1 Instructions

(a) The midterm is to be turned in by 12:10 pm.
(b) Each question is worth 4 points.
(c) Attempt as many questions as you can; you will be given partial credit.

2 Problems

1. Language Design Principles: Using the various languages discussed in class, explain the following concepts:
   (i) Generality.
   (ii) Uniformity.
   (iii) Extensibility.
   (iv) Restrictability.

2. CFG Design:
   (i) A palindrome is a word that reads the same forward and backward; for instance, “noon” is a palindrome over the English alphabet. Consider the alphabet \( \Sigma = \{0, 1\} \). Design a CFG that represents the set of palindromes over \( \Sigma \). (2 points.)
   (ii) Let \( \Sigma = \{0, 1\} \) denote an alphabet. Design a CFG that represents the set of all strings that contain at least one pair of consecutive 0s in them. (2 points.)

3. CFG Ambiguity:
   (i) When is a CFG \( G \) said to be ambiguous? When is a language said to be inherently ambiguous? (2 points.)
   (ii) Let \( G = \langle V, T, P, S \rangle \) denote a CFG, with \( V = \{S\} \), \( T = \{a, b\} \), and production rules \( P \) given by:
   \[
   S \rightarrow aSbS \mid bSaS \mid \epsilon
   \]
   Is \( G \) ambiguous? Justify your answer with a proof or counterexample. (2 points.)

4. Semantics: Enumerate the differences between:
   (i) Lexical and dynamic scoping. (1 point.)
   (ii) Static and dynamic Type checking. (1 point.)

   Is it possible to define the semantics for a language that is dynamically scoped but statically type checked? Justify your answer. (2 points.)
5. **Type Theory:** Consider the following block of C code:

```c
struct A
{
    int i;
    char j;
};

struct B
{
    int i;
    char j;
};

struct A x, *p;
struct B y, *q;
```

Which of the following statements lead to static errors? Explain.

(i) `x = y;`
(ii) `x = (struct A) y;`
(iii) `p = q;`
(iv) `p = (struct A*) q;`