B.TECH/IT/4TH SEM/INFO 2201/2022

FORMAL LANGUAGE & AUTOMATA THEORY
(INFO 2201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Which of the following regular expressions over {a, b} denotes all words begin and end with 'a' and in between any word using 'b'
(a) ab^*a (b) $a + ab^*a$ (c) $(a+b)^*a$ (d) $a(a+b)^*a$

(ii) A grammar in CNF may contain productions like
(a) A -> B (b) A -> BC (c) A ->aB (d) A ->Abcd

(iii) $L= \{ a^n b^{2n} \mid n>=1\}$ is accepted by
(a) a DFA (b) a NFA (c) a PDA (d) none of these

(iv) Input sequence of an information lossless machine can be determined from the knowledge of
(a) only output sequence
(b) output sequence and initial state
(c) output sequence, initial state and final state
(d) initial state.

(v) Using Pumping Lemma if we select a string w such that $w \in L$, and w=xyz. Which of the following cannot be an empty string?
(a) x (b) y (c) z (d) All of the mentioned.

(vi) If a machine of n states is μ definite, then
(a) $\mu \leq n - 1$ (b) $\mu \geq n - 1$ (c) $\mu = n - 1$ (d) none of these.

(vii) Consider the following grammar
$S \rightarrow aABC \mid a$
$A \rightarrow aA \mid B$
$B \rightarrow aBA \mid C$
$C \rightarrow \lambda \mid aC$
The null-able variables for the above grammar are

(a) S, A, B, C (b) S, A, C (c) A, B (d) A, B, C.

(viii) Which of the following automata takes stack as auxiliary storage?
(a) Finite automata (b) Push down automata
(c) Turing machine (d) All of the mentioned.

(ix) Which of the following is true?
(a) Merger graph is directed graph (b) Compatible graph is directed graph
(c) Both are directed (d) None of these.

(x) Difference between Turing machine and Two-way FA is in
(a) Input Tape (b) Read Write head (c) Finite Control (d) All of these.

Group – B

2. (a) In response to an unknown input sequence, the machine of the following table produces the output sequence 1110000010, find the input sequence to the machine if it is known that its initial state is A and its final state is F.

	NS,z	
PS	x=0	x=1
A	B,1	C,0
B	D,1	B,1
C	E,1	B,0
D	A,0	E,0
E	F,0	D,1
F	D,0	A,1

Can the machine produce the output sequence 11011000 when both its initial and final states are A? [(CO1,CO4)(Evaluate/HOCQ)]

(b) A long sequence of pulses enters a two I/P, two O/P synchronous sequential circuit , which is required to produce an O/P pulse z=1 whenever the sequence 10110 occurs. Overlapping sequences are accepted; for example, if the input is 0101101101001……., the required O/P is 0000010010000…….
(i) Draw a state diagram.
(ii) Select an assignment and show the excitation and O/P tables.

[(CO1,CO4)(Evaluate/HOCQ)]

(4 + 3) + (2 + 3) = 12

3. (a) Prove that the following machine has a finite memory

PS	NS,z	
	x=0	x=1
A	B,0	D,0
B	C,0	C,0
C	D,0	A,0
D	D,0	A,1

[(CO1,CO4)(Evaluate/HOCQ)]

(b) Consider the following machine:

PS	NS,Z			
	I1	I2	I3	I4
A	___	B,1	E,1	D,0
B	C,0	A,1	B,0	___
C	C,0	D,1	___	A,0
D	___	E,1	B,__	___
E	B,0	___	C,__	B,0

Find the minimal closed covering with justification.

[(CO1,CO4)(Understand/LOCQ)]

(c) Consider the following machine:

PS	NS,Z	
	x=0	x=1
A	B,1	H,1
B	F,1	D,1
C	D,0	E,1
D	C,0	F,1
E	D,1	C,1
F	C,1	C,1
G	C,1	D,1
H	C,0	A,1

(i) Find the equivalence partition for the machine shown in following table
(ii) Show a standard form of the corresponding reduced machine.
(iii) Find a minimum length sequence that distinguishes state A from state B.

[(CO1,CO4)(Understand/LOCQ)]

(4 + 3) + (2 + 2 + 1) = 12

Group - C

4. (a) Using Thompson's Construction rules design a NFA with ∈-transition for *r*=10(00+1)*(0+1) and convertsits equivalent DFA. [(CO3)(Create/HOCQ)]

(b) Design a DFA that will accepts those words from ∑={ a, b} where the numbers of 'b' is divisible by three. [(CO3)(Create/HOCQ)]

(c) Design a DFA which accepts the language L= {1^m01^n | m, n are positive}.

[(CO3)(Create/HOCQ)]

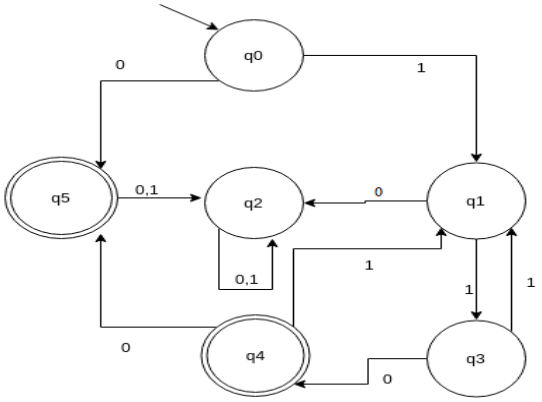
(3 + 3) + 2 + 4 =12

5. (a) Convert the following Non-deterministic Finite Automata(NFA) to Deterministic Finite Automata(DFA).

∑ / PS	0	1
q_0	q_0, q_1	q_3
q_1	q_2	q_2, q_3
q_2	q_1, q_2	q_0, q_2, q_3
q_3	q_1, q_3	q_2

Where q_0 is the initial state and q_3 is the final state. [(CO3)(Apply/IOCQ)]

(b) Using Ardens' theorem find out the regular expression for the following FA:



[(CO3)(Understand/LOCQ)]

(c) Design a Moore machine that gives an output '1' if input of binary sequence is even number of 0's followed by odd number of 1's . [(CO2)(Create/HOCQ)]

4 + 5 + 3 = 12

Group - D

6. (a) Construct regular grammar G for the following Deterministic Finite Automata (DFA):

$\partial(q_0, a) = q_0$, $\partial(q_1, a) = q_f$, $\partial(q_f, a) = q_f$

$\partial(q_0, b) = q_1$, $\partial(q_1, b) = q_f$, $\partial(q_f, b) = q_0$

Where q_0 is the initial state and q_f is the final state. [(CO2)(Apply/IOCQ)]

(b) Show that the following grammar is ambiguous

$S \rightarrow a \mid abSb \mid aAb,$

$A \rightarrow bS \mid aAAb.$ [(CO2)(Understand/LOCQ)]

(c) Prove that $L = \{a^i b^j \mid j = i^2\}$ is not Context Free Language. [(CO3)(Apply/IOCQ)]

(d) Explain Pumping Lemma for Context Free Language. [(CO3)(Understand/LOCQ)]

4 + 3 + 3 + 2 = 12

7. (a) Consider the grammar G= ({S,A,B}, {0,1}, P,S})
where P: S→ 0S1 | 0A| 0 | 1B | 1; A→0A | 0; B→ 1B | 1.
Test whether the string,001010, is in language generated by the grammar or not. [(CO2)(Understand/LOCQ)]

(b) Convert the following productions into Chomsky's Normal Form (CNF):-

$B \rightarrow aBB \mid C \mid abA$

$C \rightarrow aCC \mid aa \mid D \mid a$

$D \rightarrow \lambda \mid dd.$ [(CO3)(Apply/IOCQ)]

(c) Construct a DFA corresponding to the following regular grammar

$S \rightarrow aS \mid bS \mid aA$

$A \rightarrow bB$

$B \rightarrow aC$

$C \rightarrow \in.$ [(CO2)(Apply/IOCQ)]

2 + 5 + 5 = 12

Group – E

8. (a) Design a PDA to accept the following language L ={ w Є (a , b)* | w has the equal number of a's and b's}. [(CO5,CO6)(Create/HOCQ)]
   (b) Construct a PDA for the following language
   $L=\{a^n b^{n+2} \mid n>0\}$. [(CO5,CO6)(Apply/IOCQ)]
   (c) Explain Instantaneous Description (ID) in PDA with an example. [(CO5,CO6)(Understand/IOCQ)]

4 + 4 + 4 = 12

9. (a) Explain the working principle of Universal Turing Machine. [(CO5,CO6)(Understand/LOCQ)]
   (b) Differentiate between Multitape Turing Machine and Nondeterministic Turing Machine. [(CO5,CO6)(Analyze/IOCQ)]
   (c) Design Turing Machine over $\sum = \{0,1\}$ to accept the language $L=\{1^m 0^m \mid m > 0\}$. [(CO5,CO6)(Create/HOCQ)]

3 + 3 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	23.96	33.33	42.71

Course Outcome (CO):

After the completion of the course students will be able to

1. Recall Knowledge of elementary discrete mathematics including the notion of set, function, relation, product, partial order, equivalence relation, graph & tree.
2. Classify, describe and discuss different types of Grammar (Chomsky's classification: Type 0. Type1, Type 2 and Type 3) and its corresponding Machines like (TM, LBA, PDA, FA).
3. Describe, Evaluate and express the different concepts in automata theory and formal languages such as formal proofs, (non-) deterministic automata, regular expressions, regular languages, context-free grammars, context-free languages, different Machines (LBA, Turing, DFA, NFA, nPDA, dPDA).
4. Apply powerful model of computation since they help computer scientists understand the limits of mechanical computation by providing a precise definition of an 'algorithm' or 'mechanical procedure'.
5. Construct different languages (type0-unresticted language, type1-context sensitive language, type2- context free language, type 3: regular language) and Turing machines.
6. Develop and Evaluate different Machines corresponding different types of language like Unrestricted language: Turing Machine (TM), context sensitive language: Linear Bounded Automata, Context free language: Push Down Automata, Regular language: Finite Automata.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question