End of Course Assessment (EOC): Final Study Guide
Digital Electronics

Directions: *Complete all of the work in your engineering notebook. Completion of this review study guide will count like an engineering notebook check worth 30 points.*

A. Scientific Notation vs. Engineering Notation

#1
- Explain how to write numbers in scientific notation.
- Explain how to write numbers in engineering notation.
- What are the SI prefixes that you will need to memorize in order to write numbers in Scientific notation or engineering notation?

B. Component Identification: Resistors and Capacitors

#2
- What is a resistor?
- How do you determine the nominal value for a resistor?
- What is a capacitor?
- How do you determine the nominal value for a capacitor?

C. Circuit Theory Laws:

#3-11
- What is current, voltage, and resistance?
- What is Ohm's Law?
- What is the difference between Parallel Circuits and Series Circuits?

D. Analog vs. Digital Signals

#12-13
- What is a logic level?
- What is an analog Signal?
- What is a digital Signal?

E. Number Systems

#14
- Binary
  - i. Why do engineers use the binary system to express numbers?
  - ii. How do you convert from decimal→ binary and from binary→ decimal?
- Octal
  - i. How do you convert from octal → Decimal and from decimal → octal?
- Hexadecimal
  - i. How do you convert from hexadecimal → decimal and from decimal → hexadecimal?

F. Combinational Design   Logic: AOI

#15
- What is AOI Logic? What do each of the gates represent in AOI logic?
- How do you write a truth table if given 2 inputs, 3 inputs, etc.?
- How do you find minterms from a truth table?
- How do you write a logic expression from minterms or from a truth table?
- How do you draw circuits from logic expressions?
- How do you derive a truth table from an existing circuit using "method 1"?
- How do you derive a truth table from an existing circuit using "method 2"?

G. Alternative Combinational Design Logic:

#18-21
- NAND Logic
  - i. What is NAND logic? What do each of the gates represent in NAND logic?
- NOR Logic
  - i. What is NOR logic? What do each of the gates represent in NOR logic?
- What are the pros/cons of using NAND/NOR logic over AOI logic?

H. Circuit Simplification Techniques
- i. Boolean Algebra

#16-17
  - Explain how to simplify logic expressions using Boolean Algebra.
- ii. DeMorgan's Theorems

#22-23
  - Explain how to simplify logic expressions using DeMorgan's Theorems.

#24   iii. K-Mapping
- Explain how to simplify logic expressions using the K-mapping technique.

#25

I. Seven Segment Displays
- What does each "segment" represent?
- What is the different between a Common Anode and a common cathode?
- Explain how you could display any number using a seven segment display.

#26

J. Multiplexers and DeMultiplexers
- What are they?
- Provide examples of each

#27

K. Binary Addition
- Explain how you perform binary addition/subtraction.

L. XOR/XNOR
- What is XOR/XNOR Logic? What do each of the gates represent in AOI logic?
- Be sure to know the truth table and the logic expressions for both XOR and XNOR gates.

#26
- What is the difference between a half-adder and a full adder?
- How do you determine the 'Sum' and the 'Cout'?

M. Flip-Flops
- What is a Flip Flop?
  - i. D Flip Flops vs. J/K Flip Flops
  - ii. Positive Edge Trigger vs. Negative Edge Trigger

#28-40
- How to you determine the signal of "Q" for a D flip flop and a J/K flip flop? Hint: Memorize the table
- What are asynchronous inputs?
- What are the functions of the present and the clear?
  - i. Makre sure that you can draw the signal of "Q" for a D flip flop that has a preset and clear!
- What is an asynchronous counter?
  - i. What determines the count limit?
  - ii. What is the ripple effect?
  - iii. What is the different between an up-counter and a down-counter?
  - iv. What are 2 limitations of asynchronous counters?
  - v. How do you modify a flip flop to count from 0→5 ?
- What is a synchronous counter?
  - i. How to you create a synchronous counter?
  - ii. MEMORIZE THE TRANSITION TABLE FOR J/K FLIP FLOPS!
  - iii. How do you determine the logic for a synchronous counter using the transition table?
- What is MSI?
  - i. What is the difference between the 74LS163 and the 74LS193 MSI logic chips?

N. State Machines
- What is a state machine?
- What are some examples are of state Machines?
- How do you dram a state graph?
- What are state variables?
- How do you draw the transition table from the state graph?

#41

2

EXAMPLE PROBLEMS

Scientific Notation vs. Engineering Notation

1. Express the following quantities in Scientific Notation and Engineering Notation

		Scientific	Engineering
a.	9437502876	9.437502876×10^9	9.437502876×10^9
b.	.000031645	3.1645×10^{-5}	31.645×10^{-6}
c.	.00000006185	6.185×10^{-8}	61.85×10^{-9}
d.	431 TΩ	4.31×10^{14}	431×10^{12}
e.	0.00000000356	3.56×10^{-9}	3.56×10^{-9}
f.	934,000,000	9.34×10^8	0.934×10^9
g.	3,510,000	3.51×10^6	3.51×10^6
h.	0.00092	9.2×10^{-4}	0.92×10^{-3}

✱ memorize prefixes!

Component Identification: Resistors and Capacitors

2. If the given the color bands, find the value of each resistor and the calculated tolerance. If given the value of a resistor, find the color bands and calculate the tolerance.

✱ colors on EQN sheet!

| Color Bands	Value	Tolerance
2 6 × 100K Red, blue, green, silver	2600K or 2.6 M	10%
2 2 × 1 Red, red, black, gold	22	5%
5 2 × 10 Green, red, brown, silver	520	10%
7 3 × 1K Violet, orange, orange, silver	7300	10%
4 7 × 10K Yellow, violet, yellow	470KΩ ±5%	Gold
.2 2 × 100K red, red, Green	2.2×10^6 Ω 2.2MΩ ±5% 2,200,000	Gold
4 7 × 100 Yellow, violet, red	4.7×10^3 4.7KΩ ±10% 4700	Silver
3 3 × 100 orange, orange, red	3.3×10^3 3.3KΩ ±5% 3300	Gold

✓

3

SERIES = current is EQUAL

PARALLEL = Voltage is EQUAL

Circuit Theory Laws:

Ohm's Law

Equation	Variables	Units	Unit Symbols
Current = $\dfrac{\text{Voltage}}{\text{Resistance}}$	$I = \dfrac{V}{R}$	Ampere = $\dfrac{\text{Volts}}{\text{Ohms}}$	$A = \dfrac{V}{\Omega}$

I = Amps

0.000

V = Volts

R = Ohms

0.000
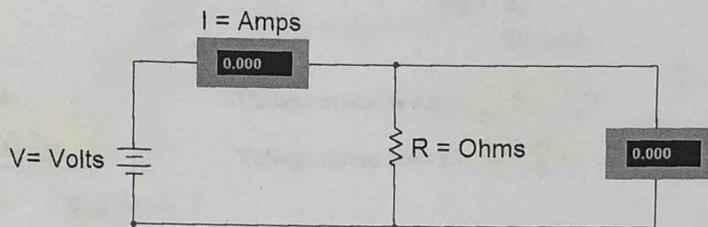
3. On a camping trip, you decide to use a cordless air pump to inflate an inflatable mattress. If the air pump is powered by a 9 volt battery with a resistance of 18 ohms, what is the amount of current flowing through the circuit?

$$I = \frac{V}{R}$$

$$I = \frac{9V}{18\,\Omega}$$

$$I = 0.5 \text{ amps}$$

4. A DJ uses a 110 volt outlet to plug in a strobe light. If the current flowing through the light is 0.050 amps, how much resistance is within the circuit?

$$V = I \cdot R$$

$$R = \frac{V}{I}$$

$$R = \frac{110V}{0.050 \text{ amps}} = 2200\,\Omega$$

5. You finally found the MP3 player that you have wanted for months. While you are waiting in the check-out line, you read the back of the packaging. The manufacturer has guaranteed that the player will perform consistently with a resistance of 40 ohms and a current of 0.1 amps. What is the voltage for the MP3 player?
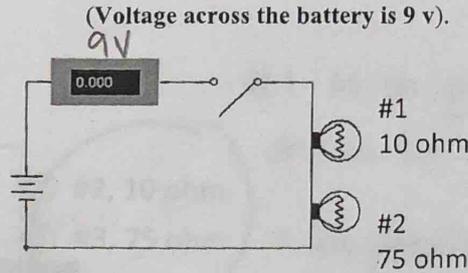
$$V = I \cdot R$$

$$V = (40\,\Omega)(0.1 \text{ amps})$$

$$= 4V$$

4

✓

6. Use the image below to answer the questions

(**Voltage across the battery is 9 v**).

9V

0.000

#1
10 ohm

#2
75 ohm

$$V = I \circ R$$

$$R_T = 10\,\Omega + 75\,\Omega = 85\,\Omega$$

Current ___0.106___ A   Voltage across battery ___9___ V

Voltage across bulb #1 __10.6__ V   Voltage across bulb #2 __7.95__ V

$$I_T = \frac{V_T}{R_T} = \frac{9V}{85\,\Omega}$$

$$I_T = 0.106 \text{ amps}$$

Bulb #1

$$V_1 = I_1 \circ R_1 = (0.106)(10\,\Omega) = 10.6 ✓$$

Creating a Parallel Circuit

7. Solve the circuit shown below (Voltage = 9v). Once the switch is closed find the values below:

9V

0.000 A

#1
10 ohm

#2
75 ohm

0.000 A   0.000 A
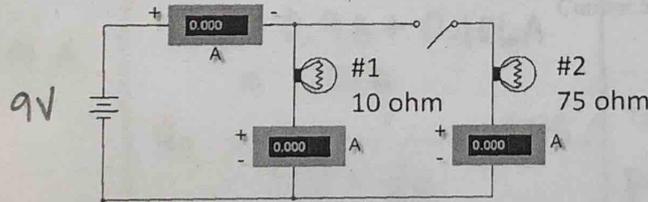
Bulb #2

$$V_2 = I_2 \circ R_2$$
$$= (0.106A)(75\,\Omega)$$
$$= 7.95 V$$

$$\text{Bulb \#1} = \frac{9V}{10\,\Omega} = 0.9 A$$

Bulb #2

Current at bulb #1 ___0.9___ A
Current at bulb #2 ___0.12___ A
Current total ___1.02___ A

$$\text{Bulb \#2} = \frac{9V}{75\,\Omega} = 0.12 A$$

Bulb #1 ___9V___ V   Bulb #2 ___9___ V

Current total =
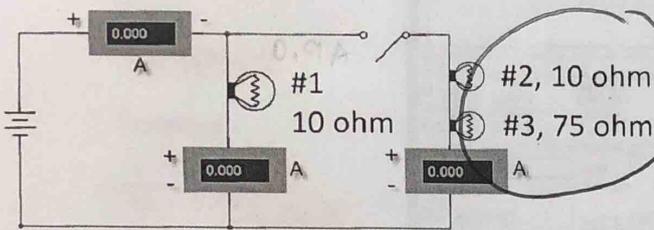$$0.9A + 0.12A = 1.02 A$$

parallel

✓

5

$$V = I \cdot R \qquad I = \frac{V}{R}$$

* this is a combo of the previous 2 circuits!

Creating a Combination Circuit

8. Solve the circuit shown below.

#1 is in parallel w/ #2 & #3

#2 is in series w/ #3

= In parallel $R_T = 10\Omega + 75\Omega$
$= \boxed{85\Omega}$

$I_{2/3} = \dfrac{9V}{85\Omega} = 0.106A$

$V_1 = 9V$ (series)

$\left[\begin{array}{l} V_2 = (10\Omega)(0.106A) = 1.06V \\ V_3 = (75\Omega)(0.106A) = 7.95V \end{array} \right]$ series

parallel $\left[\begin{array}{l} I_1 = \dfrac{9V}{10\Omega} = 0.9A \end{array} \right.$

$\left[\begin{array}{l} I_T = 0.9A + 0.106A \\ \quad = 1.01A \\ R_T = \dfrac{1}{\frac{1}{10} + \frac{1}{85}} = 8.95\Omega \end{array} \right]$ parallel

Voltage across battery 9V

Voltage across bulb #1 ___9___ V   Voltage across bulb #2 __1.06__ V

Voltage across bulb #3 __7.95__ V

Current at bulb #1 ___0.9___ A

Current at bulb #2 and #3 __0.106__ A

Total current __1.01__ A

Total Resistance __8.95__ ohm

9. Explain the difference between a series and a parallel circuit.

series — current is EQUAL through each component!

parallel — VOLTAGE IS EQUAL across each component!

10. Explain the difference between the *voltage* output at the battery and the voltage across each bulb in the series circuit.

The voltage across each bulb, is not the same as the voltage across the battery.

11. Explain the relationship between the *voltage* output at the battery and the voltage across each bulb in the parallel circuit?

The voltage across each bulb is the same as the voltage across the battery

✓

6

Analog vs. Digital Signals

12. For each of the two analog signals shown below, determine the amplitude (peak), amplitude (peak-peak), period (T), and frequency (F). Be sure to put your answer in proper engineering notation and use the correct units.

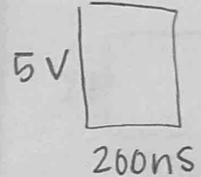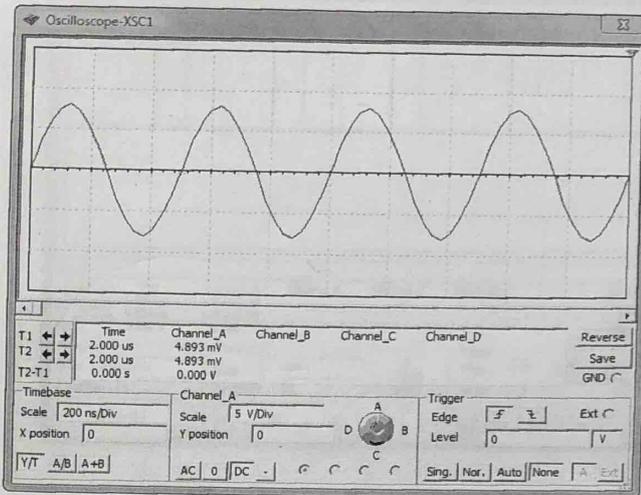Amp (peak):

7.5 V

Amp (peak-peak):

15 V

Period:

500ns

Frequency:

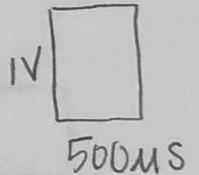$$\frac{1}{T} = \frac{1}{500ns}$$

Amp (peak):

2V

Amp (peak-peak):

4V

Period:

1000 µS

Frequency:

$$\frac{1}{1000 µS}$$

5 V ☐ 200ns

1V ☐ 500µS

7 ✓
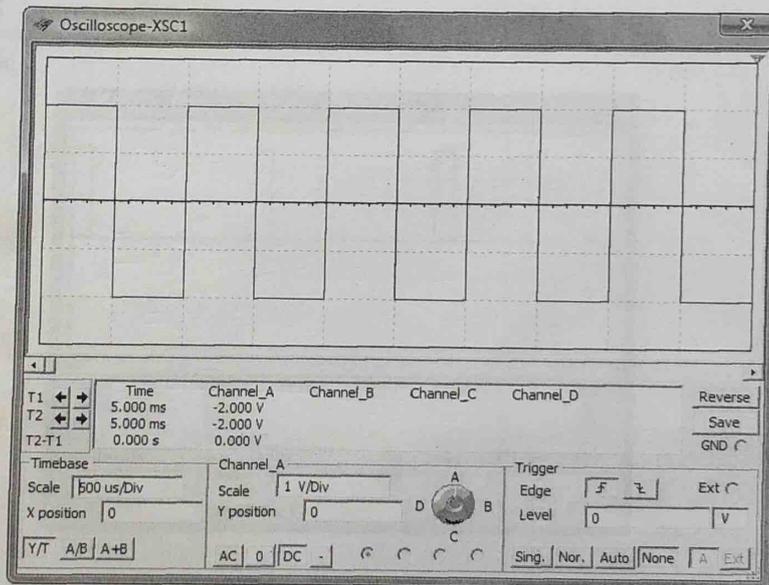
13. For each of the two digital signals shown below, determine the amplitude, period (T), frequency (F), time high (t_H), time low (t_L), and duty cycle (DC). Be sure to put your answer in proper engineering notation and use the correct units.

Amplitude:

5V

Period:

400µs

Frequency:

$\frac{1}{400µs}$

Time High:
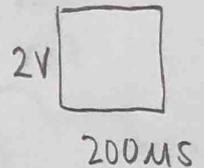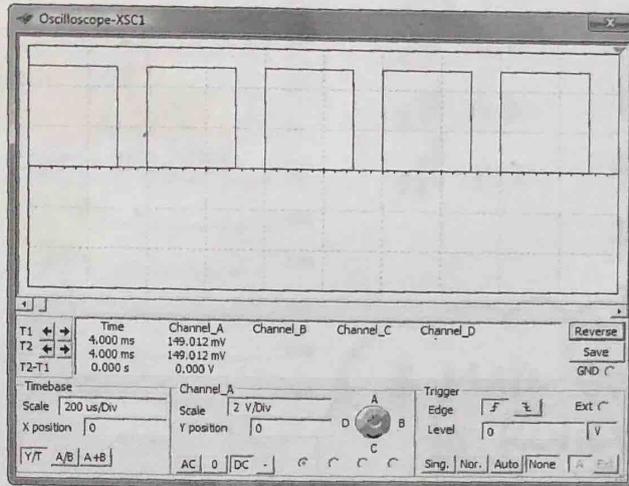
300µs

Time Low:

100µs

Duty Cycle:

$$\frac{T_H}{T} \cdot 100 = \frac{300µs}{400µs} = 75\%$$

Oscilloscope-XSC1

	Time	Channel_A	Channel_B	Channel_C	Channel_D	
T1 ← →	4.000 ms	149.012 mV				Reverse
T2 ← →	4.000 ms	149.012 mV				Save
T2-T1	0.000 s	0.000 V				GND

Timebase | Channel_A | Trigger
Scale 200 us/Div | Scale 2 V/Div | Edge f $\uparrow$ Ext
X position 0 | Y position 0 | Level 0 V
Y/T A/B A+B | AC 0 DC - | Sing. Nor. Auto None

2V [square] 200µs

Amplitude: 5V

Period: 1650µs

Frequency: $\frac{1}{1650µs}$

Time High: 125µs

Time Low: 1500µs

Duty Cycle:

$$\frac{125µs}{1650µs} \cdot 100 = 7.8\%$$

Oscilloscope-XSC1

	Time	Channel_A	Channel_B	Channel_C	Channel_D	
T1 ← →	5.000 ms	0.000 V				Reverse
T2 ← →	5.000 ms	0.000 V				Save
T2-T1	0.000 s	0.000 V				GND

Timebase | Channel_A | Trigger
Scale 500 us/Div | Scale 2 V/Div | Edge f $\uparrow$ Ext
X position 0 | Y position 0 | Level 0 V
Y/T A/B A+B | AC 0 DC - | Sing. Nor. Auto None

2V [square] 500µs

Duty Cycle

$$\frac{T_H}{T} \cdot 100 = \%$$

8
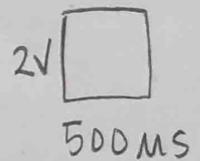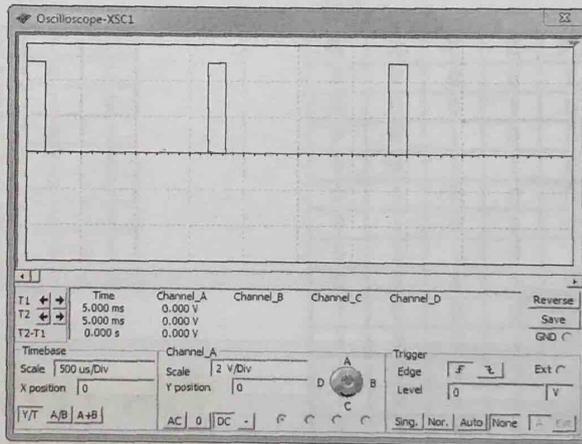
Number Systems

14. Convert the following numbers.
   a. $41_{(10)}$ 101001   (2)
   b. $96_{(10)}$ 1100000   (2)
   c. $147_{(10)}$ 1001 0011   (2)
   d. $864_{(10)}$ 1101 100000   (2)
   e. $1056_{(10)}$ 1000 0100 000   (2)
       512 32 2
   f. $1000100010_{(2)}$ 546   (10)
   g. $1111011_{(2)}$ 123   (10)
       64 8 4 2 1
   h. $1001110_{(2)}$ 78   (10)
       32 8 2 1
   i. $101011_{(2)}$ 43   (10)
       128 16 4 1
   j. $10010101_{(2)}$ 149   (10)

a) 2)41 20 r=1
   2)20 10 r=0
   2)10 5 r=0
   2)5 2 r=1
   2)2 1 r=0
   2)1 0 r=1

b) 2)96 48 r=0
   2)48 24 r=0
   2)24 12 r=0
   2)12 6 r=0
   2)6 3 r=0
   2)3 1 r=1
   2)1 0 r=1

Make sure to Review OCTAL, and HEXADECIMAL!

Combinational Design Logic: AOI

15. Write the unsimplified SOP Equation for each Truth Table

memorize K-mapping FORMAT!

$F_1 =$

X	Y	F_1
0	0	1
0	1	0
1	0	1
1	1	1

$F_2 =$

W	X	Y	F_2
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

$F_3 =$

W	X	Y	Z	F_3
0	0	0	0	1
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

$F_1 = \overline{X}\,\overline{Y} + X\overline{Y} + XY$

$F_2 = \overline{W}\,\overline{X}\,\overline{Y} + \overline{W}X\overline{Y} + W\overline{X}Y + WX\overline{Y}$

$F_3 = \overline{W}\,\overline{X}\,\overline{Y}\,\overline{Z} + \overline{W}XY\overline{Z} + W\overline{X}YZ + WX\overline{Y}\overline{Z}$

16. Write the simplified SOP Equation for each of the above truth tables using BOOLEAN Logic.

F_1

	$\overline{Y}$	Y
$\overline{X}$	1	0
X	1	1

$F_1 = \overline{Y} + X$

F_2

	$\overline{Y}$	Y
$\overline{W}\,\overline{X}$	1	0
$\overline{W}X$	1	0
WX	1	0
$W\overline{X}$	0	1

$F_2 = \overline{W}\,\overline{Y} + X\overline{Y} + W\overline{X}Y$

OR

$F_2 = \overline{Y}(\overline{W}+X) + W\overline{X}Y$

F_3

	$\overline{Y}\,\overline{Z}$	$\overline{Y}Z$	$Y\overline{Z}$	$Y\overline{Z}$
$\overline{W}\,\overline{X}$	1	0	0	0
$\overline{W}X$	0	0	0	1
WX	0	0	1	0
$W\overline{X}$	1	0	0	0

Same as above

9 ✓
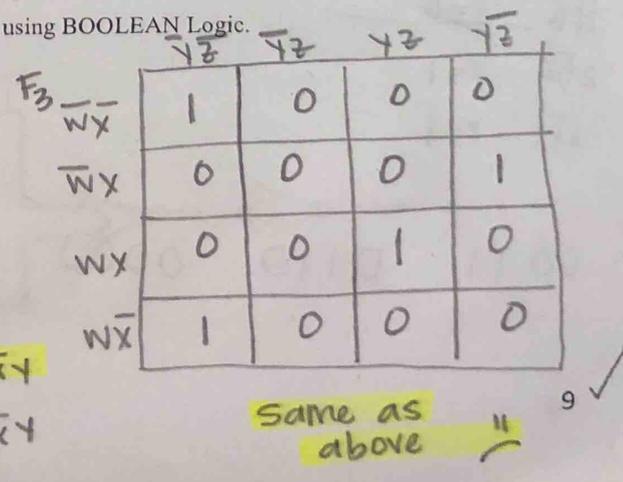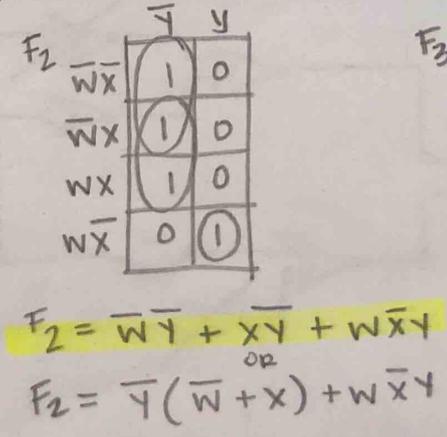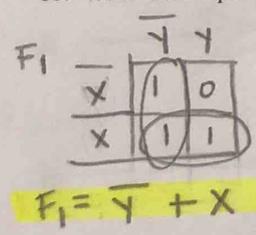
17. Write the un-simplified Boolean expression that represents the logic circuit shown below.
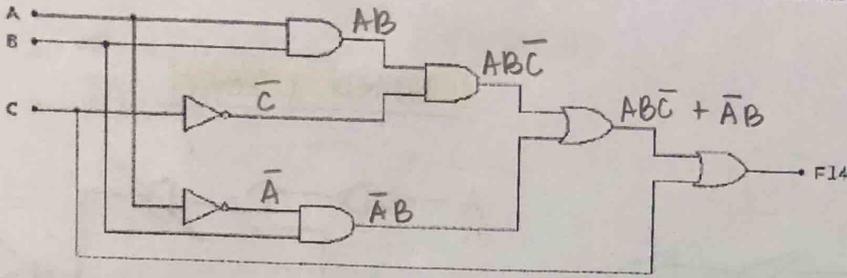
$$F_{14} = AB\bar{C} + \bar{A}B + C$$

Alternative Combinational Design Logic:
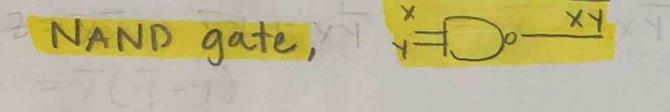
18. Draw the following SOP Equations using NAND Only Logic.
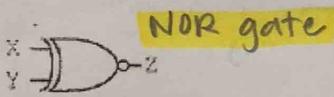
    a. $AB + CD + C$

    ✳ SEE BACK of pg

    b. $A\bar{B} + \bar{B}C + C\bar{D}$

19. The Truth table shown at the right represents which gate? Draw the symbol that represents the gate and list the name and the equation.
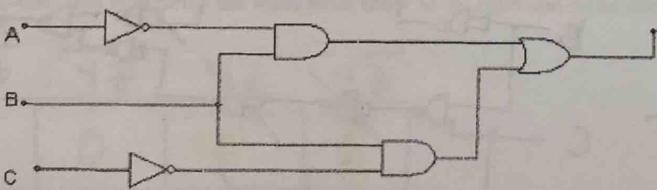
    NAND gate, $\overline{XY}$

X	Y	Z
0	0	1
0	1	1
1	0	1
1	1	0

20. Draw the truth table for the gate shown below.

     NOR gate

X	Y	Z
0	0	1
0	1	0
1	0	0
1	1	0

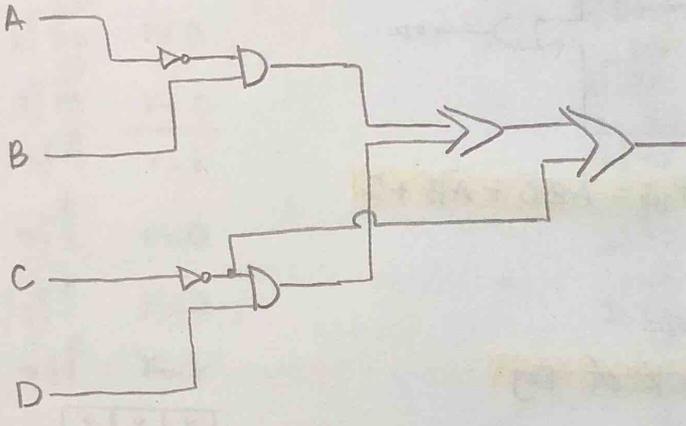21. Convert the following circuit to NOR only.

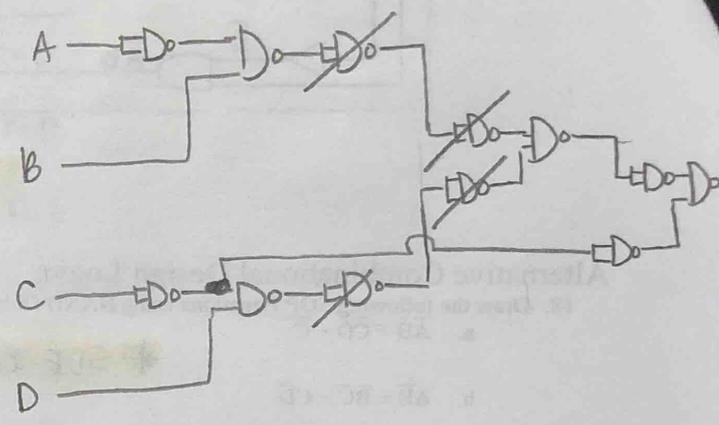✳ Memorize

• GATE LOGIC!
• NAND GATES
• NOR GATES!

10
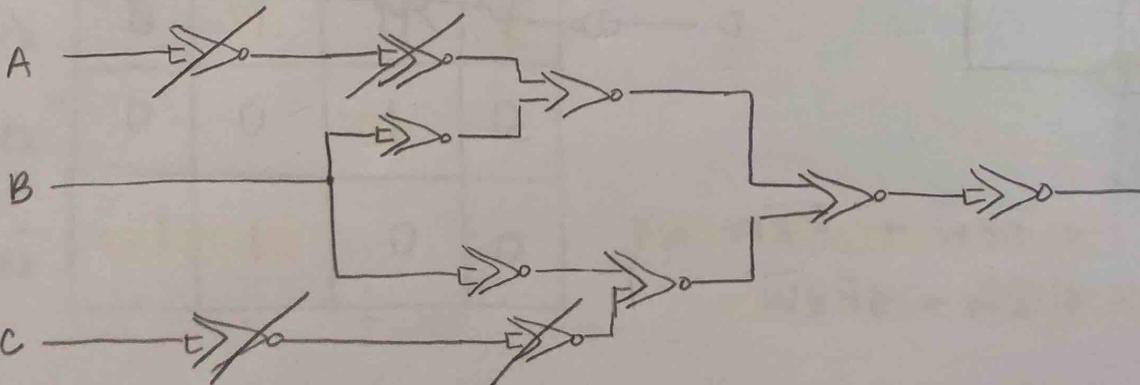
18. **NAND ONLY**
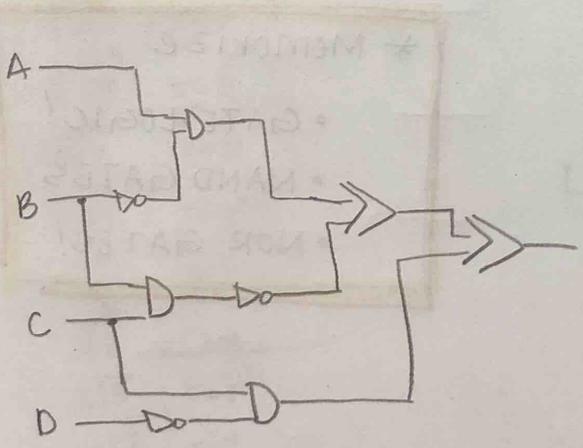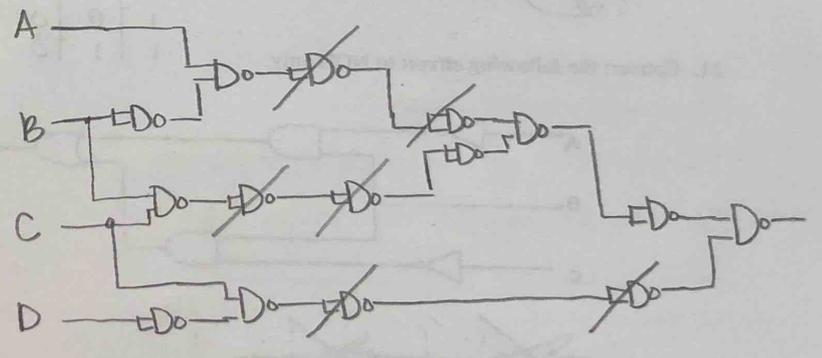
(a) $\bar{A}B + \bar{C}D + \bar{C}$

AOI LOGIC

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

AOI LOGIC

NAND LOGIC

22. Using DeMorgan's Theorems, simplify each of the equations.

see back

   a. $\overline{(\overline{W}X+WZ)} + \overline{(\overline{WZ} + XZ)}$

   b. $\overline{X\overline{Y}Z} + \overline{\overline{X}YZ}$

23. Simplify using DeMorgan's Techniues

$$F_5 = \overline{\overline{AB}+C} + ABC + \overline{\overline{A}+B+\overline{C}}$$

$$= \left(\overline{\overline{\overline{AB}}} \cdot \overline{C}\right) + ABC + \overline{\overline{A}} \cdot \overline{B} \cdot \overline{\overline{C}}$$

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

24. Create a K-map that represents the truth table show at the right and write down the simplified expression.

	$\overline{Y}\overline{Z}$	$\overline{Y}Z$	YZ	$Y\overline{Z}$
$\overline{W}\,\overline{X}$	0	0	1	1
$\overline{W}X$	0	1	0	1
WX	0	0	1	0
$W\overline{X}$	1	1	0	0

| W	X	Y	Z	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

$$F = W\overline{X}\overline{Y} + \overline{W}Y\overline{Z} +$$
$$\overline{W}X\overline{Y}Z + \overline{W}\,\overline{X}YZ + WXYZ$$

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22(a) $\overline{\overline{(\overline{W}x + wz)} + \overline{(\overline{wz} + xz)}}$

$\overline{\overline{(\overline{W}x + wz)}} \cdot \overline{\overline{(\overline{wz} + xz)}}$

$= \boxed{(\overline{W}x + wz)(\overline{wz} + xz)}$

(b) $\overline{\overline{x\overline{y}z} + \overline{\overline{x}yz}}$

$\overline{\overline{x\overline{y}z}} \cdot \overline{\overline{\overline{x}yz}}$

$\overline{x\overline{y}z} \cdot \overline{\overline{x}yz}$

$(\overline{x} + \overline{\overline{y}z}) \cdot \overline{\overline{x}yz}$

$(\overline{x} + \overline{\overline{y}} + \overline{z}) \cdot \overline{\overline{x}yz}$

$(\overline{x} + y + \overline{z})(\overline{\overline{x}yz})$

Seven Segment Displays

25.

What logic values need to be place on the inputs (a) through (g) of the **common-cathode** seven segment display in order to display the number 2?
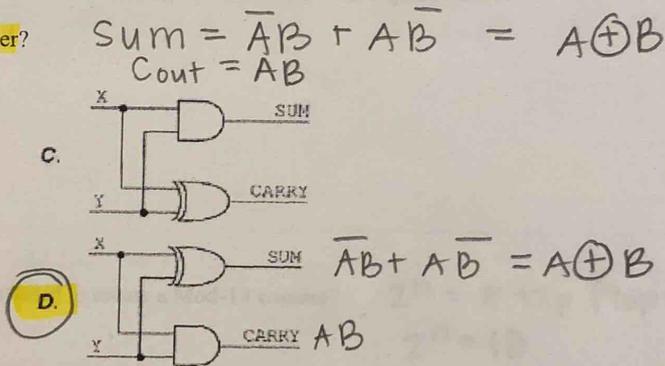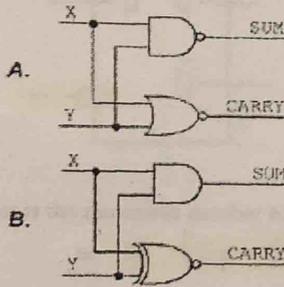
Common anode is → $0V$ = segment off
the opposite! $5V$ = segment on.
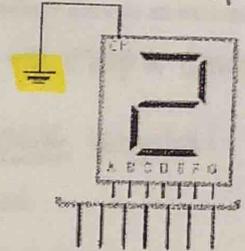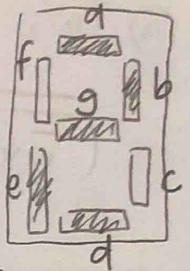
A	B	C	D	E	F	G
5V	5V	0V	5V	5V	0V	5V

Multiplexers and DeMultiplexers

26. Which of the following circuits is a half adder?

$Sum = \overline{A}B + A\overline{B} = A \oplus B$
$Cout = AB$

A. SUM, CARRY

B. SUM, CARRY

C. SUM, CARRY

D. SUM $\overline{A}B + A\overline{B} = A \oplus B$
CARRY AB

Binary Addition

27. Perform the following binary addition problems

a.
```
 010011
+100101
```

b.
```
 111011
+011010
```

(a)
```
  1 1 1 1
  0 1 0 0 1 1
  1 0 0 1 0 1
-------------
1 0 0 0 0 0 0
```

(b)
```
  1 1 1
  1 1 1 0 1 1
  0 1 1 0 1 0
-------------
1 0 1 0 1 0 1
```

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28. What is the basic function of a flip-flop ~~and transparent latch?~~

to provide memory for the system!

29. What functions do the synchronous and asynchronous inputs serve on flip-flops ~~and transparent latches?~~ Provide an example of each.

asynchronous – input will affect output at any time → ripple counter.

*synchronous – inputs will only affect outputs on CLOCK signal.*

30. What are some of the typical applications of flip-flops? Describe how each of these applications work.

– Event detector, data synchronizer, frequency divider, shift register.

31. How are Q and Q' outputs of a flip flop affected by setting the active high asynchronous PRESET input to a logic one?

If the preset is activated the Q will go HIGH, and Q̄ will go LOW!

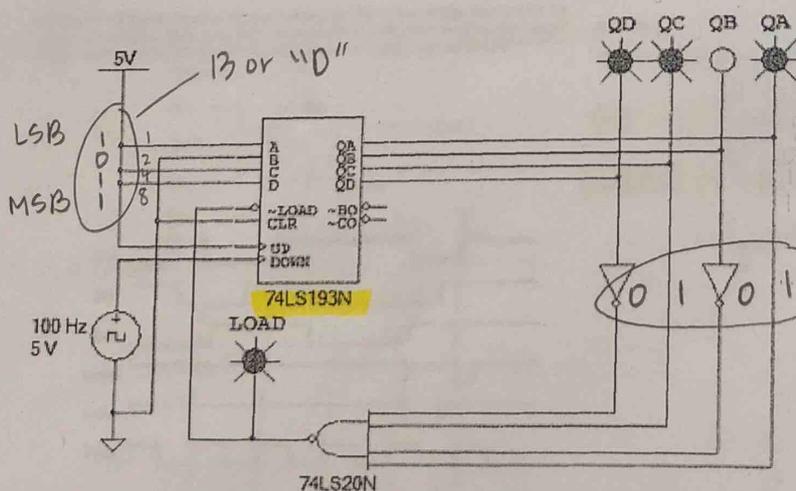32. Draw the negative edge triggered flip flop with active high preset and clear in the space below.
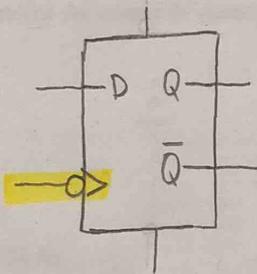
33. What is the minimum number of flip flops needed to create a Mod-18 counter?

= 5 flip-flops

$2^n = $ # flip flops
$2^n = 18$

34. Look at the following counter. What is the count direction and range?

74LS193N – MSI IC
*asynchronous counter!

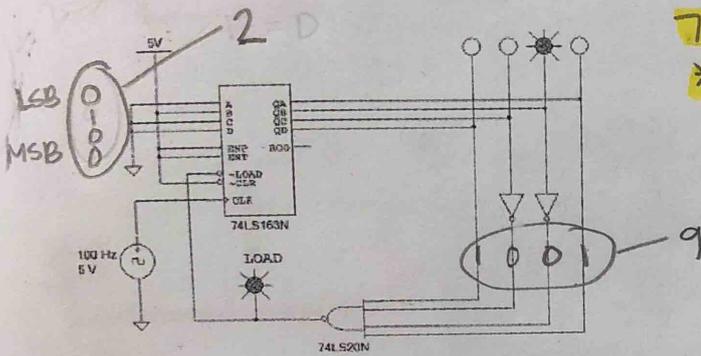*Down counter*

5, but asynchronous!

D → 6

35. Synchronous counters are also called parallel counters. What are three characteristic of synchronous counters?

— no ripple effect!   — faster.

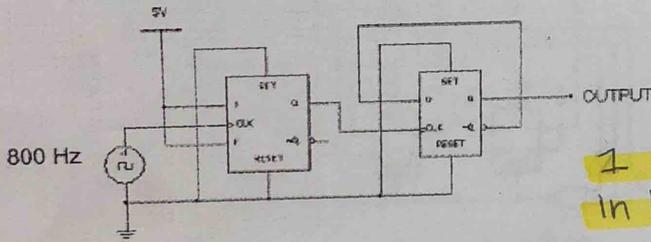— all flip-flops are <u>simultaneously</u> clocked by an external clock.

36. Look at the following counter. What is the count direction and range?

74LS163N — MSI IC
*synchronous flip flop!

$$2 \rightarrow 9$$

LSB / MSB labeled on inputs 0 1 0 0

100 Hz 5V   LOAD

74LS163N

74LS20N

37. Determine the output frequency for the circuit shown below.

800 Hz   OUTPUT

1 Flip-Flops = divide frequency in half!

$$800 \div 2 = 400 \div 2 = \boxed{200 \text{ Hz}}$$

For the 74LS76 J/K flip-flop shown below, complete the timing diagram for the output signal Que. Note that the CLK input for this flip-flop is a negative edge trigger and both the PR and CLR asynchronous inputs are active low.


Jay
Clock
Kay
Clear

74LS76N

Que
Jay
Kay
Preset
Clear
Clock
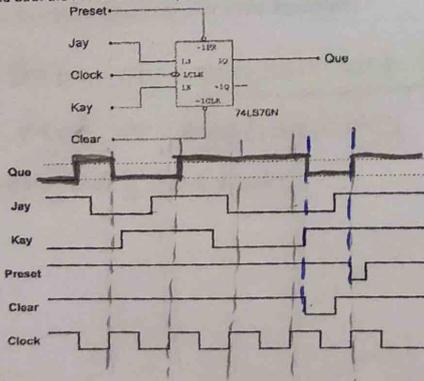
$0 \rightarrow 1$
transition
$Q=1, \bar{Q}=0$
PR → HIGH
$\bar{Q}=0, Q=1$
CLEAR → LOW
memorize!

| J	K	CLK	Q	
0	0	↑	Q_0	No change
0	1	↑	0	clear
1	0	↑	1	set
1	1	↑	$\bar{Q}_0$	toggle

38.

✓

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Using the incomplete, three-bit, asynchronous counter shown below as a starting point, design a counter that will display the binary numbers 5 down to 3 on the logic displays. You may add any additional logic as needed.

preset	clear
5 → 3	
101	011

LSB Q0 (LSB)   Q1   **MSB** Q2 (MSB)

5V

5V

positive edge!
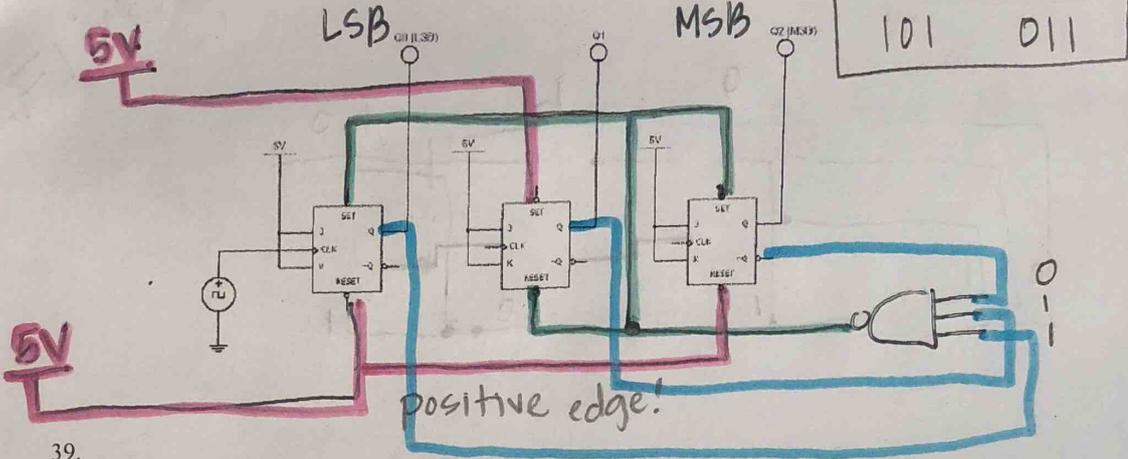
39.

40. What is the count range of the 3-bit asynchronous counter shown below.
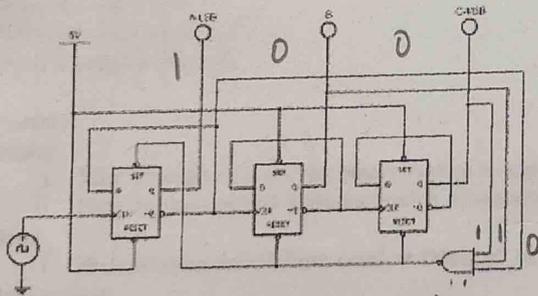
MSB LSB

$110 = 6$

$1 → 5$

preset   clear

positive edge,
upcounter!

State Machines

41. What is the basic function of a state machine?

a form of **sequential Logic** that can be used to electronically control common everyday devices.

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