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1. a) $midL(a^*ba^*)$
= b, as S can be written as xwz thus $x = a^*$, $w = b$ and $z = a^*$.
$mid(S) = w = b$ <

b) $midL(\{a^n b^n : n \geq 0\})$
if n is 0, 1, 2 then the midL() would be ε. otherwise midL() of $n \geq 2$ would be 'ab' as that is the middle.

c) No, as the languages are finite and have a finite number of strings the string generated from midL(L) may not belong in any given finite language.

d) Yes as the languages are infinite the string found of the function midL(L) will exist as a string within atleast one language.

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aa abbccc aabab

a) S -> AB
A -> aAb | C
C -> bC | ε
B -> aF | G
F -> cF | ε
G -> bGc | Gc | cW
W -> ε

b) S -> bA | bSb | ε
A -> abA | ε

c) S -> aSa | bSb | ε | A
A -> aaA | ε

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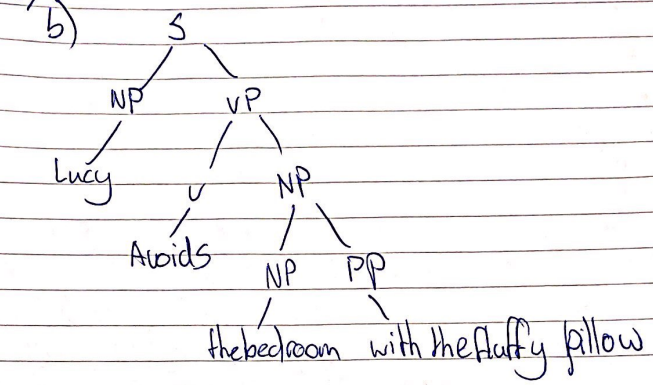
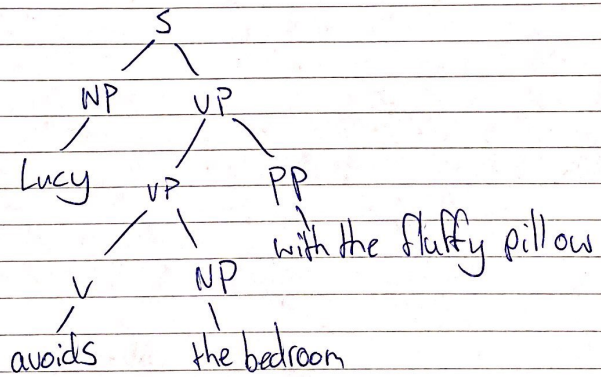
3, b)





the above two show the ambiguity

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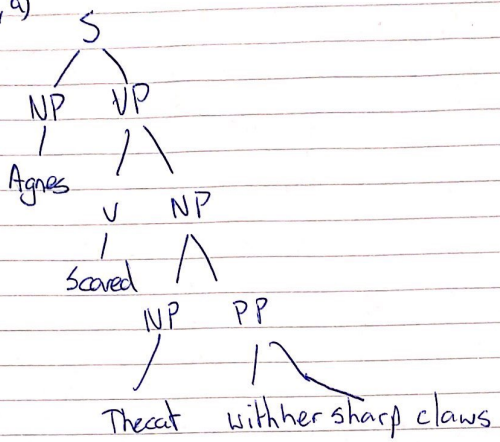
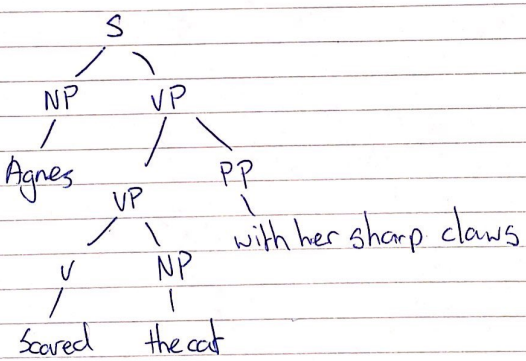
3, a)





the above two show ambiguity

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S -> TbT
T -> AAA
T -> C
A -> aA
A -> ε
C -> cC
C -> c

step 1, S -> TbT
T -> AAA
T -> C
A -> aA
A -> a
C -> cC
C -> c

step 2, S -> TbT
T -> aAaAaA
T -> cC | c
A -> aA
A -> a
C -> cC
C -> c

S -> TbT
T -> aAaAaA | cC | c
A -> aA | a
C -> cC | c

step 3, S -> TXbT
T -> XaAXaAXaA | XcC | Xc
A -> XaA | Xa
C -> XcC | Xc

step 4, S -> N, Xb N,
T -> XaN2 | XcN3 | Xc
A -> XaN2 | Xa
C -> XcN3 | Xc

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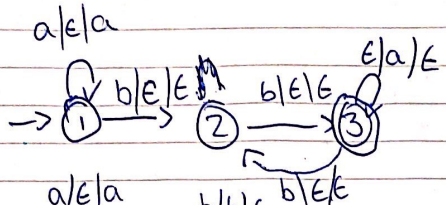
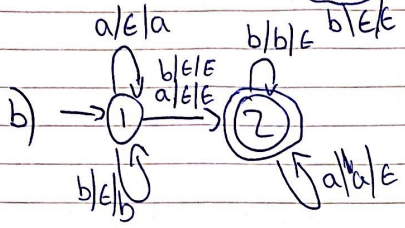
5,

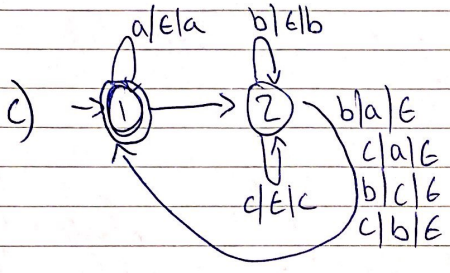
a)



b)



c)



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6,

a) language M is a context free language with elements x and y.
there can be zero or more x's and $y \leq x$, example, xxxxy.

b) $S \rightarrow xS \mid xA \mid \epsilon$
$A \rightarrow yA \mid \epsilon$

c) Yes, M is deterministic as there is only one possibility for transitions from state to state. this is based on the current input.

d) Yes, L(M) is deterministic context free as it can be accepted by a deterministic PDA and L(M) is context free via 6(a).

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7, a) $L_1 = L_2 - L_3$

$L_1 = \{0^n 1^n : n \geq 0\}$ context free
$L_2 = \{0^n 1^n 2^j : j \text{ is prime}, n \geq 0\}$ not context free
$L_3 = \{0^m 1^m 2^j : j \text{ is prime}\}$ not context free

b) $L_1^R = \neg L_2$

$L_1 = \{0^n 1^n : n \text{ is prime}\}$
$L_2 = \{0^p 1^p\} \; p \geq 0$

eg, $n = 7$
$p = 7$

$L_1^R = 00000001111111$
$L_1^R = 11111110000000$ } equal!
$\neg L_2 = 11111110000000$

S->

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abbcc

8, $i=1\ k=2\ j=2$

a) $L = \{a^i b^j c^k : i, j, k \geq 0 \text{ and } j < i+k\}$

~~Not context free~~ is context free but not regular, the language can be generated through context free grammar but is not regular as can be shown through pumping lemma

b) $L = \{a^i b^j c^k : i, j, k \geq 0 \text{ and } j > \max(i,k)\}$

Not context free as there is comparison of 3 variables independantly and the stack is only capable of comparing two variables at on instance.

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9, a) $x = 0101$

assume L is context free

Pumping length $P = 3$

string $x = 0^P 1^P 0^P 1^P$

divide x into $uvxyz$

$0^3 1^3 0^3 1^3 = \underbrace{000}_{u}\underbrace{111}_{vxy}\underbrace{000111}_{z}$

pump $uv^i xy^i z$ let $i = 2$

000111111000111

$0^3 1^5 0^3 1^3$

thus $x^r x^r \neq x$, Yes the context free languages are closed under reverse and double(L)

b) Yes it is possible for rd(L) to be regular as it would be a finite language. for example the string sxt could be $\epsilon\epsilon\epsilon$ and thus a finite regular language may be made.

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10.

a) The lindenmayer system also known as the "L-system", is a fractal generating system that produces these fractals in one or two dimensions. The underlying system that allows this is a string rewriting system that uses substitution with which rules are followed to perform on a string from a given alphabet. The system G is a triple (Σ, R, w)

b)

$$R_G = \{F \rightarrow F+F-F-F+F\}$$

the rule is to instead of going in a square path you instead need to cut a square out of the original square path by turning in and then out.