2022

COMPUTER SCIENCE

PAPER-I

Time Allowed — 3 Hours *Full Marks — 200*

If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.

*Answers may be given either in **English** or in **Bengali** but all answers must be in one and same language.*

Answer *any five* questions.

1. (a) Suppose you have to give Rs. N to your friend. You have enough numbers of 500, 200, 100, 50, 20, 10 rupee notes each at your disposal. Your goal is to give Rs. N to your friend with minimum number of notes. For example, Rs. 600 can be changed 1 using three Rs. 200 notes as well as using one Rs. 500 note and one Rs. 100 note. However, the later one uses minimum number of notes.
   (i) Either prove correctness or provide counter example of the following greedy strategy: keep picking highest denomination as much as you can!
   (ii) Provide a set of denominations for which the above greedy strategy will fail.

   (b) There is a sequence of n activities $a_1, a_2, ..., a_n$ with corresponding utilities $u_1, u_2, ..., u_n$. You wish to perform all these n activities according to this sequence within k days. If you perform the activities from a_i to a_j for some $1 \le i \le j \le$ non the j-th day, then your utility U_i for the j-th day is $\max\{u_l : i \le l \le j\}$. Your total utility is $\sum_{l=1}^{k} U_l$. Design a greedy algorithm to find the sequence of activities you will perform on every day which maximizes your total utility.

   (c) A string s is called a sub-sequence of another string 't', if 's' can be obtained from 't' by deleting some symbols from s. Design a dynamic programming-based algorithm that finds the longest common sub-sequence of two input strings.

   (d) Design a dynamic programming-based algorithm that finds a subset of a set of integers (given as an array of integers as input) that has the maximum sum of its elements. 10+10+10+10=40

2. (a) Let $G = (V, E)$ be a connected, weighted graph. Let T and T' be two MSTs of G and $\alpha \in R$ then show that, the number of edges in T of weight α is the same as the numbers of edges in T' of weight α.

   (b) Let $G = (V, E)$ be a connected, weighted graph, $v \in V$ be any vertex, and e be an edge with minimum weight among all the edges that incident on v. Prove that there exists a MST which includes the edge e.

   (c) Let G be a connected, weighted graph. Prove that, if all edge weights in G are distinct, then G has exactly one MST.

   (d) Prove that an infinite graph with a finite number of edges (i.e., a graph with a finite number of edges and an infinite number of vertices) must have an infinite number of isolated vertices.

   (e) Consider the following properties of an undirected graph G with n vertices.
   (i) G is connected.
   (ii) G is acyclic.
   (iii) G has $n - 1$ edges.

Prove that if G satisfies any two of the above three properties, then G also satisfies the third property, i,e.,

(i) if G satisfies properties (a) and (b), then G satisfies property (c),

(ii) if G satisfies properties (a) and (c), then G satisfies property (b),

(iii) if G satisfies properties (b) and (c), then G satisfies property (a).

As you must know, graphs satisfying these three properties are called trees. 15+5+5+5+10=40

3. (a) You are given an unsorted array $A = A[1...n]$ containing n distinct integers. Design an algorithm that outputs the smallest k elements in array A. The running time of your algorithm should be $O(n + k\log n)$. Give pseudocode and discuss running time.

(b) Write Merge sort algorithm. Let A and B be two sequences of n integers each. Given an integer m, describe an $O(n\log n)$ time algorithm for determining if there is an integer a in A and b in B such that $m = a + b$.

(c) Define a Circular Queue. Implement Insert and Delete operations on it using the link list.

(d) Write a program that counts the number of leaves of a binary tree. Use an example to demonstrate your solution. 10+10+10+10=40

4. (a) Construct a DFA for the language $L = \{w \mid w \in (a + b)^*\}$ such that $N_a(w) \bmod 3 = 0$ and $N_a(b) \bmod 5 = 0$.

(b) What is Instantaneous Description in a Pushdown Automata (PDA)? Construct a PDA for the language $L = \{ww^F \mid w \in (0, 1)^*\}$.

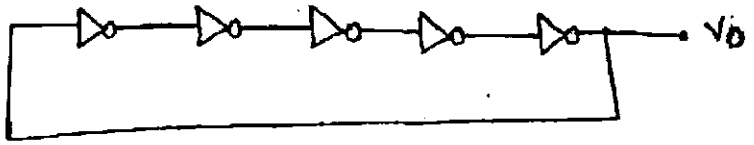
(c) What is a Lamda transition in Turing Machine? Construct a Turing Machine model for the addition of two numbers represented in unary notation. 10+(5+10)+(5+10)=40

5. (a) What is meant by isomorphic Boolean algebra? Give examples.

(b) What will be the simplified version of the Boolean expression $(x + y)(x + y') + ((xy') + x')'$?

(c) Compare and contrast the concepts of prime implicants and minterms in terms of their applications in Boolean algebra. Provide an example of a Boolean function where there are no essential prime implicants. What will be the maximum number of prime implicants for an n-variable Boolean function?

(d) For the ring oscillator shown in the figure, the propagation delay of each inverter is 100 pico sec. What is the fundamental frequency of the oscillator output?

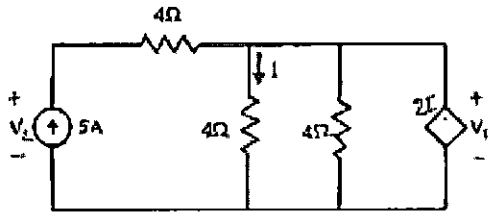


(e) Convert $59{\cdot}72_{10}$ to BCD. What will be the range of values that can be represented with 8 bit 2's compliment form? What will be the 8 bit 2's compliment form of the number – 14?

(f) Use the quine McCluskey method of minimization and find the expression for the function. $F(A, B, C, D) = ? \, m(0, 1, 2, 3, 5, 7, 8, 9, 11, 14)$. 3+5+8+4+6+14=40

6. (a) State and explain, (i) the Maximum Power Transfer theorem, (ii) Parallel RLC resonant circuit.

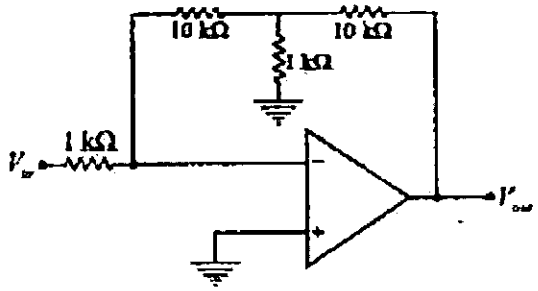
(b) In the given circuit, what will be the values of V_1 and V_2?



(c) Discuss the concept of impedance parameters and admittance parameters in 2-port networks. How are they related to S-parameters?

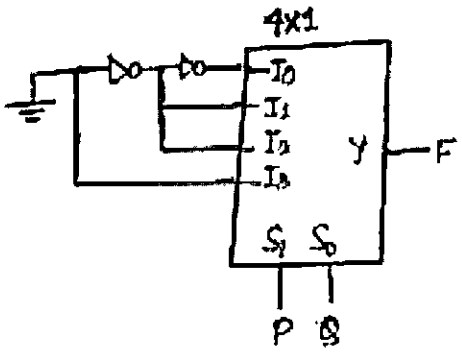
(d) Write the differences between npn and pnp transistor. Explain early effect in BJT. What is the significance of the common-mode rejection ratio (CMRR) in op-amps?

(e) Assuming the operational amplifier to be ideal, the gain Vout/Vin for the circuit shown in the given figure is 10+5+10+7+8=40



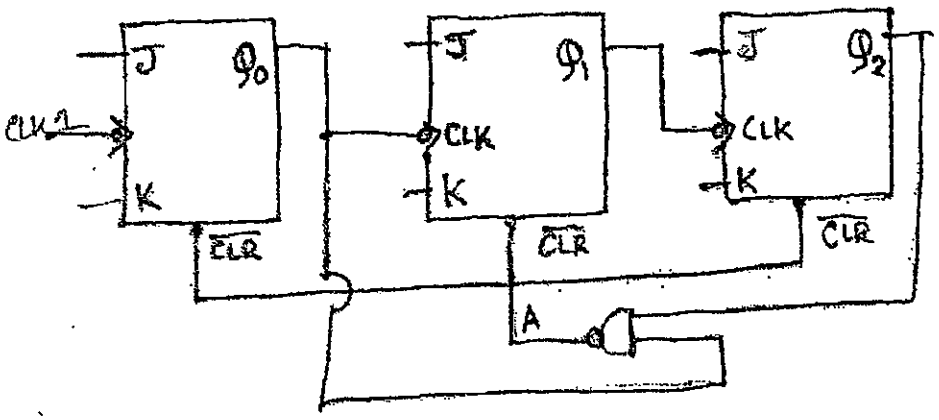
7. (a) What is a Full Adder? Write its truth table and characteristics equation and also implement full adder circuit using decoder.

(b) The minimized logic function implemented by the circuit below is (ground implies a logic "0").



(c) Give the block diagram, truth table, characteristics table, characteristics equation of JK flip flop. What is race around condition and how we can overcome this?

(d) The riple counter shown in figure is made up of negative edge triggered J-K Flip Flops. The signals levels at J and K inputs of all the flip-flops are maintained at logic 1. Assume all the outputs are cleared just prior to applying the clock signal. What will be the module number of the circuit? Explain briefly.



(e) Why are ADC used? For a 12-bit ADC with voltage range 0-5 V, what will be the resolution?

10+5+10+10+5=40

8. Answer *any four* of the following: 10×4=40

(a) CDMA

(b) Newton-Raphson method

(c) OPAmp as a differentiator

(d) Ring counter

(e) Priority Queue using Heap

(f) Dijkstra's shortest path algorithm
