1. Which of the following concepts is **not** traditionally studied in the Theory of Computation?
   (3 points)
   A. Complexity
   B. Computability
   ✓ C. Security
   D. Automata

2. If $\Sigma=\{0,1\}$, which of the following is not in Σ^*?
   (3 points)
   A. 00
   B. 010
   C. 110
   ✓ D. 012

3. Which one of the sets below is **not** in the power set for the set A= {0,1,2,3}?
   (3 points)
   A. {0,1,2}
   B. {1,2,3}
   C. {0,1,2,3}
   ✓ D. {10,2,3}

1. Given an NFA described by the 5-tuple (Q,Σ,δ,q_0,F), what is the range of the transition function δ?
   (3 points)
   1. Q
   2. Σ
   ✓ 3. $P(Q)$
   4. $Q \times \Sigma$
   5. F

2. For an NFA, how many transitions (edges) may exist for a given state (node) when reading a particular input symbol from the language's alphabet?
   (3 points)
   1. Exactly one
   2. None
   3. More than one
   ✓ 4. Any of the above

1. Which of the following is **not** a valid property of a finite automaton?
   (3 points)

   A. It may accept many strings but only recognizes one language.

   B. It must read all the input symbols provided.

   C. After reading each symbol, the machine moves to another state or remains in the current state.

   ✓ D. It may terminate without accepting or rejecting the input string.

2. For the FA given by the 5-tuple (Q,Σ,δ,q_0,F), which of the following is the correct domain for the transition function δ?
(3 points)

   A. Q

✓ B. $Q \times \Sigma$

   C. Σ

   D. $Q \times F$

3. Assuming that the language recognized by a DFA **is not empty**, how many accept states can a DFA have?
(3 points)

   A. only one

   B. an infinite number

✓ C. one or more (but a finite number)

   D. none of the above

1. Which one of the following strings (words) is not in the language B= $\{0^n1^n | n \geq 0\}$?
   (3 points)
   1. ε
   2. 01
   3. 0011
   ✓ 4. 1100
   5. 000111

2. Which string (word) is not in the language described by the regular expression a(a*b)*?
   (3 points)
   1. a
   2. ab
   3. abb
   ✓ 4. baa
   5. aabab

3. Suppose M = (Q,Σ,δ,q_0,F) is an NFA and N = $(Q',\Sigma,\delta',p_0,F')$ is an equivalent DFA. If Q contains 3 states and F has 2 accept states, how many unique states would F' (initially) have in the DFA before simplification?
(3 points)

1. 4
2. 5
3. ✓ 6
4. 7

1. The cartesian product of two DFAs is commonly used to construct a single DFA for the _____ of two regular languages.
   (3 points)
   A. complement
   ✓ B. intersection
   C. union
   D. symmetric difference

2. For which of the following regular languages would it be easier to build a DFA of its **complement** first? Assume Σ = {0,1}.
   (3 points)

   A. {w|w starts with a 0 and ends with a 0}.

   B. {w|w has exactly two 1's}

   ✓ C. {w|w does not have 010 nor 110 as substrings}

   D. {w|w has at least one 0}

3. Which of the following would be the appropriate operation to implement (via an NFA) if one want to recognize a repeating substring of any size? *(3 points)*

   A. union

   B. intersection

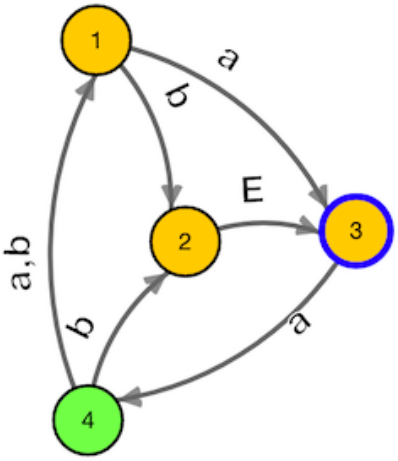
   ✓ C. star operation (*)

   D. complement

3. Which of the following expressions is equivalent to A^+?
(3 points)

1. A>A*
2. A+A*
3. A**
4. ✓ A°A*
5. A¬A*

1. Consider the 4-state NFA given below and assume E represents an ε (epsilon) transition, State 3 is the start state and State 4 is the accept state. Which of the following represents the start state of the **equivalent DFA**? Σ={a,b}.



(3 points)

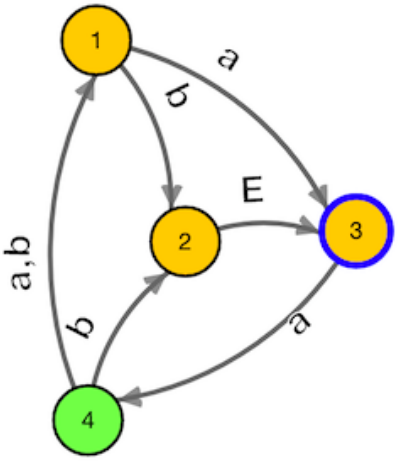
✓ A. {3}

B. {2,3}

C. {2,3,4}

D. None of the above.

2. Consider the 4-state NFA given below and assume E represents an ε (epsilon) transition, State 3 is the start state and State 4 is the accept state. Which of the following is the state transitioned to from state {1,4} upon reading an "a" from the input word in the **equivalent DFA**? Σ={a,b}.



(3 points)

A. {3}

✓ B. {1,3}

C. {1,2,3}

D. None of the above.

1. Suppose C={w|w has an equal no. of 0s and 1s} is regular. Consider s = 0^p1^p, where p is the pumping length for C. Suppose s= xyz, where x is ε. Which of the strings below would still be in C?
(3 points)

✓ 1. xyz
2. xyyz
3. xyyyz
4. all of the above

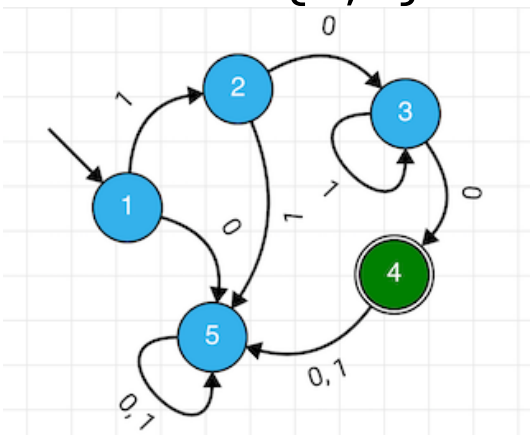
2. Suppose C={w|w has an equal no. of 0s and 1s} is regular. Consider s = 0^p1^p, where p is the pumping length for C. Suppose s= xyz, where x is ε. Which of the strings below would still be in C?
(3 points)

1. xz
2. xyyz
3. xyyyz
4. ✓ none of the above

3. The **minimum pumping length** (mpl) for a language A is the smallest integer p that is a pumping length for A. It can be shown that the mpl is the **maximum** number of transitions you can take in a minimized DFA for the language without repeating a state. For the language A defined by the reg. expression 01*, the mpl is 2. What would be the mpl of the language B defined by the reg. expression 0001*?
(3 points)

   A. 5
   ✓ B. 4
   C. 3
   D. 2

1. Which of the following regular expressions describes the language recognized by the DFA below? Note: Σ={0,1}.



(3 points)

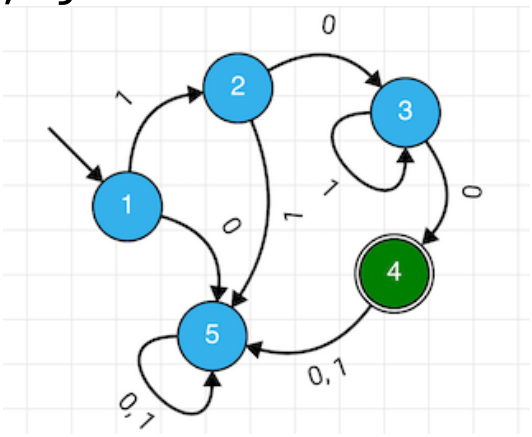
A. 110*1

B. 1*010

✓ C. 101*0

D. 1010*

2. What is minimum pumping length for the language recognized by the DFA below? Note: Σ={0,1}.



(3 points)

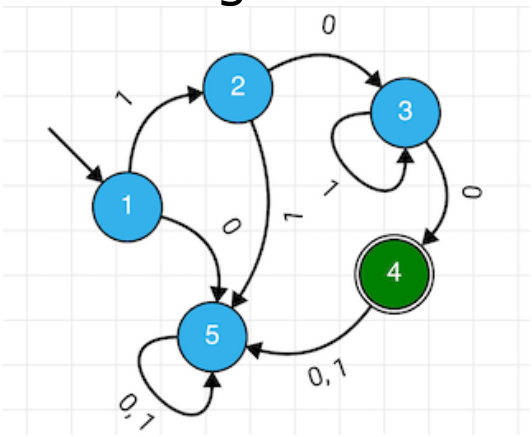
A. 2

B. 3

✓ C. 4

D. 5

3. We know that the DFA below recognizes the regular language given by 101*0 for Σ={0,1}. How many additional states would be needed if we wanted to modify the DFA to recognize any string containing 101*0 as a substring?



(3 points)

A. 1

B. 2

C. 3

✓ D. none of above

1. What is the form of the rule that would be useful when equal counts of terminals a and b are needed and a's must come before b's in a CFL? Assume R is a variable. *(3 points)*
   1. R→Rba
   2. R→bRa
   ✓ 3. R→aRb
   4. R→ε
   5. R→baR

2. Consider a grammar with the 4 rules below and start variable E:

$$E \rightarrow E+E \mid E*E \mid (E) \mid a$$

Which of the following words could not be generated by this grammar? (terminals in blue)

(3 points)

1. (a+a)+a
2. (a+a)*a
3. ✓ (a+a)a
4. a*(a+a)
5. none of the above

3. How many DFAs can be constructed to recognize all the words of the language $\{w|w=0^n1^n0^n\}$ for $n>0\}$, assuming $\Sigma=\{0,1\}$?
(3 points)

1. one
2. an infinite number
3. ✓ zero
4. three
5. none of the above

1. Which of the following is the correct updated rule for replacing the nonterminal S after the A -> ε rule is removed from the following CFG: S -> AS|bA, A -> B|ε, B -> b ?
(3 points)

A. S -> AS | bA | A

B. S -> AS | b

C. S -> S | b

✓ D. S -> AS | S | bA | b

2. Which of the following is the correct updated rule for replacing the nonterminal S after the B -> ε rule is removed from the following CFG: S -> ASB|BAB, B -> b|ε, A -> Aa|ε ?
(3 points)

✓ A. S -> ASB | BAB | AS | AB | BA | A

B. S -> ASB | BAB | AS | AB | BA

C. S -> ASB | BAB | AB | BA

D. S -> ASB | BAB | AS | S | AB | BA

3. Which of the following is the correct conversion of the grammar rule S -> SAA | bA to CNF?
(3 points)

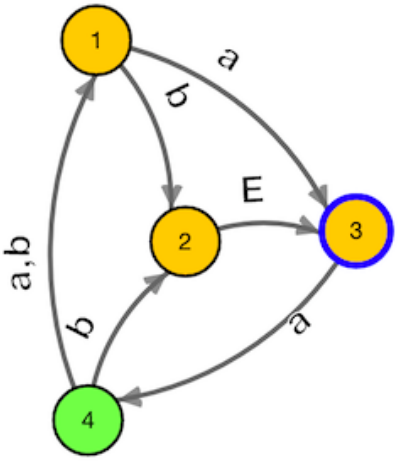
A. S -> A_1A|BA, A_1->AS, B->b

B. S -> A_1A|bA, A_1->AS

✓ C. S -> A_1A|BA, A_1->SA, B->b

D. S -> A_1|AB, A_1->SA, B->b

3. Consider the 4-state NFA given below and assume E represents an ε (epsilon) transition, State 3 is the start state and State 4 is the accept state. Which of the following is the state transitioned to from state {4} upon reading a "b" from the input word in the **equivalent DFA**? Σ={a,b}.



(3 points)

A. {2}

B. {1,2}

✓ C. {1,2,3}

D. None of the above.

1. Which step of CNF conversion for CFGs was executed below?

Before:

$S_0 \rightarrow S$

$S \rightarrow AS|ASB|SB|S$

$A \rightarrow aAS|aS|a$

$B \rightarrow SbS|A|bb$

After:

$S_0 \rightarrow S$

$S \rightarrow AS|ASB|SB|S$

$A \rightarrow aAS|aS|a$

$B \rightarrow SbS|bb|aAS|aS|a$

(3 points)

A. Step 1 (New start variable)

B. Step 2 (Remove ε rules)

✓ C. Step 3 (Remove unit rules)

D. Step 4 (Final conversion)

2. Which step of CNF conversion for CFGs was executed below?

(Before)	(After)
$S_0 \rightarrow S$	$S_0 \rightarrow S$
$S \rightarrow ASB \mid SB$	$S \rightarrow AS \mid ASB \mid SB \mid S$
$A \rightarrow aAS \mid aS \mid a$	$A \rightarrow aAS \mid aS \mid a$
$B \rightarrow SbS \mid A \mid \varepsilon \mid bb$	$B \rightarrow SbS \mid A \mid bb$

(3 points)

A. Step 1 (New start variable)

✓ B. Step 2 (Remove ε rules)

C. Step 3 (Remove unit rules)

D. Step 4 (Final conversion)

3. How many right-hand-sides are not in proper CNF form before Step 4 is applied?

$S_0 \rightarrow AS|ASB|SB$
$S \rightarrow AS|ASB|SB$
$A \rightarrow aAS|aS|a$
$B \rightarrow SbS|bb|aAS|a$

(3 points)

A. 5

B. 6

✓ C. 7

D. 8