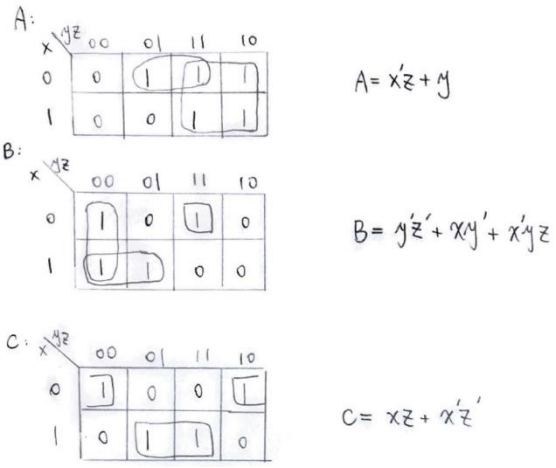
HW4

1. (20%) Design a combinational circuit with three inputs, x (MSB), y, and z (LSB), and three outputs, A (MSB), B, and C (LSB). When the binary input is 0, 1, 2, or 3, the binary output is three greater than the input (xyz=001 (1) => ABC=100 (4), xyz=011 (3) => ABC=110 (6).). When the binary input is 4, 5, 6, or 7, the binary is two less than the input (xyz=110(6) =>ABC=100 (4), xyz=100 (4) => ABC=010(2)).
   (a) Derive the truth table. (5%)
   (b) Derive the simplified Boolean expressions for A, B, and C using maps. (10%)
   (c) Draw the related logic diagram. (5%)

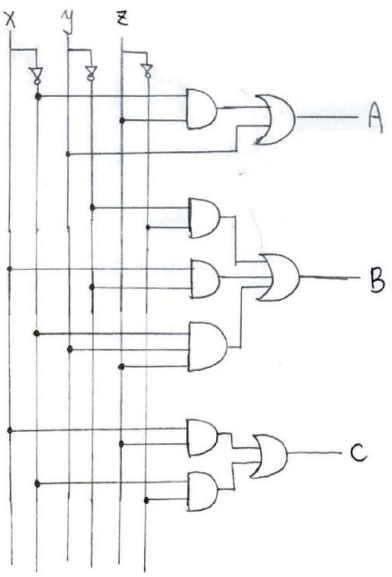
   (a)

x	y	z	A	B	C
0	0	0	0	1	1
0	0	1	1	0	0
0	1	0	1	0	1
0	1	1	1	1	0
1	0	0	0	1	0
1	0	1	0	1	1
1	1	0	1	0	0
1	1	1	1	0	1

   (b)



   (c)



2. (10%) Design an excess-3-to-binary decoder using the unused combinations of the code as don't-care conditions.

e0	e1	e2	e3	b0	b1	b2	b3
0	0	0	0	x	x	x	x
0	0	0	1	x	x	x	x
0	0	1	0	x	x	x	x
0	0	1	1	0	0	0	0
0	1	0	0	0	0	0	1
0	1	0	1	0	0	1	0
0	1	1	0	0	0	1	1
0	1	1	1	0	1	0	0
1	0	0	0	0	1	0	1
1	0	0	1	0	1	1	0
1	0	1	0	0	1	1	1
1	0	1	1	1	0	0	0
1	1	0	0	1	0	0	1
1	1	0	1	x	x	x	x
1	1	1	0	x	x	x	x
1	1	1	1	x	x	x	x

e_0e_1 \ e_2e_3	00	01	11	10
00	X	X	0	X
01	0	0	0	0
11	1	X	X	X
10	0	0	1	0

$b_0 = e_0e_1 + e_0e_2e_3$

e_0e_1 \ e_2e_3	00	01	11	10
00	X	X	0	X
01	0	0	1	0
11	0	X	X	X
10	1	1	0	1

$b_1 = e_1'e_2' + e_1e_3e_3 + e_1'e_3'$

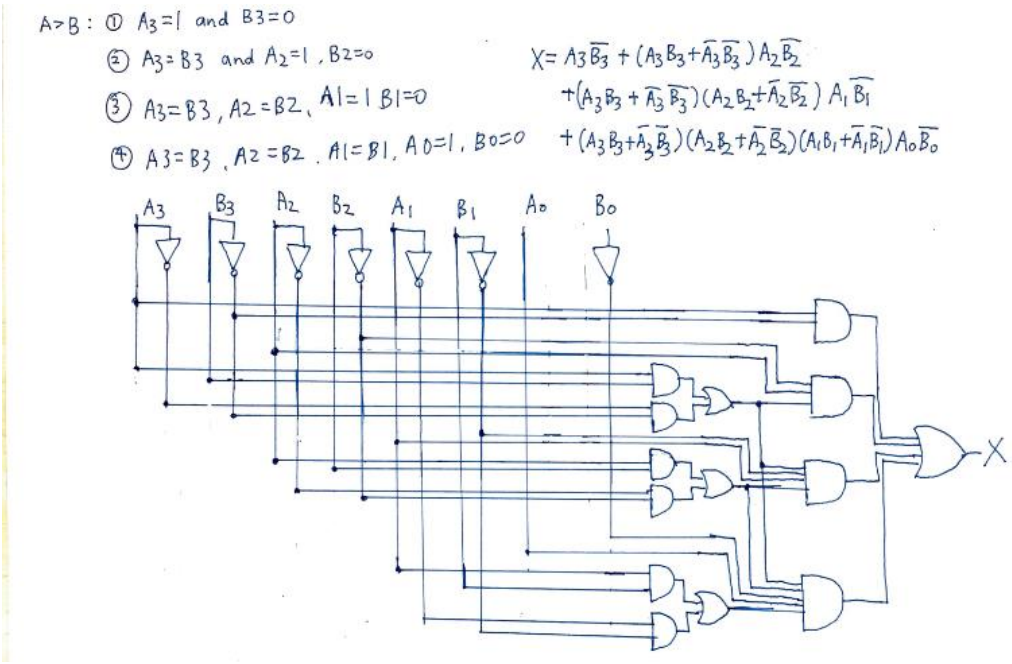
e_0e_1 \ e_2e_3	00	01	11	10
00	X	X	0	X
01	0	1	0	1
11	0	X	X	X
10	0	1	0	1

$b_2 = e_2'e_3 + e_2e_3'$

e_0e_1 \ e_2e_3	00	01	11	10
00	X	X	0	X
01	1	0	0	1
11	1	X	X	X
10	1	0	0	1

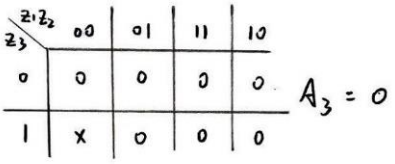
$b_3 = e_3'$

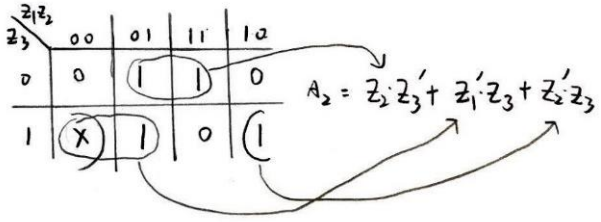
3. (10%) Design a combinational circuit that compares two 4-bit unsigned numbers A and B to see whether A is greater than B. The circuit has one output X, so that X = 0 if A ≤ B and X = 1 if A > B.

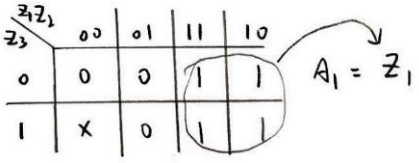


4. (10%) Design a 3-bit absolute value calculator. (Z=|z|).
   以下提供兩種不同的做法供同學參考：
   (I)

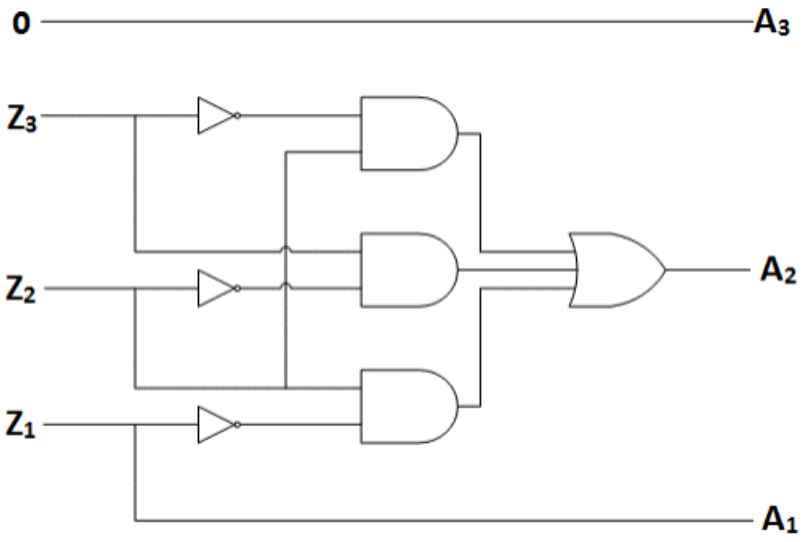
	z_3	z_2	z_1	A_3	A_2	A_1
0	0	0	0	0	0	0
1	0	0	1	0	0	1
2	0	1	0	0	1	0
3	0	1	1	0	1	1
-4	1	0	0	x	x	x
-3	1	0	1	0	1	1
-2	1	1	0	0	1	0
-1	1	1	1	0	0	1



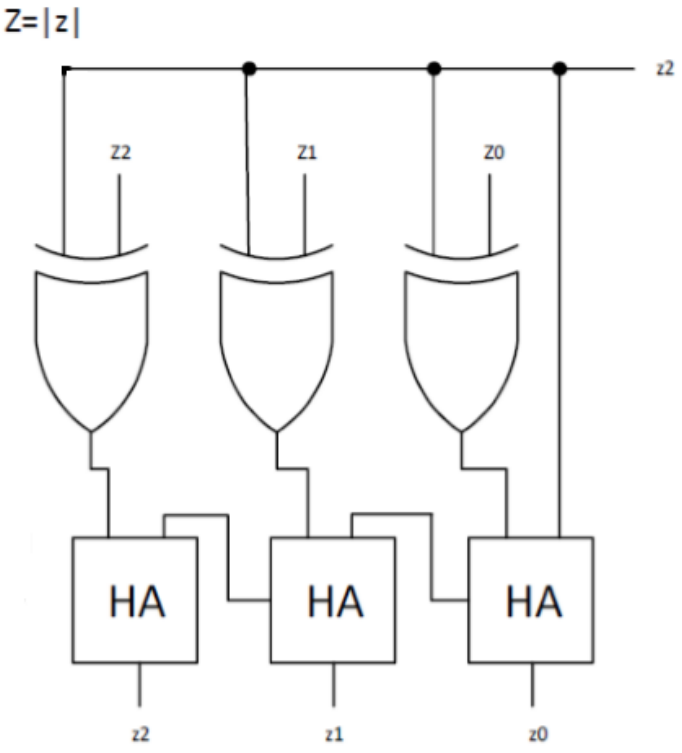




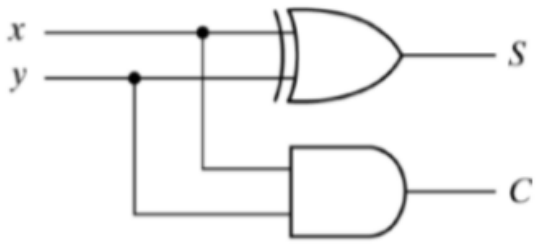
Logic Diagram



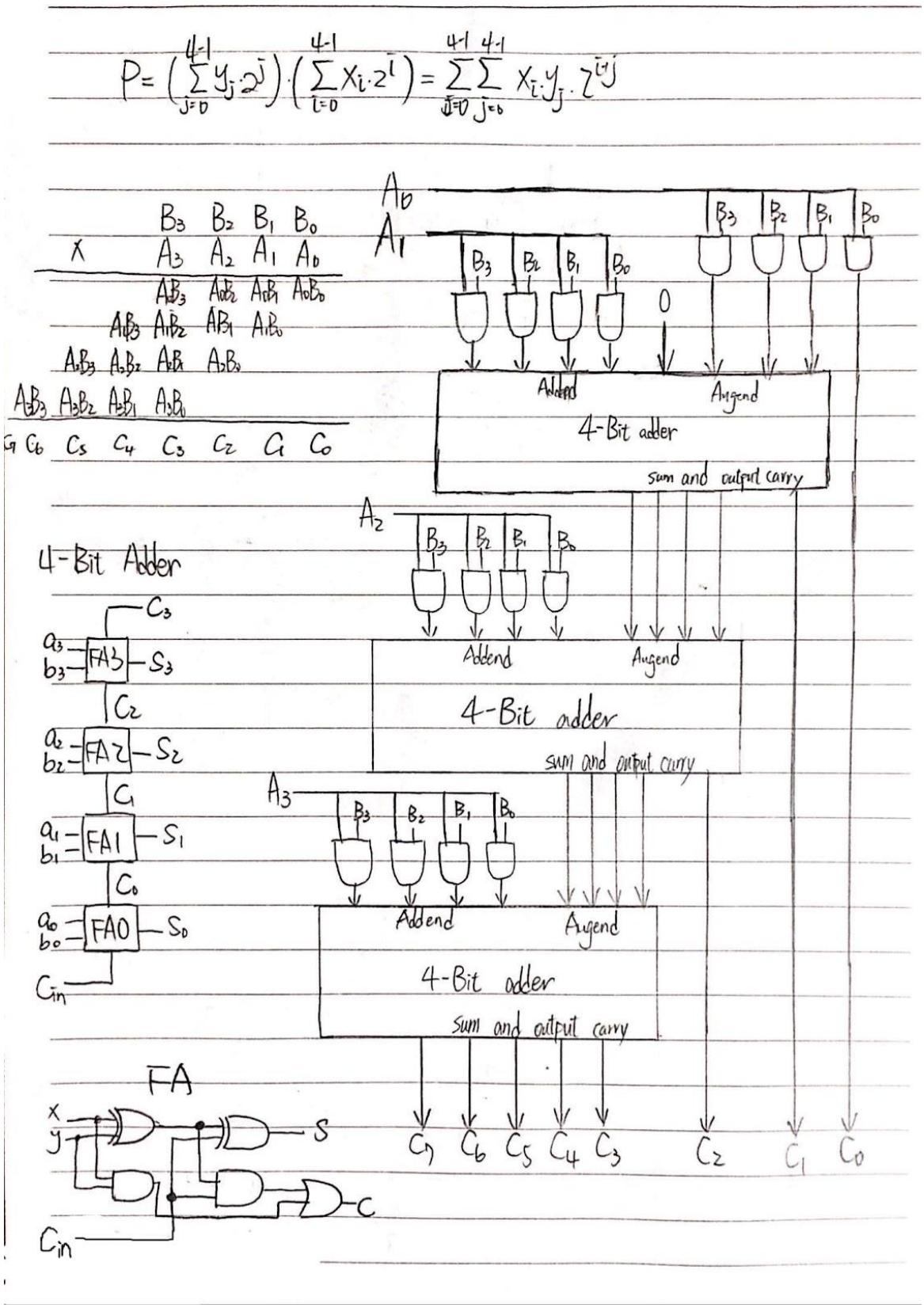
(II)



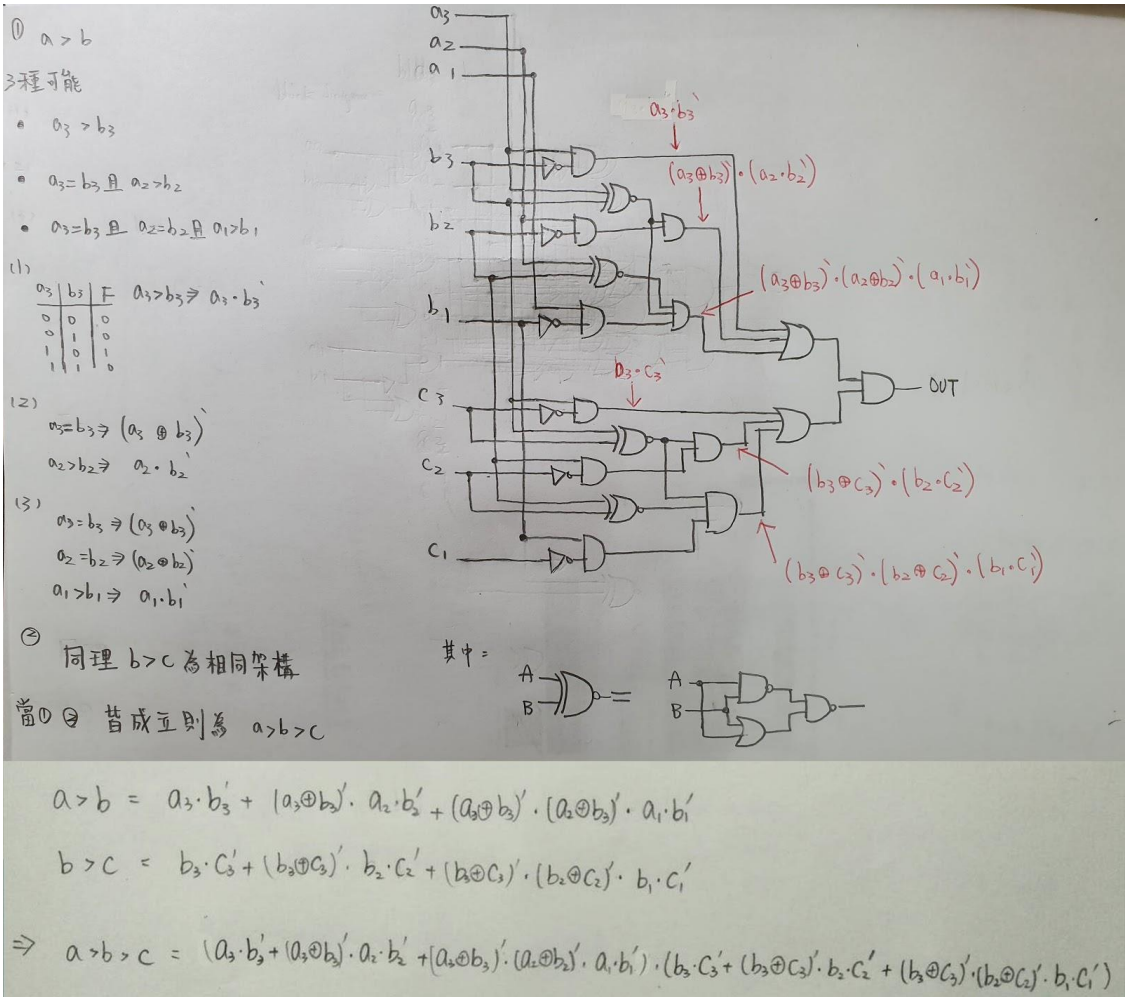
Half adder



5. (10%) Design a 4x4 multiplier using four-bit adders (Ripple-Carry adders) and other logic gates.



6. (20%) Design a three-way magnitude comparator that outputs true if its three inputs are in strict order: a>b>c. a, b, and c are all three-bit unsigned numbers.

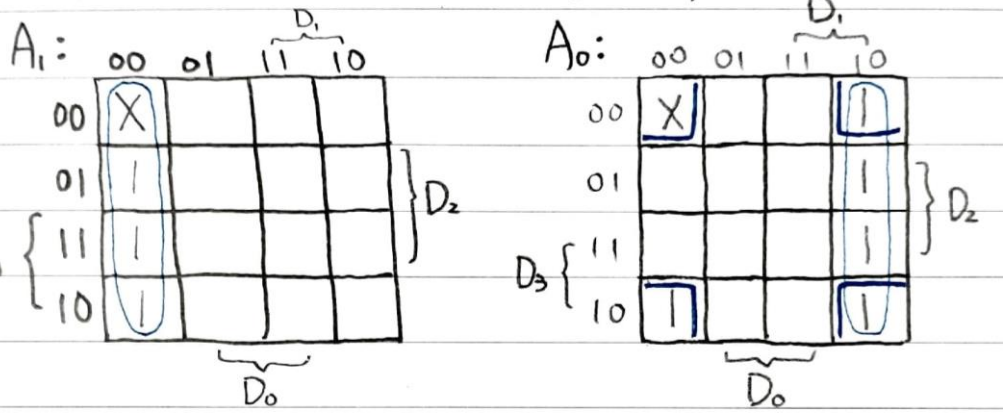


7. (10%) Design a 4->2 priority encoder with input D[3:0] and output A[1:0] where D_0 has the highest priority and D_3 has the lowest priority.

* 本題需注意 valid (V) 為 priority encoder 的一部分，因此不能省略

7.

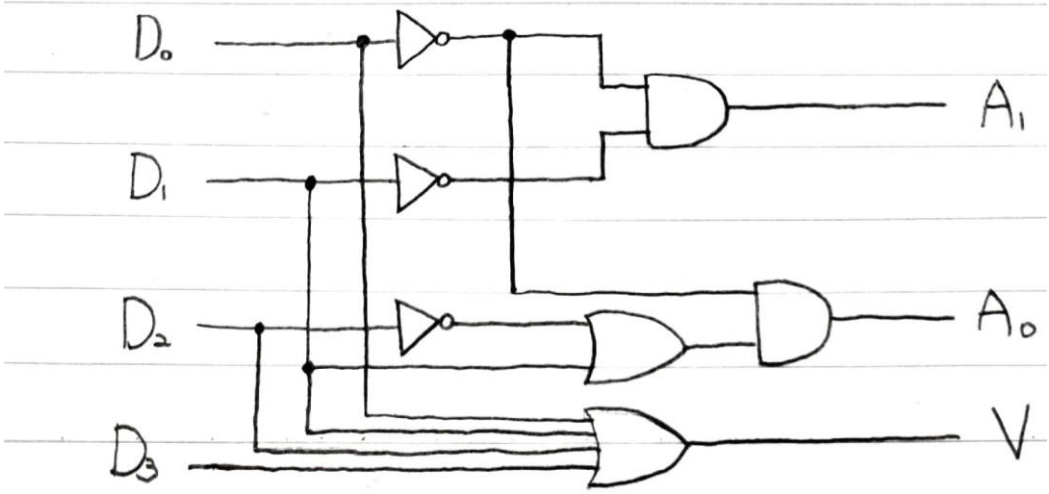
Inputs				Outputs		
D_3	D_2	D_1	D_0	A_1	A_0	V
0	0	0	0	X	X	0
X	X	X	1	0	0	1
X	X	1	0	0	1	1
X	1	0	0	1	0	1
1	0	0	0	1	1	1



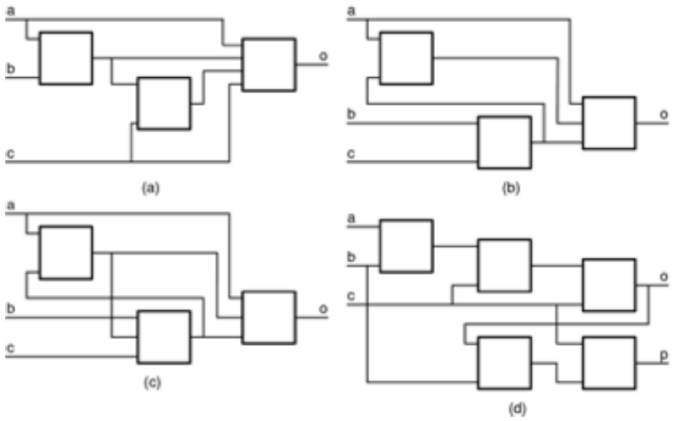
$$A_1 = D_1' D_0'$$

$$A_0 = D_1 D_0' + D_2' D_0' = D_0'(D_1 + D_2')$$

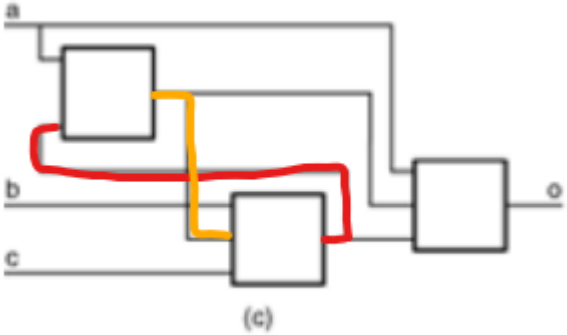
$$V = D_0 + D_1 + D_2 + D_3$$



8. (10%) Which of the following circuits are combinational? Each box in the figure is itself a combinational circuit.



Ans : (a)(b)(d) are combinational.
參考老師上課講義 Combinational Logic P.6



(c) is a sequential logic circuit because the feedback variable can remember the history of the circuits .
(a)(b)(d) are combinational circuits whose outputs at any time are determined directly and only from the present input combination.