BITS PILANI, DUBAI CAMPUS

FIRST SEMESTER 2013- 2014

Comprehensive Examination

Course Code: CS C351/CS F351 **III YEAR** **Date: 26.12.2013**

Course Title: Theory of Computation **Max Marks: 40**
Duration: 3 hours **Weightage: 40%**

---

1. Consider the following grammar G:

S -> XY
X -> aX | bX | a
Y -> Y a | Y b | a

(i) Give a leftmost derivation of **abaabb**. **1M**
(ii) What is L(G)? **1M**

2. Design an NFA that accepts the language consisting of the set of those string over {a,b} whose third-to-the-last symbol is b. For example **abaa** and **abba** are in the language. Draw the state diagram. **2M**

3. Check whether the given CFG is ambiguous or not for the input string by drawing derivation trees. **1M**

If expr1 then if expr2 then stmt1 else stmt2

Production rules are:

STMT -> if EXPR then STMT
| if EXPR then STMT else STMT

4. Construct a parse tree for the input string **foo(a,b)** using the CFG given below. **2M**

stmt	→	assignment
	→	subr call
assignment	→	id := expr
subr call	→	id (arg list)
expr	→	primary expr_tail
expr_tail	→	op expr
	→	€
Primary	→	id
	→	subr call
	→	(expr)
op	→	+
	→	-
	→	*
	→	/
arg list	→	expr args_tail
args_tail	→	, arg_list
	→	€

5. Give context-free grammars (complete definition) that generate the following languages:

(i) $\{w \in \{0,1\}^* \mid$ the length of w is odd and the middle symbol is 0$\}$. **1M**

(ii) The language A of strings of properly balanced left and right brackets: every left bracket can be paired with a unique subsequent right bracket and every right bracket can be paired with a unique preceding left bracket. Moreover, the string between any such pair has the same property. Comment about the grammar. **2M**

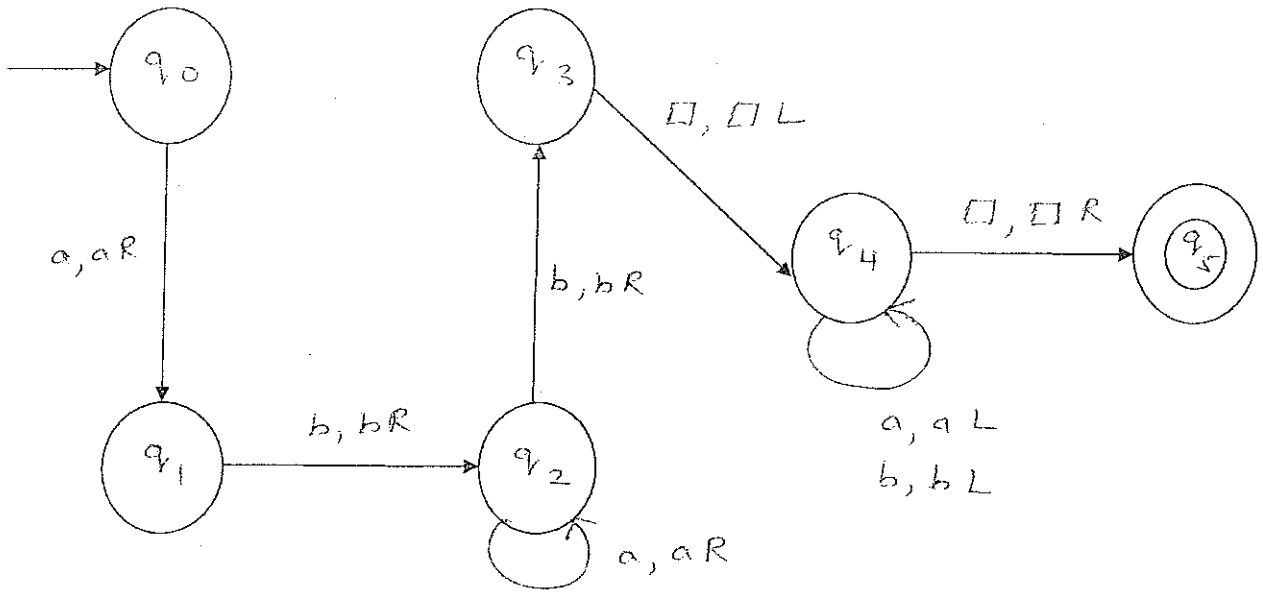
6. Design a Finite State Machine for the following problem definition:
A finite string recognizer has one input (X) and one output (Z). The output is asserted whenever the input sequence ---010--- has been observed as long as the sequence 100 has never been seen. **3M**

Sample Input Output Behavior

X : 00101010010---
Z : 00010101000---

X : 11011010010---
Z : 00000001000---

7. Consider the following turing machine M:



(i) Give the computation path trace for initial configuration ***q0abab***. **1M**
(ii) Give the computation path trace for initial configuration **q0abba**. **1M**
(iii) Give a regular expression for L(M). **1M**

8. Write the production rules for the grammar which accepts the expression **2-3+4** , where terminals are +, -, 0, 1, 2...9 and non-terminal is S. Also show the derivation of the string. **2M**

9. Let A and B be two languages. Define the regular operations **union, concatenation** for A and B. Also find **A*** if **2M**

A = {good, bad}
B = {boy, girl}

10. Given M = ({0, 1, 2, 3, 4}, {a, b}, δ, 0, {4}) where δ is given by the table below:

	a	b
0	1	0
1	2	0
2	4	3
3	1	4
4	4	4

(i) Draw the state diagram for this DFA. **1M**
(ii) Informally describe the language that M accepts. **1M**
(iii) For each of the following strings, determine whether the string is accepted. List the sequence of states using the transition $|-_M$. **2M**
(a) abaabaaa
(b) aabab

11. What does the following Turing machine transition function meant for? Justify and prove your answer using a sample input string. **4M**

q	Ø	State	Symbol	Direction
s	▷	r0	▷	->
r0	0	r0	0	->
r0	1	r1	0	->
r0	␣	l	0	<-
r1	0	r0	1	->
r1	1	r1	1	->
r1	␣	l	1	<-
l	0	l	0	<-
l	1	l	1	<-
l	▷	halt	▷	-

12. Convert the CFG given below to an equivalent PDA and check for sample input string. **3M**

E -> E + T | T
T -> T * F | F
F -> (E) | a

13. Construct a bottom up parser using the CFG given below and check for the string **Book that flight** using right most derivation. Show Shift reduce actions in tabular form. Also show the derivation of another input string of your choice according to the grammar. **3M**

S -> NP VP
S -> Aux NP VP
S -> VP
NP -> Det NOM
NOM -> Noun
NOM -> Noun NOM
VP -> Verb
VP -> Verb NP

Det -> that | this | a | the
Noun -> book | flight | meal | man
Verb -> book | include | read
Aux -> does

14. Explain the following with diagram:

(i) CIRCUIT_SAT is in NP. **2M**
(ii) Cook_Levin Theorem. **2M**

15. Suppose we have s widgets that we are interested in selling at an Internet auction web site. A prospective buyer i can bid on multiple lots by saying that he or she is interested in buying s_i widgets at a total price of w_i dollars. If multiple-lot requests, such as this, cannot be broken up (that is buyer i wants exactly s_i widgets), then determining if we can earn w dollars from this auction gives rise to the KNAPSACK problem. Prove that KNAPSACK is NP_complete. **2M**

BITS PILANI, DUBAI CAMPUS

FIRST SEMESTER 2013- 2014

Test-II (Open Book)

Course Code: CS C351/CS F351 **III YEAR** **Date: 31.10.2013**

Course Title: Theory of Computation **Max Marks: 20**
Duration: 50 minutes **Weightage: 20%**

Note: Only prescribed Text book and handwritten class notes are allowed.

---

1. Give the derivation of the string ***95-2**** using the grammar given below: **2M**

string → digit string operator
| string digit operator
| digit
digit → 0 | 1 | 2 | ... | 9
operator → * | / | + | -

2. Use the following CFG to derive the string ***baa baa*** . **6M**

Goal -> SheepNoise
SheepNoise -> SheepNoise baa
| baa

(i) Construct the bottom up parser.
(ii) Construct a PDA A equivalent to the above CFG and test whether the string given above is in N(A).

3. Construct the grammar rules for the following specification: **2M**
(i) Non terminal symbols are <sentence>, <verbphrase>, <nounphrase> and <verb>.
(ii) Start symbol is <sentence>.
(iii) Check for the sentence ***Jane did the assignment***

4. Given the following ambiguous context free grammar. **3M**

S -> Ab | aaB
A -> a | Aa
B -> b

Find the string **s** generated by the grammar that has two leftmost derivations. Show the two derivation trees for the string **s**.

5. Give an NFA for the set of all binary strings that have either the number of 0's odd or the number of 1's not a multiple of 3 or both. (Draw the transition diagram.) **4M**

6. Find a context free grammar for the given language over the alphabet **3M**
$\{a,b\} : a^n b^{n+2} \mid n >= 0\}$
Check for a sample string.

BITS PILANI, DUBAI CAMPUS

FIRST SEMESTER 2013- 2014

Test-I (Closed Book)

Course Code: CS C351/CS F351 **III YEAR** **Date: 30.09.2013**

Course Title: Theory of Computation **Max Marks: 20**

Duration: 50 minutes **Weightage: 20%**

---

1. What is Kleene star of a language L. **1M**

2. Let L_1 = {ab,bba} and L_2 = {aa,b,ba}, What is L_1L_2? **1M**

3. Design a DFA to accept the language

L = {w | w has both an even number of 0's and even number of 1's}

(i) Draw the state transition diagram. **2M**
(ii) Give the definition. **2M**
(iii) Draw the transition table. **1M**
(iv) Show the sequence of steps using transition $|-_M$, for the string 110101. **1M**

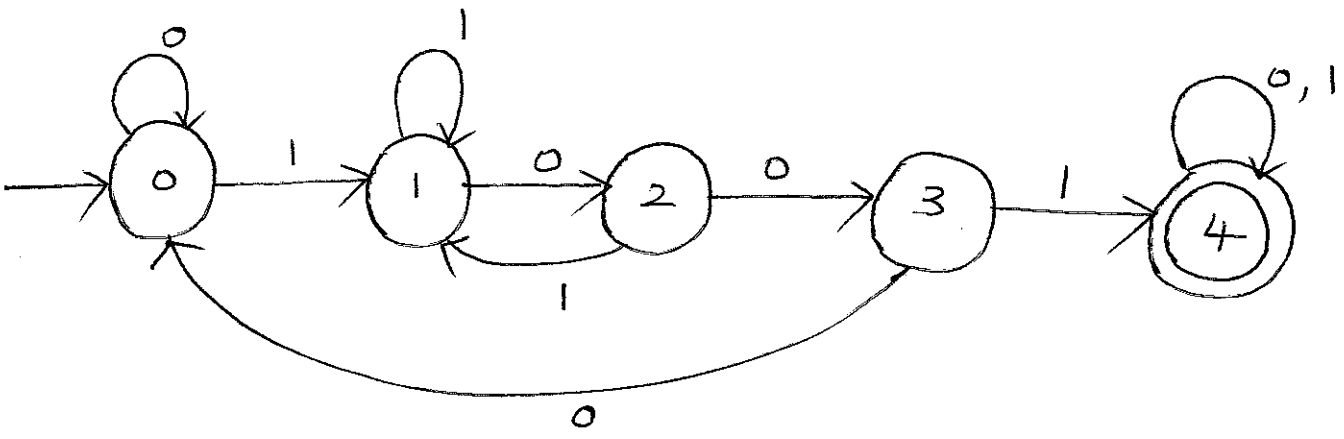
4. Design a Finite State Machine for the following problem definition:
A vending machine accepts nickels (5 cents), dimes (10 cents) and quarters (25 cents). When a total of 30 cents or more has been deposited, the machine immediately returns the amount in excess of 30 cents. When 30 cents has been deposited and any excess refunded, the customer can push an orange button and receive an orange juice or push a red button and receive an apple juice. Also give the transition table. **6M**

5. For Σ = {a,b} construct a DFA that accepts the set consisting of all strings with no more than 3 a's. **2M**

6. Give DFA that recognize the following language, where the alphabet is {a,b,c}:

L1 consists of all strings that contain *cca.* **2M**

7. What language does M1 accept? **2M**



BITS PILANI, DUBAI CAMPUS

FIRST SEMESTER 2013- 2014

Quiz-II (Closed Book)

A

Course Code: CS C351/CS F351 **III YEAR** **Date: 05.12.2013**

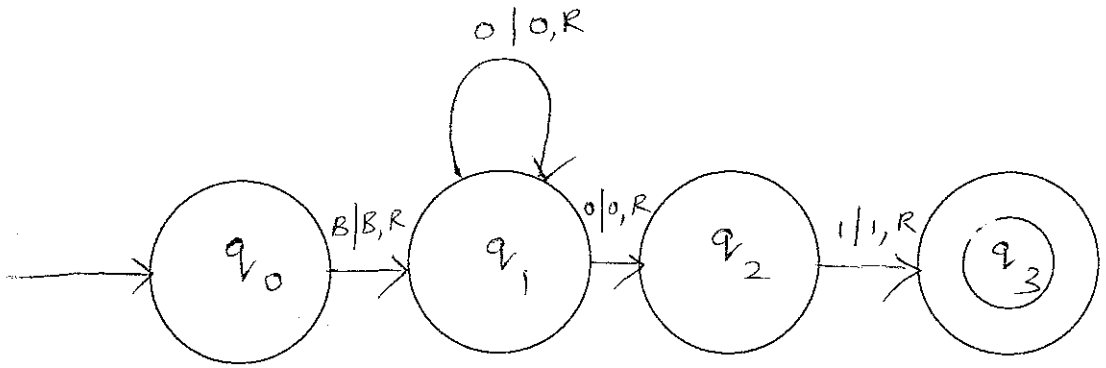
Course Title: Theory of Computation **Max Marks: 10**
Duration: 20 minutes **Weightage: 10%**

Name:_____ **ID:** _____

---

1. If L is a recursive language, then its _____ is also recursive. **1M**

2. Given the turing machine M in figure below, with input alphabets $\sum = \{0,1\}$, tape alphabets $\Gamma = \{0,1,B\}$, find out the language L(M) accepted by this machine. **1M**



3. Let M be the turing machine defined by the following functions.

δ (q0,a)	=	(q1,x,R)
δ (q0,b)	=	(q3,x,R)
δ (q1,a)	=	(q1,a,R)
δ (q1,b)	=	(q3,b,R)
δ (q3,b)	=	(q3,b,R)
δ (q3,z)	=	(q3,z,R)
δ (q3,a)	=	(q4,z,L)
δ (q4,z)	=	(q4,z,L)
δ (q4,b)	=	(q3,z,R)
δ (q4,a)	=	(q3,z,R)
δ (q4,x)	=	(q5,z,R)
δ (q5,z)	=	(q5,z,R)
δ (q5,□)	=	(qf,z,R)

a. Draw the state diagram of M. **1M**
b. Trace the computation for the input **abbaaa**. **2M**
c. Trace the computation for the input **baa**. **1M**
d. Comment on the language of M. **2M**

4. Consider the Turing Machine:
M = ($\{q_0, q_1, q_2, q_3\}$, {a, b}, {a, b, #, □ }, δ, q_0, □, { q_3}), where δ is given by:

$\delta(q_0, a) = (q_1, a, L)$
$\delta(q_0, b) = (q_0, b, R)$
$\delta(q_0, □) = (q_0, □, R)$
$\delta(q_0, \#) = (q_0, \#, R)$
$\delta(q_1, a) = (q_1, a, L)$
$\delta(q_1, b) = (q_2, b, R)$
$\delta(q_1, □) = (q_1, □, L)$
$\delta(q_1, \#) = (q_1, \#, R)$
$\delta(q_2, a) = (q_2, a, R)$
$\delta(q_2, b) = (q_2, b, R)$
$\delta(q_2, □) = (q_3, □, L)$
$\delta(q_2, \#) = (q_2, \#, R)$

Trace the computation of M (until it halts if it halts) starting with the instantaneous description: **#a$q_0$bb□bb□□□aba** **2M**

BITS PILANI, DUBAI CAMPUS

FIRST SEMESTER 2013- 2014

Quiz-I (Closed Book)

A

Course Code: CS C351/CS F351 **III YEAR** **Date: 10.10.2013**

Course Title: Theory of Computation **Max Marks: 10**
Duration: 20 minutes **Weightage: 10%**

---

1. Let G be the grammar. **1M**

```
<assign>    ->   <id> := <expr>
<id          ->   A | B | C
<expr>      ->   <id> + <expr>
             |    <id> * <expr>
             |    (<expr>)
             |    <id>
```

Give a derivation of the string A := B * (A + C).

2. Describe in English, the language defined by the grammar: **2M**

```
<S>  ->   <A> <B> <C>
<A>  ->   a <A> | a
<B>  ->   b <B> | b
<C>  ->   c <C>  | c
```

(Give your answer in one line)

3. Give a CFG for the language
$L = \{0^i 1^j 0^k \mid j > i+k\}$. Check for a sample string. **2M**

4. Consider the grammar given below **3M**

```
<pop>    :=   [<bop>, <pop>]   |   <bop>
<bop>    :=   <boop>  |  (<pop>)
<boop>   :=   x | y | z
```

(i) What are the nonterminal symbols?

(ii) What are the terminal symbols?

(iii) What is the start symbol?

(iv) Draw a parse tree for the sentence [(x),[y,x]]

5. To construct Context Free Grammar for the following diagram. 2M