

Subject: Theory of computation
Topic: Automata

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Introduction to Automata Theory

Reading: Chapter 1

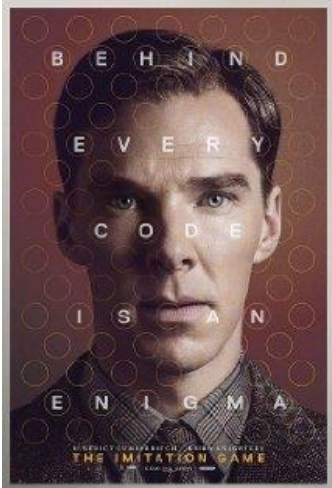
What is Automata Theory?

- *Study of abstract computing devices, or “machines”*
- **Automaton = an abstract computing device**
 - Note: A “device” need not even be a physical hardware!
- **A fundamental question in computer science:**
 - Find out what different models of machines can do and cannot do
 - The *theory of computation*
- Computability vs. Complexity

(A pioneer of automata theory)

Alan Turing (1912-1954)

- Father of Modern Computer Science
- English mathematician
- Studied abstract machines called **Turing machines** even before computers existed
- Heard of the Turing test?



Theory of Computation: A Historical Perspective

1930s	<ul style="list-style-type: none">• Alan Turing studies Turing machines• Decidability• Halting problem
1940-1950s	<ul style="list-style-type: none">• “Finite automata” machines studied• Noam Chomsky proposes the “Chomsky Hierarchy” for formal languages
1969	Cook introduces “intractable” problems or “ NP-Hard ” problems
1970-	Modern computer science: compilers, computational & complexity theory evolve

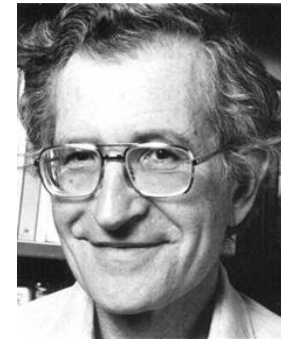
Languages & Grammars

An **alphabet** is a set of symbols:
Or “**words**” $\{0,1\}$
↓
Sentences are strings of symbols:
 $0,1,00,01,10,1,\dots$
A **language** is a set of sentences:
 $L = \{000,0100,0010,\dots\}$
A **grammar** is a finite list of rules defining a language.

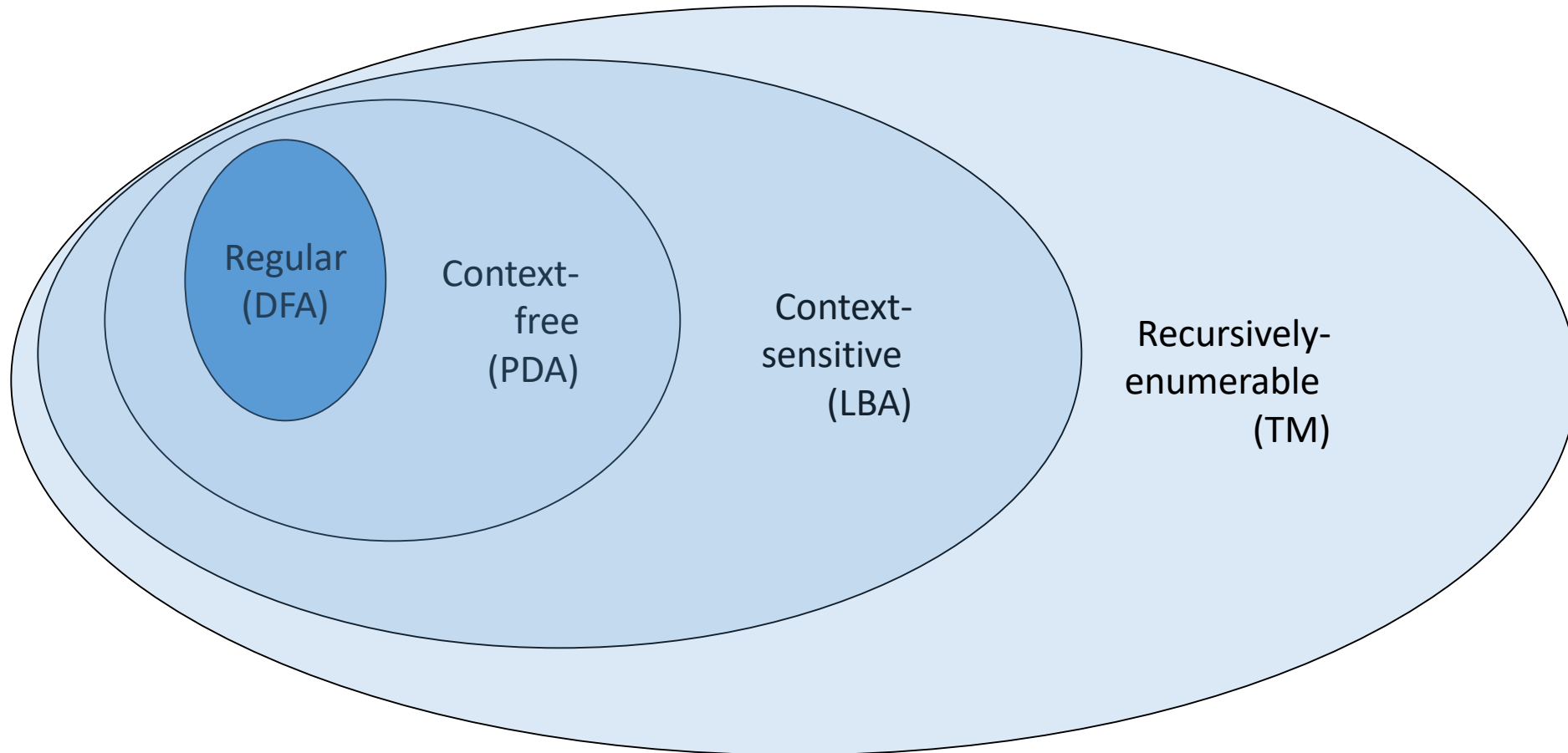
$S \longrightarrow 0A$	$B \longrightarrow 1B$
$A \longrightarrow 1A$	$B \longrightarrow 0F$
$A \longrightarrow 0B$	$F \longrightarrow \epsilon$

- Languages: “A language is a collection of sentences of finite length all constructed from a finite alphabet of symbols”
- Grammars: “A grammar can be regarded as a device that enumerates the sentences of a language” - nothing more, nothing less
- *N. Chomsky, Information and Control, Vol 2, 1959*

The Chomsky Hierarchy



- A containment hierarchy of classes of formal languages



The Central Concepts of Automata Theory

Alphabet

An alphabet is a finite, non-empty set of symbols

- We use the symbol Σ (sigma) to denote an alphabet
- Examples:
 - Binary: $\Sigma = \{0,1\}$
 - All lower case letters: $\Sigma = \{a,b,c,\dots,z\}$
 - Alphanumeric: $\Sigma = \{a-z, A-Z, 0-9\}$
 - DNA molecule letters: $\Sigma = \{a,c,g,t\}$
 - ...