

1.1

We label each rule from top to bottom 1 - 6.

We see that rule 3:

$$B \rightarrow B ; + V \mid + V$$

Is left-recursive as the B in the production can keep expanding infinitely without consuming anything. We remove the left recursion with the following modification:

$$B \rightarrow + V ; B \mid + V$$

This gives rise to a new problem, the common prefix +. When we consume a + we have no way of knowing which rule to follow next (i.e. if we should add a  $V ; B$  or only a  $V$ ). To fix this, we perform left factoring by factoring the parts after  $+ V$  out of  $B$ :

$$\begin{aligned} B &\rightarrow + V I \\ I &\rightarrow ; B \mid \epsilon \end{aligned}$$

No other rule has left recursion, and consequently the grammar is now LL(1) parsable. The full grammar with numbered productions becomes:

1.  $S \rightarrow i C B E F n$
2.  $C \rightarrow c$
3.  $B \rightarrow + V I$
4.  $I \rightarrow ; B$
5.  $I \rightarrow \epsilon$
6.  $V \rightarrow x$
7.  $V \rightarrow y$
8.  $E \rightarrow e B$
9.  $E \rightarrow \epsilon$
10.  $F \rightarrow f$
11.  $F \rightarrow \epsilon$

## 1.2

Non-terminal	FIRST	FOLLOW	NULLABLE
S	$i_1$	\$	NO
C	$c_2$	+	NO
B	$+_3$	$e, f, n$	NO
I	$i_4 \epsilon_5$	$e, f, n$	YES
V	$x_6 y_7$	$;, e, f, n$	NO
E	$e_8 \epsilon_9$	$f, n$	YES
F	$f_{10} \epsilon_{11}$	$n$	YES

## 1.3

LL(1) table:

	$i$	$c$	+	;	$x$	$y$	$e$	$f$	$n$
S	1								
C		2							
B			3						
I				4			5	5	5
V					6	7			
E							8	9	9
F								10	11

No cell has more than one number (rule), so there are no conflicts → the grammar can be parsed with an LL(1) algorithm. Moreover, the grammar is unambiguous.