

Nullable, First and Follow

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11 de dezembro de 2017

```
E → T E'
E' → + T E'
E' → - T E'
E' →
T → F T'
T' → * F T'
T' → / F T'
T' →
F → id
F → num
F → ( E )
```

Esta é a gramática livre de contexto!

$E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

Acertando a gramática

Símbolo inicial: **E**

Novo símbolo inicial: **S**

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

Acertando a gramática

Símbolo inicial: **E**

Novo símbolo inicial: **S**

Nova regra de produção: $S \rightarrow E \$$

$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow

Tabela de símbolos anuláveis, conjuntos first e conjuntos follow

$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow
S			
E'			
T			
T'			
F			
E			

Tabela de símbolos anuláveis, conjuntos first e conjuntos follow

$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow
S	×		
E'	×		
T	×		
T'	×		
F	×		
E	×		

Encontrando os símbolos não terminais anuláveis

Inicialmente nenhum símbolo não terminal é anulável

S → E **\$**

E → T E'

E' → + T E'

E' → - T E'

E' →

T → F T'

T' → * F T'

T' → / F T'

T' →

F → **id**

F → **num**

F → (E)

NT	Nullable	First	Follow
S	x		
E'	x		
T	x		
T'	x		
F	x		
E	x		

Regra com terminal no lado direito é inútil

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
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 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x		
E'	x		
T	x		
T'	x		
F	x		
E	x		

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 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x		
E'	x		
T	x		
T'	x		
F	x		
E	x		

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 $T' \rightarrow / F T'$
 $T' \rightarrow$
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 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x		
E'	x		
T	x		
T'	x		
F	x		
E	x		

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E'	x		
T	x		
T'	x		
F	x		
E	x		

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S	x		
E'	x		
T	x		
T'	x		
F	x		
E	x		

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T'	x		
F	x		
E	x		

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NT	Nullable	First	Follow
S	x		
E'	x		
T	x		
T'	x		
F	x		
E	x		

Regra com terminal no lado direito é inútil

$S \rightarrow E \$$
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 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x		
E'	x ✓		
T	x		
T'	x		
F	x		
E	x		

Lado direito da regra é vazio

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x		
E'	x ✓		
T	x		
T'	x ✓		
F	x		
E	x		

Lado direito da regra é vazio

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x		
E'	x ✓		
T	x		
T'	x ✓		
F	x		
E	x		

Lado direito da regra não é anulável

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x		
E'	x ✓		
T	x		
T'	x ✓		
F	x		
E	x		

Lado direito da regra não é anulável

$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\ E \)$

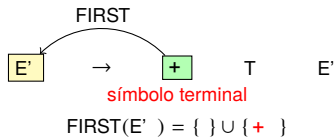
NT	Nullable	First	Follow
S	x		
E'	x ✓		
T	x		
T'	x ✓		
F	x		
E	x		

Encontrando os conjuntos first

Inicialmente são vazios

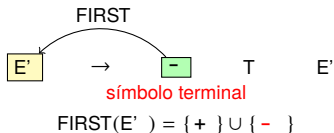
$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow
S	x		
E'	x ✓	+	
T	x		
T'	x ✓		
F	x		
E	x		



$S \rightarrow E \quad \$$
 $E \rightarrow T \quad E'$
 $E' \rightarrow + \quad T \quad E'$
 $E' \rightarrow - \quad T \quad E'$
 $E' \rightarrow$
 $T \rightarrow F \quad T'$
 $T' \rightarrow * \quad F \quad T'$
 $T' \rightarrow / \quad F \quad T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\quad E \quad)$

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓		
F	x		
E	x		



$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓		
F	x		
E	x		

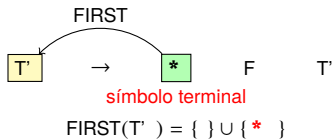
$E' \rightarrow$

O lado direito da regra é ϵ

Logo a regra é inútil

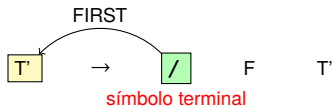
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓	*	
F	x		
E	x		



$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
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 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓	* /	
F	x		
E	x		



$$\text{FIRST}(T') = \{ * \} \cup \{ / \}$$

$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓	* /	
F	x		
E	x		

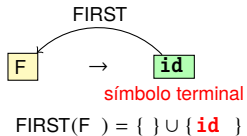
$T' \rightarrow$

O lado direito da regra é ϵ

Logo a regra é inútil

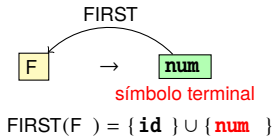
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓	* /	
F	x	id	
E	x		



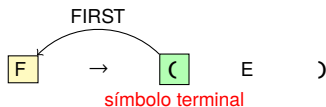
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×		
E'	×	+	-
T	×		
T'	×	*	/
F	×	id	num
E	×		



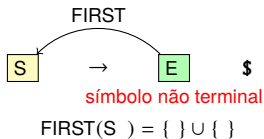
$S \rightarrow E \quad \$$
 $E \rightarrow T \quad E'$
 $E' \rightarrow + \quad T \quad E'$
 $E' \rightarrow - \quad T \quad E'$
 $E' \rightarrow$
 $T \rightarrow F \quad T'$
 $T' \rightarrow * \quad F \quad T'$
 $T' \rightarrow / \quad F \quad T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (\quad E \quad)$

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓	* /	
F	x	id num (
E	x		



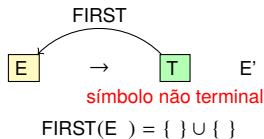
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
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NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓	* /	
F	x	id num (
E	x		



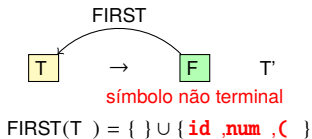
$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
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 $F \rightarrow num$
 $F \rightarrow (\ E \)$

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S	x		
E'	x ✓	+ -	
T	x		
T'	x ✓	* /	
F	x	id num (
E	x		



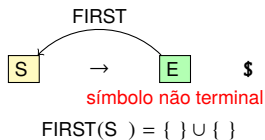
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x		



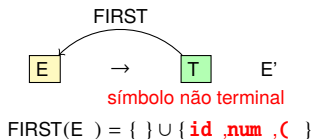
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)

NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x		



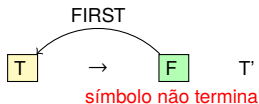
$S \rightarrow E \ \$$
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 $E' \rightarrow - \ T \ E'$
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T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x	id num (



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 $E' \rightarrow + \quad T \quad E'$
 $E' \rightarrow - \quad T \quad E'$
 $E' \rightarrow$
 $T \rightarrow F \quad T'$
 $T' \rightarrow * \quad F \quad T'$
 $T' \rightarrow / \quad F \quad T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (\quad E \quad)$

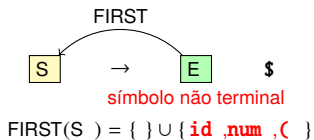
NT	Nullable	First	Follow
S	x		
E'	x ✓	+ -	
T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x	id num (



$FIRST(T) = \{id, num, (\} \cup \{id, num, (\}$

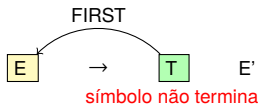
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (
T'	×	* /	
F	×	id num (
E	×	id num (



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 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
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 $F \rightarrow num$
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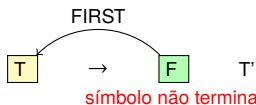
NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x	id num (



$$\text{FIRST}(E) = \{id, num, (\} \cup \{id, num, (\}$$

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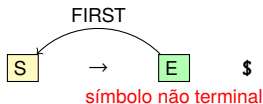
NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x	id num (



$FIRST(T) = \{id, num, (\} \cup \{id, num, (\}$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

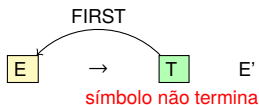
NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x	id num (



$FIRST(S) = \{ id, num, (\} \cup \{ id, num, (\}$

$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (\ E \)$

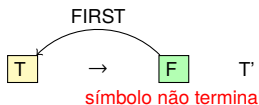
NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x	id num (



$$\text{FIRST}(E) = \{id, num, (\} \cup \{id, num, (\}$$

$S \rightarrow E \quad \$$
 $E \rightarrow T \quad E'$
 $E' \rightarrow + \quad T \quad E'$
 $E' \rightarrow - \quad T \quad E'$
 $E' \rightarrow$
 $T \rightarrow F \quad T'$
 $T' \rightarrow * \quad F \quad T'$
 $T' \rightarrow / \quad F \quad T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (\quad E \quad)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (
T'	x ✓	* /	
F	x	id num (
E	x	id num (



$FIRST(T) = \{id, num, (\} \cup \{id, num, (\}$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

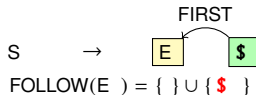
NT	Nullable	First	Follow
S	×	id num (
E'	× ✓	+ -	
T	×	id num (
T'	× ✓	* /	
F	×	id num (
E	×	id num (

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (
T'	×	* /	
F	×	id num (
E	×	id num (

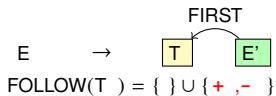
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (
T'	×	* /	
F	×	id num (
E	×	id num (\$



$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (
E	x	id num (\$



S → E \$

E → T E'

E' → + T E'

E' → - T E'

E' →

T → F T'

T' → * F T'

T' → / F T'

T' →

F → id

F → num

F → (E)

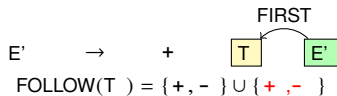
NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (
E	×	id num (\$

E → T E'

Não há nenhum símbolo após o último não terminal

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (
E	x	id num (\$



$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

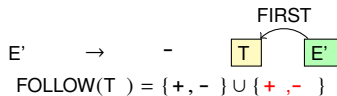
NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (
E	×	id num (\$

$E' \rightarrow + T E'$

Não há nenhum símbolo após o último não terminal

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (
E	x	id num (\$



$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (
E	×	id num (\$

$E' \rightarrow - T E'$

Não há nenhum símbolo após o último não terminal

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (
E	x	id num (\$

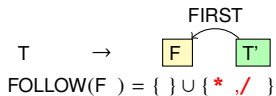
$E' \rightarrow$

Nenhum símbolo não terminal no lado direito da regra

Regra inútil

$S \rightarrow E \quad \$$
 $E \rightarrow T \quad E'$
 $E' \rightarrow + \quad T \quad E'$
 $E' \rightarrow - \quad T \quad E'$
 $E' \rightarrow$
 $T \rightarrow F \quad T'$
 $T' \rightarrow * \quad F \quad T'$
 $T' \rightarrow / \quad F \quad T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (\quad E \quad)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (* /
E	×	id num (\$



$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

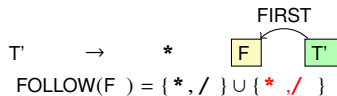
NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (* /
E	×	id num (\$

$T \rightarrow F T'$

Não há nenhum símbolo após o último não terminal

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (* /
E	×	id num (\$



$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (\ E \)$

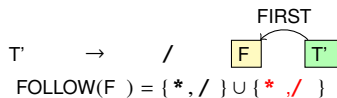
NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (* /
E	×	id num (\$

$T' \rightarrow * F T'$

Não há nenhum símbolo após o último não terminal

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (* /
E	x	id num (\$



$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (* /
E	×	id num (\$

$T' \rightarrow / F T'$

Não há nenhum símbolo após o último não terminal

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	
T	×	id num (+ -
T'	×	* /	
F	×	id num (* /
E	×	id num (\$

$T' \rightarrow$

Nenhum símbolo não terminal no lado direito da regra

Regra inútil

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (* /
E	x	id num (\$

$F \rightarrow id$

Nenhum símbolo não terminal no lado direito da regra

Regra inútil

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (* /
E	x	id num (\$

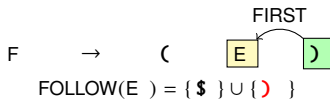
$F \rightarrow num$

Nenhum símbolo não terminal no lado direito da regra

Regra inútil

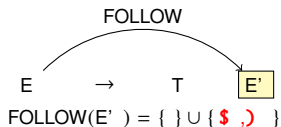
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (* /
E	x	id num (\$)



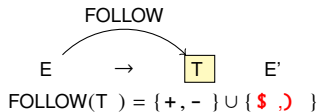
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ -
T'	x ✓	* /	
F	x	id num (* /
E	x	id num (\$)



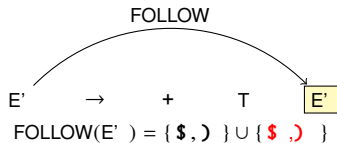
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	
F	×	id num (* /
E	×	id num (\$)



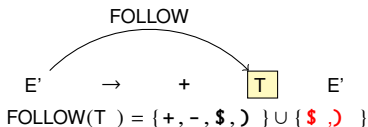
$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	
F	x	id num (* /
E	x	id num (\$)



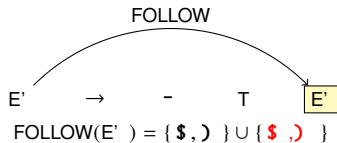
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	
F	×	id num (* /
E	×	id num (\$)



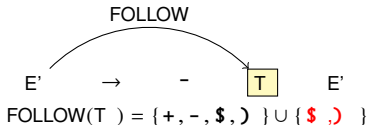
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	
F	×	id num (* /
E	×	id num (\$)



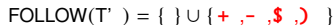
$$E' \rightarrow - T E'$$

T	×	id num (+ - \$)
T'	× ✓	* /
F	×	id num (* /
E	×	id num (\$)



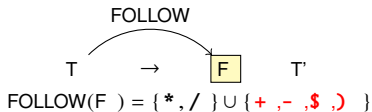
$$T \rightarrow F \quad T'$$

E	\times	id	num	(*	/
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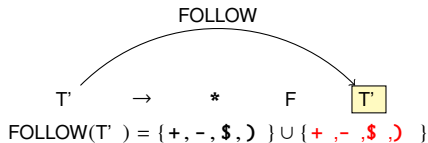
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)



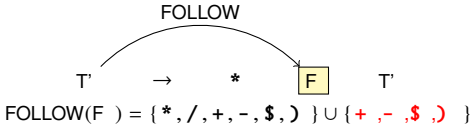
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)



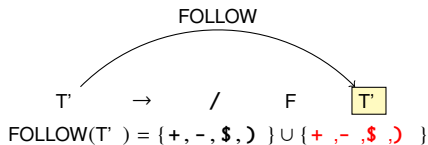
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)



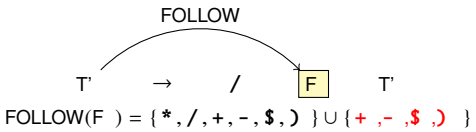
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)



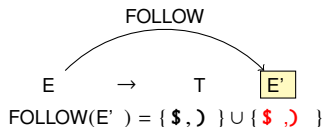
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)



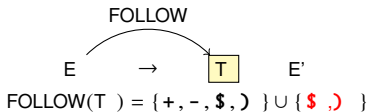
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)



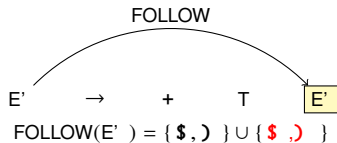
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)



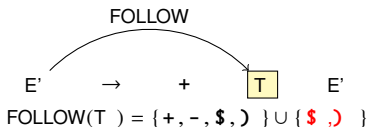
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)



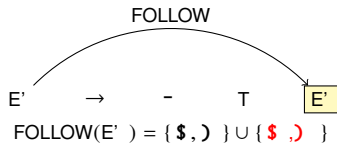
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)



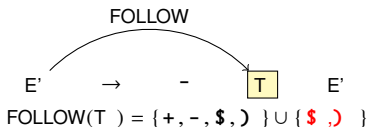
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)



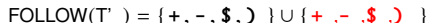
S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)



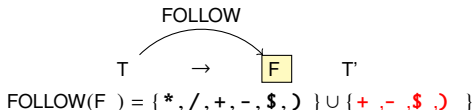
$$T \rightarrow F \quad T'$$

F	x	id	num	(*	/	+	-	\$)
---	---	----	-----	---	---	---	---	---	----	---



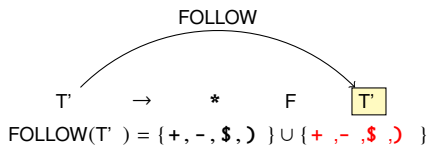
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)



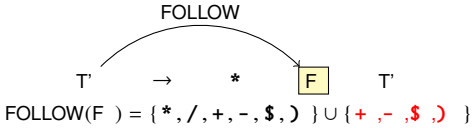
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)



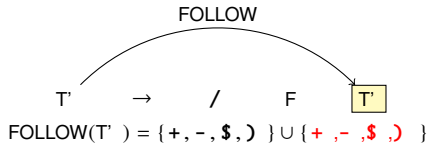
$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)



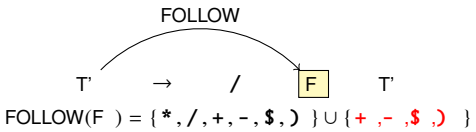
```
T' →  
F → id  
F → num  
F → ( E )
```

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)



$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)



$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S									
E'									
T									
T'									
F									
E									

Construção da tabela LL(1)

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S									
E'									
T									
T'									
F									
E									

$FIRST(E \$) = \{ \} \cup \{ id \text{ num } (\}$

$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'									
T									
T'									
F									
E									

$S \rightarrow$
 $\quad id \ num \ ($
 $\quad \quad E \ \$$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'									
T									
T'									
F									
E									

$$\text{FIRST}(T E') = \{ \} \cup \{ id \text{ num } (\}$$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'									
T									
T'									
F									
E		T E'						T E'	T E'

$E \rightarrow T E'$
 $id \ num \ ($

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'									
T									
T'									
F									
E		T E'						T E'	T E'

$FIRST(+ T E') = \{ \} \cup \{ + \}$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'					+ T E'				
T									
T'									
F									
E		T E'						T E'	T E'

$E' \rightarrow + T E'$
 $+$

$S \rightarrow E \ \$$
 $E \rightarrow T \ E'$
 $E' \rightarrow + \ T \ E'$
 $E' \rightarrow - \ T \ E'$
 $E' \rightarrow$
 $T \rightarrow F \ T'$
 $T' \rightarrow * \ F \ T'$
 $T' \rightarrow / \ F \ T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (\ E \)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'					+ T E'				
T									
T'									
F									
E		T E'						T E'	T E'

$FIRST(- \ T \ E') = \{ \} \cup \{ - \}$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'					+ T E'	- T E'			
T									
T'									
F									
E		T E'						T E'	T E'

$E' \rightarrow - T E'$
 $-$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T									
T'									
F									
E		T E'						T E'	T E'

$E' \rightarrow$
 $\$)$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T									
T'									
F									
E		T E'						T E'	T E'

$FIRST(F T') = \{ \} \cup \{ id \text{ num } (\}$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	∈		∈		+ T E'	- T E'			
T		F T'						F T'	F T'
T'									
F									
E		T E'						T E'	T E'

$T \rightarrow$
 $id \quad num \quad ($

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'									
F									
E		T E'						T E'	T E'

$$\text{FIRST}(* F T') = \{ \} \cup \{ * \}$$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	∈		∈		+ T E'	- T E'			
T		F T'						F T'	F T'
T'				* F T'					
F									
E		T E'						T E'	T E'

$T' \rightarrow * F T'$
 $\quad \quad *$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'				* F T'					
F									
E		T E'						T E'	T E'

$$\text{FIRST}(/ F T') = \{ \} \cup \{ / \}$$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'				* F T'			/ F T'		
F									
E		T E'						T E'	T E'

$T' \rightarrow /$
 $F T'$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'	€		€	* F T'	€	€	/ F T'		
F									
E		T E'						T E'	T E'

$T' \rightarrow$
 $+ - \$)$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'	€		€	* F T'	€	€	/ F T'		
F									
E		T E'						T E'	T E'

$\text{FIRST}(\text{id}) = \{ \} \cup \{ \text{id} \}$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'	€		€	* F T'	€	€	/ F T'		
F								id	
E		T E'						T E'	T E'

$F \rightarrow \text{id}$
 id

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'	€		€	* F T'	€	€	/ F T'		
F								id	
E		T E'						T E'	T E'

$$\text{FIRST}(\text{num}) = \{ \} \cup \{ \text{num} \}$$

S	→	E	\$
E	→	T	E'
E'	→	+	T E'
E'	→	-	T E'
E'	→		
T	→	F	T'
T'	→	*	F T'
T'	→	/	F T'
T'	→		
F	→	id	
F	→	num	
F	→	(E)	

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'	€		€	* F T'	€	€	/ F T'		
F								id	num
E		T E'						T E'	T E'

$$F \rightarrow \begin{matrix} \text{num} \\ \text{num} \end{matrix}$$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow id$
 $F \rightarrow num$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	x	id num (
E'	x ✓	+ -	\$)
T	x	id num (+ - \$)
T'	x ✓	* /	+ - \$)
F	x	id num (* / + - \$)
E	x	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'	€		€	* F T'	€	€	/ F T'		
F								id	num
E		T E'						T E'	T E'

$$\text{FIRST}((E)) = \{ \} \cup \{ (\}$$

$S \rightarrow E \$$
 $E \rightarrow T E'$
 $E' \rightarrow + T E'$
 $E' \rightarrow - T E'$
 $E' \rightarrow$
 $T \rightarrow F T'$
 $T' \rightarrow * F T'$
 $T' \rightarrow / F T'$
 $T' \rightarrow$
 $F \rightarrow \text{id}$
 $F \rightarrow \text{num}$
 $F \rightarrow (E)$

NT	Nullable	First	Follow
S	×	id num (
E'	×	+ -	\$)
T	×	id num (+ - \$)
T'	×	* /	+ - \$)
F	×	id num (* / + - \$)
E	×	id num (\$)

	\$	(	)	*	+	-	/	id	num
S		E \$						E \$	E \$
E'	€		€		+ T E'	- T E'			
T		F T'						F T'	F T'
T'	€		€	* F T'	€	€	/ F T'		
F		(E)						id	num
E		T E'						T E'	T E'

$F \rightarrow (E)$
 $($