Module 3&4

1. **Define the following terms.**

(a) CFG
(b) CFL
(c) Derivation and derivation tree
(d) Yield of a parse tree
(e) Ambiguous grammar
(f) Inherently Ambiguous grammar
(g) Sentence and Sentential form
(h) CNF
(i) GNF
(j) NULL production
(k) Useless Symbol
(l) Unit Production
(m) Left recursion

2. What is Pushdown Automata? Explain the working principles of a PDA with a block diagram.

3. What is the instantaneous description (ID) of a PDA?

4. Define the language accepted by PDA.

5. What is Deterministic PDA (DPDA) and Nondeterministic PDA (NPDA)?

6. State and prove the pumping lemma for Context Free Language (CFL). Show that $L= \{a^n b^n c^n | n \geq 1\}$ is not context free.

7. Write down the closure properties of CFL. Prove that the family of CFL's are closed under union, concatenation and star closure.

8. Differentiate between regular grammar and context-free grammar.

9. Write CFG for the following languages.

(a) L={W| W contains strings of at least two a's and W Ɛ {a,b}*}
(b) $L= \{ a^x b^y \mid x \neq y \}$
(c) $L= \{a^i b^j c^k \mid i+j=k, i>=0 \text{ and } j>=0\}$
(d) $L= \{a^i b^j c^k \mid i+j=k, i>=1 \text{ and } j>=1\}$
(e) $L= \{a^i b^j c^k \mid i+k=j, i>=0 \text{ and } k>=0\}$
(f) $L= \{a^i b^j c^k \mid i+k=j, i>=1 \text{ and } k>=1\}$
(g) $L= \{a^i b^j c^k \mid j+k=i, j>=0 \text{ and } k>=0\}$
(h) $L= \{a^i b^j c^k \mid j+k=i, j>=1 \text{ and } k>=1\}$

(i) L= $\{a^i b^j c^k \mid i+2j=k, i>=1 \text{ and } j>=1\}$
(j) L= $\{0^{n+2}1^n \mid n>=1\}$
(k) L=$\{a^n b^{2n} \mid n>=1\}$.
(l) L=$\{a^{2n}b^n \mid n>=1\}$
(m) L= $\{ a^x b^y \mid x > y \text{ and } y>=0 \}$
(n)L= $\{ a^x b^y \mid y> x \text{ and } x>=0 \}$
(o) L={Strings of a's and b's, with equal no. of a's and b's}
(p) L=$\{a^n b^n c^i \mid n>=0, i>=1\} \cup \{a^n b^n c^m d^m \mid n, m >=0\}$
(q)L={W | W contains balanced parenthesis. Consider (,),{,},[,]}

10. Design PDA for the following languages.
(a) L=$\{a^n b^n \mid n>=1\}$. Show the ID for aabb.
(b) L=$\{wcw^R \mid w \in \{a,b\}^*\}$. Show the ID for abbcbba
(c) L=$\{ww^R \mid w \in \{a,b\}^*\}$. Show the ID for baab. Is it DPDA or NPDA?
(d) L = $\{W \mid N_a(W)= N_b(W)\}$. Show the ID for babaab. Is it DPDA or NPDA?
(e) L=$\{a^n b^{2n} \mid n>=1\}$. Show the ID for aabbbb
(f) L=$\{a^{2n}b^n \mid n>=1\}$. Show the ID for aaaabb
(g) L={W | W contains balanced parenthesis. Consider (,),{,},[,]} . Show the ID for ({})
(h) L=$\{a^n b^n c^m d^m \mid n,m >=1\}$. Show the ID for aabbcccddd

11. Eliminate NULL production , unit production and useless symbols from the following grammar and convert it to CNF.

$S \rightarrow ABC|BaB$
$A \rightarrow aA|BaC|aaa$
$B \rightarrow bBb|a|D$
$C \rightarrow CA|AC$
$D \rightarrow \varepsilon$

12. Convert the following CFG to PDA by empty stack

$I \rightarrow a \mid b \mid Ia \mid Ib \mid I0 \mid I1$
$E \rightarrow I \mid E*E \mid E+E \mid (E)$

13. Convert the following CFG to PDA by empty stack

$S \rightarrow aABB \mid aAA$
$A \rightarrow aBB \mid a$
$B \rightarrow bBB \mid A$
$C \rightarrow a$

14. What is ambiguous grammar? Show that the following grammar is ambiguous. Write the equivalent unambiguous grammar.

E → E+E | E-E | E*E | E/E | (E) | id

15. What is CNF and GNF. Convert the following grammar to GNF.

S → aBa | abba
A → ab | AA
B → aB | a

16. Convert the following CFG to CNF

S → AB|AC
A → aA|bAa|a
B → bbA|aB|AB
C → aCa|aD
D → aD|bC

17. Convert the following CFG to PDA

S → aA
A → aABC|bB|a
B → b
C → c

Module 5

1. Define a TM. Explain the working principle of TM with a neat block diagram.
2. Explain Multitape Turing machine and Non-deterministic Turing machine with a neat block diagram.
3. Write short notes on:
   (a) Decidability and Undecidability
   (b) Halting problem of TM
   (c) Recursive and recursively enumerable language

4. Design a TM to accept the language L = { $a^n b^n$| n>=1}. Show the ID for aabb.

5. Design a TM to accept the language L = { $a^n b^n c^n$| n>=1}. Show the ID for aabbcc.

6. Design a TM to accept the language L = { W| W is a palindrome}. Show the ID for babab.

7. Design a TM to accept the language L = { WW^R| W Ɛ {a,b}*}. Show the ID for abba.

8. Design a TM to accept the language L = { W| $N_a(W)=N_b(W)$ and W Ɛ {a,b}*}. Show the ID for abba.

9. Design a TM to accept the language L = { W| W contains a substring bab and W Ɛ {a,b}*}. Show the ID for ababa.

10. Design a TM to accept the language L = { W| W ends with abb and W Ɛ {a,b}*}. Show the ID for baabb.

11. Design a TM to add two numbers and show the ID for 2+4

12. Design a TM to subtract two numbers and show the ID for 2-4