CS 202

Design and Analysis of Algorithms

Assignment 1

[Question 1] Java Code Explanations

You are assigned the task of understanding, explaining, and documenting a chunk of legacy code written in Java.

```
public class Choose{

  // generate all r-elements subset from the array e
  // which contians n elements. The r-elements subset
  // is stored in array a.

  public static int e[], n;
  public static int a[], r;
  public static void process(int a[]){
    for (int i=0; i<a.length; i++)
      System.out.print(a[i]+" ");
    System.out.println();
  }

  public static void choose(int b, int c){
    // choose c+1 elements out of b..n-1
    if (c<0) process(a);
    else
      for (int i=b; i<n-c; i++){
        a[c]=e[i];
        choose(i+1,c-1);
      }
  }

  public static void main(String args[]){
    n = Integer.parseInt(args[0]);
    r = Integer.parseInt(args[1]);
    e = new int[n];
    a = new int[r];
    for (int i=0; i<n; i++) e[i] = i;
    choose(0, r-1)
  }
}
```

Function "choose" is implemented in a recursive way, please investigate how this function interacts with itself with a different set of parameters, and figure out the core logic. Next, you are expected to add some clear comments and explain what the function does at each main step. Third, draw a diagram with the input instance `n = 6` and `r = 3`, what are the expected outputs?

Please write your answer in a word document A1.docx, and keep your answer within 2 pages for this question.

[Question 2] The index of the combinations

Given a set of consecutive integers starting from 0, such as [0, 1, 2, 3, 4], and a specific combination of these integers, write a program that determines the index of this combination in the lexicographical sorted order of all combinations. The index should start from 0.

For example, given integer `n = 5`, and a specific combination `[2, 4, 0]`, the expected output is 4. Explanation: Since we have 3 elements in `[2, 4, 0]`, we should consider the index of `[2, 4, 0]` in all 3-element combinations from `[0, 1, 2, 3, 4]` (`n = 5` defines a set of 5 consecutive integers starting from 0). There are 10 3-element combinations of `[0, 1, 2, 3, 4]` in the lexicographical sorted order: {`[0, 1, 2]`, `[0, 1, 3]`, `[0, 1, 4]`, `[0, 2, 3]`, `[0, 2, 4]`, `[0, 3, 4]`, `[1, 2, 3]`, `[1, 2, 4]`, `[1, 3, 4]`, `[2, 3, 4]`}. The combination `[2, 4, 0]` is equivalent to combination `[0, 2, 4]`, therefore, its index is 4.

A test input starts with the number of index queries below, and each index query is described by one line that contains the value of *n* and a specific query combination. For the above example, the input would be "`5 2 4 0`" where 5 represents `n`, and "`2 4 0`" represents the query combination. One line of output is expected for each index query, and there are no leading or tailing whitespaces. The maximum value of `n` is `50` (`n ≤ 50`), and there is at least 1 element in the query combination. There will be 6 test inputs with 1 mark each, 2 additional marks are awarded if your code is implemented using recursion given that your code passes all 6 sets of test inputs. The remaining 2 marks are awarded with the correct justification of the time complexity of your algorithm, which you should specify it in the comment box when submitting on eLearn.

Your code should be submitted to the course's **online judge** for evaluation against the 5 additional test inputs, besides the sample input below.

Sample Input

```
10
5 2 4 0
5 1 3 2
8 2 4 0
8 1 3 2
3 2
4 1
5 4 3 1 2
8 7 2 6 1 3 5
9 5 0 7 3 8 6 1
10 8 3 9 0 7 4 5 2
```

Sample Output

```
4
6
7
21
2
1
4
24
19
31
```

[Question 3] Asymptotic Analysis

Using any of the techniques for solving recurrence in class, provide an asymptotic bound for *T(n)* for each of the following recurrences:

i. $T(n) = 12 \cdot T\left(\frac{n}{4}\right) + n^2$

ii. $T(n) = 3 \cdot T\left(\frac{n}{3}\right) + n \log n$

Please write your answer in the word document A1.docx, and keep your answer within 1 page for this question.