Xi'an Jiaotong-Liverpool University
西交利物浦大学

Module Code	Examiner	Department	Tel
INT201	Yushi Li	Intelligent Science	5351

1st SEMESTER 22-23 FINAL EXAMINATION

Undergraduate

Decision Computation and Language

TIME ALLOWED: *2 hours*

INSTRUCTIONS TO CANDIDATES

1. **This is a blended close-book exam and the duration is 2 hours.**
2. **Total marks available are 100. This accounts for 80% of the final mark.**
3. **Answer all questions. Relevant and clear steps should be included in the answers.**
4. **Only English solutions are accepted. For online students, answers need to be handwritten and fully and clearly scanned or photographed for submission as one single PDF file via LEARNING MALL.**
5. **Online students should use the format "Module Code-Student ID.filetype" to name their files before submitting to Learning Mall. For example, "INT201-18181881.pdf".**

Question 1

Indicate true or false of the following statements, and briefly justify your answers. (**21 Marks**)

(a) If A is regular, then A must be finite. (**3 Marks**)

False

(b) If A has an NFA, then A is nonregular. (**3 Marks**)

False

(c) The transition function of an NFA is $\delta : Q \times \Sigma \to Q$. (**3 Marks**)

False $P(Q)$

(d) If A is recognized by an NFA, then A is a context-free language. (**3 Marks**) True

(e) Every context-free language is also regular. (**3 Marks**)

False

(f) If a language A has a regular expression, then A has a CFG in Chomsky normal form. (**3 Marks**)

True

(g) Every Turing-decidable language is also Turing-recognizable. (**3 Marks**)

True

Question 2

Let $\Sigma = a, b$. Define the language $A = \{w \in \Sigma^* \mid w = sbab \text{ for some string } s \in \Sigma^*\}$. (**12 Marks**)

(a) List the first 4 strings in A^* in lexicographic order. (**4 Marks**)

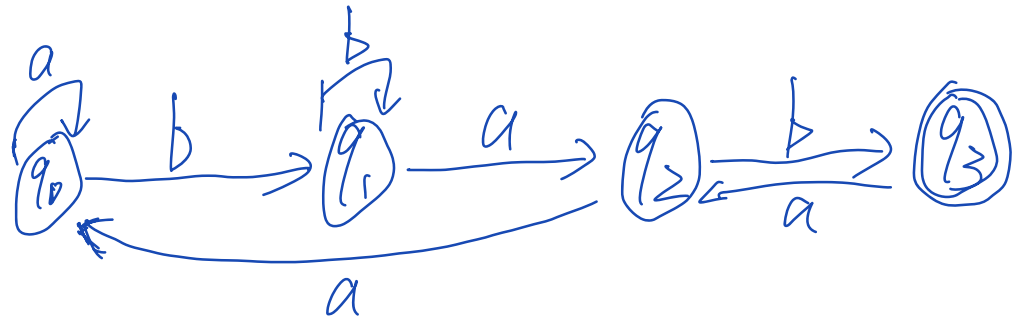
(b) Is A closed under reversal? If so, give a proof. If not, give a counterex-

2. (1) bab, abab, bbab, aabab

(2) Assume $w = abab$ $w^R = baba$

where w^R is not end with bab so it not closed

(3)



3. (a) i ✗ ii ✓ iii ✓

(b)

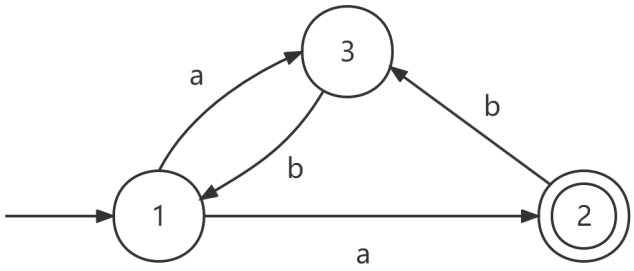
	a	b
{1}	{2,3}	{∅}
{2,3}	{∅}	{1,3}
{1,3}	{2,3}	{1}
Empty set	{∅}	{∅}

ample. (**2 Marks**)

(c) Draw a DFA for A. (**6 Marks**)

Question 3

An NFA over alphabet $\Sigma = \{a, b\}$ is given by the diagram below. (**11 Marks**)



(a) Which of the following strings are accepted by it? (**3 Marks**)
i. abaaba
ii. abbabba
iii. abababababa

(b) Convert it to the equivalent DFA by filling the entries of the table.
(**8 Marks**)

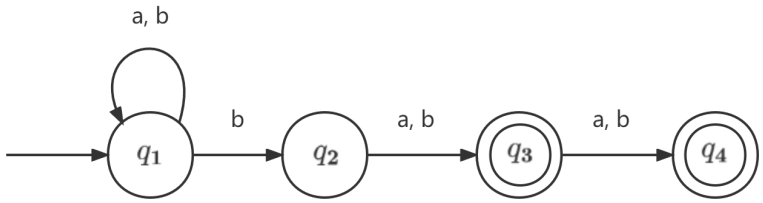
	a	b
{1}		
{2, 3}		
{1, 3}		
Empty set {}		

Question 4

Given the following two finite automata, find out their equivalent regular

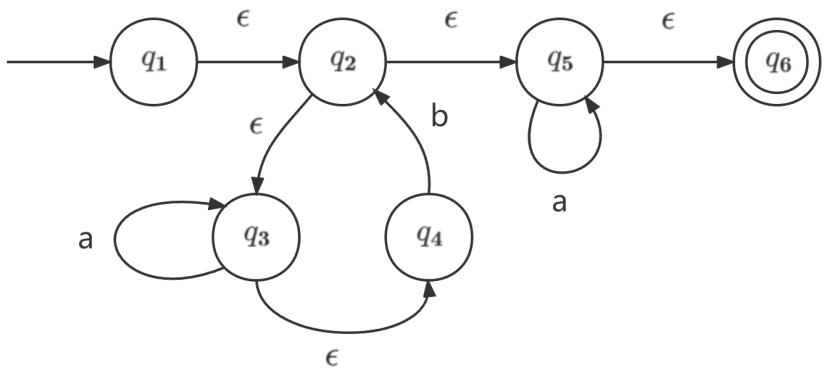
expressions.(**10 Marks**)

(a)



(**5 Marks**)

(b)



(**5 Marks**)

Question 5

The original CFG is shown as follows, and convert it to Chomsky normal form. (**15 Marks**)

$$S \rightarrow ASA \mid aB$$
$$A \rightarrow B \mid S$$
$$B \rightarrow b \mid$$

Question 6

Pushdown automata are given by the diagrams below. (**10 Marks**)

4. (1) $(a \cup b)^* b (a \cup b)[(a \cup b) \cup \varepsilon]$

(2) $(a^* b)^* a^*$

5. Step1: $S_0 \to S$

$S \to ASA \mid aB$

$A \to B \mid S$

$B \to b \mid \varepsilon$

Step2: $S_0 \to S$

$S \to ASA \mid a \mid aB$

$A \to B \mid S \mid \varepsilon$

$B \to b$

Step3: $S_0 \to S$

$S \to ASA \mid SA \mid AS \mid S \mid a \mid aB$

$A \to B \mid S$

$B \to b$

Step4: $S_0 \to ASA \mid SA \mid AS \mid a \mid aB$

$S \to ASA \mid SA \mid AS \mid a \mid aB$

$A \to b \mid ASA \mid SA \mid AS \mid a \mid aB$

$B \to b$

Step5: $S_0 \to AN \mid SA \mid AS \mid a \mid aB$ $\quad N \to SA$

$S \to AN \mid SA \mid AS \mid a \mid aB$ $\quad B \to b$

$A \to b \mid AN \mid SA \mid AS \mid a \mid aB$

Step 6: $S_0 \to AN \mid SA \mid AS \mid RB \mid a$

$S \to AN \mid SA \mid AS \mid RB \mid a$

$A \to AN \mid SA \mid AS \mid RB \mid a \mid b$

$N \to SA$

$R \to a$

$B \to b$

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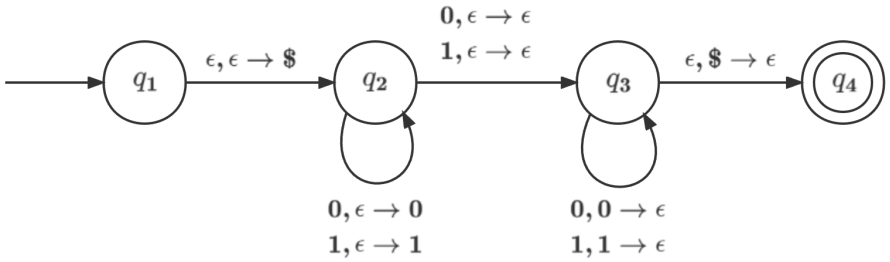
6. (a) i ✗ ii ✗ iii ✓

(b) i ✓ ii ✗ iii ✗

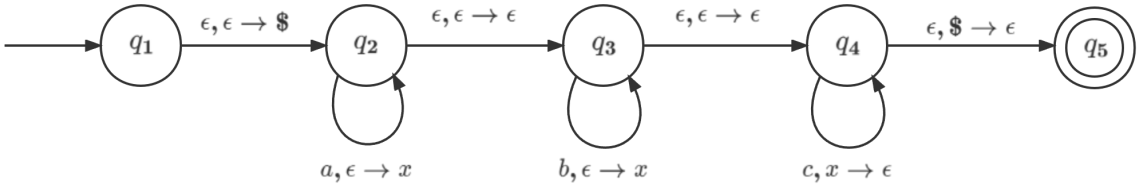
(c) $L = \{ w = a^k b^l c^n \mid \text{where } k+l=n,\ k, l, n \geq 0 \}$

(a)



Which of the following strings are accepted by it?
i. 000111
ii. 1110011
iii. 1100011
(**3 Marks**)

(b)



Which of the following strings are accepted by it?
i. *aabccc*
ii. *aaabcc*
iii. *aaabbbccccc*
(**3 Marks**)

(c) What is the language accepted by the pushdown automata shown in (b)?
(**4 Marks**)

Question 7

Consider the Turing machine M (B denotes the blank symbol):
$Q = \{q_0, q_1, q_2, q_3\}$
$\Sigma = \{0, 1\}$
$\Gamma = \{0, 1, \text{B}\}$
start state: q_0
$q_{accept} = q_3$
$q_{reject} = \text{B}$
δ is defined as follows:
$\delta(q_0, 0) = (q_0, 0, R)$
$\delta(q_0, 1) = (q_1, 1, R)$
$\delta(q_1, 0) = (q_1, 0, R)$
$\delta(q_1, 1) = (q_2, 1, R)$
$\delta(q_2, 0) = (q_2, 0, R)$
$\delta(q_2, 1) = (q_3, 1, R)$
(**10 Marks**)

(a) If initially 1100 is placed on the tape, which state will the machine be halting at? Assume the head of the machine initially points to the left-most 1. (**5 Marks**)

(b) If initially 1101 is placed on the tape, which state will the machine be halting at? (**5 Marks**)

Question 8
Briefly answer the following questions. (**11 Marks**)

(a) What are recursive and recursively enumerable languages? Which one of the two sets stands for decidable problems? (**5 Marks**)

(b) What is a reduction? Briefly explain how this technique can be used to

prove that certain problems are undecidable. (**6 Marks**)

7. (a) 1. q_0 1100 q_2 (b) 1. q_0 1101 q_3

2. 1 q_1 100 2. 1 q_1 101

3. 11 q_2 00 3. 11 q_2 01

4. 110 q_2 0 4. 1101 q_1

5. 1100 q_2 B 5. 1101 q_3 B

8. (a)