TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2076 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. Formally define regular expressions. Explain the diagonalization principle with an example. [2+5]
2. Distinguish between deterministic and non-deterministic finite automata. Design a DFA with $\Sigma = \{0, 1\}$ which accepts the strings with an even number of 0's followed by a single 1} [2+5]
3. Construct an NDFA for the language (ba)*U(bab)*. Convert the NDFA into a DFA. [2+5]
4. Define what is a closure property. Prove that regular languages are closed under union, concatenation and kleene star operation. [1+6]
5. Explain ambiguity in CFG with example. Write the CFG for the language $L = \{a^i b^j c^k : i=j \text{ or } j=k\}$. Generate the strings $a^3 b^4 c^4$ using your grammar. [3+4]
6. Define Chomsky Normal Form. [1+6]

   Convert the following CFG into CNF.

   G = (V, Σ, R, S) where
   V = {S, X, Y}
   Σ = {a, b, c}
   R given by
   $S \rightarrow aXbX$
   $X \rightarrow aY \mid bY \mid \varepsilon$
   $Y \rightarrow X \mid c$
7. Differentiate between Finite Automata and Pushdown Automata. Design a PDA which accepts all the strings of languages $L = \{a^n b c^{2n} : n > 1\}$. [2+5]
8. Design a single tape deterministic Turing Machine that accepts $L = \{wcw^R : w \in \{0, 1\}^*$ and c is single 0 or 1 or e (empty string). [7]
9. Compare Turing machine with PDA and FA. Explain Chomsky hierarchy of language with suitable diagram and examples. [4+4]
10. Define the term Turing Decidable. Show that Union and Intersection of two recursive languages is recursive. [3+5]
11. What is the significance of a Universal Turing Machine? Explain its working mechanism. [2+3]
12. Explain NP-complete problems with example. [3]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Chaitra

Exam.	Regular / Back		
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. Define Regular Language. Write regular expressions for the language in which strings start and end with same symbol over alphabet Σ={a,b}. [3]
2. Explain Diagonalization principle with suitable example. [4]
3. Design DFA for following Language $L = \{w : w \in \{a,b\}^*,$ w has even number of 'a' and odd number of 'b' }. Also Test your design for "aabbb". [5+2]
4. Construct NFA an convert it to its corresponding DFA for the language represented by following Regular Expression: (ab U bb)*a [7]
5. What is the application of pumping lemma? Use pumping lemma for regular languages to show the language $L=\{a^p: p \text{ is prime}\}$ is not regular. [2+5]
6. Write a context free grammer for he language L={wε{a,b}* : w has equal number of a's and b's}. Use leftmost and rightmost derivation to generate strings "aababb". Also draw parse tree for the same. [7]
7. Define Ambiguous Grammer with example. Convert the following CFG into CNF with explanation of each step. [2+5]
   G ={V, Σ, R, S} where
   V= {S, A, a,b} is set of variables
   Σ= {a,b} is the Alphabet of terminals
   R={S →aAb|bAa|e, A→SS}; Note: e donates "Empty String"
   S is Starting State
8. Design a PDA which accepts all the strings of language $L=\{a^nb^mc^md^n : n,m>0\}$. [7]
9. Design a Turing Machine that recongnizes the string of matched parenthesis. Also, test your design for "(())()" showing all configurations. [5+2]
10. Explain how unrestricted grammar can be used to generate the language $L= \{a^nb^nc^n : n> o\}$. Describe the structure of different types of grammars as defined by Chomsky Hierarchy. [5+2]
11. Define Church Turing Thesis. Why is it called a thesis? [2+1]
12. Define Recursive and Recursively enumerable Languages. Prove that the complement of recursive language is also recursive. [2+2]
13. Describe the working mechanism of Universal Turing machine with example. [5]
14. Define computational complexity and polynomial Time Reduction. Explain Class NP-Problems. [2+3]

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TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2076 Ashwin

Exam.	Back		
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.*
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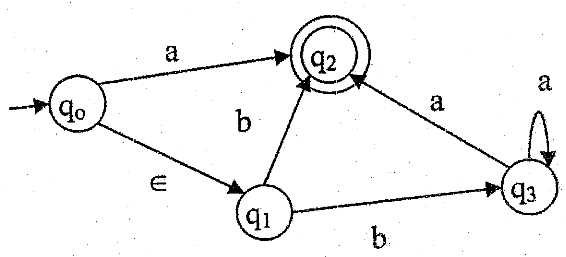
- ✓ *Assume suitable data if necessary.*

1. Determine Regular Expression for the following Language L={ $w \in \{a,b\}^*$: w contains at-least one 'a' OR at-least one 'b'}. [2]
2. Prove by using Principle of Mathematical Indication: [5]

$$1+2+3+...+n = \frac{n^2+n}{2}; \text{ for } n \geq 0$$

3. Define configuration of DFA. Design a DFA that accepts the language L={$w \in \{a,b\}$: w has neither 11 nor 00 as substring}. [2+5]
4. Convert following NDFA to DFA. [7]



5. State pumping lemma for regular language. Show that L={ $a^n b a^n$: n>0} is not regular. [2+5]
6. Construct CFG for following language: L={ww^R: $w \in \{a,b\}^*$ }
   Also, use the grammar to derive the string "abba" and draw parse tree for it. [7]
7. Define Chomsky Normal Form.
   Convert the following CFG into CNF.
   G= (V,Σ,R,S) where V={S, A, B, a, b}, Σ={a, b}, R given by
   s → AB
   A→ aAA/e
   B→bBB/e [2+5]
8. Design PDA for following language: L={$a^{2n}b^{3n}$: $n \geq 0$}
   Also test your design for "aabbb". [7]
9. Explain a multi-tape Turning Machine. Design a single tape deterministic Turing Machine which accepts the given string w over alphabet Σ={a, b, c} and w contain equal number of a, b, c. [2+5]
10. Differentiate between Context Free and Unrestricted Grammars. Design a Turing Machine that replaces symbol 'a' with 'b' and 'b' with 'a' for any string $w \in \{a,b\}^*$. Show the processing of machine (configuration transition) for string "ababa". [2+5]
11. What do you mean by Church Turing thesis? Show that the union of two recursively enumerable languages is recursively enumerable. [3+4]
12. What is "Halting Problem"? How can you prove that it is unsolvable? [5]
13. Define polynomial time reduction. Explain P and NP problems with examples. [1+4]

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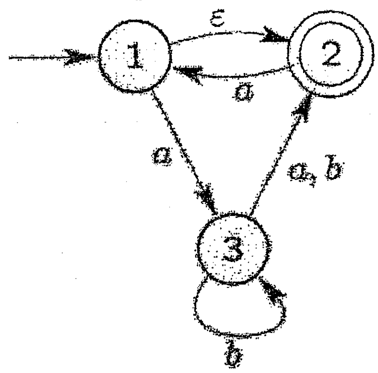
33 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Chaitra

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]

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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# to #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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43 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2073 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.*
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- ✓ *Assume suitable data if necessary.*

1. Explain dovetailing technique with suitable example. Write a regular expression for even number of 'a' followed by odd number of 'b' over an alphabet $\Sigma = \{a, b\}$. [3+4]
2. Differentiate between NFA and DFA. Design a DFA that accepts the language $L = \{x : x \in \{0,1\}^* \mid 10110$ does not occurs as a substring in $x\}$. Verify your design with supporting examples. [2+5]
3. State Pumping Lemma for Regular Language. Use Pumping Lemma and prove that Language $L = \{w : w \in \{0,1\}^*$, and w has an equal number of 0's and 1's$\}$ is not regular. [2+5]
4. Why is NDFA important although it is equivalent to a DFA? Design NDFA which accepts $L = \{W \mid W \in \{a,b\}^*$ such that W contains either two consecutive a's or two consecutive b's$\}$. [2+5]
5. Define ambiguity in CFG. Write CFG for $L = w \in \{a,b\}^* :$ w is a palindrome$\}$ and also draw parse trees for the derivation of any two strings of length even and odd. [2+5]
6. Define Chomsky Normal Form (CNF). Convert the following CFG into CNF. $G = (V, \Sigma, R, S)$ where $V = \{S, A, B, a, b\}$, $\Sigma = \{a, b\}$ and R is given by
   $\{S \rightarrow A, S \rightarrow B, A \rightarrow aBa, A \rightarrow e, B \rightarrow bAb, B \rightarrow e\}$. Where e is empty symbol? [2+5]
7. Design a PDA that accepts those strings "having total number of 'a' equal to the sum of number of 'b' and 'c' with sequence of a,b,c,(i.e $a^i b^j c^k : i = j + k$). Hence test your design for the string "aaaabbcc". [7]
8. Compare Turing machine with Finite Automata (FA) and Push down Automata (PDA). [5]
9. Design a Turing machine to accept language $L = \{WW^R \mid W \in \{0,1\}^*\}$. Show processing for the string 101101. [5]
10. Explain unrestricted grammar with suitable example. Is unrestricted grammar is superset of Context Free Grammar? Justify your answer. [4+3]
11. What is recursive language? Mention its properties. Prove that "A language is recursive if and only if both it and its complement are recursively enumerable." [2+2+5]
12. Define Computational Complexity and Polynomial Time Reduction. Also explain NP hard and NP-Complete problems. [2+3]

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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.*
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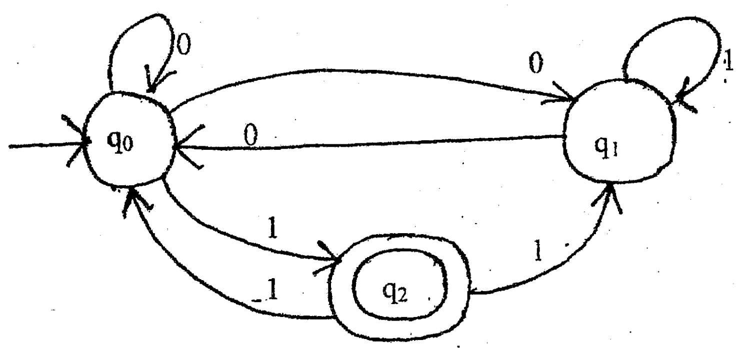
1. State the diagonalizable principle. Use principle of mathematical induction principle to prove $n^4 - 4n^2$ is divisible by 3 for $n \geq 0$. [3+4]
2. What is the significance of finite automata? Design a DFA that accepts the strings over an alphabet $\sum = \{0,1\}$ that either start with 01 or end 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 $L = \{a^n cb^n : n \geq 0\}$ 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

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.*
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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

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.*
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1. State pigeonhole principle. Prove the following statement by using mathematical induction: $1\times1!+2\times2!+3\times3!+\ldots\ldots\ldots\ldots+n\times n! = (n+1)!-1$ 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)? $\{S,L,M,N,a,b,c\}$, $\sum=\{a,b,c\}$,

   $R=\{S\rightarrow MaN|bL|bM, L\rightarrow ab|cN|Ml|\varepsilon, M\rightarrow a|cM, N\rightarrow abN\}$ 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

2071 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.*
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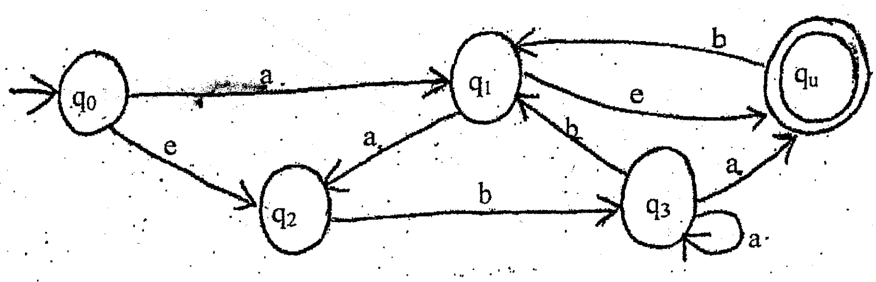
1. Define countably infinite and uncountable sets with example. Use principle of mathematical induction to prove (5^n-1) is divisible by 4 for all integers $n \geq 0$. [3+4]
2. Design a Deterministic Finite Automata (DFA) for the regular expression (a(ab)*b)*. Verify your design by taking one accepted 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, Σ, R, S), where
   V = {S, A, B, a, b}
   Σ = {a, b}
   R = {S → aAb | Ba | A, A → SS| e, B → e}
7. Define the term ambiguity and inherent ambiguity in parse tree. For a CFG given by G = (V, Σ, R, S) with V = {S}, Σ = {a} and production rules R is defined as: [4]

   S → SS,
   S → 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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43 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Kartik

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.*
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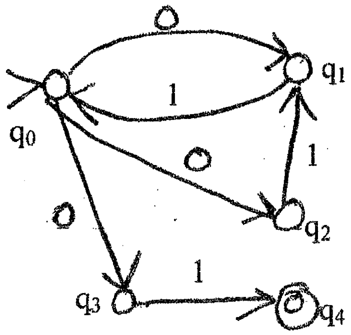
- ✓ *Assume suitable data if necessary.*

1. Explain what an equivalence relation is. Show by induction that for any $n \geq 0$, $1+2+.......+n = (n^2+n)/2$. [2+3]
2. Let $\Sigma = \{a,b\}$. Write a regular expression for the language with all strings in Σ^* with no more than three a's. [3]
3. Formally define a Deterministic Finite Automation (DFA) [5]
4. Design a DFA accepting strings over the alphabet $\{0,1\}$ defined by $\{0\ 0\}^* \{11\}^*$. [5]
5. Convert the following non-deterministic finite automation to DFA. [5]



6. State the pumping lemma for regular language. Show that the language $L = \{a^n : n \text{ is prime}\}$ is not regular using the pumping lemma. [5]
7. Define Context Free Grammar (CFG) along with an example. [5]
8. Convert the following CFG to Chomsky Normal Form (CNF) [5]

   $G = (V, \Sigma, R, S)$ where $V = \{S, A, B, a, b\}$

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

   $R = \{S \rightarrow aAbB, A \rightarrow aA, A \rightarrow a, B \rightarrow bB\}$
9. Design a pushdown automation to accept $L = \{ww^R;\ w \in \{a,b\}^*\}$. Show how it accepts the string "abbbba". [5]
10. Using the pumping theorem for context free languages show that $L = \{a^n b^n c^n : n \geq 0\}$ is not context free. [5]
11. What is a Turing machine? Describe its operation. [5]
12. Construct a Turing machine to transform $\sqcup w \underline{\sqcup}$ into $\sqcup\sqcup w \underline{\sqcup}$, where w is a string containing no blanks and $\sqcup$ represents blank. [7]
13. Construct a Grammar to accept the language $L = \{a^n b^n c^n : n \geq 1\}$ [5]
14. Explain the Church-Turing thesis. Show that the Halting problem is undecidable. [3+7]
15. Explain what is the class P. Describe the Traveling Salesman Problem. [3+2]

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1001/-

43 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Shawan

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 and explain pigeon-hole principle with an example. [3]
2. Prove that $\frac{1}{2}+\frac{1}{6}+\frac{1}{12}+.....+\frac{1}{n(n+1)}=\frac{n}{n+1}$ using mathematical Induction Principle. [4]
3. Design a DFA that accepts the language given by L = {w∈ {0, 1}*: w begins with 0 and ends with 10}. Your design should accept strings like 010, 011110, 000010, 01011010 and should not accept strings like 1010, 0011, 01011. [6]
4. Find the regular expression represented by NFA M= (K, Σ, Δ, s, F) where $K=\{q_0, q_1, q_2, q_3, q_4, q_5\}$, Σ= {a,b}, $s=q_0$, $F=\{q_5\}$ and Δ is given as follows. [5]

δ / Σ	a	b	∈
$\rightarrow q_0$	-	-	q_1
q_1	q_2	q_4	-
q_2	-	q_3, q_4	-
q_3	q_3	q_3	q_5
q_4	q_2, q_4	-	-
$*q_5$	-	-	-

5. Show that L= {w∈ {a, b}*: w has equal number of a's and b's} is not regular by using pumping lemma for regular language. You may use closure properties along with pumping lemma. [5]
6. Explain about decision algorithms for regular language. [5]
7. State and proof the pumping lemma for regular language. [6]
8. Prove that language which contains set of strings of balanced parentheses is not regular. [5]
9. Define a context-free Grammer. Convert the following productions into chomsky Normal form. [2+4]

   $S \rightarrow abAB$

   $A \rightarrow bAB/E$

   $B \rightarrow BAa/A/E$

10. Describe the trausition function of push-down Automata. [4]

11. Design a Turing machine that reads binary strings and counts the number of 1's in the sequence. If there is odd number of 1 in the input string, machine just halts with doing nothing. Otherwise machine should add 1 to the input binary number if it is even number and subtract 1 from the input binary number if it is odd number. For example if input string is #1110#, it just halts after counting odd number of 1's. For #101#, it subtracts 1 to get #100# and for #1010#, it adds 1 to get #1011#. [7]

12. Let M1, M2 and M3 be three Turing machines, can you combine these three Turing machines to get new Turing machine M? If yes, elaborate your idea with required theory and illustration. Explain unrestricted grammar with suitable example. [5+5]

13. What is universal turning machine? Explain with example, how universal turing machine works? [5]

14. What do you mean by Church-Turing Thesis? Explain Turing recognizable languages and Turning decidable language with suitable examples. [2+2]

15. Why computational complexity analysis is required? Define class NP and explain how Travelling Salesman Problem (TSP) is Class NP problem. [1+4]

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44 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Ashad

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. Explain the induction principle with suitable example. [3]
2. In a class of 49 students prove that there will be at least one month where 5 or more students have their birthday. [4]
3. Differentiate between DFA and NDFA. Define a DFA that accepts the language $L = \{ X \varepsilon \{0,1\}^*: 0110$ occurs as a substring in $X\}$ [3+4]
4. Design an NDFA for a language defined as $(ab)^*(ba)^* \cup aa^*$. Give two strings that are accepted by this NDFA and two that are rejected. [5+2]
5. Show that if a language is regular then it is accepted by finite automata. [7]
6. State Chomsky Normal Form (CNF). Constructruct a Push Down Automata (PDA) that accepts the language $L = \{a^n b^{2n} \mid n > 0\}$ [2+5]
7. Write a C.F.G to generate a language $\alpha = \{a^n b^m c^m d^n: m, n \geq 1\}$. Show how this grammar can generate the strings $a^2 b^4 c^4 d^2$. [5+2]
8. Let $G = (V, \Sigma, R, S)$ be a CFG, then prove that any string W E L (G) of length greater than $\phi (G)^{|V - \Sigma|}$ can be rewritten as $W = uvxyz$ in such a way that either v or y is non empty and $uv^n xy^n z$ is in L(G) for every $n \geq 0$ [7]
9. Define the symbol writing machine and head moving machine. How can these be combined to form complex Turing machines? Explain. [3+4]
10. Given the starting configuration $(s, D\cup W\underline{\cup})$ design a Turing machine to compute $(h, D\cup W \cup W\underline{\cup})$ where h is a halting state and 'W' contains only non blank symbols but can be empty. [6]
11. What is recursive function theory. [4]
12. What is church-turing thesis? Explain. [4]
13. Prove that if L is recursive then $\overline{L}$ is also recursive. [5]
14. What is class- NP? Explain. [5]

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BCT II/I

44 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2069 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. Define the Cartesian product. What is the use of Pigeonhole principle? [1+2]
2. Use mathematical induction to prove the following: 1+2+............+n = n(n+1)/2 [4]
3. Design an NDFA for a language defined as (baUb)* U(bbUa*) . Give two strings that are accepted by this NDFA and 2 that are rejected. [5+2]
4. Define configuration in reference to FA. Prove that regular language are closed under Kleene-star. [2+5]
5. What is pumping lemma for regular languages? Can you use this to assert a language is regular? Justify your answer with reference to the language $L = \{a^n b^m c^n : m, n \geq 0\}$ [3+4]
6. Formally define PDA. Design a PDA to accept a language $L = \{a^n bc^n : n \geq 0\}$ [2+5]
7. Where is the main application of pumping lemma? State the pumping lemma for context free languages and explain with suitable examples. [2+5]
8. Write a C.F.G to generate a language $L = \{a^{4n} \mid n \geq 1\}$. Convert this to C.N.F [3+4]
9. What is a turing machine? Define the term configuration in reference to a turing machine. [3+3]
10. Construct a Turing machine that replace every 0 and 1 with every 1 and 0 in binary string (i.e. $f(a) = \bar{a}$, where "a" is a binary string). [6]
11. What is unrestricted grammar? Explain. [5]
12. What is universal turing machine? Explain. [4]
13. Prove that if L recurive then it is recursively ennumerable. [5]
14. What is class P? Explain. [5]

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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→XYZ | XY | aZ, X→abX | ε, Y→bY | cZ | ab, Z→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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Examination Control Division
2061 Baishakh

Programme	BCT	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Theory of Computation

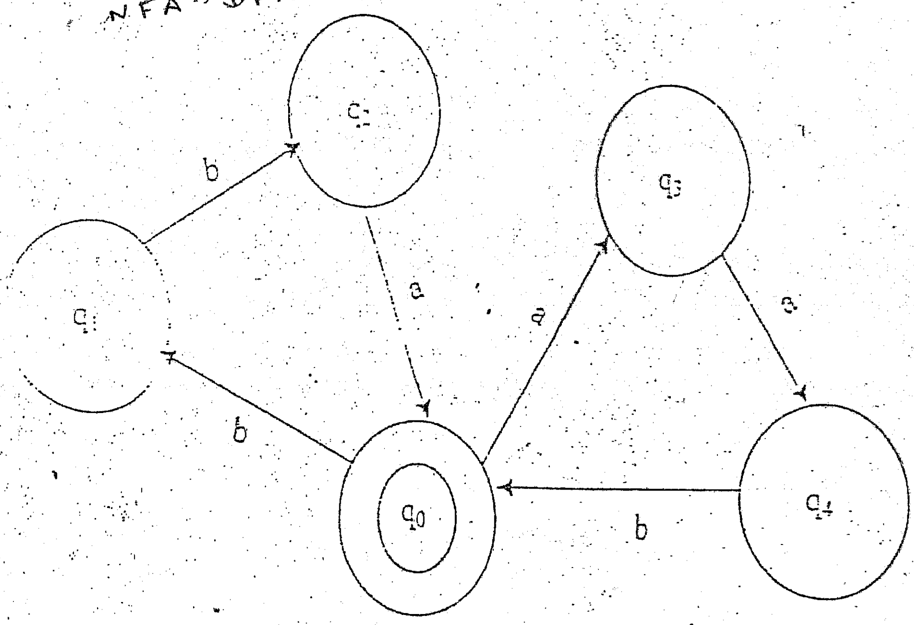
- Candidates are required to give their answers in their own words as far as practicable.
- *Attempt All questions.*
- *The figures in the margin indicate Full Marks.*
- *Assume suitable data if necessary.*

1. (a) Explain what do you know about transitive and antisymmetric action along with suitable directed graphs and examples. Prove that $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$. (4+4)

   (b) State and explain diagonalization principle with suitable examples. Prove the following using principle of mathematical induction.
   For any $n>=0$, $1+2+........+n = (n^2+n)/2$ (5+3)

2. (a) Design a deterministic finite automaton M that accepts the language $L(M) = \{ w \in \{a, b\}^* :$ w has an odd number of a's and an even number of b's }. (8)

   (b) Construct deterministic finite automata equivalent to the nondeterministic automata shown below. Take q_0 as your start state as well as your final or acceptance state.



(8)

3. (a) Differentiate between context free grammar and context dependent grammar? Explain with suitable practical examples. Explain the properties of regular expressions. (5+3)

   (b) Using the principle of context free grammar, capture expression $(x_1 + x_2 / x_1) * (x_1 * x_2 + x_2)$. Also draw it's parse tree. (6+2)

4. (a) What is a pushdown automaton? Justify how pushdown automaton is better than deterministic finite state machine. (8)

   (b) Construct pushdown automata that accept the language $L = \{ w \in \{a, b\}^* :$ w has twice as many b's as a's }. Check your design using input babbab. (8)

5. (a) Explain the properties of recursive and recursively language with suitable examples. (6)

   (b) Is Turing machine a complete computer, justify your answer? Design a Turing machine with finite set of states as q_0 and q_1, alphabets are 'a' and blank, initial state is q_0 and assume suitable transitions. (10)

44 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2066 Bhadra

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

Subject: - Theory of Computation

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

1. a) Write whether or not the following are true. [1+1+1+1]

   i) $\Phi \subseteq \Phi$ ii) $\{a,b\} \subseteq \{a,b,c,d\}$
   iii) $\{a,b,\{a,b\}\} - \{a,b\} = \{a,b\}$ iv) $\{a,b\} \in \{a,b,c,d\}$

   b) Let $f: S \mapsto S$, R be a relation $R \subseteq S \times S$ then show that R is an equivalence relation on set S when $\forall s,t \in S$, $(s,t) \in R$ if and only if $f(s) = f(t)$. [6]

   c) Use the method of induction to show that $n^3 + 2n$ is divisible by 3. [6]

2. a) Write regular expression for the language $L = \{w \in \{a,b\}^* : w$ contains more than two a$\}$. [4]

   b) Construct a Non Deterministic Finite Automation, N1, corresponding to the regular expression $((ab \cup aab)a^*)^*$. [6]

   c) Construct an equivalent Deterministic Finite Automation corresponding to Non-Deterministic Finite Automation N1 above. [6]

3. a) Show that the class of regular languages is closed under the operation of concatenation. [4]

   b) Use the Pumping lemma to show whether or not the language $L = \{ww^R : w \in \{a,b\}^*\}$ is regular. [6]

   c) Convert the following Context Free Grammar into Chomsky normal form. [6]
   $S \rightarrow Ab$, $A \rightarrow AA$, $A \rightarrow B$, $B \rightarrow a$

4. a) Construct a Pushdown Automation that recognizes the language $L = \{a^i b^j c^k : i,j,k \geq 0$, and ether $i = j$ or $j = k\}$. [8]

   b) Use pumping lemma to show whether or not the language $L = \{a^n b^n c^n : n \geq 0\}$ is context free. [4]

   c) Show that the class of Context Free Languages is not closed under the operation of complementation. [4]

5. a) Construct a Turing machine that computes the function that replaces symbol a with symbol b and symbol b with symbol a for strings $w \in \{a,b\}^*$. Show the processing of this machine on the string w = ababa in terms of configuration transition and final output. [6]

   b) Construct a Grammar that computes the function $f(w) = w^R$, $w \in \{a,b\}^*$. Show how this grammar computes the function in terms of processing of string w = babba and producing of the final output. [6]

   c) What are recursive and recursively enumerable languages? What are class P and class NP languages? Based on these definitions what can you say about the definition of algorithm? [4]

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44 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2066 Chaitra

Exam.		Back	
Level	BE	Full Marks	80
Programme	BCT	Pass Marks	32
Year / Part	III / 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.*
- ✓ *All questions carry equal marks.*
- ✓ *Assume suitable data if necessary.*

1. a) Define symmetric relation. Prove using mathematical induction that

$$1.2.3 + 2.3.4 + \ldots . n(n+1)(n+2) = \frac{n(n+1)(n+2)(n+3)}{4}$$

b) What is a regular expression? Give a regular expression representing the language L defined as L = {w ∈ {0, 1}* : w has two or three occurances of 1, the first and second of which are not consecutive}. Also explain in brief how the given expression represents the stated language.

2. a) Prove that deterministic finite automata (DFA) represents the same class of languages as regular language.

b) Construct an NDFA to accept the language (ab ∪ aba) * a. Convert the same to a DFA.

3. a) What is a pushdown automata? Design a PDA to accept the language $L = \{a^n b^n : n \geq 0\}$. Verify that it indeed accepts e, a^2b^2 and a^3b^3.

b) Given a context free grammar G = (V, Σ, R, S) defined as follows. Convert it to Chomsky normal form.

V = {S, A, B, a, b}
Σ = {a, b}
R = {S → bA, S → aB, A → bAA, A → aS, A → a, B → aBB, B → bS, B → b}

4. a) What is a turing machine? Prove that if $L \leq \overline{Z}^*$ is recursive than $\overline{L}$ is also recursive.

b) Design a turing machine that accepts the string $a^n b^{2n}$ for $n \geq 0$. Verify it for a^2b^4.

5. a) Define a k-tape turing machine? What is meant by primptive recursive functions? Explain with suitable example.

b) Define complexity theory? Distinguish between non-deterministic polynomially bounded versus exponentially bounded class.

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44 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2065 Shrawan

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

Subject: - Theory of Computation

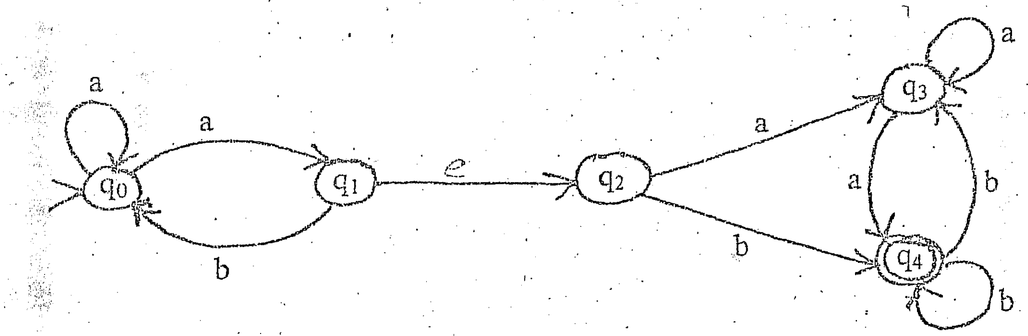
- Candidates are required to give their answers in their own words as far as practicable.
- *Attempt All questions.*
- *All questions carry equal marks.*
- *Assume suitable data if necessary.*

1. a) Define transitive relation. Use mathematical induction to prove that $n^4 - 4n^2$ is divisible by 3 for all $n \geq 0$.

   b) Let $\Sigma = \{a,b,c\}$ be an alphabet. w_1 and w_2 are any two strings on Σ and L_1 and L_2 are two Languages i.e. $L_1 \subseteq \Sigma^*$ and $L_2 \subseteq \Sigma^*$. Define formally the terms $w_1.w_2$ and $L_1.L_2$. Also give examples over given Σ.

2. a) What is an NDFA? Why is it so named? Prove that $L2 = \{w^R : w \in L\}$ is regular if L is regular.

   b) Convert the following NDFA to DFA.



3. a) Define context free language. Is the language L defined over $\Sigma = \{a,b,c\}$ as $L = \{a^n b^n c^n : n \geq 0\}$ context free? Give necessary arguments.

   b) Convert the context free grammer $G = (V,\Sigma,R,S)$ define below to Chomsky normal form.

   $V = \{S,A,B,0,1\}$
   $\Sigma = \{0,1\}$
   $R = \{S \rightarrow 1A, S \rightarrow 0B, A \rightarrow 1AA, A \rightarrow 0S, A \rightarrow 0, B \rightarrow 0BB, B \rightarrow 1\}$

4. a) Distinguish between recursive and recursively enumerable languages. Prove that if L and I are both recursively enumerable than L is recursive.

   b) Design a Turing machine $M = (K, \Sigma, \delta, s, H)$ that starts at $(s, \Delta \sqcup W \underline{\sqcup})$ and computes $(h, \Delta \sqcup W \sqcup W \underline{\sqcup})$ where $h \in H$ and $W \in (\Sigma - \{\Delta, \sqcup\})^*$ and $\Sigma = \{a,b\}$.

5. a) What is an universal Turing Machine? State and explain the halting problem.

   b) Distinguish between the Class-P and Class-NP with suitable examples.

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2064 Jestha

Exam.	Regular/Back		
Level	BE	Full Marks	80
Programme	BCT	Pass Marks	32
Year / Part	III / 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.*

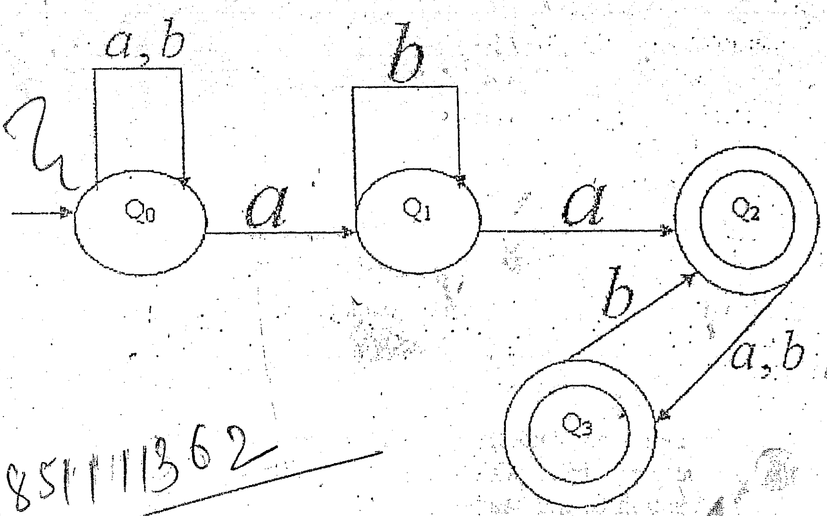
1) State the pigeonhole principle and prove the following by the principle of mathematical induction.

$$\sum_{i=1}^{n} \frac{1}{i(i+1)} = \frac{n}{(n+1)}$$

[2 + 6 = 8]

2) Design a deterministic finite state automaton M, which accepts the language L = {w ε (0, 1)* : every string w in the language L contains 00 as substring}. [8]

3) Construct a deterministic finite automata equivalent to the nondeterministic automata shown below. Take Q_0 as your start state and Q_2 and Q_3 as your final or acceptance state. Here a and b denote the input symbols.



[8]