T = { 0, 1, 2, 3, 4 }, S is the start symbol, and the productions are as follows:
$S \rightarrow A, S \rightarrow B, S \rightarrow 4, A \rightarrow 012S, B \rightarrow 012S3S.$
Show that the grammar G is ambiguous.

(b) Provide a Type 2 (context-free) grammar for the following language L over the input alphabet { 0, 1 }:
L = { α | the string α has more 0's than 1's }

(2 + 4) + 6 = 12

7. G = (V, T, S, P) is a Type 2 grammar, with V = { S, A, B, 0, 1, 2, 3, 4 }, T = { 0, 1, 2, 3, 4 }, S as the start symbol and the following five production rules:

$$S \rightarrow A, S \rightarrow B, S \rightarrow 4, A \rightarrow 012S, B \rightarrow 012S3S.$$

Let L be the language generated by G.

(i) Design a pushdown acceptor (pda) M that accepts L.

(ii) Describe the steps by which the input string '012430124' is accepted by M. Also explain why the input string '0124340124' is not accepted by M.

(6 + 3 + 3) = 12

Group - E

8.(a) Two positive integers m and n are written on a Turing machine tape in unary notation. The integer m is to the left of the integer n on the tape, and a single blank cell separates the two integers. At start the read/write head is positioned on the leftmost 1 of m. Give the state transition diagram of a Turing machine M that will halt on the leftmost 1 of m if $m \geq n$, and will halt on the leftmost 1 of n if $m < n$. Clearly state any assumptions made.

(b) Describe how M operates on the following two sets of inputs:
(i) m = 5 , n = 2; (ii) m = 2, n = 3.

8 + 4 = 12

9.(a) Explain what is meant by a 'Universal Turing Machine'. Can every effective procedure be implemented by such a machine assuming the input is appropriately supplied?

(b) What is the 'Halting Problem' for Turing Machines? What do we mean when we say that the Halting Problem for Turing machines is unsolvable?

6 + 6 = 12

M.TECH/CSE/2ND SEM/CSEN 5201/2017

THEORY OF COMPUTATION
(CSEN 5201)

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

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
<u>Any 5 (five)</u> from Group B to E, taking <u>at least one</u> 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) It is known that the deterministic finite state acceptor (dfsa) M recognizes all the binary strings (and only those) in the regular expression 0*1011*. Then M must have at least n states, where n equals to
(a) 2 (b) 3 (c) 4 (d) 5.

(ii) If L_1 and L_2 are two context free languages. Then $L_1 \cap L_2$
(a) need not be regular but can be context free
(b) need not be context free but can be context sensitive
(c) is always regular
(d) is always context free.

(iii) If it is known that the total number of strings of length < = 4 using n terminal symbols exceeds 300, then n must be at least
(a) 2 (b) 3 (c) 4 (d) 5.

(iv) A positive integer m when written in binary notation (with no leading zeroes) has a length of 21 binary digits. When m is written in decimal notation (with no leading zeroes), its length will be exactly n decimal digits, where n is
(a) 4 (b) 5 (c) 6 (d) 7.

(v) The Pumping Lemma for Context-Free Languages can be used to prove that a given language L
(a) is not Type 0 (b) is not Type 1
(c) is not Type 2 (d) is not Type 3.

(vi) A machine M has been designed that, given a positive integer n as input, accepts n if and only if n is a perfect square. Then which one of the following alternatives is false?
(a) M cannot be a deterministic finite state acceptor (dfsa)
(b) M cannot be a deterministic pushdown acceptor (dpda)
(c) M cannot be a non-deterministic pushdown acceptor (ndpda)
(d) M cannot be a Turing machine.

(vii) If the original nondeterministic finite state automata(ndfsa) has n states, the corresponding deterministic finite state automata (dfsa) cannot have
(a) more than n states (b) more than 2n states
(c) more than 2^n states (d) more than (n-1) states.

(viii) 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) $\{0^m1^n0^r \mid 0<m, 0<n, 0<r\}$.

(ix) 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.

(x) We are supplied as input the state tables of two deterministic finite state acceptors (dfsas) M_1 and M_2.The input alphabet is { 0, 1 }. We want to find out whether the languages $L(M_1)$ and $L(M_2)$ are identical sets, i.e., whether they contain exactly the same strings. Then which statement below is true?
(a) There is a dfsa that will solve the problem.
(b) There is an ndpda that will solve the problem but not a dfsa.
(c) There is a Turing machine that will solve the problem but not an ndpda.
(d) There is no effective procedure for solving the problem.

Group – B

2. Consider the set of strings L_1 on the alphabet {0, 1} that contains *Even* number of 0's. Consider another set of strings L_2 on the alphabet {0, 1} that contains *Odd* number of 1's.

(i) Design a deterministic finite state acceptor (dfsa) M_1 that will accept $L_1 \cap L_2$. Show both the state table and the state transition diagram of M_1.

(ii) Explain the design in brief with the help of suitable examples.

(8 + 4) = 12

3. (a) A non-deterministic finite state acceptor (ndfsa) M_1 has the state table shown below. S is the start state, and B and C are goal states. Convert M_1 to an equivalent deterministic finite state acceptor (dfsa) M_2 and clearly mark the start and goal states.

	0	1
→S	B,C	S,A
A	A,C	---
*B	---	A
*C	C	C

(b) Minimize the number of states in M_2 designed above and get a reduced dfsa M_3.

8 + 4 = 12

Group – C

4. (a) Construct a non-deterministic finite state acceptor (ndfsa) M on the input alphabet { 0, 1, 2 } that accepts a string α if and only if α is contained in the regular expression 0*1*2*.

(b) Construct a non-deterministic finite state acceptor (ndfsa) N on the input alphabet { 0, 1, 2 } that accepts a string α if and only if α is *not* contained in the regular expression (01 + 2)*.

5 + 7 = 12

5. (a) Use the Pumping Lemma for Regular Languages, to show that the language $L = \{ 0^m1^n0^m1^n \mid m > 5, n > 10 \}$ is not regular.

(b) Prove that the Regular Languages are closed under union, intersection, concatenation and star closure operation.

6 + 6 = 12

Group - D

6. (a) When is a Type 2 (context-free) grammar said to be ambiguous? Consider the grammar G = (V, T, S, P) where V = { S, A, B, 0, 1, 2, 3, 4 },