

# HW4 solution 2016

1.

(a)

$$F = \Sigma(2,7,8,10,11,12,13,14) + d(5,9,15)$$

yz \ wx	00	01	11	10
00	0	0	1	1
01	0	x	1	x
11	0	1	x	1
10	1	0	1	1

Sum of products:

$$F = w + xz + x'yz'$$

(b)

yz \ wx	00	01	11	10
00	0	0	1	1
01	0	x	1	x
11	0	1	x	1
10	1	0	1	1

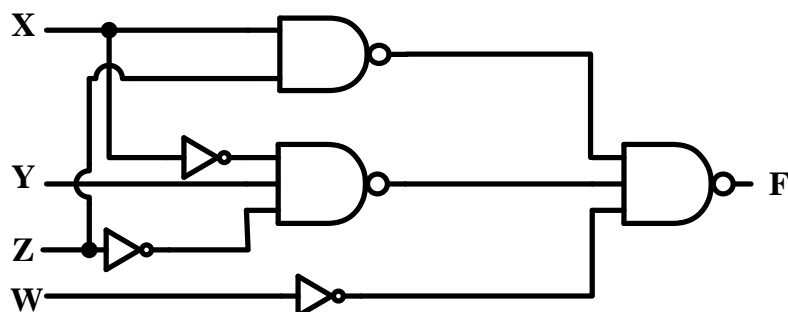
Product of sums:

$$F' = w'y' + w'x'z + w'xz'$$

$$F = (w+y)(w+x+z')(w+x'+z)$$

(c)

$$F = (w'(xz)'(xyz')')'$$



(d)

For sop:

w.  $xz$  and  $x'yz'$  are both of PIs and EPIs

2.

(a),(b),(d)

3.

(a)

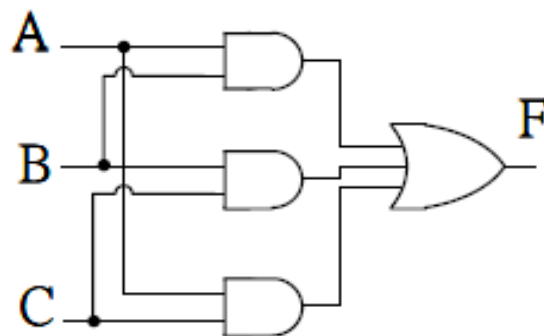
A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

(b)

A \ BC	00	01	11	10
0	0	0	1	0
1	0	1	1	1

$$F = BC + AC + AB$$

(c)



(d)

$BC, AC, AB$  are both of the PIs and EPIs.

4.

(a)

$$T1=B'C, T2=A'B, T3=A+B'C, T4=(T2\oplus D)=A'BD'+AD+B'D,$$

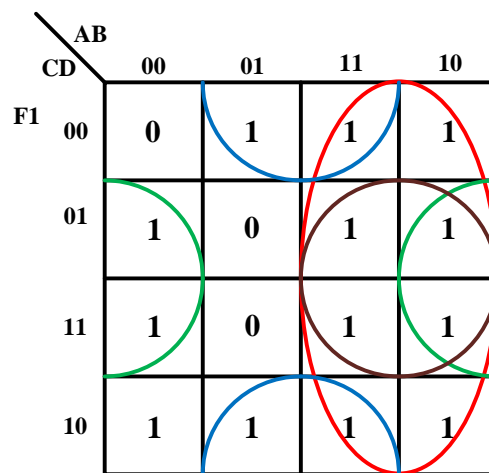
$$F1=T3+T4=A+B'C+B'D+BD'$$

$$F2=T2+D=A'B+D$$

(b)

A	B	C	D	T1	T2	T3	T4	F1	F2
0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1	1	1
0	0	1	0	1	0	1	0	1	0
0	0	1	1	1	0	1	1	1	1
0	1	0	0	0	1	0	1	1	1
0	1	0	1	0	1	0	0	0	1
0	1	1	0	0	1	0	1	1	1
0	1	1	1	0	1	0	0	0	1
1	0	0	0	0	0	1	0	1	0
1	0	0	1	0	0	1	1	1	1
1	0	1	0	1	0	1	0	1	0
1	0	1	1	1	0	1	1	1	1
1	1	0	0	0	0	1	0	1	0
1	1	0	1	0	0	1	1	1	1
1	1	1	0	0	0	1	0	1	0
1	1	1	1	0	0	1	1	1	1

(c)



$$F1 = A + B'C + B'D + BD'$$

		AB			
		00	01	11	10
F2	CD				
	00	0	1	0	0
	01	1	1	1	1
	11	1	1	1	1
	10	0	1	0	0

$$F2 = A'B + D$$

		AB			
		00	01	11	10
T1	CD				
	00	0	0	0	0
	01	0	0	0	0
	11	1	0	0	1
	10	1	0	0	1

$$T1 = B'C + A$$

		AB			
		00	01	11	10
T2	CD				
	00	0	1	0	0
	01	0	1	0	0
	11	0	1	0	0
	10	0	1	0	0

$$T2 = A'B + C$$

		AB			
		00	01	11	10
T3	CD	00	01	11	10
	00	0	0	1	1
	01	0	0	1	1
	11	1	0	1	1
	10	1	0	1	1

$$T3 = A + B'C$$

		AB			
		00	01	11	10
T4	CD	00	01	11	10
	00	0	1	0	0
	01	1	0	1	1
	11	1	0	1	1
	10	0	1	0	0

$$T4 = AD + B'D + A'BD'$$

5.

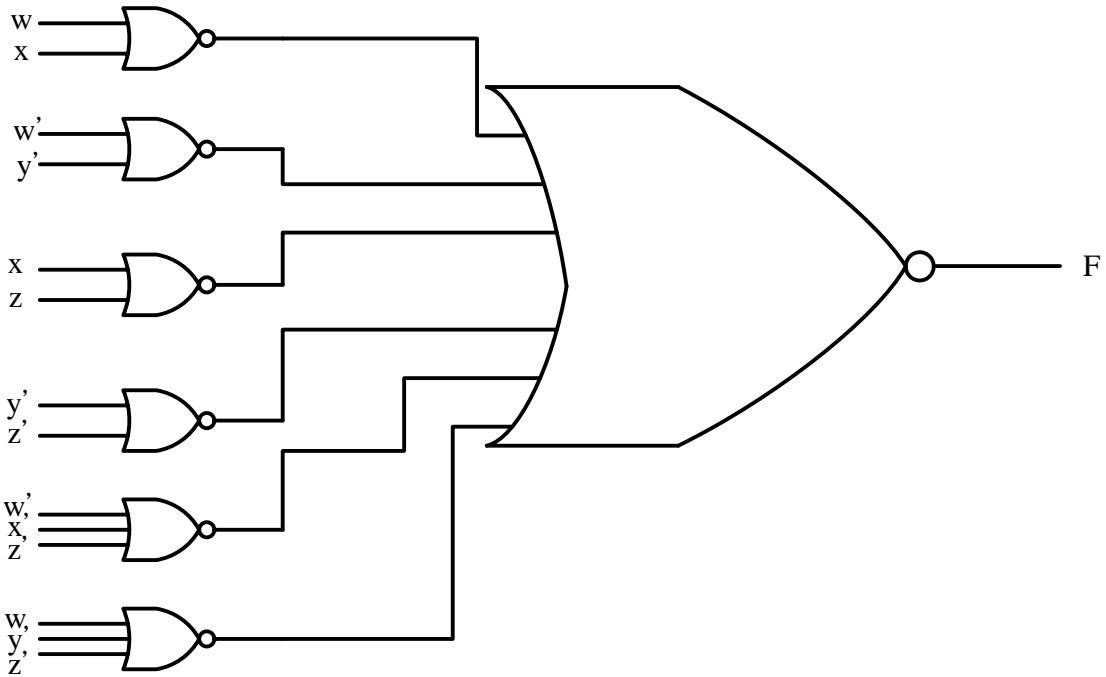
$$F = W'XYZ' + WX'Y'Z + WXY'Z' + W'XY'Z = \sum(5,6,9,12)$$

		wx			
		00	01	11	10
	yz	00	01	11	10
	00	0	0	1	0
	01	0	1	0	1
	11	0	0	0	0
	10	0	1	0	0

$$F' = w'x' + wy + x'z' + yz + wxz + w'yz$$

$$F = (w+x)(w'+y')(x+z)(y'+z')(w'+x'+z')(w+y'+z')$$

$$F = \left[ (w+x)' + (w'+y')' + (x+z)' + (y'+z')' + (w'+x'+z')' + (w+y'+z')' \right]'$$



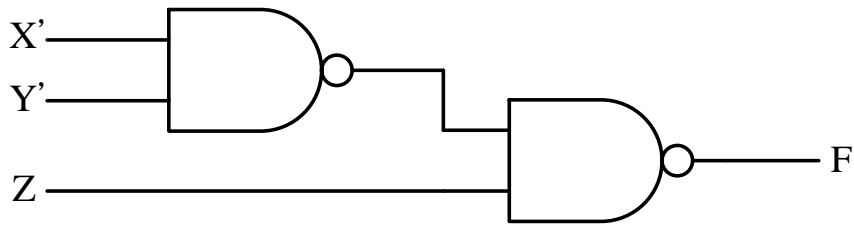
6.

$$F(x,y,z) = (x'+y'+z')(y'+z')(x'+z')$$

x	y	z	F
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

	YZ	00	01	11	10
X	0	1	1	0	1
1		1	0	0	1

$$F = Z' + X'Y' = (Z(X'Y'))'$$

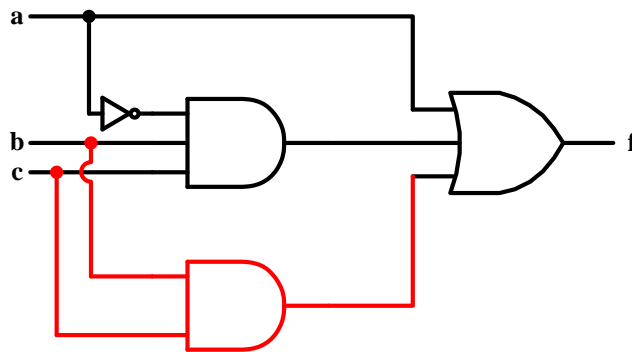


7.

(a)

a \ bc	00	01	11	10
0	0	0	1	0
1	1	1	1	1

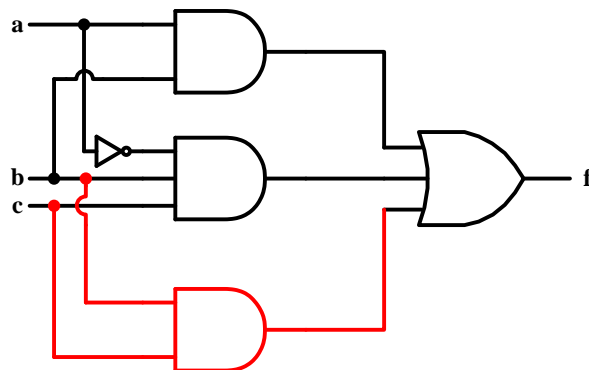
$f = a + a'bc + bc$  (to avoid static-1 hazard)



(b)

a \ bc	00	01	11	10
0	0	0	1	0
1	0	0	1	1

$f = ab + a'bc + bc$  (to avoid static-1 hazard)



8.

(a)

a	b	S	C <sub>o</sub>
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

(b)

$$S = ab' + a'b$$

a \ b	0	1
0	0	1
1	1	0

$$C_o = ab$$

a \ b	0	1
0	0	0
1	0	1

(c)

For S:

$ab'$  and  $a'b$  are both of PIs and EPs

For C<sub>o</sub>:

$ab$  is both of PIs and EPs

9.

Code:

```
module halfadder(input a, input b, output co, output s);
```

```
assign co=a&b;
```

```
assign s=(~a&b)|(a&~b);
```

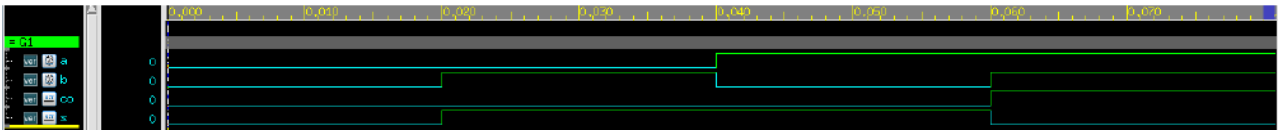
```
endmodule
```



Test bench:

```
module a9_t;
reg a,b;
wire co,s;
halfadder ha(.a(a),.b(b),.co(co),.s(s));
initial begin
a=0;b=0;
#5 a=0;b=1;
#5 a=1;b=0;
#5 a=1;b=1;
end
endmodule
```

Simulation results:



10.

Code:

```
module top_module(A,B,C,F);
input A,B,C;
output F;
assign F=(A&B)|(B&C)|(A&C);
endmodule
```

Test bench:

```
module testbench;
reg A;
reg B;
reg C;
wire F;
top_module uut (.A(A), .B(B), .C(C), .F(F));
initial begin
A = 0;B = 0;C = 0;
```

