LATHROP ENGINEERING

Name:

UNIT 2: AOI DESIGN

Digital Electronics Unit Due Date: **September 26, 2019**

Welcome to the second unit of *Digital Electronics*! After a tough first two weeks, we get to slow things down and really dig into the mathematics behind circuit logic. In addition, we'll learn how to create basic circuits using something called "AOI Logic". Where the last two units were all about exposing you to a variety of digital electronics concepts, this unit is all about truly *understanding* what you're doing. In the end, the expectation is that you learn the following elements of digital logic:

- How truth tables work and how to create logic expressions from them
- What AOI logic gates are and how to combine them to form circuits from truth tables
- How to get an AOI circuit working in multisim and on a breadboard
- How to follow the circuit design process to solve a real-world problem

As we move through this unit, you are responsible for making adequate progress through the assignments, and for being done by the Unit Due Date (**September 26, 2019**). You are also responsible for completing each part before moving on to the next. Our unit is broken up into three main parts:

Part 1: **Logic Expressions** *(30 pts) Approx. 3 days*		
The first part of this unit is all about Truth Tables. Truth Tables are grids that use 0/1 to represent all the combinations of off/on for a potential circuit. These will then be used to help create unsimplified logic expressions. We'll then look at the AND, OR, and INVERTER (AOI) logic gates and start to build basic circuits by hand that represent specific logical situations.		Take Notes on Logic Expressions
		Truth Tables Assignment
		Take Notes on Logic Analysis
		AOI Circuits/Truth Tables Assign.
		Check-off from Mr. Benshoof

Part 2: **Logic Implementation** *(40 pts) Approx. 3 days*		
Next we need to consider actually implementing an AOI design. We'll also practice converting smoothly between truth tables, logic expressions, and AOI circuits. The more fluent we are with those systems the better! From there we'll tackle some algebra concepts that will let us simplify logic expressions and make our AOI circuits much more efficient. We'll also consider how circuit efficiency impacts the overall cost and structure of an AOI circuit.		Notes on AOI Implementation
		AOI Implementation Assignment
		Multisim & Breadboard
		Notes on Simplifying Expressions
		Simplifying Expressions Assign.
		Take Digital Logic Quiz **(Sept 20)**
		Check-off from Mr. Benshoof

Part 3: **Majority Vote** *(30 pts) Approx. 3 days*		
Our last challenge of the unit asks you to follow the circuit design process to turn a real-life problem into a truth table, then a logic expression, then an AOI circuit. We'll then simulate the circuit in Multisim and continue with breadboarding. At the end, you'll have a much better sense of what it's like to design and build a complete working circuit.		Truth Table & Logic Expressions
		AOI Circuit Designs
		Multisim & Breadboarding
		Flow Chart & Notes
Achievement: Recreate the Majority Vote Circuit using new parameters		

(30 pts) Approx. 3 days

The first part of this unit is all about getting used to the idea of truth tables and how to use them to understand and create both unsimplified logic expressions as well as basic circuits. Simply put, a *truth table* is a grid that helps organize all the possible combinations of inputs for a circuit, and then describes the resulting outputs from that same circuit. Truth tables are useful in many branches of mathematics, and they're almost always the first step in our work as digital engineers.

1. Start by watching the video *Combinational Logic Overview* which will summarize briefly how truth tables are meant to be used with a basic example. Take good notes!
2. Then, watch the *Truth Tables to Logic Expressions* video and add to your notes so that you have at least a full page. Pay particularly close attention to creating logic expressions from the truth table.
3. Now, complete the *Truth Tables Assignment*. Take your time and make sure you understand what the truth table is trying to represent!
4. Next, watch the videos *AOI Logic Analysis* as well as *AOI Overview*. Both of these together will help explain where circuits come from in a truth table. Make sure you take a full page of notes on this topic!
5. Complete the *AOI Circuits to Truth Tables Assignment.*
6. Check your assignments with the key to make sure everything makes sense and that any questions you have get answered.
7. Have Mr. Benshoof check-off your completed assignments before you move on!

Example Truth Table, Expression, & Circuit

Part 1: Tasks	*5 points*	*4-3 points*	*2-1-0 points*
Logic Expressions Notes	+ Watch both the *Combinational Logic Overview* and *Truth Tables to Logic Expressions* videos + Take a full page of notes on those concepts	- Less than a full page of logic notes	- Very brief or no notes in your engineering notebook
	10-8 points	*7-4 points*	*3-0 points*
Truth Tables Assignment	+ Complete the *Truth Tables Assignment*	- Assignment incomplete - Assignment not corrected	- Assignment missing - Assignment totally incomplete
	5 points	*4-3 points*	*2-1-0 points*
Logic Analysis Notes	+ Watch the *AOI Logic Analysis* and *AOI Overview* videos + Take a full page of good notes on AOI circuits & logic	- Less than a full page of notes on AOI logic	- Very brief or no notes in your engineering notebook
	10-8 points	*7-4 points*	*3-0 points*
AOI Circuits to Truth Tables Assignment	+ Complete the *AOI Circuits to Truth Tables Assignment*	- Assignment not fully complete - Assignment not corrected	- Assignment missing

(40 pts) Approx. 3 days

The second part of this unit is all about working fluently with logic expressions. You'll start by looking at how to take those logic expressions and create good AOI circuits from them. After that, we'll continue the process by simulating those circuits in Multisim and eventually creating them on a breadboard. Here you'll get to investigate the difference between Sum-Of-Product and Product-Of-Sum expressions and learn why we like Sum-Of-Product the most. Finally, we'll wrap up this part of the unit with a close look at Boolean Algebra and how some mathematical rules can help us simplify our logic expressions and make our work significantly easier!

1. Start by watching the *AOI Implementation* presentation and taking some good notes. Make sure your page of notes emphasizes when each of the three gates (AND/OR/INVERTER) are used and how they work logically.
2. Then, complete the *AOI Implementation Activity*
3. Use Multisim to create the AOI circuits from the activity. Make sure you understand the organization of an IC chip (the 74LS## chips) and how many gates are present on each one. This will help you make good decisions about how many chips to use. (*hint: we want to use as few as possible!*)
4. Once your Multisim circuit simulations work, breadboard your SOP circuit and confirm again that it works as intended. (Do Not breadboard the second POS circuit).
5. Next, watch the *Simplifying Expressions* presentation and the *Simplification Overview* video. Take a full page of good notes, and be sure to include the "Expression Simplifying Rules" of Boolean algebra. You can print the reference sheet from the website and include it in your notes if you want!
6. Next, complete the *Simplifying Expressions Assignment*. This will be a tough one, but the key is to show all your steps. That way the more problems you do, the more references you'll have for future work. Also, the more work you show the better Benshoof will be able to help you find mistakes.
7. Finally, take the Unit 2 Quiz on Digital Logic linked on our website. Take the quiz on or before **September 20!**

Part 2: Tasks	*5 points*	*4-3 points*	*2-1-0 points*
Notes on AOI Implementation	+ You took a full page of notes on AOI circuit creation. + Your notes include details about And, Or, and Inverter gates specifically	- Your notes are less than a full page	- Very brief or no notes
AOI Implementation Assignment	+ You drew all four AOI circuits in your engineering notebook.	- You only drew three of the circuits in your engineering notebook	- You drew fewer than three circuits in your notebook.
Multisim & Breadboard	+ You completed the Multisim circuit for both the SOP and POS circuits. + You completed the breadboarding for the SOP circuit	- You did not complete both Multisim circuits - You did not complete the breadboarding	- You did not complete the breadboarding or Multisim circuits
Notes on Simplifying Expressions	+ You took a full page of notes on simplifying logic expressions + Your notes include the Boolean algebra rules	- Your notes are less than a full page	- Very brief or no notes
	10-8 points	*7-4 points*	*3-0 points*
Simplifying Expressions Assign.	+ You completed the entire *Simplifying Expressions Assignment* + You corrected your work with the answer key and made corrections	- You did not finish the assignment - You did not correct your assignment	- You did not do the assignment at all - Your assignment is missing
Take Unit 2 Quiz: Digital Logic	+ You took the Unit 2 Quiz on the website by the Quiz Due Date + Grade is based on number correct	N/A	(0 pts) You did not take the Unit 2 Quiz

(30 pts) Approx. 3 days

The final part of the unit asks you to use what you've learned to design, simulate, and build a circuit to address the following situation:

A Board of Directors consists of a president, vice president, secretary, and treasurer. When they need to make a decision, they take a vote. If one side of the vote gets a simple majority (3 or 4 in agreement), then that side clearly wins. In the occasions where there is a tie in the voting (2-2), then the president's tie breaks the vote. As an example, if the president and treasurer both vote 'no' while the vice president and secretary both vote 'yes', then the tie is broken in favor of the president's 'no' vote.

The board would like a digital voting system with switches and lights because switches and lights are cool.

1. Create a truth table of the "Majority Vote" situation.
2. Use your truth table to make an unsimplified logic expression.
3. Use Boolean Algebra to simplify your logic expression.
4. *HAVE MR. BENSHOOF CONFIRM YOUR SIMPLIFIED LOGIC EXPRESSION BEFORE CONTINUING!*
5. Create an AOI circuit of your simplified logic expression.
6. Simulate your circuit in Multisim and confirm that it works as intended.
7. Build your circuit on your breadboard using the built-in switches and LEDs. Confirm that it works as intended.
8. Write/Draw a flow chart in your engineering notebook that describes this circuit design process. Include a few details about each step to summarize the work that goes in to creating a complete working digital circuit.

Part 3: Tasks	*5 points*	*4-3 points*	*2-1-0 points*
Truth Table	+ Your truth table includes all necessary inputs/outputs + Your truth table is correct	- Your truth table is not correct	- Your truth table is missing
Logic Expressions	+You created an unsimplified logic expression + You showed your work to simplify your logic expression with algebra	- One of your expressions is missing - You did not show your simplifying work	- Both your expressions are missing - Your expressions are wrong
AOI Circuit	+ Your AOI Circuit only uses 2-input gates + Your AOI Circuit accurately represents your logic expression	- Your circuit does not use only 2-input gates - Your circuit is wrong	- Your circuit is missing
Multisim	+ Your Multisim circuit works correctly	- Your Multisim circuit does not work correctly	- Your Multisim circuit is missing
Breadboarding	+ You completely breadboarded your working circuit. + You used the built in switches and LEDs	- You did not finish breadboarding - Your circuit did not work as intended	- Your breadboarded circuit is not started
Flow Chart & Notes	+ Your created a circuit design flow chart that describes the process + You included additional details to describe the process more	- Your flow chart is missing important parts	- You did not make a flow chart or notes on the process

Achievement: Recreate your circuit (up through the Multisim simulation – no breadboarding) in which there are 5 board members, the president's vote is worth 2 votes, and the president's vote breaks ties.