Learning Objectives

After completing this unit, you should be able to:

- Evaluate digital circuits that use AND, OR, XOR, and NOT.
- Convert binary integers to/from decimal, hexadecimal, ASCII.
- Identify the highest integer that can be represented with n bits.
- Implement a half adder, full adder, and 4-bit ripple carry adder.
- Add 8-bit binary numbers without converting to/from decimal.
- Describe how RAM is organized (e.g., 8-bit cells, addresses).
- Describe how hard drives, optical drives, and flash drives work.

Textbook Sections

1.1 Bits and Their Storage
1.2 Main Memory
1.3 Mass Storage
1.4 Representing Information as Bit Patterns
1.5 The Binary System

Video Lectures

- Binary and Hex
- Bless and Logisim
- How Computer Memory Works
- How Hard Drives Work

Assignments

Act02 Bits and Bytes; Chapter 1 Problems

Lab02 Logisim Tutorial; Ripple Carry Adder

Unit 2 Checklist: Sep 02 – Sep 08

Before Wednesday	**Date Completed**
FINISH models 1 and 2 of the Bits and Bytes activity	
READ textbook 1.1 Bits and Their Storage (take notes) ANSWER questions 1, 5, and 6 in your notes	
READ textbook 1.5 The Binary System (take notes) ANSWER questions 1, 2, and 5 in your notes	
WATCH video lecture: Binary and Hex (take notes) WATCH video lecture: Bless and Logisim (take notes)	
DO tutorial: Logisim Beginner's Steps 0-4	
START Lab11: Logisim ripple carry adder	(10 pts)
Before Friday	**Date Completed**
READ textbook 1.2 Main Memory (take notes) ANSWER questions 1, 2, and 3 in your notes	
READ textbook 1.3 Mass Storage (take notes) ANSWER questions 4, 5, and 6 in your notes	
READ textbook 1.4 Representing as Bit Patterns (take notes) ANSWER questions 1, 3, and 7 in your notes	
WATCH video: How Computer Memory Works (take notes) WATCH video: How Hard Drives Work (take notes)	
START Act02 exercises (complete at least 75%)	(15 pts)
Before Monday	**Date Completed**
COMPARE your Lab02 and Act02 with the solutions in Canvas	
SUBMIT Quiz02 – 1st attempt closed: see what you don't know	
STUDY your notes, ask questions on Piazza, meet with the TAs	
SUBMIT Quiz02 – 2nd attempt open: try to get the full 10 points	(10 pts)

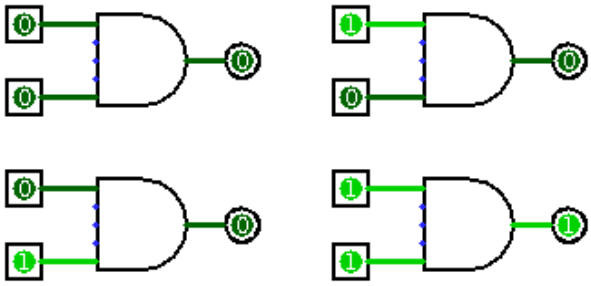
TAKE Exam02	(40 pts)

Activity 2: Bits and Bytes

Computer hardware is made up of billions of tiny electronic circuits that use low and high voltages to represent the values 0 and 1. These binary digits, or "bits" for short, are the building blocks of all digital technology.

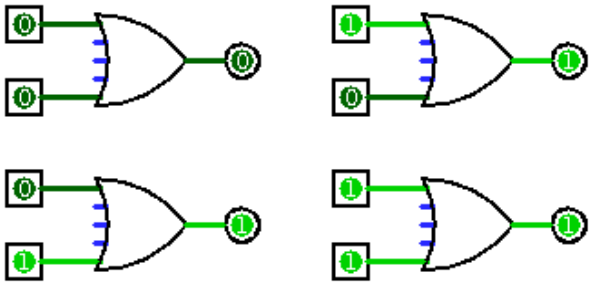
Model 1 Logic Gates

Complete the following tables based on the diagrams.



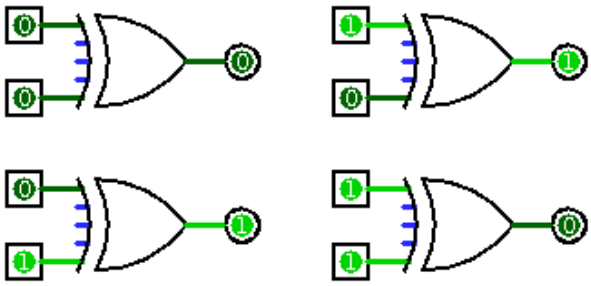
AND

Inputs	Output
0 0	
0 1	
1 0	
1 1	



OR

Inputs	Output
0 0	
0 1	
1 0	
1 1	



XOR

Inputs	Output
0 0	
0 1	
1 0	
1 1	

NOT

Input	Output
0	
1	

Questions (10 min) **Start time:** _____

1. In the circuit diagrams, what does the color (brightness) of the the lines represent?

2. For each type of gate, describe the circumstances when it will output the value 1.

AND:

OR:

XOR:

NOT:

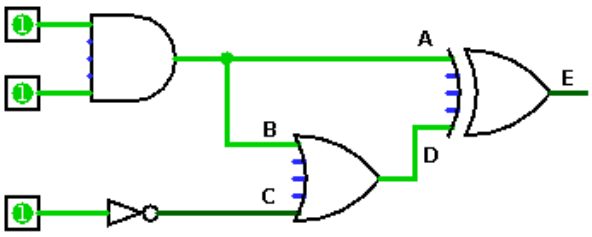
3. As a team, define the following words as they are used in everyday English.

logic:

gate:

4. Based on your definitions, what do you think a "logic gate" represents?

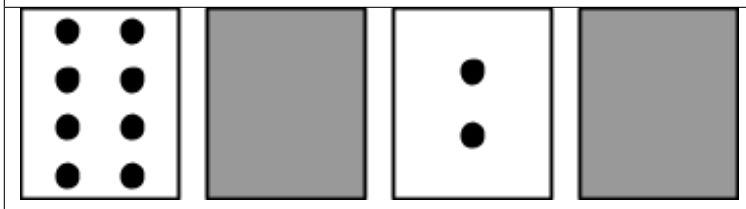
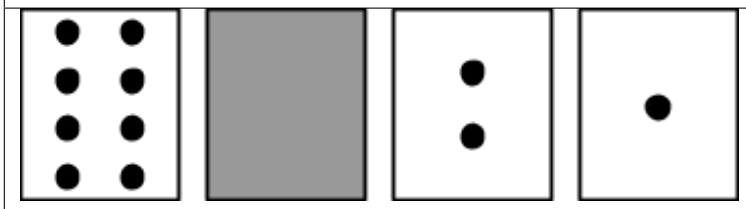
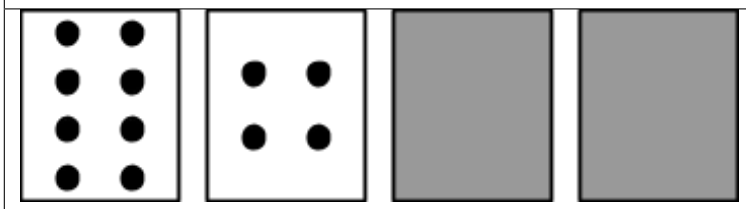
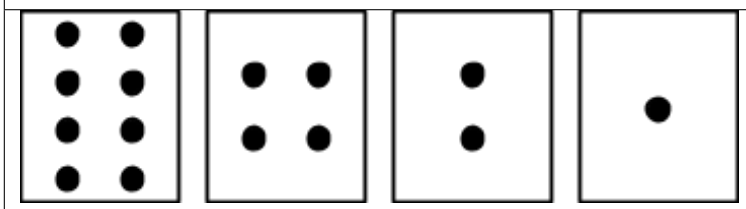
5. In the example circuit below, what are the values of *A*, *B*, *C*, *D*, and *E*?



6. How would *A*, *B*, *C*, *D*, and/or *E* change if the top input were zero?

Model 2 Binary Numbers

Each team has four cards that are ordered from the card with the most dots (8) to the card with the least dots (1). The cards represent four binary digits, or in other words, a 4-bit number.

Binary	Decimal
 1 0 1 0	
 1 0 1 1	
 1 1 0 0	
 1 1 1 1	

Questions (15 min) **Start time:** _____

7. In the table above, write the decimal value for each row by counting the number of dots.

   a) What is the largest decimal number that can be represented by four bits?

   b) What is the smallest decimal number that can be represented by four bits?

   c) How many possible decimal numbers can be represented by four bits?

8. Examine the binary notation below the cards. Explain in a full sentence what a 0 means about the card's dots and what a 1 means.

9. Complete the following table by writing the binary representation of the decimal numbers 0 to 15 using four bits. (And check your answers for #7.)

Decimal	Binary	Hex
0		0
1		1
2		2
3		3
4		4
5		5
6		6
7		7
8		8
9		9
10		A
11		B
12		C
13		D
14		E
15		F

10. ***Hexadecimal*** is shorthand for binary. For example, 0xD5 in hex is 1101 0101.

a) What is 0x2E in binary?

b) What is 0x74 in binary?

c) What is 0xB00 in binary?

d) What is 0xFAD in binary?

11. Based on the table in #9, explain why binary is sometimes referred to as base-2, decimal as base-10, and hexadecimal as base-16.

12. Explain the humor: "There are only 10 types of people in the world: those who understand binary, and those who don't."

13. Typically computers group 8 bits together at a time (8 bits are also called 1 ***byte***). Fill in the number of dots for the four new cards:

14. What is the largest number that can be represented by:

a) five bits?

b) six bits?

c) seven bits?

d) eight bits?

e) *n* bits?

15. Most computers built since the year 2000 have 64-bit processors. Before then, 32-bit processors were the norm. What is the advantage of having more bits?

16. In terms of logic gates and digital circuits, what is the disadvantage of having more bits?

Chapter 1: Data Storage

Complete the following Chapter Review Problems on pages 73–77.

#1 (what is the output for each?)

#5 (what is in memory at the end?)

#8 (what is the most significant bit?)

#16 and #17 (latency time, access time)

#19 and #20 (ASCII in binary and hex)

#26 (binary to base 10) – *divide them up and do 3 each*

#27 (base 10 to binary) – *work on these ones together*

[Based on #6] What is the largest 8-bit integer? What is the largest 10-bit integer? Describe a quick way to calculate the maximum value for a given number of bits.

[Based on #32] Perform each of the following 5-bit additions without converting to/from decimal. Identify each case in which the answer is incorrect because of overflow.

```
  00101      11111      01111      10111      11111      00111
+ 01000    + 00001    + 00001    + 11010    + 11111    + 01100
--------   --------   --------   --------   --------   --------
```