Def: A regular grammar (RG) is a CFG where all productions are of the form \( \alpha \rightarrow \beta \) where \( \beta \) has the form of \( aB \) or \( a \) where \( a \in V_t \) and \( B \in V_n \).

Def: Regular expressions are those expressions that can be constructed from the following rules:

1. \( \phi \) is a regular expression denoting the empty set.
2. \( \varepsilon \) is a regular expression denoting the language consisting of only the empty string, i.e. \( \{ \lambda \} \).
3. \( a \) where \( a \in V_t \) is a regular expression.
4. if \( e_1 \) and \( e_2 \) are regular expressions denoting the languages \( L_1 \) and \( L_2 \), then
   a. \( e_1 \mid e_2 \) \( L_1 \cup L_2 \)
   b. \( e_1 e_2 \) \( L_1 L_2 \)
   c. \( \{ e_1 \} \) \( L_1^* \)
are regular expressions.

Def: A deterministic finite state acceptor (DFA) is a 5-tuple \( (Q, V_t, M, q_0, Z) \) where

1. \( Q \) is a finite non-empty set called the states,
2. \( V_t \) is the alphabet,
3. \( M \) is a mapping from \( Q \times V_t \rightarrow Q \),
4. \( q_0 \) is the start state where \( q_0 \in Q \), and
5. \( Z \subseteq Q \) is a non-empty set of final states.

e.g.

Non-determinism versus determinism

\[ L(\text{NFA}) = L(\text{DFA}) \]
Regular Language $\rightarrow$ regular grammar

\{ a^n b a^n \mid n, m > 0 \} 

Click [here](#) for an answer:

regular grammar $\rightarrow$ regular expression

$$
S \rightarrow a S \\
\mid a B \\
B \rightarrow b C \\
C \rightarrow a C \\
\mid a
$$

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regular grammar $\rightarrow$ NFA

\[
\begin{align*}
S & \rightarrow a\ S \\
& \quad |\ a\ A \\
A & \rightarrow b\ B \\
B & \rightarrow a\ C \\
C & \rightarrow a\ C \\
& \quad |\ \lambda
\end{align*}
\]

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FSA $\rightarrow$ regular grammar

Click [here](#) for an answer

FSA $\rightarrow$ regular expression

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regular expression $\rightarrow$ FSA

$$a^+ b a^+$$

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NFSA $\rightarrow$ DFSA

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\[ S \rightarrow a\ S \]
\[ | \ a\ A \]
\[ A \rightarrow b\ B \]
\[ B \rightarrow a\ B \]
\[ |\ a \]

\[ a^+ \ b\ a^+ \]

\[ q_0 \rightarrow a\ q_1 \]
\[ q_1 \rightarrow a\ q_1 \]
\[ |\ b\ q_2 \]
\[ q_2 \rightarrow a\ q_3 \]
\[ q_3 \rightarrow a\ q_3 \]
\[ |\ \lambda \]

\[ a^+ \ b\ a^+ \]

which simplifies to
\[ a^+ \ b\ a^+ \]