# BU CS 332 – Theory of Computation

## Lecture 9:

- Midterm I review

Reading:

Sipser Ch 0-2.3

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# Midterm I Topics

# Deterministic FAs (1.1)

- Given an English description of a language $L$, write its formal description (and vice versa)
- Given an English or formal description of a language $L$, draw the state diagram of a DFA recognizing $L$ (and vice versa)
- Know the formal definition of a DFA (A DFA is a 5 tuple…) and convert between state diagram and formal description
- Know the formal definition of how a DFA computes
- Regular operations: Union, concatenation, star and closure of regular languages under regular operations, construction for closure under complement
  - Cross-product construction for union/intersection

# Nondeterministic FAs (1.2)

- Given an English or formal description of a language $L$, draw the state diagram of an NFA recognizing $L$ (and vice versa)
- Know the formal definition of an NFA
- Know the power set construction for converting an NFA to a DFA
- Proving closure properties: Know the constructions for union, concatenation, star
- Recall other closure properties: reverse, intersection, complement

# Regular Expressions (1.3)

- Given an English or formal description of a language $L$, construct a regex generating $L$ (and vice versa)
- Formal definition of a regex
- Know how to convert a regex to an NFA
- Know how to convert a DFA/NFA to a regex

# Non-regular Languages (1.4)

- Know the proof ideas for the pumping lemma for regular languages
- Understand the statement of the pumping lemma and how to apply it
- Beyond the pumping lemma: Showing languages are non-regular by combining pumping lemma with closure properties

# Context-free Grammars (2.1)

- Given an English or formal description of a language $L$, give a CFG (in Backus-Naur form) generating $L$ (and vice versa)
- Formal definition of a CFG (A CFG is a 4-tuple…), context-free languages
- Parse trees, derivations

# Non-context-free Languages

- Know the proof ideas for the pumping lemma for CFLs
- Understand the statement of the pumping lemma and how to apply it
- Beyond the pumping lemma: Showing languages are non-context-free by combining pumping lemma with closure properties

# Exam Tips

# Study Tips

- Review problems from HW 0-3, discussion sections 1-3, solved exercises/problems in Sipser, and suggested exercises on the homework
  - We will literally ask you a question from the homework exercises, so make sure you understand these
- While you are not required to prepare a cheat-sheet, this is a great way to study!

# Study Tips

- Make sure you know how to solve the problems on the practice midterm and are familiar with the format. The format/length of the real midterm will be very similar.

- If you need more practice, there are lots of problems in the book. We’re happy to talk about any of these problems in office hours.

# For the exam itself

- You may cite without proof any result…
  - Stated in lecture
  - Stated and proved in the main body of the text (Ch. 0-2.3)
  - These include worked-out examples of state diagrams, regexes, CFGs, non-regular/non-CF languages

- Not included above: homework problems, discussion problems, (solved) exercise/problems in the text

- Showing your work / explaining your answers will help us give you partial credit

# Practice Problems

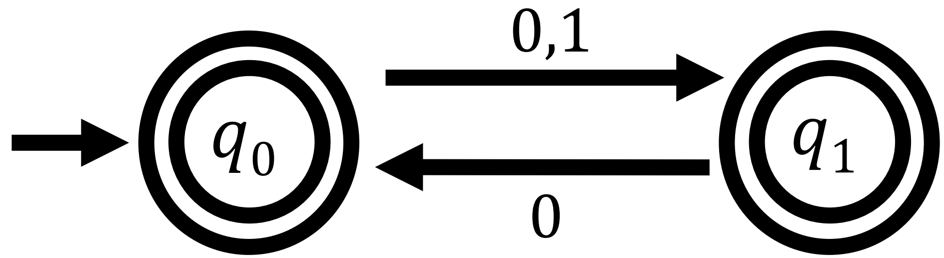
# Regular Languages

# Name six operations under which the regular languages are closed

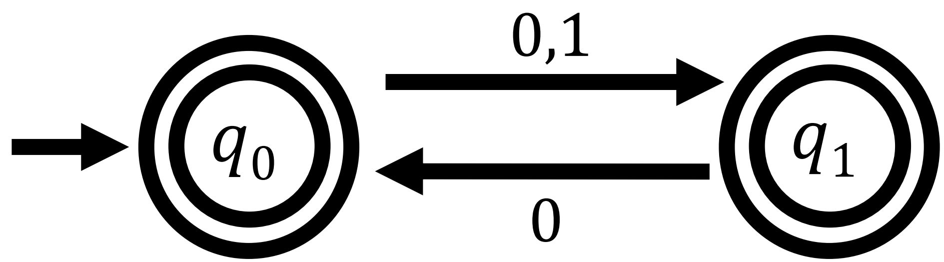
# Prove or disprove: The non-regular languages are closed under union

# Give the state diagram of an NFA recognizing the language (01 U 10)*

# Give an equivalent regular expression for the following NFA



# Give an equivalent regular expression for the following NFA



Let $R$ be a regular expression with $n$ symbols. If we convert $R$ into an NFA using the procedure described in class, how many states could it have in the worst case?

# Is the following language regular?

$$\{a^n a^n | n \geq 0\}$$

# Is the following language regular?

$$\{0^n 1^n | 0 \leq n \leq 2020\}$$

Let $L = \{w \in \{0,1\}^* \mid w \text{ has the same number of 0s and 1s}\}$.
Let $p$ be a pumping length and $s = (01)^p$.
Give a decomposition of $s = xyz$ which **can** be pumped in $L$.
Is $L$ regular?

# Context-Free Languages

Name three operations under which the context-free languages are closed.

Name two operations under which the CFLs are *not* closed

# What language is generated by the CFG

$$S \rightarrow aSb \mid bY \mid Ya$$
$$Y \rightarrow bY \mid aY \mid \varepsilon \quad ?$$

# Give a CFG for the language

$$\{w\ \#0^n \mid n \geq 0, |w| = n\}$$

# Give a PDA recognizing the language

$$\{0^n 1^n | \, n \geq 0\}$$

Prove that $\{w \in \{0,1\}^* \mid w \text{ is a palindrome with the same number of 0s and 1s}\}$ is not context-free