Name: _____

Solutions

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.

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? Ⓐ*Non-literal tokens may have data associated with them, such as the actual number for a token representing numbers. Literal tokens have no such data.*

   (b) Provide a code snippet that defines the literal tokens `+` and `*`. Ⓐ `literals = ['+', '-']`

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

   Ⓐ*Language (simple arithmetic expressions) symbols: (*`i`*,* `n`*,* $+$*,* $-$*,* $*$*,* $/$*). Metalanguage (CFG) symbols: (*S*,* F*,* $\rightarrow$*). Meta-metalanguage symbols: (*$|$*). [There is some permissible variation for metalanguage v. meta-metalanguage.]*

(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`

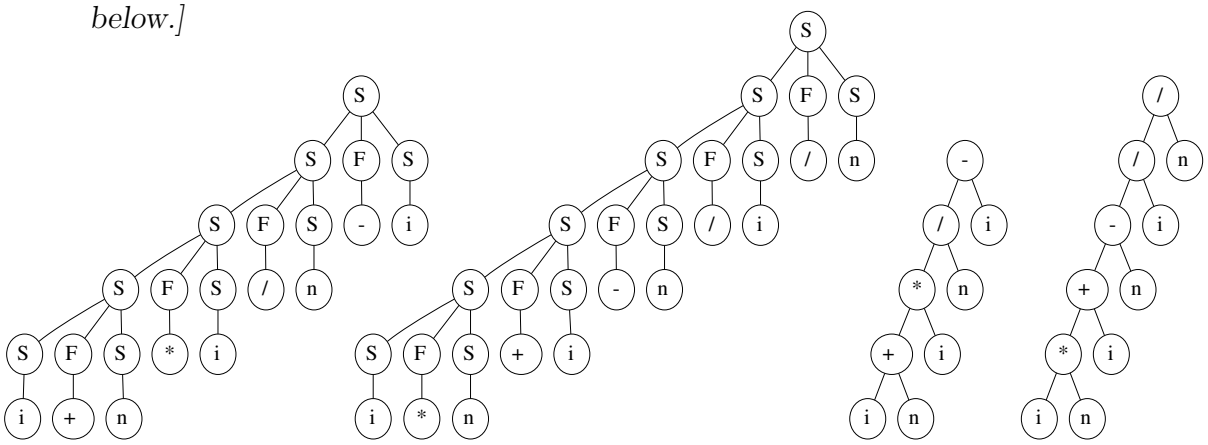
Ⓐ *Both sentences are valid.*

$$
\begin{aligned}
\underline{S} &\Rightarrow \underline{S}FS \\
&\Rightarrow \underline{S}FSFS \\
&\Rightarrow \underline{S}FSFSFS \\
&\Rightarrow \underline{S}FSFSFSFS \\
&\Rightarrow i\underline{F}SFSFSFS \\
&\Rightarrow i+\underline{S}FSFSFS \\
&\Rightarrow i+n\underline{F}SFSFS \\
&\Rightarrow i+n*\underline{S}FSFS \\
&\Rightarrow i+n*i\underline{F}SFS \\
&\Rightarrow i+n*i/\underline{S}FS \\
&\Rightarrow i+n*i/n\underline{F}S \\
&\Rightarrow i+n*i/n-\underline{S} \\
&\Rightarrow i+n*i/n-i
\end{aligned}
$$

$$
\begin{aligned}
\underline{S} &\Rightarrow \underline{S}FS \\
&\Rightarrow \underline{S}FSFS \\
&\Rightarrow \underline{S}FSFSFS \\
&\Rightarrow \underline{S}FSFSFSFS \\
&\Rightarrow \underline{S}FSFSFSFSFS \\
&\Rightarrow i\underline{F}SFSFSFSFS \\
&\Rightarrow i*\underline{S}FSFSFSFS \\
&\Rightarrow i*n\underline{F}SFSFSFS \\
&\Rightarrow i*n+\underline{S}FSFSFS \\
&\Rightarrow i*n+i\underline{F}SFSFS \\
&\Rightarrow i*n+i-\underline{S}FSFS \\
&\Rightarrow i*n+i-n\underline{F}SFS \\
&\Rightarrow i*n+i-n/\underline{S}FS \\
&\Rightarrow i*n+i-n/i\underline{F}S \\
&\Rightarrow i*n+i-n/i/\underline{S} \\
&\Rightarrow i*n+i-n/i/n
\end{aligned}
$$

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.

Ⓐ *No changes are needed since both original sentences are valid. [Leftmost two trees below.]*



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

Ⓐ *[Rightmost two trees above.]*