CS154

Name: ________________________ Date: ____________

__Note__: The purpose of the following questions is:

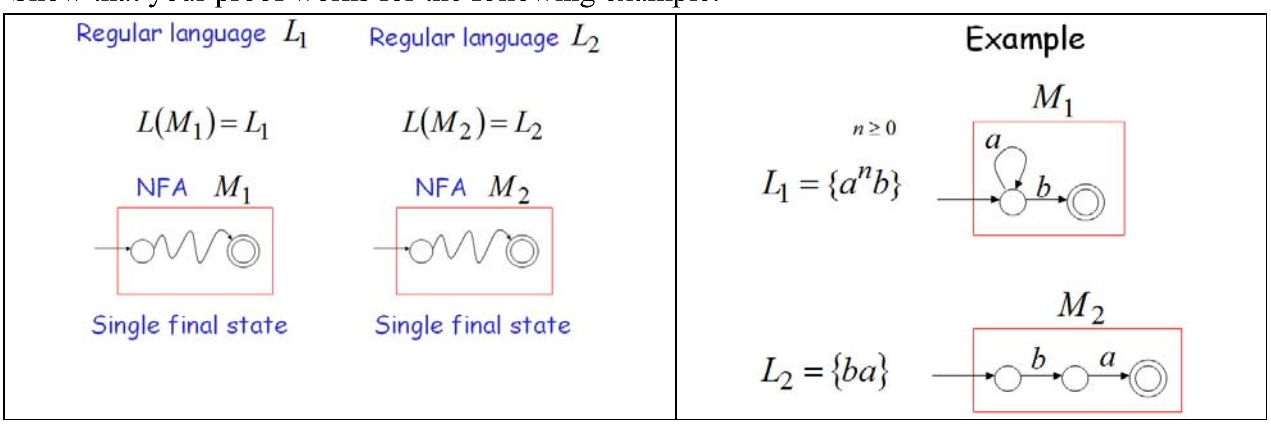
• *Enhance learning*	• *Summarized points*	• *Analyze abstract ideas*

Class 4: Properties of Regular Languages

1. [Slide 2-4] <u>Prove</u> that any NFA can be converted to an equivalent NFA with a single final state.
2. [Slide 5] Extreme case: show that an NFA *without* final state be converted to an equivalent NFA with a single final state.
3. [Slide 7-22] For regular languages L_1 and L_2 prove that:

$$\left.\begin{array}{rl} \text{Union:} & L_1 \cup L_2 \\ \text{Concatenation:} & L_1 L_2 \\ \text{Star:} & L_1{}^* \\ \text{Reversal:} & L_1{}^R \\ \text{Complement:} & \overline{L_1} \\ \text{Intersection:} & L_1 \cap L_2 \end{array}\right\} \text{Are regular Languages}$$

Show that your proof works for the following example:



4. [Slide 24-30] One way of describing regular languages is via the notation of `regular expressions`. This notation involves a combination of strings and symbols from some alphabet ∑, parentheses, and the operators +, ., and *. The simplest case is the language *{a}*, which will be denoted by a regular expression *a*. We will use + do denote union. We use . for concatenation and * for a star-closure. Complete the following table

	Language	**Corresponding regular expression**
1.	{a}	a
2.	{a, b, c}	
3.		(a + (b.c))*

5. A *regular* language over an alphabet Σ is one that can be obtained from the very simplest languages over Σ, those containing a single string of length 0 or 1, using only the operations of union, concatenation, and Kleene *. A regular language can therefore be described by an explicit formula.

a) Find the corresponding regular expression for each of the following languages:

	Language	**Corresponding regular expression**
1.	$\{\lambda\}$	
2.	{0}	
3.	{001} (i.e., {0}{0}{1})	
4.	{0, 1} (i.e., $\{0\} \cup \{1\}$)	
5.	{0, 10} (i.e., $\{0\} \cup \{10\}$)	
6.	$\{1, \lambda\}\{001\}$	
7.	$\{110\}^*\{0, 1\}$	
8.	$\{1\}^*\{10\}$	
9.	$\{10, 111, 11010\}^*$	
10.	$\{0, 10\}^*(\{11\}^* \cup \{001, \lambda\})$	

6. [Slide 31-34] Complete the following table

	Language	**Corresponding regular expression**
1.		$r = (a + b)^*(a + bb)$
2.		$r = (aa)^*(bb)^*b$
3.		$r = (0+1)^*00(0+1)^*$
4.		$r = (1+01)^*(0+\lambda)$

7. [Slide 33] For $\Sigma = \{0, 1\}$, give the regular expression r such that

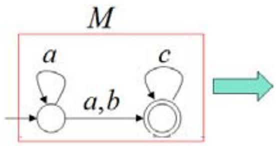
$$L(r) = \{w \in \Sigma^* : w \text{ has at least one pair of consecutive zeros}\}.$$

8. [Slide 34] Find a regular expression for the language

$$L(r) = \{w \in \{0,1\}^* : w \text{ has no pair of consecutive zeros}\}.$$

9. [Slide 38-50] Prove the following **Theorem:**
Let *r* be a regular expression. Then there exists some nondeterministic finite acceptor that accepts *L(r)*. Consequently, *L(r)* is a regular language.

10. [Slide 51] From ***M*** construct the equivalent **Generalized Transition Graph (GTG)** in which transition labels are regular expressions:



11. [Slide 52-56] Find regular expressions for the languages accepted by the following automata.