**Practice Assignment 2**

1. Give a context-free grammar (CFG) for each of the following languages over the alphabet Σ = {*a,b*}:
   1. All strings in the language *L* : {*anbma*2*n*|*n,m* ≥ 0}
   2. All nonempty strings that start and end with the same symbol.
   3. All strings with more a’s than b’s.

2. Consider the grammar below that generates roman numerals, with terminals {**c***,***l***,***x***,***v***,***i**}. *c* = 100*,l* = 50*,x* = 10*,v* = 5*,i* = 1. Notice that we use lowercase characters here to represent the numerals, to distinguish them from the non-terminals.

|  |  |  |
| --- | --- | --- |
| *S* | → | **x***TU* | **l***X* | *X* |
| *T* | → | **c** | **l** |
| *X* | → | **x***X* | *U* |
| *U* | → | **i***Y* | **v***I* | *I* |
| *Y* | → | **x** | **v** |



1. Draw a parse tree for 47: “xlvii”.
2. Is this grammar ambiguous?

3. Let *L* be the language {*w* ∈ {*a,b*}∗|*w* contains exactly one more *b* than *a*}.

* 1. Give a context-free grammar that generates *L*.
  2. Give a leftmost derivation and a parse tree in your grammar for the string *abbabab*.
  3. Give an unambiguous grammar for the language L of the previous problem.

(This is a difficult problem, but give it a try. As a hint, you can use three variables other than the start symbol. One variable generates strings with the same number of a’s as b’s, the second variable generates strings with the same number of a’s as b’s that have the additional property that every prefix has at least as many a’s as b’s, and the third variable generates all strings with the same number of a’s as b’s that have the additional property that every prefix has at least as many b’s as a’s.)

4. Prove L4 = {} is not a Context-free Language

5. Prove L5 = {s2s | s} is not a Context-free Language