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PLC

Test 2

- Notes on the submission file:
  - There are 7 files: 4 .txt test files, 1 code file Lex_Parse.py, 1 readme file (this one), and 1 PDF of the LR(1) parse table.
  - Lexer and Parser code are both in 1 file called Lex_Pase.py.
  - Only run Lex_Parse.py
  - Choose test file to run by changing the hard coded path in run time code:

```
390   #token list created
391   mytokens, lex_stat = mylex.tokenize("no_error_test1.txt")
```

    Choose the test file by typing the file name in the tokenize function

PART A: Define Token rules (using Regex)

Token name	Regex rule		Token name	Regex rule
case_key:	case		**module:**	%
itr_key:	itr		**assign:**	=
other_key:	other		**EQ:**	==
times_key:	times		**NEQ:**	!=
int_key:	nat		**LT:**	<
lit_int8b:	0|-?[1-9])[0-9]*		**GT:**	>
lit_int8b	0|-?[1-9])[0-9]*_b8		**LTE:**	<=
lit_int4b	0|-?[1-9])[0-9]*_b4		**GTE:**	>=
lit_int2b	0|-?[1-9])[0-9]*_b2		**L_paren:**	\(
lit_int1b	0|-?[1-9])[0-9]*_b1		**R_paren:**	\)
var_name:	[a-zA-Z_]{1,7}		**L_bracket:**	\[
end_stmt:	\.		**R_bracket:**	\]
add:	\+		**BEGIN:**	BEGIN
subtract:	-		**END:**	END
multiply:	*			
divide:	/			

Section B: define production rules

<Start> ::= BEGIN <Statement_list>

<Statement_list> ::= <Statement> <Statement_list>
| END

<Statement> ::= nat <Var_decl>
| case <Case>
| itr <Itr>
| var_name <Var_assign>

<Var_decl> ::= var_name "."

<Var_assign> ::= "=" <Math_expr>

<Case> ::= <Boolean_expr> "[" <If_true> other "[" <If_false> "."

<Boolean_expr> ::= "(" <Number> <Rela_op> <Number> ")"
<Rela_op> ::= ">" | "<" | "==" | "!=" | "<=" | ">="

<If_true> ::= <Statement> <If_true> | "]"
<If_false> ::= <Statement> <If_false> | "]"

<Itr> ::= <Number> times "[" <To_repeat> "."
<To_repeat> ::= <Statement> <To_repeat> | "]"

PART B: (page 2)

<Math_expr> ::= <sum>
<Sum> ::= <Mul> "+" <Sum>
| <Mul>
<Mul> ::= <Div> "*" <Mul>
| <Div>
<Div> ::= <Subtr> "/" <Div>
| <Subtr>
<Subtr> ::= <Mod> "-" <Subtr>
| <Mod>
<Mod> ::= <Factor> "%" <Mod>
| <Factor>
<Factor> ::= "(" <Math_expr> ")"
| <Number>

<Number> ::= lit_int8b
| lit_int4b
| lit_int2b
| lit_int1b
| var_name

- Notes on production rules:
  - var_name is any var_name token

- 6 levels of precedence in math expressions (Low to High):
  1. Sum
  2. Multiply
  3. Divide
  4. Subtract
  5. Module
  6. Parentheses

PART C: PROVE RULE SET CONFORM TO LL

My production rules conform to LL because it does not have left hand recursion and it passes the pairwise disjointness test.

- No left hand recursion:
  - In my grammar, there are 4 non-terminals that uses recursion (<Statement_list>, <If_true>, <If_false>, <To_repeat>). However, each of these rules have an alternatives that contains only one terminal symbol. Those terminal symbols would stop the recursion (like a base case). In all cases, there is no left hand recursion.
  - In my mathmetical_expression Non-terminal symbol <math_expr>, there is recursion being used but it does not lead to indirect left hand recursion in any case.

- Pass the pairwise disjointness test:
  - FIRST <Start> ::= {BEGIN}
  - FIRST <Statement_list> ::= {nat, case, itr, var_name, END}
  - FIRST <Statement> ::= {nat}, {case}, {itr}, {var_name}
  - FIRST <Var_decl> ::= {var_name}
  - FIRST <Var_assign> ::= {“=”}
  - FIRST <Case > ::= {“(“}
  - FIRST <Boolean_expr> ::= {“(“}
  - FIRST <Rela_op> ::= {“>”}, {“<”}, {“==”}, {“!=”}, {“<=”}, {“>=”}
  - FIRST <If_true> ::= {nat, case, itr, var_name}, {“]”}
  - FIRST <If_false> ::= {nat, case, itr, var_name}, {“]”}
  - FIRST <Itr> ::= {lit_int8b}, { lit_int4b }, {lit_int2b }, { lit_int1b }, {var_name}
  - FIRST <To_repeat> ::= {nat, case, itr, var_name}, {“[“}
  - FIRST <Math_expr> ::= {“(“, {lit_int8b, lit_int4b, lit_int2b , lit_int1b, var_name}}
  - FIRST <Sum> ::= {“(“, {lit_int8b, lit_int4b, lit_int2b , lit_int1b, var_name}}
  - FIRST <Mul> ::= {“(“, {lit_int8b, lit_int4b, lit_int2b , lit_int1b, var_name}}
  - FIRST <Div> ::= {“(“, {lit_int8b, lit_int4b, lit_int2b , lit_int1b, var_name}}

PART C (PAGE 2)

- FIRST <Subtr> ::= {“(“, {lit_int8b, lit_int4b, lit_int2b , lit_int1b, var_name}}
- FIRST <Mod> ::= {“(“, {lit_int8b, lit_int4b, lit_int2b , lit_int1b, var_name}}
- FIRST <Factor> ::= {“(“, {lit_int8b, lit_int4b, lit_int2b , lit_int1b, var_name}}
- FIRST <Number> ::= {lit_int8b}, { lit_int4b }, {lit_int2b }, { lit_int1b }, {var_name}

➔ Because there are no matching terminal symbols in each of the non terminals’ FIRST sets (the alternatives of each non-terminal is disjoint), these grammar rules passes the pairwise disjointness test

PART D: PROVE GRAMMAR IS UNAMBIGUOUS

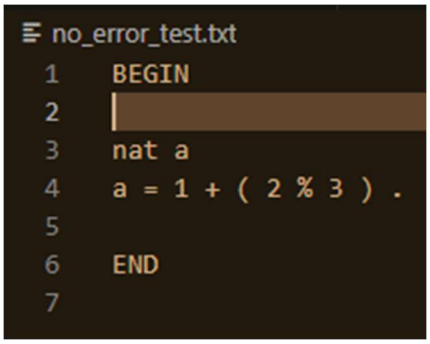
- My grammar is not ambiguous because It passes the pairwise disjointness test and because It is not possible to generate a string that has more than one parse tree in this grammar.

PART E: LEXICAL ANALYZER

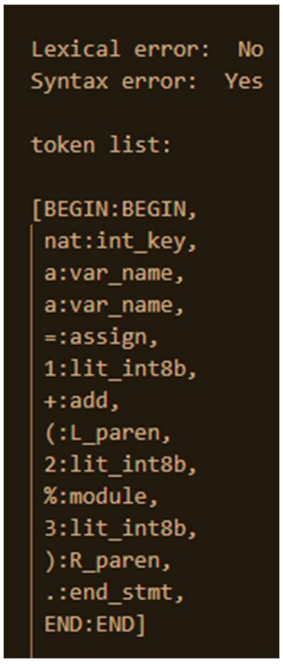
The lexical analyzer should:

- Recognize all tokens
- Produce a list of those tokens
- Print error message for lexical error
- Be object-oriented
- Have comments

Example 1: test file with no errors



Output:



The lexical analyzer recognized all tokens in the test file, produced a complete list of those tokens, confirmed that there were no lexical errors

PART E: (Page 2)

Code snippet of lexical analyzer:

```
64   #-------------------------------------------------------------
65   #                            LEXER
66   #-------------------------------------------------------------
67   class Lexer:
68       #read program (text file) and create a list of tokens
69       def tokenize(self, file):…
101
102
```

This tells us that the lexical analyzer is object-oriented and it has comments for its function

Test file with lexical error:

```
1   BEGIN
2
3   nat &&}
4
5   END
6
```

Its output:

```
[Running] python -u "d:\Coding\Python files\PLC\Exam
BEGIN

nat &&}

END


Lexical error:  &&}  at index:  2  (invalid lexeme)
```

This shows that the Lexer will print an error message when there is a lexical error.

PART F: SYNTACTICAL ANALYZER

My program only tells the user if there is a syntax error, it does not ouput a specific error message for most errorss

Examples:

- Test file with correct syntax:

```
BEGIN

nat a .
a = 13 - ( 3 % ( 8 / 2 ) - 50 ) .
nat b .
b = 0 .
itr 5 times [ b = b + 1 . ] .

END
```

- Its output:

```
BEGIN

nat a .
a = 13 - ( 3 % ( 8 / 2 ) - 50 ) .
nat b .
b = 0 .
itr 5 times [ b = b + 1 . ] .

END


Lexical error:  No
Syntax error:  No
```

This means that the variable declaration, the mathematical expression, the variable initialization, and the itr loop are all in the correct grammar.

PART F: (PAGE 2)

- Test file with syntax error in itr loop (missing brackets):

```
1   BEGIN
2
3   nat a .
4   a = 13 - ( 3 % ( 8 / 2 ) - 50 ) .
5   nat b .
6   b = 0 .
7   itr 5 times  b = b + 1 .
8
9   END
10
```

- Its output:

```
BEGIN

nat a .
a = 13 - ( 3 % ( 8 / 2 ) - 50 ) .
nat b .
b = 0 .
itr 5 times  b = b + 1 .

END


Syntax error: "[" expected
Lexical error:  No
Syntax error:  Yes
```

This shows that the syntax analyzer can find the correct syntax error in the text file

PART G: TEST FILES

- No_error_test1.txt:

```
no_error_test1.txt
1   BEGIN
2
3   nat a .
4   nat b .
5
6   a = 13_b1 - ( 3 % ( 8 / 2 ) - 50 ) .
7   b = a % 7 - 2 * 3 + ( a - 10 / ( a * 2 ) ) .
8
9   END
```

- Its output:

```
Lexical error:  No
Syntax error:  No

token list:

[BEGIN:BEGIN,
 nat:int_key,
 a:var_name,
 .:end_stmt,
 nat:int_key,
 b:var_name,
 .:end_stmt,
 a:var_name,
 =:assign,
 13_b1:lit_int1b,
 .:end_stmt,
 b:var_name,
 =:assign,
 a:var_name,
 +:add,
 7:lit_int8b,
 -:subtract,
 2:lit_int8b,
 *:multiply,
 3:lit_int8b,
 +:add,
 (:L_paren,
 a:var_name,
 -:subtract,
 10:lit_int8b,
 *:multiply,
 (:L_paren,
 a:var_name,
 *:multiply,
 2:lit_int8b,
 ):R_paren,
 ):R_paren,
 .:end_stmt,
 END:END]
```

PART G: TEST FILES

- No_error_test2.txt:

```
no_error_test2.txt
1   BEGIN
2
3   nat a .
4   nat b .
5   nat count .
6   a = 0 .
7
8   case ( a == 2 ) [ itr 6 times [ a = a + 1 . ] .
9   | | | | | | b = 0 .
10  | | | | | | b = b + a .
11  | | | | | | count = count + 1 .
12  ]
13  other [ b = -99 . ] .
14
15  END
```

- Its output:

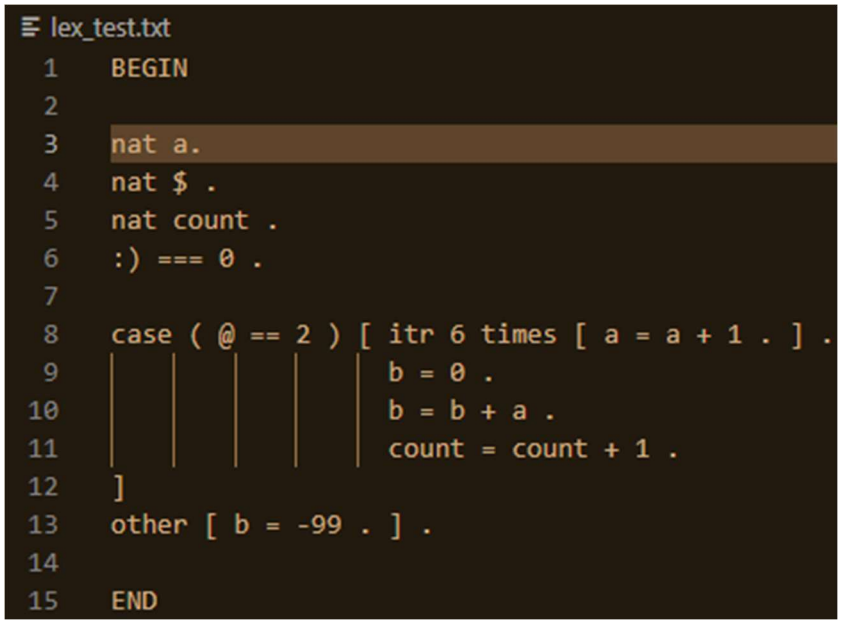
```
Lexical error:  No
Syntax error:  No

token list:

[BEGIN:BEGIN,
nat:int_key,
a:var_name,
.:end_stmt,
nat:int_key,
b:var_name,
.:end_stmt,
nat:int_key,
count:var_name,
.:end_stmt,
a:var_name,
=:assign,
0:lit_int8b,
.:end_stmt,
case:case_key,
(:L_paren,
a:var_name,
==:EQ,
2:lit_int8b,
):R_paren,
[:L_bracket,
itr:itr_key,
6:lit_int8b,
times:times_key,
[:L_bracket,
a:var_name,
=:assign,
a:var_name,
+:add,
1:lit_int8b,
.:end_stmt,
]:R_bracket,
.:end_stmt,
b:var_name,
=:assign,
0:lit_int8b,
.:end_stmt,
b:var_name,
=:assign,
b:var_name,
+:add,
a:var_name,
.:end_stmt,
count:var_name,
=:assign,
count:var_name,
+:add,
1:lit_int8b,
.:end_stmt,
]:R_bracket,
other:other_key,
[:L_bracket,
b:var_name,
=:assign,
-99:lit_int8b,
.:end_stmt,
]:R_bracket,
.:end_stmt,
END:END]
```

PART G: TEST FILES

- lex_test.txt: has 5 lexical errors



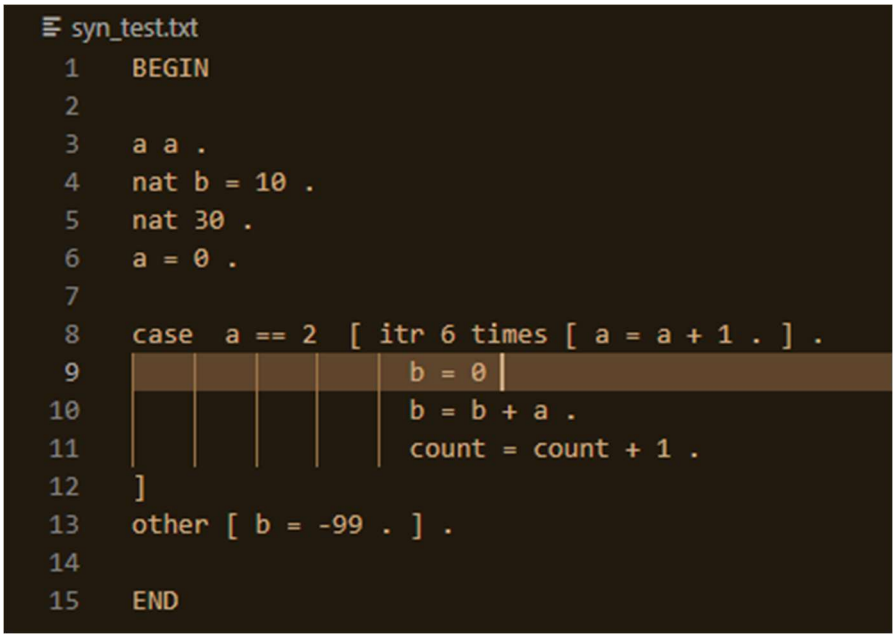
1. line 3: a. is not a valid variable name (a and "." Need to be separate)
2. line 4: $ is not a token in this language
3. line 6: :) is not a token in this language
4. line 6: === is not a token in this language
5. line 8: @ is not a token in this language

- Its output:

```
Lexical error:  a.  at index:  2  (invalid lexeme)
```

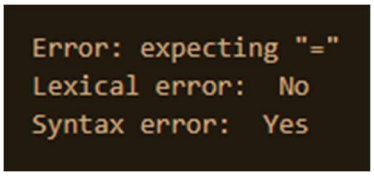
PART G: TEST FILES

- syn_test.txt: has 5 syntax errors



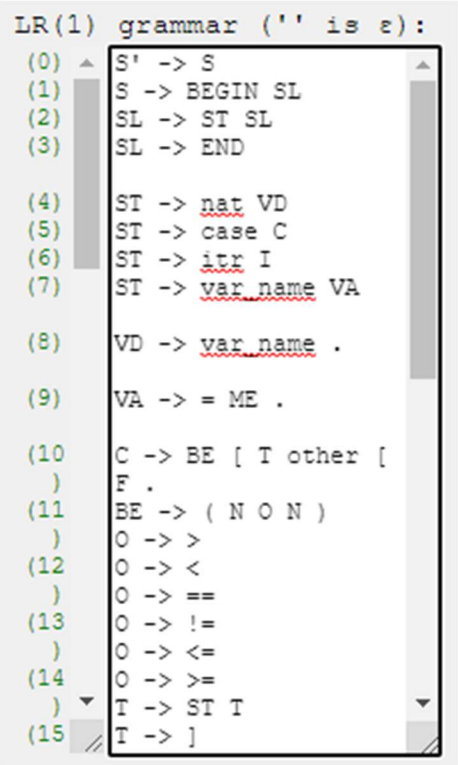
1. line 3: var_name can only be followed by “=”, a a . is not correct for var_assign
2. line 4: nat is first token -> this Is a var_declaration statement. Var_declaration does not have “=” or integer literals -> “=” and 10 should not be there
3. line 5: nat is first token -> this Is a var_declaration statement. Token nat can only be followed by a var_name, not 30.
4. line 8: “ a == 2 “ needs to have parentheses, correct syntax is “(a == 2)”
5. line 9: This is a var_assign statement, it needs “.” To end the statement.

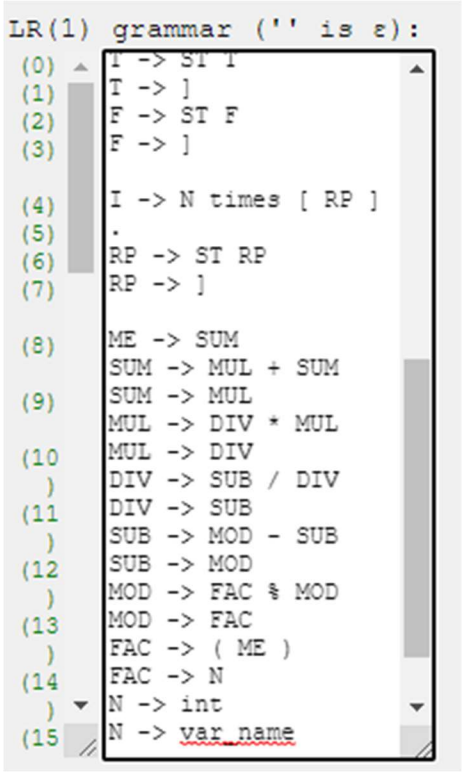
- Its output:



PART H: LR(1) PARSE TABLE

- The grammar input into the parser generator:





S = <Start> , SL = <Statement_list>, ST = <Statement>,

VD = <Var_decl>, VA = <Var_assign>, C = <Case>,

BE = <Boolean_expr>, O = <rela_op>, T = <If_true>,

F = <If_false>, I = <Itr>, RP = <To_repeat>,

ME = <Math_expr>, SUM = <Sum>, MUL = <Mul>,

DIV = <Div>, SUB = <Subtr>, MOD = <Mod>,

FAC = <Factor>, N = <Number>, int = {lit_int1b, lit_int2b, lit_4b, lit_8b}

PART H: (PAGE 2)

- FIRST table generated:

FIRST table	
Nonterminal	**FIRST**
S'	{BEGIN}
S	{BEGIN}
SL	{END,nat,case,itr,var_name}
ST	{nat,case,itr,var_name}
VD	{var_name}
VA	{=}
C	{(}
BE	{(}
O	{>,<,==,!=,<=,>=}
T	{nat,case,itr,var_name,]}
F	{nat,case,itr,var_name,]}
I	{int,var_name}
RP	{nat,case,itr,var_name,]}
ME	{(,int,var_name}
SUM	{(,int,var_name}
MUL	{(,int,var_name}
DIV	{(,int,var_name}
SUB	{(,int,var_name}
MOD	{(,int,var_name}
FAC	{(,int,var_name}
N	{int,var_name}

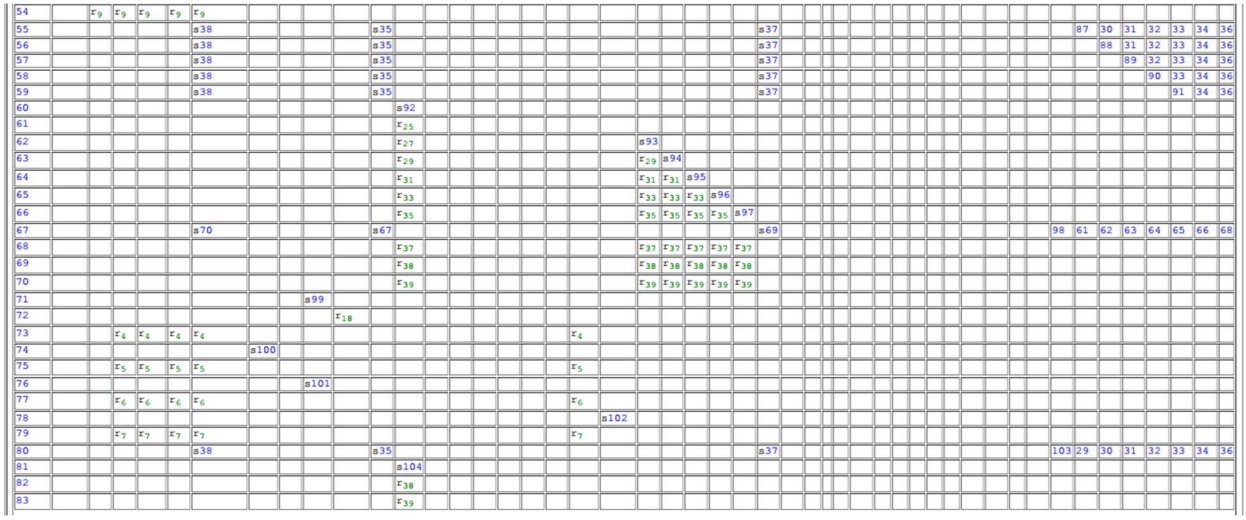
  - This table matches exactly with the pairwise disjoint test performed in part C

- **LR(1) parse table generated**:

LR table

State	ACTION																											GOTO																				
	BEGIN	END	nat	case	itr	var_name	.	=	[	other	(	)	>	<	==	!=	<=	>=	]	times	+	*	/	-	%	int	$	S'	S	SL	ST	VD	VA	C	BE	O	T	F	I	RP	ME	SUM	MUL	DIV	SUB	MOD	FAC	N
0	s2																												1																			
1																											acc																					
2		s5	s6	s7	s8	s9																								3	4																	
3																											r_1																					
4		s5	s6	s7	s8	s9																								10	4																	
5																											r_3																					
6						s12																										11																
7											s15																							13	14													
8						s19																				s18													16									17
9								s21																									20															
10																											r_2																					
11		r_4	r_4	r_4	r_4	r_4																																										
12							s22																																									
13		r_5	r_5	r_5	r_5	r_5																																										
14									s23																																							
15						s26																				s25																						24
16		r_6	r_6	r_6	r_6	r_6																																										
17																				s27																												
18																				r_{38}																												
19																				r_{39}																												
20		r_7	r_7	r_7	r_7	r_7																																										
21						s38					s35															s37															28	29	30	31	32	33	34	36
22		r_8	r_8	r_8	r_8	r_8																																										
23			s42	s43	s44	s45													s41												40						39											
24													s47	s48	s49	s50	s51	s52																		46												
25													r_{38}	r_{38}	r_{38}	r_{38}	r_{38}	r_{38}																														
26													r_{39}	r_{39}	r_{39}	r_{39}	r_{39}	r_{39}																														
27									s53																																							
28							s54																																									
29							r_{25}																																									
30							r_{27}														s55																											
31							r_{29}														r_{29}	s56																										
32							r_{31}														r_{31}	r_{31}	s57																									
33							r_{33}														r_{33}	r_{33}	r_{33}	s58																								
34							r_{35}														r_{35}	r_{35}	r_{35}	r_{35}	s59																							
35						s70					s67															s69															60	61	62	63	64	65	66	68
36							r_{37}														r_{37}	r_{37}	r_{37}	r_{37}	r_{37}																							
37							r_{38}														r_{38}	r_{38}	r_{38}	r_{38}	r_{38}																							
38							r_{39}														r_{39}	r_{39}	r_{39}	r_{39}	r_{39}																							
39										s71																																						
40			s42	s43	s44	s45													s41												40						72											
41										r_{19}																																						
42						s74																										73																
43											s15																							75	76													
44						s19																				s18													77									78
45								s80																									79															
46						s83																				s82																						81
47						r_{12}																				r_{12}																						
48						r_{13}																				r_{13}																						
49						r_{14}																				r_{14}																						
50						r_{15}																				r_{15}																						
51						r_{16}																				r_{16}																						
52						r_{17}																				r_{17}																						
53			s42	s43	s44	s45													s86												85									84								
54		r_9	r_9	r_9	r_9	r_9																																										

PART H: (PAGE 4)



State	BEGIN	END	nat	case	itr	var_name	.	=	[	other	(	)	>	<	==	!=	<=	>=	]	times	+	*	/	-	%	int	$	S'	S	SL	ST	VD	VA	C	BE	O	T	F	I	RP	ME	SUM	MUL	DIV	SUB	MOD	FAC	N
84																			s105																												
85			s42	s43	s44	s45													s86											85										106								
86																			r24																												
87							r26																																									
88							r28														r28																											
89							r30														r30	r30																									
90							r32														r32	r32	r32																								
91							r34														r34	r34	r34	r34																								
92							r36														r36	r36	r36	r36	r36																							
93						s70					s67														s69																							
94						s70					s67														s69																							
95						s70					s67														s69																							
96						s70					s67														s69																							
97						s70					s67														s69																							
98												s112																																				
99			s42	s43	s44	s45													s115											114							113										
100			r8	r8	r8	r8													r8																												
101			s42	s43	s44	s45													s41											40							116										
102								s117																																							
103							s118																																								
104								r11																																							
105							s119																																								
106																			r23																												
107												r26																																			
108												r28									r28																											
109												r30									r30	r30																								
110												r32									r32	r32	r32																								
111												r34									r34	r34	r34	r34																								
112												r36									r36	r36	r36	r36	r36																								
113							s120																																								
114			s42	s43	s44	s45													s115											114							121										
115							r21																																								
116										s122																																					
117			s42	s43	s44	s45															s86															85								123			
118			r9	r9	r9	r9															r9																										
119		r22	r22	r22	r22	r22																																								
120		r10	r10	r10	r10	r10																																								
121							r20																																								
122										s124																																					
123																					s125																										
124			s42	s43	s44	s45															s115															114								126			
125							s127																																								
126							s128																																								
127			r22	r22	r22	r22															r22																										
128			r10	r10	r10	r10															r10																										

Link to PDF of Parse table:[LR(1) parse table]

PART H: (PAGE 5)

- **Code sample 1**: “BEGIN var_name = int . END” (Pass)
- ```
  Input (tokens): BEGIN var_name = int . END
  ```
- This is a Var_assign statement: it follows the grammar correctly and ends the statement with “.” Like it should.
- Its trace:
-

Trace			
Step	Stack	Input	Action
1	0	BEGIN var_name = int . END $	s2
2	0 BEGIN 2	var_name = int . END $	s9
3	0 BEGIN 2 var_name 9	= int . END $	s21
4	0 BEGIN 2 var_name 9 = 21	int . END $	s37
5	0 BEGIN 2 var_name 9 = 21 int 37	. END $	r_{38}
6	0 BEGIN 2 var_name 9 = 21 N	. END $	36
7	0 BEGIN 2 var_name 9 = 21 N 36	. END $	r_{37}
8	0 BEGIN 2 var_name 9 = 21 FAC	. END $	34
9	0 BEGIN 2 var_name 9 = 21 FAC 34	. END $	r_{35}
10	0 BEGIN 2 var_name 9 = 21 MOD	. END $	33
11	0 BEGIN 2 var_name 9 = 21 MOD 33	. END $	r_{33}
12	0 BEGIN 2 var_name 9 = 21 SUB	. END $	32
13	0 BEGIN 2 var_name 9 = 21 SUB 32	. END $	r_{31}
14	0 BEGIN 2 var_name 9 = 21 DIV	. END $	31
15	0 BEGIN 2 var_name 9 = 21 DIV 31	. END $	r_{29}
16	0 BEGIN 2 var_name 9 = 21 MUL	. END $	30
17	0 BEGIN 2 var_name 9 = 21 MUL 30	. END $	r_{27}
18	0 BEGIN 2 var_name 9 = 21 SUM	. END $	29
19	0 BEGIN 2 var_name 9 = 21 SUM 29	. END $	r_{25}
20	0 BEGIN 2 var_name 9 = 21 ME	. END $	28
21	0 BEGIN 2 var_name 9 = 21 ME 28	. END $	s54
22	0 BEGIN 2 var_name 9 = 21 ME 28 . 54	END $	r_{9}
23	0 BEGIN 2 var_name 9 VA	END $	20
24	0 BEGIN 2 var_name 9 VA 20	END $	r_{7}
25	0 BEGIN 2 ST	END $	4
26	0 BEGIN 2 ST 4	END $	s5
27	0 BEGIN 2 ST 4 END 5	$	r_{3}
28	0 BEGIN 2 ST 4 SL	$	10
29	0 BEGIN 2 ST 4 SL 10	$	r_{2}
30	0 BEGIN 2 SL	$	3
31	0 BEGIN 2 SL 3	$	r_{1}
32	0 S	$	1
33	0 S 1	$	acc
  ```

PART H: (PAGE 6)

- **Code sample 2**: “BEGIN itr int times [nat var_name .] . END” (Pass)
- Input (tokens): BEGIN itr int times [nat var_name .] . END
- This is an itr (for loop) statement: the grammar: “itr (int or var_name) times [statement] .” is properly followed
- Its trace:

Trace			
Step	Stack	Input	Action
1	0	BEGIN itr int times [nat var_name .] . END $	s2
2	0 BEGIN 2	itr int times [nat var_name .] . END $	s8
3	0 BEGIN 2 itr 8	int times [nat var_name .] . END $	s18
4	0 BEGIN 2 itr 8 int 18	times [nat var_name .] . END $	r_{38}
5	0 BEGIN 2 itr 8 N	times [nat var_name .] . END $	17
6	0 BEGIN 2 itr 8 N 17	times [nat var_name .] . END $	s27
7	0 BEGIN 2 itr 8 N 17 times 27	[nat var_name .] . END $	s53
8	0 BEGIN 2 itr 8 N 17 times 27 [53	nat var_name .] . END $	s42
9	0 BEGIN 2 itr 8 N 17 times 27 [53 nat 42	var_name .] . END $	s74
10	0 BEGIN 2 itr 8 N 17 times 27 [53 nat 42 var_name 74	.] . END $	s100
11	0 BEGIN 2 itr 8 N 17 times 27 [53 nat 42 var_name 74 . 100	] . END $	r_8
12	0 BEGIN 2 itr 8 N 17 times 27 [53 nat 42 VD	] . END $	73
13	0 BEGIN 2 itr 8 N 17 times 27 [53 nat 42 VD 73	] . END $	r_4
14	0 BEGIN 2 itr 8 N 17 times 27 [53 ST	] . END $	85
15	0 BEGIN 2 itr 8 N 17 times 27 [53 ST 85	] . END $	s86
16	0 BEGIN 2 itr 8 N 17 times 27 [53 ST 85] 86	. END $	r_{24}
17	0 BEGIN 2 itr 8 N 17 times 27 [53 ST 85 RP	. END $	106
18	0 BEGIN 2 itr 8 N 17 times 27 [53 ST 85 RP 106	. END $	r_{23}
19	0 BEGIN 2 itr 8 N 17 times 27 [53 RP	. END $	84
20	0 BEGIN 2 itr 8 N 17 times 27 [53 RP 84	. END $	s105
21	0 BEGIN 2 itr 8 N 17 times 27 [53 RP 84 . 105	END $	r_{22}
22	0 BEGIN 2 itr 8 I	END $	16
23	0 BEGIN 2 itr 8 I 16	END $	r_6
24	0 BEGIN 2 ST	END $	4
25	0 BEGIN 2 ST 4	END $	s5
26	0 BEGIN 2 ST 4 END 5	$	r_3
27	0 BEGIN 2 ST 4 SL	$	10
28	0 BEGIN 2 ST 4 SL 10	$	r_2
29	0 BEGIN 2 SL	$	3
30	0 BEGIN 2 SL 3	$	r_1
31	0 S	$	1
32	0 S 1	$	acc

PART H: (PAGE 7)

- **Code sample 3**: “BEGIN var_name = int \ itr . END” (Fail: itr keyword should not be in Var_assign statement)
- Input (tokens): BEGIN var_name = int \ itr . END
- This is a Var_assign statement:
- Its trace:

Trace				Tree
Step	Stack	Input	Action	
1	0	BEGIN var_name = int \ itr . END $	s2	
2	0 BEGIN 2	var_name = int \ itr . END $	s9	
3	0 BEGIN 2 var_name 9	= int \ itr . END $	s21	
4	0 BEGIN 2 var_name 9 = 21	int \ itr . END $	s37	
5	0 BEGIN 2 var_name 9 = 21 int 37	\ itr . END $		

PART H: (PAGE 8)

- **Code sample 4**: “BEGIN var_name = var_name + int \ var_name END” (Fail: Var_assign statement needs an end_stmt token “.”)
- Input (tokens): BEGIN var_name = var_name + int \ var_name END
- This is a Var_assign statement:
- Its trace:

Trace				Tree
Step	Stack	Input	Action	
1	0	BEGIN var_name = var_name + int \ var_name END $	s2	
2	0 BEGIN 2	var_name = var_name + int \ var_name END $	s9	
3	0 BEGIN 2 var_name 9	= var_name + int \ var_name END $	s21	
4	0 BEGIN 2 var_name 9 = 21	var_name + int \ var_name END $	s38	
5	0 BEGIN 2 var_name 9 = 21 var_name 38	+ int \ var_name END $	r_{39}	
6	0 BEGIN 2 var_name 9 = 21 N	+ int \ var_name END $	36	
7	0 BEGIN 2 var_name 9 = 21 N 36	+ int \ var_name END $	r_{37}	
8	0 BEGIN 2 var_name 9 = 21 FAC	+ int \ var_name END $	34	
9	0 BEGIN 2 var_name 9 = 21 FAC 34	+ int \ var_name END $	r_{35}	
10	0 BEGIN 2 var_name 9 = 21 MOD	+ int \ var_name END $	33	
11	0 BEGIN 2 var_name 9 = 21 MOD 33	+ int \ var_name END $	r_{33}	
12	0 BEGIN 2 var_name 9 = 21 SUB	+ int \ var_name END $	32	
13	0 BEGIN 2 var_name 9 = 21 SUB 32	+ int \ var_name END $	r_{31}	
14	0 BEGIN 2 var_name 9 = 21 DIV	+ int \ var_name END $	31	
15	0 BEGIN 2 var_name 9 = 21 DIV 31	+ int \ var_name END $	r_{29}	
16	0 BEGIN 2 var_name 9 = 21 MUL	+ int \ var_name END $	30	
17	0 BEGIN 2 var_name 9 = 21 MUL 30	+ int \ var_name END $	s55	
18	0 BEGIN 2 var_name 9 = 21 MUL 30 + 55	int \ var_name END $	s37	
19	0 BEGIN 2 var_name 9 = 21 MUL 30 + 55 int 37	\ var_name END $		