LATHROP ENGINEERING

Name:

UNIT 5: THE BIRTHDAY PROBLEM

Digital Electronics Unit Due Date: **November 27, 2019**

Welcome to the fifth unit of Digital Electronics! This unit will review the biggest ideas from the semester as we tackle what some would call the biggest challenge in all of Digital Electronics: *The Birthday Problem*. After some short review, you'll be asked to plan, simulate, and build a digital circuit that can turn binary counting into the digits of your birthday. It'll be a big challenge, but it's really cool when it finally works. After that, we'll learn how to use a new tool called a Programmable Logic Device (PLD). In the end, the expectation is that you learn the following elements of digital logic:

- How to use the Circuit Design Process to plan out a complex circuit
- How to simulate your circuit in Multisim and breadboard the working circuit
- How to use Multisim to program a Programmable Logic Device (PLD)

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 (**November 27, 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: **Review** *(10 pts) Approx. 2 days*		
As we get started back into the Circuit Design Process, it's essential that we review key information from the semester. Here you'll take a little time to review the ideas of 7-segment displays, binary counting, truth tables, k-mapping, AOI logic, and NAND/NOR logic. All of these ideas will be crucial in successfully planning, simulating, and building your final birthday problem circuit!		Notes on Circuit Design Process
		Review Notes 1
		Review Notes 2
		Check-off from Mr. Benshoof

Part 2: **Plan, Simulate & Build** *(50 pts) Approx. 6 days*		
The most intense part of this unit is the planning, simulating, and breadboarding of your final birthday circuit. Your job here will be to create a circuit that can display the digits in your date of birth. You'll follow the Circuit Design Process to plan out the circuit needed to display your birthday before drawing, simulating, and finally breadboarding it!		Written Plan for Birthday Circuit
		Birthday Circuit Multisim
		Birthday Circuit Breadboarding
		Check-off from Mr. Benshoof
Achievement: Complete your birthday problem breadboarding successfully!		

Part 3: **PLDs** *(10 pts) Approx. 2 days*		
The last part of our unit looks at a cool digital electronics tool called a "Programmable Logic Device". This Aruino-ish chip is able to store a Multisim PLD file in its memory so that rather than breadboard all the IC chips by hand, we can just upload a circuit to the chip and breadboard the switches and lights onto the proper pins. It's a cool tool, and we'll use it to take the birthday problem one step further!		Notes on PLDs and their Use
		Simple PLD Tutorial
		PLD Birthday Problem
		Check-off from Mr. Benshoof

(10 pts) Approx. 2 days

As we get ourselves ready to tackle The Birthday Problem, it is essential that we review six key components of the circuit design process that we've covered this semester. In this first part to our unit, you'll just review those key concepts. The website has some videos and presentations that we looked through earlier this semester for your to use as a review tool. You've already seen most of them, so if you want to skip around and review your own notes or other things instead, that's fine. In the end, you should end up with some detailed notes though.

1. **Circuit Design Process Notes:** Take a full page of notes on the Circuit Design Process. Start by copying the flow chart into your engineering notebook. Then, add some of your own personal notes in connection with each step to help you remember what you've already learned and how the different parts all fit together.
2. **Review Notes 1:** There are six (6) big topics that we need to review before diving into the Birthday Problem. Take a page of notes on the first three big topics. A few thoughts on each are provided here to get you thinking, remembering, and writing:
    a. **7-Segment Displays:** Don't forget the naming of each segment, and the fact that we were looking at how to control these with display drivers.
    b. **Binary Counting:** This has funny video on our website, watch it and remember how we count in binary (in particular, how to count from 0 to 7 in a 3-bit binary system).
    c. **Truth Tables:** Remember that we have 2^n outputs if we have *n* inputs. We also use these to organize when lights/signals should be on/off.
3. **Review Notes 2:** Take a second page of notes on the last three big review ideas. You can re-watch the videos and presentations if you find that helpful, or you can research and recreate your own notes on these topics.
    a. **K-Mapping:** Remember the setup for K-mapping and the groupings we look for.
    b. **AOI Circuit Design:** Remember what the symbols look like and what each of them means
    c. **NAND/NOR Circuit Design:** Remember how we substitute NAND/NOR gates for the regular AOI gates in a circuit!

Part 1: Tasks	*4 points*	*3-2 points*	*1-0 points*
Circuit Design Process Notes	+ You took a full page of notes on the Circuit Design Process + Your notes include some of your own thoughts on those steps as you remember them from last semester	- Your notes are only the picture from the website	- Very brief or no notes in your engineering notebook
	3 points	*2 points*	*1-0 points*
Review Notes 1	+ Your notes include details and reminders about: + 7-segment displays + Binary counting + Truth Tables	- Your notes are missing one of the elements	- Your notes are missing more than one element
Review Notes 2	+ Your notes include details and reminders about: + K-Mapping + AOI Circuit design + NAND/NOR Circuit design	- Your notes are missing one of the elements	- Your notes are missing more than one element

(50 pts) Approx. 6 days

The second part of our unit is – without a doubt – the majority of the work. Here you'll be asked to create a circuit (described in detail below) that can display the digits of your birthday. As you do this, you'll plan out your circuit with pictures, a truth table, K-maps, and written circuit diagrams. You'll then Multisim and Breadboard your birthday circuits.

The Birthday Problem

Design a combinational logic circuit that has three inputs and seven outputs. When the inputs (X, Y, and Z) create a count from 000 to 111, the seven outputs (a through g) generate the logic required to display your date of birth on a seven-segment display. The date of birth will be displayed in the MM-DD-YY format. For example, if you were born on May 12, 2001, your design will display 05-12-01.

(more detailed description available on the Birthday Problem handout)

1. **Circuit Design Planning:** You worked through the entire Circuit Design Process in your engineering notebook. You defined the problem and drew a simple picture to illustrate the goal. Your notes continue and include:
    a. Truth tables for each of the seven segments
    b. K-Maps for each of the seven segments
    c. Simplified expressions for each of the seven segments
    d. AOI Circuits for each of the seven segments
    e. NAND/NOR circuits (as you decide) for the segments you want to use them for
2. **Multisim:** You now need to get back into Multisim and create your circuit simulation. Take your time and organize it carefully. You'll only use 3 input (SPDT) switches and you'll have a total of seven (7) outputs for the seven segments of the display. Work carefully and confirm that the circuit functions as intended before moving on!
3. **Breadboarding:** Now for the hard part: Get out your DMS Breadboard and create your complete birthday problem circuit on the breadboard. If you need more physical space to fit all your IC chips, then you can have extra breadboards attached to give you the extra room. Be careful, take your time, and keep your wires neat!

Part 1: Tasks	*20-15 points*	*14-6 points*	*5-0 points*
Written Plan for Birthday Circuit	+ You recorded your circuit design process in your engineering notebook including: + Truth Tables + K-Mapping + Simplified Expressions + AOI/NAND/NOR Circuits	- Your notes do not include all the parts of the circuit design process	- Your notes are significantly lacking - Your notes are missing completely
	15 points	*14-10 points*	*9-0 points*
Birthday Circuit Multisim	+ Your circuit is completely modeled in Multisim + Your circuit meets the circuit criteria (at least one NAND and at least one NOR) + Your circuit works properly	- Your Multisim circuit is incomplete - Your Multisim circuit does not meet all criteria	- Your Multisim circuit is significantly lacking - Your Multisim circuit is missing completely
Birthday Circuit Breadboarding	+ Your breadboarded circuit is complete + Your breadboarded circuit works as intended	- Your breadboarded circuit does not quite work right	- Your breadboarded circuit is very incomplete
Achievement: Complete your birthday problem breadboarding successfully!			

(10 pts) Approx. 2 days

The final part of our unit is about Programmable Logic Devices (PLDs). PLDs are used to create complex digital circuits in a small and compact way. Similar to an Arduino – which has multiple pins and can be programmed to work exactly how we want – a PLD can be used in a breadboard and each of the 48 pins can be assigned a different job (input or output) as needed. One of the great things about PLDs is that many of them like our CMOD S6 chips can be programmed from right inside Multisim. In this part of the unit, you'll learn how to use PLDs and even use them to simplify your Birthday Problem.

1. **PLD Notes:** Take some time to watch the *PLD Overview* and *Example of using PLD Mode in Multisim* videos. Take a full page of notes on what the CMOD S6 PLD chip can do and what tools you'll need to use in Multisim to get things working.

   Super Secret Bonus: Watch the Super Secret Bonus Logic Converter Tutorial for fun Multisim Pro-tips. It'll be 4 minutes well spent!

2. **Simple PLD Tutorial:** Get the PLD Tutorial handout and follow the directions to get your first PLD circuit built and uploaded to the PLD. Then, breadboard it as shown (very simple) and confirm that it works as expected. Once that's done, it's not too big of a step to reprogram it with multiple inputs (maybe 3) and multiple outputs (how about 7?) so that your Birthday Problem circuit can run off the CMOD chip.
3. **PLD Birthday Problem:** Finally, make a new PLD file that contains 3 inputs and 7 outputs. Copy your birthday problem circuit into the PLD mode. Some people are successful with literally copy-pasting their circuit… other students have been more successful rebuilding the circuit within the PLD mode. Either way should work.

   Upload your circuit and get your CMOD chip wired into the breadboard. You should only have to connect 1 wire to the power pin, 1 wire to the ground pin, 3 wires from switches to the input pins, and 7 wires to the display segments. In theory, it's much simpler! Confirm that it works as intended.

Part 3: Tasks	*2 points*	*1 point*	*0 points*
PLD Notes	+ You took a full page of notes on the CMOD S6 chip + Your notes include some details about what Multisim tools we'll use in PLD Mode	- Your notes are missing important elements	- Your notes are missing many parts - You took no notes
Simple PLD Tutorial	+ You followed the simple PLD Tutorial to get your PLD to turn a light on and off using two switches	- N/A	- You did not complete the PLD Tutorial
	5 points	*4-2 points*	*1-0 points*
PLD Birthday Problem	+ You created a PLD file and copied your birthday problem circuit components into the PLD file + You got your birthday problem uploaded to the PLD + You got the PLD breadboarded and the birthday problem working again	- You got things copied in but did not connect inputs/outputs - You did not get the breadboarding together after uploading your design	- You did not complete the birthday problem with the PLD