33 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2075 Ashwin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Theory of Computation *(CT502)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Write a regular expression for the language in which strings start and end with different symbol over alphabet $\sum = \{a, b\}$. [3]

   b) Define Diagonalization Principle. Explain Principle of mathematical induction with suitable example. [1+3]

2. What are the components of finite automata? Design a DFA that accepts the strings given by L = {w∈ {a, b}*: w has number of a divisible by 3 and number of b by 2}. [1+6]

3. List closure properties of regular language. If M and N are any two regular languages then show that L = (M∪N) is also regular language. [2+5]

4. Write the statement of Pumping lemma for regular languages. Show that $L = \{a^n b^n, n > 0\}$ is not a regular language by using pumping lemma. [3+4]

5. Write Context Free Grammar for the Language $L = \{a^i b^j c^i : i, j > 0\}$ over the alphabet $\sum = \{a, b, c\}$. Use Leftmost, rightmost derivation to generate strings "aabbbcc". Also draw parse tree for the same. [7]

6. Convert following CFG into CNF with explanation of each steps. G = (V, Σ, R, S), where
   V = {S, X, Y, a, b, c},
   Σ = {a, b, c},
   R = {S→aXbX, X→aY|bY|XY|∈, Y→aX|c}. [7]

7. What is additional feature PDA has when compared with finite automata? Explain. Design a Pushdown Automata (PDA) which accepts all the strings of language $L = \{a^n b^m c^{2n}; n, m > 0\}$. [2+5]

8. Design a Turing machine that increments any binary strings by one with $\sum = \{0, 1, \#\}$. Hence test your design for ##11<u>#</u> to <u>#</u>100#. [7]

9. How multi-tape Turing machine is different from multi-track Turing Machine? Does any variation of Turing machine have more computational power than standard Turing machine? Explain. [2+5]

10. Describe in detail about on universal Turing machines with example. [5]

11. Explain the Church Turing thesis. Show that the "halting problem" is undecidable. [3+4]

12. Explain NP hard and NP-Complete Problems with reference to polynomial time reduction. [5]

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33 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2074 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

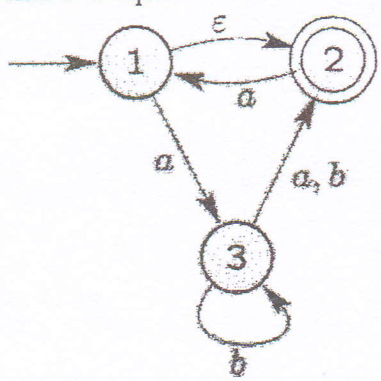
Subject: - Theory of Computation *(CT502)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. What are regular expressions? Find the equivalence classes for the set N = {1, 2, 3, 4, 5 ....} corresponding to the equivalence relation R = {(a, b): (a+b) is even number}. [2+5]

2. Explain finite automata with their application. Design a DFA that accepts the language L = {w ε {a, b} : w must have either aaa or bbb as a substring}. [2+5]

3. Convert the following NFA into it's equivalent DFA. [7]



4. State the pumping lemma for the regular languages. Show that the Language $L = \{0^{n^2} \mid n >= 1\}$ not regular e.g. if n = 1, w = 0, n = 2, w = 0000.n = 3, w = 000000000 [2+5]

5. Define context free Grammar (CFG). Show that $L = \{a^n b^{2n} c^{3n} : n > 0\}$ is not context free language by using Pumping lemma for CFL. [2+5]

6. Convert the following CFG into CNF. G = {V, T, P, S} [7]

   Where, V = {S, A, B, C, a, b, c}
   T = {a, b, c}
   P = {S →ABA | ab A | BC, A → aA | ε , B → baB | c, C → aC}

7. Design a push down automaton (PDA) for $L = \{a^n b^{2n} : n \geq 1\}$. Hence test for "aaabbb" and "aabbbb". [5+2]

8. Define Turing Machine. Design a single tape deterministic Turing Machine which reverses the given string w, over alphabet Σ = {a, b}. [2+5]

9. Explain how unrestricted grammar can be used to generate the language $L = \{a^n b^n c^n : n > 0\}$.
   Is there any difference between CFG and Unrestricted grammar? Explain [4+2]

10. Explain encoding technique of universal Turing machine. Show that complement of recursive language is recursive. [5+4]

11. What do you mean by Church-Turing Thesis? State when a problem is said to be decidable and give an example of an undecidable problem. [2+2]

12. Explain P and NP class of problems. [5]

43 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2074 Ashwin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

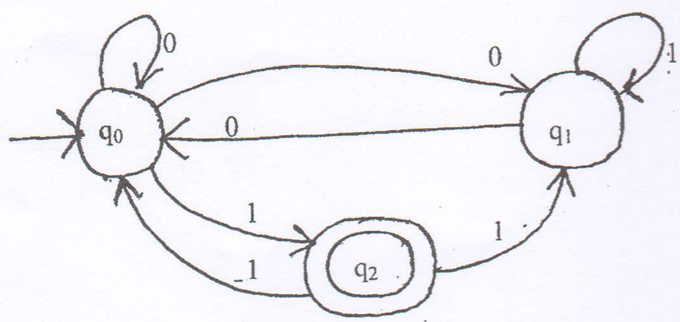
Subject: - Theory of Computation *(CT502)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. State the diagonalizable principle. Use principle of mathematical induction principle to prove $n^4 - 4n^2$ is divisible by 3 for $n \geq 0$. [3+4]

2. What is the significance of finite automata? Design a DFA that accepts the strings over an alphabet $\sum = \{0,1\}$ that either start with 01 or end with 01. Hence test your design for any two strings. [1+6]

3. Differentiate between DFA and NDFA. Convert the following NDFA to its DFA. [2+5]



4. Define Closure properties of Regular Language. Prove that regular Language are closed under Union, Intersection and Complementation operation. [1+6]

5. Define pumping lemma for context free language. Prove that language $L = \{WW | W \in \{1,0\}^*\}$ is not context free. [2+5]

6. Convert following CFG into CNF with explanation of each steps. G=(V,Σ,R.S), where [7]

   $V = \{S,A,B,a,b\}$,

   $\Sigma = \{a,b\}$

   $R = \{S \rightarrow ASB | \in, A \rightarrow aAS | a, B \rightarrow AB | b | \in\}$.

7. Mention role of parse tree in context free grammar. Design a PDA that accepts $L = \{a^n b^{2n+1}, n > 0\}$ and check it for string aabbbbb. [2+5]

8. Design a single tape deterministic Turing machine which accepts all strings defined for the language $L = \{a^n c b^n : n \geq 0\}$ over alphabet $\sum = \{a,b,c\}$. [5]

9. Design a multi-tape Turing machine which act as Copying machine over the alphabets $\sum = \{0,1\}$ that transforms string of the form "#10#" into "#10#10#". [5]

10. Define unrestricted grammar. Explain possible extensions of Turing machine in brief. [1+6]

11. What is universal Turing machine? How Universal Turing machine works? Explain. [5]

12. Explain Halting problem. Is it solvable problem? Discuss. [4]

13. What are two factors affecting the computational complexity of a problem? Explain class NP with suitable example. [1+4]

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43 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Shrawan

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BCT	Pass Marks	32
Year / Part	II/ I	Time	3 hrs.

Subject: - Theory of Computation *(CT502)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. State pigeonhole principle. Prove the following statement by using mathematical induction: $1\times1!+2\times2!+3\times3!+...........+n\times n! = (n+1)!-1$ where $(n\geq1)$. [2+5]
2. Define Configuration of DFA. Design a Deterministic Finite Automata (DFA) for language $L = \{w \, \varepsilon \{0,1\} : w$ has both 01 and 10 as substrings$\}$. Verify your design by taking one accepted and one rejected strings. [2+5]
3. Construct a NFA for the language (ab*a U b*aa). Provide any two accepted strings and two rejected strings. [7]
4. State pumping lemma for regular language and use this theorem to prove that $L = \{a^n b^{2n} : n \geq 1\}$ is not regular. [7]
5. Construct a PDA which accepts the language $L = \{a^n b^{n+m} c^m : n, m \geq 1\}$. Verify your design by taking s string "abbbcc" as example. [7]
6. What is Chomsky? Normal Form (CNF)? $\{S, L, M, N, a, b, c\}$, $\sum = \{a, b, c\}$,

   $R = \{S \to MaN|bL|bM, L \to ab|cN|Ml|\varepsilon, M \to a|cM, N \to abN\}$ and S is the start symbol. [2+5]
7. Construct a CFG for the language $L = a^n b^{2n}, n > 0$ and use this grammar to generate the string aabbbb. Also construct the parse tree. [5+2]
8. Design a Turing Machine (TM) which accepts the following language $L = \{W \, \varepsilon \{x, y, z\}^* : w$ has equal no. of x's, y's and z's$\}$. Verify your design for the string "#xyxyzz#". [6]
9. Design a two tape Turing machine that acts as a binary adder. Assume both the strings are kept at first tape and separated by a semicolon and output is desired at the same tape. [7]
10. Explain Recursive and Recursively Enumerable Languages with suitable examples of each language. [4]
11. Define unrestricted grammar. Explain, how unrestricted grammar can be defined as super set of CFG and Regular Grammar? Explain the church-turing thesis. [2+3+4]
12. Explain class P and NP problems with example. What is NP-complete problem? [5]

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43 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2072 Chaitra

Exam.	**Regular**		
Level	BE	**Full Marks**	80
Programme	BCT	**Pass Marks**	32
Year / Part	II / I	**Time**	3 hrs.

Subject: - Theory of Computation *(CT502)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Define Catesian Product. Use Mathematical Induction to show [1+3]

   $1.1!+2.2!+.........+n.n! = (n+1)!-1$ for $n \geq 1$

b) Find the regular expression for the language L = {W ∈ {0, 1}*: has 0101 as substring. [3]

2. Construct a DFA over {a,b} accepting strings having even number of 'a' and odd number of 'b'. [7]
3. Define DFA formally. State and prove closure properties of regular languages. [7]
4. Define pumping lemma for regular language. Use pumping lemma for regular language to show $L = \{a^n ba^n \text{ for } n = 0,1,2......\}$ is not regular. [2+5]
5. Define the configuration of PDA. Design a PDA that accepts $L = \{a^{3n}b^n, n > 0\}$ and check the string aaaaaabb. [7]
6. Define context free grammer.Convert the given Context Free Grammar (CFG) into equivalent CNF [2+5]

   S→AB

   A→aAA | e

   B→bBB | e, Here: e means empty symbol

7. a) Write a CFG for the regular expression R = 0*1(OUI)* [4]

   b) Use concept of closure property to prove that intersection of Context Free Languages is not Context Free. [3]

8. Design a Turing machine to compute the function $f(n) = n+1$, where n be a binary string. Show the processing for the string 10111. [6]
9. Define Multitape Turing Machine. With the help of suitable example, explain how Universal Turing machine works. [2+5]
10. State Church Turing thesis. What is a recursive language? [2+2]
11. Show that if a language L and its complement both are recursively enumerable, then L and its complement is recursive. Explain the halting problem. [4+5]
12. Write short notes on: [5]

    a) Computational Complexity

    b) NP hard and NP Complete Problems

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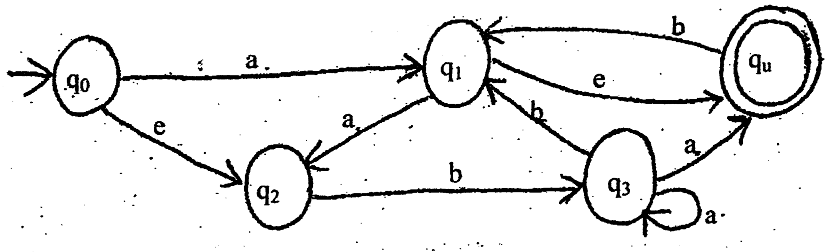
43 TRIBHUVAN UNIVERSITY				
INSTITUTE OF ENGINEERING	**Exam.**	Regular		
Examination Control Division	**Level**	BE	**Full Marks**	80
2071 Chaitra	**Programme**	BCT	**Pass Marks**	32
	Year / Part	II / I	**Time**	3 hrs.

Subject: - Theory of Computation *(CT502)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Assume suitable data if necessary.*

1. Define countably infinite and uncountable sets with example. Use principle of mathematical induction to prove $(5^n - 1)$ is divisible by 4 for all integers $n \geq 0$. [3+4]
2. Design a Deterministic Finite Automata (DFA) for the regular expression (a(ab)*b)*. Verify your design by taking one accepted and one rejected strings. [5+2]
3. State pumping lemma for regular language. Use this lemma to prove language, $L = \{a^{n^2} : n \geq 0\}$ is not regular. [2+5]
4. What are the differences between a DFA and a NFA? Convert the following NFA in to its equivalent DFA. [2+5]



5. Construct CFG for language, $L(G) = \{a^m b^n : m, n > 0, m \geq n\}$. Use this grammar to generate string "aaab". And also draw the parse tree. [4+1+1]
6. Convert following CFG to CNF [5]

   $G = (V, \Sigma, R, S)$, where
   $V = \{S, A, B, a, b\}$
   $\Sigma = \{a, b\}$
   $R = \{S \rightarrow aAb \mid Ba \mid A, A \rightarrow SS \mid e, B \rightarrow e\}$
7. Define the term ambiguity and inherent ambiguity in parse tree. For a CFG given by $G = (V, \Sigma, R, S)$ with $V = \{S\}$, $\Sigma = \{a\}$ and production rules R is defined as: [4]
   $S \rightarrow SS$,
   $S \rightarrow a$.
   Obtain the language L(G) generated by this grammar.

8. Design a PDA that accepts language, $L = \{a^n b^{3n} : n \geq 1\}$. Test your design for string "abbb". [5+1]

9. Write the differences between CFG and unrestricted grammar with example. Design a Turing machine that reads binary string and doubles the number represented by that string. A binary number is doubled if a '0' is added on the right end of the number. [3+5]

10. Define head shifting and symbol writing Turing Machines. Design a Turing Machine (TM) which computes following function $f(w) = ww^R$, where w^R is the reverse of string and $w \in \{0,1\}^*$. If your input string is #01#then TM should give the output string as #0110#. [3+6]

11. Define class-P and class-NP problems with example. How do they relate to NP-complete problems? [5]

12. What is an "Algorithm" according to Church-Turing Thesis? Why is it called thesis and not a theorem? Prove that if a language 'L' and its complement '$\overline{L}$' both are recursively enumerable, then L is recursive. [2+1+6]

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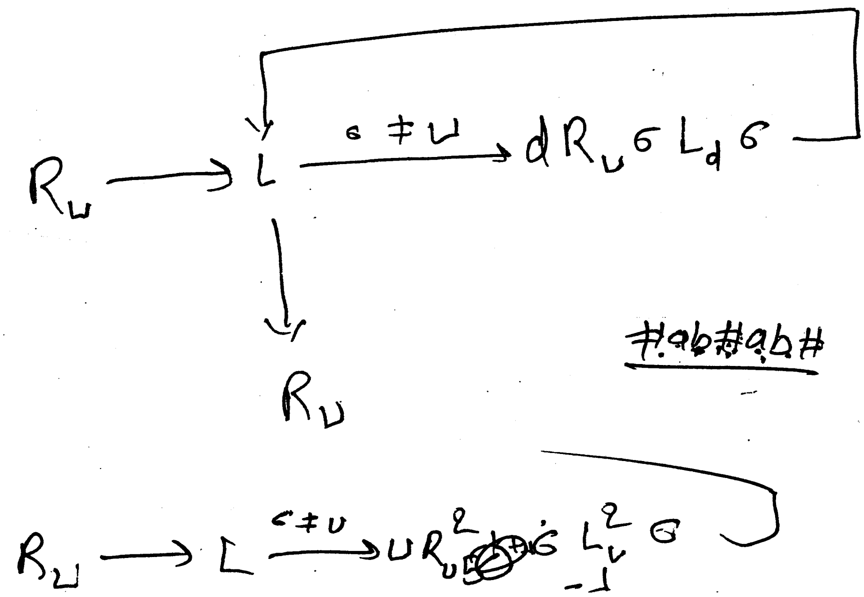

$5^K \cdot 5 - 1$

$5 \cdot K^k - 1$ $\quad 5(5^K - 1 + 1) - 1$

$5 \cdot 5^K - 5 + 4$ $\quad 5(5^K - 1) + 5 - 1$

$5(5^K - 1) + 4$ $\quad + 4$

43 TRIBHUVAN UNIVERSITY INSTITUTE OF ENGINEERING **Examination Control Division** **2070 Chaitra**	**Exam.**	Regular		
	Level	BE	**Full Marks**	**80**
	Programme	BCT	**Pass Marks**	32
	Year / Part	II / I	**Time**	3 hrs.

Subject: - Theory of Computation *(CT502)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Justify that "The complement of diagonal set is different from each row sets." with the help of diagonalization principle. Show that if 3n+2 is odd then n is odd by using proof by contradiction technique. [3+4]
2. Design a DFA that accepts the language L = {x ε {1,1}*: x has an even number of 0's and an even number of 1's}. Verify your design for at least two strings that are accepted by this DFA and 2 strings that are rejected. [5+2]
3. Show that for any Regular expression R, there is a NFA that accepts the same language represented by R. Construct a e-NFA for regular expression bb (a U b)*ab [3+3]
4. Use pumping lemma to prove that $L = \{a^n b^{2n} : n \geq 1\}$ is not regular. [4]
5. Consider the **regular grammar** G = (V, Σ, R, S) where [4]
   V = {S,A,B,a,b}, Σ = {a,b}
   R = {S → abA / B / baB / e
   A → bS / a
   B → aS
   }
   Construct a finite automaton M such that L (M) = L (G)
6. Write context free grammars (CFG) for the languages $L1 = \{a^m b^n c^n : m \geq 1, n \geq 1\}$ and $L2 = \{a^n b^n c^m : m \geq 1, n \geq 1\}$. Do you think that $L = (L1 \cap L2)$ is also context free? If not prove that the language thus obtained is not context free by using pumping lemma for context free language. [4+6]
7. Convert following CFG into CNF with explanation of each step. G = (V,Σ,R,S), where [6]
   V = {S, X, Y, Z, a, b, c},
   Σ = {a, b, c}
   $R = \{S \to XYZ \mid XY \mid aZ,\ X \to abX \mid \varepsilon,\ Y \to bY \mid cZ \mid ab,\ Z \to aXZ\}$
8. Design a PDA that accepts all the palindromes defined over {a, b}*. Your design should accept strings like ε, a, b, aba, bab, abba, babab etc. [5]
9. Define the term configuration of Turing Machine. Design a Turing machine which accepts the set of all palindromes over alphabets {0,1} [2+5]
10. Is Turing Machine a complete computer, support your answer in reference to different roles of Turing machines? Justify that unrestricted grammar can generate the language $L = \{a^n b^n c^n : n \geq 1\}$ [3+3]
11. Define Multiple tapes Turing machine. With reference to language they accept, compare Multiple tapes Turing machine with single tape Turing machine. [4]
12. "Turing machines is believed to be the ultimate calculating mechanism", elaborate with the help of Church-Turing thesis. How halting problems suffer the computational procedures? Explain with suitable example. [5+4]
13. With reference to Polynomial Time Reducibility, explain NP hard and NP- Complete Problems. [5]

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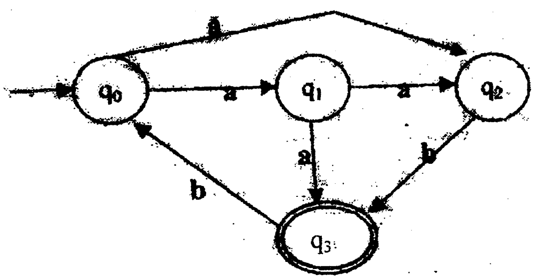
44 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BCT	Pass Marks	32
Year / Part	II / I	Time	3 hrs.

Subject: - Theory of Computation *(CT 502)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. What are the differences between reflexive relation and reflexive closure? Use mathematical induction to show that $2^n < n!$ for any positive integer $n \geq 4$. [2+5]
2. Design DFA that accepts the language L = { W∈{0, 1}*: W is the multiple of five.} Check your design for 1010. [7]
3. Convert the following NDFA into equivalent DFA. [7]



4. Show that $L = \{a^{2n} ba^n : n \geq 1\}$ is not regular by using Pumping Lemma for regular language. Test all possible cases. [7]
5. What is CFG? Design CFG for the language $L(G) = \{WW^R: W \in \{0, 1\}^*\}$. [2+5]
6. Convert following CFG into CNF. G = (V, Σ, R, S), where [7]

   V = {S, A, B, C, a, b, c},
   Σ = {a, b, c},
   R = {S→ABA|abA|BC, A→aA|∈, B→baB|c, C→aC}.
7. Design a Nondeterministic PDA to accept the language L(G) = {W ε{0, 1}*: W has equal number of 0's and 1's}. Check your design for 001110. [7]
8. Design a turning machine that scans to left to find at least two a's. Machine should print "yes" if at least two a's are present otherwise it must print "no" and then halts. Hence test your design for Δ#b#ab#ba# to Δ#yes#ab#ba#. Where Δ and # represent left end and blank symbols respectively with Σ = { Δ, #, a, b}. [9]
9. Explain about Unrestricted Grammar. Design a Turing Machine that accepts the language $L = \{a^nb^n: n \geq 0\}$. Show all configuration of TM for aabb. [2+6]
10. Define universal turning machine and explain its encoding technique in detail with suitable example. List undecidable problems about turning machine and grammar. [5+4]
11. Explain class-P and class-NP, with examples. [5]

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44 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Baishakh

Exam.	**Regular / Back**		
Level	BE	**Full Marks**	80
Programme	BCT	**Pass Marks**	32
Year / Part	II / I	**Time**	3 hrs

Subject: - Theory of Computation

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Let N be a set of natural numbers and R be any relation defined as R = {(a, b): $a \leq b$}. Now test whether R is an equivalence relation or not. Prove that the function $f(x) = x^5 + 5x^3 + 16x + 5$ cannot have more than one real root by using proof by contradiction technique. [3+4]

2. How finite automata are useful in various fields? Design a DFA that accepts the language given by (M) = {w∈{0, 1}*: w does not contain four consecutive 0's}. Hence test your design for 01010001. [1+5]

3. Minimize the following DFA (Draw initial diagram first). Specify performed operations in each step. [5]

δ/Σ	0	1
$\rightarrow q_0$	q_1	q_2
$*q_1$	q_1	q_3
$*q_2$	q_2	q_2
$*q_3$	q_5	q_2
$*q_4$	q_4	q_2
$*q_5$	q_4	q_2
q_6	q_5	q_6
q_7	q_5	q_6

4. Check whether L = {$a^{n!}$: $n \geq 0$} is regular or not by using Pumping Lemma for regular language. [5]

5. State closure properties of regular language and explain diagrams. [5]

6. What is ambigious grammar? Write Context Free Grammar for the language given by L = {w∈{(,)}*}: each string in w has balanced parentheses}. Use same to derive leftmost and rightmost derivations for (()) (). Hence also draw parse tree. [1+2+4+1]

7. What are the importance of CNF? Convert following CFG into CNF with explanation of each steps. [1+6]

G = (V, Σ, R, S), where
V = {S, A, B, a, b}
Σ = {a, b}
R = {S→bA/ Ba/ AaA,
A→S/e,
B→aB/ab}

8. Design a Non deterministic PDA for the language given by L(M) = $\{a^n b^n : n > 0\}$. Hence explain how it processes strings like aabb? [4+2]

9. What is Turing-decidable language? Design a Turing machine that recognizes the language given by L = $\{a^n b^n c^n : n \geq 0\}$. Hence test your design for #aabbcc. [1+5+2]

10. List three criteria that should be satisfied by a Turing machine. How unrestricted grammar differ from context free grammar? Design a Turing machine that recognizes the strings of matched parenthesis. [2+2+5]

11. State and explain halting problem with suitable example. Why Church's Turing thesis can not be a theorem? List unsolvable problems about grammar? [5+2+2]

12. State computational complexity theory. Explain class NP with suitable example. [1+4]

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