CS69001 Computing Laboratory – I

Practice Exercises: Set 1

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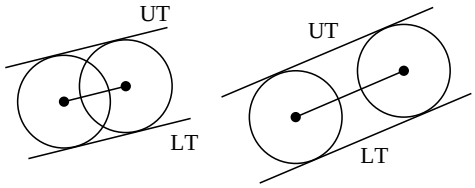
1. Propose a user-defined data type to represent a point in the two-dimensional plane. Write a function that, given three points A, B, C as input, returns the area of the triangle ABC.

2. Let C_1 and C_2 be two circles of the same radius r with centers at (c_1, d_1) and (c_2, d_2), respectively. Assume that $c_1 \neq c_2$ and $d_1 \neq d_2$. Write a program to compute the common upper and lower tangents to the circles.



3. Write an $O(n)$-time function that, given a positive integer n as input, finds and prints a narrowest interval $[i, j]$ such that $\sum_{r=i}^{j} \binom{n}{r} \geqslant 0.9 \times 2^n$. (**Hint:** Search around the center.)

4. *Catalan numbers* $C(n)$, $n \geqslant 0$, are defined recursively as follows.

$$\begin{aligned} C(0) &= 1, \\ C(n) &= C(0)C(n-1) + C(1)C(n-2) + C(2)C(n-3) + \cdots + C(n-1)C(0) \text{ for } n \geqslant 1. \end{aligned}$$

(a) Write a recursive function to return $C(n)$.

(b) Write a non-recursive function to return $C(n)$. **Note:** Use the given formulas for Catalan numbers. Do not use other formulas like $C(n) = \binom{2n}{n}/(n+1)$.

5. Write a function (may be recursive) to print the Gray code of length n. For example, for $n = 3$, you should print the following sequence of codewords: 000, 001, 011, 010, 110, 111, 101, 100.

6. Let $n \geqslant k \geqslant 0$ be integers. Write a recursive function to print all the k-element subsets of $\{1, 2, 3, \ldots, n\}$.

7. You are given an $n \times n$ matrix M and a $k \times k$ matrix P of bits for some $n \geqslant k \geqslant 0$. Write a function to find a $k \times k$ submatrix (contiguous) of M, which has the smallest Hamming distance with P.

8. Large integers like `3141592653589793238462643383279502884197169399375l` can be represented by a linked list of its digits (with the least significant digit at the beginning of the list).

(a) Write a function that reads a positive integer as a character string of decimal digits, and returns a linked list storing the number in the format mentioned above.

(b) Write a function to add two large integers in the above format.

(c) Write a function to multiply two large integers in the above format.

9. In a *circular linked list*, the next pointer of the last node points back to the first node in the list. Write a function that, given a circular linked list and a positive integer k, replaces the key at each node by the maximum of the next k elements in the list. For example, if the input list is $3, 1, 6, 2, 7, 4, 5, 2, 9, 8, 5, 2$, and $k = 3$, the list should be updated to $6, 7, 7, 7, 5, 9, 9, 9, 8, 5, 3, 6$. Notice that no new linked list is to be created. The existing list must be modified.

10. A file `input.txt` stores student records. The first line of the file stores the count n of students. This is followed by n lines, each storing a roll number (a string like `19CS60Z99`), the CGPA of the student (a real number like `8.76`), and finally the name of the student (may contain spaces). The three fields in each line are separated by one or more spaces (or tabs). Read the student records, sort the records based on student names, and write the sorted records to a file `output.txt` in the format `Name RollNo CGPA`. You may use any sorting algorithm.

11. Write a function to generate and print all those strings of length n over the alphabet $\{a, b, c\}$, in which no two consecutive symbols are the same. For example, your function should print *ababcba*, but not *ababcca*.

12. Write a function that given a month (in the range $[1-12]$), and a year (in the range $[1800-3000]$) prints the calendar of the given month of the given year in a 5×7 matrix. For example, the calendar of March 2019 would be printed as follows.

```
     March 2019
Su Mo Tu We Th Fr Sa
31                1  2
 3  4  5  6  7  8  9
10 11 12 13 14 15 16
17 18 19 20 21 22 23
24 25 26 27 28 29 30
```

13. You are given a list of dates as an array of strings. Sort the dates chronologically. Print the sorted list.

(a) The dates are provided in the EU format **`DD-MMM-YYYY`**, like **`17-Jul-2019`**.

(b) The dates are provided in the US format **`MMM DD, YYYY`**, like **`Jul 17, 2019`**.

14. You are given an $n \times n$ matrix M of integers.

(a) Sort each row of M in the ascending order.

(b) Sort each column of M in the descending order. (Will the rows remain sorted?)

(c) Write a function that, given an integer x, finds out whether x is an element of M. Assume that you have applied the sorting phases of Parts (a) and (b). Your program should run in $O(n)$ time.

15. **(a)** Build a stack S of integers. Write functions to implement the initialize, top, push, and pop operations for S.

(b) Use the stack operations to evaluate a postfix expression involving integer operands and the operators **`+`**, **`-`**, **`*`**, **`/`**, and **`%`**. For example, the postfix expression **`100 2 11 * 8 3 - / 5 + %`** evaluates to $100 \,\%\, ((2*11)/(8-3)+5) = 1$ (use integer arithmetic).