3 (Sem–5/CBCS) CSC HC 2

2022

COMPUTER SCIENCE

(Honours)

Paper : CSC–HC–5026

(Theory of Computation)

Full Marks : 80

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer ***any ten*** of the following questions as directed : 1×10=10

   (a) If Σ is an alphabet, then Σ^* denotes the set of strings obtained by concatenating zero or more symbols from Σ. *(State true **or** false)*

   (b) An _____ is an abstract model of a digital computer. *(Fill in the blank)*

   (c) Each move of a deterministic automaton is uniquely determined by the current configuration. *(State true **or** false)*

(d) Any language is defined by a unique DFA, but the converse is not true.
*(State true **or** false)*

(e) For every regular language there exists some deterministic finite acceptor.
*(State true **or** false)*

(f) NFA cannot make a transition without consuming an input symbol.
*(State true **or** false)*

(g) Regular languages is not closed under concatenation.
*(State true **or** false)*

(h) Pumping Lemma is used as a proof for regularity of a language.
*(State true **or** false)*

(i) A grammar is said to be _____ if all productions are of the form $A \to Bx$:

(i) non-linear

(ii) left-linear

(iii) right linear

(iv) None of the above
(Choose the correct option)

(j) A language generated by a right-linear grammar is always regular.
*(State true **or** false)*

(k) A context-free grammar G is said to be _____ if there exists some $w \in L(G)$ that has at least two distinct derivation trees. *(Fill in the blank)*

(l) Any production of a context-free grammar of the form $A \to B$, where $A, B \in V$, is called a _____.
(Fill in the blank)

(m) For every context-free language there is an NPDA that accepts it.
*(State true **or** false)*

(n) The family of context-free languages is closed under intersection.
*(State true **or** false)*

(o) Regular expression for the language $\Sigma = \{0, 1\}$ of strings of length at least two that begin with 0 and end in 1 is _____. *(Fill in the blank)*

(p) Regular expression for the language $\Sigma = \{0, 1\}$ of strings of length at least two that have a 1 as their second symbol is _____. *(Fill in the blank)*

(q) The family of regular languages is closed under reversal.
*(State true **or** false)*

(r) For any context-free language L, there exists an NPDA M such that $L = L(M)$. *(State true **or** false)*

2. Define the following terms: ***(any five)*** 2×5=10

(a) Language

(b) Grammar

(c) Automata

(d) Indistinguishable states of a DFA

(e) Parse tree

(f) Ambiguous grammar

(g) Unit production

(h) Useless production

(i) Chomsky normal form

(j) Greibach normal form

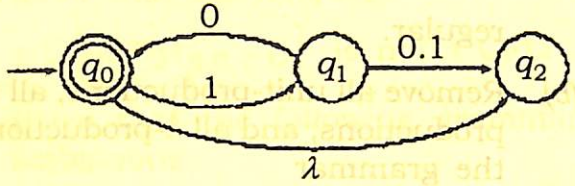
3. Answer ***any four*** of the following questions : 5×4=20

(a) Give formal definition of DFA. Write *any two* differences between DFA and NFA. 3+2=5

(b) Find DFA for the language

$$L = \left\{ ab^n a^m : n \geq 2, m \geq 3 \right\}.$$

(c) Convert the NFA into DFA



(d) Prove that regular languages is closed under union and intersection.

(e) Find context-free grammars for the following languages (with $n \geq 0, m \geq 0$).

(i) $L = \left\{ a^n b^m : n \leq m+3 \right\}$

(ii) $L = \left\{ a^n b^m : n \neq m-1 \right\}$

(f) Define pumping lemma for context-free languages.

(g) Convert the grammar $S \rightarrow ab \mid aS \mid aaS$ into Greibach normal form.

(h) Give formal definition of NPDA.

4. Answer ***any four*** of the following questions : 10×4=40

(a) Show that the set $L = \left\{ a^{i^2} : i \geq 1 \right\}$ is not regular.

(b) Remove all unit-productions, all useless productions, and all λ-productions from the grammar

$S \to aA \mid aBB,$
$A \to aaA \mid \lambda,$
$B \to bB \mid bbC,$
$C \to B.$

(c) Write regular expressions for the language of strings : $\Sigma = \{0, 1\}$

(i) that begin and end with the same symbol

(ii) of length at least two that begin with 0 and end in 1

(iii) of length at least k that have a 1 in position k

(iv) of length at least two that have a 1 in the second-to-last position

(v) that contain at least two 1's and at most one 0

(d) Construct an NPDA for accepting the language

$L = \left\{ w \in \{a, b\}^* : n_a(w) = n_b(w) \right\}$

(e) Show that the language

$L = \left\{ 0^n 1^n 2^n : n \geq 0 \right\}$ is not a CFL.

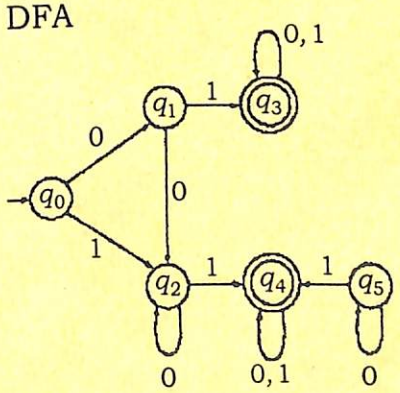
(f) Show that the following grammar is ambiguous

$S \to AB \mid aaB,$
$A \to a \mid Aa,$
$B \to b.$

(g) $S \to AB \mid aB,$
$A \to aab \mid \lambda,$
$B \to bbA.$

Convert the grammar into Chomsky normal form.

(h) Reduce the number of states from the DFA



(i) Show that if L is a nonempty language such that any w in L has length at least n, then any DFA accepting L must have at least $n+1$ states.

(j) Show that $L = \{a^n b^{2n} : n \geq 0\}$ is a deterministic context-free language.
