Spring'23 CPSC 323.02 Compilers & Languages
HW #1 [100 points]
Submission deadline: February 26, 11:59PM, submit it on Canvas

*Any class content /HW shall **NOT** be made publicly accessible without the written consent of the instructor.*

Lexical Analysis: ***RE; NFA; DFA; Subset construction***

1. (10 pts) Given the RE $R = (ab|b)^*c$, which of the following string is (are) in *L(R)*?
   ababbc c babc abab

2. (10 pts) Given the RE $R = ab^*c(a|b)c$, which of the following string is (are) in *L(R)*?
   acac acbbbc abcac abcc

3. (10 pts) If $\sum = \{a, b\}$, write a regular expression whose language is all strings beginning and ending with b.

4. (10 pts) If $\sum = \{0, 1\}$, write a regular expression whose language is all strings containing exactly three 1s.

5. (10 pts) Draw an NFA for a machine that recognizes the language that is the set of all binary strings containing 000 or 100 as substring.

6. (10 pts) Draw an NFA for a machine that recognizes the language the set of all binary strings such that the fifth symbol from the right end is 0.

7. (30 pts) For each of the following NFA, draw the state diagram; then following the *subset construction*, construct for each of NFAs an equivalent DFA.

   a.

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

   b.

	a	b	c	ϵ
1	{1, 2}	{2}	{1, 3}	{}
2	{3}	{2, 3}	{1}	{4}
3	{3, 4}	{2}	{2, 4}	{1}
4	{1}	{2}	{3}	{}

8. (10 pts) Construct an NFA that recognizes the RE $a(a|bc)^*$, and find the equivalent DFA.

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CPSC 323-02

RE: A B

$\{\epsilon, \underbrace{ab}_{A^1}, \underbrace{b}_{B^1}, \underbrace{abab}_{A^2}, \underbrace{bb}_{B^2}, \underbrace{abb}_{AB}, \underbrace{bab}_{BA}, \ldots\}$

$\{A^0 \cup B^0\}$

1. (10 pts) Given the RE $R = (ab|b)^*c$, which of the following string is (are) in $L(R)$?
   ✓ $ababbc$ ✓ c ✓ $babc$ $abab$

$(ab|b) = \{ab\} \cup \{b\} = \{ab, b\}$

$(ab|b)^* = \{\epsilon, ab, abab, ababab, \ldots, b, bb, bbb, \ldots\}$

$(ab|b)^*c = \{c, abc, abcabc, abcabcabc, \ldots, bc, bbc, bbbc, \ldots\}$

– RE: $(a|b)^*$ can be both ab and ba

ababbc = AABC

babc = BAC

$\{c, abc, bc, abbc, babc, ababbc, bababc, abcbabbc, babcbabc, \ldots\}$

$\boxed{ababbc, c, babc}$

2. (10 pts) Given the RE $R = ab^*c(a|b)c$, which of the following string is (are) in $L(R)$?
   $acac$ $acbbbc$ $abcac$ $abcc$

$(a|b) = \{a, b\}$

$(a|b)c = \{ac, bc\}$

$c(a|b)c = \{cac, cbc\}$

$ab^* = a\{\epsilon, b, bb, bbb, \ldots\}$

$ab^*c(a|b)c = \{acac, bcac, acbc, abcac, abcbc, abbcac, abbcbc, \ldots\}$

$\boxed{acac, abcac}$

$a\overbrace{\{\epsilon, b, bb, \ldots, b^i\}}^{b^*}c$

$(ab)^* \neq ab^*$

3. (10 pts) If $\sum = \{a, b\}$, write a regular expression whose language is all strings beginning and ending with b.

$$R = b(a|b)^* b$$

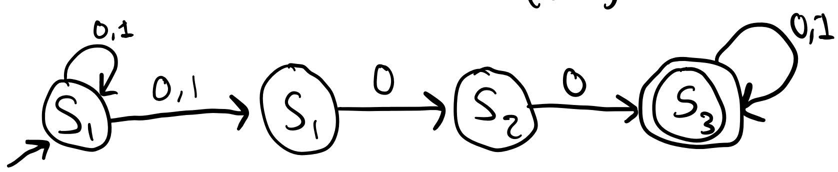
4. (10 pts) If $\sum = \{0, 1\}$, write a regular expression whose language is all strings containing exactly three 1s.

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

5. (10 pts) Draw an NFA for a machine that recognizes the language that is the set of all binary strings containing 000 or 100 as substring.

Binary strings: $\Sigma = \{0,1\}$

$\underbrace{\text{AnyBits}}_{(0+1)^*}$ $\underline{0+1}$ $\underline{0}$ $\underline{0}$ $\underbrace{\text{AnyBits}}_{(0+1)^*}$ $RE = (0+1)^*(0+1)00(0+1)^*$

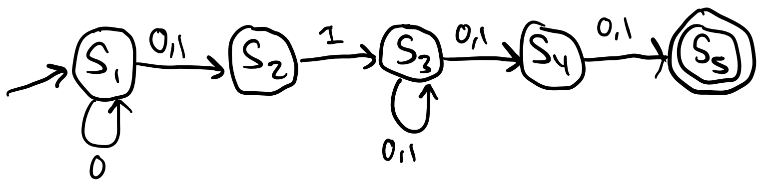


6. (10 pts) Draw an NFA for a machine that recognizes the language the set of all binary strings such that the fifth symbol from the right end is 0.

Binary Strings: $\Sigma = \{0,1\}$

$\underline{0}$ $\underline{\text{AnyBits}}$ $\underline{\text{AnyBits}}$ $\underline{\text{AnyBits}}$ $\underline{\text{AnyBits}}$

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



7. (30 pts) For each of the following NFA, draw the state diagram; then following the *subset construction*, construct for each of NFAs an equivalent DFA.

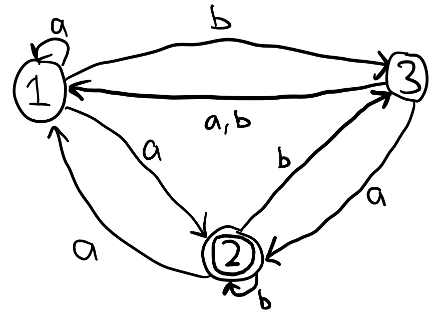
a.

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

b.

	a	b	c	ϵ
1	{1, 2}	{2}	{1, 3}	{}
2	{3}	{2, 3}	{1}	{4}
3	{3, 4}	{2}	{2, 4}	{1}
4	{1}	{2}	{3}	{}

a)



(State Diagram NFA)

- All states that have 2 in them are accepting states

$\delta(1,a) = \{1,2\}$ $\delta(3,a) = \{1,2\}$

$\delta(1,b) = \{3\}$ $\delta(3,b) = \{1\}$

$\delta(\{1,2\},a) = \delta(\{1\},a) \cup \delta(\{2\},a) = \{1,2\} \cup \{1\} = \{1,2\}$

$\delta(\{1,2\},b) = \delta(\{1\},b) \cup \delta(\{2\},b) = \{3\} \cup \{2,3\} = \{2,3\}$

$\delta(\{2,3\},a) = \delta(\{2\},a) \cup \delta(\{3\},a) = \{1\} \cup \{1,2\} = \{1,2\}$

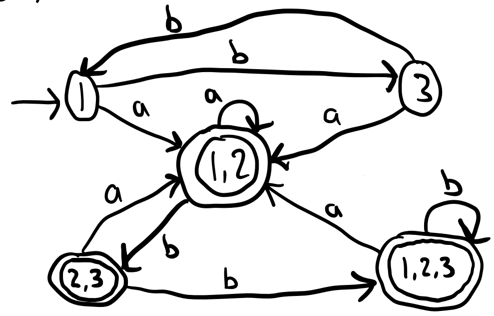
$\delta(\{2,3\},b) = \delta(\{2\},b) \cup \delta(\{3\},b) = \{2,3\} \cup \{1\} = \{1,2,3\}$

$\delta(\{1,2,3\},a) = \delta(\{1\},a) \cup \delta(\{2\},a) \cup \delta(\{3\},a) = \{1,2\}$

$\delta(\{1,2,3\},b) = \delta(\{1\},b) \cup \delta(\{2\},b) \cup \delta(\{3\},b) = \{1,2,3\}$

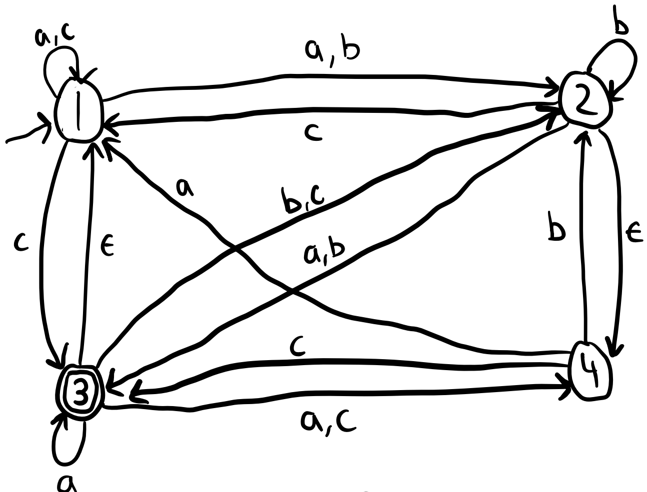
Current State	Inputs a	b
[1]	[1,2]	[3]
[1,2]	[1,2]	[2,3]
[3]	[1,2]	[1]
[2,3]	[1,2]	[1,2,3]
[1,2,3]	[1,2]	[1,2,3]

State table for equivalent DFA



(DFA State Diagram)

b)



(NFA State Diagram)

$\{1\} \times \epsilon\text{-closure}\{1\} = \{1\}$

$\delta(\{1\},a) = \{1,2\} = \epsilon\text{-closure}(\{1,2\}) = \epsilon\text{-closure}(\{1\}) \cup \epsilon\text{-closure}(\{2\}) = \{1\} \cup \{2,4\} = \{1,2,4\}$

$\delta(\{1\},b) = \{2\} = \epsilon\text{-closure}(\{2\}) = \{2,4\}$

$\delta(\{1\},c) = \{1,3\} = \epsilon\text{-closure}(\{1,3\}) = \epsilon\text{-closure}(\{1\}) \cup \epsilon\text{-closure}(\{3\}) = \{1\} \cup \{1,3\} = \{1,3\}$

$\delta(\{2,4\},a) = \delta(\{2\},a) \cup \delta(\{4\},a) = \{3\} \cup \{1\} = \epsilon\text{-closure}(\{3\}) \cup \epsilon\text{-closure}(\{1\}) = \{1,3\} \cup \{1\} = \{1,3\}$

$\delta(\{2,4\},b) = \delta(\{2\},b) \cup \delta(\{4\},b) = \{2,3\} \cup \{2\} = \epsilon\text{-closure}(\{2,3\}) \cup \epsilon\text{-closure}(\{2\}) = \{1,2,3,4\}$

$\delta(\{2,4\},c) = \delta(\{2\},c) \cup \delta(\{4\},c) = \{1\} \cup \{3\} = \epsilon\text{-closure}(\{3\}) \cup \epsilon\text{-closure}(\{1\}) = \{1,3\} \cup \{1\} = \{1,3\}$

$\delta(\{1,3\},a) = \delta(\{1\},a) \cup \delta(\{3\},a) = \{1,2,3,4\}$

$\delta(\{1,3\},b) = \delta(\{1\},b) \cup \delta(\{3\},b) = \{2,4\}$

$\delta(\{1,3\},c) = \delta(\{1\},c) \cup \delta(\{3\},c) = \{1,2,3,4\}$

$\delta(\{1,2,4\},a) = \delta(\{1\},a) \cup \delta(\{2\},a) \cup \delta(\{4\},a) = \{1,2,3,4\}$

$\delta(\{1,2,4\},b) = \{1,2,3,4\}$

$\delta(\{1,2,4\},c) = \{1,3\}$

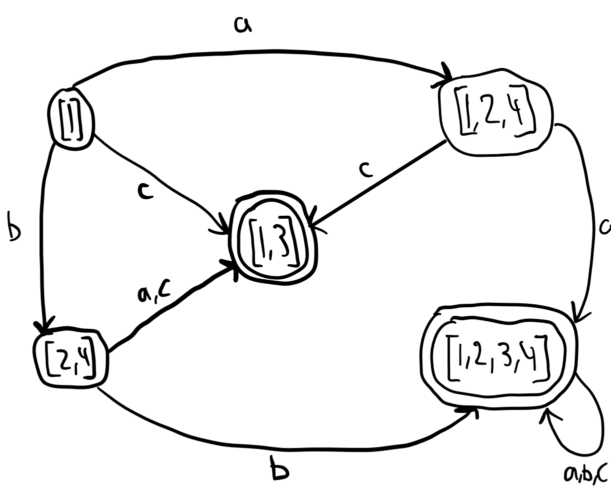
$\delta(\{1,2,3,4\},a) = \{1,2,3,4\}$

$\delta(\{1,2,3,4\},b) = \{1,2,3,4\}$

$\delta(\{1,2,3,4\},c) = \{1,2,3,4\}$

Current State	Inputs a	b	c
[1]	[1,2,4]	[2,4]	[1,3]
[2,4]	[1,3]	[1,2,3,4]	[1,3]
[1,3]	[1,2,3,4]	[2,4]	[1,2,3,4]
[1,2,4]	[1,2,3,4]	[1,2,3,4]	[1,3]
[1,2,3,4]	[1,2,3,4]	[1,2,3,4]	[1,2,3,4]

State table for equivalent DFA

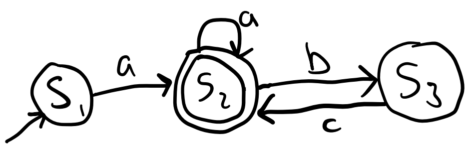


DFA Diagram

8. (10 pts) Construct an NFA that recognizes the RE $a(a|bc)^*$, and find the equivalent DFA.

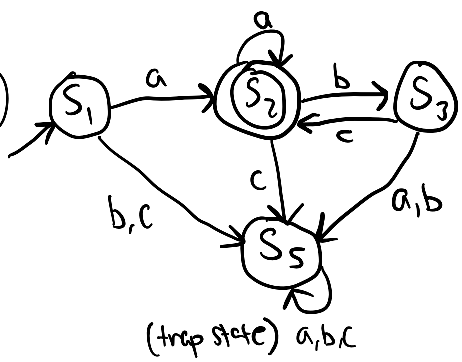
$RE = a(a|bc)^*$

(NFA)



	a	b	c
S_1	S_2	$\emptyset$	$\emptyset$
S_2	S_2	S_3	$\emptyset$
S_3	$\emptyset$	$\emptyset$	S_2

(DFA)



	a	b	c
S_1	S_2	$\emptyset$	$\emptyset$
S_2	S_2	S_3	$\emptyset$
S_3	$\emptyset$	$\emptyset$	S_2
$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$