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Data Structures and Algorithms

ICS 1018

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Should there be any issue accessing the code that accompanied this document you can find a copy of the code on https://github.com/Sean-Powell/DataStructureAndAlgorithmsAssignment

# Question 1:

In question one a list from 1 to 1024 was taken. First using the properties of the multiplication matrix and the fact that after the leading diagonal the numbers are repeated. So, the number of numbers can be reduced from 1024^2 which is 1,048,576 to the summation of 1 to 1023 which has a value of 523,776. This simple optimization manages to remove 524,800 numbers which is over half the search space.

An object called a multinumber was defined this object stores the 2 factors of the number and the product of the number. A list is created using the above defined optimization. This list is then sorted using merge sort (n log n) using the product as the factor to be sorted by. This groups all the products that are the same together, thus allowing us to only search this block of numbers to find the different factors that can make up that product. This allows us to search a vastly smaller search space than if we had to search the entire list every time.

This can be achieved by after obtaining the sorted tree first we find the index that the block of new products starts at, then find the index where the last number of that block is found. The space in between these two indexes are then searched for the different factors that can be used to get to that product. If a match is found the result is outputted to the console. When the block is being searched the search is only on the indexes in the block that are greater than itself as if the elements index is less than the element being checked currently then this comparison has already been made when the block with the lower index was being checked.

### Testing:

Since the large size of the output of this method, I have uploaded a copy of the outputs to both my github and included a text file copy on the disk. The file might not open in notepad as it is 7MB. When ran the program found 264,206 pairs and took 23 seconds to do it.

# Question 2:

Question two first prompts the user to enter an equation in RPN format. The user inputted string the elements in the string are separated via a space between each element. If the element is a number, then it is added to the stack. If the element is a +, -, \* or / then the last 2 elements on the stack are popped off. If the operation is a subtraction or a division then the elements are switched. The respective operation is then preformed on the two element the result is then added back to the stack. This is repeated until the end of the user inputted expression is reached. If at any point there are not enough elements on the stack to preform an operation or there is more than one number on the stack at the end of user inputted equation being process, then the equation is said to be invalid. Otherwise at the end of the expression the answer is displayed, and the equation is said to be valid. At every step of the process the state of the stack is outputted to the console.

## Testing:

The rpn expression “ 5 5 \* 26 2 / + 10 + 22 2 \* -“ was entered into the program. The output was the following

|  |
| --- |
| 5 5 \* 26 2 / + 10 + 22 2 \* -  [5.0]  [5.0, 5.0]  Multiplication:  [25.0]  [25.0, 26.0]  [25.0, 26.0, 2.0]  Division:  [25.0, 13.0]  Addition:  [38.0]  [38.0, 10.0]  Addition:  [48.0]  [48.0, 22.0]  [48.0, 22.0, 2.0]  Multiplication:  [48.0, 44.0]  Subtraction:  [4.0]  The Equation is valid |

An invalid expression of “5 5 \* -“ was then tried with the following output

|  |
| --- |
| [5.0]  [5.0, 5.0]  Multiplication:  [25.0]  The Equation is invalid |

# Question 3:

The fact that if a number is a factor of the number that we are checking to be prime will be equal to or less than the square root allows us to only check up to and including the square root to further optimize this function to find a prime number.

First the user is prompted to enter either 1 or 2. If the user enters 1 then the method that checks if a number is prime or not. It does this by first calculating the square root of the number then rounds the number up if it Is not an integer. After this it looks through all the numbers from 2 up to the square root checking if the numbers are a factor of the number being checked. After it gets to the number 11 it uses the optimization defined below to further improve the efficiency of the function. If it finds that none of the number up to and including the square root is a factor, then is returns true. If it does locate a factor, then it returns false.

## Optimization:

After it gets to the number 11 its starts alternating in adding 2,3,2 to the number. This is because after the number 11, all the even numbers and the multiples of 5 can be skipped. This is achieved by using a size 3 array holding 1,2,1. The code that looped through this is shown below, the j is incremented outside the method itself. When j == 3 it is reset back to 0 to stop an array out of bounds exception.

|  |
| --- |
| **private int[] additionAmount = {1, 2, 1};**  **private int addAmount(){**  **if(j == 3){**  **j = 0;**  **}**  **return additionAmount[j];**  **}** |

If the user inputs a 2 then the program executes the sieve of Eratosthenes. This method first creates a scanner object reading from System.in it then prompts the user on what number they want to run the sieve up to. This will loop up until the user enters a number that is greater than 0. The square root is then calculated and rounded up in the case that it is not an integer. The method then populates a list of numbers from 2 all the way up until n. This also uses the addAmount method as outlined above to reduce the numbers in the list. The method then loops through from 2 through till the number it retrieves from the list is greater than the square root. If it is less then it goes through the list checking if that number is a factor, of any number in the list. If it is a factor, then the number that it is a factor of it will be removed. After it has gone through all the numbers less than the square root it then prints the list with 4 numbers on every line. This printing is in a try catch block so that if there are not 4 numbers in the list left to be printed it won't crash and will only print the amount that is left and will create a new line at the end.

There is also the check that if the current index is >= to the length of the list then it will exit the loop. This stops the program from suffering from an out of bounds exception in the case that the user inputted the upper limit of 2 for the sieve. Since it the list starts at 0 the last element in the list will be 1. However, the square root of 2 is still 2 so this would cause the function to try access index 2 of the array, thus causing the exception.

## Testing:

First the number 10 was checked if it is prime. The program outputted “false” indicating 10 is not prime. The number 5 was then checked. The program outputted true. Indicating that 5 is prime. The sieve of Eratosthenes was then run up to the number 100 the program then outputted the following prime numbers.

|  |
| --- |
| 2, 3, 5, 7,  11, 13, 17, 19,  23, 29, 31, 37,  41, 43, 47, 53,  59, 61, 67, 71,  73, 79, 83, 89,  97, |

# Question 4:

The user is first prompted to enter either 1 to add numbers to the Binary Search Tree(BST) or 2 to search the BST to see if the user inputted number can be found within the tree.

If 1 is selected the program prompts the user to input a number, the first number the user inputs will serve as the root node for the BST. After this each time the user enters a new number, the BST will be traversed, and a new node is created for the new number and inputted in the correct location. If the number is greater than equal to the number currently stored in the node it will traverse to the right otherwise it will traverse to the left. This will loop until the user enters a none integer value to exit the input loop.

If the user inputs 2 the program will prompt the user to input an integer and will then traverse through the tree checking each node if the data stored within it is a match to the data value being searched for. This is managed in a recursive manner with the following function.

|  |
| --- |
| **private boolean findNode(int \_input, Node \_nodeBeingChecked){**  **if(\_nodeBeingChecked == null){//checks if node being checked is equal to null**  **return false;**  **}else if(\_input == \_nodeBeingChecked.getData()){**  **//checks if the nodes data is equal to the search**  **return true;**  **}else{**  **//the traversals also check if the node that is being traversed to are equal to null.**  **//If they are the data is not in the tree.**  **if(\_nodeBeingChecked.getData() >= \_input) { //traverse to the right**  **return \_nodeBeingChecked.getRightNode() != null &&**  **findNode(\_input, \_nodeBeingChecked.getRightNode());**  **}else{//otherwise it will traverse to the left**  **return \_nodeBeingChecked.getLeftNode() != null &&**  **findNode(\_input, \_nodeBeingChecked.getLeftNode());**  **}**  **}**  **}** |

The node is defined as follows, A Node rightNode and a Node leftNode both storing the respective object for both the left and right node this is set to null if there is no node. There is also the Data element that holds the integer value of that node in the BST.

When the user finally enters -1 to exit the question the tree is displayed using the output:

“Data: X Left Node: Y Right Node Z”

With X being the data from the current node, Y being the data from the left node and Z being the data from the right node. This method uses recursion to display the whole tree. Y and Z being set within the method if there is a node in that location if not the method will output null instead of a data value.

## Testing:

The numbers 12, 25, 4, 3, 6, 7, 20, 100 were added to the tree in that order and then the tree was outputted.

The program was also queried to see if numbers 10 and 12 were in the list. The program outputted

“A node with that data could not be found in the tree” and “There is a node in the tree with that data” respectively.

When the method was exited it displayed the data in the tree, which was the following.

|  |
| --- |
| Data: 12 Left Node: 4 Right node: 25  Data: 4 Left Node: 3 Right node: 6  Data: 3 Left Node: null Right node: null  Data: 6 Left Node: null Right node: 7  Data: 7 Left Node: null Right node: null  Data: 25 Left Node: 20 Right node: 100  Data: 20 Left Node: null Right node: null  Data: 100 Left Node: null Right node: null |

# Question 5:

This uses the Babylonian method for computing the square root of a number. The user is prompted to input the number that they want the square root to be approximated for. They are then further prompted to input the degrees of accuracy they want to achieve. The Babylonian method is then started with this data, first the square root is guessed to be half the original number. The same line is then looped to the number of iterations as required by the user this uses the following code.

|  |
| --- |
| **for(int i = 0; i < \_iterations; i++){**  **ans = (ans + (\_number / ans)) \* 0.5;**  **}** |

After this loop is completed the final answer is returned and then it is outputted to the user.

## Testing:

The program was tested using the number 627 and 6 iterations. The program resulted in the approximate square root of “25.041717838356103” using the windows calculator resulted in “25.03996805109783” Showing a low about of error, this error can mostly be removed by doing more iterations. The number was once again run using 12 iterations with the following result “25.03996805109783” which resulted in the same number as the windows calculator.

# Question 6:

This function takes a list of integers to be checked for duplicate numbers. This is achieved by first hashing the integer using SHA-256 this is then checked to see if there is a collision in the list of hashes. If there Is a collision the integer that was hashed to obtain this hash is added to the list of duplicate numbers otherwise the hash is added to the list of hashes. Finally, the list of duplicate numbers is outputted.

Hashing is used since the list of integers does not change then in this case the hashing function can be considered O(1). With the overall efficiency of this method being O(nk) with n size being the size of the list of integers to be inputted and k being the number of unique numbers in the list.

## Testing:

Numbers “5, 7, 12, 32, 45, 6, 7, 1, 5” were added to the list. The numbers, “7,5” were said to be duplicate numbers. The method was the ran again with the inputs “1,2,3,4,5” it outputted an empty list indicating that there are no duplicate numbers.

# Question 7:

This function first takes an input ArrayList of integers into the function then recursively finds the largest number. It does this by first checking the length of the ArrayList that is passed to the method, if the list is of size 1 then then number is returned. If it is not then the first number is stored in num1 then it is removed from the list, the new list is then passed recursively to the method. This repeats until the above base case is reached. Once it is reached the number returned from the recursive method is stored in num2. Num1 and num2 are then compared and the largest integer out of them is returned. In the case that the numbers are the same then num2 is returned. Eventually when all the recursive calls have been handled the original method that was called will return the largest number in the list that was passed to it.

## Testing:

The list of integers “65, 23, 43, 1, 124, 2, 3, 5, 6, 7, 8, 3, 2, 3, 56” was inputted. The program outputted that 124 was the largest number.

# Question 8:

This method requires the user to input the degree of the angle in radians, then the user is requested to input the degree of accuracy they would like to calculate. Finally, the user is prompted on if they want to run the cosine or sine expansion. The program then calculates either cosine or sine respectively with the following code \_radians being the angle and \_degrees being the degrees of accuracy required. \_degrees being the degrees of accuracy requested by the user. The answer in the form of a double is returned to the user.

|  |
| --- |
| double cosExpansion(double \_radians, int \_degrees){  double ans = 0;  for(int i = 0; i < \_degrees; i++){  if(i == 0){  ans = 1;  }else {  ans += (Math.pow(-1, i) \* Math.pow(\_radians, 2 \* i)) / factIt(2 \* i);  }  }  return ans;  }  double sinExpansion(double \_radians, int \_degrees){  double ans = 0;  for(int i = 0; i < \_degrees; i++){  if(i == 0){  ans = \_radians;  }else{  ans += (Math.pow(-1, i) \* Math.pow(\_radians, (2 \* i) + 1) / factIt((2 \* i) + 1));  }  }  return ans;  } |

factIt is an iterative method for calculating the factorial of a number as shown below.

|  |
| --- |
| private long factIt(int x){  long ans = 1;  while(x >= 1){  ans = ans \* x;  x--;  }  return ans;  } |

## Testing:

First the sine expansion was tested, using 0.61 radians and 6 degrees of expansion the result of this expansion was “0.5729” this was the repeated using the same values expect this time on the cosine expansion the result was “0.8196”

# Question 9:

This question prompts the user to input the degree that they wish to calculate up to. The method is done using both the BigInteger and an iterative approach to increase the degrees the program can calculate too. The BigInteger stops the overflow error from happening and the iterative approach to the method makes it so the method does not use too much memory during the calculation.

The method works such that both the current Fibonacci number and the previous one is set to 1 at the start. The current one is set equal to a temp variable and then the old one is added to the new one and the old one is set to the value store in the temp variable. This loops for n-2 times with n being the amount of degrees of accuracy required with as the first two degrees are 1. After the method has calculated the number the number is then outputted to the user.

## Testing:

The program was asked to calculate the 150th degree of Fibonacci sequence. The resulting output was: 9969216677189303386214405760200 This appears to be correct as I checked it with <https://www.bigprimes.net/archive/fibonacci/150/> There does not appear to be a visible upper limit to the calculation. The 500,000,000 million Fibonacci sequence was attempted to be calculated and it did not give an error just was terminated for time constraints.

# Run Class:

The run class that is run when the program is first called it has a while loop that runs until the user inputs -1, otherwise it will prompt the user which of the above questions they want to run prompting them to input from 1 to 9. If the user inputs anything other than this the program will notify the user that they have inputted an invalid input. This class then manages some user input and the calling of the different classes to run the respective questions. The class also contains the method responsible for allowing string input.

# Code Listing:

## Question 1:

PairMatrix class:

|  |
| --- |
| import java.util.ArrayList;  class PairMatrix {  private ArrayList<MultiNumber> LIST;  private MergeSort MS = new MergeSort();//creates an instance of the Mergesort class  private int pairsFound;//Counter for holding the number of pairs found  void start() {  final int listSize = 1024; //stores the size of the list  pairsFound = 0;//Sets the pairsFound counter to 0  LIST = new ArrayList<>();//creates the list that will be populated with the total list of products and factors  long start = System.currentTimeMillis();//gets the time the operation starts  populateList(listSize);//creates the list of products and factors and stores them in the above list  findPairs();//finds the pairs of numbers and outputs them.  System.out.println("Pairs Found: " + pairsFound); //outputs the number of pairs found  long end = System.currentTimeMillis(); //finds the time the operation ended at  System.out.printf("Time taken: %d\n", ((end - start) / 1000)); //outputs the time it took in seconds to finish  }  private void populateList(int \_listSize) {  /\*  1  1 2  1 2 3  1 2 3 4  1 2 3 4 5  On line n after the nth element in that line the products are then repeated. We can use this fact to reduce  the number of products to be checked from 1024^2 to the summation of 1 to 1024  \*/  for (int i = 0; i < \_listSize; i++) {  for (int j = 0; j <= (i - 1); j++) {  MultiNumber num = new MultiNumber((i + 1), (j + 1), ((i + 1) \* (j + 1)));  LIST.add(num);  }  }  }  private boolean checkFactors(MultiNumber \_num1, MultiNumber \_num2) {//returns false if they match  //Gets and stores the 4 factors.  int factor1, factor2, factor3, factor4;  factor1 = \_num1.getFactor1();  factor2 = \_num1.getFactor2();  factor3 = \_num2.getFactor1();  factor4 = \_num2.getFactor2();  //compares all the factors to make sure none of them match  return factor1 != factor2 && factor1 != factor3 && factor1 != factor4 && factor2 != factor3 &&  factor2 != factor4 && factor3 != factor4;  }  //find first num of same num  //find last num of that num;  //Check for pairs between the 2 found index  //print pairs  private void findPairs() {  /\*  Sorting the list with MergeSort first allows us to further optimise the process via, finding the block of products  that are the same, allows the process to search only against that block of products instead of the entire list of products  this drastically  \*/  LIST = MS.mergeSort(LIST); //This sorts the list using MergeSort.  //LIST.sort(Comparator.comparingInt(MultiNumber::getProduct)); //This was previously used however default search methods are not allowed  int firstNumIndex, lastNumIndex = 0, currentNum = 0; //Variables to hold the first and final index of the block and the blocks value  MultiNumber num1, num2;// variables for holding the two MultiNumber objects being compared to reduce ArrayList calls.  int i = 0;  try {//it is surrounded by a try catch block to catch any potential errors that can occur during the logic the  //exception is then ignored.  while (i < LIST.size()) {//loop through till the end of the list  /\*  checks if the currents numbers product is different from the one stored in currentNum  this is always the case the first time as the number is set to 0  \*/  if (LIST.get(i).getProduct() != currentNum) {  firstNumIndex = i;//the index at which the new block of numbers starts  lastNumIndex = i;//the index at which the block ends it is assumed to be the same as the start  /\*  The list is then incremented until there is an different number at the lastNumIndex + 1  if the number is the same the lastNumIndex is incremented. This is surrounded in a try catch block  in case when incrementing the new index is out of the ArrayLists bounds. This exception is ignored.  \*/  try {  if (LIST.get(lastNumIndex + 1).getProduct() == currentNum) {  lastNumIndex++;  }  } catch (Exception ignore) {  }  /\*  The program then loops through this block trying all the combinations against each other to see if  the possible pairs match the criteria. If it does match the criteria then it prints out the output to  the console.  \*/  for (int j = firstNumIndex; j <= lastNumIndex; j++) {  num1 = LIST.get(j);//The number is stored here to reduce access requests to the list  //the (-1 \* (firstNumIndex - j)) is for increasing the starting index so previous comparisons are  //not made again  for (int k = firstNumIndex + (-1 \* (firstNumIndex - j)); k <= lastNumIndex; k++) {  if (j == k && (k + 1) > lastNumIndex) {  k++;  }  num2 = LIST.get(k);  if (checkFactors(num1, num2) && num1.getProduct() == num2.getProduct()) {  System.out.println("(" + num1.getFactor1() + "\*" + num1.getFactor2() + ")and(" +  num2.getFactor1() + "\*" + num2.getFactor2() + ")" + " = " +  num1.getProduct());  pairsFound++;  }  }  }  }  i = lastNumIndex;//This sets i to the lastNumIndex, so as not to recheck part of a number block  i++;//i is then incremented.  }  } catch (Exception ignore) {  }  }  } |

MultiNumber Object:

|  |
| --- |
| class MultiNumber {  /\*  This is a object that is used in the PairMatrix class. It stores the product of two numbers as well as its two factors  it also has 3 methods defined to return both the factors and the product. When creating a new MultiNumber then you need  to pass both the factors and the resultant product.  \*/  private int factor1;  private int factor2;  private int product;  MultiNumber(int \_factor1, int \_factor2, int \_product){  factor1 = \_factor1;  factor2 = \_factor2;  product = \_product;  }  int getFactor1(){  return factor1;  }  int getFactor2(){  return factor2;  }  int getProduct(){  return product;  }  } |

MergeSort class:

|  |
| --- |
| import java.util.ArrayList;  /\*  This is a merge sort implementation that is made to sort through the products in the MultiNumber arrays that are passed  to it.  \*/  class MergeSort {  ArrayList<MultiNumber> mergeSort(ArrayList<MultiNumber> \_list){  //assert \_list != null;  if(\_list.size() <= 1){  return \_list;  }  int halfSize = (int) Math.ceil(\_list.size() / 2);  ArrayList<MultiNumber> leftSide = new ArrayList<>();  ArrayList<MultiNumber> rightSide = new ArrayList<>();  int currentNumIndex = 0;  for (MultiNumber aList : \_list) {  if (currentNumIndex < halfSize) {  leftSide.add(aList);  currentNumIndex++;  } else {  rightSide.add(aList);  }  }  leftSide = mergeSort(leftSide);  rightSide = mergeSort(rightSide);  return mergeLists(leftSide, rightSide);  }  private ArrayList<MultiNumber> mergeLists(ArrayList<MultiNumber> \_list1, ArrayList<MultiNumber> \_list2){  //assert \_list1 != null && \_list2 != null;  ArrayList<MultiNumber> result = new ArrayList<>();  while(!\_list1.isEmpty() && !\_list2.isEmpty()){  //MultiNumber num1 = \_list1.get(0);  //MultiNumber num2 = \_list2.get(0);  if(\_list1.get(0).getProduct() < \_list2.get(0).getProduct()){  result.add(\_list1.get(0));  \_list1.remove(0);  }else{  result.add(\_list2.get(0));  \_list2.remove(0);  }  }  while(!\_list1.isEmpty()){  result.add(\_list1.get(0));  \_list1.remove(0);  }  while(!\_list2.isEmpty()){  result.add(\_list2.get(0));  \_list2.remove(0);  }  return result;  }  } |

## Question 2:

RPNCalc class:

|  |
| --- |
| import java.util.Stack;  class RPNCalc {  private String input;//inputs are separated via spaces  private Stack<Double> stack = new Stack<>();  void SetInput(String \_newInput) {  /\*  Sets the input that the user inputted to the calculator, also checks if the input has been set to null as the  method that gets the user input can pass null to this function if an error occurs.  \*/  assert \_newInput != null;  input = \_newInput;  }  boolean validateInput(){  /\*  This method first splits the input into different elements with a regex of " " this list is then processed, if  the method finds a + - / \* then it will remove the top two numbers from the stack preform the respective operation  on these two number then will add the answer back onto the stack. If the element is not an operation symbol then  it is added to the stack. This function is surrounded in a try catch block as various errors can occur during  the processing. The main on being that there was an invalid input entered and when an operation was attempted there  was not two numbers on the stack to preform an operation on. This method will return false if there is any error  or by the end of the input there is more than one element on the stack. If there is only one element on the stack  Then the method will return true as the input was a valid RPN formula.  \*/  String[] splitInput = input.split(" ");  try {  for (String aSplitInput : splitInput) {  switch (aSplitInput) {  case "+":  stack.push(stack.pop() + stack.pop());  System.out.println("Addition:");  System.out.println(stack.toString());  break;  case "-":  double secondNum = stack.pop();  double firstNum = stack.pop();  System.out.println("Subtraction:");  stack.push(firstNum - secondNum);  System.out.println(stack.toString());  break;  case "\*":  stack.push(stack.pop() \* stack.pop());  System.out.println("Multiplication:");  System.out.println(stack.toString());  break;  case "/":  secondNum = stack.pop();  firstNum = stack.pop();  System.out.println("Division:");  stack.push(firstNum / secondNum);  System.out.println(stack.toString());  break;  default:  double temp = Integer.parseInt(aSplitInput);  stack.push(temp);  System.out.println(stack.toString());  break;  }  }  stack.pop();  return stack.empty();  }catch (Exception e){  return false;  }  }  } |

## Question 3:

PrimeNumbers Class:

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| import java.util.ArrayList;  import java.util.Scanner;  class PrimeNumbers {  /\*  //This is an array of numbers that is the difference between the 1,3,7,9 after the number 11. This save both memory  and processing time as it removes all the numbers that are even or divisible by 5  \*/  private int[] additionAmount = {1, 2, 1};  private int j;//stores which element in the additionalAmount array is next to be used.  private int addAmount(){  /\*  This method when called will return the correct amount from the additionalAmount array,  it also resets j back to 0 when it reaches 3 this stops an arrayOutOfBoundsException from happening.  \*/  if(j == 3){  j = 0;  }  return additionAmount[j];  }  Boolean isPrime(int \_x) {  /\*  This method takes an input integer from the user \_x. The square root of the number that was inputted and then  rounded up. The method then checks if the input is dividable with no remainder by the current number. If the number  is less than the square root but greater than 11. Then the addAmount method that was outlined above. If the method  finds a factor it will return false if it reaches the end of the for loop without finding any factors then it will  return true  \*/  j = 0;  int sqr = (int) Math.ceil(Math.sqrt(\_x));  for (int i = 2; i <= sqr; i++) {  if (\_x % i == 0) {  return false;  }  if (i >= 11) {  i += addAmount();  }  }  return true;  }  void sieve() {  /\*  This method first creates a scanner object reading from System.in it then prompts the user on what number they  want to run the sieve up to. This will loop up until the user enters a number that is greater than 0  The square root is then calculated and rounded up in the case that it is not an integer. The method then populates  a list of numbers from 2 all the way up until n. This also uses the addAmount method as outlined above to reduce  the numbers in the list. The method then loops through from 2 through till the number it retrieves from the list  is greater than the square root. If it is less then it goes through the list checking if that number is a factor  of any number in the list. If it is a factor then the the number that it is a factor of it removed. After it has  gone through all the number less than the square root it then prints the list with 4 numbers on every line.  This printing is in a try catch block so that if there is not 4 numbers in the list left to be printed it won't crash  and will only print the amount that is left and will create a new line at the end.  \*/  int n;  j = 0;  Scanner scan = new Scanner(System.in);  while (true) {  System.out.println("Please input the n you wish to go to");  n = scan.nextInt();  if (n > 0) {  break;  }  }  int sqrtN = (int) Math.ceil(Math.sqrt(n));  boolean end;  //Populate listOfPrimes up to including n;  ArrayList<Integer> listOfPrimes = new ArrayList<>();  for (int i = 2; i <= n; i++) {  listOfPrimes.add(i);  if (i >= 11) {  i += addAmount();  }  }  for (int i = 0; i < sqrtN; i++) {  if (i >= listOfPrimes.size()) {  /\*this stops the program from throwing an error in the cases where the square root of the number is larger than the size of the list  Since the list starts at 2 if the user was to input the upper limit is 2 then, the list will be 1 size and the square root will be 1  but since the array starts from 0 there is gonna be two access requests with the latter one causing an out of bounds exception.  \*/  i = sqrtN + 1;  } else {  if (listOfPrimes.get(i) <= sqrtN) {  j = 0;  int divisor = listOfPrimes.get(i);  end = true;  while (end) {  try {  if (listOfPrimes.get(j) % divisor == 0 && listOfPrimes.get(j) != divisor) {  listOfPrimes.remove(j);  }  j++;  } catch (Exception e) {  end = false;  }  }  }  }  }  for (int i = 0; i < listOfPrimes.size(); i = i + 4) {  try {  System.out.print(listOfPrimes.get(i) + ", ");  System.out.print(listOfPrimes.get(i + 1) + ", ");  System.out.print(listOfPrimes.get(i + 2) + ", ");  System.out.println(listOfPrimes.get(i + 3) + ", ");  } catch (Exception e) {  System.out.println();  break;  }  }  }  } |

## Question 4:

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| import java.util.Scanner;  class BinaryTree {  private Scanner scan = new Scanner(System.in);  private boolean firstNode = true;  private Node rootNode = null;  void start() {  boolean run = true;  while (run) {  try {  System.out.println("Enter 1 to add to the tree, Enter 2 to find if a number is in the tree. -1 to quit");  int input = scan.nextInt();  switch (input) {  case 1:  System.out.println("Enter anything other than a number to stop entering numbers");  while (true) {  try {  System.out.println("Enter an integer: ");  addNode(scan.nextInt());  } catch (Exception ignore) {  scan = null;  scan = new Scanner(System.in);  break;  }  }  break;  case 2:  System.out.println("Enter the number you wish to find in the list");  input = scan.nextInt();  if (findNode(input, rootNode)) {  System.out.println("There is a node in the tree with that data");  } else {  System.out.println("A node with that data could not be found in the tree");  }  break;  case -1:  printTree(rootNode);  run = false;  break;  default:  System.out.println("invalid input");  }  } catch (Exception ignore) {  scan = null;  scan = new Scanner(System.in);  }  }  }  private boolean findNode(int \_input, Node \_nodeBeingChecked) {  if (\_nodeBeingChecked == null) {//checks if node being checked is equal to null  return false;  } else if (\_input == \_nodeBeingChecked.getData()) {//checks if the nodes data is equal to the search  return true;  } else {//the traversals also check if the node that is being traversed to are equal to null. If they are the data is not in the tree.  if (\_nodeBeingChecked.getData() >= \_input) { //if the data is larger than the input it will traverse to the right  return \_nodeBeingChecked.getRightNode() != null && findNode(\_input, \_nodeBeingChecked.getRightNode());  } else {//otherwise it will traverse to the left  return \_nodeBeingChecked.getLeftNode() != null && findNode(\_input, \_nodeBeingChecked.getLeftNode());  }  }  }  private void printTree(Node \_node) {  if (\_node == null) {  return;  }  System.out.print("Data: " + \_node.getData() + " Left Node: ");  if (\_node.getLeftNode() != null) {  System.out.print(\_node.getLeftNode().getData());  } else {  System.out.print("null");  }  System.out.print(" Right node: ");  if (\_node.getRightNode() != null) {  System.out.print(\_node.getRightNode().getData());  } else {  System.out.print("null");  }  System.out.println();  printTree(\_node.getLeftNode());  printTree(\_node.getRightNode());  }  private void addLeftNode(Node \_oldNode, int \_data) {  if (\_oldNode.getLeftNode() != null) {  Node leftNode = \_oldNode.getLeftNode();  if (\_data >= leftNode.getData()) {  addRightNode(leftNode, \_data);  } else {  addLeftNode(leftNode, \_data);  }  } else {  \_oldNode.setLeftNode(new Node(\_data, null, null));  }  }  private void addRightNode(Node \_oldNode, int \_data) {  if (\_oldNode.getRightNode() != null) {  Node rightNode = \_oldNode.getRightNode();  if (\_data >= rightNode.getData()) {  addRightNode(rightNode, \_data);  } else {  addLeftNode(rightNode, \_data);  }  } else {  \_oldNode.setRightNode(new Node(\_data, null, null));  }  }  private void addNode(int \_input) {  if (firstNode) {  firstNode = false;  rootNode = new Node(\_input, null, null);  } else {  if (\_input >= rootNode.getData()) {  addRightNode(rootNode, \_input);  } else {  addLeftNode(rootNode, \_input);  }  }  }  } |

Node Object:

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| class Node {  /\*  This is the method that outlines the behaviour of the node for the BinaryTree. Each node has references to two more  nodes, a right node and a left node. It also stores a data value. When creating a new node you need to pass the data  and information on the left and right node if these nodes do not exist then it should be set to null. There is also  methods that have been defined to get the left and right node and the data that is stored in the node. There is also  the methods for setting the right and left node.  \*/  private Node leftNode;  private Node rightNode;  private int data;  Node(int \_data, Node \_leftNode, Node \_rightNode){  data = \_data;  rightNode = \_rightNode;  leftNode = \_leftNode;  }  void setLeftNode(Node \_node){  leftNode = \_node;  }  void setRightNode(Node \_node){  rightNode = \_node;  }  Node getLeftNode(){  return leftNode;  }  Node getRightNode(){  return rightNode;  }  int getData(){  return data;  }  } |

## Question 5:

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| class BabMethod {  /\*  This method first halves the number that the user inputted as the first guess for the square root. The runs the  method for getting closer to the actual value by the number of iterations the user requested be run.  \*/  double approximate(int \_number, int \_iterations){  double ans = \_number / 2;//first guess  for(int i = 0; i < \_iterations; i++){ //runs for how many iterations the user requested  ans = (ans + (\_number / ans)) \* 0.5;  }  return ans;//returns the answer  }  } |

## Question 6:

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| import java.nio.charset.StandardCharsets;  import java.security.MessageDigest;  import java.security.NoSuchAlgorithmException;  import java.util.ArrayList;  import java.util.Arrays;  import java.util.Scanner;  class DuplicateNumbers {  private Scanner scan = new Scanner(System.in);  /\*  Change this method to use a hashing function to see if numbers appear multiple times in the list.  \*/  void findDuplicatesHash(ArrayList<Integer> \_list){  ArrayList<byte[]> hashList = new ArrayList<>();  ArrayList<Integer> duplicateNumbers = new ArrayList<>();  try{  MessageDigest messageDigest = MessageDigest.getInstance("SHA-256");  boolean found;  for (Integer a\_list : \_list) {  byte[] hash = messageDigest.digest(a\_list.toString().getBytes(StandardCharsets.UTF\_8));  found = false;  for (byte[] aHashList : hashList) {  if (Arrays.equals(hash, aHashList)) {  found = true;  }  }  if (found) {  duplicateNumbers.add(a\_list);  } else {  hashList.add(hash);  }  }  System.out.println(duplicateNumbers.toString());  }catch(NoSuchAlgorithmException e){  e.printStackTrace();  }  }  /\*  This method prompts the user to enter numbers to populate the list of numbers that will be checked for unique numbers  this will once again loop until the user enters a input that is not a number.  \*/  ArrayList<Integer> popList(){  ArrayList<Integer> list = new ArrayList<>();  while (true){  try{  System.out.println("Enter a number to add to the list, enter any thing other than a number to stop");  list.add(scan.nextInt());  }catch(Exception e){  return list;  }  }  }  } |

## Question 7:

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| import java.util.ArrayList;  import java.util.Scanner;  class HighestInt {  /\*  This method is called so that the user can input the numbers to the list that they want to check. It will loop until  the user inputs anything other than a number.  \*/  ArrayList<Integer> populateList(){  ArrayList<Integer> list = new ArrayList<>();  Scanner scan = new Scanner(System.in);  while(true){  try{  System.out.println("Enter a number to add it to the list, enter anything other than a number to quit");  list.add(scan.nextInt());  }catch (Exception e){  return list;  }  }  }  /\*  This method recursively checks a list for the largest number that is in it. It does this by recursively calling itself  working its way down the list till it is at the last element. It then returns this number. Then as it goes back through  its calls it will check the number that, that specific call removed from the list. The method will return the largest  of these two numbers.  \*/  int largestInt(ArrayList<Integer> \_list){  if(\_list.size() == 1){  return \_list.get(0);  }else{  int num1 = \_list.get(0);  \_list.remove(0);  int num2 = largestInt(\_list);  if(num1 > num2){  return num1;  }else{  return num2;  }  }  }  } |

## Question 8:

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| public class Expansion {  double cosExpansion(double \_x, int \_y){  double ans = 0;  for(int i = 0; i < \_y; i++){  if(i == 0){  ans = 1;  }else {  ans += (Math.pow(-1, i) \* Math.pow(\_x, 2 \* i)) / factIt(2 \* i);  }  }  return ans;  }  double sinExpansion(double \_x, int \_y){  double ans = 0;  for(int i = 0; i < \_y; i++){  if(i == 0){  ans = \_x;  }else{  ans += (Math.pow(-1, i) \* Math.pow(\_x, (2 \* i) + 1) / factIt((2 \* i) + 1));  }  }  return ans;  }  private long factIt(int x){  long ans = 1;  while(x >= 1){  ans = ans \* x;  x--;  }  return ans;  }  } |

## Question 9:

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| import java.math.BigInteger;  public class FibSequence {  /\*  The method iteratively loops through calculating the fibonacci sequence up to the degree that the user desires.  \*/  BigInteger fibonacci(long \_n){  BigInteger oldFib = BigInteger.valueOf(1);  BigInteger fibValue = BigInteger.valueOf(1);  BigInteger temp;  for(long i = 0; i < (\_n - 2); i++){  temp = fibValue;  fibValue = fibValue.add(oldFib);  oldFib = temp;  }  return fibValue;  }  } |