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.
   - E-books may be used *subject to the restrictions* noted in class.
   - Computers are not permitted, except when used strictly as e-books.
   - 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.

   Write your name in the space provided above.

WAIT UNTIL INSTRUCTED TO CONTINUE TO REMAINING QUESTIONS.

Do not write on this page below this point.

Q	Full	Score
1	1	
2	9	
3	10	
4	10	
5	10	
total	40	

2. (9 pts.) Answer the following briefly, **in the context of the *PLY* system as discussed in class**.

   (a) What is the main difference between literal and non-literal tokens?

   (b) Provide a code snippet that defines the literal tokens `+` and `*`.

   (c) Provide a code snippet that defines the non-literal tokens `node` and `edge`.

3. (10 pts.) Consider the following context-free grammar.

$$\begin{aligned} S &\rightarrow S\ F\ S \mid \texttt{i} \mid \texttt{n} \\ F &\rightarrow + \mid - \mid * \mid / \end{aligned}$$

(a) For each symbol used above (S, F, $\rightarrow$, $|$, `i`, `n`, $+$, $-$, $*$, $/$), indicate whether it belongs to the *language* (defined by the grammar) or the *metalanguage* or the *meta-metalanguage*. Provide *brief* explanations **iff** you wish to qualify for any partial credit.

(b) For each of the following *sentences*, state clearly whether the 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.

(1) `i + n * i / n - i`

(2) `i * n + i - n / i / n`

[additional space for earlier material]

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

[additional space for earlier material]

5. (10 pts.) Repeat Question 4 but provide abstract syntax trees (ASTs) instead of parse trees.

[additional space for earlier material]