1. Give a context-free grammar for each of the following languages.

a) L= {w | w contains even number of 0's}

b) L={w | w contains twice as many 1s as 0s}

c) L={w | w contains even number of 0s and 1s}

d) L={w | where each 0's is followed by at least as many 1's}

e) L(G) = { $a^i b^j c^k$ | i, j, k ≥ 0 and i=j or i=k}. ∑={a,b,c}

f)) L(G) = { $a^i b^j c^k$ | j > i+k}. ∑={a,b,c}

g) L(G) = { $a^n b^m$ | 0 < n < m < 3n}.∑={a,b}

h) L(G) = set of all strings w over {a, b} such that w is not palindrome.

i) L={w | w = w^R AND |w| is even, w is a palindrome}

j) L(G) = { $a^i b^j c^k$ | i, j, k ≥ 0 and i=j or j=k}. ∑={a,b,c}

k) L(G) = { $a^n b^m c^m d^{2n}$| n ≥ 0, m > 0}

l) L= {w | w contains at least 4 a's}

2. What does the following CFGs do?

a) S⟶ ZSZ|0
Z⟶ 0|1

b) S⟶ 0E0|1E1|ε
E⟶ 1E|0E|ε

c) S⟶ AB
A⟶ 0A1|ε
B⟶ 1B|ε

d) S⟶ ε|1S1S1S0S | 1S1S0S1S | 1S0S1S1S | 0S1S1S1S

e) S⟶ aSbb |aSb| ε

3. Convert the following Regular expressions to a CFG.

a) a(b|c*)

b) 0*1(0 + 1)*

c) (a + b)*(a* + (ba)*)

d) (a+b)* aa (a+b)*

e) a* + a(a|b)*

4. Consider the following context-free grammar ∑={0,1}. Give leftmost and rightmost derivations for the following strings and check parse-tree ambiguity.

a) S → 0A | 1B
A → 0AA| 1S | 1
B → 0S |1BB| 0

String: 001101

b) S → A 1 B
A → 0A | ε
B → 0B |1B| ε

Strings: 10100, 0010101

c) D → TL
T → c | Tc
L → L.V | V
V → a | b | 0 | 1| Va | Vb | V0 | V1

Strings: cabb0011.ab1 (Rightmost derivation)

d) S → S + S
S → Sa | Sb | ε

String: abb + aab + baba

e) S → SA | ε
A → aa | ab | ba | bb

String: aabbba

f) S → aEbS
S → aEbScS | ϵ
E → d

String: adbadbadbc

5. Are the following CFGs ambiguous? Are they inherently ambiguous? If not, then give its unambiguous representation.

a) $S \rightarrow Ab \mid AaB$
$A \rightarrow a \mid Aa$
$B \rightarrow b$

b) $S \rightarrow aS \mid aSbS \mid \epsilon$