ENGR 101
Engineering Technology

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Victoria
UNIVERSITY OF WELLINGTON
Te Whare Wānanga
o te Ūpoko o te Ika a Māui
CAPITAL CITY UNIVERSITY

Week 4 Lecture 7a

- Main topics
  - Introduction to Engineering Technology
  - Number system
  - Logic Gates
  - Boolean Algebra

- Course web page:
  https://ecs.wgtn.ac.nz/Courses/XMUT101_2021T1/

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Exercise 6.1

Use the Boolean Laws to simplify the following expressions:

(Note: $\overline{A}$ = A' or $\overline{C}$ = C')

(a) $X = A\,B\,C + \overline{A}\,B + A\,B\,\overline{C}$

(b) $X = \overline{A}\,B\,\overline{C} + A\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C}$

(c) $AB + \overline{A}\,C + B\,C = AB + \overline{A}\,C$

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

Boolean Algebra Laws

	Name of Law	Properties
1.	Identity Law	A+0=A; A+1=1; A.0=0; A.1=A
2.	Commutative Law	A.B = B.A; A+B = B+A
3.	Associative Law	A.(B.C) = A.B.C; A+(B+C) = A+B+C
4.	Idempotent Law	A.A = A; A+A = A
5.	Double Negative Law	A'' = A
6.	Complement Law	A.A' = 0; A+A' = 1
7.	Law of Union	A+1 = A; A+0 = A
8.	DeMorgan's Theorem	(AB)' = A'+B'; (A+B)' = A'.B'
9.	Distributive Law	A.(B+C) = (A.B) + (A.C); A+(BC) = (A+B).(A+C)
10.	Absorption Law	A.(A+B) = A; A+(A.B) = A
11.	Common Identities Law	A.(A'+B) = AB; A+(A'B) = A+B

Exercise 6.1(c): AB + A’C+ BC = AB + A’C

LHS – Left Hand Side of equal sign

AB + A’C + BC = AB + A’C	Boolean Law used

Exercise 6.1(c): AB + A'C+ BC = AB + A'C

LHS – Left Hand Side of equal sign

AB + A'C + BC = AB + A'C	Boolean Law used
LHS = AB + A'C + (1).BC	Identity Law A.1 = A

Exercise 6.1(c): AB + A'C+ BC = AB + A'C

LHS – Left Hand Side of equal sign

AB + A'C + BC = AB + A'C	Boolean Law used	
LHS = AB + A'C + (1).BC	Identity Law	A.1 = A
= AB + A'C + (A+A')(BC)	Complement Law	(A+A') = 1

Exercise 6.1(c): AB + A'C+ BC = AB + A'C

LHS – Left Hand Side of equal sign

AB + A'C + BC = AB + A'C	Boolean Law used	
LHS = AB + A'C + (1).BC	Identity Law	A.1 = A
= AB + A'C + (A+A')(BC)	Complement Law	(A+A') = 1
= AB + A'C + ABC + A'BC	Distributive Law	A.(B + C) = AB + AC

Exercise 6.1(c): AB + A'C+ BC = AB + A'C

LHS – Left Hand Side of equal sign

AB + A'C + BC = AB + A'C	Boolean Law used	
LHS = AB + A'C + (1).BC	Identity Law	A.1 = A
= AB + A'C + (A+A')(BC)	Complement Law	(A+A') = 1
= AB + A'C + ABC + A'BC	Distributive Law	A.(B + C) = AB + AC
= AB + ABC + A'C + A'BC	Commutative Law	A + B = B + A

Exercise 6.1(c): AB + A'C+ BC = AB + A'C

LHS – Left Hand Side of equal sign

AB + A'C + BC = AB + A'C	Boolean Law used	
LHS = AB + A'C + (1).BC	Identity Law	A.1 = A
= AB + A'C + (A+A')(BC)	Complement Law	(A+A') = 1
= AB + A'C + ABC + A'BC	Distributive Law	A.(B + C) = AB + AC
= AB + ABC + A'C + A'BC	Commutative Law	A + B = B + A
= AB(1 + C) + A'C (1 + B)	Distributive Law	A.(B + C) = AB + AC

Exercise 6.1(c): AB + A'C+ BC = AB + A'C

LHS – Left Hand Side of equal sign

AB + A'C + BC = AB + A'C	Boolean Law used	
LHS = AB + A'C + (1).BC	Identity Law	A.1 = A
= AB + A'C + (A+A')(BC)	Complement Law	(A+A') = 1
= AB + A'C + ABC + A'BC	Distributive Law	A.(B + C) = AB + AC
= AB + ABC + A'C + A'BC	Commutative Law	A + B = B + A
= AB(1 + C) + A'C (1 + B)	Distributive Law	A.(B + C) = AB + AC
= AB(1) + A'C (1)	Identity Law	A+1 = 1

Exercise 6.1(c): AB + A'C+ BC = AB + A'C

LHS – Left Hand Side of equal sign

AB + A'C + BC = AB + A'C	Boolean Law used	
LHS = AB + A'C + (1).BC	Identity Law	A.1 = A
= AB + A'C + (A+A')(BC)	Complement Law	(A+A') = 1
= AB + A'C + ABC + A'BC	Distributive Law	A.(B + C) = AB + AC
= AB + ABC + A'C + A'BC	Commutative Law	A + B = B + A
= AB(1 + C) + A'C (1 + B)	Distributive Law	A.(B + C) = AB + AC
= AB(1) + A'C (1)	Identity Law	A+1 = 1
= AB + A'C	Identity Law	A.1 = A
= RHS		

Exercise 6.1

Use the Boolean rules to simplify the following expressions:

(Note: $\overline{A}$ = A' or $\overline{C}$ = C')

(a) $X = A\,B\,C + \overline{A}\,B + A\,B\,\overline{C}$

(b) $X = \overline{A}\,B\,\overline{C} + A\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C}$

(c) $AB + \overline{A}\,C + B\,C = AB + \overline{A}\,C$

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

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used
= (AA'+AC+BA'+BC)(B+C)	Distributive Law A.(B + C) = AB + AC

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0
= (AC + BA' + BC)(B+C)		

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0
= (AC + BA' + BC)(B+C)		
= [AC + B(A' + C)] (B+C)	Distributive Law	A.(B + C) = AB + AC

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0
= (AC + BA' + BC)(B+C)		
= [AC + B(A' + C)] (B+C)	Distributive Law	A.(B + C) = AB + AC
= ABC + ACC + BB(A'+C) + BC(A'+C)		
3rd term 4th term		

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0
= (AC + BA' + BC)(B+C)		
= [AC + B(A' + C)] (B+C)	Distributive Law	A.(B + C) = AB + AC
= ABC + ACC + BB(A'+C) + BC(A'+C)		
= ABC + AC + B(A'+C) + BC(A'+C)	Idempotent Law	A.A = A

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0
= (AC + BA' + BC)(B+C)		
= [AC + B(A' + C)] (B+C)	Distributive Law	A.(B + C) = AB + AC
= ABC + ACC + BB(A'+C) + BC(A'+C)		
= ABC + AC + B(A'+C) + BC(A'+C)	Idempotent Law	A.A = A
= AC(B + 1) + B(A' + C) (1 + C)	Distributive Law	A.(B + C) = AB + AC

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0
= (AC + BA' + BC)(B+C)		
= [AC + B(A' + C)] (B+C)	Distributive Law	A.(B + C) = AB + AC
= ABC + ACC + BB(A'+C) + BC(A'+C)		
= ABC + AC + B(A'+C) + BC(A'+C)	Idempotent Law	A.A = A
= AC(B + 1) + B(A' + C) (1 + C)	Distributive Law	A.(B + C) = AB + AC
= AC + B(A' + C)	Identity Law	A+1 = 1

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0
= (AC + BA' + BC)(B+C)		
= [AC + B(A' + C)] (B+C)	Distributive Law	A.(B + C) = AB + AC
= ABC + ACC + BB(A'+C) + BC(A'+C)		
= ABC + AC + B(A'+C) + BC(A'+C)	Idempotent Law	A.A = A
= AC(B + 1) + B(A' + C) (1 + C)	Distributive Law	A.(B + C) = AB + AC
= AC + B(A' + C)	Identity Law	A+1 = 1
= AC + A'B + BC	Commutative Law	A + B = B + A

Exercise 6.1(d): (A+B)(A'+ C)(B+C) = (A+B)(A'+C)

LHS – Left Hand Side of equal sign

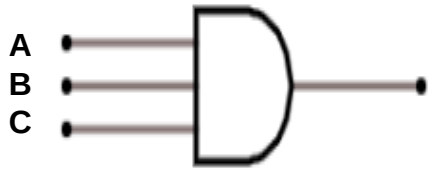
LHS = (A+B)(A'+C)(B+C)	Boolean Law used	
= (AA'+AC+BA'+BC)(B+C)	Distributive Law	A.(B + C) = AB + AC
= (0 + AC + BA' + BC)(B+C)	Complement Law	A.A' = 0
= (AC + BA' + BC)(B+C)		
= [AC + B(A' + C)] (B+C)	Distributive Law	A.(B + C) = AB + AC
= ABC + ACC + BB(A'+C) + BC(A'+C)		
= ABC + AC + B(A'+C) + BC(A'+C)		
= AC(B + 1) + B(A' + C) (1 + C)	Distributive Law	A.(B + C) = AB + AC
= AC + B(A' + C)	Identity Law	A+1 = 1
= AC + A'B + BC	Commutative Law	A + B = B + A
RHS = (A+B)(A'+C) = AA'+ AC+BA'+BC	Right Hand Side of equal sign	

Drawing Logic Circuits

Exercise 6.1 (a): $x = ABC + \overline{A}B + AB\overline{C}$

$= ABC + A'B + ABC'$

1st term



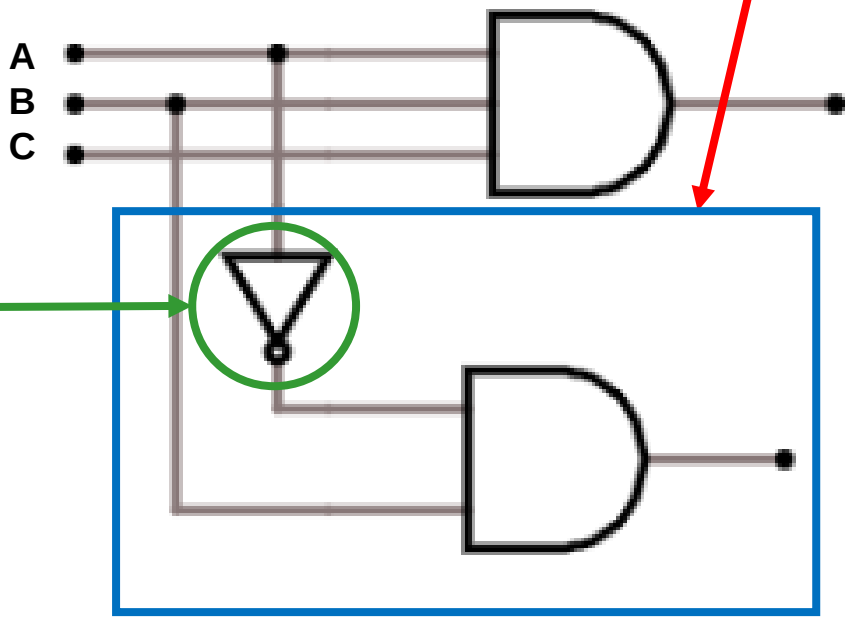
AND gate

Drawing Logic Circuits

Exercise 6.1 (a): $x = ABC + \bar{A}B + AB\bar{C}$

$= ABC + A'B + ABC'$

2nd term

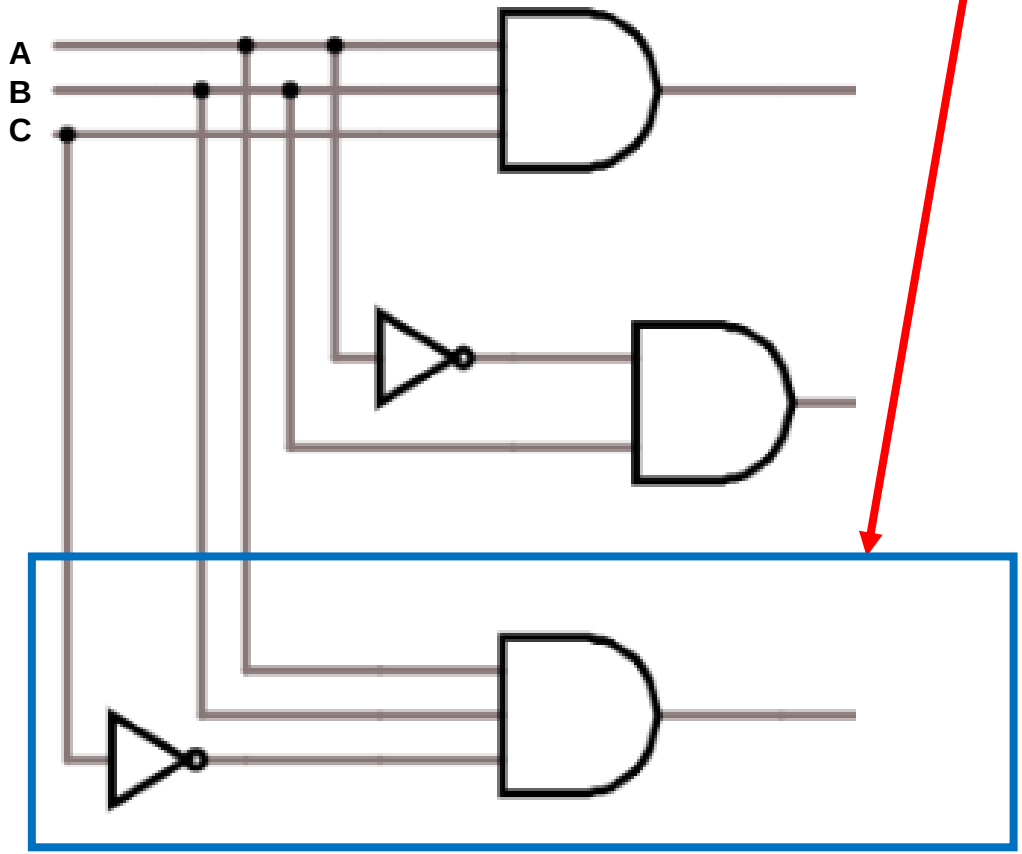


Inverter

Drawing Logic Circuits

Exercise 6.1 (a): $x = ABC + \bar{A}B + AB\bar{C}$

$= ABC + A'B + ABC'$ 3rd term

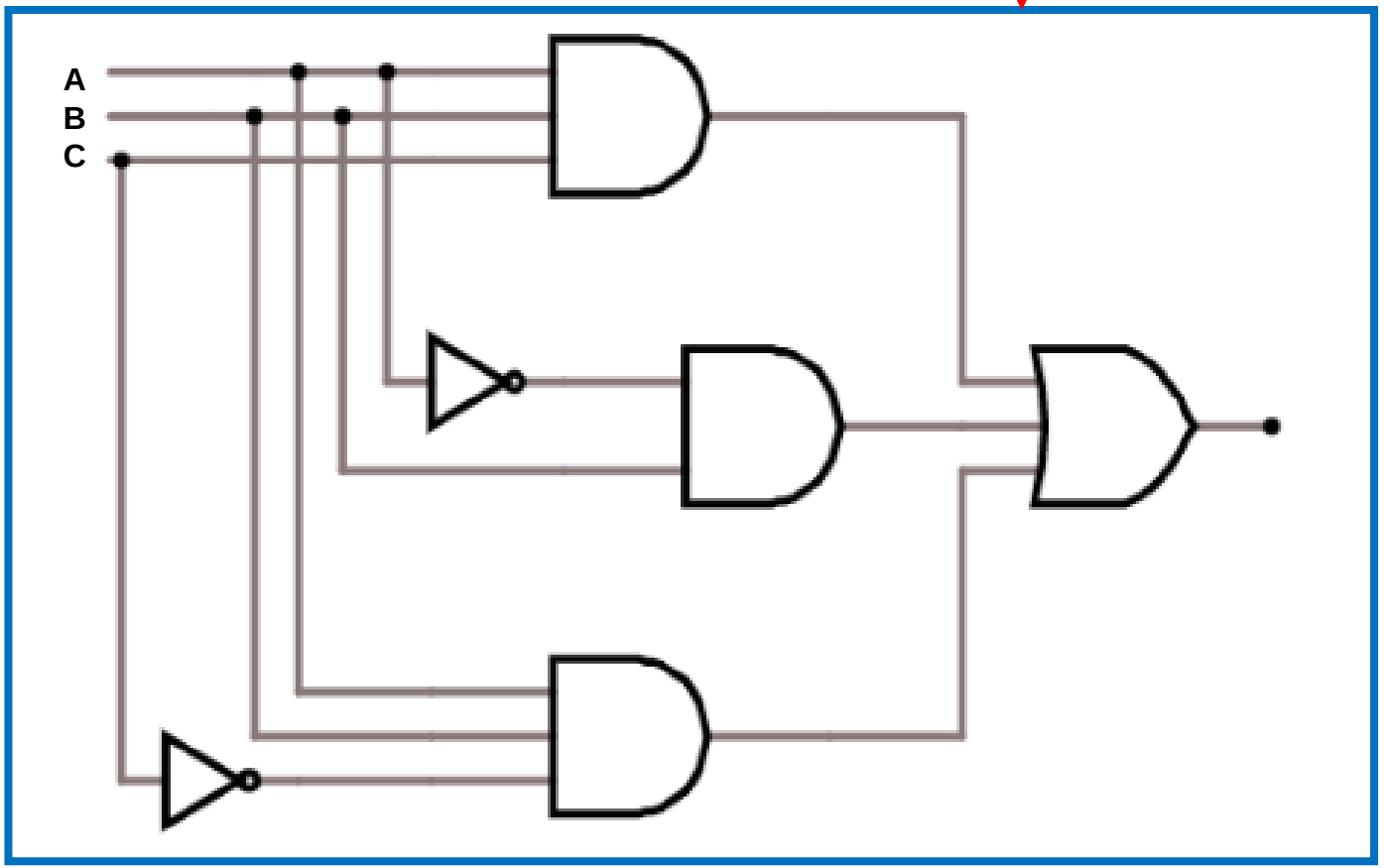


Drawing Logic Circuits

Exercise 6.1 (a): $x = ABC + \bar{A}B + AB\bar{C}$

$= ABC + A'B + ABC'$ Boolean expression

Logic circuit



Exercise 6.1(a) $x = A\,B\,C + \overline{A}\,B + A\,B\,\overline{C}$

	Boolean Law used
x = ABC + A'B + ABC'	3) Distributive Law A.(B+C) = (A.B) + (A.C)
= AB(C + C') + A'B	
= AB(1) + A'B	6) Complement Law A+A' = 1
= B(A + A')	3) Distributive Law A.(B+C) = (A.B) + (A.C)
= B	6) Complement Law A+A' = 1

Exercise 6.1

Use the Boolean Laws to simplify the following expressions:

(Note: $\overline{A}$ = A' or $\overline{C}$ = C')

(a) $X = A\,B\,C + \overline{A}\,B + A\,B\,\overline{C}$

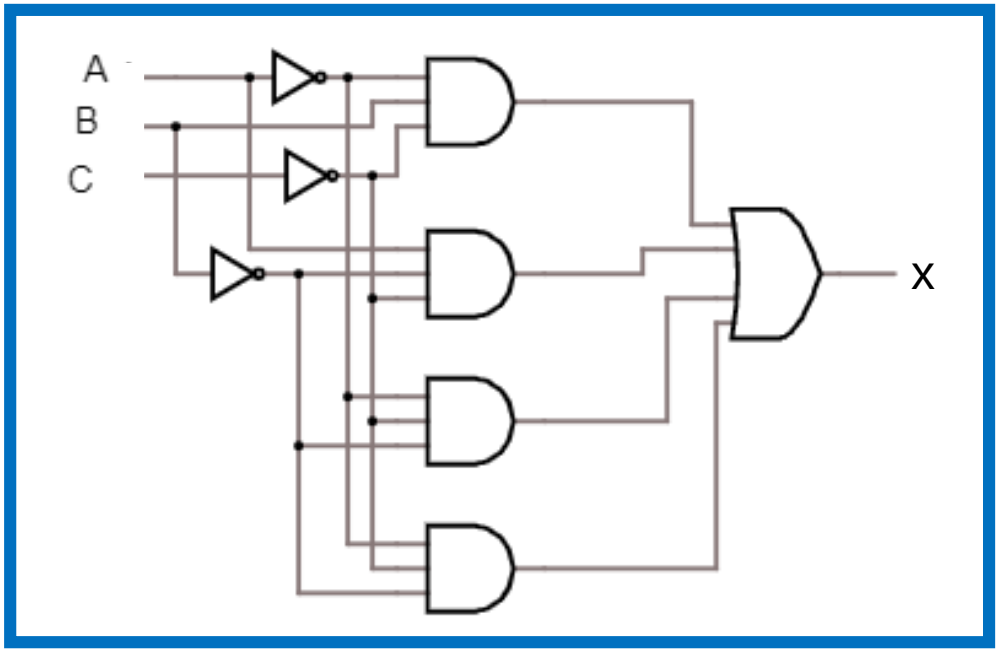
(b) $X = \overline{A}\,B\,\overline{C} + A\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C} + \overline{A}\,B\,\overline{C}$

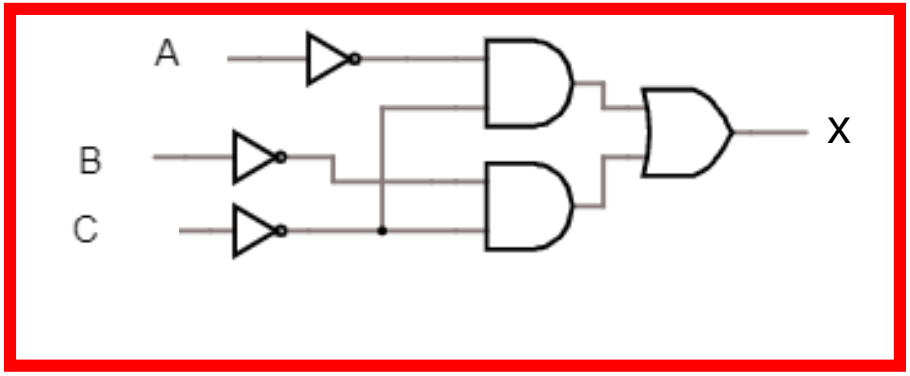
(c) $AB + \overline{A}\,C + B\,C = AB + \overline{A}\,C$

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

Exercise 6.1(b) $x = \overline{A}\,B\,\overline{C} + A\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,\overline{C}$

Original expression: x = A'BC' + AB'C' + A'B'C' + A'B'C'





Simplified expression: x = A'C' + B'C'

Week 4 Lecture 7a

- Boolean Algebra
  - Simplifying using the Boolean Laws

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