Q.1) a)

	D	Clk	Q	notes
a	0	0	0	after c, d
b	0	0	1	after e, f,
c	0	1	0	after a, b, g
d	1	0	0	after a, g
e	0	1	1	after h
f	1	0	1	after b, h
g	1	1	0	after c
h	1	1	1	after e, d, f

DC

	00	01	11	10
a	(a), 0	c, -	-, -	d, -
b	(b), 1	c, -	-, -	f, -
c	a, -	(c), 0	g, -	-, -
d	a, -	-, -	h, -	(d), 0
e	b, -	(e), 1	h, -	-, -
f	b, -	-, -	h, -	(f), 1
g	-, -	c, -	(g), 0	d, -
h	-, -	e, -	(h), 1	f, -

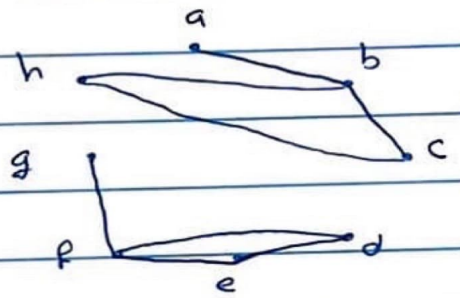
b)

	00	01	11	10
a	(a), 0	b, X	-, -	d, X
b	a, X	(b), 1	(b), 1	c, X
c	b, 0	-, -	b, X	(c), 0
d	c, X	(d), 1	c, 1	(d), 1

c)

	a	b	c	d	e	f	g
b	d,h ✗	✓					
c	a,e ✗	a,e c,g ✗	c,g d,h ✗				
d	a,e b,f ✗	a,e f,b ✗	b,f d,h ✗	✓			
e	a,e b,f ✗	g,c a,e b,f ✗	b,f c,g ✗	✓	✓		
f	b,f d,h ✗	b,f c,g ✗	f,b c,g ✗	h,d ✗	h,d ✗	✓	
g	d,h ✗	✓	✓	h,d a,e ✗	a,e h,d ✗	c,g a,e ✗	c,g ✗
h							

(a,b), (b,c), (b,h), (c,h), (e,d), (d,f), (e,f), (f,g)



→ h, b, c

→ f, d, e

	00	01	11	10
a	ⓐ,0	b,-	-,-	d,-
b,c,h	a,-	ⓑ,0	ⓒ,0	ⓗ,0
d,e,f	ⓔ,1	ⓕ,1	g,-	ⓓ,1
g	-,-	f,-	ⓖ,1	h,-

	00	01	11	10
A	Ⓐ,0	B,-	-,-	C,-
B	A,-	Ⓑ,0	Ⓑ,0	Ⓑ,0
C	Ⓒ,1	Ⓒ,1	D,-	Ⓒ,1
D	-,-	C,-	Ⓓ,1	B,-

state assignment : a = A , b,c,h = B , d,e,f = C , g = D

d) $Y = ya + ab + by$

i)

y \ ab	00	01	11	10
0	0	0	1	0
1	0	1	1	1

→ transition table

$Y = ab + ya + yb$

ii) excitation table of SR:

y	Y	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

y \ ab	00	01	11	10
0	0	0	1	0
1	0	X	X	X

S - table

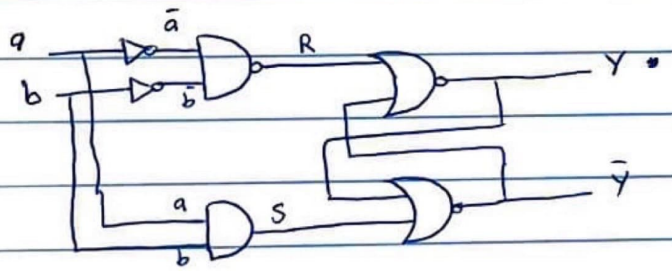
$S = ab$

y \ ab	00	01	11	10
0	X	X	0	X
1	1	0	0	0

R - table

~~R = (a b)~~

$R = \bar{a} \cdot \bar{b}$



Q2) a. $F = (ab)' \cdot (cd)'$

$\frac{dF}{db} = F(b=1) \oplus F(b=0)$

$= \bar{a} \cdot (cd)' \oplus (cd)'$

$= (cd)' (\bar{a} \oplus 1) = a(cd)'$

. F is sensitive to b when $a.(cd)' = 1$

$\boxed{a=1}$, $(cd)' = 1$

c	d
0	0
0	1
1	0

⇒

a	c	d
1	0	0
1	0	1
1	1	0

. b sa0, when $b \cdot \frac{dF}{db} = 1$

⇒ $\boxed{b=1}$, same as above ⟹ test vectors :

a	b	c	d
1	1	0	0
1	1	0	1
1	1	1	0

• b sa1, when $b' \cdot \frac{\partial F}{\partial b} = 1$

$\Rightarrow b' = 1 \Rightarrow b = 0$

$\Rightarrow$ test vectors

a	b	c	d
1	0	0	0
1	0	D	1
1	0	1	0

b) D-algorithm : ① y sa0

① backtrace phase : send 1 to y

$\Rightarrow (cd)' = 1 \Rightarrow y = D$

$\overrightarrow{cd}$
00
01
10

② propagation phase : x must be 1 $\rightarrow (ab)' = 1$

$\overrightarrow{ab}$
00
01
10

$\Rightarrow F = D \rightarrow$ (no fault / Fault)

(F = 1 → no fault), (F = 0 → Faulty)

• test vectors

a	b	c	d
0	0	0	0
0	D	0	1
0	0	1	0
0	1	0	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	0	1
1	0	1	0

---

② y sa1

① backtrace phase : send 0 to y

$\Rightarrow (cd)' = 0$

$\overrightarrow{cd} = 11$ $\Rightarrow y = \bar{D}$

② propagation phase : x must be 1 $\rightarrow (ab)' = 1$

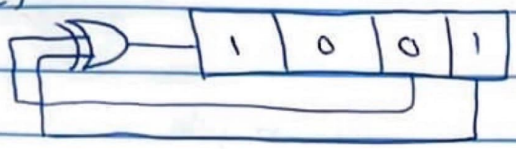
$\overrightarrow{ab}$
00
01
10

$\Rightarrow F = D' \Rightarrow (F = 0$ no Fault), (F = 1 → Faulty)

• test vectors

a	b	c	d
0	0	1	1
0	1	1	1
1	0	1	1

c)



- generate 6 test vectors

① 1 0 0 1 ← initial state.

② 1 1 0 0

③ 0 1 1 0

④ 1 0 1 1

⑤ 0 1 0 1

⑥ 1 0 1 0

⑦ 1 1 0 1

d) $\boxed{a \equiv b}$ by collapsing $\rightarrow$ $\begin{cases} \boxed{a\ sa0 \equiv b\ sa0} \equiv x\ sa1 \\ a\ sa1 \equiv b\ sa1 \equiv x\ sa0 \end{cases}$

$\begin{cases} x\ sa0 \equiv y\ sa0 \equiv F\ sa0 \\ x\ sa1 \equiv y\ sa1 \equiv F\ sa1 \end{cases}$

$\begin{cases} y\ sa0 \equiv d\ sa1 \equiv c\ sa1 \\ y\ sa1 \equiv d\ sa0 \equiv c\ sa0 \end{cases}$ $\quad$ $\begin{cases} c\ sa1 \equiv d\ sa1 \\ c\ sa0 \equiv d\ sa0 \end{cases}$

- test vectors for a & b sa0:

a	b	c	d
1	1	0	0
1	1	0	1
1	1	1	0

sa1

a	b	c	d
1	0	0	0
1	0	0	1
1	0	1	0

For x & y & F, sa0:

a	b	c	d
0	0	0	0
0	0	0	1
0	0	1	0
0	1	0	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	0	1
1	0	1	0

sa1:

a	b	c	d
0	0	1	1
0	1	1	1
1	0	1	1

For c & d sa0:

a	b	c	d
0	0	1	1
0	1	1	1
1	0	1	1

sa1:

a	b	c	d
0	0	0	1
0	1	0	1
1	0	0	1

a b c d	a/0	a/1	b/0	b/1	c/0	c/1	d/0	d/1	x/0	x/1	y/0	y/1	F/0	F/1	Fault %
1001	X	(✓)	X	(✓)	X	✓	X	(✓)	(✓)	X	✓	X	✓	X	$\frac{7}{14}$ = 50%
1100	(✓)	X	(✓)	X	X	X	X	X	X	X	X	X	X	X	$\frac{2}{14}$ = 14%
0110	X	X	X	X	X	X	X	X	✓	X	(✓)	X	(✓)	X	$\frac{3}{14}$ = 21%
1011	X	X	X	X	(✓)	X	(✓)	X	X	(✓)	X	(✓)	X	(✓)	$\frac{5}{14}$ = 36%
0101	X	X	X	X	X	(✓)	X	✓	✓	X	✓	X	✓	X	$\frac{5}{14}$ = 36%
1010	X	✓	X	✓	X	X	X	X	✓	X	✓	X	✓	X	$\frac{5}{14}$ = 36%

Maximum Fault coverage will be 50%.

Fault coverage → 100% → since all vectors covers all cases of Fault.

e) a b c d

1001 → F = 1

1100 → F = 0

0110 → F = 1

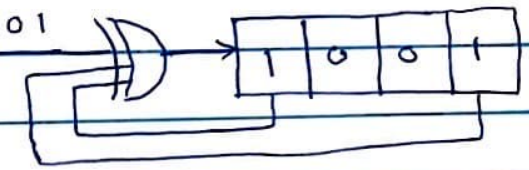
1011 → F = 0

0101 → F = 1

1010 → F = 1

F

110101



1001

⇒ 1100

1110

0111

1011

1101

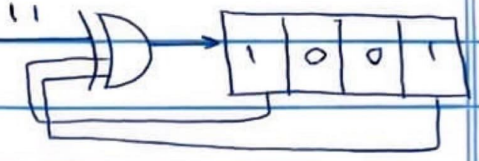
1110 → good signature

f)

a b c d		F
1 0 0 1	→	F = 1
1 1 0 0	→	F = 1
0 1 1 0	→	F = 1
1 0 1 1	→	F = 0
0 1 0 1	→	F = 1
1 0 1 0	→	F = 1

F

1 1 0 1 1 1



1 0 0 1

⇒ 1 1 0 0

0 1 1 0

1 0 1 1

0 1 0 1

0 0 1 0

1 0 0 1 ≠ 1 1 1 0

↳ bad signature → Faulty circuit