MULTIMEDIA UNIVERSITY

PDS0101 Introduction to Digital Systems

Tutorial 4 SAMPLE SOLUTIONS

Tutorial outcomes

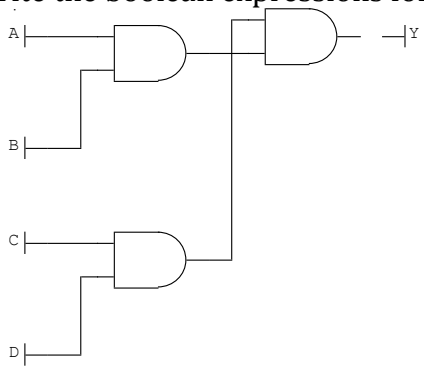
By the end of today's tutorial, you should be able to

- apple the basic laws and rules of boolean algebra
- apply DeMorgan's theorems to boolean expressions
- simplify boolean expressions using boolean algebra

Theory based questions

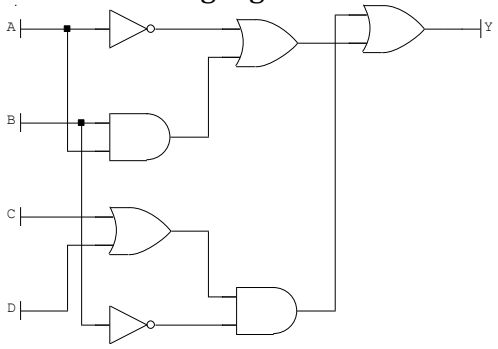
1. Write the boolean expressions for the outputs from the following logic circuits

a)



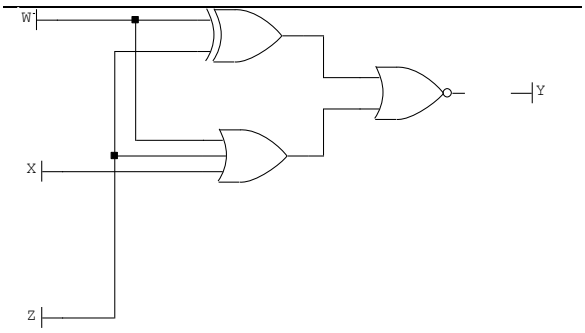
Y=ABCD

b)



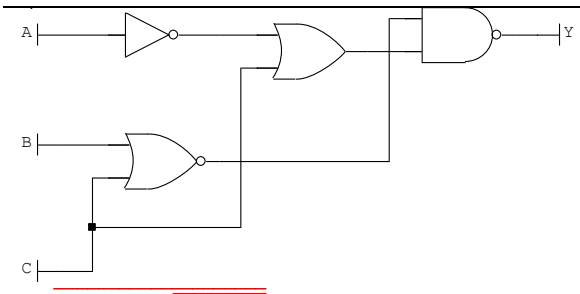
Y=(A'+AB)+(B'(C+D))

c)



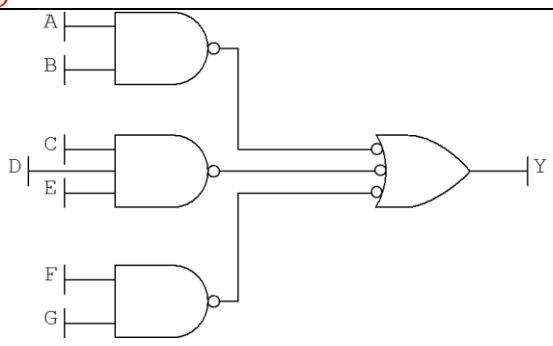
$Y=\overline{(W \oplus Z) + (W + X + Z)}$

d)



$Y=\overline{(\bar{A} + C)(\overline{B + C})}$

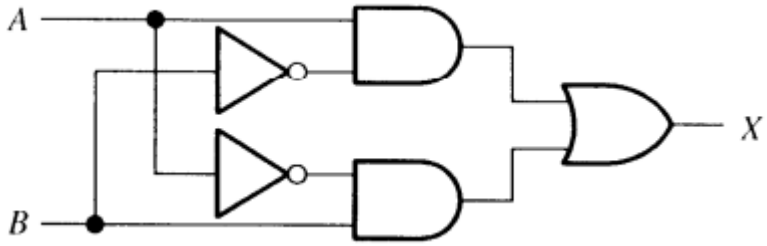
e)



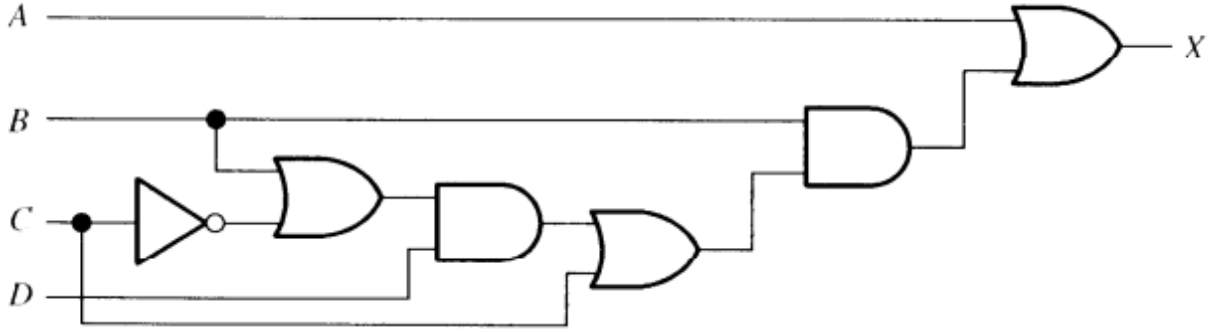
$Y=AB + CDE + GF$

2. Draw the logic circuit represented by the following boolean expressions

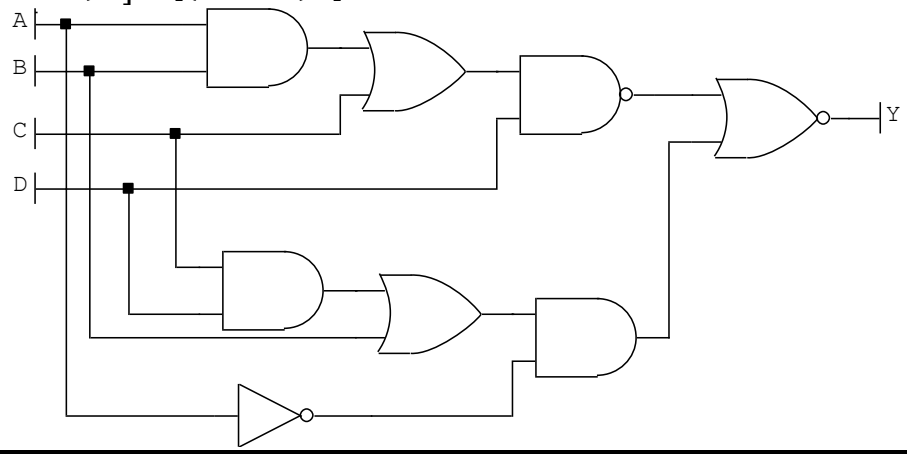
a) $Y = A\bar{B} + \bar{A}B$



b) $Y = A + B[C + D(B + \bar{C})]$



c) $Y = \overline{[(AB + C)D]} + [(CD + B)\bar{A}]$



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3. Define and describe De Morgan's first and second theorem

See notes

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4. Apply DeMorgan's theorems to the following expressions

a) $\overline{(A + \bar{B})} = \bar{A}\bar{\bar{B}} = \boldsymbol{\bar{A}B}$

b) $\overline{\bar{A}B} = \bar{\bar{A}} + \bar{B} = \boldsymbol{A + \bar{B}}$

c) $\overline{(A + \bar{B} + C + \bar{D})} + \overline{(ABC\bar{D})} = \bar{A}B\bar{C}D + \bar{A} + \bar{B} + \bar{C} + \bar{\bar{D}} = \boldsymbol{\bar{A}B\bar{C}D + \bar{A} + \bar{B} + \bar{C} + D}$

d) $\overline{\left(A\bar{B}(C + \bar{D})\right)} = \overline{A\bar{B}} + \overline{(C + \bar{D})} = \boldsymbol{\bar{A} + B + \bar{C}D}$

e) $\overline{(\overline{ABC})(\overline{EFG})} + \overline{(\overline{HIJ})(\overline{KLM})} = \overline{\overline{ABC} + \overline{EFG} + \overline{HIJ} + \overline{KLM}}$
$= \overline{ABC + EFG + HIJ + KLM} = (\overline{ABC})(\overline{EFG})(\overline{HIJ})(\overline{KLM})$
$= (\boldsymbol{\overline{A} + \overline{B} + \overline{C}})(\boldsymbol{\overline{E} + \overline{F} + \overline{G}})(\boldsymbol{\overline{H} + \overline{I} + \overline{J}})(\boldsymbol{\overline{K} + \overline{L} + \overline{M}})$

f) $\overline{(\overline{A+B})(\overline{C+D})(\overline{E+F})(\overline{G+H})}$
$= (\overline{A+B})(\overline{C+D})(\overline{E+F})(\overline{G+H}) = \boldsymbol{\overline{A}\,\overline{B}\,\overline{C}\,\overline{D}\,\overline{E}\,\overline{F}\,\overline{G}\,\overline{H}}$

Applied knowledge questions

6. Using boolean algebra rules, simplify the following expressions as much as possible

a) $A(\bar{A} + AB)$

A' + AB
= A'(B + B') + AB
= A'B + A'B' + AB
= (A' + A)B + A'B'
= B + A'B'
= A' + B

b) $(A + \bar{B})(A + C)$

(A+B')(A+C)
= AA+AC+AB'+B'C
= A+AC+AB'+B'C
= A(1+C+B')+B'C
= A+B'C

c) $AB + (\bar{A} + \bar{B})C + AB$

= AB+(A'+B')C
= AB+(AB)'C
= **AB+C**

d) $\bar{A}B + \bar{A}B\bar{C} + \bar{A}BCD + \bar{A}B\bar{C}\bar{D}E$

=A'B(1+C'+CD+C'D'E)
=**A'B**

e) $(a' + b')(a + b)$

= a'a+b'b+a'b+ab'
=**a'b+ab'**

f) $(a' + b' + c')(a + b + c)$ ← optional may require lecture 5

= ~~a'a+b'b+c'c~~+a'b+ac'+ab'+b'c+ac'+bc'
= a'b+a'c+ab'+b'c+ac'+bc'
= a'b(c+c')+a'c(b+b')+ab'(c+c')+b'c(a+a')+ac'(b+b')+bc'(a+a')
= a'bc+a'bc'+a'bc+a'b'c+ab'c+ab'c'+ab'c+a'b'c+abc'+ab'c'+abc'+a'bc'
= a'bc+a'bc'+a'b'c+ab'c+ab'c'+abc'
= a'bc+ab'c' + (a'+a)bc'+(a'+a)b'c = a'bc+ab'c' + bc'+b'c
= **a'b+ab'+bc'+b'c**

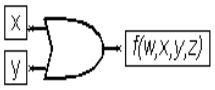
7. Using boolean algebra rules, simplify the following functions and draw the resulting logic circuit of *f*

(a) $f(w,x,y,z) = x + xyz + \bar{x}yz + wx + \bar{w}x + \bar{x}y + \bar{x}yw$

$= x(1 + yz + w + \bar{w}) + \bar{x}y(z + 1 + w)$

$= x + \bar{x}y$

$= x + y$



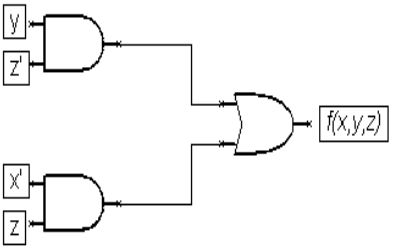
(b) $f(x,y,z) = y\bar{z}(\bar{z} + \bar{z}x) + (\bar{x} + \bar{z})(\bar{x}y + \bar{x}z)$

$= y\bar{z} + \bar{x}y + \bar{x}z + \bar{x}y\bar{z} + \bar{x}z\bar{z}$

$= y\bar{z} + \bar{x}y + \bar{x}z$

$= y\bar{z} + \bar{x}y\bar{z} + \bar{x}yz + \bar{x}z$

$= y\bar{z} + \bar{x}z$



(c) $f(w,x,y,z) = (w + x)(\bar{w} + y)(x + y + z)$

$= (wy + \bar{w}x + xy)(x + y + z)$

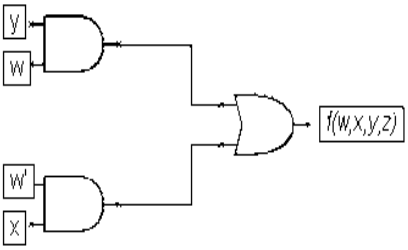
$= wxy + wy + wyz + \bar{w}x + \bar{w}xy + \bar{w}xz + xy + xyz$

$= wy(x + 1 + z) + \bar{w}x(1 + y + z) + xy(1 + z)$

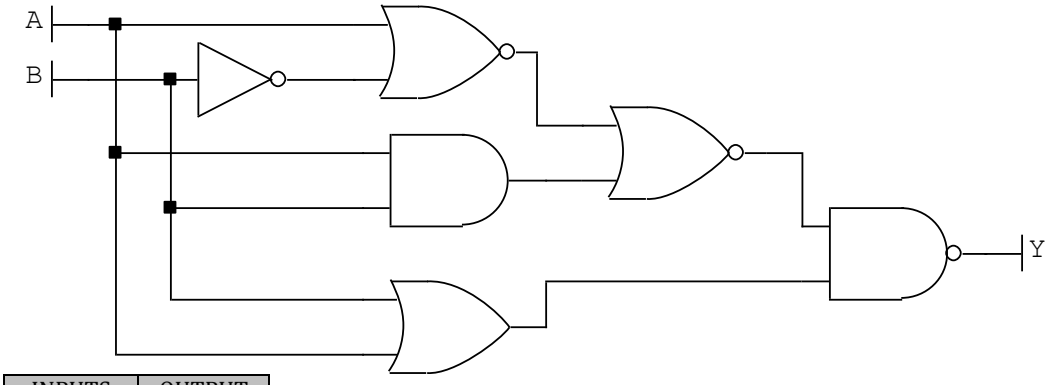
$= wy + \bar{w}x + xy$

$= wy + \bar{w}x + \bar{w}xy + wxy$

$= wy + \bar{w}x$



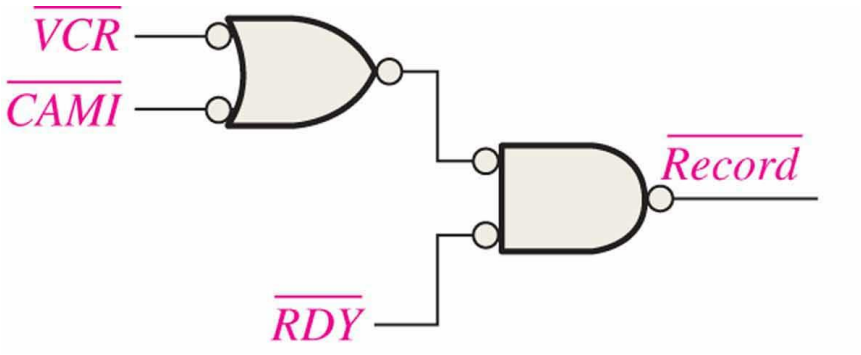
8. Derive the truth table for the circuits shown below



a)

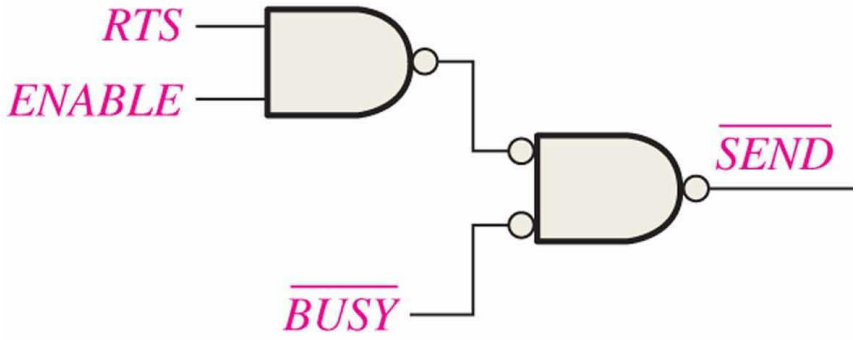
INPUTS		OUTPUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

b)



INPUTS			OUTPUT
$\overline{VCR}$	$\overline{CAMI}$	$\overline{RDY}$	$\overline{RECORD}$
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

c)



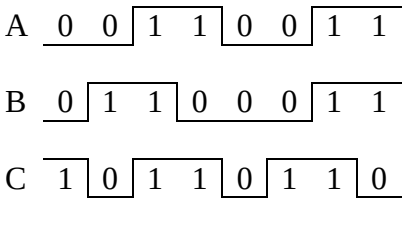
INPUTS			OUTPUT
RTS	$ENABLE$	$\overline{BUSY}$	$\overline{SEND}$
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

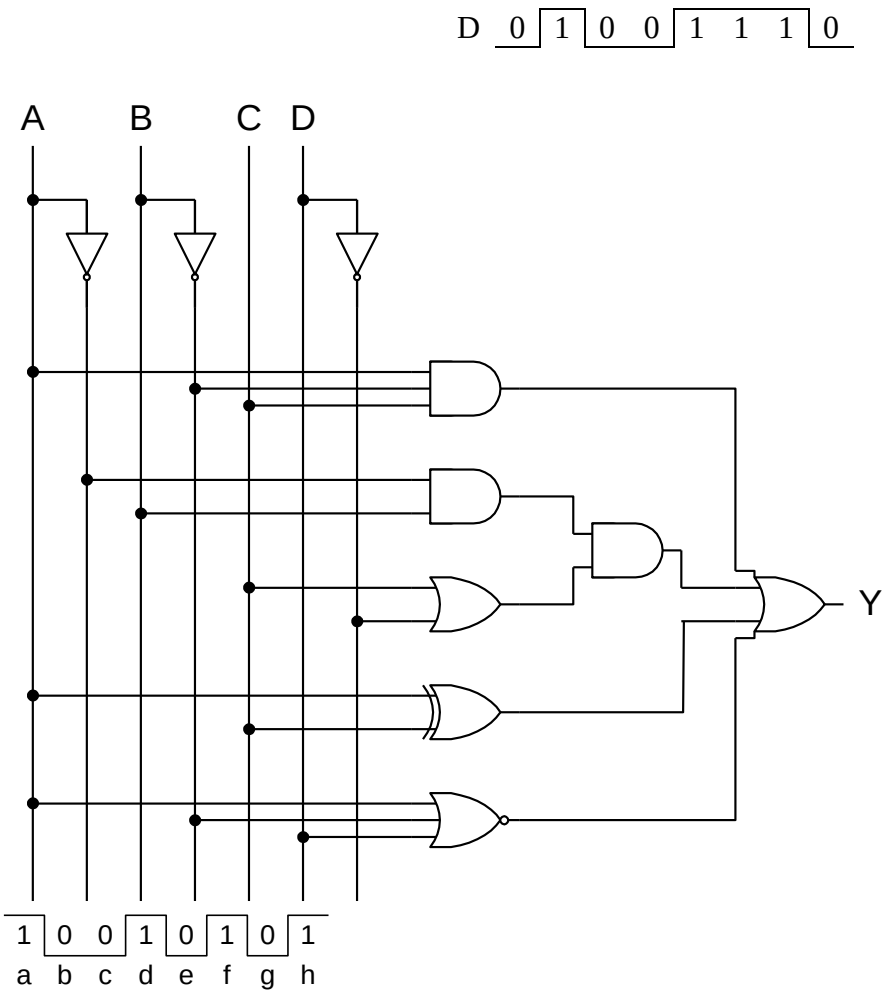
9. The Boolean expression of a logic circuit is given as:

$$Y = A\overline{B}C + \overline{A}B(C + \overline{D}) + (A \oplus C) + \overline{A + \overline{B} + D}$$

(a) Draw the implementation of the logic circuit given above

(b) If the inputs A, B, C and D are varying according to the timing diagram below, what should be waveform at Y?




D 0 1 0 0 1 1 1 0
A
B
C
D
Y
1 0 0 1 0 1 0 1
a b c d e f g h