

### Question 1

Test case number	Current Status	Inputs					Expected outputs		Next State
		C	H	N	S	X	D	G	
1 Start							Welcome	F	S0
2 S0	T						Welcome	F	S0
3 S0		T					Welcome	F	S0
4 S0			T				Welcome	F	S0
5 S0				T			Ready	F	S1
6 S0					T		Welcome	F	S0
7 S1	T						Ready	F	S1
8 S1		T					Ready	F	S1
9 S1			T				Dispensing	F	S2
10 S1				T			Ready	F	S1
11 S1					T		Ready	F	S1
12 S2	T	T					Dispensing	F	S2
13 S2		T	T				Dispensing	F	S2
14 S2	T	T					Dispensing	T	S2
15 S2		T					Dispensing	F	S2
16 S2	-	-	-	-	-		Ready	F	S1
17 S2			T				Please Pay Cashier	F	S3
18 S3	T						Welcome	F	S0
19 S3		T					Please Pay Cashier	F	S3
20 S3			T				Please Pay Cashier	F	S3
21 S3				T			Please Pay Cashier	F	S3
22 S3					T		Please Pay Cashier	F	S3

Length	Sequence	Response	Equivalence	Carry to next level
0	Idle	D="Welcome",IG	-	No
1	S	D="Ready",IG	-	Yes
	C	D="Welcome",IG	Idle	No
	H	D="Welcome",IG	Idle	No
	N	D="Welcome",IG	Idle	No
	X	D="Welcome",IG	Idle	No
2	SS	D="Ready",IG	S	No
	SC	D="Ready",IG	S	No
	SH	D="Ready",IG	S	No
	SN	D="Dispensing",IG	-	Yes
	SX	D="Ready",IG	S	No
3	SNS	D="Dispensing",IG	SN	No
	SNC	D="Dispensing",IG	SN	No
	SNH	D="Dispensing",IG	SN	No
	SNN	D="Dispensing",IG	SN	No
	SNX	D="Please pay Cashier",IG	-	Yes
4	SNXS	D="Please pay Cashier",IG	SNX	No
	SNXC	D="Welcome",IG	Idle	No
	SNXH	D="Please pay Cashier",IG	SNX	No
	SNXN	D="Please pay Cashier",IG	SNX	No
	SNXX	D="Please pay Cashier",IG	SNX	No

Question 2

Test case number	Inputs			Expected Outputs
	LDT	Day Type	Discount Type	Fare
1	0:00:00	Weekday	Standard	\$2.75
2	0:00:00	Weekend	Student	\$2.09
3	0:00:00	Holiday	Senior	\$3.71
4	4:59:59	Weekend	Standard	\$2.20
5	4:59:59	Weekday	Student	\$2.61
6	4:59:59	Weekday	Senior	\$2.47
7	4:59:59	Holiday	Veteran	\$3.57
8	5:00:00	Holiday	Standard	\$5.62
9	5:00:00	Weekday	Student	\$3.56
10	5:00:00	Weekend	Senior	\$2.70
11	8:59:59	Holiday	Student	\$5.35
12	8:59:59	Weekday	Veteran	\$3.26
13	8:59:59	Weekend	Teacher	\$2.73
14	9:00:00	Weekend	Veteran	\$1.89
15	9:00:00	Weekday	Teacher	\$2.53
16	9:00:00	Holiday	Worker	\$2.06
17	14:59:59	Holiday	Teacher	\$3.79
18	14:59:59	Weekday	Worker	\$1.37
19	14:59:59	Weekend	Standard	\$2.20
20	15:00:00	Weekend	Worker	\$1.50
21	15:00:00	Weekday	Standard	\$3.75
22	15:00:00	Holiday	Student	\$5.32
23	17:59:59	Holiday	Standard	\$5.62
24	17:59:59	Weekend	Student	\$2.85
25	17:59:59	Weekday	Senior	\$3.37
26	18:00:00	Weekend	Senior	\$1.98
27	18:00:00	Weekday	Veteran	\$2.39
28	18:00:00	Holiday	Teacher	\$3.76
29	23:59:59	Holiday	Senior	\$3.71
30	23:59:59	Weekend	Veteran	\$1.89
31	23:59:59	Weekday	Teacher	\$2.53
32	0:00:00	Holiday	Veteran	\$3.57
33	0:00:00	Weekend	Teacher	\$2.00
34	0:00:00	Weekday	Worker	\$1.37
35	4:59:59	Weekend	Worker	\$1.10
36	4:59:59	Holiday	Teacher	\$3.79
37	5:00:00	Holiday	Worker	\$2.81
38	5:00:00	Weekday	Veteran	\$3.26
39	5:00:00	Weekend	Teacher	\$2.73
40	8:59:59	Weekday	Standard	\$3.75
41	8:59:59	Weekend	Senior	\$2.70
42	8:59:59	Holiday	Worker	\$2.81

43	9:00:00 Weekend	Standard	\$2.20
44	9:00:00 Weekday	Student	\$2.61
45	9:00:00 Holiday	Senior	\$3.71
46	14:59:59 Weekend	Student	\$2.09
47	14:59:59 Weekday	Senior	\$2.47
48	14:59:59 Holiday	Veteran	\$3.57
49	15:00:00 Weekend	Veteran	\$2.58
50	15:00:00 Weekday	Teacher	\$3.45
51	15:00:00 Holiday	Senior	\$5.06
52	17:59:59 Weekday	Worker	\$1.87
53	17:59:59 Weekend	Veteran	\$2.58
54	17:59:59 Holiday	Teacher	\$5.17
55	18:00:00 Holiday	Standard	\$4.12
56	18:00:00 Weekday	Student	\$2.61
57	18:00:00 Weekend	Worker	\$1.10
58	23:59:59 Holiday	Student	\$3.90
59	23:59:59 Weekday	Standard	\$2.75
60	23:59:59 Weekend	Worker	\$1.10

Problem 3:- Minimize exp. using k-map.

(a)  $a'b'd' + a'c'd + ac'd + a'cd'$

	$cd'$	$cd$	$cd'$	$cd$
$a'b$	1		1	
$a'b$	1	1		1
$ab$		1		
$ab'$		1		

$a'cd' + a'b'c' + c'd$

(b)  $a'b'c'd' + ab'c'd + ab'cd + a'bcd + abc'd + abcd$

	$cd'$	$cd$	$cd'$	$cd$
$a'b'$	1			
$a'b$			1	
$ab$	1	1	1	
$ab'$	1	1		

$a'b'c'd' + bcd + ad$

(c)  $a'b + a'b'c'd + ac'd'$

	$cd'$	$cd$	$cd'$	$cd$
$a'b'$	1	1	1	1
$a'b$		1		
$ab$	1			
$ab'$	1			

$ac'd' + a'cd' + a'b'$

$$\textcircled{1} \quad abc'd + a'b'c'd' + ab'c'd' + abc'd' + a'bc'd + ab'c'd + a'bc'd'$$

<del>a'b'c'd'</del>	<del>cd'</del>	<del>c'd</del>	<del>cd</del>	<del>cd'</del>
a'b	1			
a'b	1	1		
ab	1	1		
ab'	1	1		

$= a'c'd' + bc' + ac'$

$$\textcircled{2} \quad a'b'c'd' + a'b'c'd + ab'cd' + a'b'cd' + a'b'cd + a'b'cd'$$

<del>a'b'cd'</del>	<del>c'd'</del>	<del>c'd</del>	<del>cd</del>	<del>cd'</del>
a'b	1	1	1	
a'b				
ab	1			
ab'	1		1	

$= a'b'c' + ac'd' + b'd'$

Question 4:-

$$\textcircled{1} \quad a'b + c'$$

	a	b	c	a'b + c'
d	F	F	F	T
	F	F	T	F
	F	T	F	T
	F	T	T	T
	T	F	F	C
	T	F	T	T
	T	T	F	F
	T	T	T	F

$$c/d = (FFF, TTT)$$

$$C = (FTT, TFF)$$

$$d = (FFF, FFT)$$

$$\begin{aligned}TOF'S &= a'b, c' \\TNF &= a+b'+c', a'b+c.\end{aligned}$$

~~$$TOF'S = a'b', ac'$$~~

~~$$TNF = a+b'+ac', a'b+a+c \quad : INF = b'+a+c', a+b+c.$$~~

$\begin{matrix} b' \\ \downarrow \\ b'+a+c' \end{matrix} \quad \begin{matrix} \downarrow \\ a+b+c. \end{matrix}$

(b)  $a'(b+c')$

$$\therefore a'b + a'c'$$

	a	b	c	<u><math>a'b+a'c'</math></u>	
d	F	F	F	T	
	F	F	T	F	
	F	T	F	T	
	F	T	T	C	T
	T	F	F	C	F
	T	F	T	F	
	T	T	F	F	
	T	T	T	F	

$$dd = (FFF, TTT)$$

$$C = (FFT, TTF)$$

$$d = (FFF, FFT)$$

$$TOF'S = a'b, a'c'$$

$$TNF = a+b'+a'c' = b'+a+c'$$

$$a'b+a+c = a+b+c.$$

(c)  $a+b'c+d$ .

$$\therefore TNF = b'+a+c', a+b+c.$$

$$\textcircled{C} \quad a + b'c + d.$$

	a	b	c	d	$a + b'c + d$
d	F	F	F	F	F
	F	F	F	T	T
	F	F	T	F	T
	F	F	T	T	T
	F	T	F	F	F
	F	T	F	T	T
	F	T	T	F	F
	F	T	T	T	T
	T	F	F	F	T
	T	F	F	T	T
	T	F	T	F	T
	T	F	T	T	T
	T	T	A	F	T
	T	T	F	T	T
	T	T	J	F	T
	T	T	T	T	T

$c/d$

$$c/d = (FFFF, TTTT), c = (FTTT, TFFF)$$

$$d = (FFFF, FFT)$$

~~TOF~~

$$TOF = a, b'c + d \Rightarrow a, b'c, d.$$

$$TNF = a' + b'c + d, a + b + c' + d, a + b'c + d'$$

Q) (ab xor cd) + abcd.

$$= (a'b') \oplus cd + ab(c'd') + abcd$$

$$= a'cd + b'cd + abc' + abd' + abcd. \quad (1)$$

Reducing (1) using K-map, we get:-

$$\underline{ab + cd}.$$

a	b	c	d	ab + cd
d	F	F	F	F
	F	F	F	F
	F	F	T	F
	F	F	F	F
	F	F	T	T
	F	T	F	F
	F	T	F	F
	F	T	T	F
	F	T	T	T
	T	F	F	F
	T	F	T	F
	T	F	F	F
	T	T	F	T
	T	T	T	T
	T	T	F	T
	T	T	T	T
	T	T	T	T

$c/d = (FTTT, TFFF)$

$c = (FTTF, TFTT)$

$d = (FFFF, FFTT)$

$TDF = ab, cd$

$TNF = a' + b' + cd, ab + c' + d'$

### Question 5

① a =  $(b < 10) \parallel c'$

$b \parallel c \rightarrow FF, FT, TF.$

Test		Input		Output
case		b	c	a
	1	10	T	F
	2	10	F	T
	3	9	F	T

② b =  $a = b' \parallel (c \geq 4)$ .

$b \parallel c \rightarrow FF, FT, TF.$

Test		Inputs		outputs
case		b	c	a
	1	F	4	T
	2	F	3	T
	3	T	3	F

$$\textcircled{c} \quad a = (b \leq 8) \& (c > 8)$$

$$x \& y = FF, FT, TF.$$

$$b \leq 8 \quad \Rightarrow c > 8$$

$$T = 8 \quad \& \quad T = 9$$

$$F = 9 \quad \& \quad F = 8.$$

Test Case	Input	Output
b	c	a
1	9	F
2	8	T
3	8	F.

$$\textcircled{d} \quad a = (b \geq 2) \& (b < 8)$$

$$b \geq 2 \quad b < 8$$

$$T = 2 \quad T = F$$

$$F = 1 \quad F = 8.$$

Test Case	Input	Output
b	a	
1.	2	T
2.	1	F
3.	7	T
4.	8	F.

② a'b + c.

Test cases = 4.

COI  
a → XTF  
b → FXF

c → TFX, TTX, FFx

Base set :- TTF, FTF, FFF.

$U_{C1} := \text{TTF}, \text{FTF}, \text{FFF}, \text{TTT}$ .

$U_{C2} := \text{TTF}, \text{FTF}, \text{FFF}, \text{FFT}$ .

b)  $a'(c+d')$

=  $a'c + a'd'$

Test cases = 5.

COI  
a → XTT, XFF

c → FXT

d → FFX

Base set :- FFT, FTT, FFF.

$a_1 = \text{FTT}, \text{FFF}, \text{TTT}$ .

$a_2 = \text{FTT}, \text{FFF}, \text{TFF}$ .

$U_{C1} = \text{FTT}, \text{FFT}, \text{FFF}, \text{TTT}, \text{TFF}$ .

$$\textcircled{c} \cdot a + b'c + d.$$

Test cases = 5.

$$C_0 \sqsupseteq a \rightarrow \cancel{XTFF}, \cancel{XTTF}, \cancel{XFFF}$$

$$b \rightarrow \cancel{FTXF} \rightarrow$$

$$c \rightarrow \cancel{FFXF} \rightarrow$$

$$d \rightarrow \cancel{FTFX}, \cancel{FTTX}, \cancel{FFFX}$$

Base set = FFFT, FTTF, FFFF.

$$U_{C1} = FFFT, FTTF, FFFF, TTTF, FTTT.$$

$$U_{C2} = FFFT, FTTF, FFFF, TTTF, FFFT$$

Question 5-2-d

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$$\textcircled{d} \quad (ab \oplus cd) + abcd.$$

$$= a'cd + b'cd + abc'd + abd' + abcd.$$

$$= ab + cd.$$

Test cases = 5

$$C_0 \sqsupseteq a \rightarrow \cancel{XTFF}, \cancel{XTTF}, \cancel{XTF}$$

$$\cancel{XTTF}, \cancel{XTTF} \quad b \rightarrow \cancel{TXFF}, \cancel{TXFT}, \cancel{TXTF}$$

$$c \rightarrow \cancel{FFXT}, \cancel{FTXT}, \cancel{TTXT}$$

$$d \rightarrow \cancel{FFTX}, \cancel{FTIX}, \cancel{TTIX}.$$

\textcircled{d}

$$U_{C1} \rightarrow \cancel{FFFF}, \cancel{TTFF}, \cancel{FTFT}, \cancel{FTTF}, \cancel{FTTF}$$

$$U_{C2} \rightarrow \cancel{TFFT}, \cancel{FFTT}, \cancel{FTTF}, \cancel{TTTF}, \cancel{FTTF}.$$

$$U_{C3} \rightarrow \cancel{TFTF}, \cancel{TTTF}, \cancel{FTTF}, \cancel{FTTF}, \cancel{FTTF}.$$

$$U_{C4} \rightarrow \cancel{TFTF}, \cancel{TTTF}, \cancel{FTTF}, \cancel{FTTF}, \cancel{FTTF}.$$

FFF, FFT, FTF,  
FTT, TFF, TFT, TTF.

③ ①  $a b' c + d'$

Test cases = 5.

CoI:  $a \rightarrow X$ ,  $b \rightarrow T$ ,  $c \rightarrow F$ ,  $d \rightarrow X$ ,  
 $\rightarrow TTTT, TFTT, FFTT, TFFT, FTFF$ .

Base set  $\rightarrow TTTT, TFTT, FFTT, TFFT$ .

$U_{C_1} = TTTT, TFTT, FFTT, TFFT, FTFF$

$U_{C_2} = TTTT, TFTT, FFTT, TFFT, TFFF$ .

$M_{C_1} = TTTT, TFTT, FFTT, TFFT, FTFF$

$M_{C_2} = TTTT, TFTT, FFTT, TFFT, FTFF$ .

Unique = FFTF, TFFF, TTTF.

Masking = FTTF, FFFF, FTFF, TTFF.

$$Q.5-2-d \quad (\bar{a}b \text{ xor } \bar{c}\bar{d}) + ab\bar{c}\bar{d}$$

$$= \cancel{ab\bar{c}\bar{d}} \bar{a}\bar{c}\bar{d} + b\bar{c}d + a\bar{b}c' + a\bar{b}d' + ab\bar{c}\bar{d}$$

$$= ab + cd.$$

$$C_0 I_a \rightarrow XTF, XFT, XTF.$$

$$C_0 I_b \rightarrow TXF, TXT, TXF.$$

$$C_0 I_c \rightarrow FFX, FTXT, TFX$$

$$C_0 I_d \rightarrow FFTX, FTTX, TFTX.$$

$$b_{S1} = a \cup b$$

$$① = FTF, TFF, TFFF$$

$$② = FTFT, TTFT, TFTT$$

$$3 = FTTF, TTTF, TFTF.$$

$$b_{S2} = C \cup d.$$

$$1 = FFFT, FFTT, FFTF.$$

$$2 = FTFT, FTTT, TFTT$$

$$3 = TFTT, TFTT, TFTF.$$

$$(a \cup b) \cup (c \cup d).$$

$$b_{S12} \cup b_{S22} = FTFT, TTFT, TFTT, FTTT, FTTF.$$

$$\text{Thus } U_{C1} = FTFT, TTFT, TFTT, FTTT, FTTF.$$