62-362 Electronic Logics && Creative Practice

Homework 1a: Logic

(due Wednesday, September 2nd at the start of class)

August 31, 2020

Today in class we (very quickly!) learned about a variety of ways of expressing the same fundamental set of information. We'll start by reviewing what we learned. The homework assignment below the review.

Review from class today

Problem 1

The first logic problem we covered was phrased like so:

> Do I have homework due today?
>
> > Q1: Do I have homework due on Monday?
> >
> > Q2: Is it Monday?

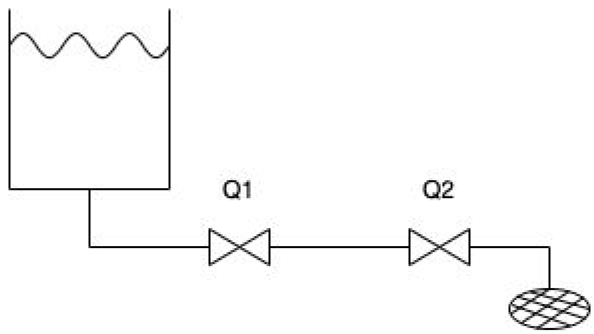
We will call this statement a **word problem**. It is merely one expression of the idea of interest, and usually it's the place we start.

Having reasoned the problem through, we drew a tabular representation of all four of the possible states our machine would need to address:

<table>
<tr><td colspan="2" rowspan="2">Do I have homework due today?</td><td colspan="2">Q1: Do I have homework due on Monday?</td></tr>
<tr><td>yes</td><td>no</td></tr>
<tr><td rowspan="2">Q2: Is it Monday?</td><td>yes</td><td>yes</td><td>no</td></tr>
<tr><td>no</td><td>no</td><td>no</td></tr>
</table>

In this drawing, the italicized words are the answers we believe our machine should provide. We refer to this representation of the data as a **truth table**. Its job is to show us the expected result of every possible computation the machine could do.

Based on our truth table, we drew a diagram of a sort of analog computer which might, by its very design, output a correct answer for any given input state:



(We decided that if water is flowing out of the rightmost pipe into the drain, the machine is answering "yes," and if water isn't flowing, the machine is answering "no.") We will call this representation a **schematic** of the actual "circuit" (in this case a hydraulic circuit) which forms the basic guts of our computing machine. It is quite descriptive and "low-level," meaning it illustrates all of the parts of how the thing could actually be built. Given a tank, some pipes, some valves and a drain, you could build the machine as shown.

Then we backtracked a bit. Looking at our truth table, we see that actually this machine's operation was performing a function which already has a name: AND. We can tell this definitively because the meaning of the logical AND is captured by this truth table:

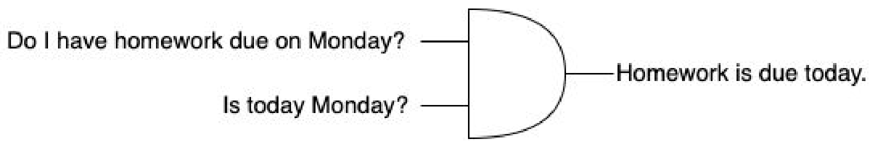
AND		Input 1	
		yes	no
Input 2	yes	*yes*	*no*
	no	*no*	*no*

This is the same as the truth table we saw before—it's just got some more generic names for the two inputs. That word "AND" (which we style in all caps) can be used to write a sort of statement of the functioning of the machine:

(Homework due on Monday) AND (today is Monday) = Homework due today

We will call this representation a **word equation**, and yet again, it is just another way of expressing the function of this machine.

Finally, we learned a diagrammatic logic symbol which can be used to represent the meaning of AND in a widely recognized form. Applying some labels from our own problem, we might use that symbol like this:



We will call this representation a **logic diagram**. It is really just yet another way of representing the information contained in this problem.

Problem 2

We added lots of complexity when we went from two input questions to four! In fact, each time we add another question, we multiply the possible cases we must cover in our output by two. In the first problem we had two questions, which meant there were $2^2 = 4$ possible outcomes. In the second problem we had four questions, which meant there were $2^4 = 16$ possible outcomes.

Let's go over each of the parts of the problem, using the nomenclature described above.

The **word problem** was as follows:

Are we able to come to class in person?
- Q1: Does the University approve?
- Q2: Have you quarantined for 10 days?
- Q3: Is your temperature normal?
- Q4: Are you impervious to getting or transmitting this disease? (A false hypothetical! But useful for our logical purposes.)

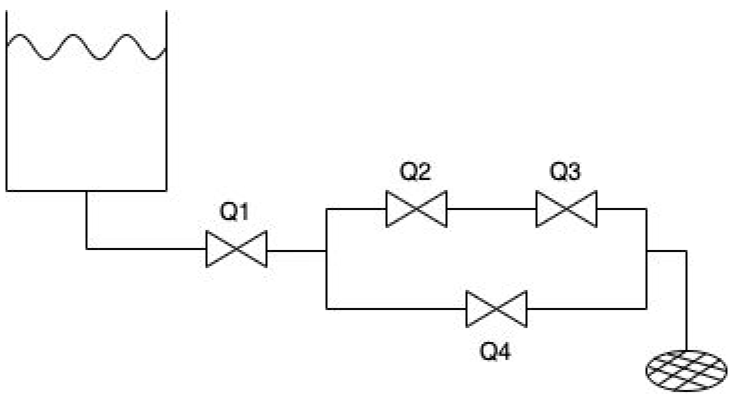
Based on that, we drew up a much bigger, uglier **truth table**, which we then dutifully filled out. Note that there are different ways of formatting a table like this; it's represented below as we drew it in class.

Are we able to come to class in person?	Q1

Q2	Q3	Q4	yes	no
yes	yes	yes	*yes*	*no*
yes	yes	no	*yes*	*no*
yes	no	yes	*yes*	*no*
no	yes	yes	*yes*	*no*
no	no	yes	*yes*	*no*
no	yes	no	*no*	*no*
yes	no	no	*no*	*no*
no	no	no	*no*	*no*

Just as before, the italicized *yes*es and *no*s are the machine's output.

One of our very own suggested a possible **schematic** that would output the values of the truth table, which looked like this:

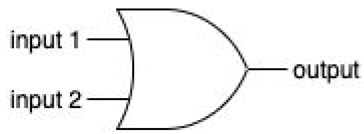


In order to see if this made sense, we tested this for the case that is colored blue in the truth table, and we found that it did, in fact, appear that it would successfully compute that outcome, based on the inputs.

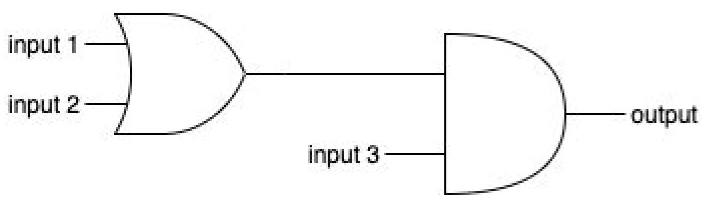
We learned another logical operator, OR. This operator has the following truth table:

OR		Input 1	
		yes	no
Input 2	yes	*yes*	*yes*
	no	*yes*	*no*

The logic diagram symbol for OR looks kind of like AND, but it’s got a pointier nose as well as a curved left edge:



And finally, we saw that these operators can be combined however you wish—meaning that the output from any operator can serve as an input for any other operator, e.g.:



In this case, the output of the OR operator serves as one of two inputs to the AND. Perhaps you can see that as soon as you can combine two of these, the sky’s the limit—you can start stringing as many operators together as you’d like, in whatever combinations you’d like, to build a logic machine.

Your homework

1. Review all of the information above and write down any questions you have. You'll have a chance to ask about these in class on Wednesday.

2. Please take a minute or two to run through every one of the sixteen states described by the truth table for Problem 2, as shown above. Make sure that they all make actual sense to you—in other words, that the sixteen output states seem like the correct consequence of their particular input configurations.
    a. While you're running through each state, look at the schematic and consider the flow of water through the pipes/valves in each case. This is a helpful way of evaluating the schematic and to start getting good at analyzing more complexity.

3. Do your best to draw out a logic diagram for Problem 2. We really didn't spend enough time in class to explain this well, so just give it a shot, and if 15 minutes later you're still stumped, don't worry about it. We'll go over this stuff on Wednesday.
    a. You are very welcome to draw it by hand. In that case, please scan or take a legible photo of your drawing.
    b. You can also do a drawing on the computer. It does not need to be pretty! We'll be showing some software you can use to help make these drawings more easily; for now, worry about the content of the drawing rather than its pixel-perfect precision.
    c. In either case, please submit (upload) your drawing via [this Canvas assignment] before the start of class on Wednesday 9/2.