

# NJIT



New Jersey's Science &  
Technology University

***THE EDGE IN KNOWLEDGE***

# **CS 280**

# **Programming Language**

# **Concepts**

## **Exam Prep**

# What To Look For

- CLOSED BOOK, CLOSED NOTES
- Some Multiple Choice Questions
- Some Short Answer Questions on topics from lecture
- Regular Expression Problems
- Parsing Problems
- Questions about scope of names

# Regular Expression Problems

- Given a description of a pattern, write a regular expression
- Given a diagram of a DFA, describe the regular expression it represents
- Given a regular expression or a diagram of a DFA, and a string, would the string be matched?

# Parsing Problems

- Would a string be recognized as part of a language specified by a set of BNF rules?
- Given a set of grammar rules, write a derivation
- Given a derivation, draw a parse tree

# Is a string in the language?

Terminals: NUMBER (a sequence of digits), ID (a sequence of characters starting with a letter), + and \*

Nonterminals: E, T, P

Start symbol: E

$E \rightarrow E + T \mid T$

$T \rightarrow T * P \mid P$

$P \rightarrow \text{NUMBER} \mid \text{ID}$

1.3 + 7

– yes

2.2 \* \* 5

– No, there is no repeated sequence of \* in the language

3.2 \* 3 + (5 \* foo)

– No, parens are not in the language

# Do a derivation

- *Tokens: +, -, (, ), INTEGER*
- *Rules:*  
$$\text{Expr} \rightarrow \text{Expr} + \text{Term} \mid \text{Expr} - \text{Term} \mid \text{Term}$$
$$\text{Term} \rightarrow \text{INTEGER} \mid ( \text{Expr} )$$
- **In EBNF:**  
$$\text{Expr} \rightarrow \text{Term} \{ (+|-) \text{Expr} \}$$
$$\text{Term} \rightarrow \text{INTEGER} \mid ( \text{Expr} )$$

# Leftmost Derivation

$\text{Expr} \rightarrow \text{Term} \{ (+|-) \text{Expr} \}$

$\text{Term} \rightarrow \text{INTEGER} \mid ( \text{Expr} )$

**2 – 1 + 4**

$\text{Expr} \rightarrow \text{Term} \{ (+|-) \text{Expr} \}$

$\text{Expr} \rightarrow \text{INTEGER} \{ (+|-) \text{Expr} \}$

$\text{Expr} \rightarrow 2 \{ (+|-) \text{Expr} \}$

$\text{Expr} \rightarrow 2 - \text{Expr}$

$\text{Expr} \rightarrow 2 - \text{Term} \{ (+|-) \text{Expr} \}$

$\text{Expr} \rightarrow 2 - \text{INTEGER} \{ (+|-) \text{Expr} \}$

$\text{Expr} \rightarrow 2 - 1 \{ (+|-) \text{Expr} \}$

$\text{Expr} \rightarrow 2 - 1 + \text{Expr}$

$\text{Expr} \rightarrow 2 - 1 + \text{Term} \{ (+|-) \text{Expr} \}$

$\text{Expr} \rightarrow 2 - 1 + 4 \{ (+|-) \text{Expr} \}$

$\text{Expr} \rightarrow 2 - 1 + 4$



# Another Derivation

Expr  $\rightarrow$  Term { (+|-) Expr }

Term  $\rightarrow$  INTEGER | ( Expr )

**( 2 + 3 ) + 12**

Expr  $\rightarrow$  Term { (+|-) Expr }

Expr  $\rightarrow$  ( Expr ) { (+|-) Expr }

Expr  $\rightarrow$  ( Term { (+|-) Expr } ) + { (+|-) Expr }

Expr  $\rightarrow$  ( INTEGER { (+|-) Expr } ) { (+|-) Expr }

Expr  $\rightarrow$  ( 2 { (+|-) Expr } ) { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + Expr ) { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + Term { (+|-) Expr } ) { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + INTEGER { (+|-) Expr } ) { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + 3 { (+|-) Expr } ) { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + 3 ) { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + 3 ) + Expr

Expr  $\rightarrow$  ( 2 + 3 ) + Term { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + 3 ) + INTEGER { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + 3 ) + 12 { (+|-) Expr }

Expr  $\rightarrow$  ( 2 + 3 ) + 12

# Show a parse tree

- *Tokens: +, -, (, ), INT, ID*
- *Rules:*

$$E \rightarrow E + T \mid E - T \mid T$$
$$T \rightarrow T * P \mid T / P \mid P$$
$$P \rightarrow \text{INT} \mid \text{ID} \mid ( E )$$

- **EBNF**

$$E \rightarrow T \{ (+|-) E \}$$
$$T \rightarrow P \{ (*|/) T \}$$
$$P \rightarrow \text{INT} \mid \text{ID} \mid ( E )$$

# Derivation and Parse Tree

2+x\*4

T { (+|-) E }

P { (\*|/) T } { (+|-) E }

INT { (\*|/) T } { (+|-) E }

2 { (\*|/) T } { (+|-) E }

2 { (+|-) E }

2 + E

2 + T { (+|-) E }

2 + P { (\*|/) T } { (+|-) E }

2 + ID { (\*|/) T } { (+|-) E }

2 + x { (\*|/) T } { (+|-) E }

2 + x \* T { (+|-) E }

2 + x \* P { (\*|/) T } { (+|-) E }

2 + x \* INT { (\*|/) T } { (+|-) E }

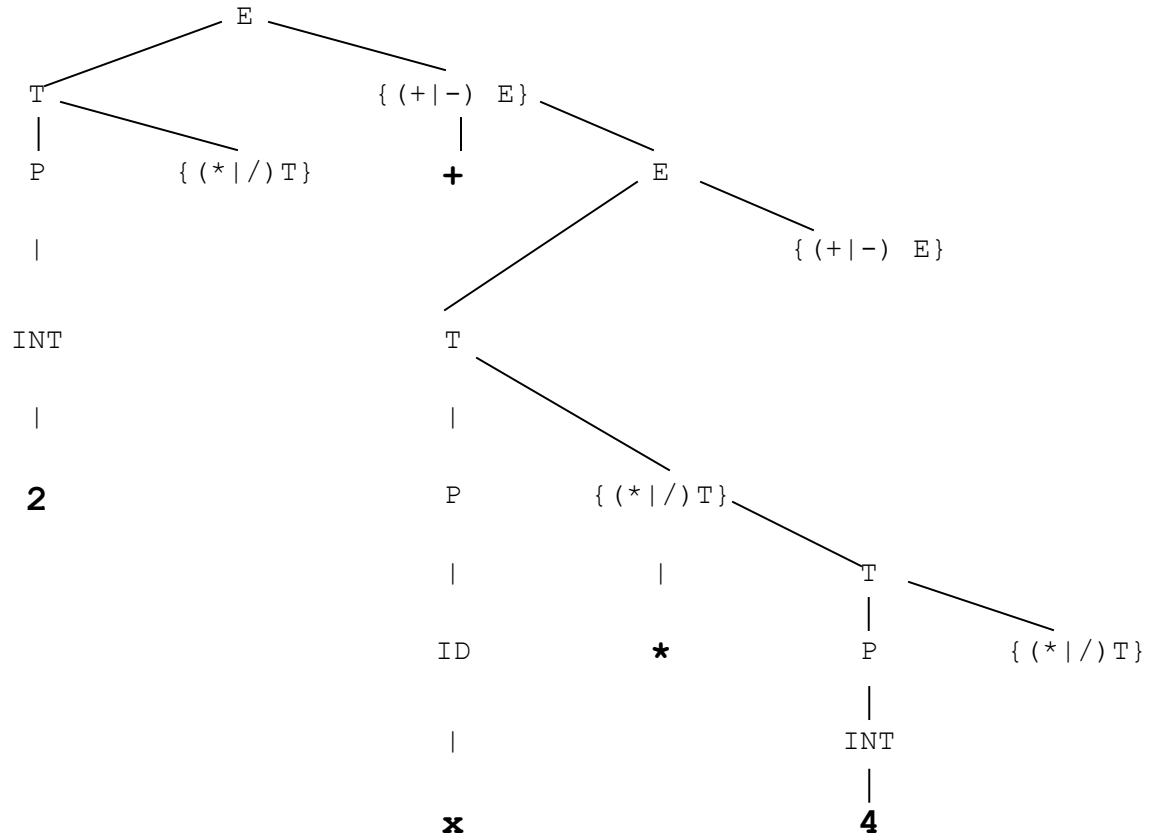
2 + x \* 4 { (\*|/) T } { (+|-) E }

2 + x \* INT { (\*|/) T } { (+|-) E }

2 + x \* 4 { (\*|/) T } { (+|-) E }

2 + x \* 4 { (+|-) E }

2 + x \* 4



# More About Derivations

- How do I know which production to choose?
  - Programatically, that is
- For each symbol, what are all the leftmost symbols derivable from that symbol? This is the “First Set”, the set of all things that could be the leftmost symbols derived from that symbol
  - The set of all terminals that can start the derivation

$Expr \rightarrow Expr + Term \mid Expr - Term \mid Term$   
 $Term \rightarrow INTEGER \mid ( Expr )$

- $First(Term)$  is  $\{ 0, 1, 2, \dots, 9, ( \}$
- $First(Expr)$  is  $First(Term)$

Expr  $\rightarrow$  Expr + Term | Expr – Term | Term  
Term  $\rightarrow$  Term \* Factor | Term / Factor |  
Term % Factor | Factor  
Factor  $\rightarrow$  Primary \*\* Factor | Primary  
Primary  $\rightarrow$  0 | ... | 9 | ( Expr )

First(Primary) = { 0-9, ( }  
First(Factor) = First(Primary)  
First(Term) = First(Factor)  
First(Expr) = First(Term)

Rewrite grammar using EBNF:

Expr  $\rightarrow$  Term { (+|-) Expr }  
Term  $\rightarrow$  Factor { (\*|/|% ) Term }  
Factor  $\rightarrow$  Primary { \*\* Factor }  
Primary  $\rightarrow$  0 | ... | 9 | ( Expr )

# Parse $5 + 2 + 3$

Expr

Expr  $\rightarrow$  Term { (+|-) Expr }

Expr  $\rightarrow$  Factor { (\*|/|%) Term } { (+|-) Expr }

Expr  $\rightarrow$  Primary { \*\* Factor } { (\*|/|%) Term } { (+|-) Expr }

Expr  $\rightarrow$  5 { \*\* Factor } { (\*|/|%) Term } { (+|-) Expr }

Expr  $\rightarrow$  5 { (\*|/|%) Term } { (+|-) Expr }

Expr  $\rightarrow$  5 { (+|-) Expr }

Expr  $\rightarrow$  5 + Expr

Expr  $\rightarrow$  5 + Term { (+|-) Expr }

Expr  $\rightarrow$  5 + Factor { (\*|/|%) Term } { (+|-) Expr }

Expr  $\rightarrow$  5 + Primary { \*\* Factor } { (\*|/|%) Term } { (+|-) Expr }

Expr  $\rightarrow$  5 + 2 { \*\* Factor } { (\*|/|%) Term } { (+|-) Expr }

Expr  $\rightarrow$  5 + 2 { (\*|/|%) Term } { (+|-) Expr }

Expr  $\rightarrow$  5 + 2 { (+|-) Expr }

Expr  $\rightarrow$  5 + 2 + Expr

...

Expr  $\rightarrow$  5 + 2 + 3 { (+|-) Expr }

Expr  $\rightarrow$  5 + 2 + 3

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