

2017

**COMPUTER AND INFORMATION SCIENCE****Paper – CISM – 302****(Automata Theory and Compiler Design)****Full Marks – 70***The figures in the margin indicate full marks**Candidates are required to give their answers in their own words as far as practicable*Answer *any five* questions

1. (a) Design a single track-single-head turing machine to compare two strings in terms of their length. Strings are represented by unary symbols. Clearly state your assumptions.

(b) Draw the state transition diagram for deterministic /nondeterministic finite automata accepting the languages :

(i)  $(11+1)^* + (00+1)^*$

(ii)  $((01+001)^* 0^*)^*$

(c) Critically comment on the capabilities of FSMs.

6+4+4

2. (a) What do you mean by 'equivalent states' and 'compatible states'? What are their implications in designing finite state machines?

(b) For the following machine determine whether or not it is lossless. If it is lossy, find a shortest output sequence produced by two different input sequences with the same initial and final states. If it is lossless, determine the order.

PS	NS	
	x = 0,	x = 1
A	B, 0	C, 0
B	D, 0	E, 1
C	E, 0	A, 1
D	E, 0	D, 0
E	C, 1	B, 1

(c) Construct regular expressions for the following languages over the alphabet set {a}

$\{ a^n \mid n \text{ is divisible by 2 or 3 or } n = 5 \}$

(d) Verify the following identity :

$(0^*01 + 10)^*0^* = (0 + 01 + 10)^*$

4+6+2+2

3. (a) Briefly comment on the pumping lemma for context free languages and its application.

(b) If  $R$  is a regular set and  $L$  is a CFL, then comment on  $R \cap L$ .

[Turn Over]

- (c) Find a reduced grammar equivalent to the following grammar :  
 $S \rightarrow AB, A \rightarrow a, B \rightarrow C|b, C \rightarrow D, D \rightarrow E, E \rightarrow a.$  4+4+3+3
- (d) Reduce the following grammar to Greibach normal form:  
 $S \rightarrow A0, A \rightarrow 0B, B \rightarrow A0, B \rightarrow 1.$
4. (a) What are the alternative forms of PDA for acceptance of strings?  
 Comment on their equivalence.
- (b) Construct the PDA equivalent to the following grammar :  
 $S \rightarrow 0AA, A \rightarrow 0S|1S|0$
- (c) Test the membership of the string 'baaba' for the following grammar :  
 $S \rightarrow AB|BC$   
 $A \rightarrow BA|a$   
 $B \rightarrow CC|b$   
 $C \rightarrow AB|a$  5+4+5
5. (a) Critically comment on 'resident compiler' and 'cross compiler'.  
 (b) In a string of length  $n$ , how many of the followings are there?  
 prefixes, suffixes, substrings, proper prefixes, subsequences.  
 (c) Comment on left-recursion and left-factoring with suitable example.
- (d) Considering the following grammar, briefly explain the steps to construct the parsing table and comment on the type of the grammar.  
 $S \rightarrow i E t S S'$   
 $S' \rightarrow e S | \epsilon$   
 $E \rightarrow b.$  2+4+3+5
6. (a) What are the primary objectives of a good compiler? Justify your answer.
- (b) What is handle? Explain the implications of handle in bottom-up parsing techniques.
- (c) Briefly explain the steps for creation of the executable version of a program, indicating the implications of header files, macro definitions, multiple pass and associated linking process.
- (d) Consider the following context-free grammar :  
 $S \rightarrow S S + | S S * | a$
- (i) Show the generation of string  $aa + a^*$ .  
 (ii) Construct the parse tree for this string.  
 (iii) What language is generated by the grammar? 3+3+3+5
- Be: fin lang ??*

2016

**COMPUTER AND INFORMATION SCIENCE****Paper – CISM – 302****(Automata Theory and Compiler Design)****Full Marks – 70***The figures in the margin indicate full marks**Candidates are required to give their answers in their own words as far as practicable*Answer *any five* questions

1. (a) Design a single track-single-head Turing machine to compute the addition of two integer numbers, represented by unary symbol sets. Clearly state your assumptions.

(b) Give regular expression that describe the following languages defined over  $\{a, b\}$

(i)  $\{w \mid w \text{ contains substrings } aba \text{ and } bab\}$

(ii)  $\{w \mid w \text{ does not contain substring } abba\}$

(c) What do you mean by parameter passing? What are the alternatives?

5+5+4

2. (a) Find the equivalence partition and a corresponding reduced machine in standard form.

PS	NS	
	$x = 0$	$x = 1$
A	B,0	E,0
B	E,0	D,0
C	D,1	A,0
D	C,1	E,0
E	B,0	D,0

(b) What do you mean by information lossless FSM? How can you find the order of losslessness of FSM?

(c) Critically comment on 'Merger Graph / Merger Table' in designing optimal FSM.

6+3+5

3. (a) Briefly comment on the pumping lemma for context free languages and its application.

(b) If  $R$  is a regular set and  $L$  is a CFL then comment on  $R \cap L$ .

(c) Find a reduced grammar equivalent to the following grammar :

$S \rightarrow AB, A \rightarrow a, B \rightarrow C \mid b, C \rightarrow D, D \rightarrow E, E \rightarrow a$

(d) Reduce the following grammar to Greibach normal form (GNF):

$S \rightarrow A0, A \rightarrow 0B, B \rightarrow A0, B \rightarrow 1$

4+4+3+3

4. (a) Comment on the acceptance of sentences by final state and empty stack of corresponding PDAs. How will you convert PDA of a given form into its equivalent in the other form?

[ Turn Over ]



(b) Build a non-deterministic FSM to recognize the language denoted by the regular expression  $(101)^*(010)^*$ . Turn the machine into a deterministic machine. example. 4+6

(c) Give regular expressions for the following languages on  $\Sigma = \{a, b\}$ :

- (i) all strings containing exactly one a.
- (ii) all strings containing no more than three a's.
- (iii) all strings containing an even number of a's.
- (iv) all strings such that the fourth to last symbol is always an a.

5. (a) What are the different phases of compilation? Briefly explain. 5+5+4

(b) What are the common strategies of code optimization? Briefly explain.

(c) Construct the parse tree and syntax tree for the expression  $((x) + (y)^* z)$  according to syntax directed definition and translation scheme. 4+4+6

6. (a) From the given grammar design the predictive parsing table for acceptance of the string  $id + id * id \$$

$E \rightarrow E + T \mid T$

$T \rightarrow T * F \mid F$

$F \rightarrow (E) \mid id$

(b) What are left recursion and left factoring? Explain with examples.

(c) What are different error recovery strategies?

7. (a) What are shift-shift and shift-reduce conflicts? Explain with examples. 8+4+2

(b) Construct the SLR parsing table for the grammar

$E \rightarrow E + T \mid T; T \rightarrow T * F \mid F; F \rightarrow (E); E \rightarrow id$

(c) Explain the following techniques with suitable examples :

- (i) Copy propagation and dead code elimination
- (ii) elimination of common sub-expression.

3+8+3

2015

**COMPUTER AND INFORMATION SCIENCE****Paper – CISM – 302****(Automata Theory and Compiler Design)****Full Marks – 70***The figures in the margin indicate full marks**Candidates are required to give their answers in their own words as far as practicable***Answer any five questions**

1. (a) Design a single track-single-head Turing machine to multiply two numbers, represented by unary symbols. Given numbers are to be retained. Clearly state your assumptions.

(b) What is a lossless FSM? Define the states of an inverse machine in terms of the states of a lossless machine with order of losslessness  $\mu$ . Justify your answer.

(c) Justify the statement — 'Equivalence partition of completely specified FSM is unique'.

(d) Critically comment on nonuniqueness of the reduced and minimal machine corresponding to a given incompletely specified FSM. 5+3+3+3

2. (a) Realize the following FSM

PS	NS		OUTPUT	
	x=0	x=1	x=0	x=1
A	A	D	0	1
B	A	C	0	0
C	C	B	0	0
D	C	A	0	1

(b) Prove that  $\{0^i 1^j \mid \gcd(i, j) = 1\}$  is not regular.

(c) Prove or disprove the following for regular expressions a, b, c:

$$1(01 + 1)^*0 = 00^*1(00^*1)^*$$

$$(a + b)^* = a^* + b^*$$

6+4+4

[ Turn Over ]

3. (a) Briefly comment on the pumping lemma for context free languages and its implications. Give an example.

(b) Comment on: "equivalence of PDA's and CFL's".

(c) What are alternative forms of PDA ? How will you justify the equivalence of alternatives forms of PDA ? Briefly explain.

6+4+4

4. (a) Draw the state transition diagram for deterministic/ nondeterministic finite automata accepting the languages:

(i)  $(0+1)(11+0^*)^*(0+1)$

(ii)  $0(11+0(00+1)^*)^*$

(b) Show that if a deterministic finite automaton M over alphabet  $\Sigma$  accepts all strings of length less than the number of states in M, then it must accept all strings over  $\Sigma$ .

(c) What are some of the errors that a compiler should detect ? What course of action should the compiler take when it detects an error ?

6+4+4

5. (a) How does left recursion create problem in top down parsing ? Explain with a small example. How would you eliminate left recursion in the grammar —

$S \rightarrow S, i | i$  ?

(b) Briefly describe the algorithm of predictive parsing ? How is the use of stack in top-down different from that in bottom-up parsing ?

(c) Write the leftmost and rightmost derivations, and draw the parse-tree for the string  $-id + id * id \wedge id$  with the grammar

$E \rightarrow E T + | T$

$T \rightarrow T F * | F$

$F \rightarrow F P \wedge | P$

$P \rightarrow E | id$

5+4+5

6. (a) Why is a symbol table used by a compiler ? Give a possible format of a symbol table record used by a compiler and state why you would use either an array, a hash table, or any other data structure to keep these records.

(b) Write an algorithm to eliminate all productions containing useless symbols from a grammar. Apply your algorithm to the following grammar

$S \rightarrow 0 | A$

$A \rightarrow AB$

$B \rightarrow 1.$

(c) Show that no left recursive grammar can be LL(1).

5+5+4



7. (a) Consider the following grammar for arithmetic expressions-

$$E \rightarrow E + T \mid T$$

$$T \rightarrow T * F \mid F$$

$$F \rightarrow (E) \mid id$$

Write the semantic actions for a syntax-directed translation scheme for converting input expressions into *intermediate code* in *three-address code* notation.

- (b) Compute *FIRST* and *FOLLOW* for each non-terminal of the following grammar.

$$S \rightarrow ictSeS \mid ictS \mid a$$

- (c) Critically comment on the optimization phases of compilation process.

5+5+4

2014

**COMPUTER AND INFORMATION SCIENCE**

**Paper – CISM – 302**

**( Automata Theory and Compiler Design )**

**Full Marks – 70**

*The figures in the margin indicate full marks*

*Candidates are required to give their answers in their own words as far as practicable*

Answer **Question No. 1** and **any four** from the rest

1. (a) What are the primary objectives of a good compiler ? Justify your answer.

(b) What do you mean by resident compiler and cross compiler ?

(c) Briefly explain the steps of creation of the executable version of a program, indicating the implications of header files, macro definitions, multiple pass and associated linking process. Justify your answer.

(d) What are deterministic and non-deterministic finite automata ?  
Briefly discuss the general steps to convert one NDFA to its equivalent DFA.

(e) Write down the regular expressions for the following :

(i) All strings of letters that contain the vowels in order.

(ii) All strings of 0's and 1's that do not contain the substring 011.

3+2+3+3+3

2. (a) Design a single track-single-head turing machine to find the difference between two numbers, represented by unary symbols. Given numbers are to be retained. Clearly state your assumptions.

(b) Draw the state transition diagram for deterministic / non-deterministic finite automata accepting the languages :

(i)  $(0+1)(11+0^*)^*(0+1)$

(ii)  $0(11+0(00+1)^*)^*$

(c) Critically comment on minimization of completely specified and incompletely specified finite state machines.

6+4+4

[Turn Over]



3. (a) What do you mean by 'equivalent states' and 'compatible states'? What are their implications in designing finite state machines?

(b) Consider the following FSM and comment on information lossless property of the same including order of losslessness. Also draw the corresponding output predecessor table of the given FSM.

PS	NS,z	
	x = 0	x = 1
A	B,0	C,0
B	D,0	E,1
C	A,1	E,0
D	E,0	D,0
E	A,1	E,1

(c) Construct regular expressions for the following languages over the alphabet set {a}

$$\{a^n \mid n \text{ is divisible by 2 or 3 or 5}\}$$

(d) Verify the following identity :

$$(0*01 + 10)*0* = (0 + 01 + 10)*$$

$$4+6+2+$$

4. (a) Briefly comment on the pumping lemma for context free languages and its applications.

(b) Construct a finite automata for recognizing identifier token. Identifier token is formed by a sequence that starts with letter or underscore followed by letter or digit and maximum upto eight characters.

(c) What are the alternative forms of PDA for acceptance of strings? Comment on their equivalence.

(d) Construct the PDA equivalent to the following grammar :

$$S \rightarrow 0BB, B \rightarrow 0S \mid 1S \mid 0$$

$$4+3+4$$

5. (a) "Every unambiguous grammar is LL(1)" — Comment on the truth / falsehood of the statement.

(b) Eliminate left recursion from the following grammar

$$S \rightarrow ABC; A \rightarrow Aa \mid d; B \rightarrow Bb \mid e; C \rightarrow Cc \mid f$$

(c) Construct an LL(1) parsing table for the following grammar :

$$S \rightarrow aBDh$$

$$B \rightarrow cC$$

$$C \rightarrow bC \mid \epsilon$$

$$D \rightarrow EF$$

$$E \rightarrow g \mid \epsilon$$

$$F \rightarrow f \mid \epsilon$$

(d) What do you mean by left factoring?

$$3+3+$$

What is LR parsing and what are its advantages ?

b) Explain the meaning of 'handle' and 'viable prefix' with suitable

(c) What is code optimization? Explain the following techniques with

example :

- (i) elimination of common sub-expression
- (ii) copy propagation and dead code elimination.

3+3+6+2

(d) What is activation record ?

2013

## COMPUTER AND INFORMATION SCIENCE

Paper - CISM-302

(Automata Theory &amp; Compiler Design)

Full Marks - 70

*The figures in the margin indicate full marks**Candidates are required to give their answers in their own words as far as practicable*Answer *any five* questions

1. (a) What is a lossless FSM? Define the states of an inverse machine in terms of the states of a lossless machine with order of losslessness  $\mu$ . Justify your answer.

(b) Justify the statement — 'Equivalence partition of completely specified FSM is unique'.

(c) What do you mean by closed partition and output consistent partition? Critically comment on their significances for the implementation of a FSM.

(d) Find the minimal form of the following machine.

	NS,z	
PS	x=0	X=1
A	B,0	E,0
B	E,0	D,0
C	D,1	A,0
D	C,1	E,0
E	B,0	D,0

3+3+3+5

2. (a) Design a single track-single-head Turing machine to compute the multiplication of two integer numbers, represented by unary symbol sets. Clearly state your assumptions.

(b) Construct regular expressions for the following languages over the alphabet set  $\{0,1,2\}$

(i) string containing at least three '0's, two '1's and one '2'.

(ii) odd number of '1's followed by even number of '2's.

[Turn Over]



(c) Prove or disprove the following for regular expressions on 0 and 1

$$1(01+1)^*0 = 00^*1(00^*1)^*$$

$$(0+1)^* = 0^*+1^*$$

6+

3. (a) Briefly comment on the pumping lemma for regular sets and its application.

(b) Comment on the closure properties of context free languages.

What is quotients of languages?

(c) Test the membership of the string 'baaba' for the following grammar :

$$S \rightarrow AB \mid BC$$

$$A \rightarrow BA \mid a$$

$$B \rightarrow CC \mid b$$

$$C \rightarrow AB \mid a$$

5+5+4

4. (a) Comment on the acceptance of sentences by PDA.

(b) Find CNF and GNF equivalent of the following grammar :

$$E \rightarrow E + E$$

$$E \rightarrow E * E$$

$$E \rightarrow (E)$$

$$E \rightarrow id$$

(c) Find a PDA which accepts strings via final state that recognizes L,

where

$$L = \{a^i b^j c^k \mid i, j, k, \geq 1 \text{ and } i+j = k\}$$

3+6+5

5. (a) With a neat diagram, explain the various phases of a compiler.

(b) What do you mean by resident compiler and cross compiler?

(c) Comment on left recursion and left factoring. Give suitable example.

(d) Explain the following techniques with suitable examples

(i) Copy propagation and dead code elimination

(ii) Elimination of common sub-expression.

5+2+3+4

6. (a) Explain the non-recursive implementation of predictive parsers with the help of the grammar

$$E \rightarrow E + T \mid T$$

$$T \rightarrow T * F \mid F$$

$$F \rightarrow (E) \mid id$$

(b) Briefly explain the types of three address code with implementation.

(c) What is data flow analysis? Explain data flow abstraction with examples.

7+4+3

7. (a) Give an overview of shift reduce parsing and write the issues in it.

(b) Explain the two types of bottom up parsing with examples.

(c) Define a Directed Acyclic Graph (DAG). Construct a DAG and write the sequence of instructions for the expression  $a + a * (b - c) + (b - c) * d$ .

(d) Write a short note on the syntax directed translation for assignment statements.

3+3+5+3

$S \rightarrow 0S0 \mid 0A0$   
 $A \rightarrow 1A \mid 1$

S (3rd Sm.)-Comp. & Inf. Sc.-302

2018

## COMPUTER AND INFORMATION SCIENCE

Paper : CISM-302

(Automata Theory and Compiler Design)

Full Marks : 70

*The figures in the margin indicate full marks.*

*Candidates are required to give their answers in their own words as far as practicable.*

Answer question nos. 1, 2 and any four questions from the rest.

2×5

1. Answer any five questions from the following :

- (a) State the Pumping Lemma for Regular Set.
- (b) What are the alternative form to recognize a sentence by Push Down Automata?
- (c) Let  $R_1$  be regular set on the alphabet  $\{0,1\}$  and let  $R_2 = \{00, 101, 110, 011\}$ . Is the difference set  $S = R_1 - R_2$  necessarily a regular set?
- (d) What are inherited and synthesized attributes?
- (e) Comment on 'information losslessness' of Finite State Machines.
- (f) What do you mean by resident compiler and cross compiler?
- (g) Which of the following describes a handle (as applicable to LR-parsing) appropriately? Justify your answer.
  - (i) It is the position in a sentential form where the next shift or reduce operation will occur.
  - (ii) It is non-terminal whose production will be used for reduction in the next step.
  - (iii) It is a production that may be used for reduction in a future step along with a position in the sentential form where the next shift or reduce operation will occur.
  - (iv) It is the production that will be used for reduction in the next step along with a position in the sentential form where the right hand side of the production may be found.

4×5

2. Answer any five questions from the following :

- (a) Consider the set of strings  $\{0^p 1^q 0^p \mid p > 0 \text{ and } q > 0\}$ . Give a type-2 grammar  $G$  that generates this set.
- (b) Briefly discuss the decision algorithms for regular sets.
- (c) How will you convert a grammar which generates leftmost derivation tree for acceptable sentences to an equivalent grammar which will generate right most derivation tree for the same set of sentences? Briefly explain with an example.

Please Turn Over



(d) What are different error recovery strategies during compilation process?

(e) Consider the following context-free grammar

$be \rightarrow be \text{ or } bt \mid bt$

$bt \rightarrow bt \text{ and } bf \mid bf$

$bf \rightarrow not \ bf \mid (be) \mid true \mid false$

(i) Show that this grammar generates all Boolean expressions.

(ii) Comment on the ambiguity of this grammar.

(f) What are LR(0) items of a LR(1) grammar and what are its implications?

(g) Prove or disprove the following for regular expressions of input alphabet (a, b)

$b(ab + b)^*a = aa^*b(aa^*b)^*$

$(a + b)^* = a^* + b^*$

3. (a) Give the regular expressions generating the following languages. In all cases the alphabet is  $\{0,1\}$ .

(i)  $L_1 = \{ w \mid w \text{ does not contain } 100 \text{ as a substring} \}$

(ii)  $L_2 = \{ w \text{ starts with } 0 \text{ and has odd length or starts with } 1 \text{ and has even length} \}$

(b) Convert the following regular expression into an equivalent NFA.

$((00)^*(11) + (01))^*$

5+5

4. (a) Prove using Pumping Lemma that  $\{0^m1^n0^{m+n} \mid m \geq 1 \text{ and } n \geq 1\}$  is not regular.

(b) Give the state transition diagram to add two strings of unary symbols which are stored on single-tape-single-head turing machine. Clearly state your assumptions.

5+5

5. (a) From the given grammar design the predictive parsing table for acceptance of the string  $id + id * id \$$ .

$E \rightarrow E + T \mid T$

$T \rightarrow T * F \mid F$

$F \rightarrow (E) \mid id$

(b) What are left recursion and left factoring? Explain with examples.

8+2

6. (a) Design FSM to check a binary number divisible by 3.

(b) For the following machine and associated assignments, derive the logical equations for state variables and output. Comment on your result.

5+5

PS	NS		Assignment
	x=0	x=1	
P	S,0	R,0	110
Q	U,0	R,1	001
R	T,0	Q,0	101
S	Q,1	T,0	000
T	P,1	S,1	011
U	R,1	S,0	100

7. (a) Design a PDA,  $M$  to accept the following context-free language on input alphabet  $\{0,1\}$

$L = \{ \alpha \mid \text{the string } \alpha \text{ contains more 1's than 0's} \}$

(b) What are shift-shift and shift-reduce conflicts? Explain with examples.

5+5

8. (a) Prove that if  $L$  is a CFL and  $R$  is a regular set, then  $L$  union  $R$  is a CFL.

(b) Explain the following techniques with suitable examples :

(i) Copy propagation and dead code elimination

(ii) Elimination of common sub-expression.

5+5

Handwritten notes:  $00001111$  with arrows pointing to the 1s.