# CSE 322

## Exam Reviews

# Basic Concepts

- Formal Languages
  - Alphabet ($\Sigma$)
  - String ($\Sigma^*$)
  - Length ($|x|$)
  - Empty String ($\varepsilon$)
  - Empty Language ($\varnothing$)

- Language/String Operations
  - "Regular" Operations:
    - Union ($\cup$)
    - Concatenation ($\bullet$)
    - (Kleene) Star ($*$)
  - Other:
    - Intersection
    - Complement
    - Reversal
    - Shuffle
    - ...

# Finite Defns of Infinite Languages

- English, mathematical
- DFAs
    - States
    - Start states
    - Accept states
    - Transitions ($\delta$ function)
    - M accepts $w \in \Sigma^*$
    - M recognizes $L \subseteq \Sigma^*$

- Nondeterminism
- NFAs
    - Transitions ($\delta$ relation)
        - Missing out-edges
        - Multiple out-edges
        - $\varepsilon$-moves
    - N accepts $w \in \Sigma^*$
    - N recognizes $L \subseteq \Sigma^*$

- Regular Expressions
    - $\varnothing$, $\varepsilon$, $a \in \Sigma$, $\cup$, $\bullet$, $*$, ( )
- GNFAs

# Key Results, Constructions, Methods

- L is regular iff it is:
  - Recognized by a DFA
  - Recognized by a NFA
  - Recognized by a GNFA
  - Defined by a Regular Expr

Proofs:

GNFA → Reg Expr

(Kleene/Floyd/Warshall: $R_{ik} R_{kk}^* R_{kj}$)

Reg Expr → NFA

(join NFAs w/ ε-moves)

NFA → DFA

(subset construction)

- The class of regular languages is closed under:
  - Regular ops: union, concatenation, star
  - Also: intersection, complementation, (& reversal, prefix, no-prefix, … )

- NOT closed under $\subseteq$, $\supseteq$

- Also: Cross-product construction (union, …)

# Applications

- "globbing"
  - lpr   *.txt
- pattern-match searching:
  - grep "Ruzzo.*terrific" *.txt

- Compilers:
  - Id  ::= letter ( letter|digit )*
  - Int ::= digit digit*
  - Float ::=
      d d* . d* ( $\varepsilon$ | E d d* )
  - (but not, e.g. expressions with nested, balanced parens, or variable names matched to declarations)
- Finite state models of circuits, control systems, network protocols, API's, etc., etc.