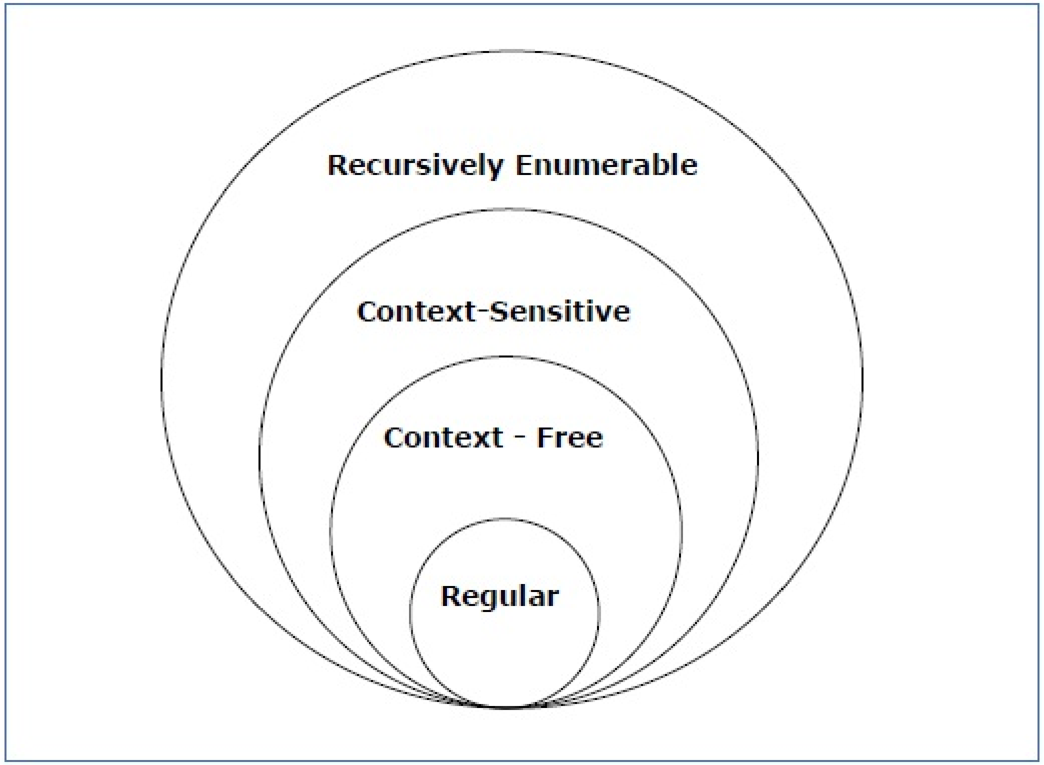
CHOMSKY CLASSIFICATION OF GRAMMARS

According to Noam Chomosky, there are four types of grammars – Type 0, Type 1, Type 2, and Type 3. The following table shows how they differ from each other –

Grammar Type	Grammar Accepted	Language Accepted	Automaton
Type 0	Unrestricted grammar	Recursively enumerable language	Turing Machine
Type 1	Context-sensitive grammar	Context-sensitive language	Linear-bounded automaton
Type 2	Context-free grammar	Context-free language	Pushdown automaton
Type 3	Regular grammar	Regular language	Finite state automaton

Take a look at the following illustration. It shows the scope of each type of grammar –



Type - 3 Grammar

Type-3 grammars generate regular languages. Type-3 grammars must have a single non-terminal on the left-hand side and a right-hand side consisting of a single terminal or single terminal followed by a single non-terminal.

The productions must be in the form $\mathbf{X \rightarrow a}$ **or** $\mathbf{X \rightarrow aY}$

where $\mathbf{X, Y \in N}$ $Nonterminal$

and $\mathbf{a \in T}$ $Terminal$

The rule $\mathbf{S \rightarrow \varepsilon}$ is allowed if **S** does not appear on the right side of any rule.

Example

```
X → ε
X → a | aY
Y → b
```

Type - 2 Grammar

Type-2 grammars generate context-free languages.

The productions must be in the form $\mathbf{A} \rightarrow \boldsymbol{\gamma}$

where $\mathbf{A} \in \mathbf{N}$ $Nonterminal$

and $\boldsymbol{\gamma} \in T \cup N*$ $Stringofterminalsandnon-terminals$.

These languages generated by these grammars are be recognized by a non-deterministic pushdown automaton.

Example

```
S → X a
X → a
X → aX
X → abc
X → ε
```

Type - 1 Grammar

Type-1 grammars generate context-sensitive languages. The productions must be in the form

$$\boldsymbol{\alpha}\ \mathbf{A}\ \boldsymbol{\beta} \rightarrow \boldsymbol{\alpha}\ \boldsymbol{\gamma}\ \boldsymbol{\beta}$$

where $\mathbf{A} \in \mathbf{N}$ $Non-terminal$

and $\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\gamma} \in T \cup N*$ $Stringsofterminalsandnon-terminals$

The strings **α** and **β** may be empty, but **γ** must be non-empty.

The rule **S** → **ε** is allowed if S does not appear on the right side of any rule. The languages generated by these grammars are recognized by a linear bounded automaton.

Example

```
AB → AbBc
A → bcA
B → b
```

Type - 0 Grammar

Type-0 grammars generate recursively enumerable languages. The productions have no restrictions. They are any phase structure grammar including all formal grammars.

They generate the languages that are recognized by a Turing machine.

The productions can be in the form of **α** → **β** where **α** is a string of terminals and nonterminals with at least one non-terminal and **α** cannot be null. **β** is a string of terminals and non-terminals.

Example

```
S → ACaB
Bc → acB
CB → DB
aD → Db
```