COS 301 Spring 2025 Midterm Exam 1 45 minutes; 45 pts.; 5 questions; 8 pgs. 2025-02-26 10:00 a.m.

Name: ____

1. (1 pt.)
   - **Read all material carefully.**
   - *If in doubt whether something is allowed, ask, don't assume.*
   - You may refer to **your** books, papers, and notes during this test. (No sharing.)
   - **E-books** may be used **subject to the restrictions** noted in class. (Briefly, do only those things with an e-book that are just as easily done with a physical book.)
   - **Computers of any kind** (including tablets, phones, and similar devices) are **not permitted** except when used exclusively as e-book readers.
   - **Network access** of any kind (cell, voice, text, data, ...) is **not permitted**.
   - Write, and draw, carefully. Ambiguous or cryptic answers receive zero credit.
   - Use class and textbook **conventions** for notation, algorithmic options, etc.
   - Questions that ask for **explanations** allocate a sizable fraction of points to those. **Answers without sufficient explanations will score very poorly.**
   - Do not add, remove, detach, or mangle pages (causes scanner problems).
   - Budget your **time**, noting that *number of points = number of minutes.*

Write your name in the space provided above.
Do not write anything else on this page.

WAIT UNTIL INSTRUCTED TO CONTINUE TO REMAINING QUESTIONS.

(Do not view any other pages.)

Do not write on this page.
(It is for use in grading only.)

Q	Full	Score
1	1	
2	9	
3	15	
4	10	
5	10	
total	45	

2. (9 pts.) Answer the following questions briefly, in the context of the *PLY* system as discussed in class and the `parser.out` excerpt below. Express your answer **without relying on** parser.out (yacc/PLY) jargon like *shift* and *reduce* but use more common terms like pushing and popping of a stack.

```
 1 state 17
 2
 3     (4) expression -> expression - expression .
 4     (3) expression -> expression . + expression
 5     (4) expression -> expression . - expression
 6     (5) expression -> expression . * expression
 7     (6) expression -> expression . / expression
 8
 9     +               reduce using rule 4 (expression -> expression - expression .)
10     -               reduce using rule 4 (expression -> expression - expression .)
11     $end            reduce using rule 4 (expression -> expression - expression .)
12     )               reduce using rule 4 (expression -> expression - expression .)
13     *               shift and go to state 10
14     /               shift and go to state 11
15
16   ! *               [ reduce using rule 4 (expression -> expression - expression .) ]
17   ! /               [ reduce using rule 4 (expression -> expression - expression .) ]
18   ! +               [ shift and go to state 8 ]
19   ! -               [ shift and go to state 9 ]
```

(a) [3 of 9 pts.] What is the action taken by the pushdown automaton described by `parser.out` when it is in state 17 and the next input token is a `*` (star character)? Which part of the parser.out listing encodes this information?

(b) [3 of 9 pts.] What is the meaning and significance of the exclamation marks (`!` characters) near the beginning of lines 16–19?

(c) [3 of 9 pts.] What is the interpretation of line 11 of the above listing? That is, what does it mean in in terms of actions taken by the pushdown automaton, and under what conditions?

3. (15 pts.) Consider the following context-free grammar, which uses ε to represent an empty (no terminals or nonterminals) right-hand side of a rule.

$$\begin{array}{rcl} S & \rightarrow & (\ F\ S\ ) \mid S\ S \mid \mathtt{i} \mid \mathtt{n} \mid \varepsilon \\ F & \rightarrow & + \mid - \end{array}$$

(a) [5 of 15 pts.] For each symbol used above, indicate whether it belongs to the *language* (defined by the grammar) or the *metalanguage* or the *meta-metalanguage* by placing a check-mark in the proper column for each row of the table below. [Provide *brief* explanations **iff** you wish to better qualify for credit, but note the points and time.]

symbol	:	language?	metalanguage?	meta-metalanguage?
S	:			
$\rightarrow$	:			
(	:			
F	:			
)	:			
$\mid$	:			
`i`	:			
`n`	:			
ε	:			
`+`	:			
`-`	:			

(b) [10 of 15 pts.] State clearly whether the following *sentence* is *valid* (belongs to the language of the grammar). If it does then provide a leftmost derivation for it; else explain (as precisely as possible) why it does not. Ignore all whitespace.

```
( + ( - ( + n i n ) i i ) n )
```

4. (10 pts.) If the sentence of Question 3 that is not valid then make as small a change as possible to yield a valid sentence. Write the sentence from that question, possibly modified as above, here. Then provide a parse tree for it that corresponds to the derivation of Question 3.

5. (10 pts.) Repeat Question 4 but provide an abstract syntax trees (AST) instead of a parse tree. *State any assumptions* made regarding the semantics of the terminals of the grammar.