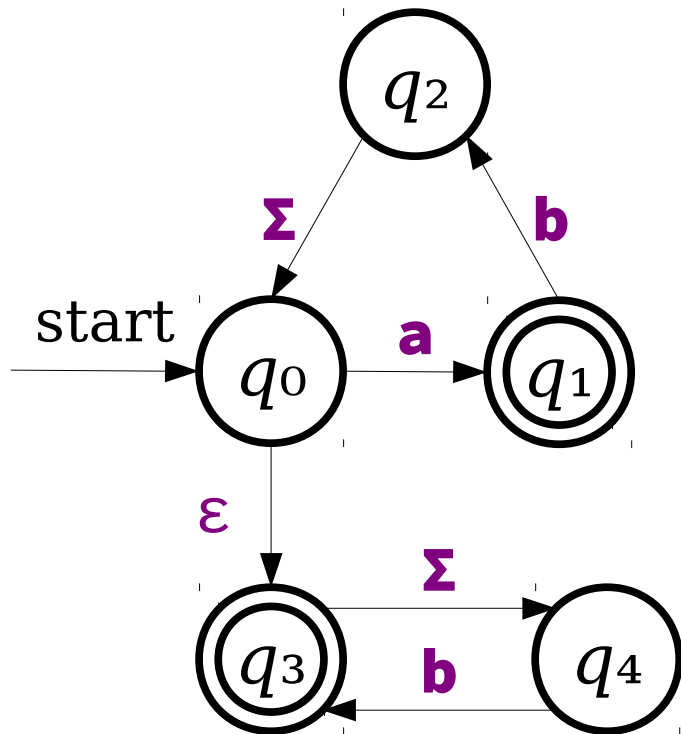


# Once More, With Epsilons!

































































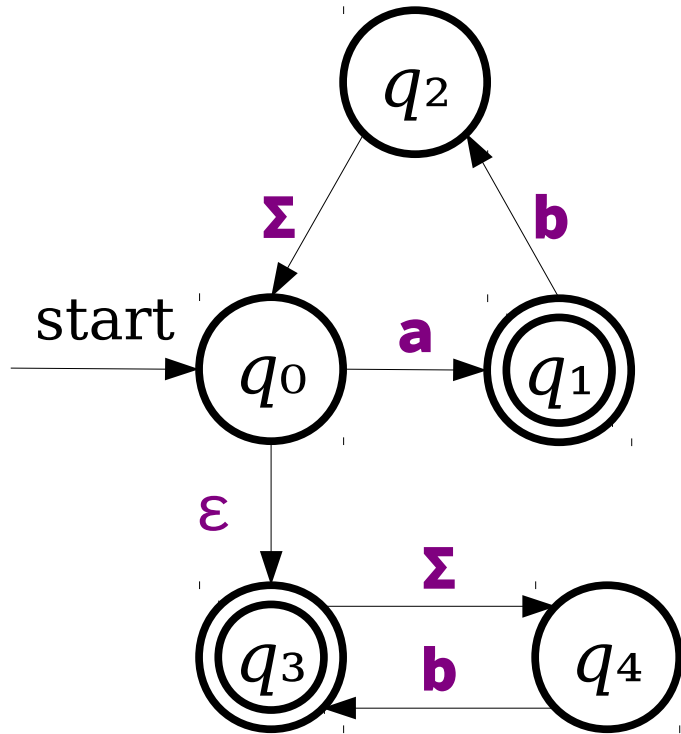






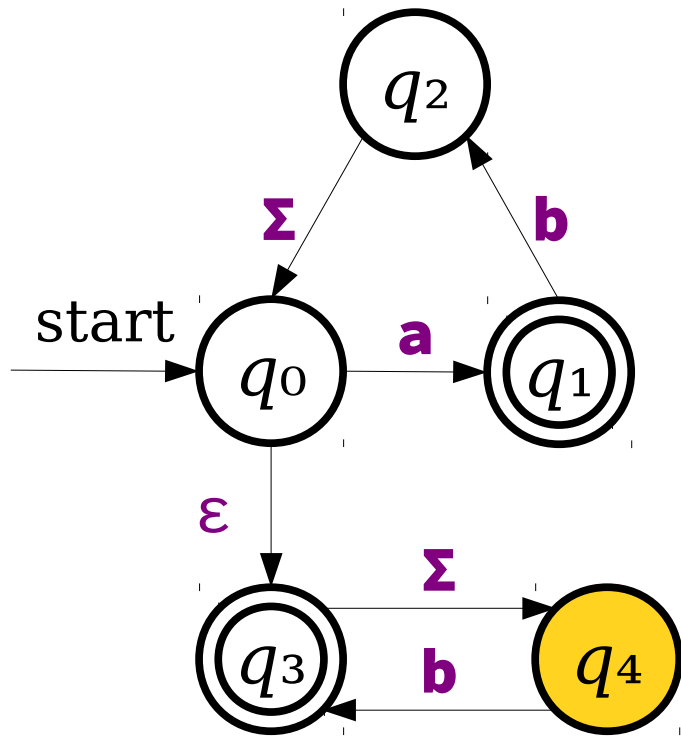


# Once More, With Epsilons!



	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	

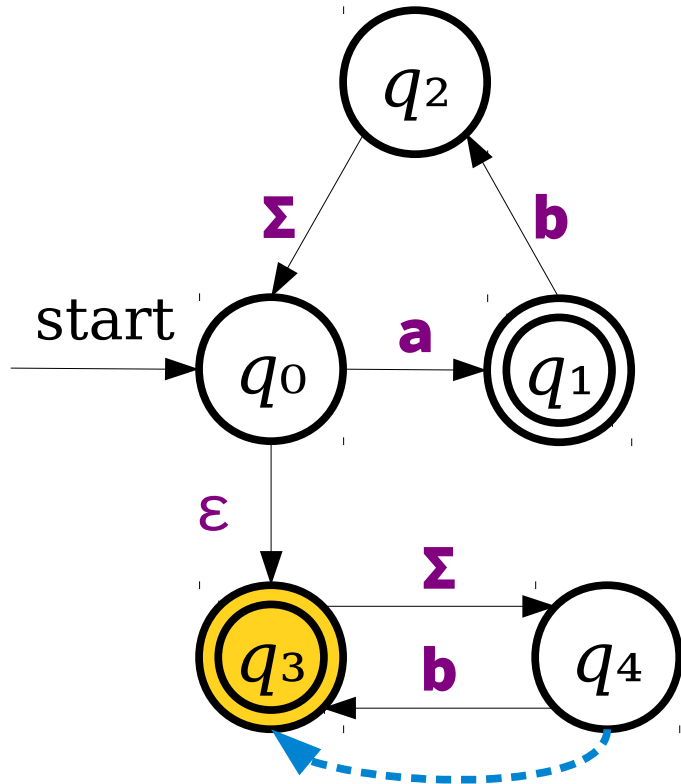
# Once More, With Epsilons!



	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	

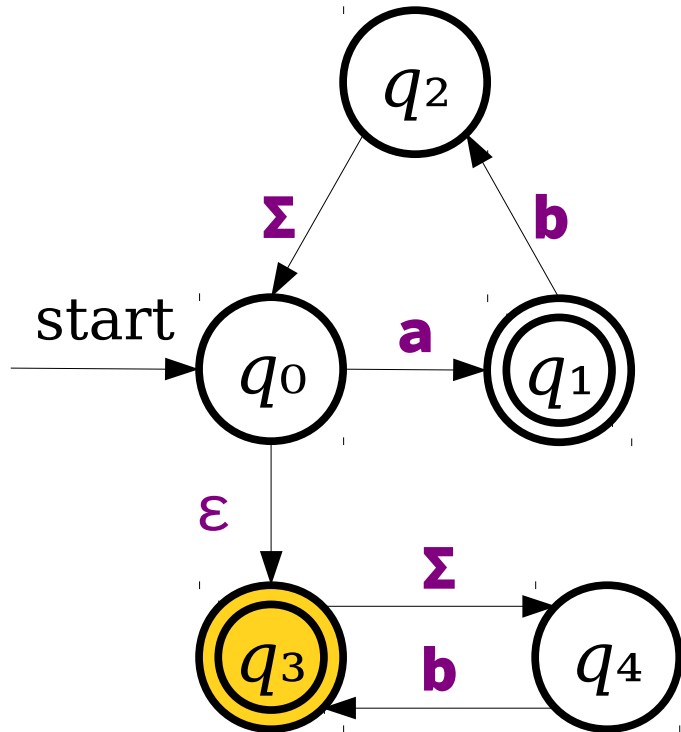


# Once More, With Epsilons!



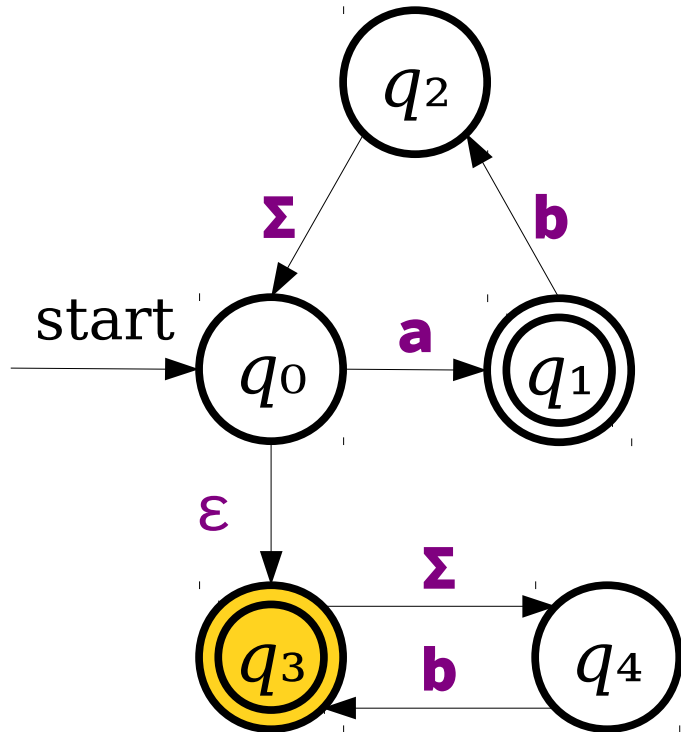
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	

# Once More, With Epsilons!



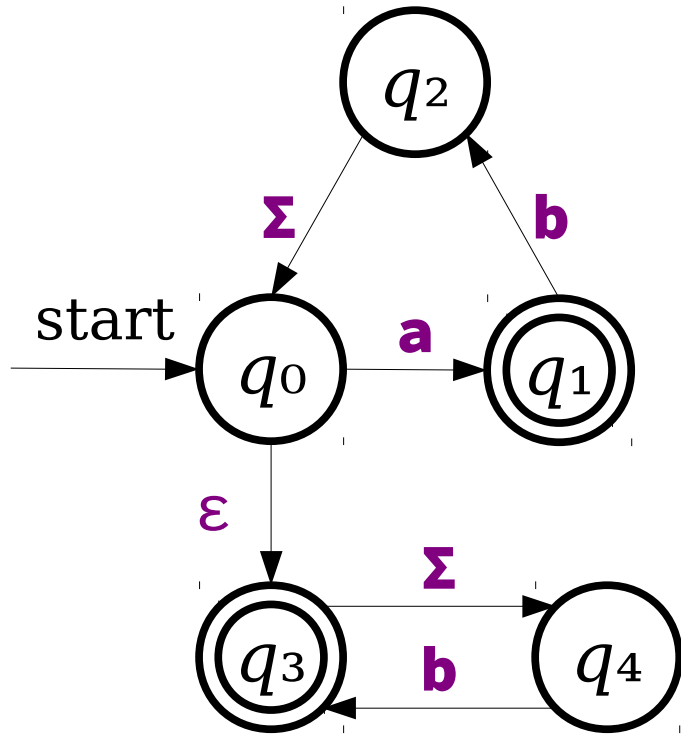
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	

# Once More, With Epsilons!



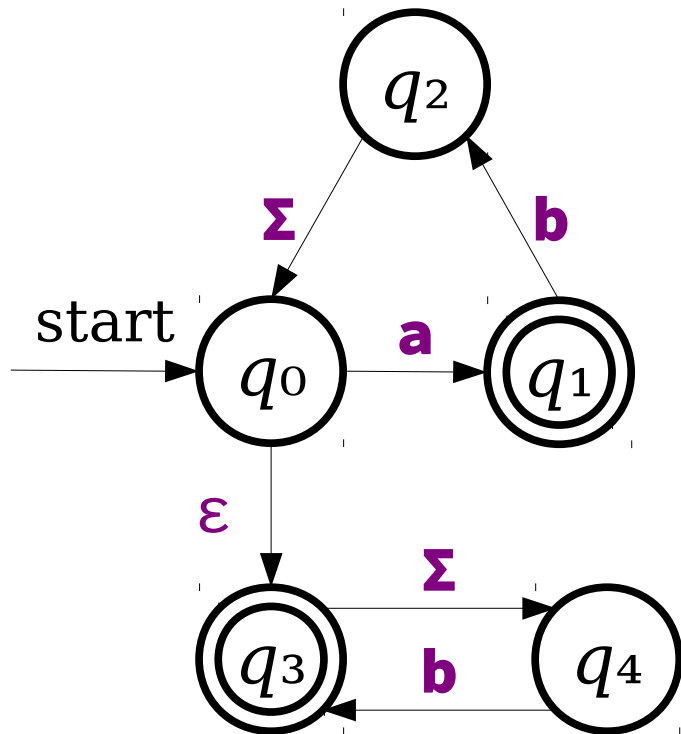
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }

# Once More, With Epsilons!



	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }

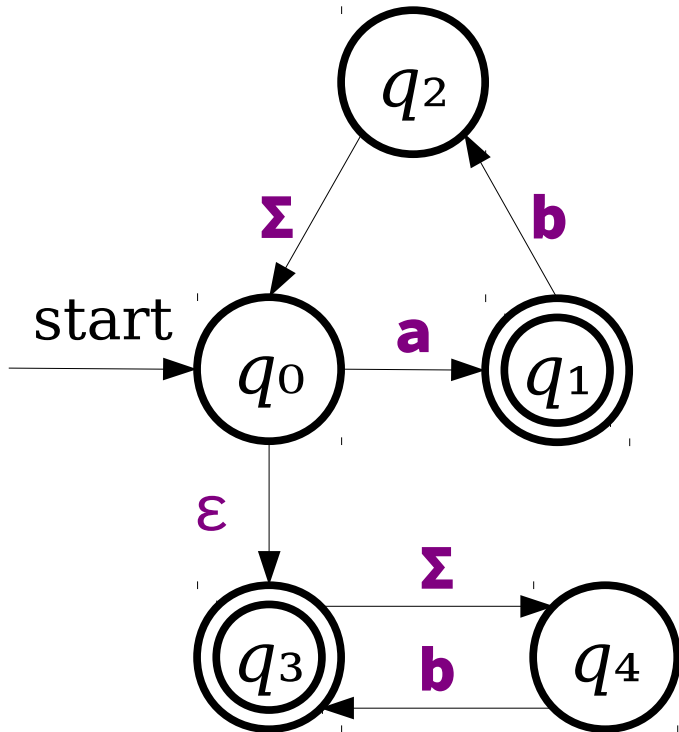
# Once More, With Epsilons!



	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

# Once More, With Epsilons!

Answer at [PollEv.com/cs103](https://www.pollEv.com/cs103) or  
text **CS103** to **22333** once to join, then **A, B, C, or D**

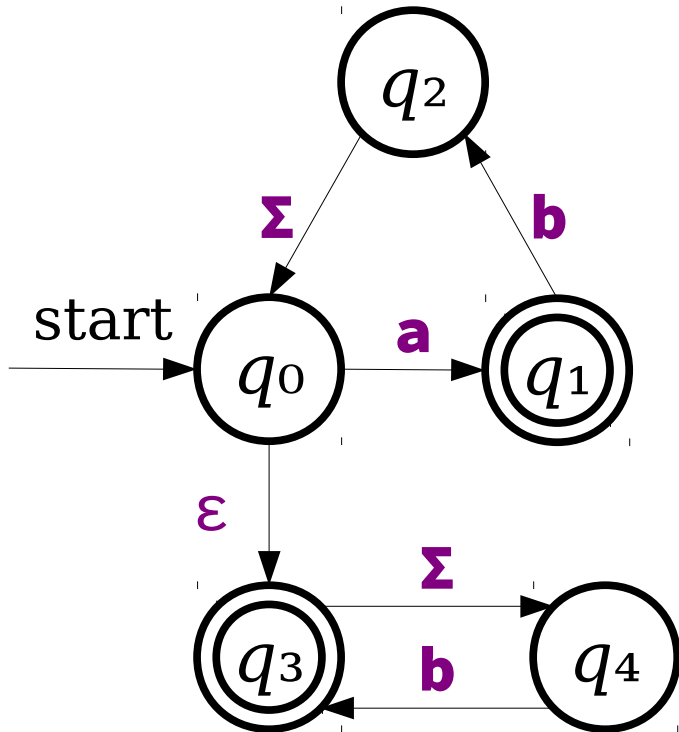


	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

What should this row look like?

A	{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
B	{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
C	{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>4</sub> }
D	{q <sub>2</sub> , q <sub>3</sub> }	∅	∅

# Once More, With Epsilons!

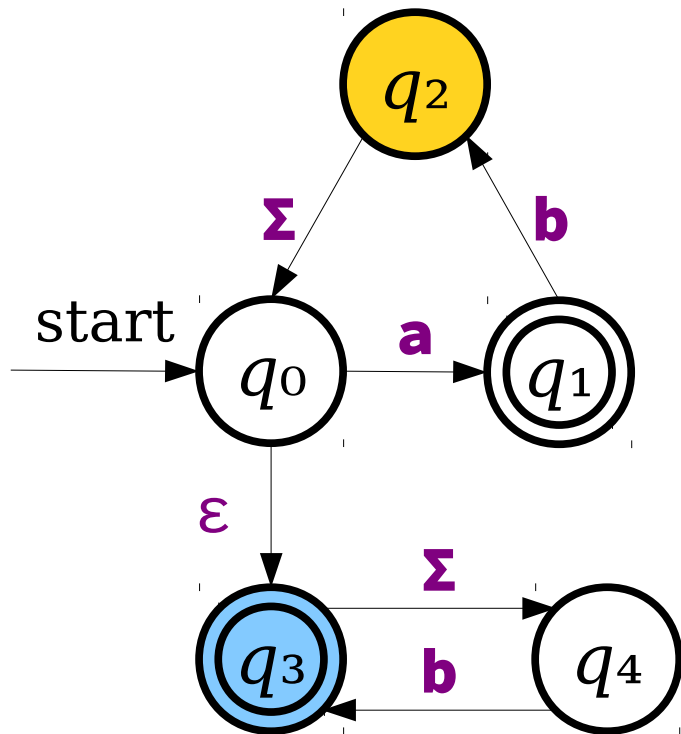


	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

What should this row look like?

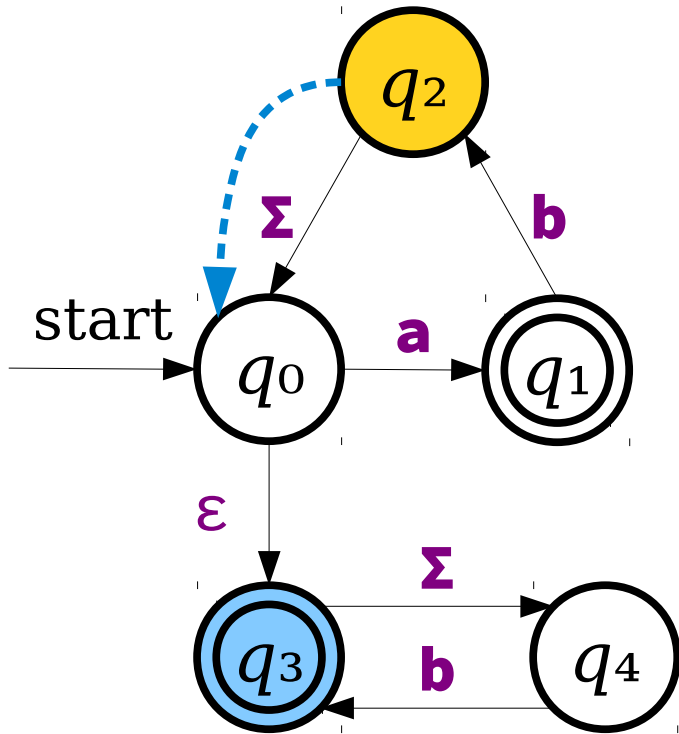
A	{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
B	{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
C	{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>4</sub> }
D	{q <sub>2</sub> , q <sub>3</sub> }	∅	∅

# Once More, With Epsilons!



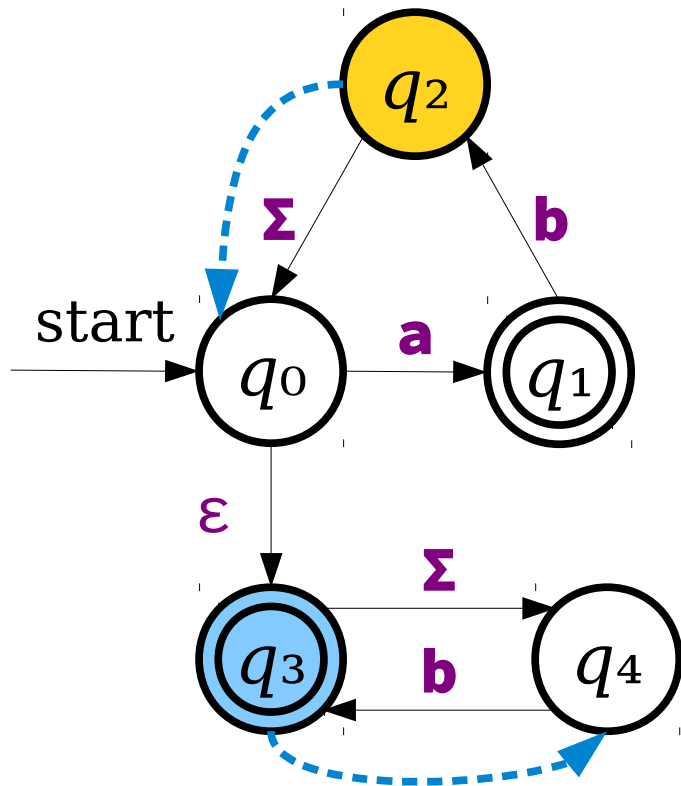
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

# Once More, With Epsilons!



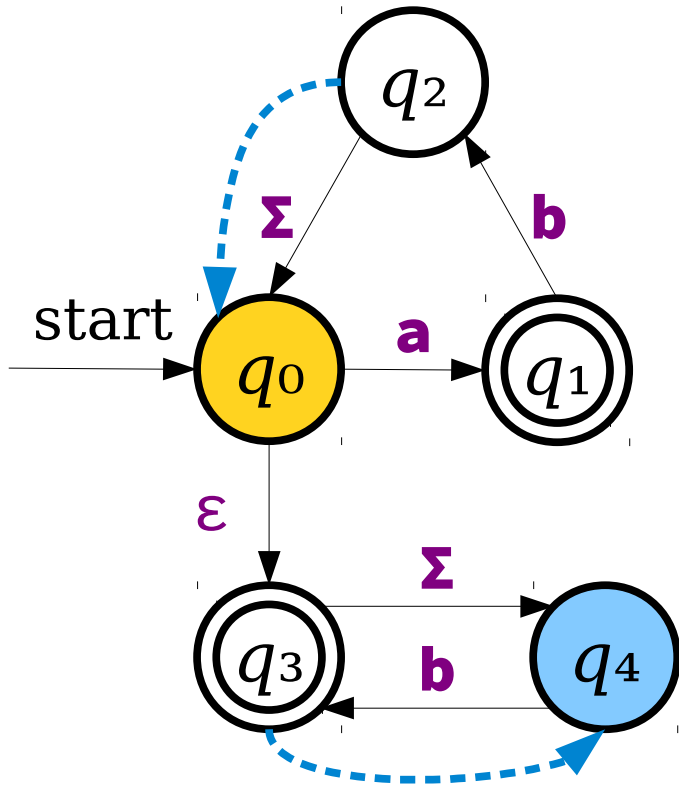
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

# Once More, With Epsilons!



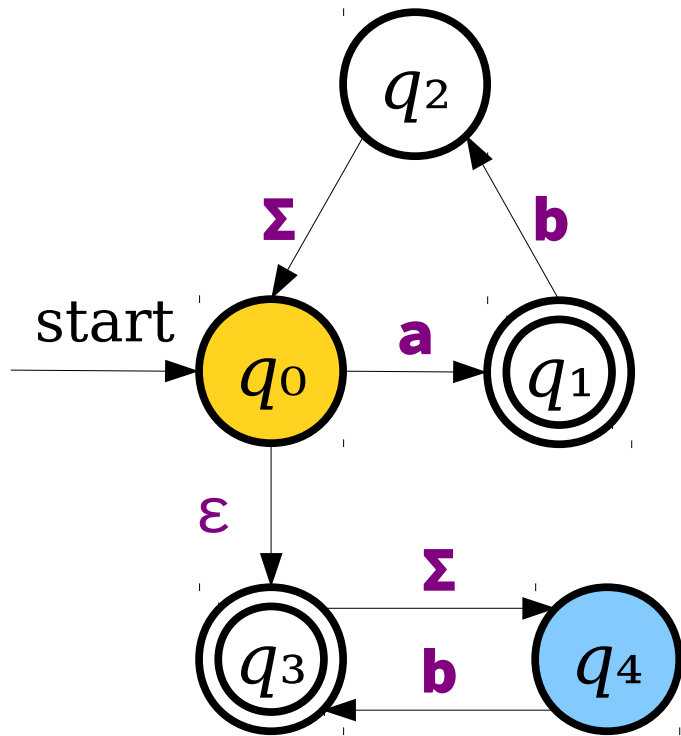
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

# Once More, With Epsilons!



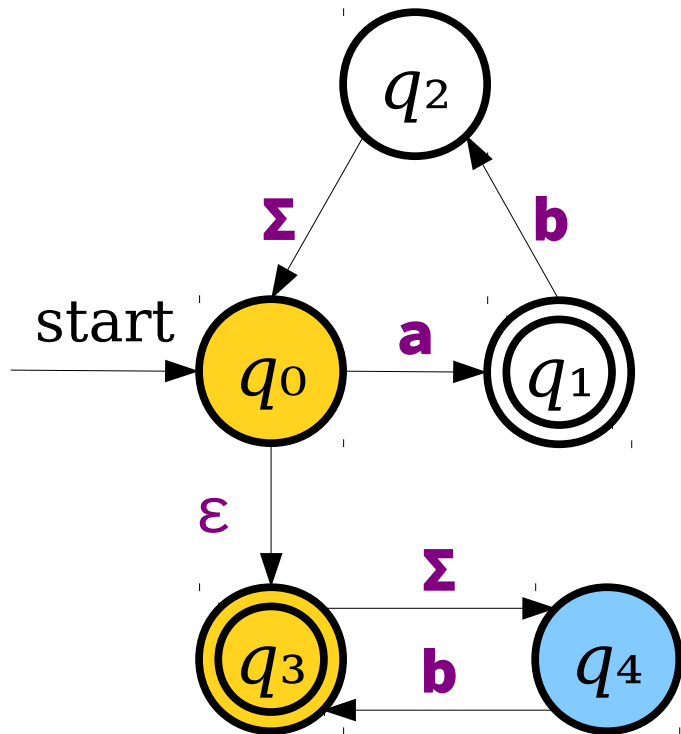
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

# Once More, With Epsilons!



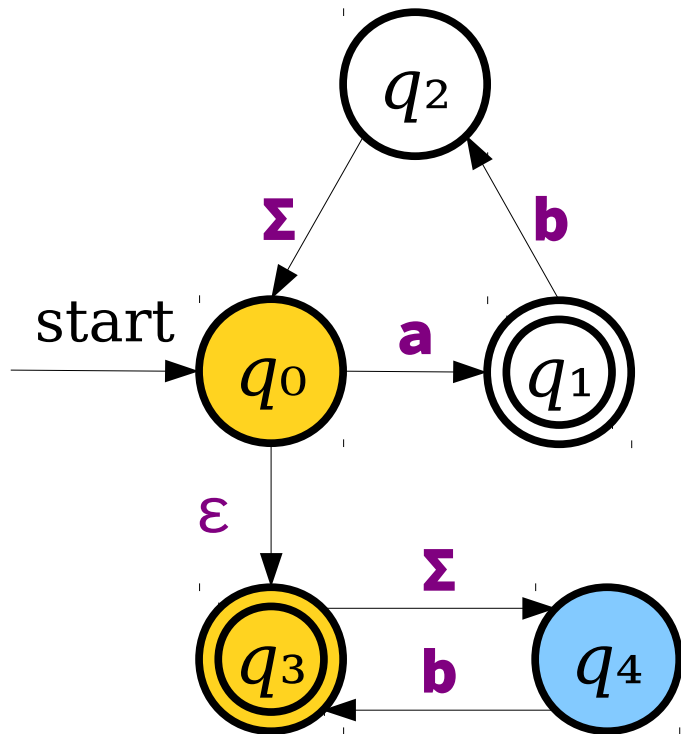
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

# Once More, With Epsilons!



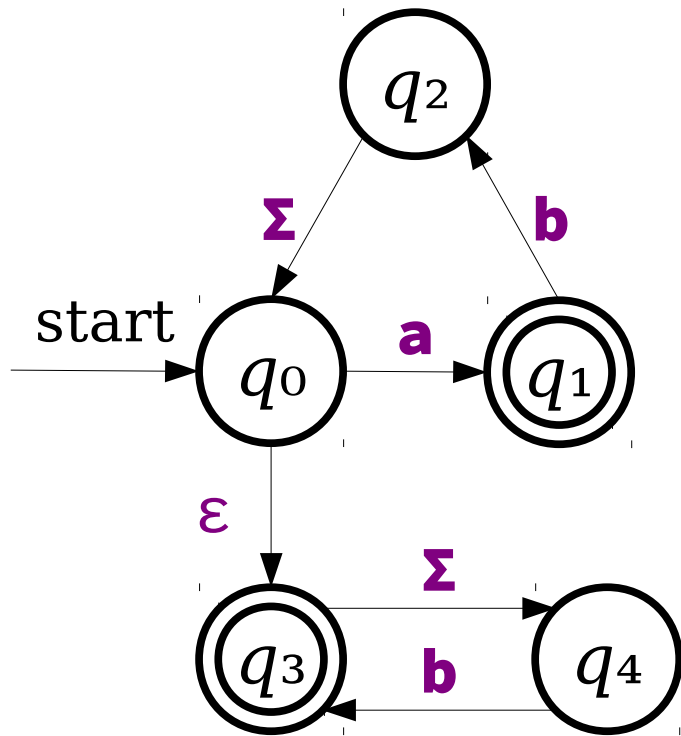
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }		

# Once More, With Epsilons!



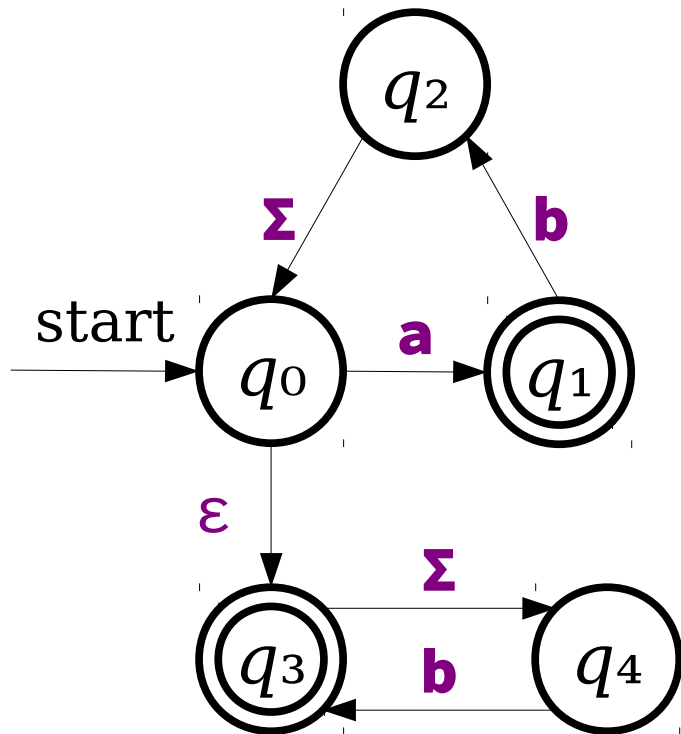
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }

# Once More, With Epsilons!



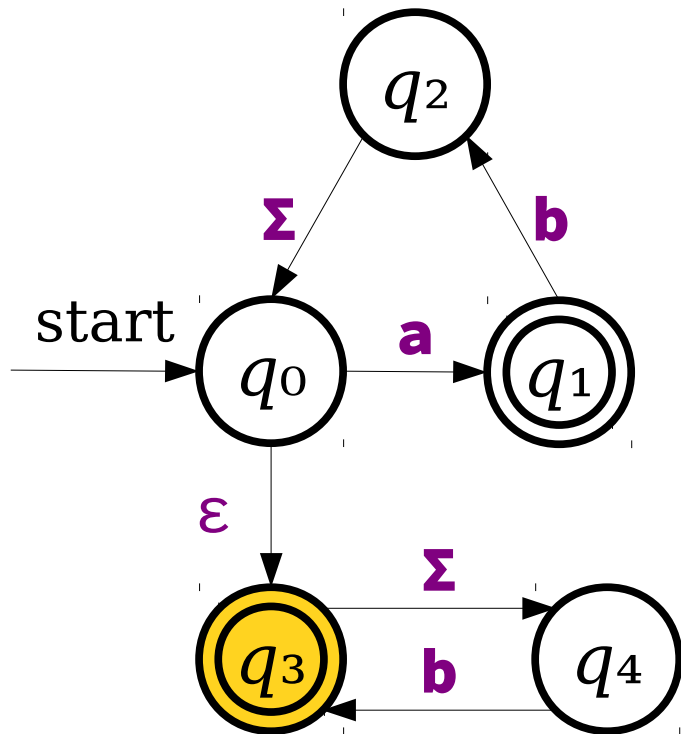
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }

# Once More, With Epsilons!



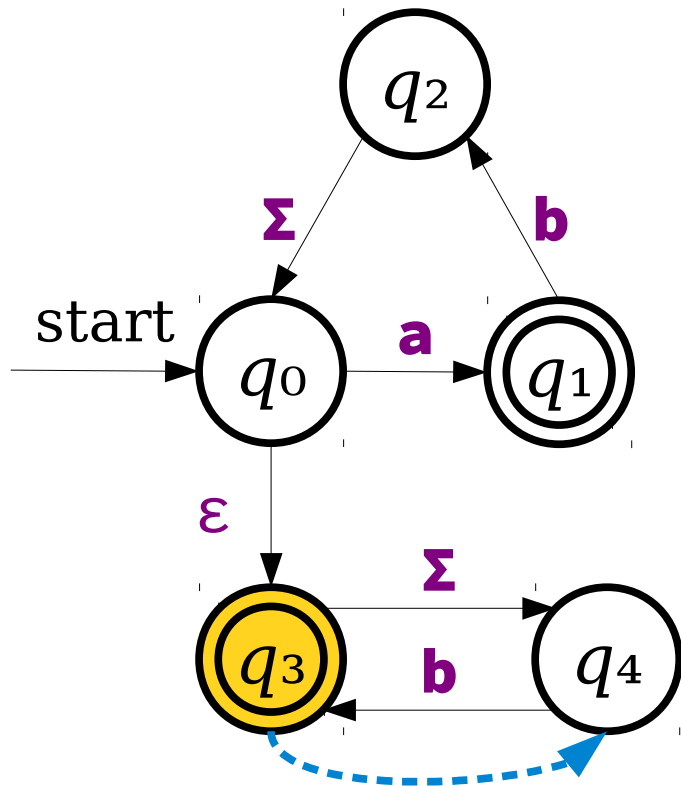
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }		

# Once More, With Epsilons!



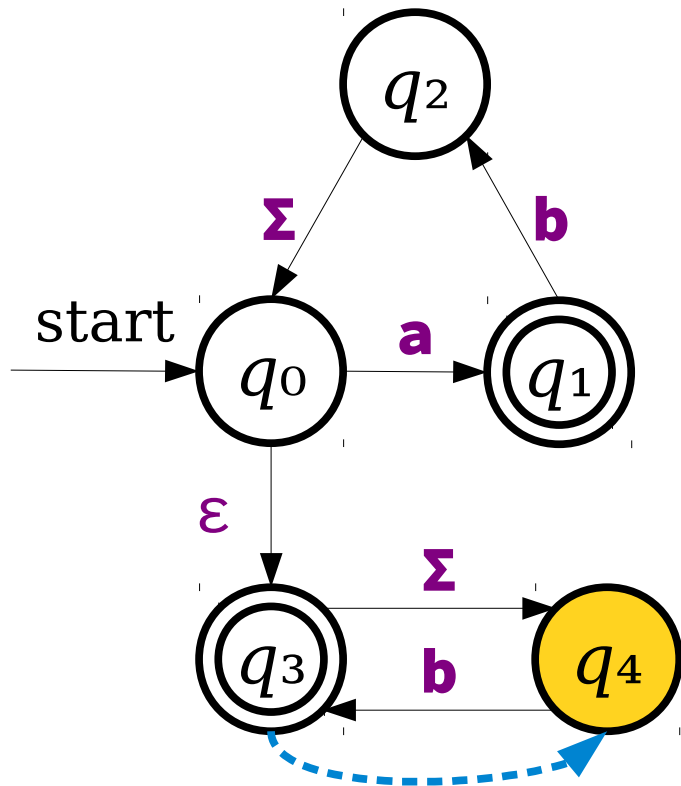
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }		

# Once More, With Epsilons!



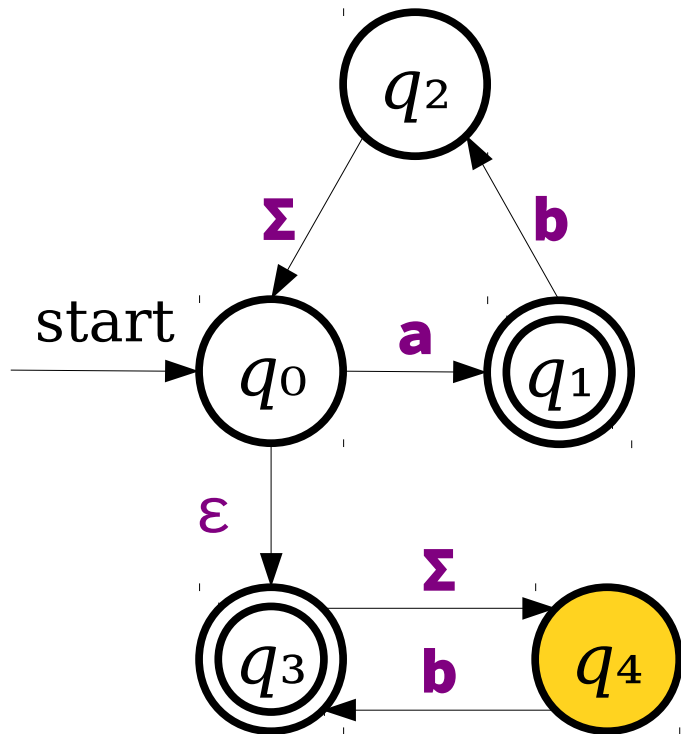
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }		

# Once More, With Epsilons!



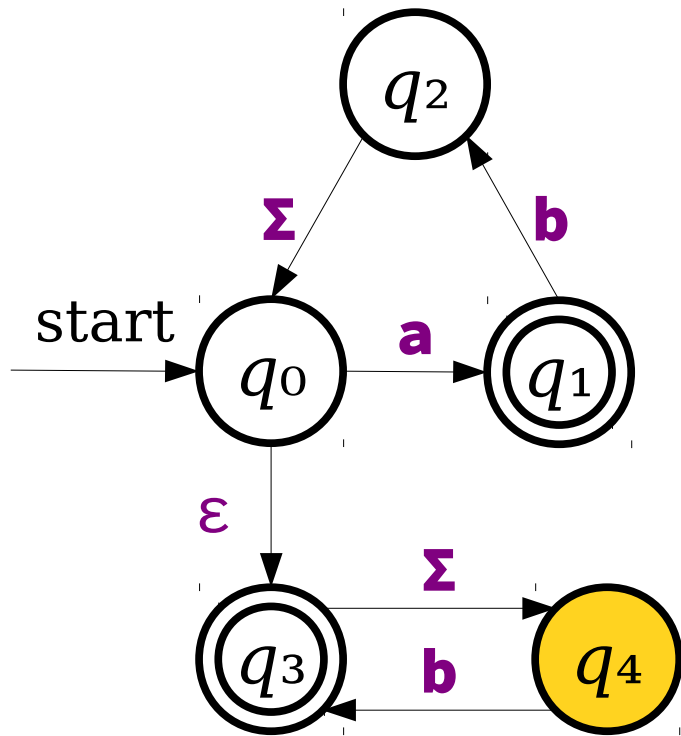
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }		

# Once More, With Epsilons!



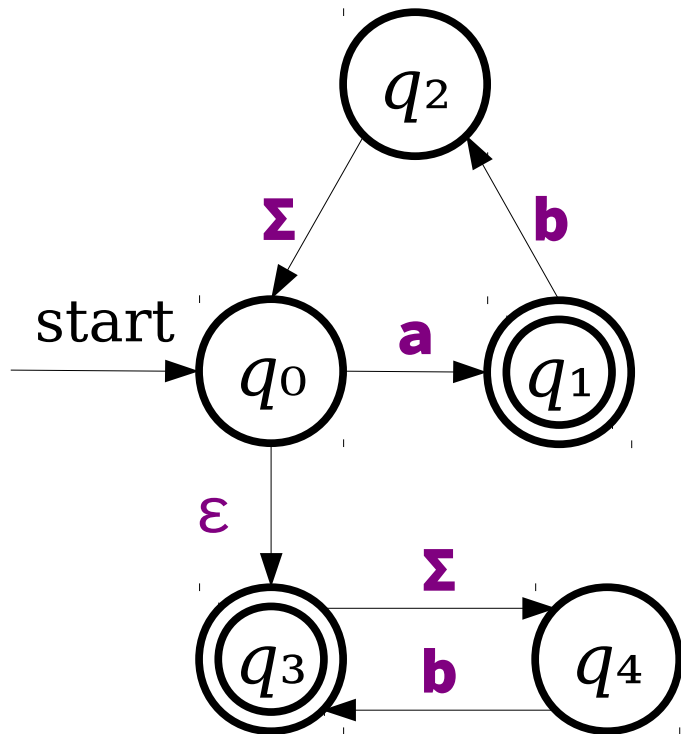
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }		

# Once More, With Epsilons!



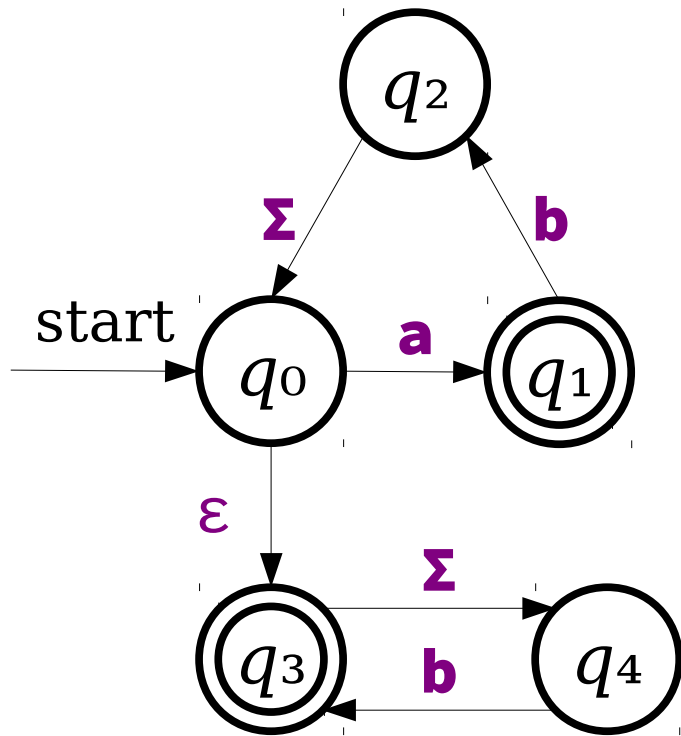
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }

# Once More, With Epsilons!



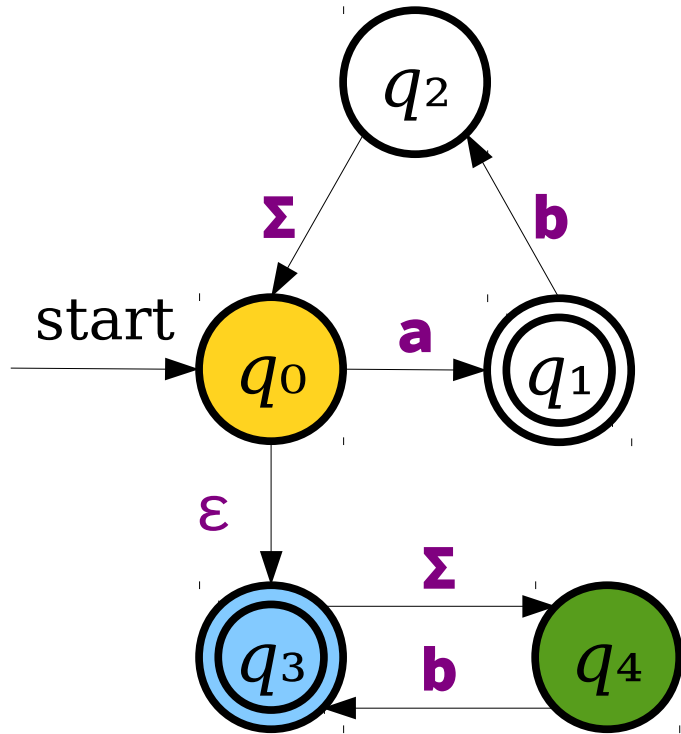
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }

# Once More, With Epsilons!



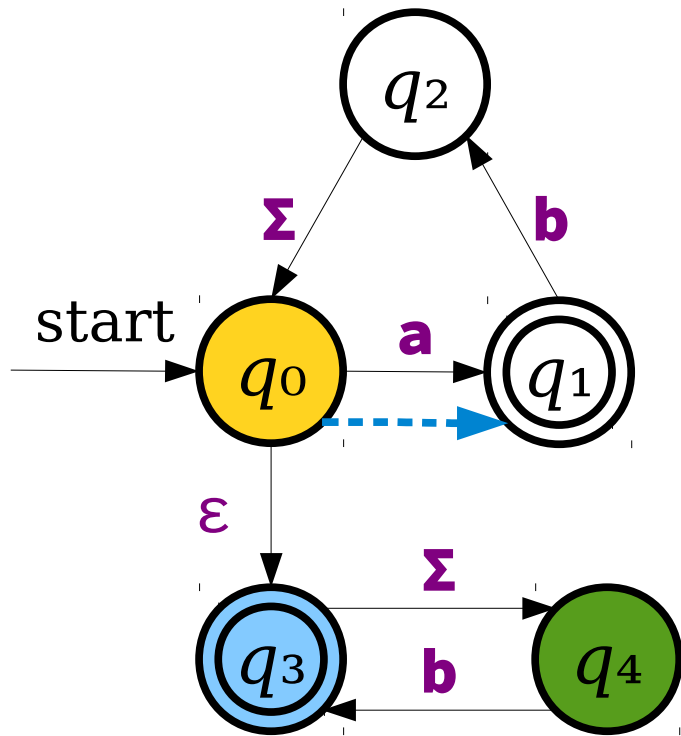
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }		

# Once More, With Epsilons!



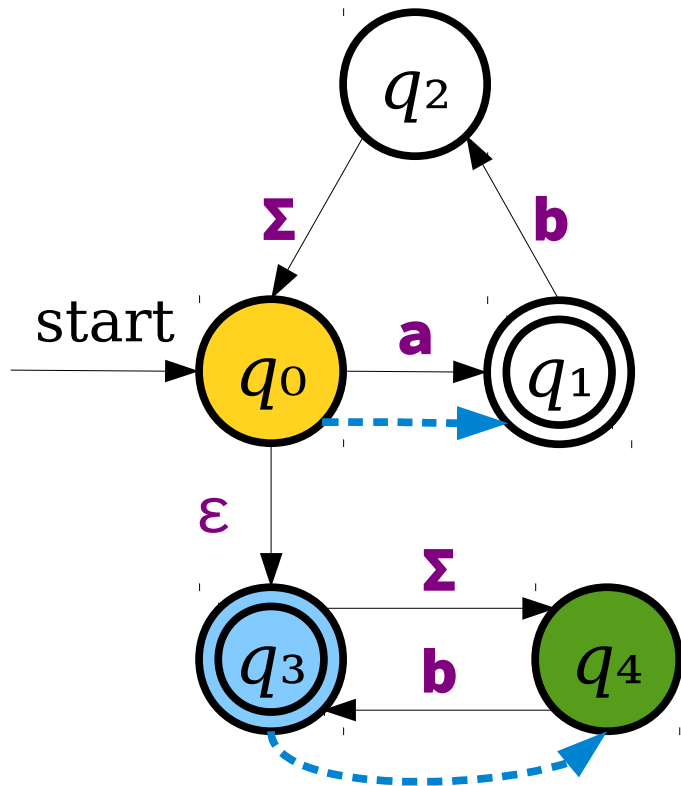
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }		

# Once More, With Epsilons!



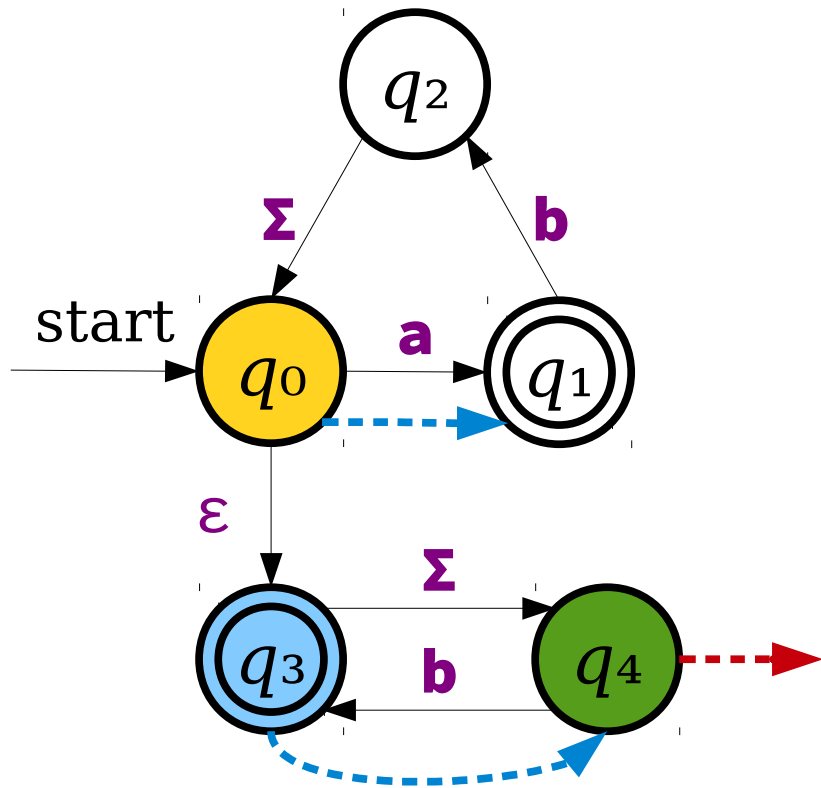
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$		

# Once More, With Epsilons!



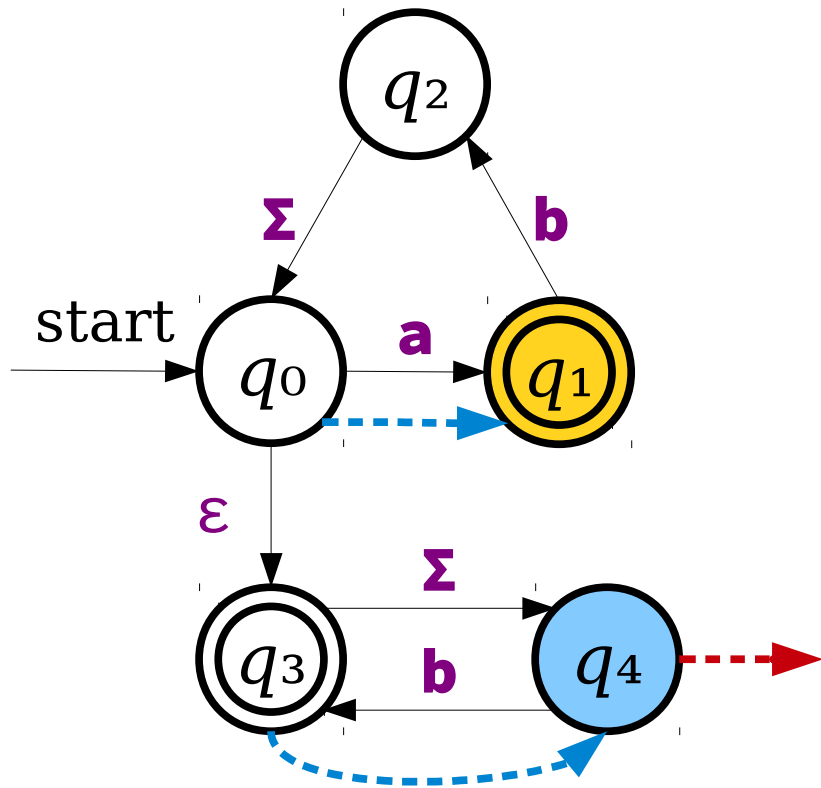
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$		

# Once More, With Epsilons!



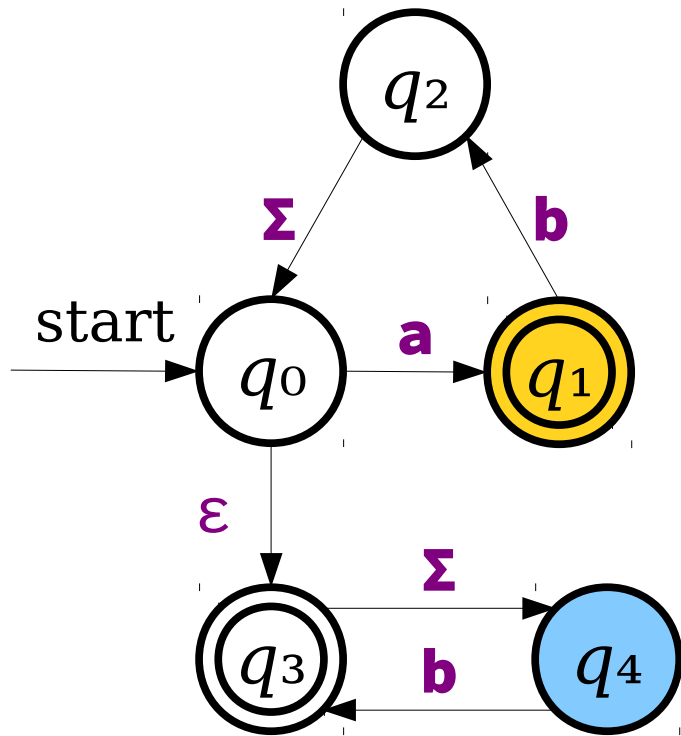
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$		

# Once More, With Epsilons!



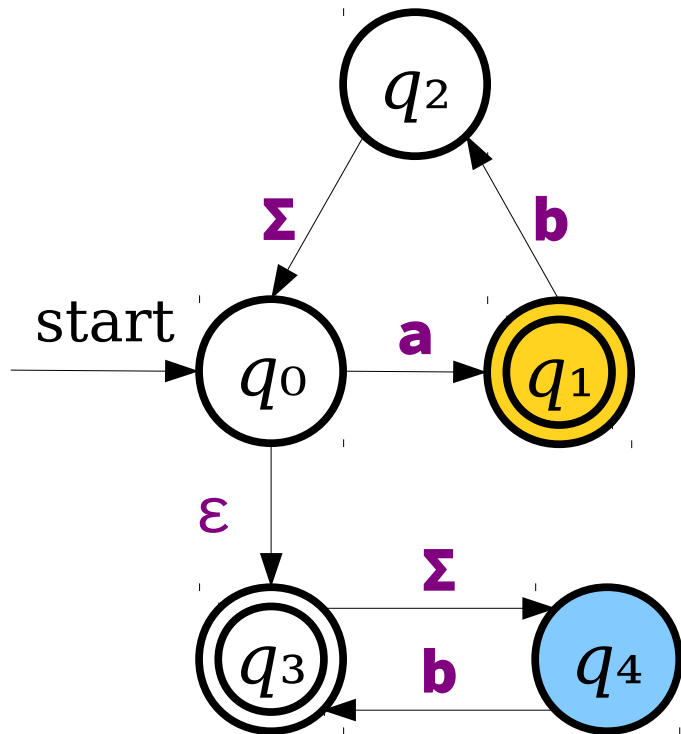
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$		

# Once More, With Epsilons!



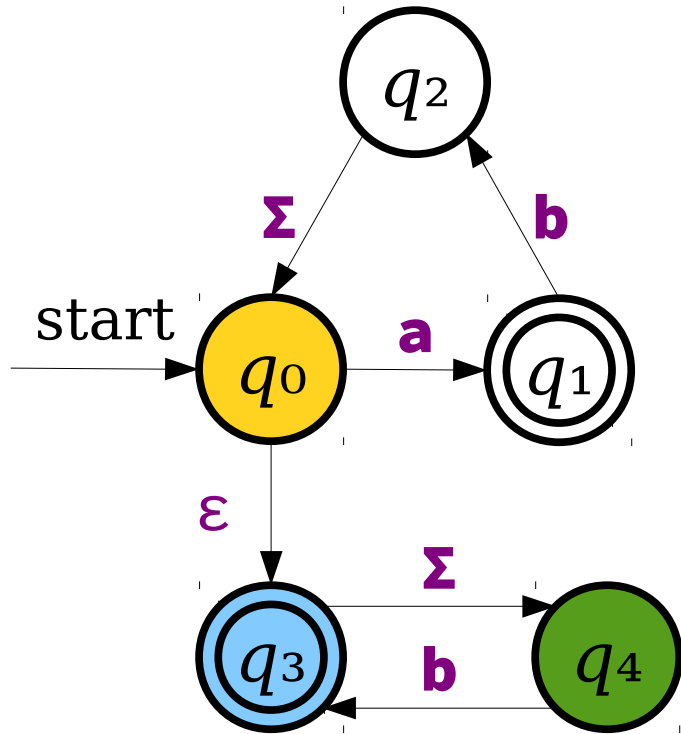
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }		

# Once More, With Epsilons!



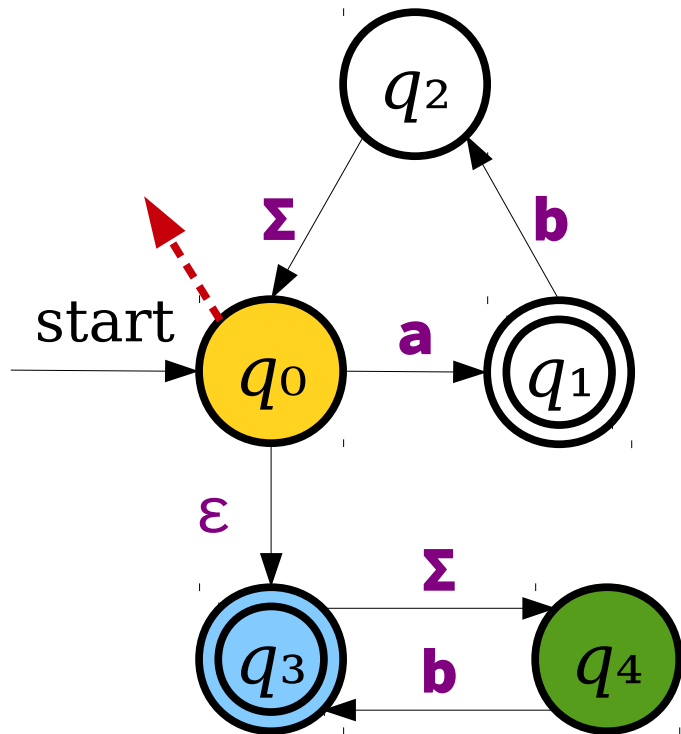
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	

# Once More, With Epsilons!



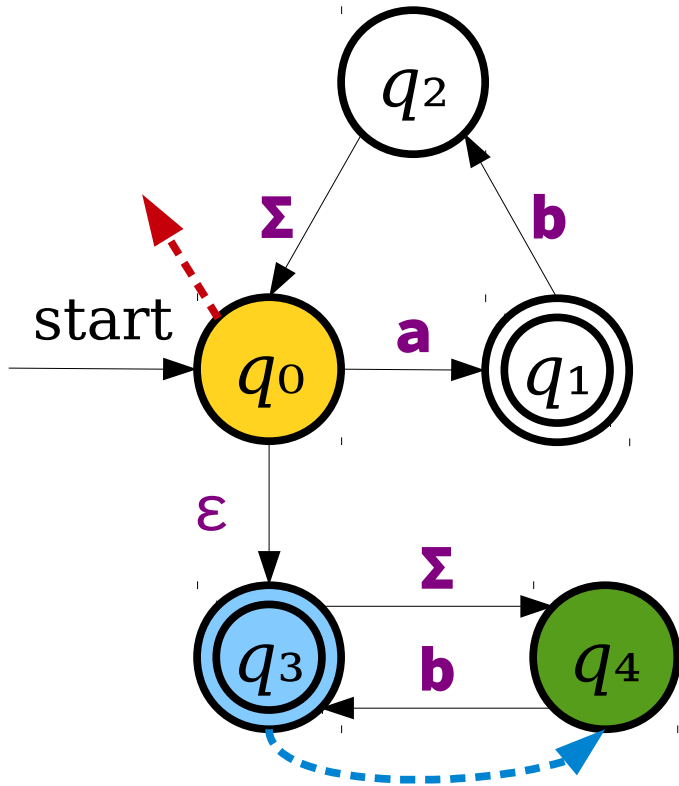
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	

# Once More, With Epsilons!



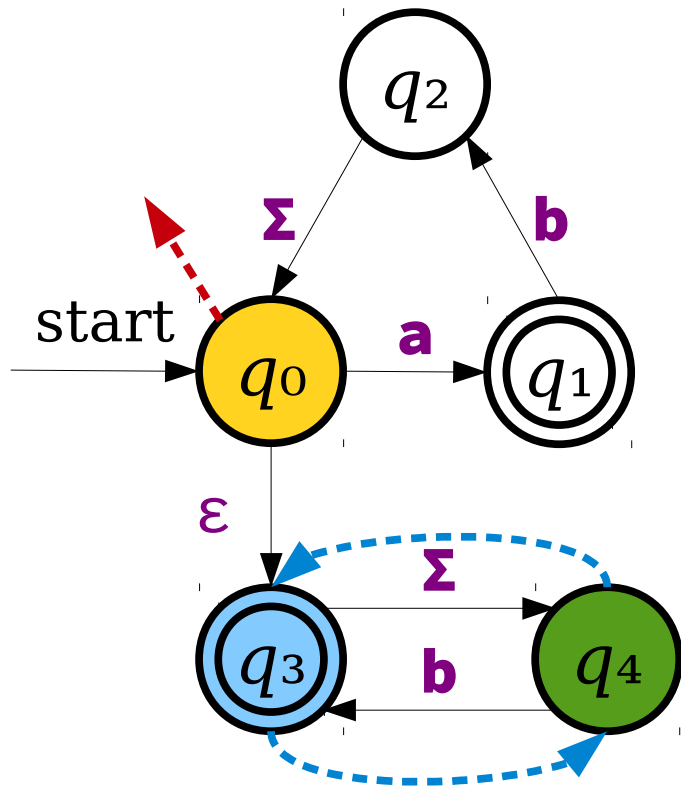
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	

# Once More, With Epsilons!



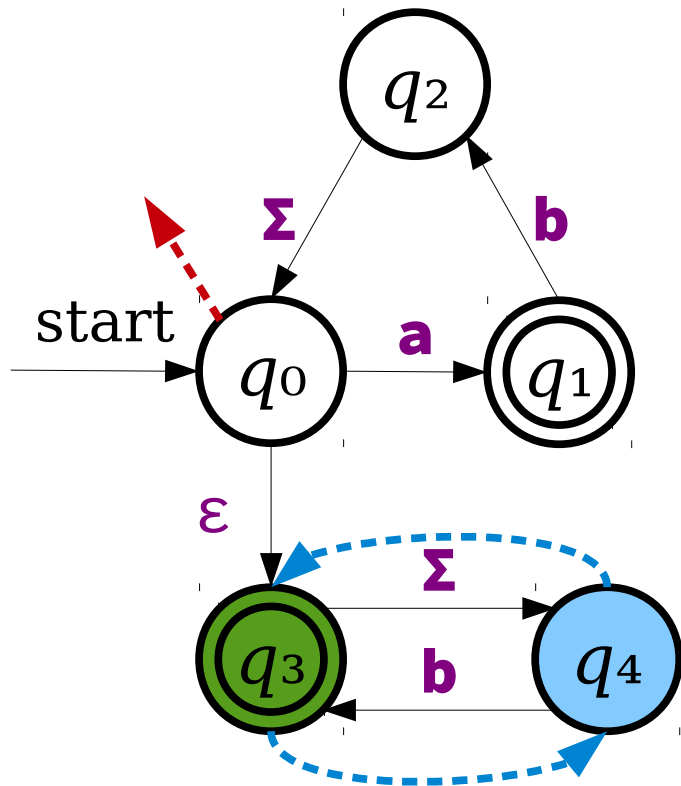
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	

# Once More, With Epsilons!



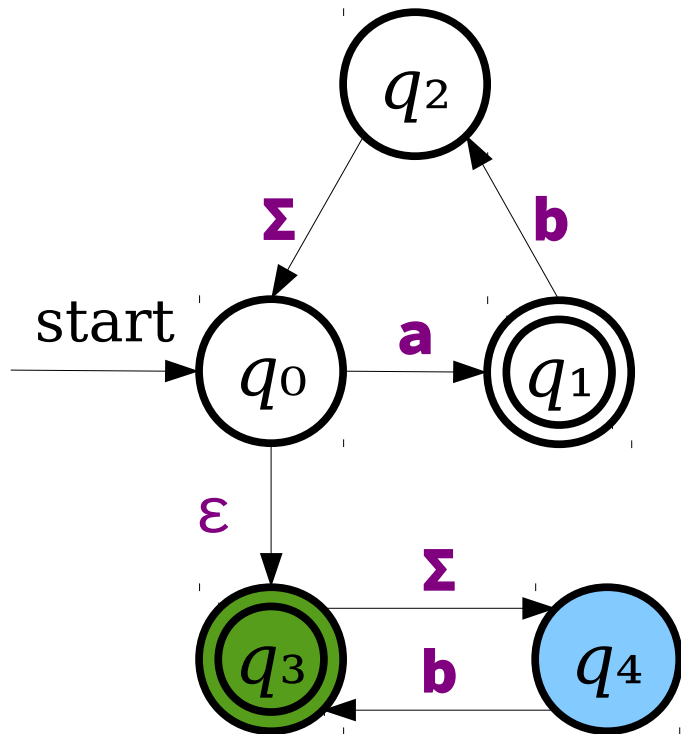
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	

# Once More, With Epsilons!



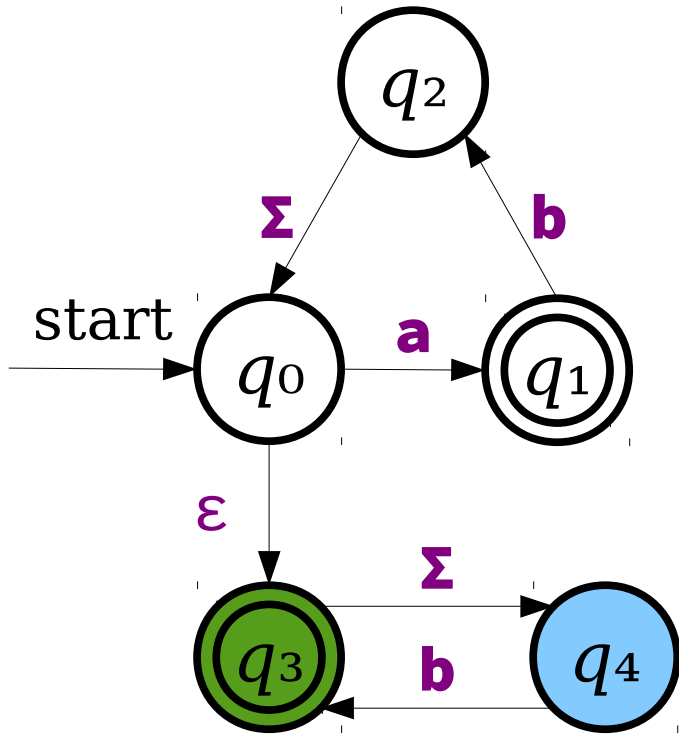
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	

# Once More, With Epsilons!



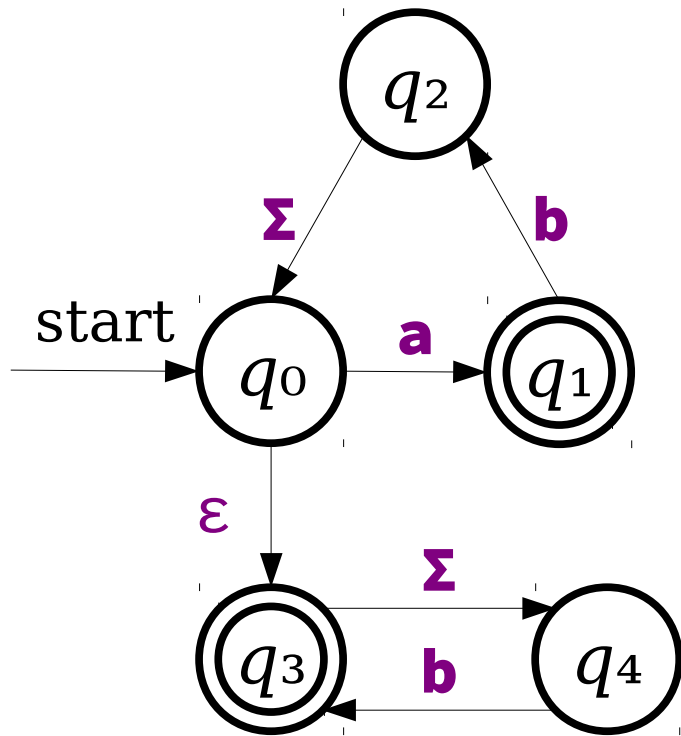
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	

# Once More, With Epsilons!



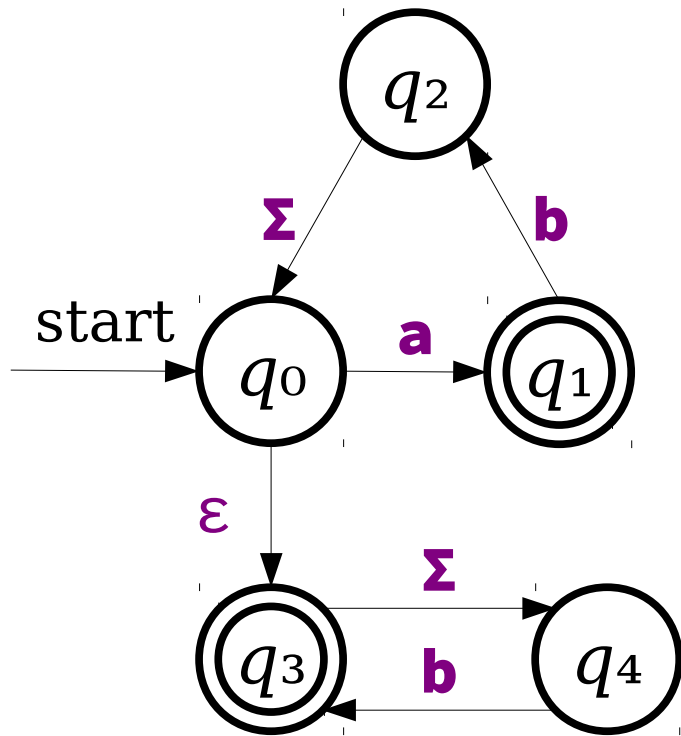
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
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{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }

# Once More, With Epsilons!



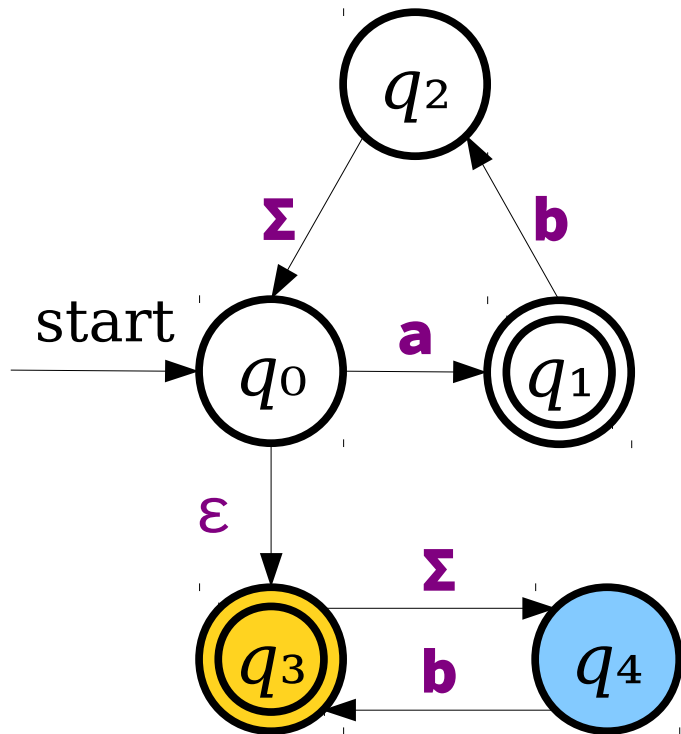
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }

# Once More, With Epsilons!



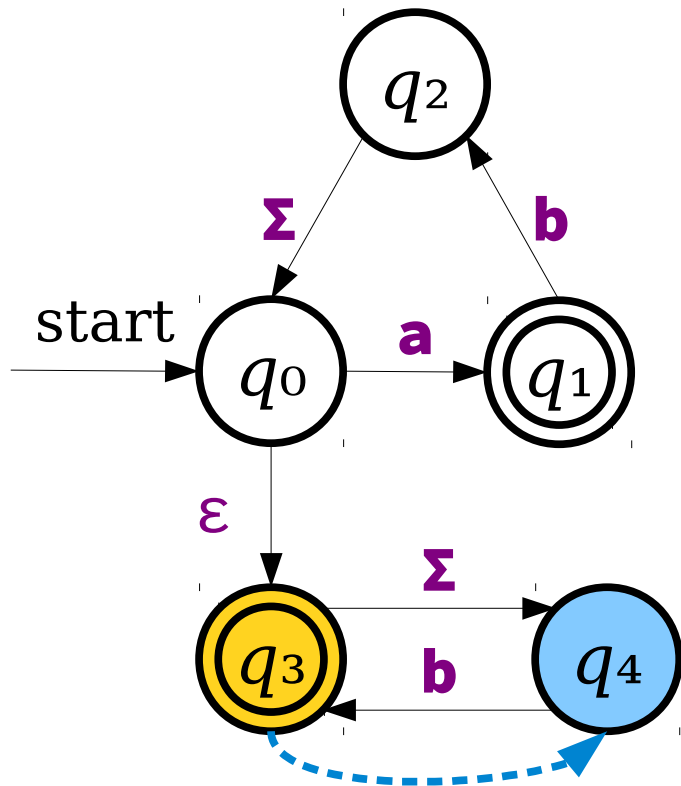
	a	b
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{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> , q <sub>4</sub> }		

# Once More, With Epsilons!



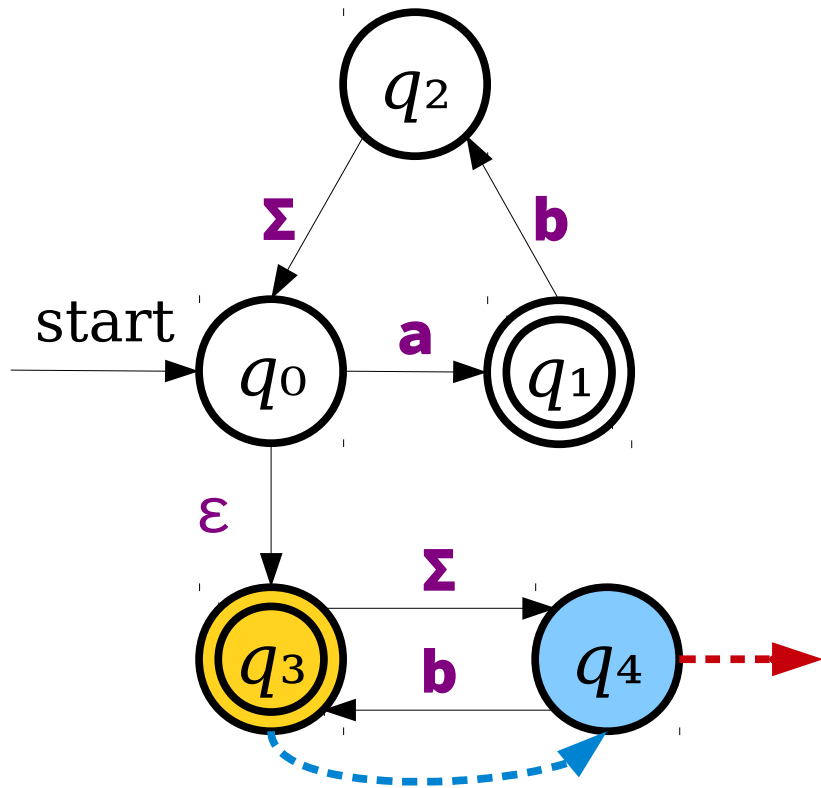
	a	b
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{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
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# Once More, With Epsilons!



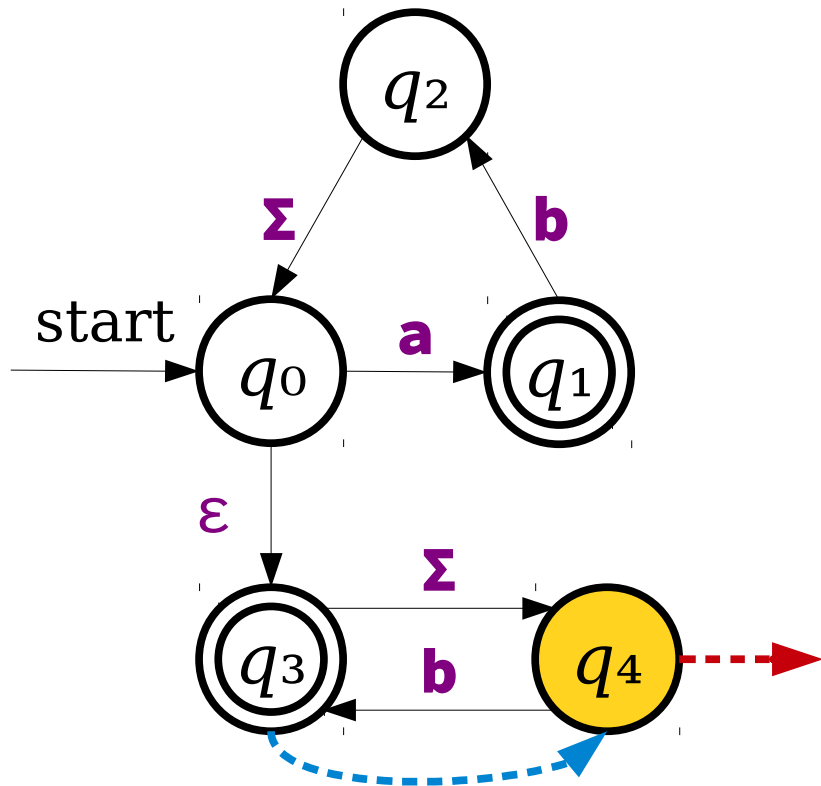
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
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{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
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# Once More, With Epsilons!



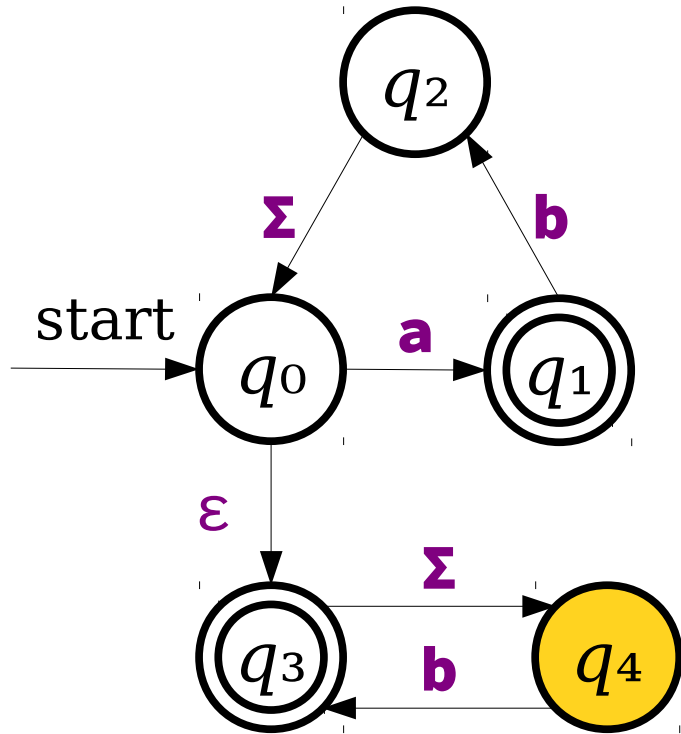
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	$\{q_3, q_4\}$
$\{q_3, q_4\}$		

# Once More, With Epsilons!



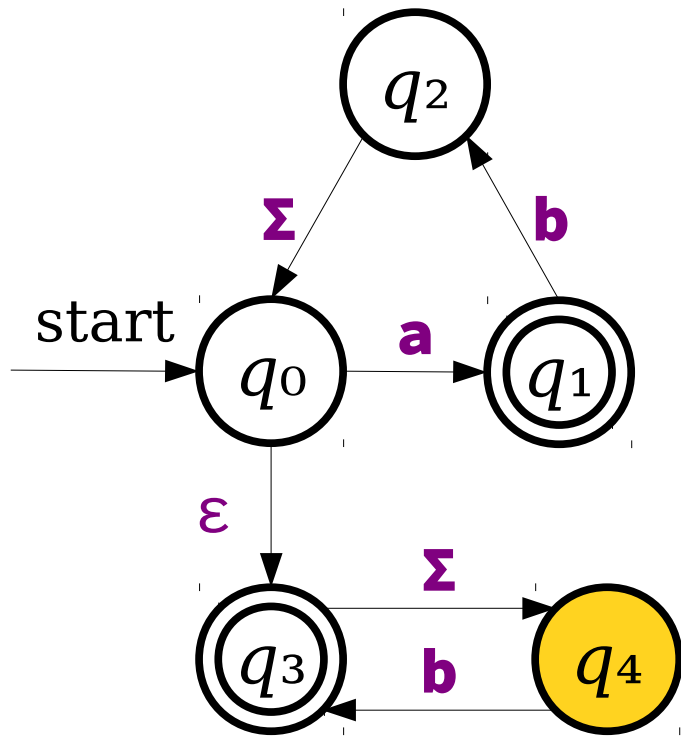
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	$\{q_3, q_4\}$
$\{q_3, q_4\}$		

# Once More, With Epsilons!



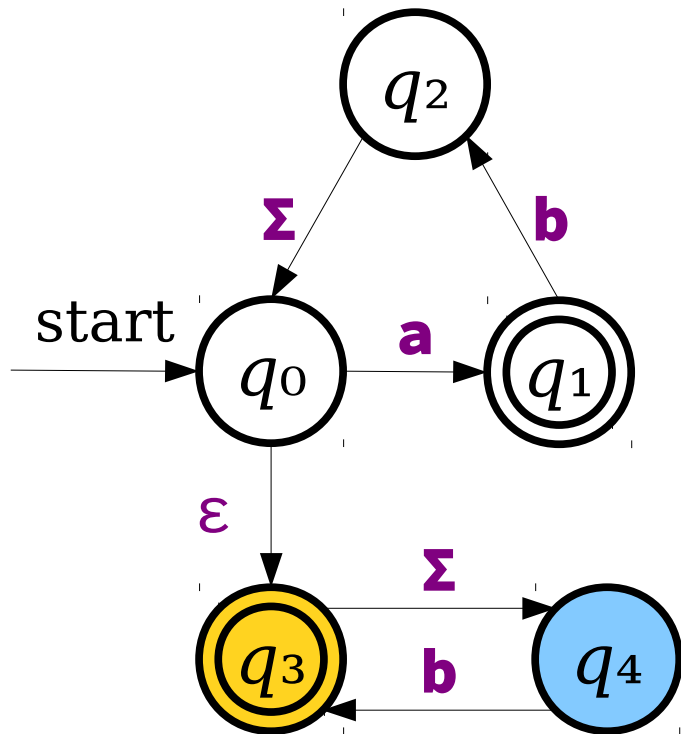
	a	b
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{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
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{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
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# Once More, With Epsilons!



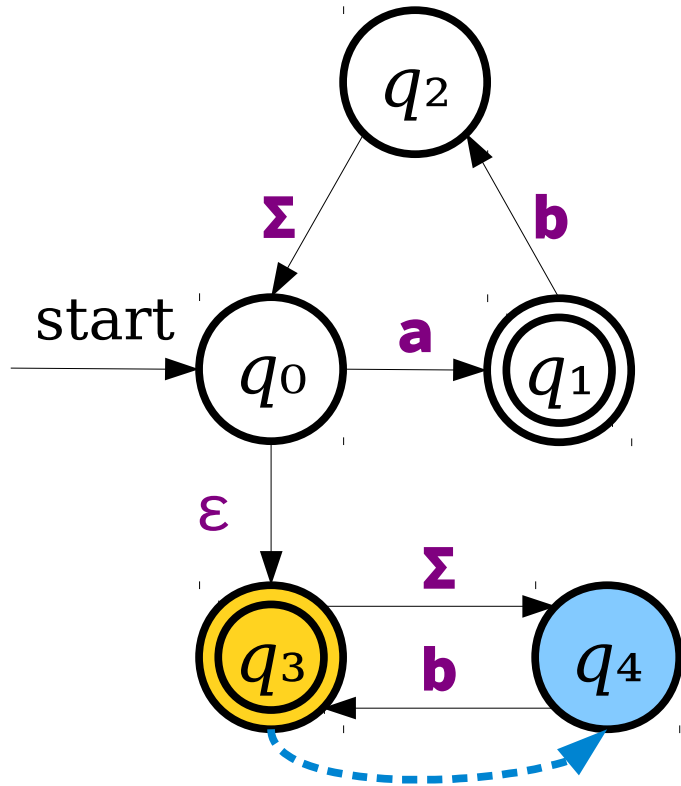
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
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# Once More, With Epsilons!



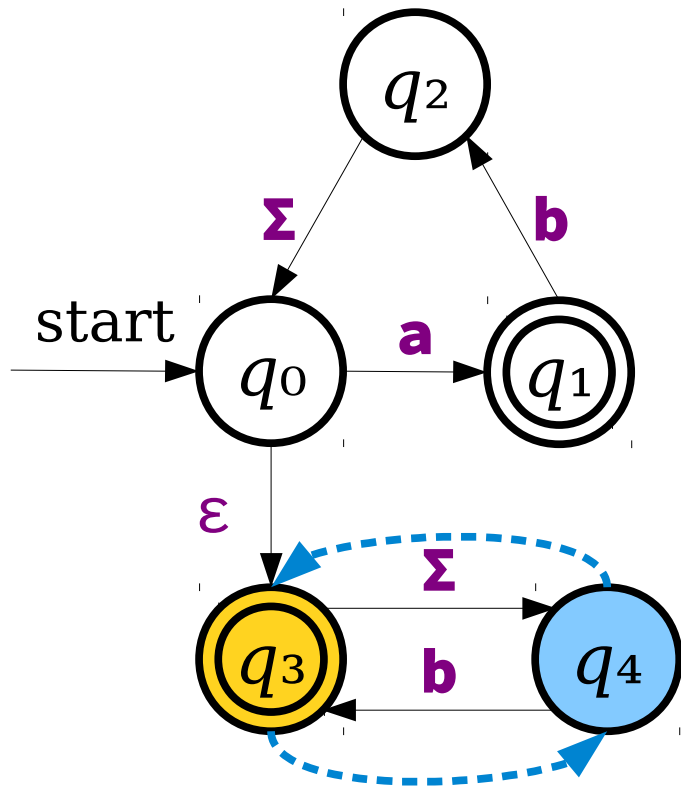
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
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{q <sub>4</sub> }	∅	{q <sub>3</sub> }
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# Once More, With Epsilons!



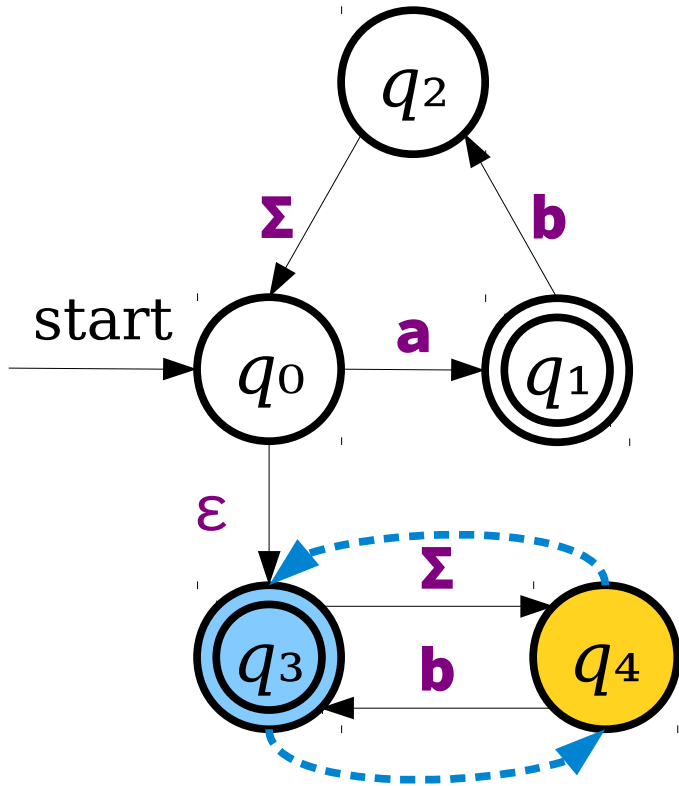
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
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{q <sub>4</sub> }	∅	{q <sub>3</sub> }
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# Once More, With Epsilons!



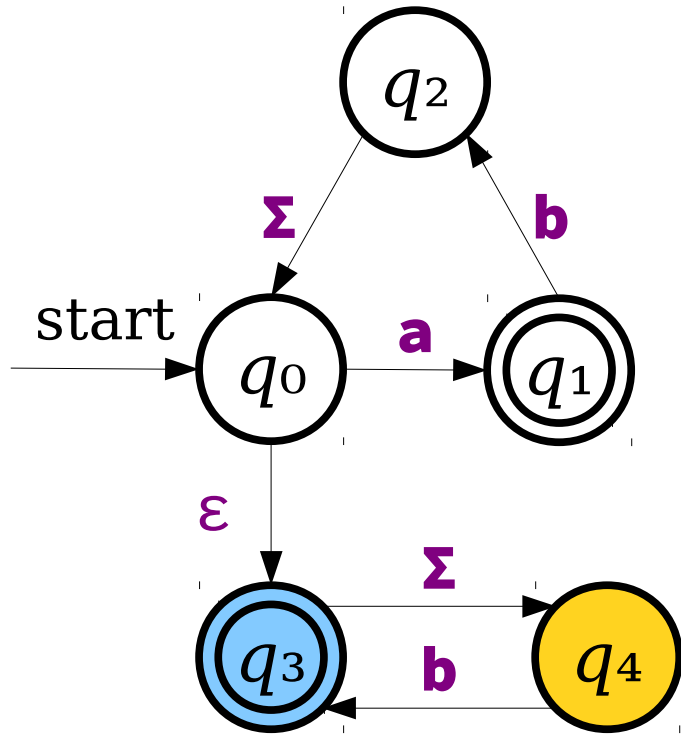
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	$\{q_3, q_4\}$
$\{q_3, q_4\}$	$\{q_4\}$	

# Once More, With Epsilons!



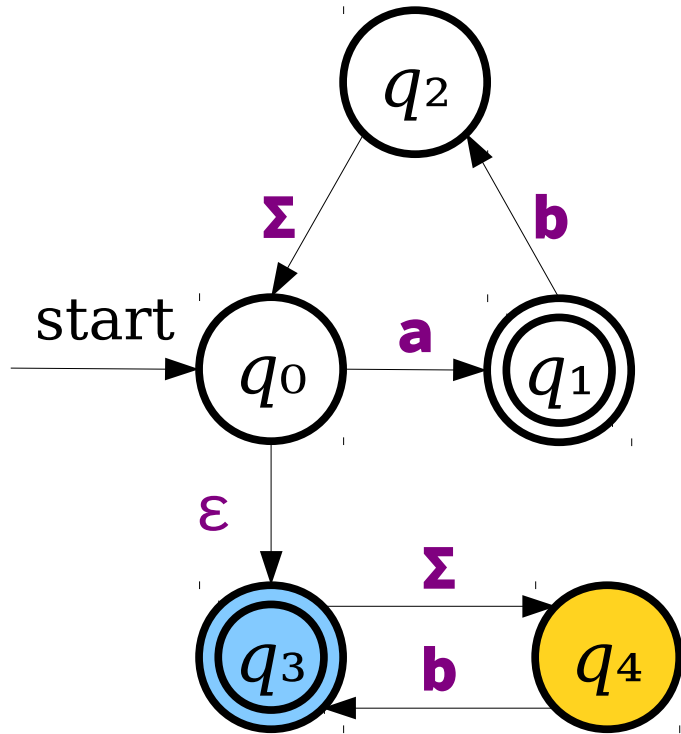
	a	b
$\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	$\{q_3, q_4\}$
$\{q_3, q_4\}$	$\{q_4\}$	

# Once More, With Epsilons!



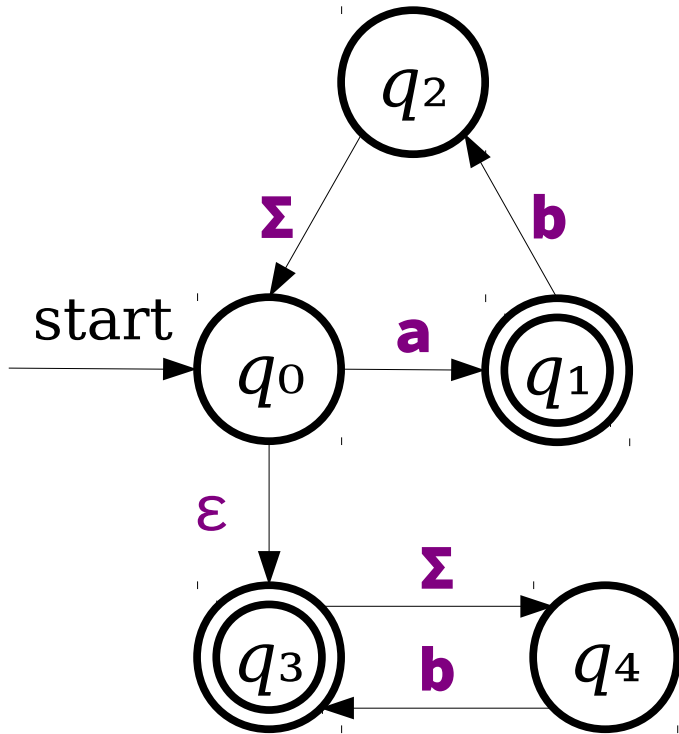
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>4</sub> }	

# Once More, With Epsilons!



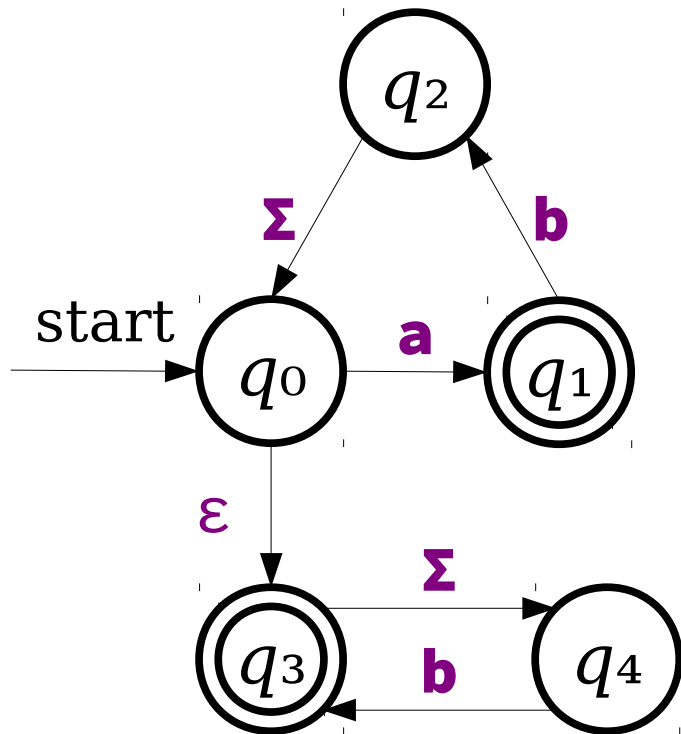
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }

# Once More, With Epsilons!



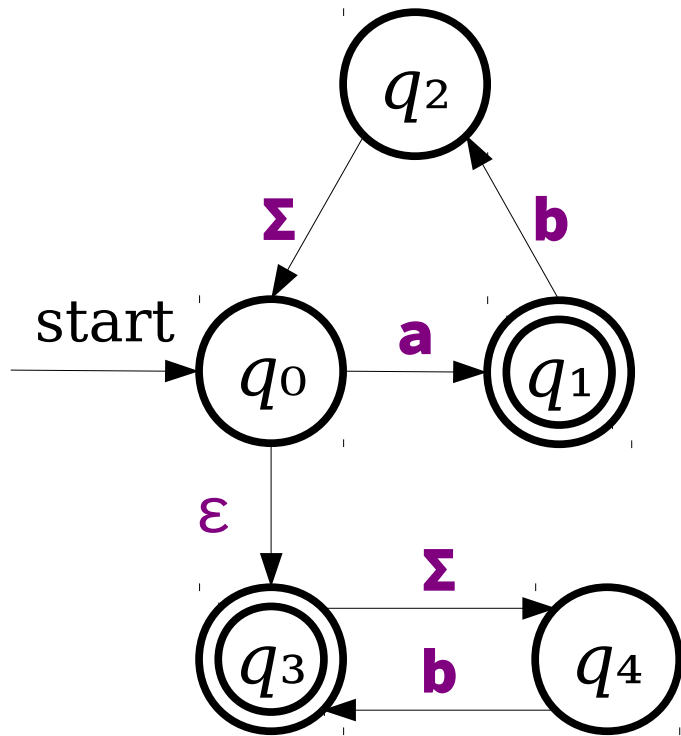
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }

# Once More, With Epsilons!



	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
∅		

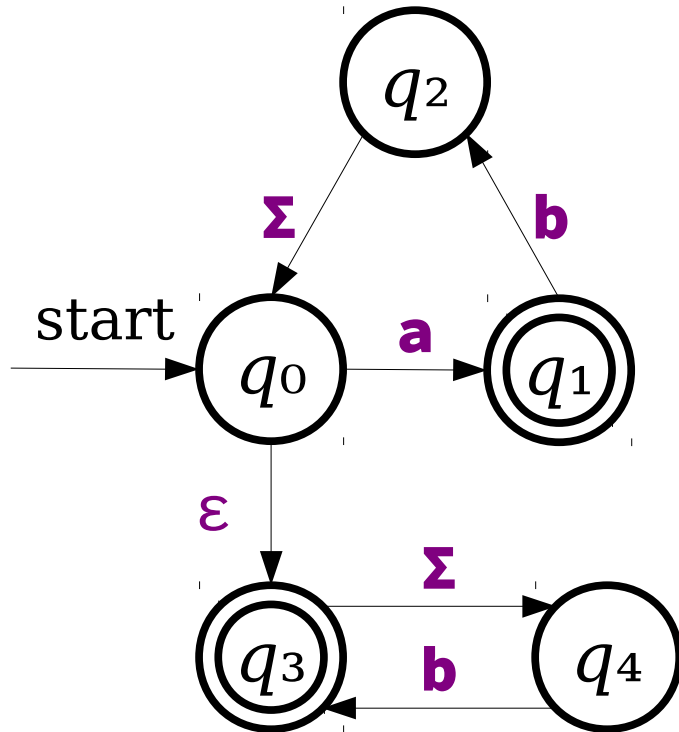
# Once More, With Epsilons!



	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
∅	∅	∅

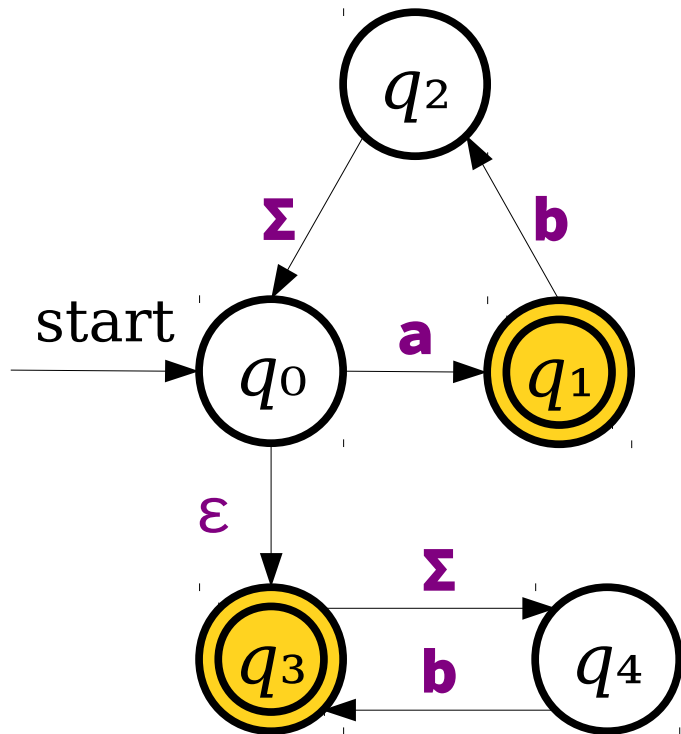
Answer at [PollEv.com/cs103](https://www.pollEv.com/cs103) or  
text **CS103** to **22333** once to join, then **a number**

How many of these rows should be marked as accepting states?



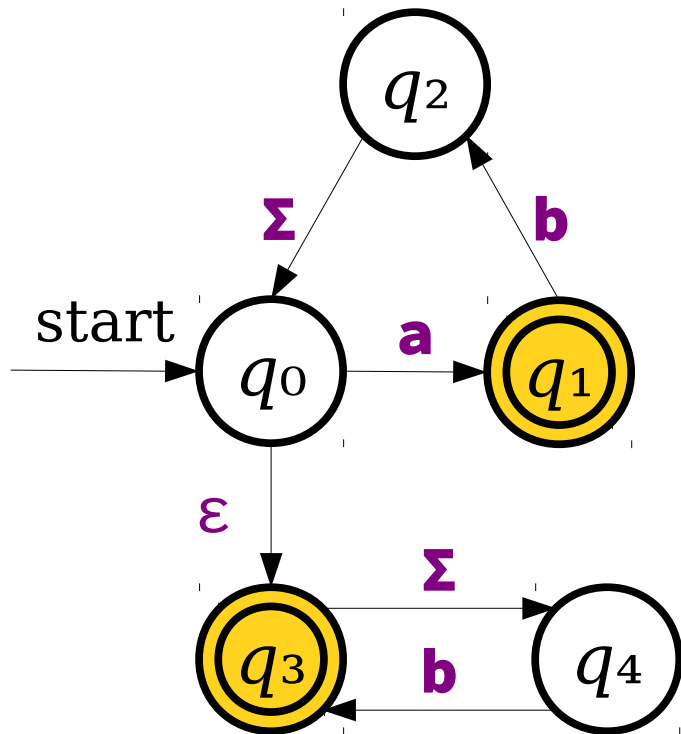
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
∅	∅	∅

# Once More, With Epsilons!



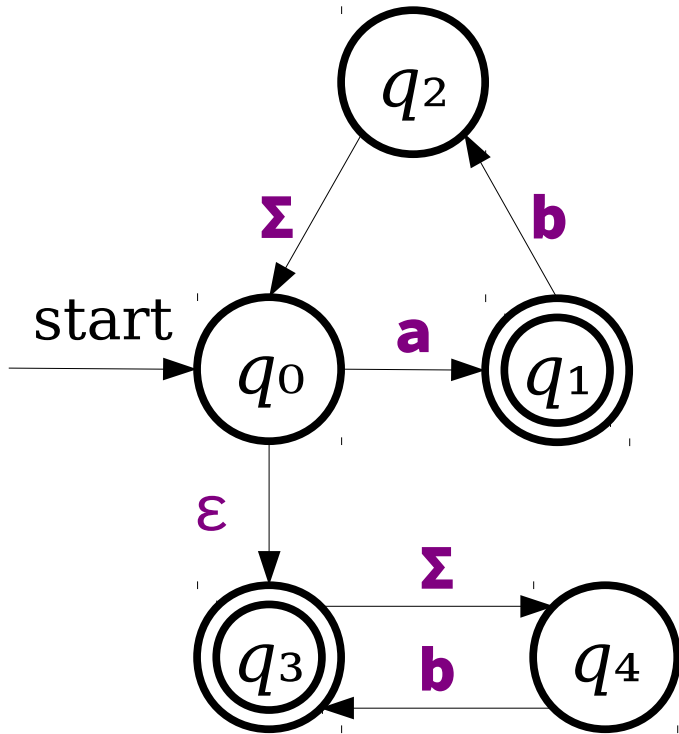
	a	b
{q <sub>0</sub> , q <sub>3</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>1</sub> , q <sub>4</sub> }	∅	{q <sub>2</sub> , q <sub>3</sub> }
{q <sub>4</sub> }	∅	{q <sub>3</sub> }
{q <sub>2</sub> , q <sub>3</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> }	{q <sub>4</sub> }	{q <sub>4</sub> }
{q <sub>0</sub> , q <sub>3</sub> , q <sub>4</sub> }	{q <sub>1</sub> , q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
{q <sub>3</sub> , q <sub>4</sub> }	{q <sub>4</sub> }	{q <sub>3</sub> , q <sub>4</sub> }
∅	∅	∅

# Once More, With Epsilons!



	a	b
$*\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$*\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$*\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$*\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$*\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	$\{q_3, q_4\}$
$*\{q_3, q_4\}$	$\{q_4\}$	$\{q_3, q_4\}$
$\emptyset$	$\emptyset$	$\emptyset$

# Once More, With Epsilons!



	a	b
$*\{q_0, q_3\}$	$\{q_1, q_4\}$	$\{q_4\}$
$*\{q_1, q_4\}$	$\emptyset$	$\{q_2, q_3\}$
$\{q_4\}$	$\emptyset$	$\{q_3\}$
$*\{q_2, q_3\}$	$\{q_0, q_3, q_4\}$	$\{q_0, q_3, q_4\}$
$*\{q_3\}$	$\{q_4\}$	$\{q_4\}$
$*\{q_0, q_3, q_4\}$	$\{q_1, q_4\}$	$\{q_3, q_4\}$
$*\{q_3, q_4\}$	$\{q_4\}$	$\{q_3, q_4\}$
$\emptyset$	$\emptyset$	$\emptyset$

# The Subset Construction

- This construction for transforming an NFA into a DFA is called the **subset construction** (or sometimes the **powerset construction**).
  - Each state in the DFA is associated with a set of states in the NFA.
  - The start state in the DFA corresponds to the start state of the NFA, plus all states reachable via  $\epsilon$ -transitions.
  - If a state  $q$  in the DFA corresponds to a set of states  $S$  in the NFA, then the transition from state  $q$  on a character  $a$  is found as follows:
    - Let  $S'$  be the set of states in the NFA that can be reached by following a transition labeled  $a$  from any of the states in  $S$ . (*This set may be empty.*)
    - Let  $S''$  be the set of states in the NFA reachable from some state in  $S'$  by following zero or more epsilon transitions.
    - The state  $q$  in the DFA transitions on  $a$  to a DFA state corresponding to the set of states  $S''$ .
- **Read Sipser for a formal account.**

# The Subset Construction

- In converting an NFA to a DFA, the DFA's states correspond to sets of NFA states.
- ***Useful fact:***  $|\wp(S)| = 2^{|S|}$  for any finite set  $S$ .
- In the worst-case, the construction can result in a DFA that is *exponentially larger* than the original NFA.
- Interesting challenge: Find a language for which this worst-case behavior occurs (there are infinitely many of them!)

A language  $L$  is called a ***regular language*** if there exists a DFA  $D$  such that  $\mathcal{L}(D) = L$ .

# An Important Result

***Theorem:*** A language  $L$  is regular iff there is some NFA  $N$  such that  $\mathcal{L}(N) = L$ .

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**Proof Sketch:** If  $L$  is regular, there exists some DFA for it, which we can easily convert into an NFA. If  $L$  is accepted by some NFA, we can use the subset construction to convert it into a DFA that accepts the same language, so  $L$  is regular.

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# Why This Matters

- We now have two perspectives on regular languages:
  - Regular languages are languages accepted by DFAs.
  - Regular languages are languages accepted by NFAs.
- We can now reason about the regular languages in two different ways.