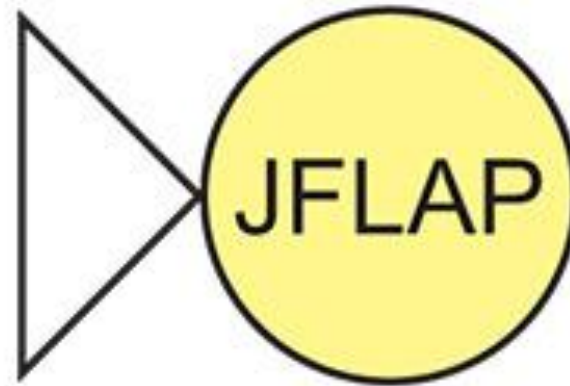




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# TEORIA DA COMPUTAÇÃO



<http://www.jflap.org/>

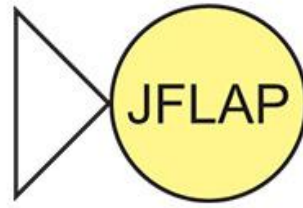
## FERRAMENTA PARA APRENDIZAGEM DOS CONCEITOS BÁSICOS DE LINGUAGENS FORMAIS E AUTÔMATOS

- ✓ Carlos Reynaldo Portocarrero Tovar (Mestrado em Ciência da Computação)
- ✓ José Norberto Sousa Lopes (Doutorado em Ciência da Computação)
  - ✓ Professora Mirtha Lina Fernández Venero
  - ✓ Disciplina: Teoria da Computação



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# CONCEITOS ... JFLAP

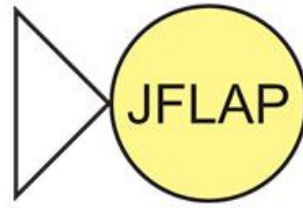


- ✓ **Java Formal Languages and Automata Package;**
- ✓ **Desenvolvido para Criar e Simular Autômatos;**
- ✓ **Facilitar a aprendizagem de Autômatos;**
- ✓ **Ferramenta Visual;**
- ✓ **Conversão de Autômatos (FN > FD);**
- ✓ **Ferramenta Interativa desenvolvida em JAVA;**



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# CONCEITOS ... JFLAP

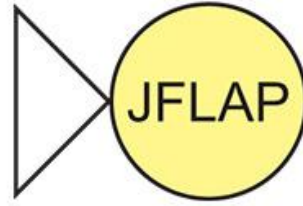


- ✓ **Criado em 1990;**
  - ✓ **Dra. Susan H. Rodger**
    - ✓ **Rensselaer Polytechnic Institute e Duke University**
- ✓ **Objetivo Principal da Ferramenta:**
  - ✓ **Facilitar o desenvolvimento e estudo de linguagens formais autômatos;**
- ✓ **Última atualização em 2016 (Brian Pester – Duke University)**

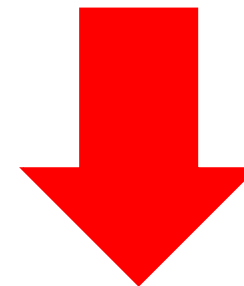


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# HISTÓRIA ... JFLAP



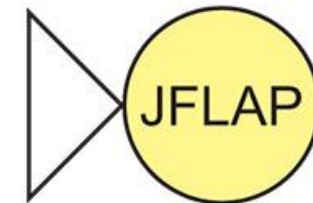
- ✓ **O JFLAP começou como uma série de ferramentas no Rensselaer Polytechnic Institute em 1990, com estudantes trabalhando sob a direção de Susan Rodger.**
- ✓ **A Duke University absorveu o projeto em 1994, quando a Dra. Rodger se mudou para lá.**
- ✓ **E ao longo de sua existência, constantemente grupos de alunos trabalham em suas atualizações;**





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# QUEM TRABALHOU NO DESENVOLVIMENTO ... JFLAP



DATA	ALUNO	INSTITUIÇÃO	FERRAMENTA
1990	Dan Caugherty	Rensselaer	NPDA
1991	Grant Poladian	Rensselaer	Tools for Automata
1992	Mark LoSacco	Rensselaer	FLAP
1992	Mike James	Rensselaer	LR Parser
1992	Danny Daglas	Rensselaer	Turing Machine Implementation
1992	Jeffrey Nesheiwat	Rensselaer	Turing Machine Implementation
1992	Jasper Wong	Rensselaer	Turing Machine Implementation
1993	Eric Luce	Rensselaer	Turing Machine Building Blocks
1993	Steve Blythe	Rensselaer	LR Parser
1994	Ugur Dogrusoz	Rensselaer	Automatic Layout of DFA in LR Parsing
1994	Bhasker Vasudevan	Rensselaer	NFA to DFA
1994	Mohan Nibhunupudi	Rensselaer	CFG to CNF
1995	Edwin Tsang	Duke University	LL and LR Parse Trees
1995	Greg Badros	Duke University	Modifications to FLAP
1995	Steve Wolfman	Duke University	L-systems
1995	Ben Hardekopf	Duke University	DFA to minimum DFA
1996	Ken Leider	Duke University	PumpLemma
1996	Anna Bilaska	Duke University	Pate: Brute Force Parser
1996	Jason Salemme	Duke University	Pate: Brute Force Parser
1996	Magda Procopiuc	Duke University	JFLAP - FLAP to Java
1996	Octavian Procopiuc	Duke University	JFLAP - FLAP to Java
1997	Alex Karweit	Duke University	JeLLRap - LL and LR parsing
1997	Robyn Geer	Duke University	JeLLRap - LL and LR parsing
1997	Eric Gramond	Duke University	Extensions to JFLAP

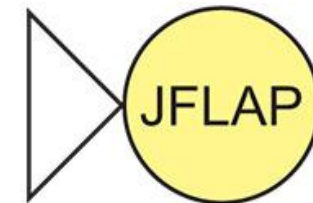


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# QUEM TRABALHOU NO DESENVOLVIMENTO ... JFLAP

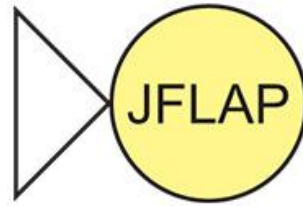


DATA	ALUNO	INSTITUIÇÃO	FERRAMENTA
1997	Alex Karweit	Duke University	JeLLRap - LL and LR parsing
1997	Robyn Geer	Duke University	JeLLRap - LL and LR parsing
1997	Eric Gramond	Duke University	Extensions to JFLAP
1998	Lenore Ramm	Duke University	L-systems
1999	Ted Hung	Duke University	Regular Expressions
2002	Thomas Finley	Duke University	JFLAP rewritten and extended in Swing, L-Systems, Many new additions
2002	Ryan Cavalcante	Duke University	JFLAP rewritten and extended in Swing
2005	Stephen Reading	Duke University	Turing Machine Building Blocks in JFLAP, Batch processing
2005	Bart Bressler	Duke University	Turing Machine Building Blocks in JFLAP
2006	Jinghui Lim	Duke University	Moore and Mealy machines, Pumping Lemma
2007	Chris Morgan	Duke University	Graph Layouts, JFLAP Tutorial, Pumping Lemma
2007	Kyung Min (Jason) Lee	Duke University	CYK Parser, User-Control Parser, JFLAP Tutorial, TM to UG
2008	Jonathan Su	Duke University	Usage and Updating of JFLAP, image formats, flexible transitions
2009	Henry Qin	Duke University	Rewrite of Turing machine Building Blocks, Many other updates.
2011	Julian Genkins	Duke University	Started redesign of JFLAP to JFLAP 8.0
2012	Peggy Li	Duke University	experimenting with sets
2012	Ian McMahon	Duke University	CYK parsing, more on Turing machines, more on redesign of JFLAP
2014	Aohui (Lawrence) Lin	Duke University	Parse Tree, Regex to NFA conversion and more redesign of JFLAP
2014	John Godbey	Duke University	More redesign of JFLAP
2015	James Cho	Duke University	Experiment with JFLAP to HTML5 with OpenDSA
2015	Martin Tamayo	Duke University	JFLAP to HTML5 with OpenDSA
2015	Sung-Hoon Kim	Duke University	JFLAP to HTML5 with OpenDSA
2016	Han "Bill" Yu	Duke University	JFLAP to HTML5 with OpenDSA
2016	Brian Pester	Duke University	JFLAP to HTML5 with OpenDSA





# COMPARAÇÃO > FUNCIONALIDADES... JFLAP



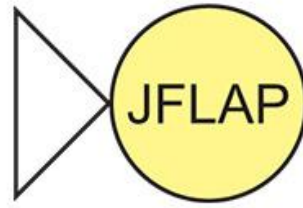
FUNCIONALIDADES	SIMULADORES			
	SAGEMoLIC	L. Emulador	JFLAP	SIMMoL
Conformidade	Alta	Baixa	Alta	Média
Portabilidade	Alta	Alta	Alta	Alta
Robustez	Alta	Alta	Alta	Alta
Usabilidade	Média	Baixa	Baixa	Média
Determinísticos	X	X	X	X
Não Determinísticos	X	X	X	
Autômatos a Pilha	X		X	
Expressões Regulares	X	X	X	X
Gramática Lineares	X	X	X	X
Gramáticas Livres de Contexto	X		X	
Máquina de Turing			X	
Lema da Boma			X	

Fonte: <http://www.mat.unb.br/~ayala/TCgroup/> - 10/2017



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# PORQUE UTILIZAR... JFLAP



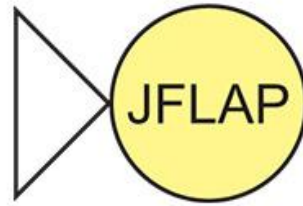
- ✓ **Facilidade na aplicação de Testes;**
- ✓ **Visualização Interativa, acompanhando passo a passo as simulações;**
- ✓ **Consolidação de Conceitos, aplicando na prática;**





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# A FERRAMENTA... JFLAP



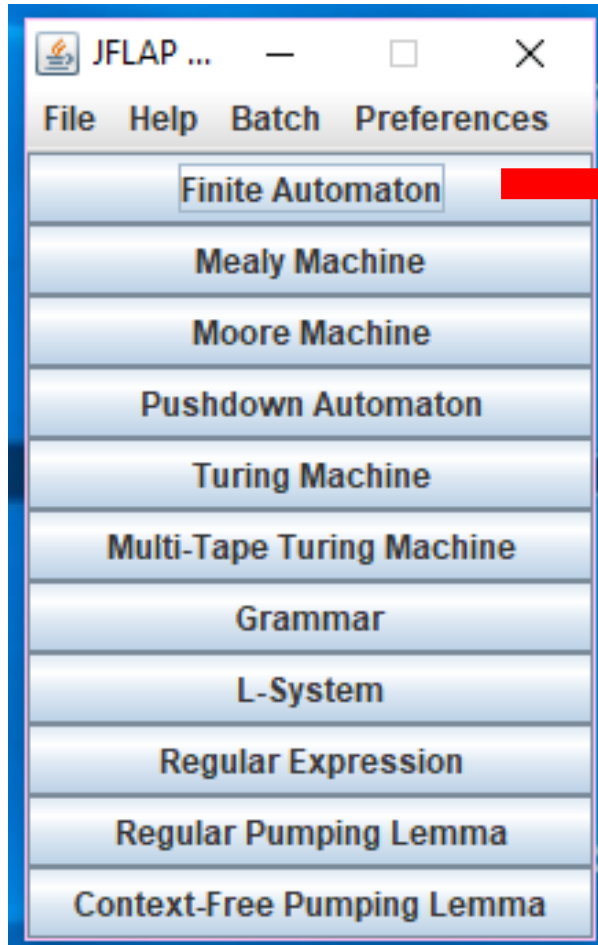
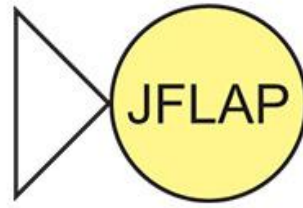
← Criando Autômatos Finitos

Tela inicial do JFLAP

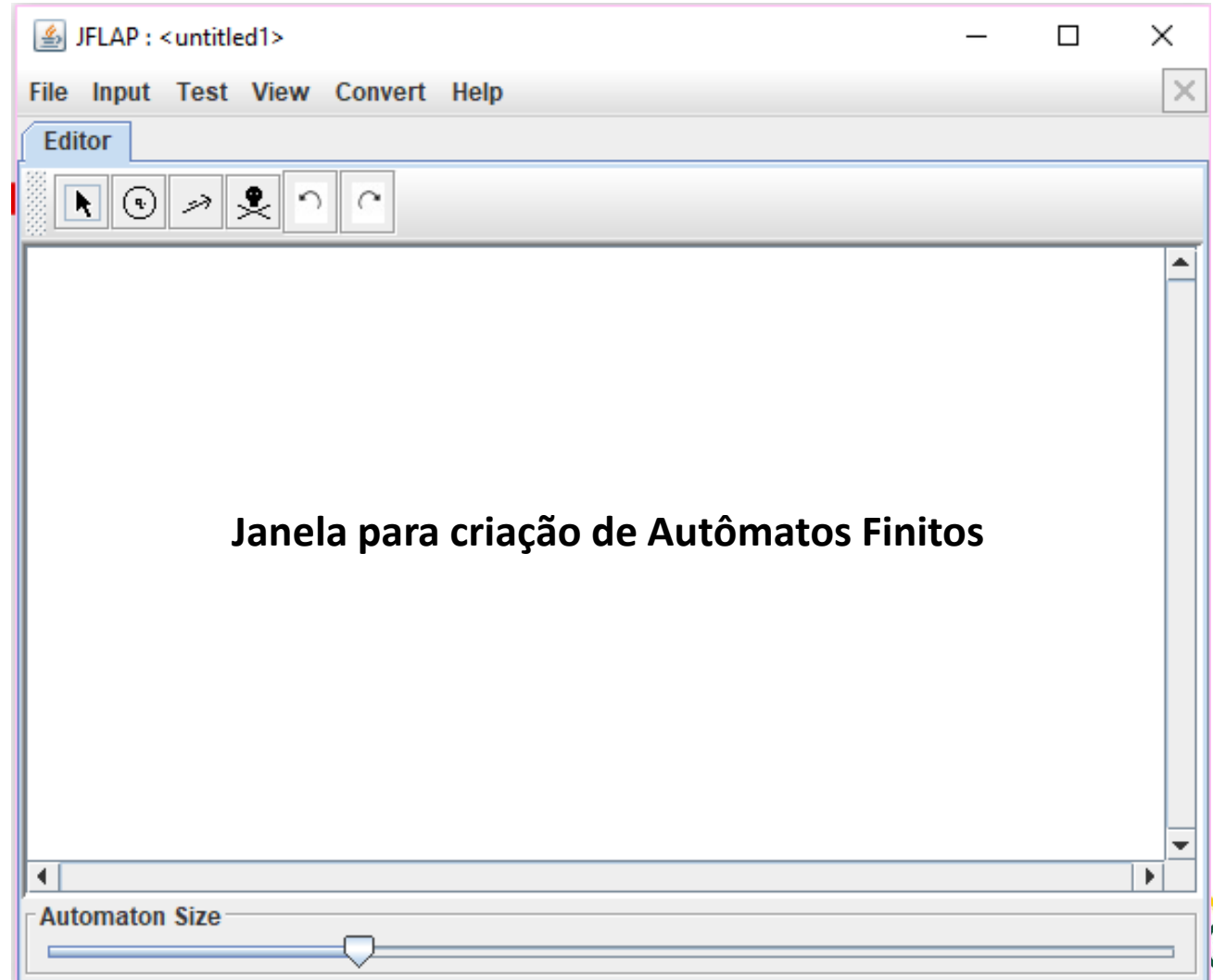


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# A FERRAMENTA... JFLAP



Tela inicial do JFLAP



Janela para criação de Autômatos Finitos

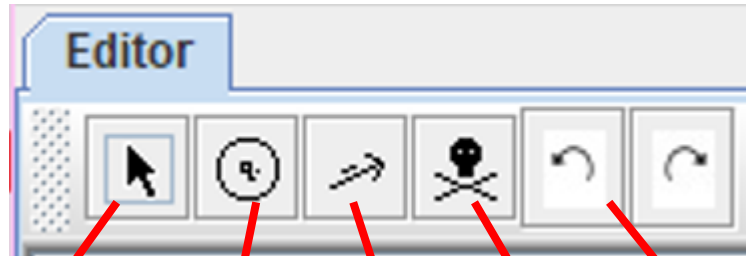
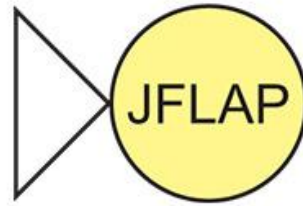


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# A FERRAMENTA... JFLAP



Ferramenta de seleção

Ferramenta para  
criação de estados

Ferramenta para  
criação das  
transições

Deletar

Voltar ou retomar  
algum processo

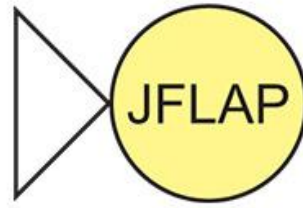


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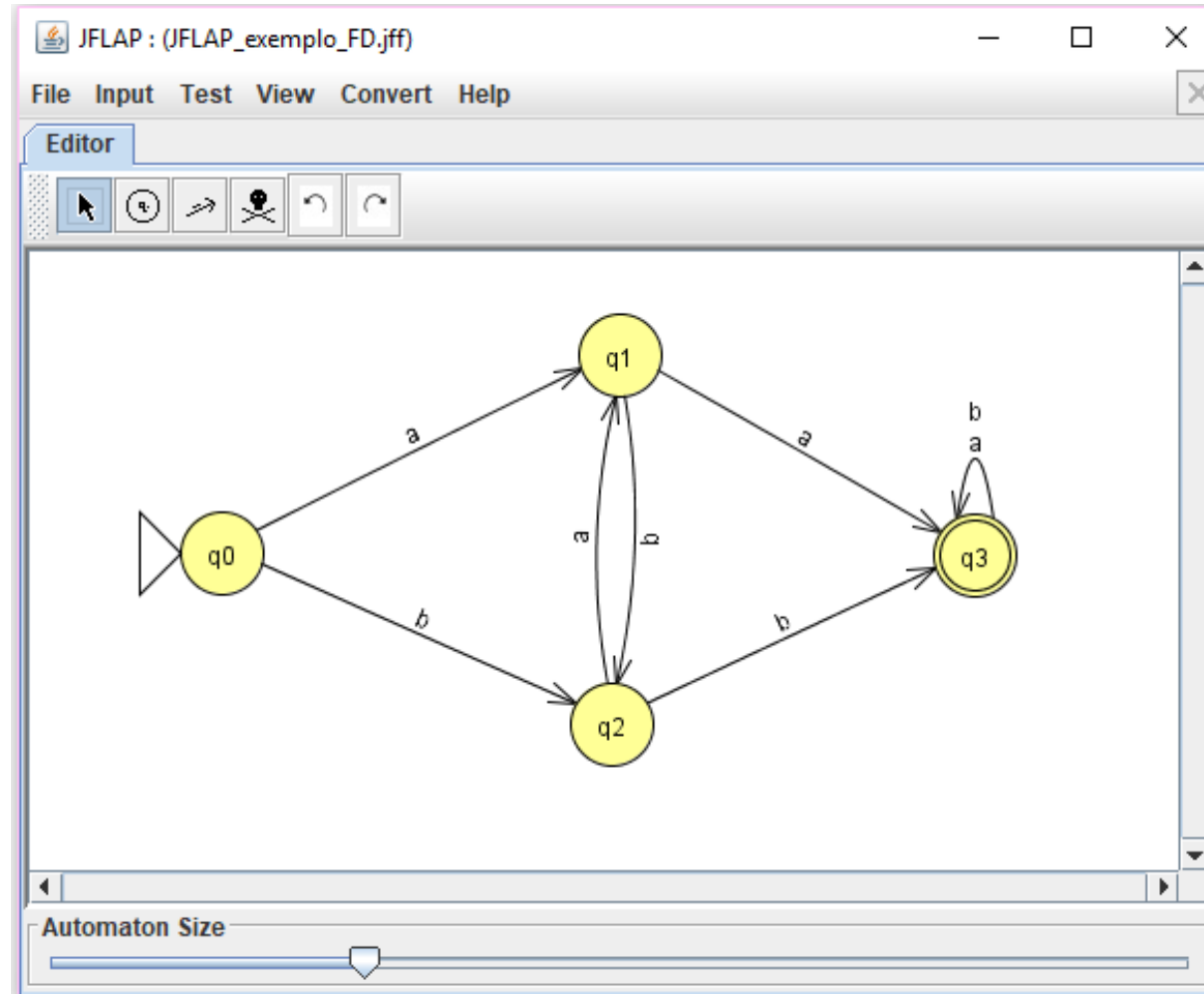


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# CRIANDO UM AUTÔMATO FINITO... JFLAP

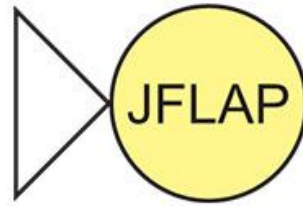


Exemplo de linguagem:  $L1 = \{ w \mid w \text{ possui aa ou bb como subpalavra} \}$





# CRIANDO UM AUTÔMATO FINITO... JFLAP



## Testando o autômato Finito Determinístico

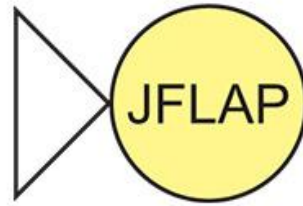
The image shows the JFLAP software interface with a Deterministic Finite Automaton (DFA) diagram. The DFA has four states: q0 (start state), q1, q2, and q3 (final state). The transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. State q3 has a self-loop on both 'a' and 'b'.

The JFLAP window shows the 'Input' menu with options: Step with Closure... (Ctrl-R), Step by State... (Ctrl+Shift-R), Fast Run... (highlighted with a red arrow), and Multiple Run (Ctrl-M). An 'Input' dialog box is open, showing the input string 'abba|' and buttons for 'Click to Open Input File', 'OK', and 'Cancelar'.

```
graph LR
    q0((q0)) -- a --> q1((q1))
    q0 -- b --> q2((q2))
    q1 -- a --> q2
    q2 -- b --> q1
    q1 -- a --> q3(((q3)))
    q2 -- b --> q3
    q3 -- a --> q3
    q3 -- b --> q3
```



# CRIANDO UM AUTÔMATO FINITO... JFLAP

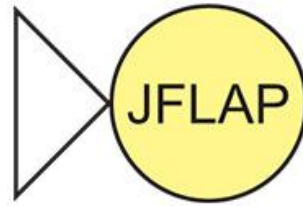


## Testando o autômato Finito Determinístico

The screenshot shows the JFLAP software interface. The main window displays a Deterministic Finite Automaton (DFA) with four states: q0, q1, q2, and q3. q0 is the start state, indicated by a triangle. q3 is the final state, indicated by a double circle. The transitions are as follows: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. State q3 has a self-loop on both 'a' and 'b'. An 'Input' dialog box is open over the diagram, with the text 'abba' entered in the input field. A red arrow points from the top right towards the input field. The dialog box also contains a 'Click to Open Input File' button, 'OK', and 'Cancelar' buttons. The JFLAP window title is 'JFLAP : (JFLAP\_exemplo\_FD.jff)' and the menu bar includes 'File', 'Input', 'Test', 'View', 'Convert', and 'Help'. The 'Editor' tab is active, and a toolbar with various editing tools is visible. At the bottom, there is a slider for 'Automaton Size'.



# CRIANDO UM AUTÔMATO FINITO... JFLAP



## Testando o autômato Finito Determinístico

The screenshot shows the JFLAP interface with a DFA diagram and a configuration window. The DFA has four states: q0 (start), q1, q2, and q3 (accept). Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', q2 to q3 on 'b', and q3 to q3 on 'a' and 'b'.

The configuration window, titled "Accepting configuration found!", shows the following configurations:

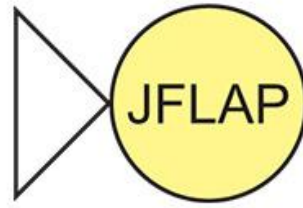
State	Input	Next State
q0	abba	↓
q1	abba	↓
q2	abba	↓
q3	abba	↓
q3	abba	↓

A red arrow points from the configuration window towards the right.



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



## Testando o autômato Finito Determinístico

The screenshot shows the JFLAP software interface. The main window displays a Deterministic Finite Automaton (DFA) with four states: q0 (start state), q1, q2, and q3 (accepting state). The transitions are as follows: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. State q3 has a self-loop on both 'a' and 'b'.

Overlaid on the main window is a dialog box titled "Accepting configuration found!". It contains a list of configurations, each with a state and the string "abba":

State	String
q0	abba
q1	abba
q2	abba
q3	abba
q3	abba

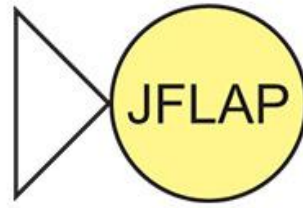
At the bottom of the dialog box are two buttons: "Keep looking" and "I'm done". A red arrow points from the right side of the dialog box towards the left.





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# CRIANDO UM AUTÔMATO FINITO... JFLAP



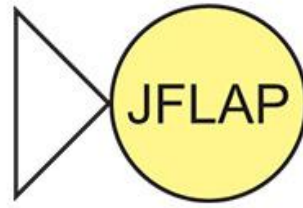
Testando estado a estado...

The screenshot shows the JFLAP software interface. The main window displays a finite automaton with four states: q0 (start state, dark green), q1 (yellow), q2 (yellow), and q3 (accept state, yellow with a double circle). Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. State q3 has a self-loop on 'a'. The 'Input' menu is open, with 'Step by State...' selected, indicated by a red arrow. The control panel at the bottom shows the current state as q0, the input string 'abba', and buttons for Step, Reset, Freeze, Thaw, Trace, and Remove.



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



Testando estado a estado...

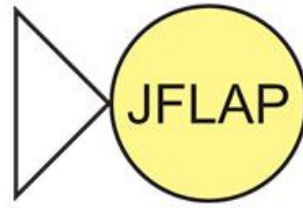
The screenshot shows the JFLAP software interface. The main window displays a finite automaton with four states: q0 (start state, dark green), q1 (yellow), q2 (yellow), and q3 (final state, yellow with a double border). Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. State q3 has a self-loop on both 'a' and 'b'.

The simulation window at the bottom shows the start state q0 and an input string 'abba'. A red arrow points to the input field. Below the input field are buttons for Step, Reset, Freeze, Thaw, Trace, and Remove.



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



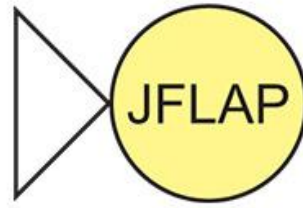
Testando estado a estado...

The screenshot shows the JFLAP software interface. The main window displays a finite automaton with four states: q0 (start state), q1, q2, and q3 (final state). The transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. State q3 has a self-loop on both 'a' and 'b'. The simulation window shows the current state as q1 and the input string 'abba'. A red arrow points to the input string. The bottom toolbar contains buttons for Step, Reset, Freeze, Thaw, Trace, and Remove.



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



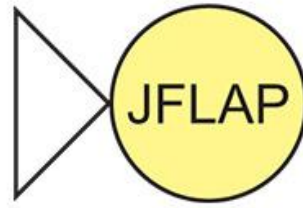
Testando estado a estado...

The screenshot shows the JFLAP software interface. The main window displays a finite automaton with four states: q0 (start state), q1, q2, and q3 (final state). The transitions are as follows: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. State q3 has a self-loop on both 'a' and 'b'. The simulation window at the bottom shows the current state as q2 and the input string 'abba'. A red arrow points to the input string. The simulation controls at the bottom include buttons for Step, Reset, Freeze, Thaw, Trace, and Remove.



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



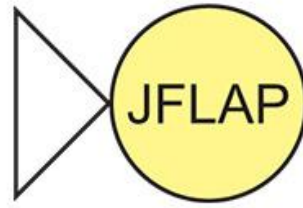
Testando estado a estado...

The screenshot shows the JFLAP application window titled "JFLAP : (JFLAP\_exemplo\_FD.jff)". The menu bar includes "File", "Input", "Test", "View", "Convert", and "Help". The "Editor" tab is active, and the "Simulate: abba" tab is selected. The main area displays a finite automaton with four states: q0 (start state, yellow circle with a triangle), q1 (yellow circle), q2 (yellow circle), and q3 (final state, dark green circle with a double circle). Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. State q3 has a self-loop on both 'a' and 'b'. The bottom panel shows the current state as q3, the input string "abba" in a text box, and a red arrow pointing to the text box. Below the text box are buttons for "Step", "Reset", "Freeze", "Thaw", "Trace", and "Remove".



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



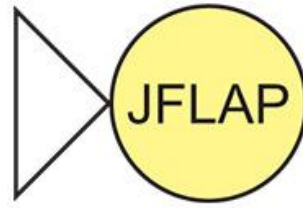
Testando estado a estado...

The screenshot shows the JFLAP application window titled "JFLAP : (JFLAP\_exemplo\_FD.jff)". The menu bar includes "File", "Input", "Test", "View", "Convert", and "Help". The "Simulate: abba" tab is active. The main area displays a finite automaton with four states: q0 (start state), q1, q2, and q3 (final state). Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q2 on 'a', q2 to q1 on 'b', q1 to q3 on 'a', q2 to q3 on 'b', and a self-loop on q3 for both 'a' and 'b'. The bottom panel shows the current state as q3 and the input string "abba". A red arrow points from a hand icon to the input field. Control buttons at the bottom are "Step", "Reset", "Freeze", "Thaw", "Trace", and "Remove".

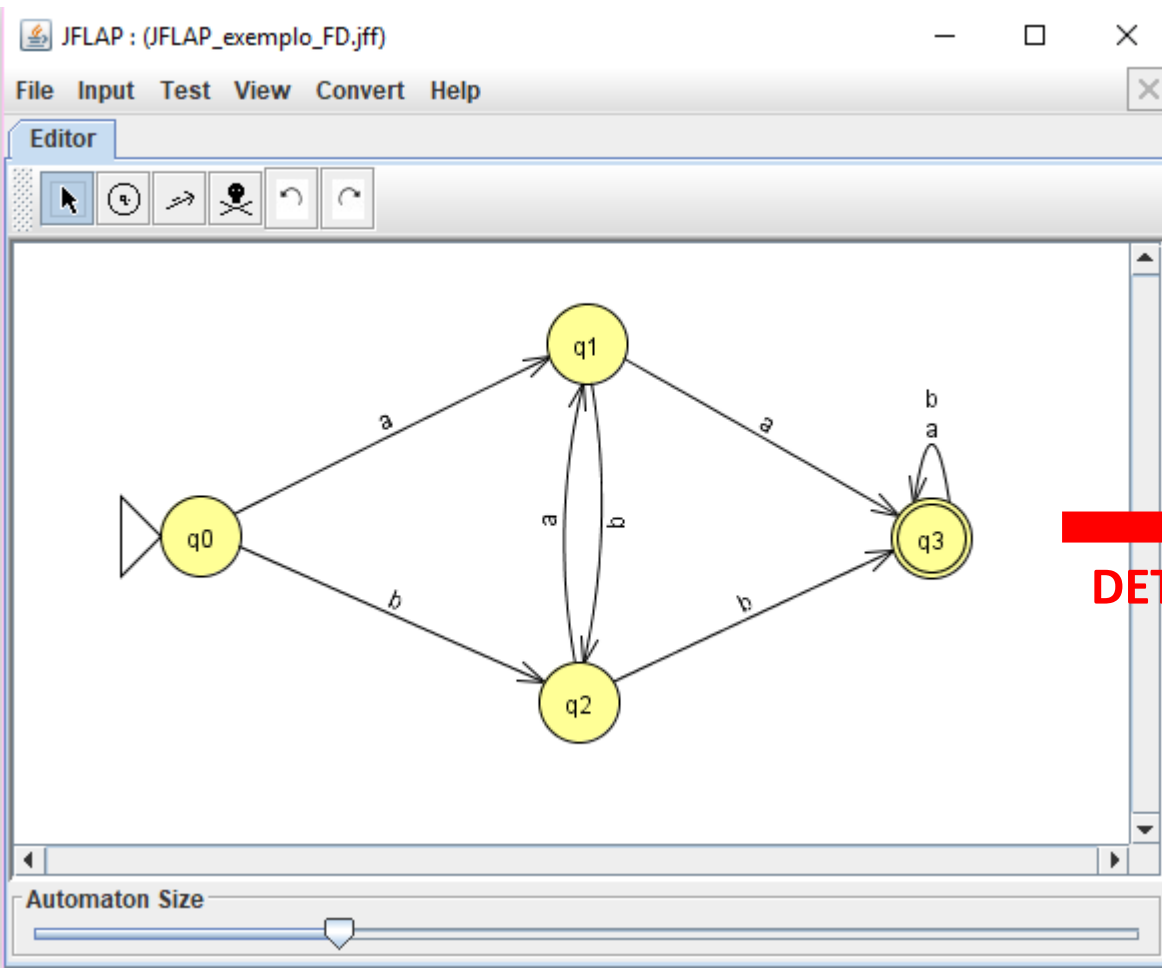


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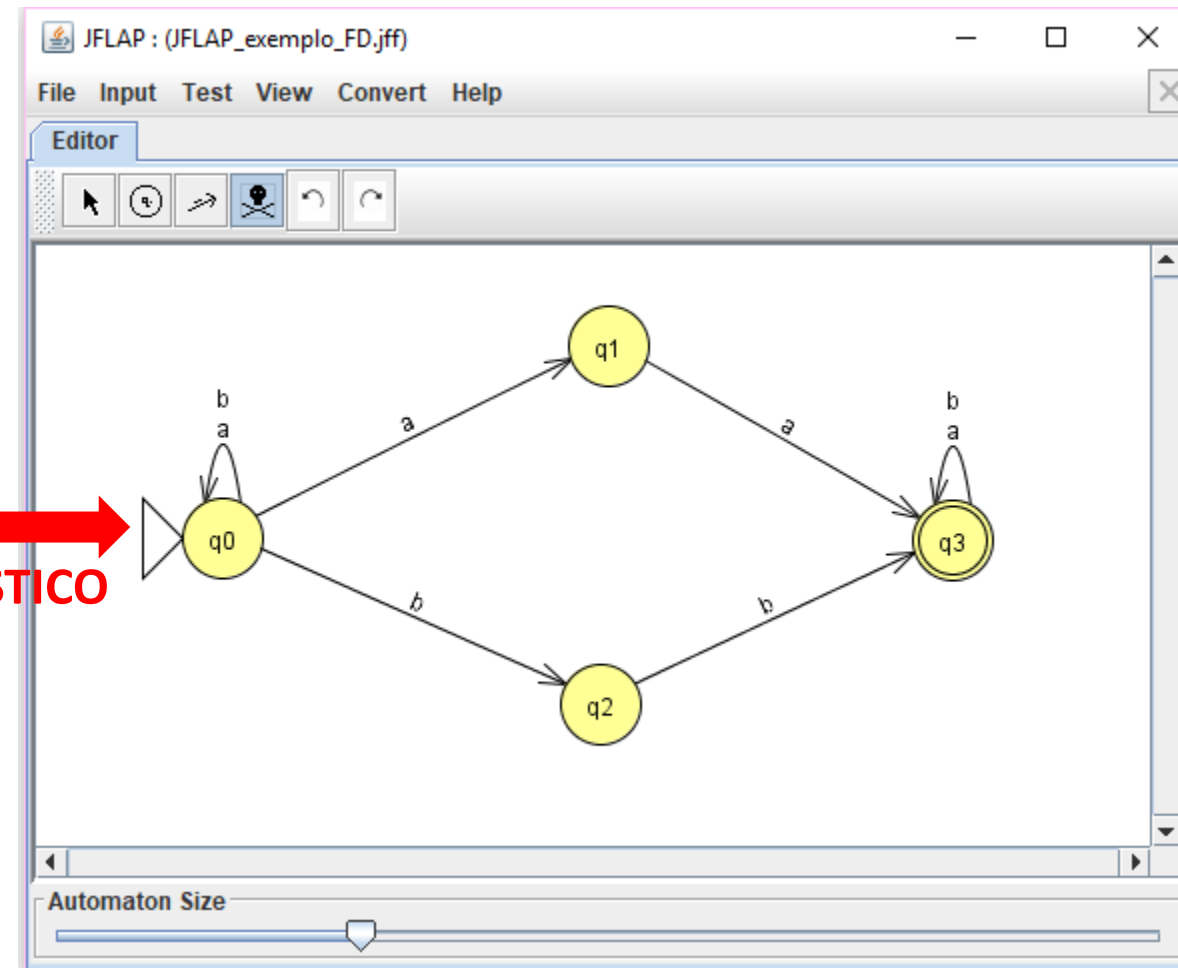
# CRIANDO UM AUTÔMATO FINITO... JFLAP



Transformando e testando o autômato Finito Determinístico em **NÃO** Determinístico



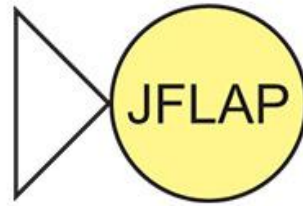
**NÃO**  
→  
**DETERMINÍSTICO**



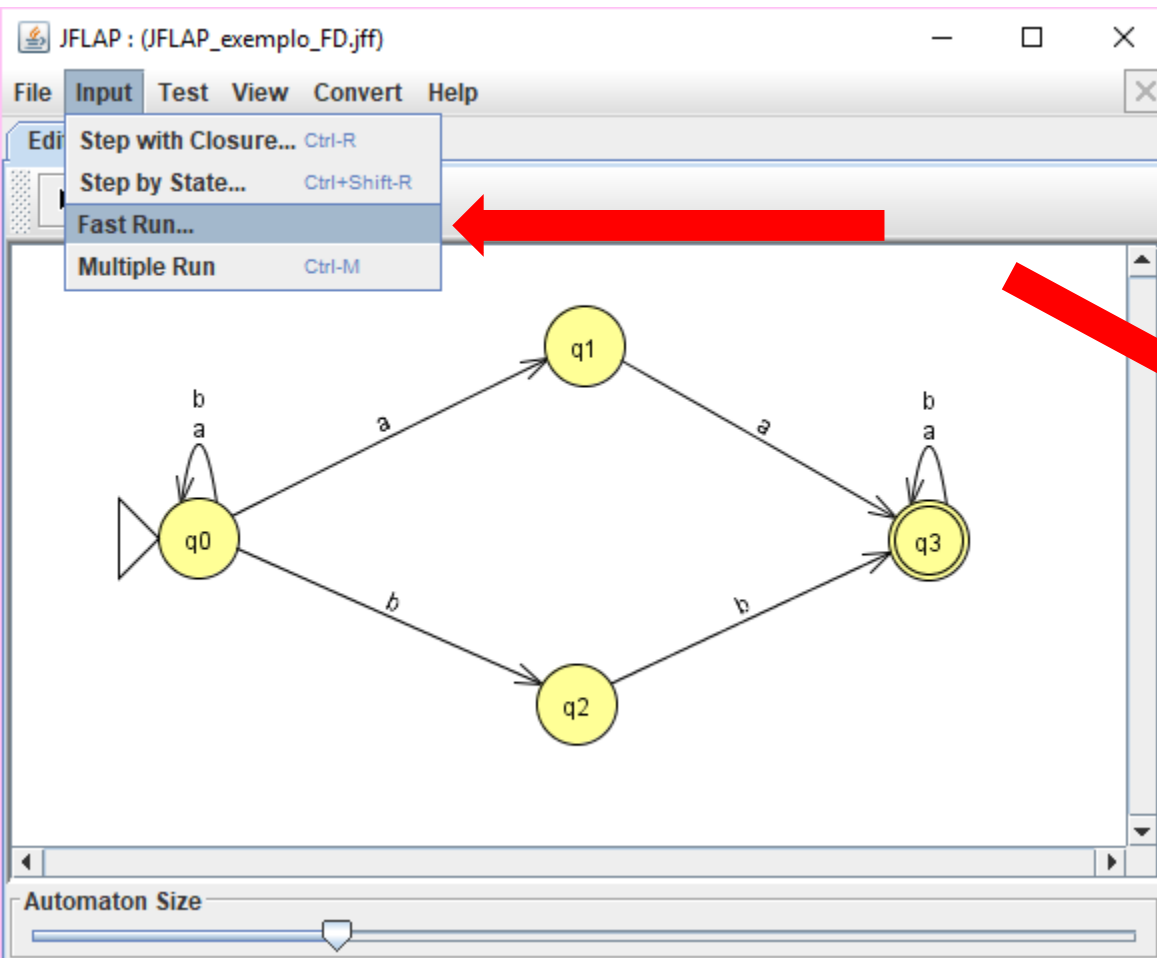


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# CRIANDO UM AUTÔMATO FINITO... JFLAP



Transformando e testando o autômato Finito Determinístico em **NÃO** Determinístico



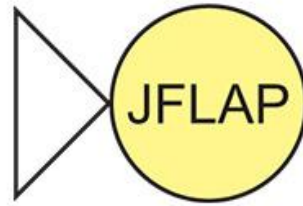
The 'Input' dialog box is shown with the following elements:

- Input field: abba
- Button: Click to Open Input File
- Buttons: OK, Cancelar

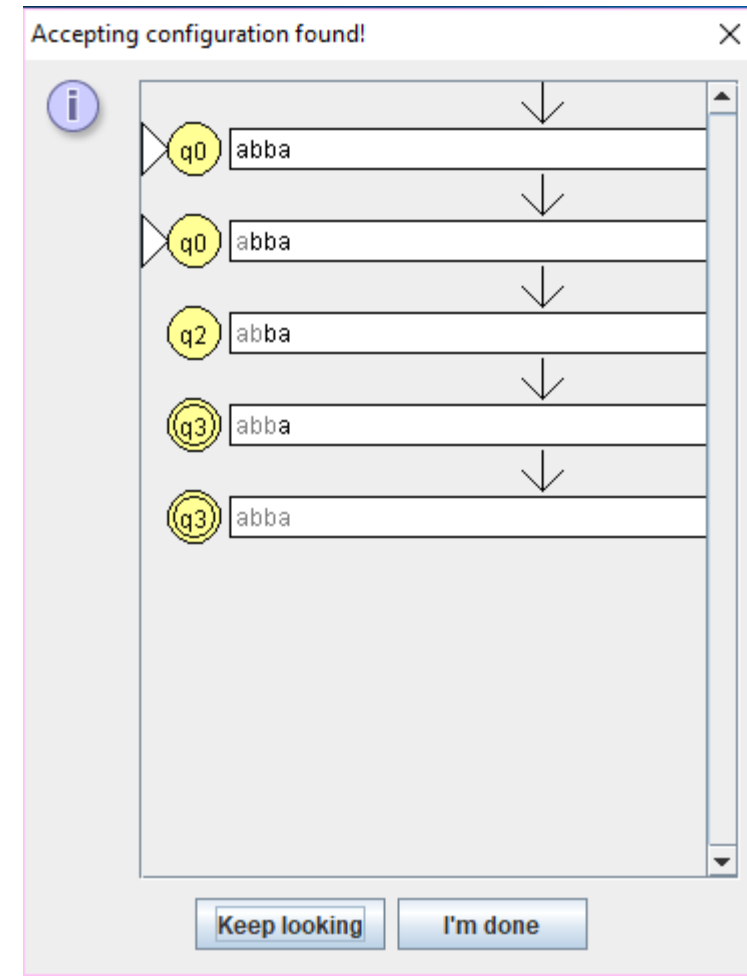
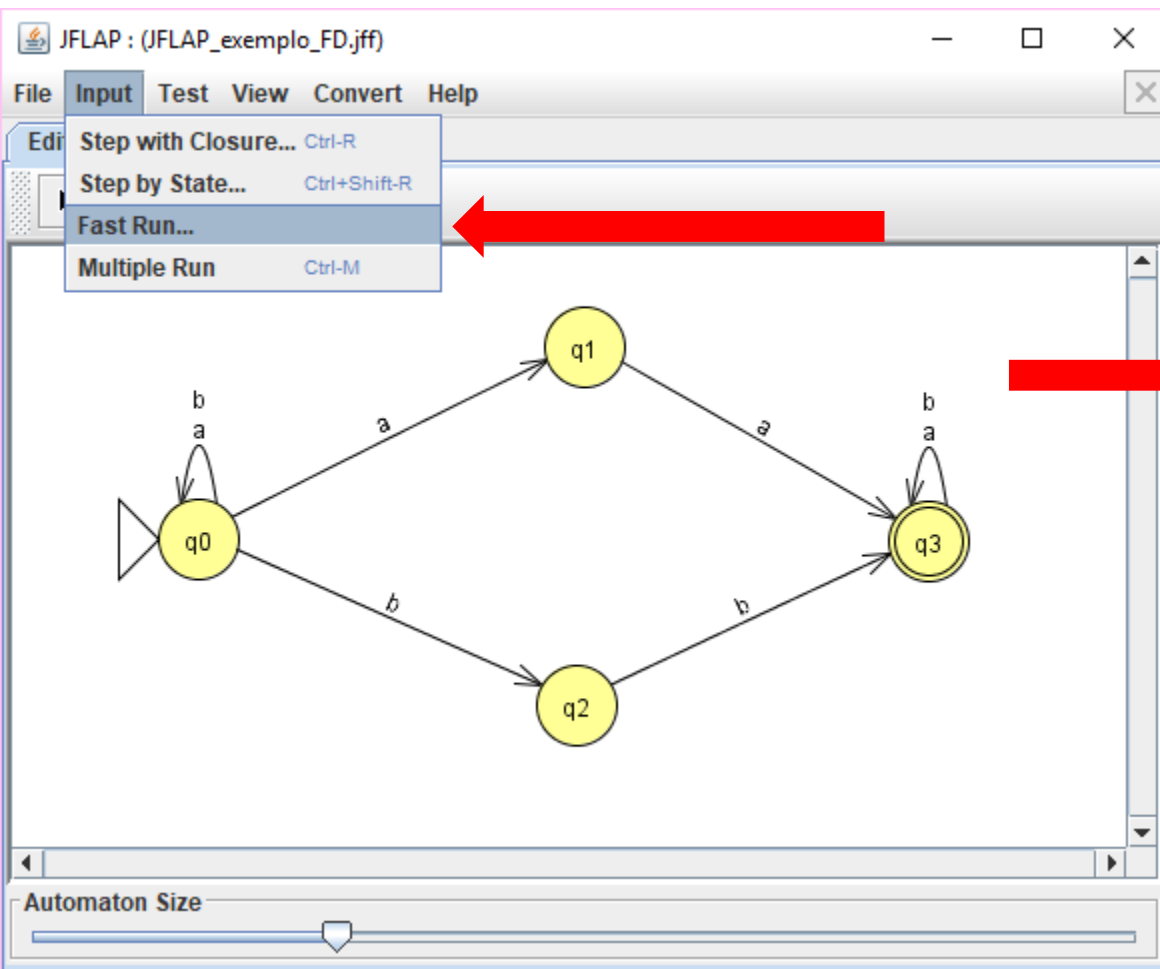




# CRIANDO UM AUTÔMATO FINITO... JFLAP



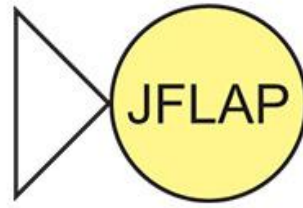
Transformando e testando o autômato Finito Determinístico em **NÃO** Determinístico



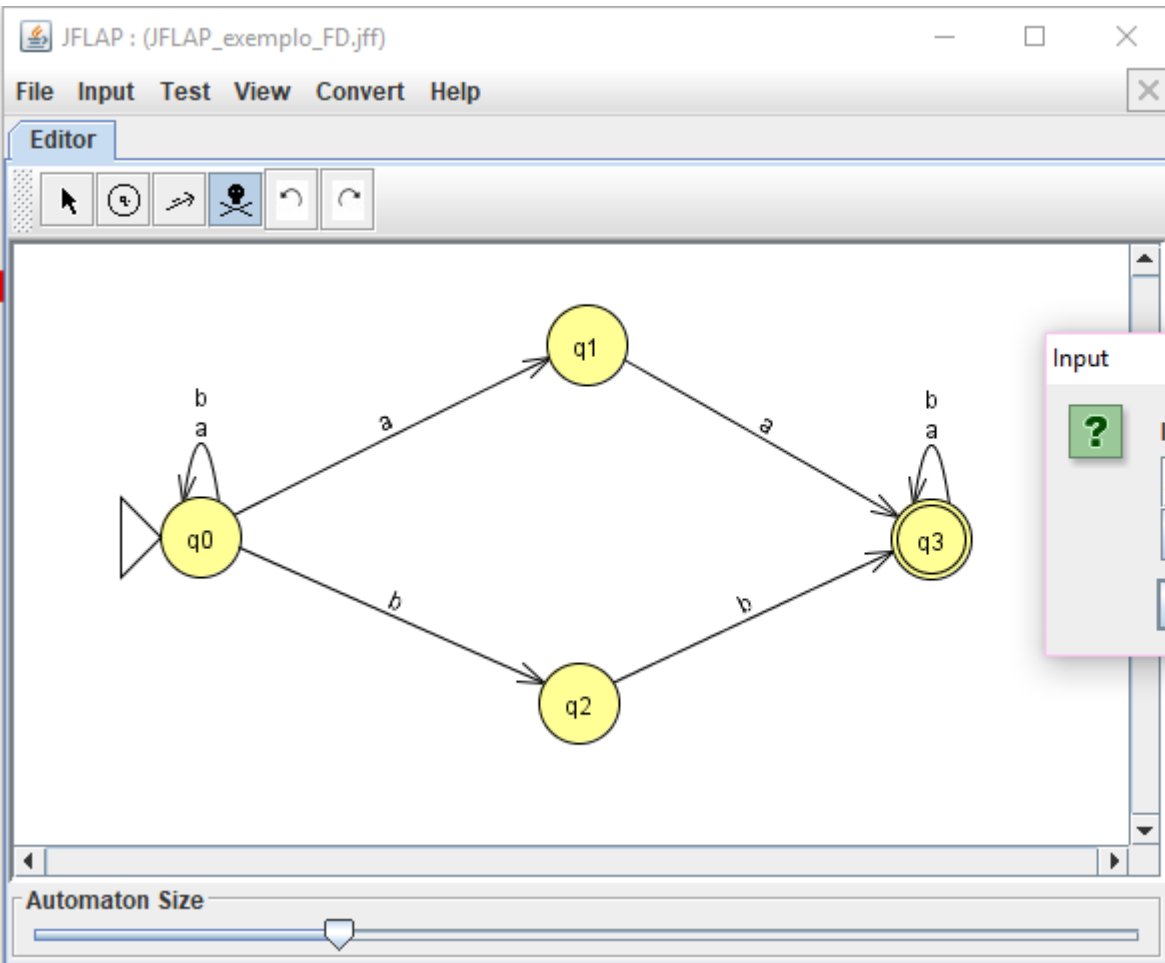


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# CRIANDO UM AUTÔMATO FINITO... JFLAP



Testando estado a estado... Autômato Finito NÃO Determinístico



Input

? Input

abba

Click to Open Input File

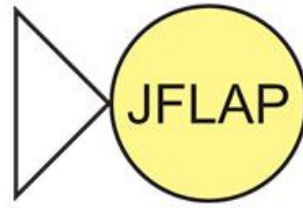
OK Cancelar





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# CRIANDO UM AUTÔMATO FINITO... JFLAP



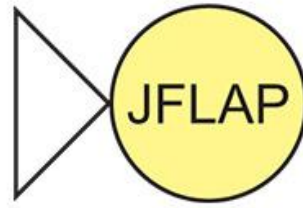
Testando estado a estado... Autômato Finito NÃO Determinístico

The screenshot shows the JFLAP software interface. The main window displays a finite automaton with four states: q0 (start state, dark green), q1, q2, and q3 (accepting state, yellow). Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. Self-loops on 'a' and 'b' are present at q0 and q3. The 'Simulate: abba' window shows the input string 'abba' with a red arrow pointing to it. The bottom control bar includes buttons for Step, Reset, Freeze, Thaw, Trace, and Remove.



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



Testando estado a estado... Autômato Finito NÃO Determinístico

The screenshot shows the JFLAP software interface. The main window displays a Non-deterministic Finite Automaton (NFA) with four states: q0, q1, q2, and q3. q0 is the start state, indicated by a triangle. q3 is an accepting state, indicated by a double circle. The transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. There are also self-loops on q0 and q3 for both 'a' and 'b'. The simulation window shows the input string 'abba' and the current state q0. A red arrow points to the 'Step' button, indicating the next action to be taken.

JFLAP : (JFLAP\_exemplo\_FD.jff)

File Input Test View Convert Help

Editor Simulate: abba

q1 q0 q2 q3

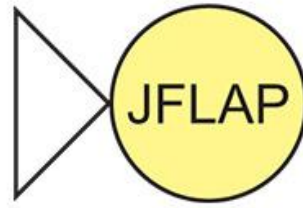
abba abba

Step Reset Freeze Thaw Trace Remove



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



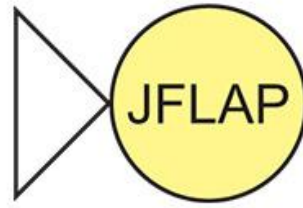
Testando estado a estado... Autômato Finito NÃO Determinístico

The screenshot shows the JFLAP software interface. At the top, the title bar reads "JFLAP : (JFLAP\_exemplo\_FD.jff)". Below it is a menu bar with "File", "Input", "Test", "View", "Convert", and "Help". The main window is titled "Editor" and "Simulate: abba". The central area displays a finite automaton diagram with four states: q0 (start state, indicated by a triangle), q1, q2, and q3 (final state, indicated by a double circle). Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. Self-loops on 'a' and 'b' are present at q0 and q3. Below the diagram is a simulation table with three columns for states q1, q2, and q0. Each column contains a text input field with the string "abba". A red arrow points to the q0 column. At the bottom, there is a control bar with buttons for "Step", "Reset", "Freeze", "Thaw", "Trace", and "Remove".



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



Testando estado a estado... Autômato Finito NÃO Determinístico

The screenshot shows the JFLAP interface with a Non-deterministic Finite Automaton (NFA) diagram and its simulation. The NFA has four states: q0 (start state), q1, q2, and q3 (final state). Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. Self-loops on q0 and q3 are labeled 'a' and 'b' respectively.

The simulation window shows the input string "abba" being processed step by step. The current state is q0, and the input string is "abba". A red arrow points to the current state q0 in the simulation window.

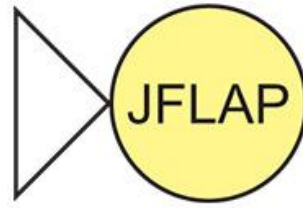
Step	State	Input
1	q0	abba
2	q1	abba
3	q2	abba
4	q3	abba

Buttons: Step, Reset, Freeze, Thaw, Trace, Remove



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



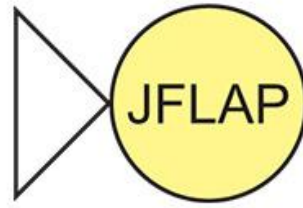
Testando estado a estado... Autômato Finito NÃO Determinístico

The screenshot shows the JFLAP software interface. The main window displays a Non-deterministic Finite Automaton (NFA) with four states: q0, q1, q2, and q3. q0 is the start state, indicated by a triangle. Transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. Both q1 and q2 have self-loops on 'a' and 'b'. q3 is a final state, indicated by a double circle. Below the diagram is a simulation area with four panels, one for each state. Each panel contains a text input field with the string 'abba'. The q3 panel is highlighted in green, indicating it is the current state. A red arrow points to the right side of the simulation area. At the bottom, there are control buttons: Step, Reset, Freeze, Thaw, Trace, and Remove.



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# CRIANDO UM AUTÔMATO FINITO... JFLAP



Testando estado a estado... Autômato Finito NÃO Determinístico

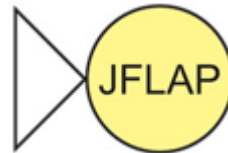
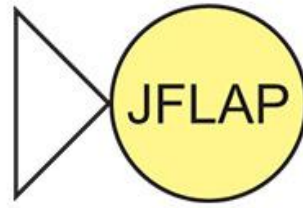
The screenshot shows the JFLAP software interface. The main window displays a Non-deterministic Finite Automaton (NFA) with four states: q0, q1, q2, and q3. q0 is the start state, indicated by a triangle. q3 is an accepting state, indicated by a double circle. The transitions are: q0 to q1 on 'a', q0 to q2 on 'b', q1 to q3 on 'a', and q2 to q3 on 'b'. There are also self-loops on q0 and q3 for both 'a' and 'b'. The simulation window shows the input string 'abba' and the current state q0. A red arrow points to the 'abba' input field in the simulation window. The bottom of the interface has control buttons: Step, Reset, Freeze, Thaw, Trace, and Remove.





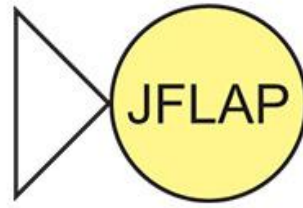
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# TESTANDO... JFLAP

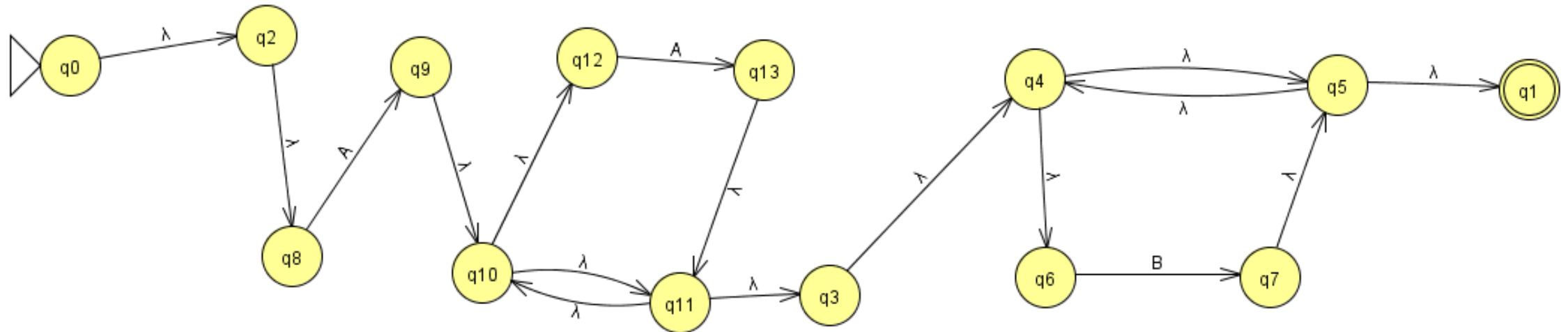


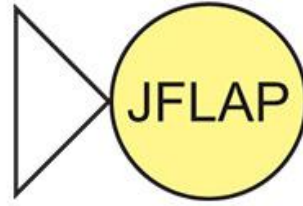


# EXPRESSÕES REGULARES AFN... JFLAP

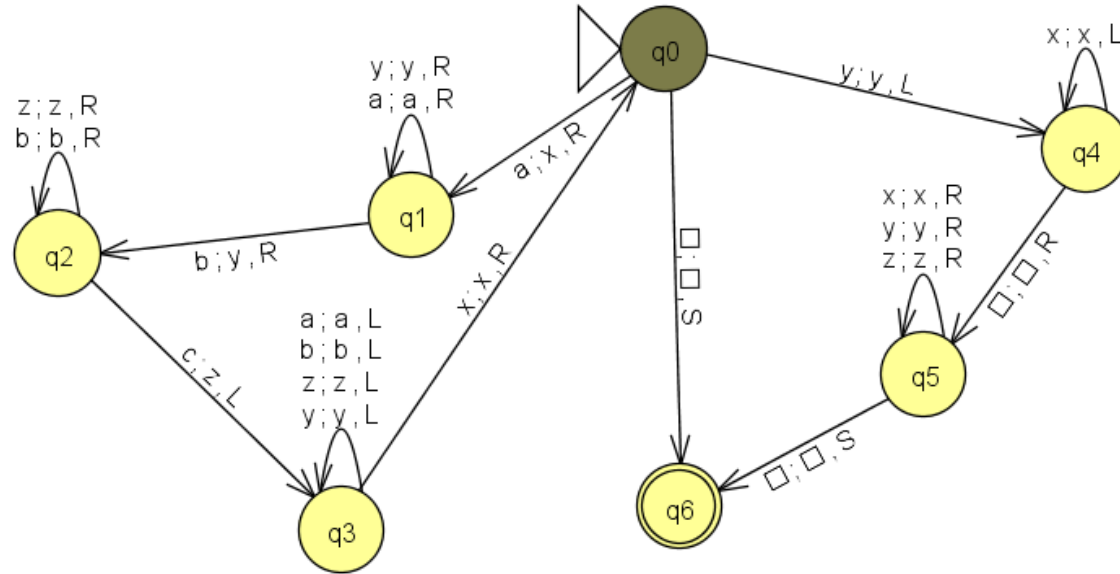


$$L = \{a^+b^*\}$$





# MAQUINA DE TURING

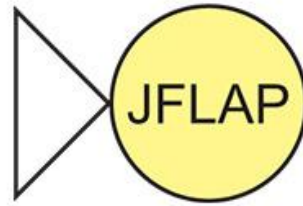


$$L = \{a^n b^n c^n\}$$



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# MAIS DOIS SIMULADORES...



**Simulador de Autômatos**

[WWW.SIMULADORDEAUTOMATOS.COM](http://WWW.SIMULADORDEAUTOMATOS.COM)



[WWW.EVOLUMA.COM/AUGER/](http://WWW.EVOLUMA.COM/AUGER/)

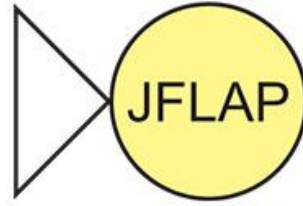


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# CONCLUSÕES... JFLAP

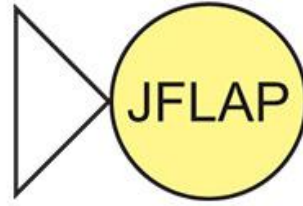


- ✓ **Facilidade de uso;**
- ✓ **Dispensa os testes de mesa;**
- ✓ **Gratuito;**
- ✓ **Suporte e confiabilidade de desenvolvimento;**
- ✓ **Interativa e Visual;**
- ✓ **Ferramenta completa, comparada aos concorrentes;**



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# REFERÊNCIAS... JFLAP



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