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1) $L_1 \to bL_2$ $\quad X = L^*M$ $\quad L_1 = A$

$L_2 \to aL_2 \cup cL_1 \cup cL_3 \cup \varepsilon$ $\quad L_2 = B$

$L_3 \to \underbrace{bL_2}_{M} \cup \underbrace{c}_{L^*}\underbrace{L_3}_{X} \cup \underbrace{\varepsilon}_{M}$ $\quad L_3 = C$

$L_3 \to c^*(bL_2 \cup \varepsilon) \Rightarrow L_3 \to c^*bL_2 \cup c^*$

plug L_3 and L_1 into L_2

$L_2 \to aL_2 \cup cbL_2 \cup c(c^*bL_2 \cup c^*) \cup \varepsilon$

$L_2 \to aL_2 \cup cbL_2 \cup cc^*bL_2 \cup cc^* \cup \varepsilon$

pull out an L_2 and use the theory:

$\to X = L \cdot X \cup M \to X = L^*M$

$\underbrace{L_2}_{X} \to \underbrace{L_2}_{X}\underbrace{(a \cup cb \cup cc^*b)}_{L^*} \cup \underbrace{cc^* \cup \varepsilon}_{M}$

$L_2 \to (a \cup cb \cup cc^*b)^*(cc^* \cup \varepsilon)$

plug L_2 into L_1 and into L_3 to get final awnser.

$L_1 \to b[(a \cup cb \cup cc^*b)^*(cc^* \cup \varepsilon)]$

$L_2 \to (a \cup cb \cup cc^*b)^*(cc^* \cup \varepsilon)$

$L_3 \to c^*b[(a \cup cb \cup cc^*b)^*(cc^* \cup \varepsilon)] \cup c^*$

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3) $[(100^*)^* \cap \overline{1^*}] \Rightarrow [\overline{\overline{(100^*)^* \cup 1^*}}]$

→	0	1	2
0	–	1	–
1	–	–	–

→	0	1	2
0	2	–	–
2	–	–	–

→	0	1	2
0	3	–	–
3	–	–	–

→	0	1	2
0	–	1	–
1	2	–	–
2	–	–	–

→	0	1	2
0	3	–	–
3	3	–	–

→	0	1	2
0	–	4	–
4	–	–	–

→	0	1	2
0	–	1	–
1	2	–	–
2	3	–	–
3	3	–	–

start →

→	0	1	2
0	–	1	–
1	2	–	–
2	3	1	–
3	3	1	–

→	0	1	2
0	–	4	–
4	–	4	–

→ complimcnt → flip A/R states construct DFA

	0	1	2
0	5	1	5
1	2	5	5
5	5	5	5
2	3	1	5
3	3	1	5

union →

→	0	1	2
0	5	1,4	5
1	2	5	5
5	5	5	5
2	3	1	5
3	3	1	5
4	–	4	–

complimcnt → dfa / flip A/R

	0	1	2
A → 0	5	1,4	5
B 5	5	5	5
C 1,4	2	4,5	5
D 2	3	1	5
E 4,5	5	4,5	5
F 3	3	1	5
G 1	2	5	5

Rename →

	0	1	2
A	B	C	B
B	B	B	B
C	D	E	B
D	F	G	B
E	B	E	B
F	F	G	B
G	D	B	B

reduce →

	0	1	2
α	α	ε	Z
β	Z	ε	Z
Z	Z	Z	Z
ε	α	Z	Z

Reduce →

DF	ABCEG		
DF	ABE	CG	

→

DF	A	BE	CG
DF	A	BE	LG
X	B	Z	ε

0 = initial state

X = final accepting state

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4) $\{S, B\}, \{a, b, c, d\}$

1) useless symbols
2) epsilon production
3) unit production

$S \to SaSbc \mid Ba$
$B \to cBd \mid S \mid \varepsilon$

$B \to \varepsilon$

$S \to SaSbc \mid Ba \mid a$
$B \to cBd \mid cd \mid S$

$B \to S$

* [leave last two symbols alone.]

$S \to SaSbc \mid Ba \mid Sa \mid a$
$B \to cBd \mid cSd \mid cd$

$X_a \to a \quad X_b \to b$
$X_c \to c \quad X_d \to d$

$S \to SX_aS[X_bX_c] \mid B[X_a] \mid S[X_a] \mid [X_a]$
$B \to X_c[BX_d] \mid X_c[SX_d] \mid [X_cX_d]$

$S \to SS_1 \mid BX_a \mid SX_a \mid X_a$
$S_1 \to X_aS_2$
$S_2 \to SS_3$
$S_3 \to X_bX_c$

$B \to X_cB_1 \mid X_cB_2 \mid X_cX_d$
$B_1 \to BX_d$
$B_2 \to SX_d$

$X_a \to a \quad X_b \to b \quad X_c \to c \quad X_d \to d$

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5) {S, A} {a, d}

$E \rightarrow B \mid B \cdot E'$

$E' \rightarrow \alpha \mid \alpha \cdot E'$

j = 1, 2

i = 1 $S \rightarrow AS \mid A \mid d$ $j = i - 1$

i = 2 $A \rightarrow SS \mid a$

1) no epsilon production
2) no unit production
→ Greibach check
3) no left recursion

$S \rightarrow A$

j = 1, 2 1, 2 $j = i - 1$

i = 1 $S \rightarrow AS \mid AA \mid d$

i = 2 $A \rightarrow (S)S \mid (S)A \mid AS \mid AA \mid a$ [remove immediate left recursion]

$A \rightarrow \underbrace{ASS}_{\alpha} \mid \underbrace{ASA}_{\alpha} \mid \underbrace{AAS}_{\alpha} \mid \underbrace{AAA}_{\alpha} \mid \underbrace{dS}_{\beta} \mid \underbrace{dA}_{\beta} \mid \underbrace{aS}_{\alpha} \mid \underbrace{aA}_{\alpha} \mid \underbrace{a}_{\beta}$

$A \rightarrow dS \mid dSA' \mid dA \mid dAA' \mid a \mid aA'$

$A' \rightarrow SS \mid SSA' \mid SA \mid SAA' \mid AS \mid ASA' \mid AA \mid AAA' \mid S \mid SA' \mid A \mid AA'$

new A into old S $A \rightarrow S$

new S into A' $S \rightarrow A'$

$S \rightarrow$

$S \rightarrow$

$A \rightarrow$

$A' \rightarrow$

$0^{n+1}\,1^{n+1}\,0^{n}$ $n \geq 0$

000 11 0

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$0^n\,1^{n-1}\,0^{n-2}$ b

000 11 0

0^{n-1} 1^{n-1} 0^n

q_3 0^{n-2} 1^{n-1} 0^n $n=3$

0 i i 000

000 111 000000 $1=5$

	0	1	0'	1'	b
$\rightarrow q_0$	$(q_1, 0', R)$	/	/	/	/
q_1	$(q_2, 0', R)$	/	/	/	/
q_2	$(q_3, 0', R)$	/	/	/	/
q_3	$(q_4, 0', R)$	$(q_2, 1', R)$	/	$(q_3, 1', R)$	(q_4, b, R)
q_4	$(q_{14}, 0, R)$	$(q_5, 1', R)$		$(q_{14}, 1', R)$	
q_{13}	$(q_6, 0', L)$	$(q_6, 1, R)$	$(q_6, 0, R)$	/	/
q_6	/	$(q_6, 1, L)$	$(q_{16}, 0', L)$	$(q_{17}, 1', L)$	/
q_7	$(q_7, 0, L)$	/	$(q_5, 0', R)$	$(q_7, 1', L)$	/
q_8	$(q_4, 0', R)$	/	$(q_8, 0', R)$	/	/
q_9	$(q_F, 0', R)$	/	/	/	/
q_F	Accepting State				