Do not open this exam until instructed to do so. The exam consists of 5 problems. Please check that you have all the pages.

The answers to the exam problems should be written in the space provided with the question. Read each question carefully before answering. Make sure you print your answer neatly!

During the exam it is prohibited to:
1. Use any books or notes.
2. Use any electronic aid, including calculators.
3. Exchange information with any person other than the exam proctor.
4. Leave the exam room before you turn in your exam.

It is strongly suggested that you use all the time available. If you finish early, double check your work. By signing below you acknowledge that you have read and understood all of the instructions above.

Good luck!

NJIT Academic Honor Code Agreement

On my honor, I pledge that I have not violated the provisions of the NJIT Academic Honor Code.

Name: ___________________________  SID: ________________________

Signature: _________________________  Section: ____________________
Problem 1.

Show that the following grammar is ambiguous by providing two distinct parse trees for some input string.

\[
\begin{align*}
E & \rightarrow T \ast E \mid T - E \mid T \\
T & \rightarrow P \ast T \mid P / T \mid P \\
P & \rightarrow I \mid E \\
I & \rightarrow a \mid b \mid c \mid \ldots \mid x \mid y \mid z
\end{align*}
\]
Problem 2.

Using the following extended BNF grammar:

\[
\begin{align*}
\text{<assign>} & \Rightarrow \text{id} := \text{<expr>} \\
\text{<expr>} & \Rightarrow \text{<expr>} + \text{<expr>} | \text{<expr>} * \text{<expr>} | (\text{<expr>}) | \text{id} \\
\text{id} & \Rightarrow A | B | C
\end{align*}
\]

Show a parse tree, if one exists, for each of the following. If no parse tree exists write “No such parse tree exists.”

a. \( A := A * (B + C) \)

b. \( B := (A + B) * (B := C) \)
Problem 3.

Given the following program:

```c
1 int h, i;
2 void B(int w) {
3    int j, k;
4    i = 2 * w;
5    w = w + 1;
6    ...
7 }
8 void A(int x, int y) {
9    float i, j;
10   B(h);
11   i = 3;
12   ...
13 }
14 void main() {
15   int a, b;
16   h = 5; a = 3; b = 2;
17   A(a, b);
18   B(h);
19   ...
20 }
```

a. Assume dynamic scoping and a call history of: main(line 17) → A(line 10) → B. For each function list all of the variables referenced and the line on which it was declared.

b. Assume dynamic scoping and a call history of: main(line 18) → B. For each function list all of the variables referenced and the line on which it was declared.
Problem 4.

Using the following grammar:

\[
\text{<integer>} \Rightarrow \text{<digit>} \mid \text{<integer><digit>}
\]

\[
\text{<digit>} \Rightarrow 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9
\]

a. Develop a leftmost derivation for the integer 9075

b. Develop a rightmost derivation for the integer 9075

c. In general how many steps are required to derive an integer with an arbitrary number of digits?
Problem 5.

Write a non-extended BNF grammar that produces strings in the following language:

\[ \Sigma = \{ a, b \} \]

\[ L = \{ w \in \Sigma^* | \text{such that } w \text{ is equal to the reverse of } w \} \]

For example, the strings \( aba \), \( bab \), and \( ababa \) are in the language, but the string \( ababab \) is not.