Anirudha Hazra
510518014

Indian Institute of Engineering Science and Technology, Shibpur

B.Tech (CST) 3rd Semester Final Examination, November 2019

Digital Logic (CS 301)

Answer any 5 questions.

F.M. 70 Time: 3 hrs

1. (a) Compare 1s and 2s complement number representation.

(b) Express the following Boolean function in a product of maxterm form.

$$F = xy + \bar{x}z$$

(c) Simplify the following Boolean function

$$F(w,\ x,\ y,\ z) = \Sigma(4,\ 5,\ 7,\ 12,\ 14,\ 15) + d(3, 8, 10).$$

(d) Define fan-out and noise-margin of a logic gate. [3 + 3 + 4 + 4]

2. (a) Which logic level limits the fan-out of TTL gates? Explain your answer with a suitable diagram.

(b) Draw the circuit diagram of a two inputs DTL NAND gate. Calculate fan-out and noise-margins of the DTL gate. The diode and transistor parameters are:
Diode: Voltage across a conducting diode = 0.7 V
Cut-in voltage = 0.6 V
Transistor: Cut-in voltage = 0.5 V, $V_{BE,sat} = 0.8V$
$V_{CE,sat} = 0.2V$
$h_{FE} = 30$ [4 + 10]

3. (a) Obtain the logic diagram that converts a four-digit binary number to a decimal number in BCD. Note that two decimal digits are needed since the binary numbers range from 0 to 15.

(b) Implement the following function with a multiplexer

$$F(A,\ B,\ C,\ D) = \Sigma(0,\ 1,\ 3,\ 4,\ 8,\ 9,\ 15)$$

[10 + 4]

4. (a) Construct a 5×32 decoder with four 3×8 decoder/demultiplexers and a 2×4 decoder. Use block diagram construction.

$J\bar{Q} + \bar{K}Q$

	J	K
$1 \to 1$	X	0
$1 \to 0$	X	1
$0 \to 1$	1	X
$0 \to 0$	0	X

(b) A combinational circuit is defined by the following three functions:

$$F_1 = \overline{x}.\overline{y} + x.y.\overline{z}$$

$$F_2 = \overline{x} + y$$

$$F_3 = x.y + \overline{x}.\overline{y}$$

Design the circuit with a decoder and external gates. [6 + 8]

5. (a) Design a BCD ripple counter using JK flip-flops and also draw the timing diagram of the said counter.

(b) Design a counter with the following binary sequence:
1, 2, 5, 3, 7, 6, 4
and repeat. Use D flip-flops in the design process. [8 + 6]

6. (a) A full-adder receives two external inputs X and Y; the carry input Z comes from the output of a D flip-flop. The carry output is transferred to the flip-flop in every clock pulse. The external output S gives the sum of X, Y and Z. Obtain the state table and state diagram of the sequential circuit.

(b) Define state equation. When is the state equation method convenient for designing sequential circuits? What is the main difference between a sequential circuit and a combinational circuit? [7 + (2+ 3+ 20)]

7. (a) Why we do not use S = 1 and R = 1 as inputs to R-S (using NOR gates) flip-flop? What is the problem in J-K flip-flop and how is it removed?

(b) Draw the logic diagram of the positive edge-triggered D flip-flop and explain its operation. [4 + 10]

8. Define lockout of counters. Design a mod-5 counter using JK flip-flop so that if the unused states 101, 110 and 111 occur, the next clock pulse will reset the counter to 000. [3 + 11]

Indian Institute of Engineering Science and Technology, Shibpur

Dual Degree (B.Tech-M.Tech) 3rd Semester Final Examination, November 2019

Subject: Mathematics-III(MA-301)

(All Engineering Branches)

Use separate answer script for each half

Time : 3 hours **Full Marks : 70**

First Half

Answer any seven questions

1. State axiomatic definition of probability. Using this definition show that for any two events A and B:

$$P(\overline{A}B) = P(B) - P(AB)$$

[5]

2. For n events $A_1, A_2, \cdots, A_n$ connected to a random experiment E, show that

$$P(A_1A_2\cdots A_n) \geq \sum_{i=1}^{n} P(A_i) - (n-1).$$

[5]

3. In an examination 60%, 70% and 75% students have passed in the subjects Physics, Chemistry and Mathematics respectively. Find the minimum percentage of students who have passed in all the subjects.

[5]

4. Show that the function

$$f(x) = \begin{cases} |x|, & -1 < x < 1 \\ 0, & \text{elsewhere} \end{cases}$$

is a possible density function and hence find the corresponding distribution function. [5]

5. Find the mean and variance of the Poisson distribution.

[5]

6. A fair coin is tossed 400 times. Using normal approximation to binomial distribution, find the probability of obtaining (i) exactly 200 heads (ii) between 190 to 210 heads, both inclusive. Given that the area under standard normal curve between $z = 0$ and $z = 0.05$ is 0.0199 and between $z = 0$ and $z = 1.05$ is 0.3531.

[5]

7. State and prove Tchebycheff's inequality for a continuous random variable.

[5]

8. The probability density function a two-dimensional random variable (X, Y) is given by

$P\overline{M}$ [illegible] = 0.25

P = 0.6 $\overline{P}M$ = 0.4

C = 0.7

M = 0.75

$$f(x,y) = \begin{cases} k(x+y), & x \geq 0,\ y \geq 0,\ x+y < 1 \\ 0, & \text{otherwise.} \end{cases}$$

Find k and evaluate $P(X < \frac{1}{2},\ Y > \frac{1}{4})$. [5]

9. Fit a straight line to the following data:

x_i	y_i
1	2.4
2	3
3	3.6
4	4
6	5
8	6

[5]

10. Define correlation coefficient between two random variables and show that it lies between -1 and +1 both inclusive. [5]

11. In a partially destroyed Laboratory record of an analysis of correlation data, the following results only are legible: Var(X)=9.

Regression equations: $8X - 10Y + 66 = 0,\ 40X - 18Y = 214.$

Find (i) the mean values of X and Y, (ii) $\rho(X,Y)$, (iii) σ_Y. [5]

12. (i) Define unbiased estimator for a population parameter.

(ii) Prove that the sample mean $\overline{X}$ is an unbiased estimator of the population mean. [2+3]

13. Find the maximum likelihood estimate of μ for a Poisson population with parameter μ. [5]

Second Half

Answer any **THREE** questions from this half
two marks are reserved for general proficiency in this half.

14. a) State and prove convolution theorem.

b) Use convolution theorem to find $L^{-1}\left\{\frac{1}{(p+2)^2(p-2)}\right\}$. [6+5=11]

15. a) Find the Laplace transform of the following :

(i) $f(t) = e^{-2t}\cos 3t + 5e^{-2t}\sin 3t$

(ii) $f(t) = \begin{cases} 3 & 0 \le t < 5 \\ 10 & 5 \le t < 8 \\ 0 & t \ge 8 \end{cases}$

b) Using Laplace transform, solve the equation $\frac{d^2y}{dt^2} + t\frac{dy}{dt} - y = 0$

if $y(0) = 0$, $\frac{dy}{dt} = 1$ for $t = 0$. [3+3+5=11]

16. a) Using Laplace transform, prove that $\int_0^\infty \left(\frac{\sin t}{t}\right) dt = \frac{\pi}{2}$.

b) Find the basic feasible solutions of the system of equations

$$x_1 + x_2 + x_3 = 8$$
$$3x_1 + 2x_2 = 18,$$
$$x_1, x_2, x_3 \ge 0.$$

[6+5=11]

17. a) Solve the following LPP by Simplex method :

$$Maximize\ Z = x_1 + x_2 + 3x_3$$
$$subject\ to \quad 3x_1 + 2x_2 + x_3 \le 3$$
$$2x_1 + x_2 + 2x_3 \le 2$$
$$x_1, x_2, x_3 \ge 0.$$

b) Prove that a hyperplane is a convex set. [8 + 3]

18. Solve the following LPP using Charnes Big M -method :

$$\begin{aligned} \textit{Minimize} \quad & Z = 2x_1 + 4x_2 + x_3 \\ \textit{subject to} \quad & x_1 + 2x_2 - x_3 \leq 5 \\ & 2x_1 - x_2 + 2x_3 = 2 \\ & -x_1 + 2x_2 + 2x_3 \geq 1 \\ & x_1,\ x_2,\ x_3 \geq 0. \end{aligned}$$

Or

Use Two Phase method to solve the following LPP :

$$\begin{aligned} \textit{Maximize} \quad & Z = 2x_1 + x_2 + x_3 \\ \textit{subject to} \quad & 4x_1 + 6x_2 + 3x_3 \leq 8 \\ & 3x_1 - 6x_2 - 4x_3 \leq 1 \\ & 2x_1 + 3x_2 - 5x_3 \geq 4 \\ & x_1,\ x_2,\ x_3 \geq 0. \end{aligned}$$

[11]

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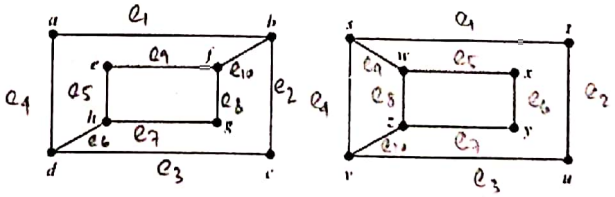
Aniruddha Hazra
510518014

Indian Institute of Engineering Science and Technology, Shibpur
B.Tech. (CST) 3rd Semester Final Examinations, November 2019
Discrete Structures (CS - 303)

Time: 3 hours **Full Marks: 70**

Answer *Q.1* and *any five* from the rest
(Write all parts of the same question together)

1. Give short answers to the following: [2x10 = 20]
   a) A compound proposition that is always _____ is called a contradiction, and the one which is neither a tautology nor a contradiction is called a _____.
   b) What are the *contrapositive* and *inverse* of the conditional statement "I come to class whenever there is going to be a test."?
   c) Two sets A and B contains a and b elements respectively. If power set of A contains 16 more elements than that of B, what are the values of a and b?
   d) A function is defined by mapping $f: A \rightarrow B$ such that A contains m elements and B contains n elements and $m \leq n$. Find the number of one-to-one functions.
   e) Are the following statements *True* or *False*?
      i. An equivalence relation has reflexive, anti-symmetric, and transitive properties.
      ii. A partially ordered relation has reflexive, symmetric, and transitive properties.
   f) Write any two properties of a simple graph.
   g) A pseudo-graph has _____ and/or _____connecting the same vertex pair.
   h) How many edges are there in a graph with 10 vertices each of degree six?
   i) What is the trade-off between *adjacency list* and *adjacency matrix* representation of graphs?
   j) Determine whether the following graphs (G & H) are isomorphic.



G *H*

2. a) Use rules of inference to show that the hypotheses "If it does not rain or if it is not foggy, then the sailing race will be held and the lifesaving demonstration will go on," "If the sailing race is held, then the trophy will be awarded," and "The trophy was not awarded" imply the conclusion "It rained."

   b) Suppose the relation on a set R is represented as $M_R = \begin{bmatrix} 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \end{bmatrix}$. Determine if this relation is *reflexive, irreflexive, symmetric, anti-symmetric, and transitive* (give reasons). Use Boolean multiplication of zero-one matrix wherever necessary.

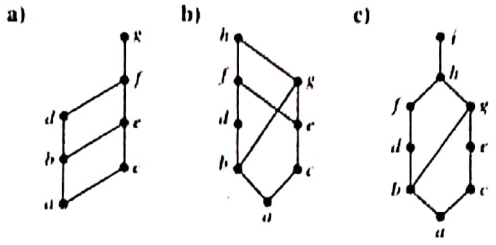
[5 + (1x5) = 10]

3. a) Prove that the transitive closure of a relation R equals the connectivity relation R^*.
   b) Use Warshall's algorithm to find the transitive closure of the relation $R = \{(2,1), (2,3), (3,1), (3,4), (4,1), (4,3)\}$ on the set $S = \{1, 2, 3, 4\}$.

[4 + 6 = 10]

4. a) Draw the *Hasse diagram* for the "less than or equal to" relation on {0, 2, 5, 10, 11, 15}. Find the maximal, minimal, greatest, and least elements in the diagram.
   b) Determine whether the posets with the following Hasse diagrams are lattices (give reasons).

a) b) c)



[(2 + ½ x4) + (2x3) = 10

5. a) State the *Fundamental Theorem of Arithmetic*.
   b) "There are infinitely many primes" – Use Euclid's method to prove this theorem.
   c) What is *Bézout's identity*? Express *gcd (252, 198) = 18* as a linear combination of 252 and 198.

[2 + 4 + (1 + 3) = 10]

6. a) Triangulation is the process of dividing a simple polygon into triangles by adding nonintersecting diagonals. Use strong induction to prove that a simple polygon with n sides, where n is an integer with $n \geq 3$, can be triangulated into $n - 2$ triangles. *(hint: "Every simple polygon with at least four sides have an interior diagonal")*
   b) Use mathematical induction to prove that $n^2 - 1$ is divisible by 8 whenever n is an odd positive integer.

[5+5 = 10]

7. a) Suppose that a weapons inspector must inspect each of five different sites twice, visiting one site per day. The inspector is free to select the order in which to visit these sites, but cannot visit site X, the most suspicious site, on two consecutive days. In how many different orders can the inspector visit these sites?
   b) Use *Generalize Pigeonhole Principle* to show that among any set of 5 integers, there are 2 with the same remainder when divided by 4.
   c) How many solutions does the equation $x_1 + x_2 + x_3 = 11$ have, where the variables are the integers with $x_1 >= 1$, $x_2 >= 2$ and $x_3 >= 3$?

[4 + 3+ 3 = 10]

Aniruddha Hazra
510518014

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

B. Tech.(CST)3rd SemesterFinalExaminations, November 2019

Subject:- Electrical Machine (EE-304)

Time: 3 hours

Full Marks: 70

(i) Answer any **three**questions from **first half** and in **second half** , answer **question 6 or question 7**, rest **two** questions from Q8,Q9,Q10,Q11.

(ii) All questions carry equal marks

(iii) Two marks are reserved in each half for neatness and organized answer-script.

FIRST HALF

1) a) What are the losses in a 3 phase induction motor?

b) A 6 pole, 50 Hz, 3-phase slip-ring induction motor has a resistance and a reactance of 0.5 Ω and 5 Ω per phase, respectively. Calculate (i) the speed at which torque is maximum, (ii) the ratio of maximum torque/starting torque. (iii) What must be the external resistance per phase have so that the starting torque is half of the maximum torque. [5+6]

2) a) Explain dynamic braking in a DC Shunt Motor.

b)A 240 V DC series motor takes 40A when giving its rated output at 1500 RPM. Its armature resistance is 0.3 Ω. Find what resistance must be added to obtain the rated torque (a) at starting and (b) at 1000 RPM. [4+7]

3) a) Explain dynamic braking in a 3-phase induction motor.

b) A 746 kW, 3-phase, 50 Hz, 16 pole induction motor has a rotor impedance of (0.02+j0.15) Ω at standstill. Full-load torque is obtained at 360 rpm. Calculate (i) the ratio of maximum to full-load torque, (ii) the speed for maximum torque and (iii) the rotor resistance to be added to get maximum starting torque. [4+7]

4) a) Derive the expression for developed torque in a 3-phase induction motor and find the condition or maximum torque.

b) A 3-ph 500 V, 50Hz induction motor with 6 poles gives an output of the 20 kW at 950 rpm with a pf of 0.8. The mechanical losses are equal to 1 kW. Calculate for this load (i) slip, (ii) rotor copper loss, (iii) input if the stator losses are 1500 W and (iv) the line current. [5+6]

5) a) Discuss the method of speed control of induction motor by changing the number of poles.

b) A 12 kW, 3-ph, 6-pole. 50 Hz, 400V, delta connected induction motor runs at 960 rpm on full-load. If it takes 85 A on direct starting, find the ratio of the starting torque to full-

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR
B. Tech.(CST)3rd SemesterFinalExaminations, November 2019
Subject:- Electrical Machine (EE-304)

Full Marks: 70 Time: 3 hours

load torque with a star-delta starter. Full-load efficiency and power factor are 88 % and 0.85 respectively. [4+7]

SECOND HALF

6) a) A 250 V wave connected compound DC generator has armature, series-field and shunt-field resistance of 0.4 Ω, 0.2 Ω and 125 Ω respectively. If this generator supplies 10 kW at rated voltage, find the e.m.f generated in the armature when the machine is connected in (i) long shunt and (ii) short shunt configuration. Ignore armature reaction and allow 1 volt per brush for contact drop.

b) What are the losses in a D.C. shunt motor. [8+3]

OR

7) a) Explain speed-current and torque-current characteristics for DC Shunt Motor.

b) A 250V, 4 pole, wave-connected DC shunt motor has armature winding with 500 conductors. The armature circuit resistance is 0.25Ω, field resistance is 125Ω and the flux per pole is 0.02 Wb. Armature reaction is neglected. If the motor draws 14 A from the mains, then compute (i) speed, (ii) the internal torque developed, (iii) the shaft power, (iv) shaft torque and (v)the efficiency with rotational losses being 300 watts.

[3+8]

8. a) What are the different methods of conversion of three phase to six phase? Describe any two methods of conversion from three to six phases using transformers with suitable circuits and phasor diagrams. [1+4=5]

b) Explain why zigzag-connected transformer requires less copper than a star connected transformer for the same rating. Discuss the advantages and disadvantages of a star-delta and star-zigzag method of transformer connections. [2+4=6]

9. a) Explain with the help of connection and phasor diagrams how a two-phase supply is obtained from three-phase supply mains using Scott-connected transformers. Hence show that the neutral point divides the teaser primary winding in the ratio 1:2. [5]

b) Scott-connected transformers supply two single phase loads at 100 V. The load across the teaser secondary is 300 kW at unity power factor and that across the main secondary is 250 kW at 0.8 p.f. lagging. For a three-phase input supply of 6600 V, calculate the

magnitude of the primary line currents. (Ignore the magnetizing currents and leakage impedance drops) [6]

10. a) Explain the double revolving field theory for single phase induction motors. Sketch its torque-speed/slip characteristics and hence show that this motor has no inherent starting torque. [5]

b) Explain with a neat circuit diagram and speed-torque characteristic, the operation of a single-phase capacitor-start capacitor-run induction motor. What is the purpose of using two capacitors and which capacitor has a higher value and why? Mention some of the applications of such a motor. [4+1+1=6]

11. a) Explain the operation of a DC series motor when connected to an AC source. What measures may be adopted to improve the performance of a DC series motor when fed from an AC supply. [5]

b) A 230 V, 50 Hz, single-phase induction motor has the following impedances for the main and the auxiliary winding:
Main winding: $Z_m = 5.95 - j22.21$ ohm
Auxiliary winding: $Z_a = 29.57 - j35.24$ ohm
A capacitor is connected in series with the auxiliary winding to obtain maximum torque at starting. Determine the following: (i) Input current at starting before capacitor is connected, (ii) Input current at starting after connecting the capacitor and (iii) (iii)Value of the capacitor (in μF) [6]

Anindita Hazra
510518014

Indian Institute of Engineering Science and Technology, Shibpur

B.Tech (CST) 3rd Semester Final Examination, November 2019
Data Structures and Algorithms (CS-302)

FULL MARKS: 70 TIME: 3 hrs.

Answer any five (5) questions. Clearly mention your assumptions, if any, while answering. Students are advised to answer all parts of a question together.

1. (a) Write down an efficient algorithm to find the largest and 2nd largest element from an array of n integers. Give an analysis of running time of your proposed algorithm.

   (b) Consider an implementation of `quicksort` algorithm that picks the pivot which partition the array $A[n]$ in such a way that $9/10th$ of the elements fall in one sub-array and remaining $1/10th$ elements fall in the other sub-array. What would be the running time of the `quicksort` algorithm in this scenario.

   (c) You are given five files F_1, F_2, F_3, F_4 and F_5 containing 20, 30, 10, 5, and 30 records (ordered) respectively. You have to merge them to form a single file of ordered records using two way merge. What would be the optimal merge patterns for this problem? [6+4+4]

2. (a) A strict $k-$ary tree is a tree in which all nodes have either k non-empty children or k empty children. Prove that in such a tree the number of external nodes E satisfies: E=(k-1)I + 1, where I is the number of internal nodes.

   (b) How many unlabeled binary trees with n nodes and height n are possible? Justify your answer. (Assume a binary tree with only one node is of height 1.)

   (c) Write a function to print nodes of a given binary tree T in the level order, i.e., all nodes at level 1 should be printed first followed by all nodes at level 2, and so on. All nodes in any level should be printed from left to right.

   (d) Prove that in a binary tree T with δ ($\delta \geq 1$) levels the number of leaves is at most $2^{\delta-1}$. [3+3+5+3]

3. (a) Write functions for the following tasks

   (i) Given an integer n as input, test if the binary representation of n has equal no of 0s and 1s.

   (ii) Given two integers n_1 and n_2 as input, test whether binary representation of n_2 is reverse of binary representation of n_1.

   (b) Given an integer k and a queue of n ($k \leq n$) integers, write a function to reverse the order of the first k elements of the queue, leaving the other elements in the same relative order.

   (c) Convert the infix expression $(A + B) * C - (D - E) * (F + G)$ into postfix expression. [(4+4)+4+2]

4. (a) Given an AVL tree T, is it always possible to build the same tree by following a sequence of insertions of nodes using the insertion method used in a Binary search tree (BST)? Justify your answer.

   (b) Prove that the minimum number of nodes in an AVL tree of height h is $N_h = (\sqrt{2})^h$ and also prove that $N_h = F_{h+2} - 1$ where F_{h+2} is the $(h+2)th$ Fibonacci number. (Assume that an AVL tree with only one node is of height 1)

   (c) A node in a binary tree is an only-child if it has a parent node but no sibling node (Note: The root does not qualify as an only child). The "loneliness-ratio" of a given binary tree T is defined as the ratio LR(T) = (The number of nodes in T that are only children) / (The number of nodes in T). Prove that for any nonempty AVL tree T we have that LR(T)$\leq$1/2.

   (d) Prove that if the closest leaf from the root in an AVL tree is at level k (assuming root is at level 1) then all the levels starting from 1 to $k-1$ has maximum possible number of nodes. [4+3+4+3]

5. (a) Draw the Red-Black tree that results after each of the integer keys 2, 1, 4, 5, 9, 3, 6, and 7 are inserted, in that order, into an initially empty Red-Black tree. Clearly show the tree that results after each insertion, and make clear any rotations or recoloring that must be performed.

   (b) Prove that in a Red-Black tree T with n internal nodes, height(T) $\leq 2floor(log_2(n+1))$, where $floor(x)$ is the greatest integer less than or equal to x.

   (c) Prove the following statements in the context of a Red Black tree.

   (i) If the black height of the tree is h then the smallest possible red-black tree is a full binary tree.

   (ii) If a Black node has only one child that child must be a Red leaf.

   [4+4+(3+3)]

6. (a) In double hashing method of collision resolution why is it necessary to take the hash table size m to be a prime?

(b) What do you mean by universal hash function?

(c) Consider an initially empty hash table of size m and an hash function $h(x) = x \ mod \ m$. In the worst case what would be the time complexity to insert n keys into the table if following techniques are used to resolve collisions?

(i) Separate ordered (ascending/descending) linked list is used

(ii) Instead of liked list each bucket is implemented as an AVL tree.

(d) Consider the same has function as above i.e. $h(x) = x \ mod \ m$. But now linear probing is used to resolve collision instead. Assume $n \leq m/2$. What would be worst-case time complexity to insert n keys. [2+2+6+4]

7. (a) What is a $2-4$ tree? what would be number of elements in a $2-4$ tree of height h

(b) Draw the $2-4$ tree that results after each of the integer keys $4, 6, 12, 15, 3, 5, 10, 8, 11, 7, 13, 14$, and 17 is inserted, in that order, into an initially empty $2-4$ tree. Clearly show the tree that results after each insertion, and make clear any split operations that must be performed.

(c) Justify the statement "For every Red-Black tree there exists a $2-4$ tree and vice versa." [3+5+6]