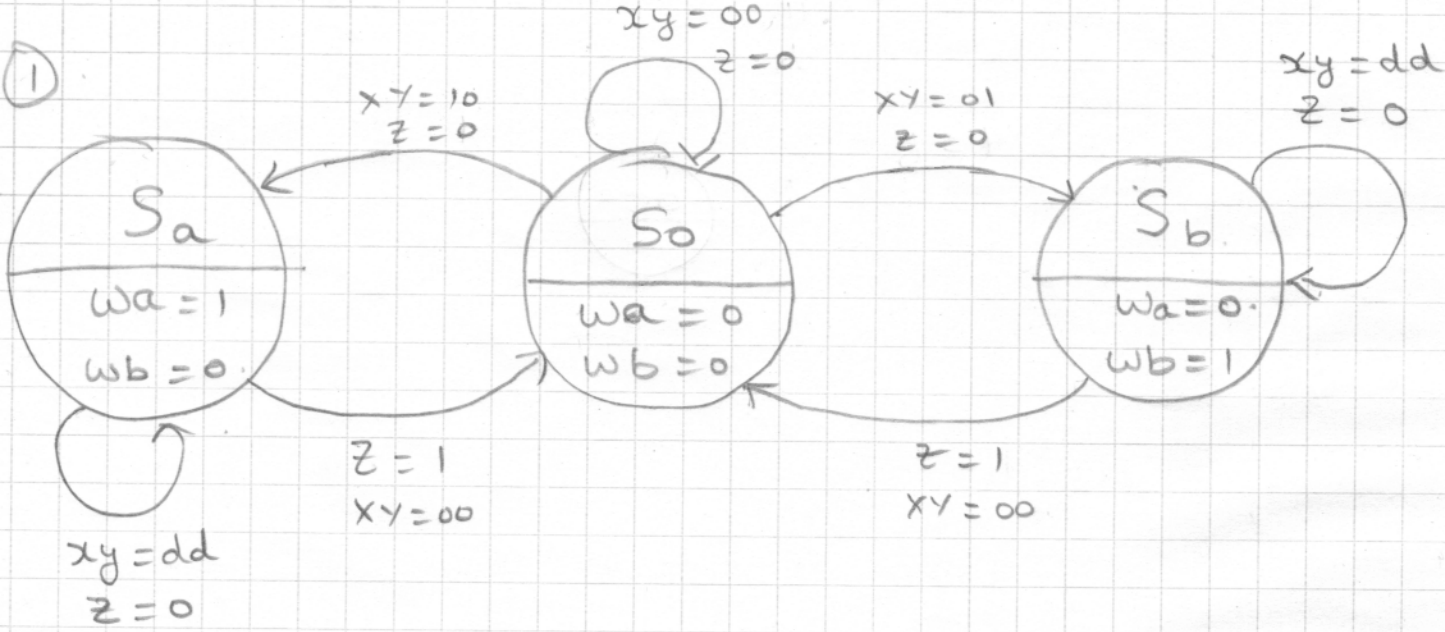
ASSIGNMENT 4
Solutions

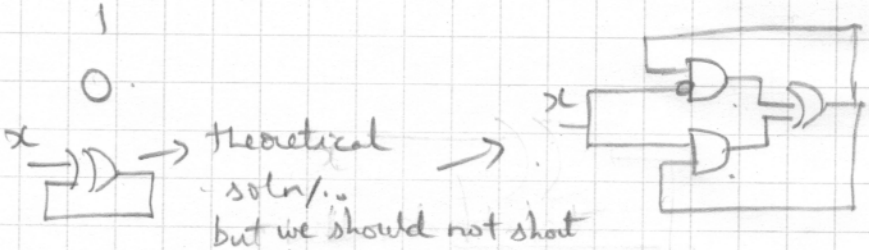
(1)



(2)

A	a^+ x=0	a^+ x=1
0	0	1
1	1	0

$a^+ = A \oplus x$



(3)

ab	a^+b^+ s=0	a^+b^+ s=1
00	(00)	10
01	00	(01)
11	00	10
10	00	11

cycle present

no races.

ab	a^+b^+ s=0	a^+b^+ s=1
00	(00)	11
01	00	(01)
11	00	01
10	00	11

race

Race between (00) → 11

3 Cases - goes to either 11, (01) or 10

eventually the system ends up in (01).

This race is non-critical

④ no hazards for C ; need to check for a, b.

Choose c first to restrict

$$(ab+\bar{a}c)(c+\bar{b})+ab$$

$c=0$ / \ $c=1$

Can reuse this level ← $ab\bar{b}+ab$ | $(ab+\bar{a})+ab$

$ab\bar{b}+ab$: $b=0$ / \ $b=1$ → 0 | a

$(ab+\bar{a})+ab$: $b=0$ / \ $b=1$ → $\bar{a}$ | $a+\bar{a}$

$a+\bar{a}$ static 1 hazard for $b=c=1$

$ab\bar{b}+ab$: $a=0$ / \ $a=1$ → 0 | $b\bar{b}+b$

dynamic hazard for $a=1$, $c=0$

$(ab+\bar{a})+ab$: $a=0$ / \ $a=1$ → 1 | b

Static 1 hazard for $b=c=1$; can be masked by oring with bc

dynamic hazard for $a=1$; $c=0$ → need to mask the static hazard $b\bar{b}$ in $(ab+\bar{a}c)(c+\bar{b})$ for $a=1$ and $c=0$.

and it with $(\bar{a}+c)$

Expression without hazards.

$$(ab+\bar{a}c)(c+\bar{b})(\bar{a}+c)+ab+bc$$

* continued

Recheck to make sure no new hazards were introduced.

$$(ab+\bar{a}c)(c+\bar{b})(\bar{a}+c)+ab+bc$$

$c=0$ / \ $c=1$

Reuse ← $ab\bar{b}\bar{a}+ab$. $(ab+\bar{a})b+ab+b$.

$b=0$ / \ $b=1$ $\quad$ $b=0$ / \ $b=1$

0 $\quad$ a . $\quad$ $\bar{a}$ $\quad$ 1

$ab\bar{b}\bar{a}+ab$ $\quad$ $(ab+\bar{a})b+ab+b$.

$a=0$ / \ $a=1$ $\quad$ $a=0$ / \ $a=1$

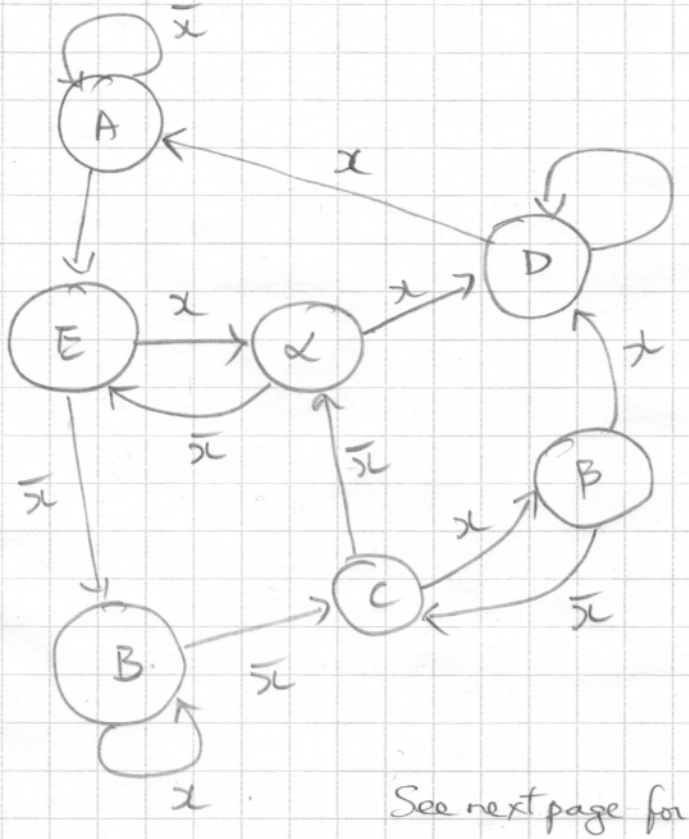
0 . $\quad$ b . $\quad$ b $\quad$ b .

No hazards !!

Final answer

$$(ab+\bar{a}c)(c+\bar{b})(\bar{a}+c)+ab+bc$$

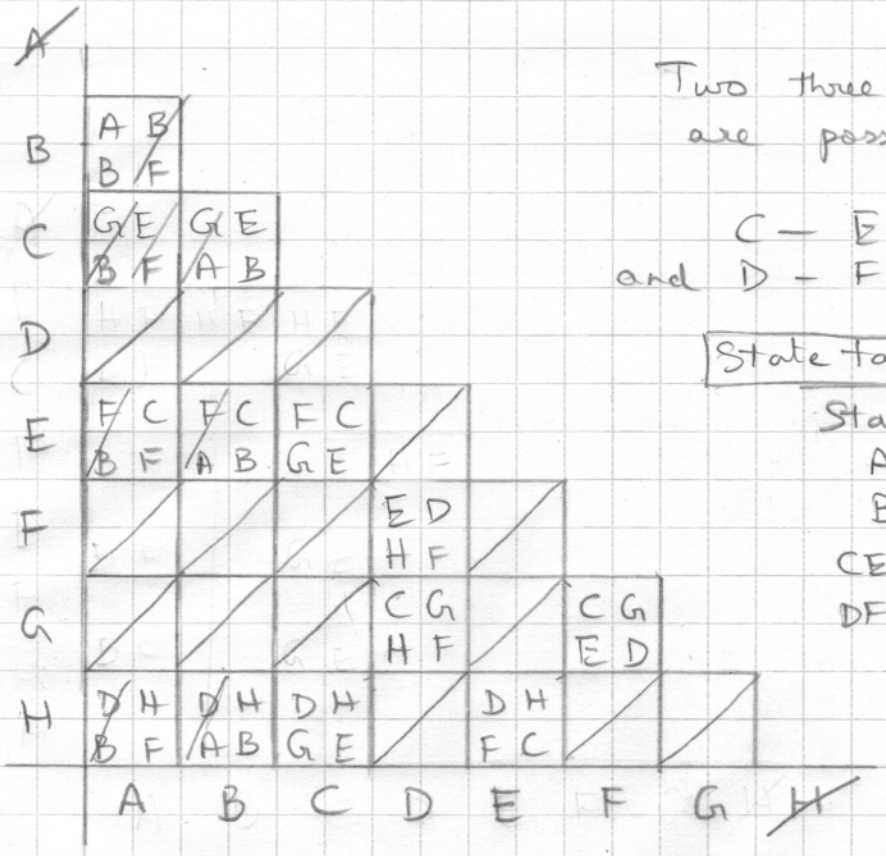
(5)



	0	1
00	A	D
01	E	α
11	B	C
10		β

See next page for alternate soln. with only one extra state.

(6)



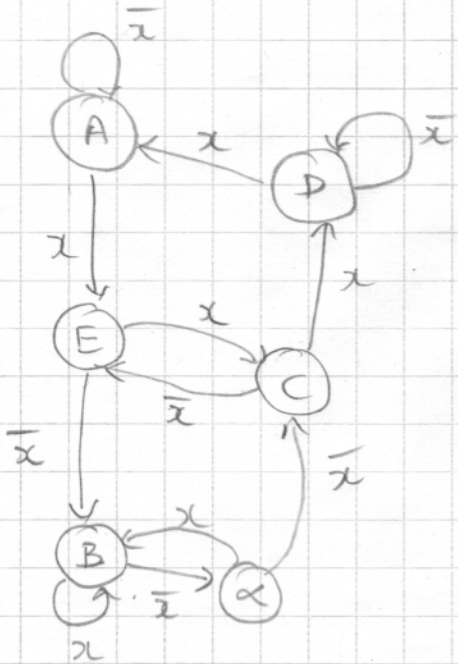
Two three way merges are possible.

C — E — H
and D — F — G

State table | Next State

State	x=0	x=1	output
A	B	DFG	0
B	A	B	0
CEH	DFG	CEH	0
DFG	CEH	DFG	1

(5) Alternate solution
with one extra state



A	D
E	C
B	α