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• Assistance from Zoey on question 2

FoCS

1 a)

a	b	a XOR (b XOR a)
F	F	F
F	T	T
T	F	F
T	T	T

b) It matches XOR

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2. $E \to E+E \mid T$
   $T \to T \times T \mid (E) \mid a$

- Non determinism makes it easy
- See included jpg

3.

Start with	Unit productions	Convert 1st rule	Convert others
$E \to E+E$	$E \to E+E$	$E \to E E_1$	$E \to E E_1$
$E \to T$	$E \to T \times T$	$E_1 \to E_2 E$	$E_1 \to E_2 E$
$T \to T \times T$	$E \to (E)$	$E_2 \to +$	$E_2 \to +$
$T \to (E)$	$T \to T \times T$	$E \to T \times T$	$E \to T D$
$T \to a$	$T \to (E)$	$E \to (E)$	$D \to D_2 T$
	$T \to a$	$T \to T \times T$	$D_2 \to \times$
		$T \to (E)$	$E \to a$
		$T \to a$	$E \to F G$
			$F \to C$
			$G \to E F_2$
			$F_2 \to)$
			$T \to a$
			$T \to F G$
			$T \to T D$

Collect them together: Chomsky normal form

$E \to E E_1 \mid T D \mid a \mid F G$
$E_1 \to E_2 E$
$E_2 \to +$
$D \to D_2 T$
$D_2 \to \times$
$F \to ($
$G \to E F_2$
$F_2 \to)$
$T \to F G \mid T D \mid a$

4. The easiest proof is to show that a subset of this language is irregular. Since $E \to T$, $T \to (E)$, we can show that strings of the form $(^n a)^n$ are in the language. Using the pumping lemma: with a finite automaton with P states, construct string $(^p a)^p$. Since there must be a loop of length $< p$ in the 1^{st} p characters, we can produce an arbitrary # of extra parenthases on the left, which shows that this CANNOT be pumped. Therefor, $(^n a)^n$ is irregular, & so is our grammar, since all strings of form $(^n a)^n$ are included.

5. a. The intersection of $\{a^i b^i c^j\}$ & $\{a^i b^j c^j\}$ is $\{a^n b^n c^n\}$, because the intersection is all strings where #a's = #b's, & # b's = # c's. By the transitive property, #a's = #c's, so $\{a^n b^n c^n\}$ is the only acceptable set. The initial two sets have been proven to be context Free in earlier homeworks, because ~~we made PDA's for them.~~

Since the intersection of two CFL is not CF, CFL's aren't closed under intersection

6. ~~Take some string in $a^n b^n c^n$~~ Assume that $\{a^n b^n c^n\}$ is a CFL. Take the string $a^p b^p c^p$, where p is the pumping length. It can be divided into 5 parts, & 2 parts must be able to be pumped. There are 2 possibilities:

1. each pumped substring contains only 1 letter. So, pumping changes ratio of those letters to the 3rd

2. One or both substrings contain more than 1 letter. Then, ratios might remain the same, but letters will be in the wrong order, so it still doesn't work.

Therefore, $\{a^n b^n c^n\}$ can't be a CFL.

6. a) i. S → NP VP → Det N VP → The girl VP
→ The girl V NP → The girl touches NP
→ the girl touches NP PP → the girl touches Det N PP
~~the boy~~ → the girl touches the boy PP → the girl touches the boy P NP → The girl touches the boy with NP
→ The girl touches the boy with Det N → ☺
"The girl touches the boy with the flower"

diverges on this line, with VP PP instead of V NP

ii. S → NP VP → Det N VP → The girl VP → the girl VP PP ..... "the girl touches the boy with the flower"

b) either ~~the~~ the girl touches ~~the~~ the boy who happens to have ~~the~~ the flower, or the girl uses the flower to touch the boy

c) "The boy sees the girl with the binoculars" is also ambiguous

6 a) S → NP VP
NP → NP PP
NP → Det AP
~~AP → Det Adj~~
VP → V NP
VP → VP PP
Det → a | the
N → boy | girl | flowers | binoculars
V → Touches | sees
PP → P NP
P → in | from | with
AP → N
AP → Adj N
Adj → Tall | purple