

Nullable, First and Follow

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$Z \rightarrow \mathbf{d}$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow \mathbf{c}$
 $X \rightarrow Y$
 $X \rightarrow \mathbf{a}$

Esta é a gramática livre de contexto!

Z $\rightarrow$ **d**

Z $\rightarrow$ X Y Z

Y $\rightarrow$

Y $\rightarrow$ **c**

X $\rightarrow$ Y

X $\rightarrow$ **a**

Acertando a gramática

Símbolo inicial: **Z**

Novo símbolo inicial: **S**

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X \ Y \ Z$

$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

Acertando a gramática

Símbolo inicial: Z

Novo símbolo inicial: S

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

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow

Tabela de símbolos anuláveis, conjuntos first e conjuntos follow

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S			
Z			
Y			
X			

Tabela de símbolos anuláveis, conjuntos first e conjuntos follow

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×		
Z	×		
Y	×		
X	×		

Encontrando os símbolos não terminais anuláveis

Inicialmente nenhum símbolo não terminal é anulável

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x		
Y	x		
X	x		

Regra com terminal no lado direito é inútil

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x		
Y	x		
X	x		

Regra com terminal no lado direito é inútil

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x		
Y	x		
X	x		

Regra com terminal no lado direito é inútil

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x		
Y	x		
X	x		

Regra com terminal no lado direito é inútil

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x		
Y	x ✓		
X	x		

Lado direito da regra é vazio

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x		
Y	x ✓		
X	x		

Lado direito da regra não é anulável

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x		
Y	x ✓		
X	x ✓		

Lado direito da regra é anulável

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x		
Y	x ✓		
X	x ✓		

Lado direito da regra não é anulável

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

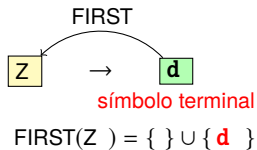
NT	Nullable	First	Follow
S	×		
Z	×		
Y	×	✓	
X	×	✓	

Encontrando os conjuntos first

Inicialmente são vazios

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×		
Z	×	d	
Y	×	✓	
X	×	✓	



$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×		
Z	×	d	
Y	×	✓	
X	×	✓	

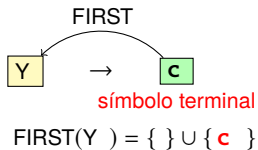
$Y \rightarrow$

O lado direito da regra é ϵ

Logo a regra é inútil

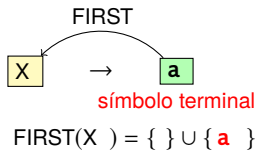
$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x	d	
Y	x ✓	c	
X	x ✓		



$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	x		
Z	x	d	
Y	x ✓	c	
X	x ✓	a	



$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

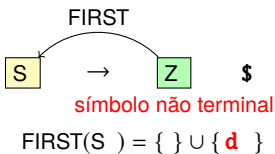
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d	
Z	×	d	
Y	×	c	
X	×	a	



$S \rightarrow Z \ \$$

$Z \rightarrow d$

$Z \rightarrow X \ Y \ Z$

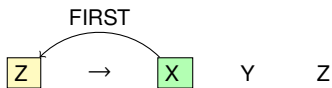
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d	
Z	×	d a	
Y	×	c	
X	×	a	



símbolo não terminal

$$\text{FIRST}(Z) = \{ d \} \cup \{ a \}$$

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

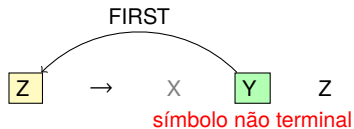
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d	
Z	×	d a c	
Y	×	✓ c	
X	×	✓ a	



$$\text{FIRST}(Z) = \{d, a\} \cup \{c\}$$

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

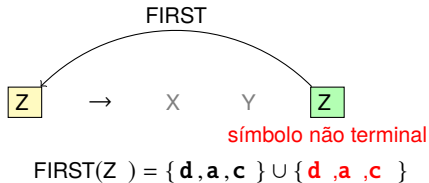
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

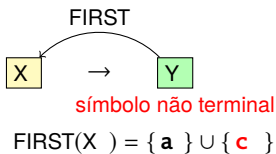
$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d	
Z	×	d a c	
Y	×	✓ c	
X	×	✓ a	



$S \rightarrow Z \ \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d	
Z	×	d a c	
Y	×	c	
X	×	a c	



S $\rightarrow$ **Z** **\$**

$Z \rightarrow d$

$Z \rightarrow X \ Y \ Z$

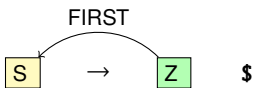
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	c	
X	×	a c	



símbolo não terminal

$$\text{FIRST}(S) = \{ \mathbf{d} \} \cup \{ \mathbf{d}, \mathbf{a}, \mathbf{c} \}$$

$S \rightarrow Z \ \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

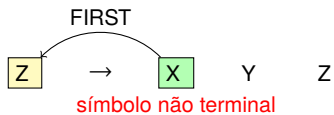
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	c	
X	×	a c	



$$\text{FIRST}(Z) = \{d, a, c\} \cup \{a, c\}$$

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

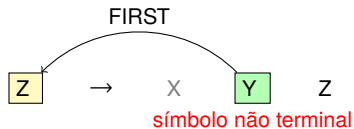
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	c	
X	×	a c	



$$\text{FIRST}(Z) = \{d, a, c\} \cup \{c\}$$

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

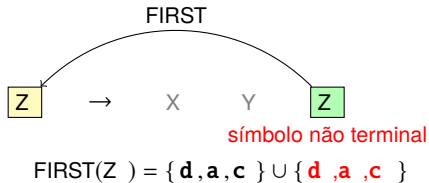
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

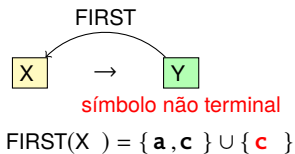
$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	✓ c	
X	×	✓ a c	



S $\rightarrow$ Z \$
Z $\rightarrow$ d
Z $\rightarrow$ X Y Z
Y $\rightarrow$
Y $\rightarrow$ c
X $\rightarrow$ Y
X $\rightarrow$ a

NT	Nullable	First	Follow
S	x	d a c	
Z	x	d a c	
Y	x ✓	c	
X	x ✓	a c	



S $\rightarrow$ **Z** **\$**

$Z \rightarrow d$

$Z \rightarrow X \ Y \ Z$

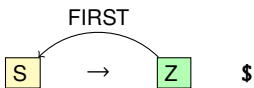
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	c	
X	×	a c	



símbolo não terminal

$$\text{FIRST}(S) = \{d, a, c\} \cup \{d, a, c\}$$

$S \rightarrow Z \ \$$

$Z \rightarrow d$

$Z \rightarrow X \ Y \ Z$

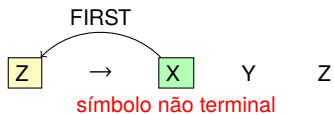
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	c	
X	×	a c	



$$\text{FIRST}(Z) = \{d, a, c\} \cup \{a, c\}$$

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

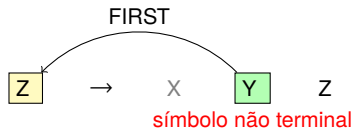
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	c	
X	×	a c	



$$\text{FIRST}(Z) = \{d, a, c\} \cup \{c\}$$

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

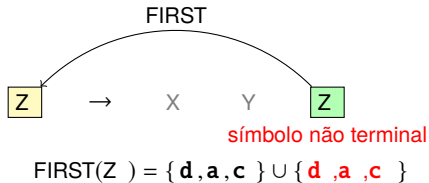
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

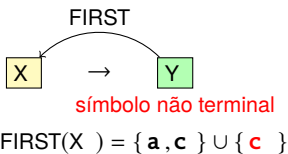
$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	✓ c	
X	×	✓ a c	



$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	
Y	×	c	
X	×	a c	



$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X \ Y \ Z$

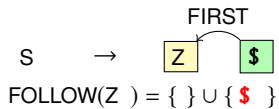
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c



$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	
X	×	✓	

$Z \rightarrow d$

Nenhum símbolo não terminal no lado direito da regra

Regra inútil

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

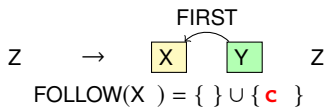
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	x	d a c	
Z	x	d a c	\$
Y	x ✓	c	
X	x ✓	a c	c



$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

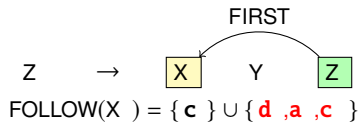
$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓ c	
X	×	✓ a c	c d a



$$X \rightarrow \mathbf{a}$$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	d a c
X	×	✓	c d a

$Z \rightarrow X \quad Y \quad Z$
 $FOLLOW(Y) = \{ \} \cup \{ d, a, c \}$

$S \rightarrow Z \$$

$Z \rightarrow d$

$Z \rightarrow X Y Z$

$Y \rightarrow$

$Y \rightarrow c$

$X \rightarrow Y$

$X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓ c	d a c
X	×	✓ a c	c d a

$Z \rightarrow X Y Z$

Não há nenhum símbolo após o último não terminal

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	d a c
X	×	✓	a c

$Y \rightarrow$

Nenhum símbolo não terminal no lado direito da regra
 Regra inútil

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	d a c
X	×	✓	a c

$Y \rightarrow c$

Nenhum símbolo não terminal no lado direito da regra

Regra inútil

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $V \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	c	d a c
X	×	a c	c d a

$X \rightarrow$

Y

Não há nenhum símbolo após o último não terminal

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	d a c
X	×	✓	a c

$X \rightarrow a$

Nenhum símbolo não terminal no lado direito da regra

Regra inútil

S $\rightarrow$ Z \$

Z $\rightarrow$ d

Z $\rightarrow$ X Y Z

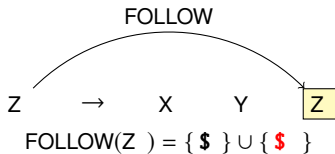
Y $\rightarrow$

Y $\rightarrow$ c

X $\rightarrow$ Y

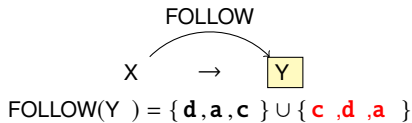
X $\rightarrow$ a

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c



$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $V \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	d a c
X	×	✓	a c



$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X Y Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S				
Z				
Y				
X				

Construção da tabela LL(1)

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S				
Z				
Y				
X				

$$\text{FIRST}(Z \$) = \{ \} \cup \{ d a c \}$$

$$X \rightarrow \mathbf{a}$$

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z				
Y				
X				

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	d a c
X	×	✓	c d a

S → Z \$
d a c

$S \rightarrow Z \ \$$
 $Z \rightarrow \mathbf{d}$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow \mathbf{c}$
 $X \rightarrow Y$
 $X \rightarrow \mathbf{a}$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z				
Y				
X				

$$\text{FIRST}(\mathbf{d}) = \{ \ } \cup \{ \mathbf{d} \}$$

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓ c	d a c
X	×	✓ a c	c d a

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z				d
Y				
X				

$Z \rightarrow d$
 d

$S \rightarrow Z \ \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z				d
Y				
X				

$$\text{FIRST}(X \ Y \ Z) = \{ \} \cup \{ a \ c \}$$

$S \rightarrow Z \ \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z				d
Y				
X				

$$\text{FIRST}(X \ Y \ Z) = \{a \ c\} \cup \{c\}$$

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z				d
Y				
X				

$$\text{FIRST}(X \ Y \ Z) = \{a \ c\} \cup \{d \ a \ c\}$$

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓ c	d a c
X	×	✓ a c	c d a

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z		X Y Z	X Y Z	d X Y Z
Y				
X				

$Z \rightarrow$
nullable
nullable
 $X \quad Y \quad Z$
 $a \ c \quad c \quad d \ a \ c$

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z		X Y Z	X Y Z	d X Y Z
Y		€	€	€
X				

$Y \rightarrow$
 d a c

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow \mathbf{c}$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z		X Y Z	X Y Z	d X Y Z
Y		€	€	€
X				

$$\text{FIRST}(\mathbf{c}) = \{ \} \cup \{ \mathbf{c} \}$$

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	c	d a c
X	×	a c	c d a

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z		X Y Z	X Y Z	d X Y Z
Y		€	€ c	€
X				

$Y \rightarrow c$
 c

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z		X Y Z	X Y Z	d X Y Z
Y		€	€ c	€
X				

$$\text{FIRST}(Y) = \{ \} \cup \{ c \}$$

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z		X Y Z	X Y Z	d X Y Z
Y		€	€ c	€
X		Y	Y	Y

nullable

$$\begin{matrix} X \\ c \ d \ a \end{matrix} \rightarrow \begin{matrix} Y \\ c \end{matrix}$$

$S \rightarrow Z \ \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z		X Y Z	X Y Z	d X Y Z
Y		€	€ c	€
X		Y	Y	Y

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

$S \rightarrow Z \$$
 $Z \rightarrow d$
 $Z \rightarrow X \ Y \ Z$
 $Y \rightarrow$
 $Y \rightarrow c$
 $X \rightarrow Y$
 $X \rightarrow a$

NT	Nullable	First	Follow
S	×	d a c	
Z	×	d a c	\$
Y	×	✓	c
X	×	✓	a c

	\$	a	c	d
S		Z \$	Z \$	Z \$
Z		X Y Z	X Y Z	d X Y Z
Y		€	€ c	€
X		Y a	Y	Y

$X \rightarrow a$
 a