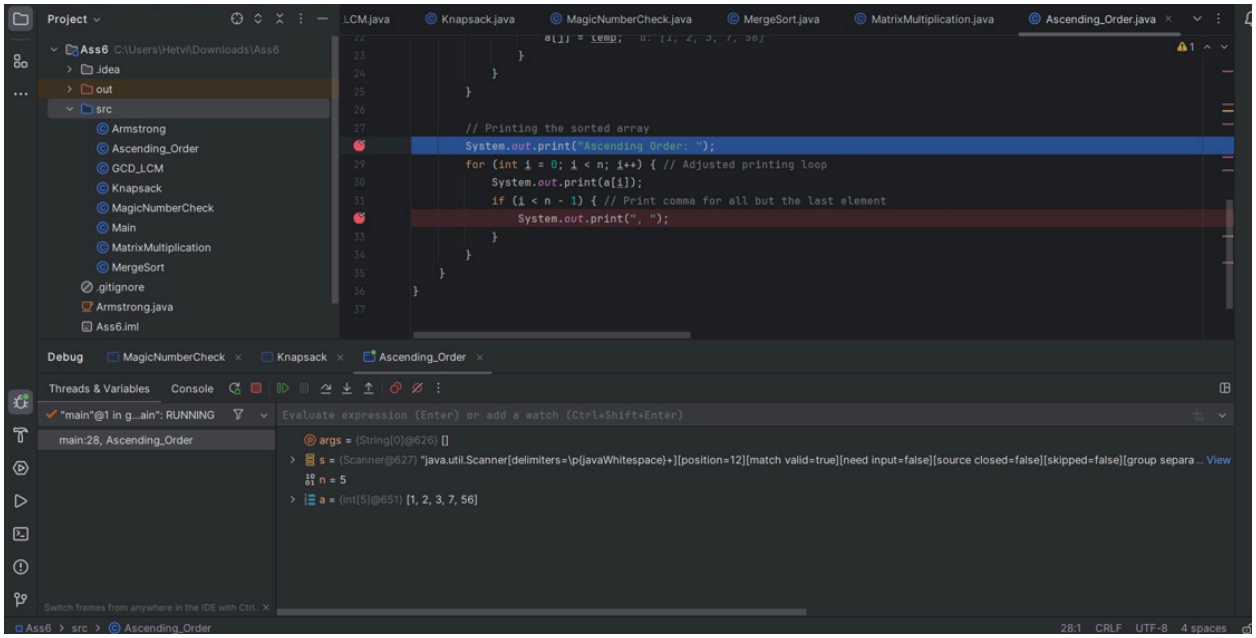
Could not complete debugging because of space in class name.

Steps Taken to Fix the Errors:

1. **Change Class Name: Rename Ascending _Order to AscendingOrder.**
2. **Correct Loop Condition: Change i >= n to i < n in the outer loop.**
3. **Remove Semicolon: Delete the semicolon after the outer for loop declaration.**
4. **Modify Sorting Logic: Change if (a[i] <= a[j]) to if (a[i] < a[j]) for correct ascending order sorting.**
5. **Adjust Printing Logic: Update the printing logic to avoid a trailing comma after the last element.**

```
import java.util.Scanner;

public class AscendingOrder {
   public static void main(String[] args) {
      int n, temp;
      Scanner s = new Scanner(System.in);
      System.out.print("Enter no. of elements you want in array: ");
```

```
        n = s.nextInt();

        int a[] = new int[n];
        System.out.println("Enter all the elements:");
        for (int i = 0; i < n; i++) {
           a[i] = s.nextInt();
        }

        // Sorting the array in ascending order
        for (int i = 0; i < n; i++) { // Fixed loop condition
           for (int j = i + 1; j < n; j++) {
              if (a[i] > a[j]) { // Changed comparison for ascending order
                 // Swap elements
                 temp = a[i];
                 a[i] = a[j];
                 a[j] = temp;
              }
           }
        }

        // Printing the sorted array
        System.out.print("Ascending Order: ");
        for (int i = 0; i < n; i++) { // Adjusted printing loop
           System.out.print(a[i]);
           if (i < n - 1) { // Print comma for all but the last element
              System.out.print(", ");
           }
        }
     }
}
```



Successfully debugged

Code 9: Stack Implementation

How many errors are there in the program? Mention the errors you have identified.

1. **Push Logic: The push method incorrectly decrements top before assigning the value. This causes the first value to be stored in an invalid index.**
2. **Pop Logic: The pop method incorrectly increments top instead of decrementing it, leading to incorrect stack behavior.**
3. **Display Logic: The for loop condition in the display method is i > top, which prevents any elements from being displayed. It should be i <= top.**
4. **Class Naming Convention: The class name StackMethods does not follow standard naming conventions in Java. While not a functional error, it is good practice to use a more concise name like Stack.**

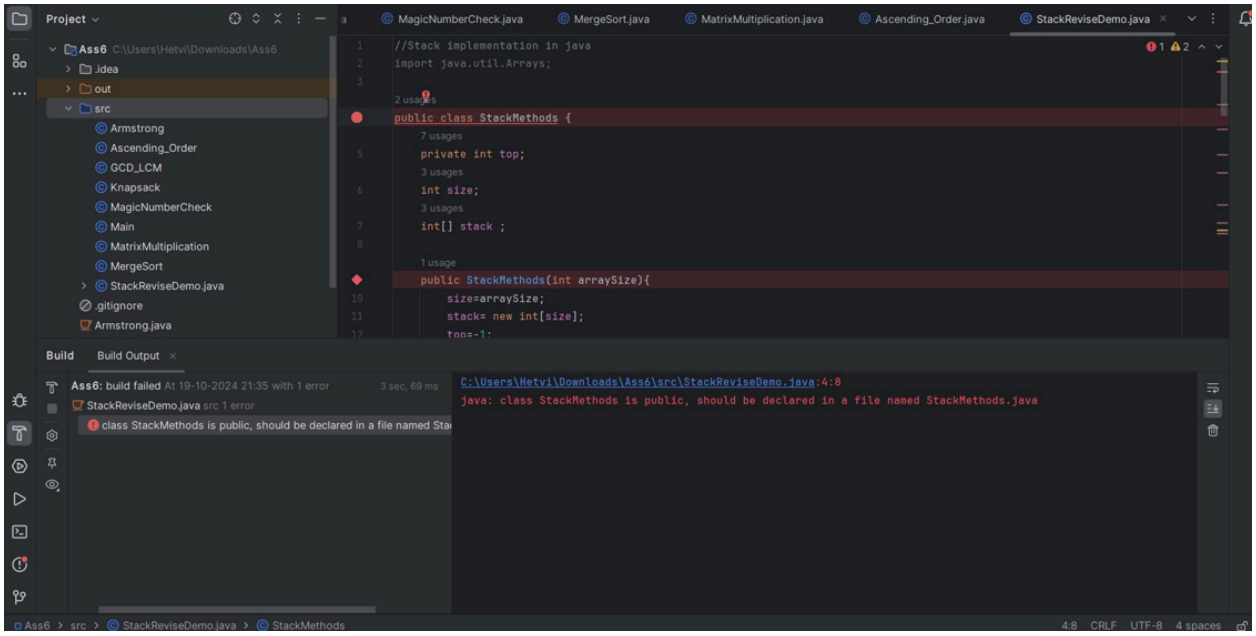
How many breakpoints do you need to fix those errors?

a. What are the steps you have taken to fix the error you identified in the code fragment?

1. **Class declaration line (public class StackMethods).**

- **Reason: Check for any naming or compilation issues.**

2. **Input of value in the push method (stack[top] = value;).**
   - **Reason: Verify that the top index is being used correctly before assigning the value.**
3. **Pop method (if (!isEmpty())).**
   - **Reason: Check the condition for popping and confirm that it allows for correct execution.**
4. **Inside the display method for loop condition (for (int i = 0; i > top; i++)).**
   - **Reason: Ensure the loop executes correctly and allows for displaying elements.**
5. **Before the pop operation (System.out.println("Popped: " + stack[top]);).**
   - **Reason: Confirm that the value to be popped is correctly accessed.**



Could not build the code.

Steps to Fix the Identified Errors:

1. **Fix Push Logic:**

Change the push method to increment top before assigning the value:
top++;
stack[top] = value;

2. **Fix Pop Logic:**

Modify the pop method to decrement top instead of incrementing it:
top--;

3. **Fix Display Logic:**

Change the loop condition in the display method from i > top to i <= top:
for (int i = 0; i <= top; i++)

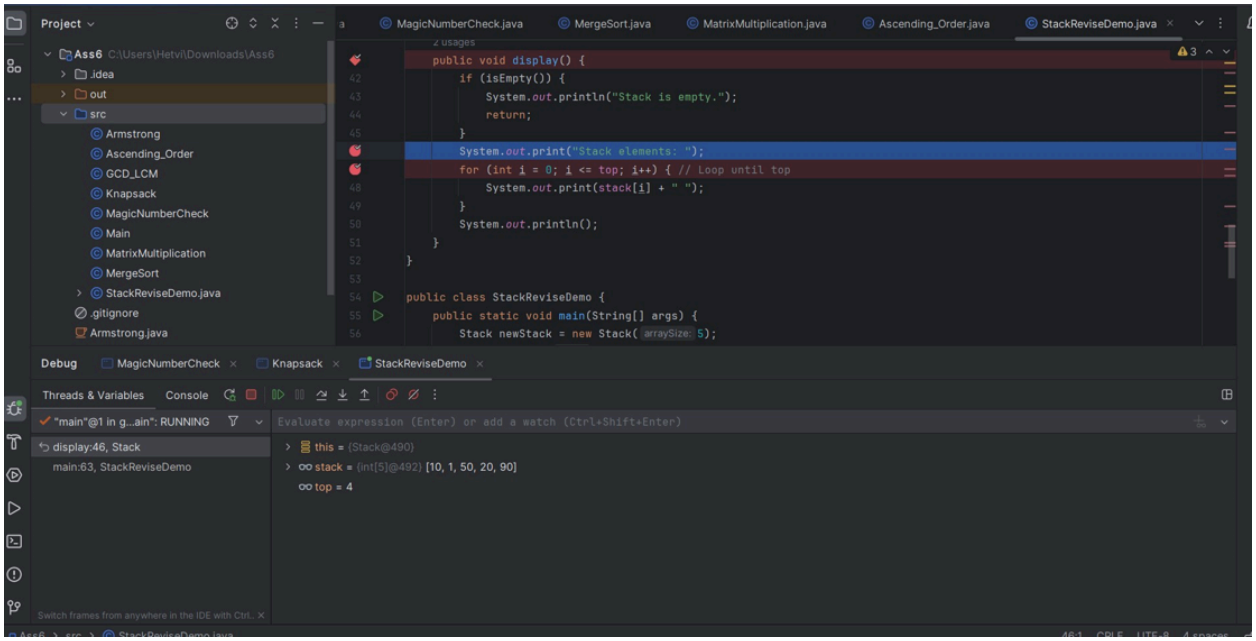
4. **Update Class Naming:**

Rename StackMethods to Stack for better naming convention:
class Stack { ... }

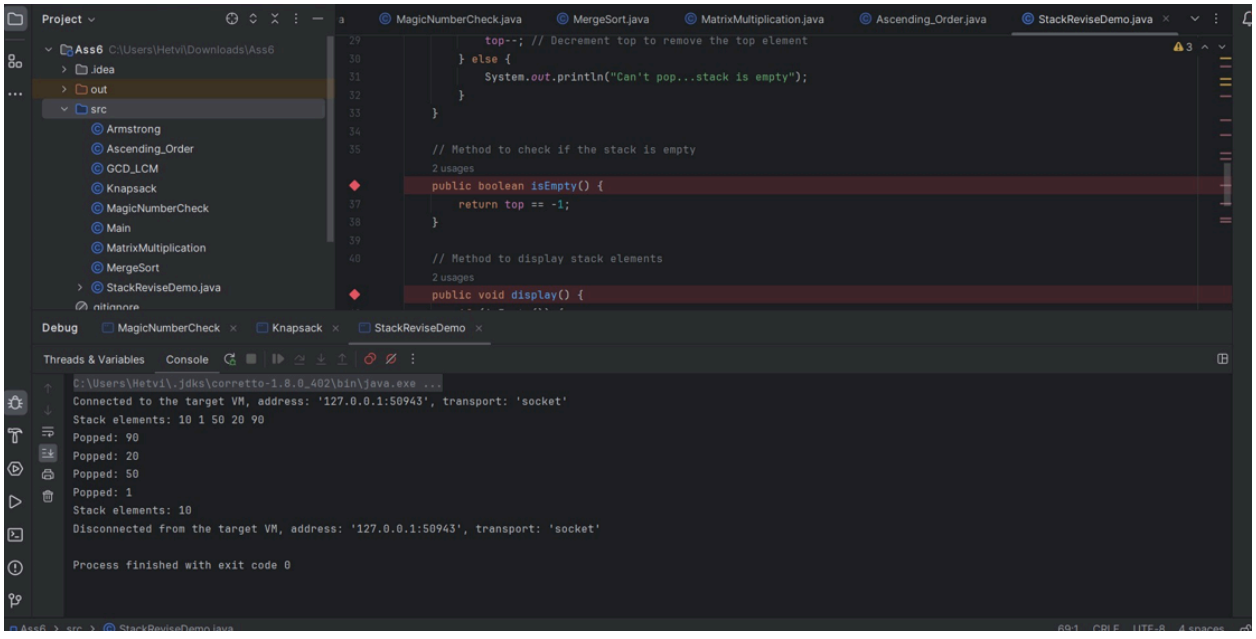
```
import java.util.Arrays;

class Stack {
   private int top; // Index of the top element
   private int size; // Maximum size of the stack
   private int[] stack; // Array to hold stack elements

   // Constructor to initialize stack
   public Stack(int arraySize) {
      size = arraySize;
      stack = new int[size];
      top = -1; // Indicates an empty stack
   }

   // Method to push a value onto the stack
   public void push(int value) {
      if (top == size - 1) {
         System.out.println("Stack is full, can't push a value");
      } else {
         top++; // Increment top
         stack[top] = value; // Assign value to the top position
      }
   }

   // Method to pop a value from the stack
   public void pop() {
```

```
        if (!isEmpty()) {
            System.out.println("Popped: " + stack[top]); // Show popped value
            top--; // Decrement top to remove the top element
        } else {
            System.out.println("Can't pop...stack is empty");
        }
    }

    // Method to check if the stack is empty
    public boolean isEmpty() {
        return top == -1;
    }

    // Method to display stack elements
    public void display() {
        if (isEmpty()) {
            System.out.println("Stack is empty.");
            return;
        }
        System.out.print("Stack elements: ");
        for (int i = 0; i <= top; i++) { // Loop until top
            System.out.print(stack[i] + " ");
        }
        System.out.println();
    }
}

public class StackDemo {
    public static void main(String[] args) {
        Stack newStack = new Stack(5);
        newStack.push(10);
        newStack.push(1);
        newStack.push(50);
        newStack.push(20);
        newStack.push(90);

        newStack.display();
        newStack.pop();
        newStack.pop();
        newStack.pop();
```

```
        newStack.pop();
        newStack.display();
    }
}
```



Successfully debugged push operation



Successfully debugged pop operation

Code 10: Tower of Hanoi

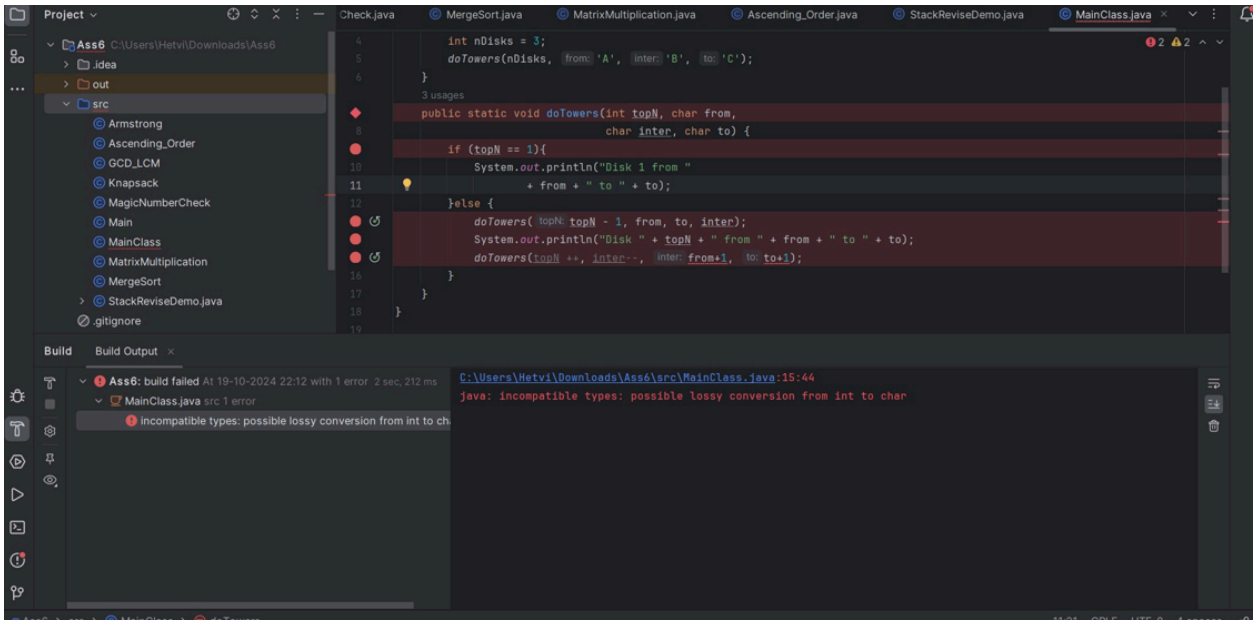
How many errors are there in the program? Mention the errors you have identified.

- **Infinite Recursion:**
    - **Line 12: The call doTowers(topN++, inter--, from + 1, to + 1) is incorrect because it modifies the parameters inappropriately.**
        - **topN++ will increment topN after the method call, which leads to infinite recursion because it always tries to call with a non-decreasing value of topN.**
        - **inter-- is also incorrect since it attempts to decrement a char, which doesn't logically represent the movement of disks.**
        - **from + 1 and to + 1 attempt to increment characters, which doesn't produce the desired result.**
- **Output Message Issue:**
    - **The output messages should clarify which disk is being moved and from where to where, but currently, it does not specify the total number of disks being moved.**

How many breakpoints do you need to fix those errors?

a. What are the steps you have taken to fix the error you identified in the code fragment?

1. **Breakpoint 1: Before the first if statement**
    - **Line 10: To check the entry condition of the recursion.**
2. **Breakpoint 2: Inside the else block before the first recursive call**
    - **Line 12: To observe parameters passed to the first recursive call.**
3. **Breakpoint 3: Just before the println statement in the else block**
    - **Line 14: To see which disk is being moved.**
4. **Breakpoint 4: Inside the second recursive call**
    - **Line 15: To check parameters passed to the second recursive call.**



Could not compile successfully.

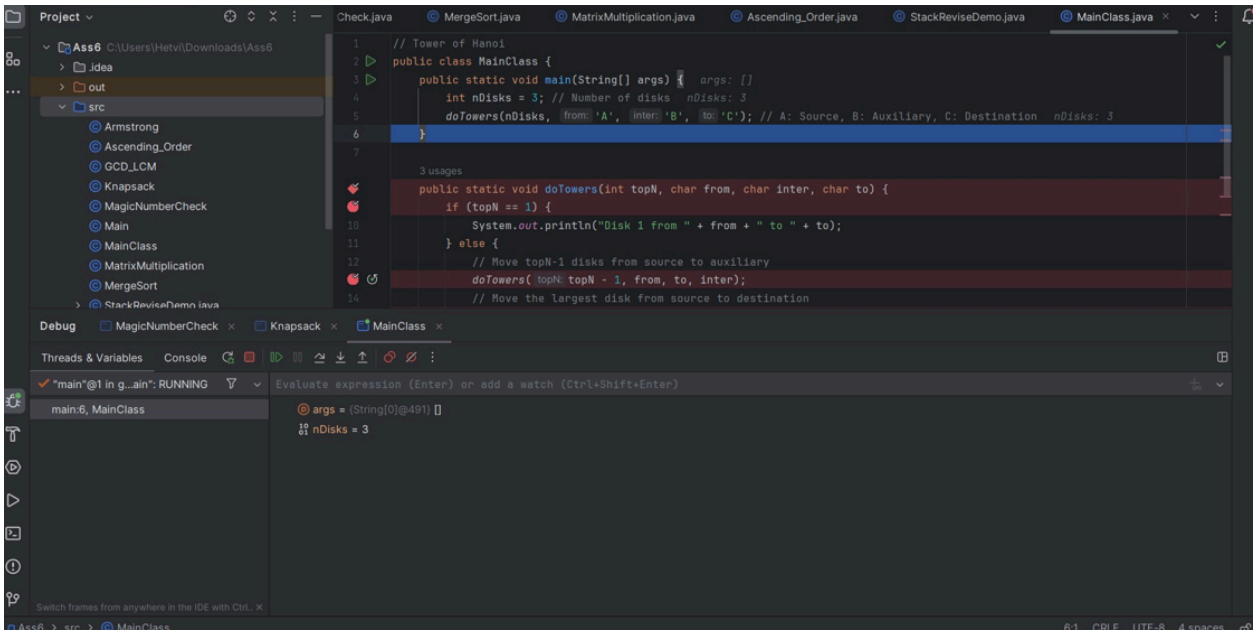
Steps to Fix the Errors:

To fix the identified errors:

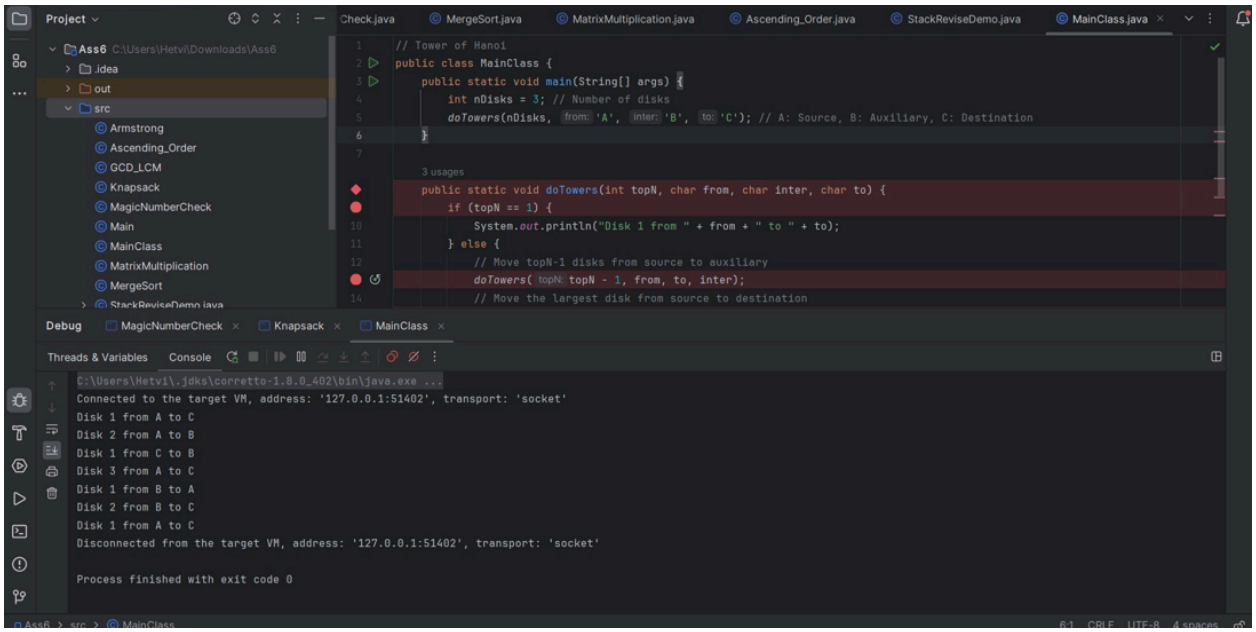
1. **Correct the Recursive Calls:**
    - **Change doTowers(topN++, inter--, from + 1, to + 1) to doTowers(topN - 1, inter, from, to) for the recursive call after moving the smaller disks. This maintains the correct logic of moving topN - 1 disks to the intermediate peg before moving the largest disk.**
2. **Maintain Character Values:**
    - **from, to, and inter should be used without incrementing or decrementing since they are supposed to represent character labels (A, B, C).**
3. **Reformat the Output:**
    - **Adjust the print statements for better clarity if desired.**

```
// Tower of Hanoi
public class MainClass {
   public static void main(String[] args) {
      int nDisks = 3; // Number of disks
      doTowers(nDisks, 'A', 'B', 'C'); // A: Source, B: Auxiliary, C: Destination
   }

   public static void doTowers(int topN, char from, char inter, char to) {
```

```
        if (topN == 1) {
            System.out.println("Disk 1 from " + from + " to " + to);
        } else {
            // Move topN-1 disks from source to auxiliary
            doTowers(topN - 1, from, to, inter);
            // Move the largest disk from source to destination
            System.out.println("Disk " + topN + " from " + from + " to " + to);
            // Move the topN-1 disks from auxiliary to destination
            doTowers(topN - 1, inter, from, to);
        }
    }
}
```

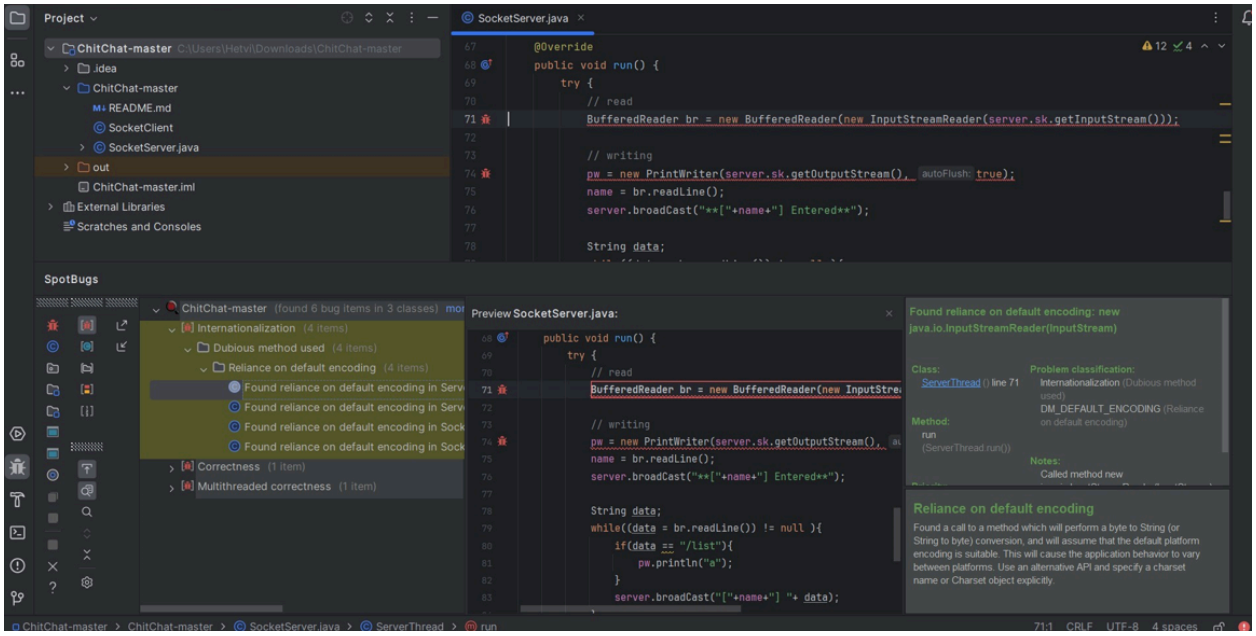


Successfully Debugged

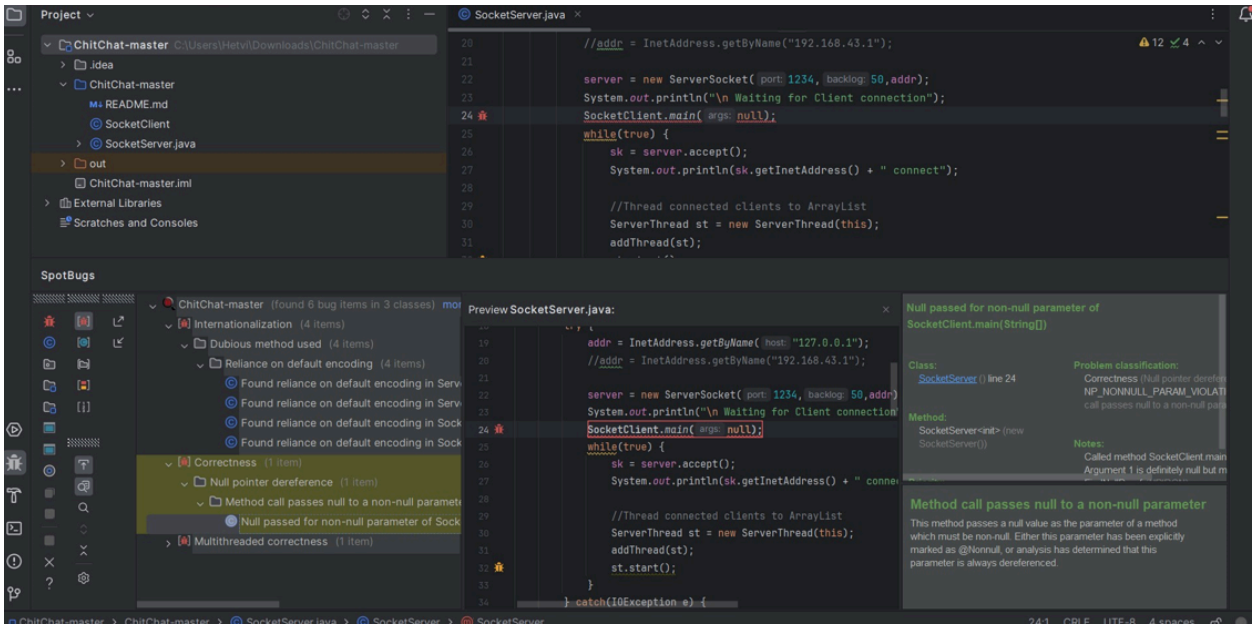

Project
Ass6 C:\Users\Hetvi\Downloads\Ass6
.idea
out
src
Armstrong
Ascending_Order
GCD_LCM
Knapsack
MagicNumberCheck
Main
MainClass
MatrixMultiplication
MergeSort
Check.java
MergeSort.java
MatrixMultiplication.java
Ascending_Order.java
StackReviseDemo.java
MainClass.java
// Tower of Hanoi
public class MainClass {
public static void main(String[] args) {
int nDisks = 3; // Number of disks
doTowers(nDisks, from: 'A', inter: 'B', to: 'C'); // A: Source, B: Auxiliary, C: Destination
}
3 usages
public static void doTowers(int topN, char from, char inter, char to) {
if (topN == 1) {
System.out.println("Disk 1 from " + from + " to " + to);
} else {
// Move topN-1 disks from source to auxiliary
doTowers(topN: topN - 1, from, to, inter);
// Move the largest disk from source to destination
Debug
MagicNumberCheck
Knapsack
MainClass
Threads & Variables
Console
C:\Users\Hetvi\.jdks\corretto-1.8.0_402\bin\java.exe ...
Connected to the target VM, address: '127.0.0.1:51402', transport: 'socket'
Disk 1 from A to C
Disk 2 from A to B
Disk 1 from C to B
Disk 3 from A to C
Disk 1 from B to A
Disk 2 from B to C
Disk 1 from A to C
Disconnected from the target VM, address: '127.0.0.1:51402', transport: 'socket'
Process finished with exit code 0

Que3 : Static analysis tool (SpotBugs)

Error code:



Correctness:



Multithreaded correctness: