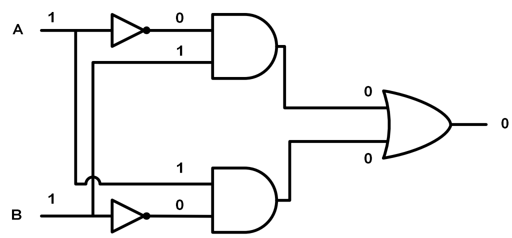
MECH 10
Fundamentals of Electronics

Mechatronics *Real Skills Real Jobs*

Class 26
Digital Logic



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MECH 10
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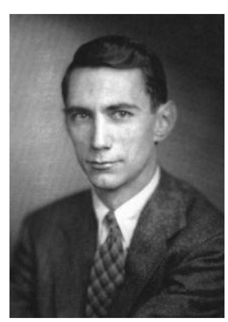
Mechatronics *Real Skills Real Jobs*

- Digital Logic
  - Boolean Logic
    - A system of logical operators (AND, OR, NOT) that form the basis of relay and digital logic

Gorge Boole


Claude Shannon

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Fundamentals of Electronics

Mechatronics
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- Digital Logic
  - Logic Voltage Levels
    - Logic **HIGH** – voltage level interpreted as a logic 1
    - Logic **LOW** – voltage level interpreted as a logic 0

Technology	Logic LOW (volts)	Logic HIGH (volts)
TTL	0 V to 0.8 V	2 V to 5 V
ECL	-5.2 V to −1.4 V	−1.2 V to 0 V
CMOS	0 V to $V_{DD}/2$	$V_{DD}/2$ to V_{DD}

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Fundamentals of Electronics

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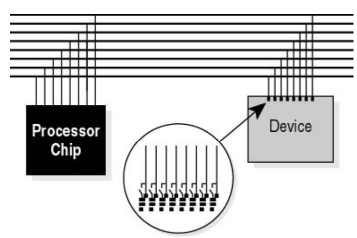
- Digital Logic
  - Information Storage Units
    - **Bit** – from binary digit
      - The output of one transistor or switch
    - **Nibble** – 4-bits
    - **Byte** – from bite
      - The output of multiple transistors
      - 8-bit de facto standard
        - 16, 32, 64 bit processors
    - **Word** – the processor bus size
      - 8, 16, 32, 64



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CIE 04
Fundamentals of
Mechatronics

- Digital Logic
  - Numbering Systems
    - Decimal – ten unique digits (from ten fingers?)
      - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
      - 9,999,999

Millions	H-Thousands	T-Thousands	Thousands	Hundreds	Tens	Ones	
						9	$= 9 \times 10^0$
					9	0	$= 9 \times 10^1$
				9	0	0	$= 9 \times 10^2$
			9	0	0	0	$= 9 \times 10^3$
		9	0	0	0	0	$= 9 \times 10^4$
	9	0	0	0	0	0	$= 9 \times 10^5$
9	0	0	0	0	0	0	$= 9 \times 10^6$

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CIE 04
Fundamentals of
Mechatronics

- Digital Logic
  - Numbering Systems
    - Binary – two unique digits (from transistor states)
      - 0, 1
      - 11111111 binary = 255 decimal

256's	128's	64's	32's	16's	8's	4's	2's	1's	
								1	$= 1 \times 2^0$
							1	0	$= 1 \times 2^1$
						1	0	0	$= 1 \times 2^2$
					1	0	0	0	$= 1 \times 2^3$
				1	0	0	0	0	$= 1 \times 2^4$
			1	0	0	0	0	0	$= 1 \times 2^5$
		1	0	0	0	0	0	0	$= 1 \times 2^6$
	1	0	0	0	0	0	0	0	$= 1 \times 2^7$
1	0	0	0	0	0	0	0	0	$= 1 \times 2^8$

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CIE 04 Fundamentals of Mechatronics

Mechatronics Real Skills Real Jobs

- Digital Logic
  - Numbering Systems
    - Binary ASCII
      - American Standard Code for Information Interchange

USASCII code chart

$b_7 b_6 b_5$ Bits					000	001	010	011	100	101	110	111
b_4	b_3	b_2	b_1	Column / Row	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	|
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

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CIE 04 Fundamentals of Mechatronics

Mechatronics Real Skills Real Jobs

- Digital Logic
  - Numbering Systems
    - Octal – eight unique digits (from 12, 24, 36 bit bytes)
      - 0, 1, 2, 3, 4, 5, 6, 7

The Yuki language in California used octal systems because the speakers count the spaces between their fingers rather than the fingers themselves.

17667215	2097152's	262144	32768	4096	512	64	8	1	
								7	$= 7 \times 8^0$
							7	0	$= 7 \times 8^1$
						7	0	0	$= 7 \times 8^2$
					7	0	0	0	$= 7 \times 8^3$
				7	0	0	0	0	$= 7 \times 8^4$
			7	0	0	0	0	0	$= 7 \times 8^5$
		7	0	0	0	0	0	0	$= 7 \times 8^6$
	7	0	0	0	0	0	0	0	$= 7 \times 8^7$
7	0	0	0	0	0	0	0	0	$= 7 \times 8^8$

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CIE 04
Fundamentals of Mechatronics

Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Numbering Systems
    - Hexadecimal – 16 unique digits
      - 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
      - FFFFFFFF hexadecimal = 42,949,672,950 decimal

"A human-friendly representation of binary-coded values in computing and digital electronics"

4294967296	268435456	16777216	1048576	65536	4096	256	16	1	
								F	= 15×16^{0}
							F	0	= 15×16^{1}
						F	0	0	= 15×16^{2}
					F	0	0	0	= 15×16^{3}
				F	0	0	0	0	= 15×16^{4}
			F	0	0	0	0	0	= 15×16^{5}
		F	0	0	0	0	0	0	= 15×16^{6}
	F	0	0	0	0	0	0	0	= 15×16^{7}
F	0	0	0	0	0	0	0	0	= 15×18^{8}

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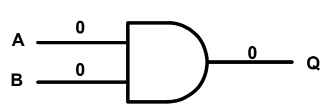
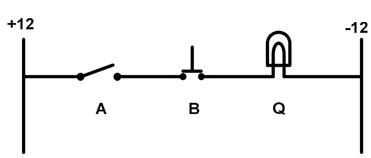
Fundamentals of Electronics

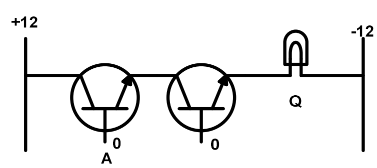
Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - AND Gate – A AND B → Q (A x B = Q)



A	B	Q
0	0	0





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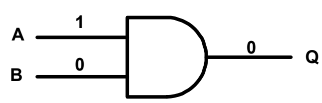
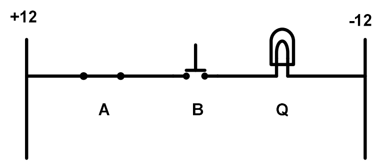
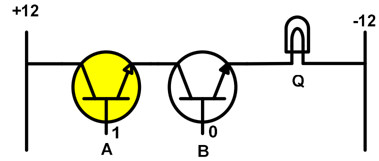
- Digital Logic
  - Boolean Logic
    - AND Gate – A AND B → Q (A x B = Q)



A	B	Q
1	0	0





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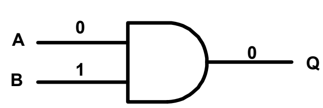
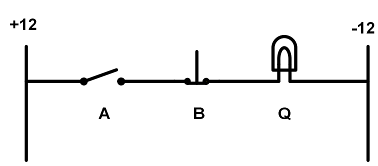
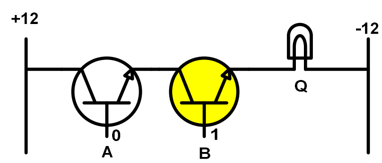
Fundamentals of Electronics
Mechatronics Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - AND Gate – A AND B → Q (A x B = Q)



A	B	Q
0	1	0





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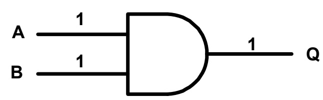
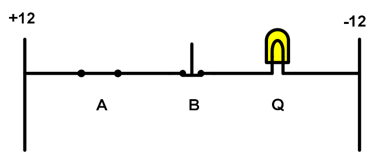
Fundamentals of Electronics

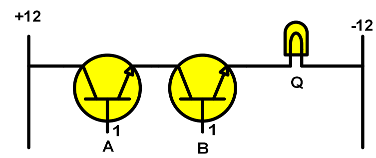
Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - AND Gate – A AND B → Q (A x B = Q)



A	B	Q
1	1	1





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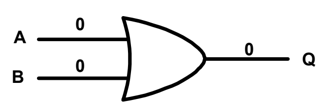
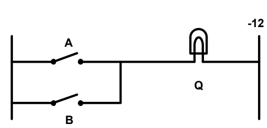
MECH 10
Fundamentals of Electronics

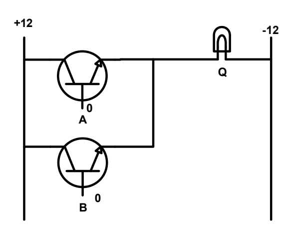
Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - OR Gate – A OR B → Q (A + B = Q)



A	B	Q
0	0	0





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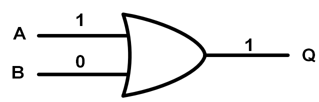
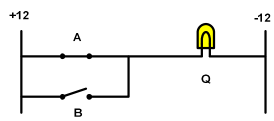
Fundamentals of Electronics

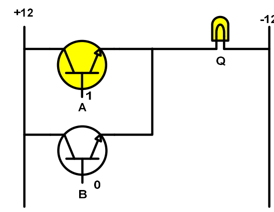
Mechatronics Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - OR Gate – A OR B → Q (A + B = Q)



A	B	Q
1	0	1





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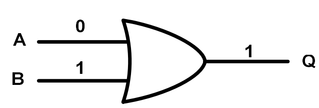
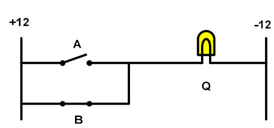
MECH 10
Fundamentals of Electronics

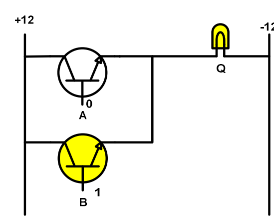
Mechatronics Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - OR Gate – A OR B → Q (A + B = Q)



A	B	Q
0	1	1





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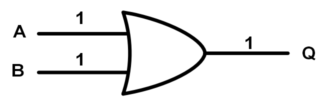
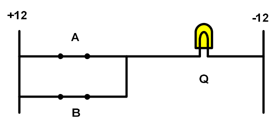
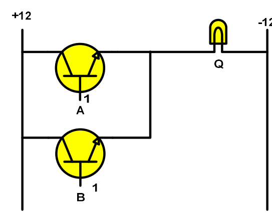
MECH 10
Fundamentals of Electronics

- Digital Logic
  - Boolean Logic
    - OR Gate – A OR B → Q (A + B = Q)



A	B	Q
1	1	1





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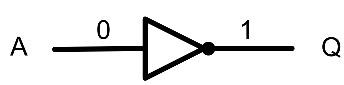
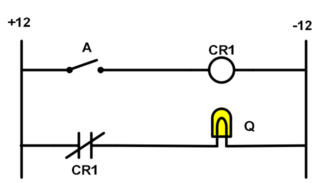
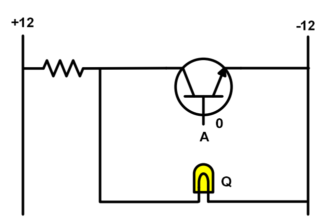
MECH 10
Fundamentals of Electronics

- Digital Logic
  - Boolean Logic
    - NOT Gate – A → $\overline{Q}$



A	Q
0	1





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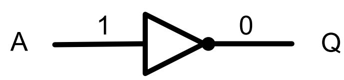
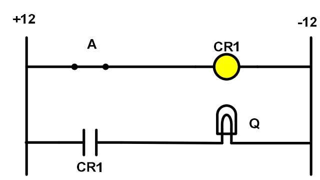
MECH 10
Fundamentals of Electronics

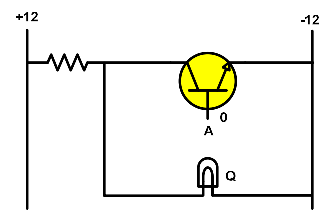
Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - NOT Gate – A → $\overline{Q}$



A	Q
1	0





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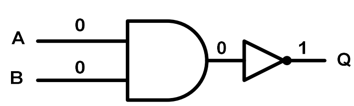
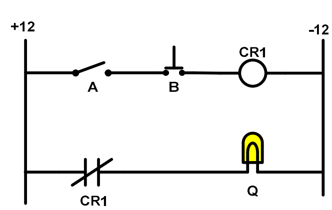
MECH 10
Fundamentals of Electronics

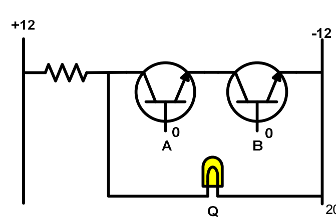
Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - NAND Gate – A AND B → $\overline{Q}$ (A x B = $\overline{Q}$)



A	B	Q
0	0	1





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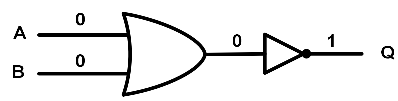
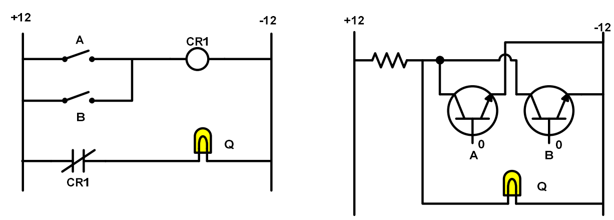
MECH 10
Fundamentals of Electronics

- Digital Logic
  - Boolean Logic
    - NOR Gate – A OR B → $\overline{Q}$ (A + B = $\overline{Q}$)



A	B	Q
0	0	1



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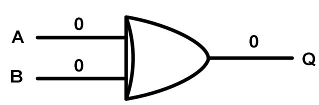
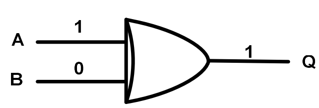
MECH 10
Fundamentals of Electronics

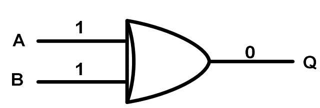
- Digital Logic
  - Boolean Logic
    - XOR Gate – A OR B (but not both) → Q



A	B	Q
0	0	0



A	B	Q
1	0	1



A	B	Q
1	1	0

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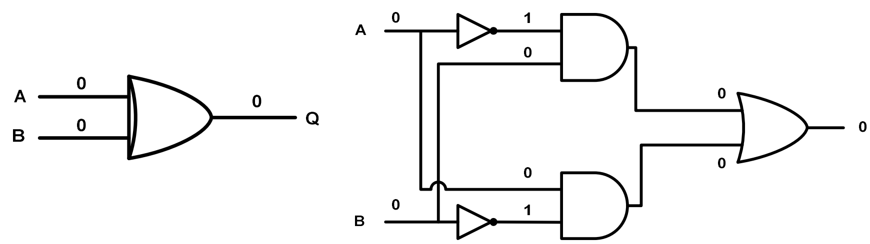
MECH 10
Fundamentals of Electronics

- Digital Logic
  - Boolean Logic
    - XOR Gate – A OR B (but not both) → Q



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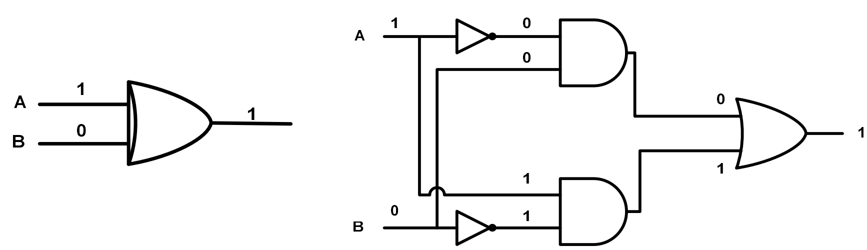
MECH 10
Fundamentals of Electronics

- Digital Logic
  - Boolean Logic
    - XOR Gate – A OR B (but not both) → Q



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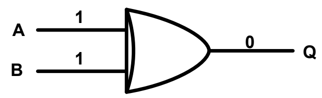
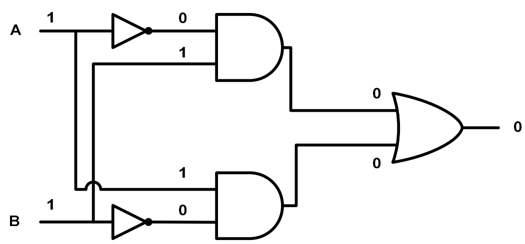
MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - XOR Gate – A OR B (but not both) → Q





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MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Boolean Logic
    - Truth Tables

AND GATE

A	B	Q
0	0	0
1	0	0
0	1	0
1	1	1

OR GATE

A	B	Q
0	0	0
1	0	1
0	1	1
1	1	1

XOR GATE

A	B	Q
0	0	0
1	0	1
0	1	1
1	1	0

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MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

- Digital Logic
  - Laboratory – Logic Gates

Learning Objectives

- Build and test digital logic gates using integrated circuits
- Construct truth tables for fundamental logic gates
- Construct a complex logic gate from fundamental logic gates

		Points Possible
Documentation	Quality of documentation (completeness, neatness, clarity, spelling, grammar, research)	**10**
Fundamental Logic Gates	All logic circuits tested and witnessed with instructor / lab technician initials	**10**
Logic Gate Inversion	AND , OR logic gates inverted, circuits tested and witnessed with instructor / lab technician initials	**10**
Fundamental to Complex Logic	XOR logic gate constructed from fundamental gates, circuits tested and witnessed with instructor / lab technician initials	**10**
Conclusions	Questions answered completely and accurately	**20**
	Total	**60**

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