# Homework 2 - LL Parsing - Solution

## Objectives

1. Demonstrate an ability to convert a grammar into an equivalent LL grammar.
2. Demonstrate an ability to produce an LR automata from a grammar.

## LL Problems

(5 pts. each) For each of these grammars, convert it to an equivalent LL grammar or else assert that it is already LL.

```
Problems                    Solutions

------------------- 1 ----------------------
S   ::= x E                 S   ::= x E
      | z                         | z
E   ::= E a E               E   ::= c E'
      | E b E               E'  ::= a E E'
      | c                         | b E E'
                                  | eps

------------------- 2 ----------------------
S   ::= z y                 Already LL
      | y E
E   ::= S a
      | x a

------------------- 3 ----------------------
S   ::= x E                 S   ::= x E S'
      | x E y                       | z
      | z                   S'  ::= y
E   ::= a E                         | eps
      | b                   E   ::= a E
                                  | b
```

# LR Problem

Consider the following grammar:

```
1   S   ::= ( S S )
2         | * V
3   V   ::= * V
4         | p
```

## Part 1

(5 pts.) First, calculate the first and follow sets for the non-terminals of the grammar.

```
First(S) = { ( , * }
First(V) = { * , p }

Follow(S) = { ( , * , ) , $ }
Follow(V) = { ( , * , ) , $ }
```

## Part 2

(30 pts.) Now, describe the LR automata for the grammar by listing the item sets (states) and filling out the action and goto tables.

**States**

0. `S ::= . ( S S )`
   `S ::= . * V`
1. `S ::= ( . S S )`
   `S ::= . ( S S )`
   `S ::= . * V`
2. `S ::= * . V`
   `V ::= . * V`
   `V ::= . p`
3. `S ::= ( S . S )`
   `S ::= . ( S S )`
   `S ::= . * V`
4. `S ::= * V .`
5. `V ::= * . V`
   `V ::= . * V`
   `V ::= . p`
6. `V ::= p .`
7. `S ::= ( S S . )`
8. `V ::= * V .`
9. `S ::= ( S S ) .`

**Action**

| | p | * | ( | ) | $ |
|---|---|---|---|---|---|
| 0 | | S | S | | |
| 1 | | S | S | | |
| 2 | S | S | | | |
| 3 | | S | S | | |
| 4 | | R2 | R2 | R2 | R2 |
| 5 | S | S | | | |
| 6 | | R4 | R4 | R4 | R4 |
| 7 | | | | S | |
| 8 | | R3 | R3 | R3 | R4 |
| 9 | | R1 | R1 | R1 | R1 |

**Goto**

| | p | * | ( | ) | $ | S | V |
|---|---|---|---|---|---|---|---|
| 0 | | 2 | 1 | | | | |
| 1 | | 2 | 1 | | | 3 | |
| 2 | 6 | 5 | | | | | 4 |
| 3 | | 2 | 1 | | | 7 | |
| 4 | | | | | | | |
| 5 | 6 | 5 | | | | | 8 |
| 6 | | | | | | | |
| 7 | | | | 9 | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |