School of Mathematical and Computational Sciences

Indian Association for the Cultivation of Science

Compiler Construction: COM 5202

Tutorial VIII (11 March 2026)

M. Sc Semester IV: 2025-2026 *Instructor:* Goutam Biswas

Exercise 1. *Consider the grammar given in Tutorial VI.*

$$
\begin{array}{rcl}
P & \rightarrow & \textbf{prog}\ DLO\ \textbf{start}\ CL \\
DLO & \rightarrow & DLO\ DL \mid \varepsilon \\
DL & \rightarrow & TY\ VL \\
TY & \rightarrow & \textbf{int} \mid \textbf{real} \\
VL & \rightarrow & VL\ \textbf{id} \mid \textbf{id} \\
CL & \rightarrow & CL\ C \mid C \\
C & \rightarrow & INC \mid OC \mid AC \\
INC & \rightarrow & \textbf{in id} \\
OC & \rightarrow & \textbf{out}\ E \mid \textbf{out str} \\
AC & \rightarrow & \textbf{id :}\ E \\
E & \rightarrow & E + T \mid E - T \mid T \\
T & \rightarrow & T * F \mid T / F \mid F \\
F & \rightarrow & -F \mid +F \mid \textbf{ic} \mid \textbf{rc} \mid \textbf{id} \mid (\ E\ )
\end{array}
$$

(a) *Remove left-recursion from the E and T production rules.*

(b) *Write a parser for the modified grammar using Bison. Note that for a LALR parser removal of left recursion is not necessary. But we wish to learn how mid-production rule actions are specified.*

(c) *Write semantic actions corresponding to the rules of OC, E, T, F and the new non-terminals E', T' introduced after the removal of left-recursions. No semantic action at this stage for* $F \rightarrow \textbf{id}$.

(d) *An example of semantic action for* $E \rightarrow T\ E'$ *is as follows:*

```
%union  {              /* type of 'yylval' (stack type)        */
int integer ;          /* type name is YYSTYPE                 */
double real ;
char *string;
}

%token PROG START INT REAL ID IN OUT <string>STR <integer>IC <real>RC
%type  <real> e ep t tp

e: t {$<real>$=$1;} ep {$$ = $3;}
;
```

Note the following points:

(a) *A sample* `Makefile` *is as follows:*

```
src = exp
objfiles = $(src).tab.o lex.yy.o

a.out :  $(objfiles)
   cc $(objfiles)

$(src).tab.c : $(src).y
    bison -d $(src).y

lex.yy.c : $(src).l
   flex $(src).l

$(src).tab.o: $(src).tab.c
   cc -Wall -c $(src).tab.c

lex.yy.o : lex.yy.c
   cc -Wall -c lex.yy.c

clean :
   rm calc $(src).tab.c $(src).tab.h lex.yy.c $(objfiles)
```

(b) `Bison` *will generate the parse (*`exp.tab.c`*) and the header file* `exp.tab.h`*:*
`$ bison -d exp.y`

(c) *Include the header file in the scanner specification* `exp.l`*. There is no* `y.tab.h`*. You may have to modify the scanner specification.*

(d) *Finally prepare a* `.tar` *file using the following command.*
`$ tar cvf <roll no>.8.tar exp.l exp.y Makefile`
Send the `.tar` *file to* `goutamamartya@gmail.com`*.*

A few input/output of the parser-interpreter are as follows:

Input: `d0`

```
prog
  real A1 A2
  int B1 B2 B3
start
  in A1
  in A2
  B1: A1/A2
  out B1
  B2: B1+2*A1/A2
```

Output:

```
$ ./a.out < d0
0.00000
```

Input: `d1`

```
prog
start
  out "Indian Association for the Cultivation of Science"
```

Output:

```
$ ./a.out < d1
Indian Association for the Cultivation of Science
```

Input: d2

```
prog
start
  out  2+5/(4-2)*3
```

Output:

```
$ ./a.out < d2
9.500000
```

Input: d3

```
prog
start
  out  2+5/(4 2)*3
```

Output:

```
$ a.out < d3
syntax error: lc:3, t:266
```

Input: d4

```
prog
  out  2+5/(4-2)*3
```

Output:

```
$ a.out < d4
syntax error: lc:2, t:264
```

Input: d4

```
prog
start
  out  2+5/4-2)*3
```

Output:

```
$ a.out < d5
1.250000
syntax error: lc:3, t:41
```

Exercise 2.
Consider the language $L_2 = \{0^n 1^m : m, n \in \mathbb{N}\} \cup \{1^m 0^n : m, n \in \mathbb{N}\}$.

(a) *Is* L_2 *regular?*

(b) *Give an* $LL(1)$ *grammar for it.*

(c) *Give a non-*$LL(1)$ *grammar for it.*

Exercise 3.

(a) *Show that the following grammar is not $LL(1)$. Can you transform it to an equivalent $LL(1)$ grammar?*

$$\begin{aligned} S &\rightarrow aA \\ A &\rightarrow a\ A\ b \mid ab \end{aligned}$$

(b) *Show that the following grammar is $LL(2)$. Can you transform it to an equivalent $LL(1)$ grammar?*

$$\begin{aligned} S &\rightarrow a\ S\ A \mid \varepsilon \\ A &\rightarrow a\ b\ S \mid c \end{aligned}$$