

Department of Computer Science and Engg.- NITK Surathkal
CS-700 Algorithms and Complexity

Assignment sheet- 1 Due Date: 4th September 2025

1. Large integers like 31415926535897932384626433832795028841971693993751 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.
2. 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.
3. 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.
4. Let $n \geq k \geq 0$ be integers. Write a recursive function to print all the k -element subsets of $\{1, 2, 3, \dots, n\}$.
5. You are given an $n \times n$ matrix M and a $k \times k$ matrix P of bits for some $n \geq k \geq 0$. Write a function to find a $k \times k$ submatrix (contiguous) of M , which has the smallest Hamming distance with P .
6. [Eight-Queens puzzle] You are given an 8×8 chessboard. Your task is to place eight queens on the board such that no queen can attack any other queen, that is, no two of the queens share the same row, column or diagonal (forward or backward). Generalize the problem to an $n \times n$ board.
7. You are given k sorted arrays A_1, A_2, \dots, A_k with a total of n elements. You are required to build an array B of size n by merging the k input arrays. You are allowed to use only $O(k)$ additional space (in addition to the arrays A_i and B). Your program should run in $O(n \log k)$ time. Use a min-priority queue to implement your algorithm. (Hint: At any point of time, the priority queue should store at most one element from each A_i .)
8. (a) A random binary tree T can be constructed as follows. Let n be the number of nodes in T . Randomly generate the numbers n_l and n_r of nodes in the left and right subtrees (so that $n = 1 + n_l + n_r$). Recursively build the left and the right subtrees, whichever is/are non-empty. Store random keys at the nodes.
(b) Let r be the root and v a leaf node in T . There is a unique r, v path $r = u_0, u_1, u_2, \dots, u_l = v$ in T . Let the key stored at node u_i be k_i . The alternating sum of these key values is $\text{altsum}(v) = k_0 - k_1 + k_2 - \dots + (-1)^l k_l$.
Write a function to print the alternating sums at all the leaf nodes in T .

9. A three-way search tree (3ST) is a rooted tree with each node storing two keys and three child pointers L, M, R. Let v be a node in the 3ST storing the keys k_1, k_2 . Let l (resp. m, r) be a key value stored in the left (resp. middle, right) subtree. We must have $l < k_1 < m < k_2 < r$.

(a) Write a function to search for a key in a 3ST.

(b) Write a function to insert a key in a 3ST.

10. Write a program to recognize balanced strings with the delimiters $\{\}\{\}\{\}$. For example, the string $\{(\{\})\}(\{\}\{\}\{\})\{\}$ is balanced. Two strings that are not balanced are $\{(\{\})\}(\{\}\{\}\{\})\{\}$ and $\{(\{\})\}(\{\}\{\}\{\})\{\}$. Use a stack.

10. Write a function that, given a graph $G = (V, E)$, finds and prints all the paths in G of length three. Your function should run in $O(|V|^4)$ time. Write the function for both the adjacency-matrix and the adjacency-list representations of G .

11. Given a Directed Graph with V vertices (Numbered from 0 to $V-1$) and E edges, check whether it contains any **cycle** or not.