FORMAL LANGUAGE & AUTOMATA THEORY
(CSEN 3102)

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

Figures out of the right margin indicate full marks.

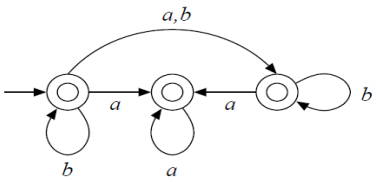
Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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) Consider the following NFA (over the alphabet {a, b}):
Which of the following is the shortest string not accepted by the given NFA?



(a) aba (b) null string (c) aab (d) None of these.

(ii) Which one of the following languages cannot be accepted by a non-deterministic pushdown acceptor (ndpda)?
(a) $\{0^m1^n \mid 0 < m, 0 < n\}$ (b) $\{0^m1^n0^m \mid 0 < m, 0 < n\}$
(c) $\{0^m1^m0^m \mid 0 < m\}$ (d) $\{0^m1^n0^r \mid 0 < m, 0 < n, 0 < r\}$.

(iii) For a Moore machine if the input string is of length n then which of the following will be the length of the output string
(a) n (b) n+1 (c) n – 1 (d) None of these.

(iv) Which of the following is the regular expression representing the language L = {all strings containing an even number of 0's} over the alphabet $\sum = \{0, 1\}$
(a) $(1^*01^*01^*)^*+ 1^*$ (b) $(1^*01^*01^*)^*$
(c) $(1^*01^*01^*)^* + 0^*$ (d) All of the above.

(v) A finite automaton requires minimum _____ number of stacks.
(a) 1 (b) 0 (c) 2 (d) None of these.

(vi) Which of the following pairs of machines given below do not have equal computing power?
(a) Deterministic and Nondeterministic finite state automata
(b) Deterministic and Nondeterministic pushdown automata
(c) Deterministic and Nondeterministic Turing Machine
(d) Multi tape Turing machine and Universal Turing machine.

(vii) Let 'X' be set of all context free languages accepted by deterministic push down automata (DPDA) and 'Y' be set of all context free languages accepted by non-deterministic push down automata (NPDA), then which of the following is true?
(a) X is proper subset of Y (b) X = Y
(c) X is proper super set of Y (d) None of these.

(viii) Given a CFG G = (V_N, ∑, P, S), deciding whether or not L(G) is empty is –
(a) decidable problem (b) un-decidable problem
(c) un-solvable problem (d) none of these.

(ix) Consider the following statements:
1. Family of CFLs is closed under union, concatenation and intersection
2. Family of CFLs is not closed under union, concatenation and star closure
3. If L1 is a CFL and L2 is a regular language, then L1∩L2 is a CFL
Now which of the following is/are true?
(a) 1 and 2 are correct (b) only 2 is correct
(c) 2 and 3 are correct (d) only 3 is correct.

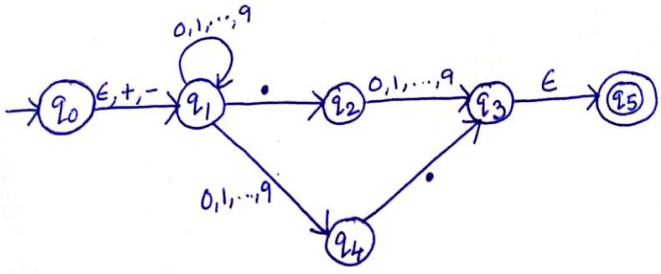
(x) Let G be a CFG in the Chomsky normal form (CNF) of a language L that does not contain ε. For any string x ∈ L of length l, what is the length of the derivation of x?
(a) l – 1 (b) 2l – 1 (c) 3l – 1 (d) 4l – 1.

Group – B

2. (a) What do you mean by 2- equivalent states? (CSEN3102.1) (Remember/LOCQ)]
(b) Consider the following language over the alphabet {a, b}:
L_1 = {x ∈ {a, b}* | x starts with 'ab' but does not end with 'ab'}.
Design a DFA for L_1. [(CSEN3102.6) (Create/HOCQ)]
(c) Construct a DFA over alphabet {0, 1} that accepts those strings that contain the pattern 001 somewhere. [(CSEN3102.6) (Create/HOCQ)]

2 + 5 + 5 = 12

3. (a) What do you mean by ϵ - closure of a state Q? Consider the NFA below. What would be the ϵ - closure of the state q0? [(CSEN3102.1) (CSEN3102.2) (Remember, Understand/LOCQ)]
(b) Consider the following ϵ - NFA representing the signed numbers, including fractions:

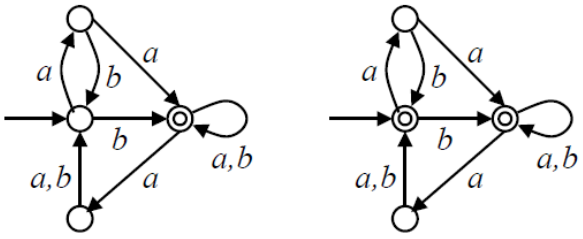


In the above NFA, the edge label between the states q_1 & q_2 and between the states q_4 & q_3 is the decimal point (.).
Construct the DFA equivalent to the given ϵ - NFA.
[(CSEN3102.6) (Create/HOCQ)]

(2 + 2) + 8 = 12

Group – C

4. (a) From the following two NFAs and two regular expressions, identify the equivalent pairs.



N_1 N_2

α_1 = (ab + (aa + b)(a + b)*a(a + b))*(aa + b)(a + b)*
α_2 = (ab + (aa + b)(a + b)*a(a + b))*(ϵ + (aa + b)(a + b)*)
The NFA N_1 is equivalent to the regular expression _____.
The NFA N_2 is equivalent to the regular expression _____.
Show the detailed steps in support of your answer.
[(CSEN3102.6) (Apply/IOCQ)]

(b) Consider the following language L over ∑ = {a, b}:
$L = \{\omega \in \Sigma^* | n_a(\omega) < n_b(\omega)\}$, where $n_a(\omega)$ represents the number of a's present in w and $n_b(w)$ represents the number of b's present in w.
Prove that L is not regular by applying pumping lemma.
[(CSEN3102.3) (CSEN3102.5)(Evaluate/HOCQ)]

(4 + 4) + 4 = 12

5. (a) (i) Prove, (1 + 00*1) + (1 + 00*1)(0 + 10*1)* (0 + 10*1) = 0*1(0 + 10*1)*
[(CSEN3102.3) (Apply/IOCQ)]

(ii) Derive a regular (Type 3) grammar for the regular expression 0*1(0 + 10*1)* [(CSEN3102.6) (Create/HOCQ)]

(b) Consider the set of all strings of odd length over ∑ = {0, 1}. Express this set in the form of a regular expression. [(CSEN3102.3) (Analyze/IOCQ)]

(c) Consider the set S of all strings α over ∑ = {0, 1, 2} such that α contains at least one 0, at least two 1's and at least three 2's. Is S a regular set?
[(CSEN3102.3)(Analyze/IOCQ)]

(3 + 5) + 2 + 2 = 12

Group – D

6. (a) Prove that if L1 and L2 is context free then L1 ∪ L2 is context free but L1 ∩ L2 need not have to be context free. [(CSEN3102.5) (Evaluate/HOCQ)]

(b) In the following context-free grammar, the set of terminal symbols is ∑ = {a, b, c}, the set of non-terminal symbols is N = {S, U, V}, and the start symbol is S. Convert the grammar to the equivalent Chomsky normal form. Show all the steps of your conversion.

S→U|V
U→ ϵ|c|aVa
V→ ϵ|c|bUb [(CSEN3102.3)(CSEN3102.5)(Apply/IOCQ)]

5 + 7 = 12

7. (a) Design a pushdown automata accepting L= {w ∈ {a,b}* : number of a's in w is exactly double of the number of b's in w}. [(CSEN3102.6) (Create/HOCQ)]
   (b) Consider the language L = {$0^a1^b0^a1^b$ | a > 0, b > 0}. Is it a context-free language? Prove your claim. [(CSEN3102.5) (Evaluate/HOCQ)]

6 + 6 = 12

Group – E

8. (a) Design a Turing machine M that recognizes the language L = {ww^R | w ∈ {0,1}* . [(CSEN3102.6) (Create/HOCQ)]
   (b) Let L be a context-free language. Is L necessarily a recursive or recursively enumerable set? Answer YES or NO for both of the cases by giving reasons. [(CSEN3102.5) (Analyse/IOCQ)]

8 + (2 + 2) = 12

9. (a) Design a Turing machine M5, which can accept the language L= {$a^nb^mc^n$ | n, m ≥ 0}. [(CSEN3102.6) (Create/HOCQ)]
   (b) Now show that M5 accepts "aaaccc" but rejects "abab" and "aabc". [(CSEN3102.5)(Analyze/IOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	6.25%	33.34%	60.41%

Course Outcome (CO):

After the completion of the course students will be able to

CSEN3102.1. Recall the basic characteristics of various types of machines, languages and grammars.
CSEN3102.2. Compare different computational models, languages and grammars based on their properties and behaviors.
CSEN3102.3. Apply formal mathematical methods to prove properties of languages, grammars, and automata.
CSEN3102.4. Apply the knowledge of theory of computation to an engineering application (e.g. designing the compilers).
CSEN3102.5. Classify formal languages and Evaluate whether a language/grammar belongs to a given type or not.
CSEN3102.6. Design automata for given languages/grammars. Generate languages / grammars for a given automaton and Construct grammars for languages and vice versa.

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

Department & Section	Submission Link
CSE - A	https://classroom.google.com/c/NDA1NzA4Mjk1NDU2/a/NDYzOTUxMDgxOTQw/details
CSE - B	https://classroom.google.com/c/NDA1MjA5NjQ5NDky/a/NDYzOTU2MzgwODI4/details
CSE - C	https://classroom.google.com/w/NDAzNTEzOTcyNDk3/tc/NDYzODcyMTMwMDA2