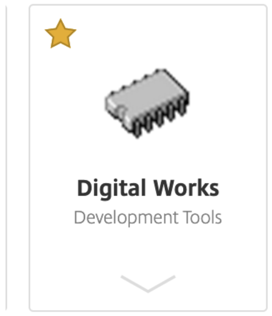
Digital Circuits Guide(CS 231)

How to Access

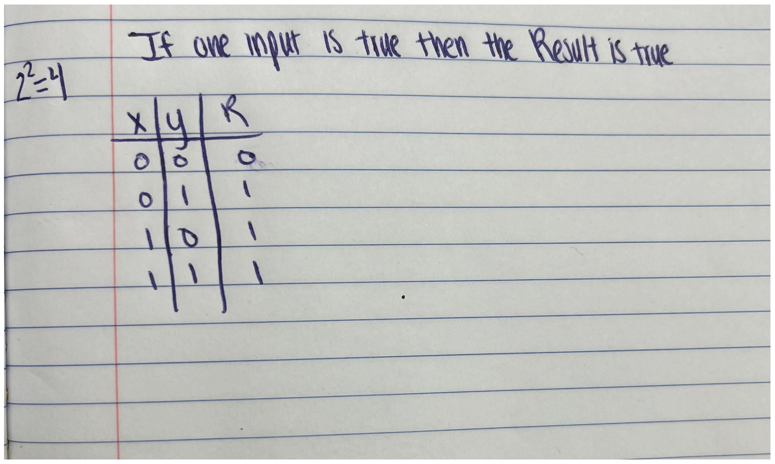
- Go to Cougar Apps and Open Digital Works



How to Make a Circuit

- ### Create a Truth Table on Paper
    a. Find how many inputs you need (make a row for each input)
    b. Find how many outputs you need (make a row for each output)
    c. 2 to the power of your # of inputs = # of input possibilities
    d. Fill in input rows with all possibilities of 0s and 1s
    e. Fill in output rows based on prompt(or special rule such as D or T flip flop)

Examples



If one input is true then the Result is true

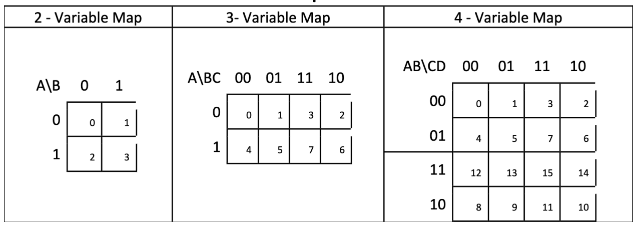
$2^2=4$

x	y	R
0	0	0
0	1	1
1	0	1
1	1	1

This is a truth table with 2 inputs(x,y) and one output(R)
2^2 is 4 so we know there are 4 possibilities for our inputs
We fill out input rows based on all possibilities of 0's and 1's
We fill out the output row(R) based on the prompt(if one or more inputs are true then output is true)

- **Create a K-Map on Paper**
    a. Draw out a K-Map for EVERY OUTPUT
    b. On paper you will draw each k-map as shown below based on the amount of inputs/variables BUT leave the boxes blank unlike the picture

The K-map Fill Order



2 - Variable Map

A\B	0	1
0	0	1
1	2	3

3- Variable Map

A\BC	00	01	11	10
0	0	1	3	2
1	4	5	7	6

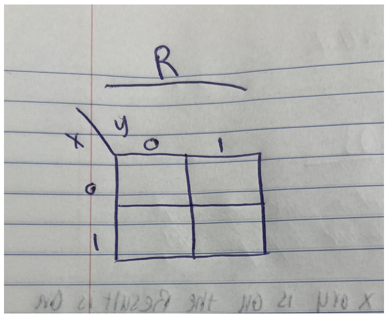
4 - Variable Map

AB\CD	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

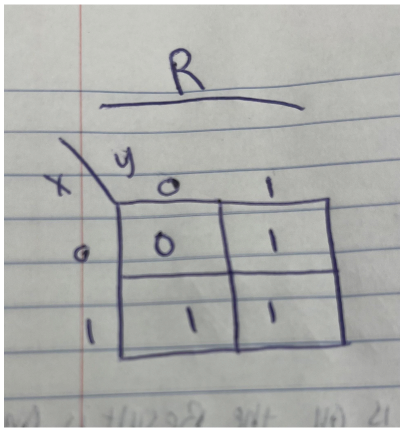
    c. Fill the boxes based on the input
    d. Group all 1’s (this is to make your equations simpler if possible)
        i. Can only group in pairs or in groups of 4
        ii. Cannot group diagonally
        iii. Can group up or down and from and one side of the box to the other
        iv. If there is no way to group then move on

Example

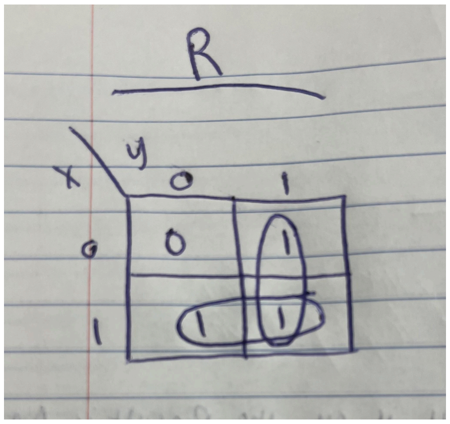
- Using the same example from the 1st step here is a k-map drawn
- We only have one output R so we know we only need one k-map
- We only have two inputs (x,y) so we know we need a 2-variable k-map



- We then fill in the k-map based on all of our possibilities
- When x is 0 and y is 0 the result is 0
- When x is 1 and y is 0 the result is 1
- When x is 0 and y is 1 the result is 1
- When x is 1 and y is 1 the result is 1



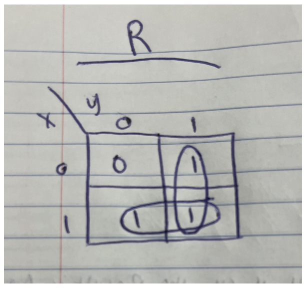
- Now we group



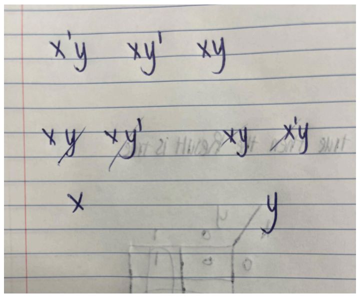
- **Find Equations on Paper**
    a. You will make equations based on your k-map results
    b. Look at your kmap and find all of the places where you have a 1
    c. Write down the input for each place there is a 1
    d. Equations will be represented in letter form not in 0's and 1's
    e. The Symbol ' means NOT
    f. For example if the inputs are labled as x and y and the input 00 results in a 1, we know that this equation is represented as x'y'
    g. Because in this example the input is 00, then the equation is (x'y') x NOT y NOT
    h. If the inputs are grouped together, compare each input and keep what they have in common, dispose of what they don't

Example

- This is the same example used as last time
- Now we need to find what inputs give us 1
- We know 01, 10, and 11 give us 1
- This means that x'y, xy', and xy are the equations that give us 1

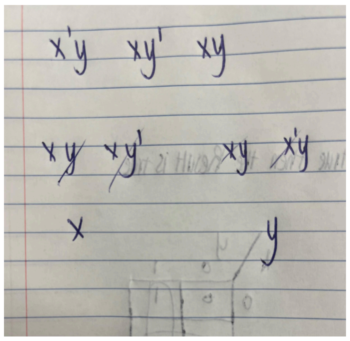


- First write down all equations where we have a result of 1
- In this case we are grouping xy and xy' / xy and x'y
- For each group compare equations and ONLY keep what they have in common
- We kept x for the first group and we kept y for the second group
- Now our equation is fully simplified to x and y
- Equation for Ciruicit for this Example: (x + y)



- **Create Cirucit in Digital Works Based on Equation**
  - Make a switch for each input (ON means 1 and OFF means 0)
  - Create a NOT gate for each input
  - Make a light for each output (ON means 1 and OFF means 0)
  - Use your equations to draw connections between the inputs to the Result
  - Use OR gates to connect two or more separate equations
  - Use AND gates for equations that have two or more inputs

Example

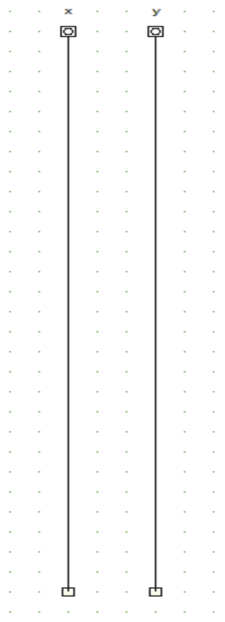
- Using the same example we will draw it in digital works
- We know our equation is x + y which means that if x or y is on then the result will be on
- 

$x'y \quad xy' \quad xy$

$xy \quad xy' \quad xy \quad x'y$

$x \quad y$

- First I create two switches and connect them to a tag device, assigning them to my two inputs of x and y



- I then assign them not gates in case our equations include x’ or y’, for this example it is not necessary because our equation is xy but it is good practice
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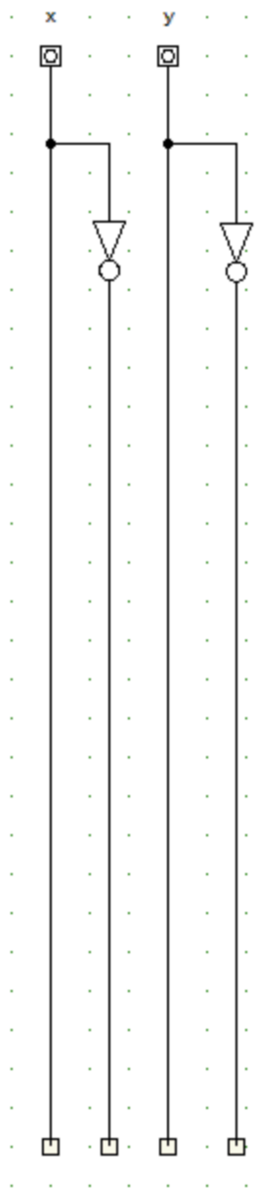
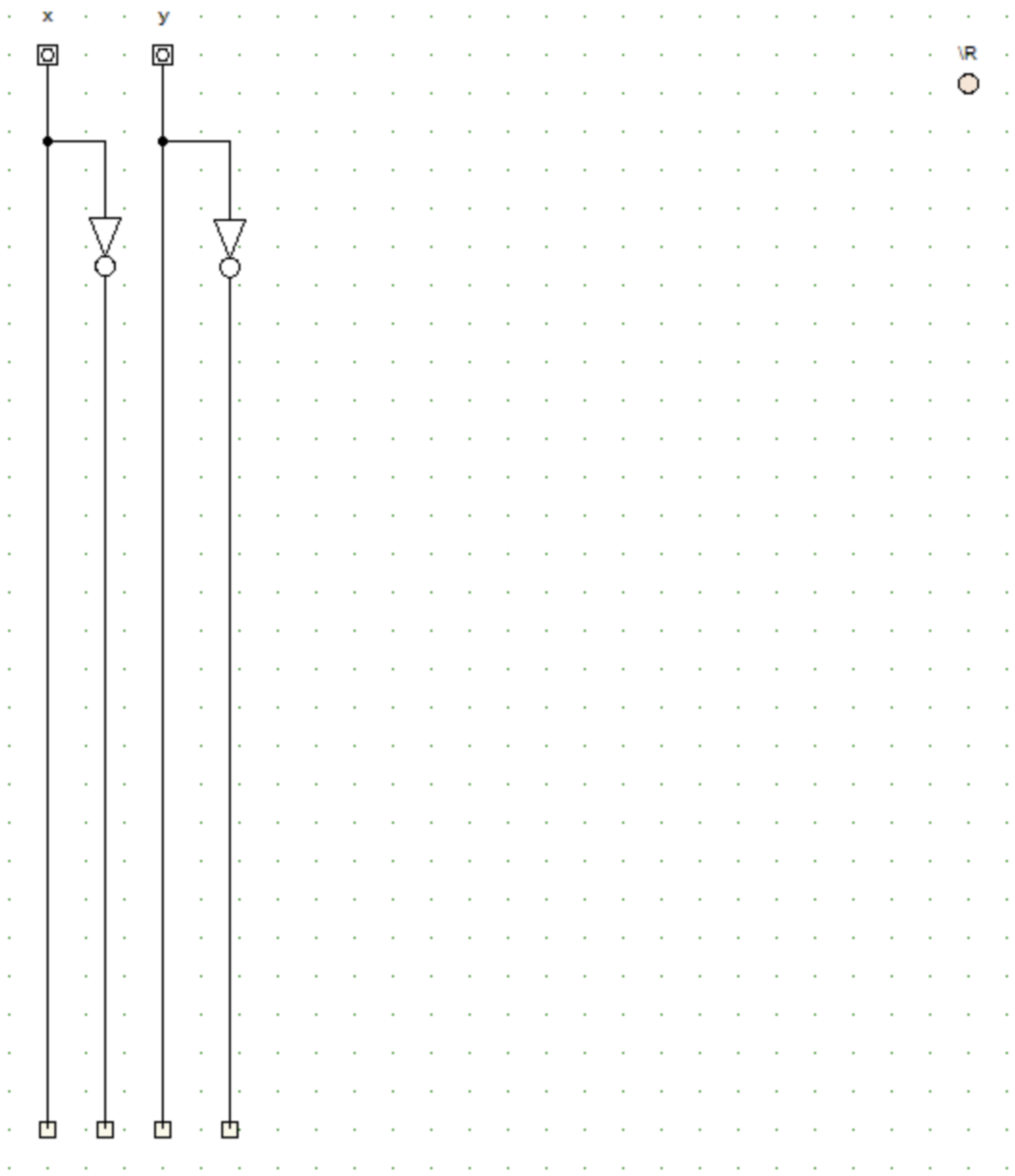
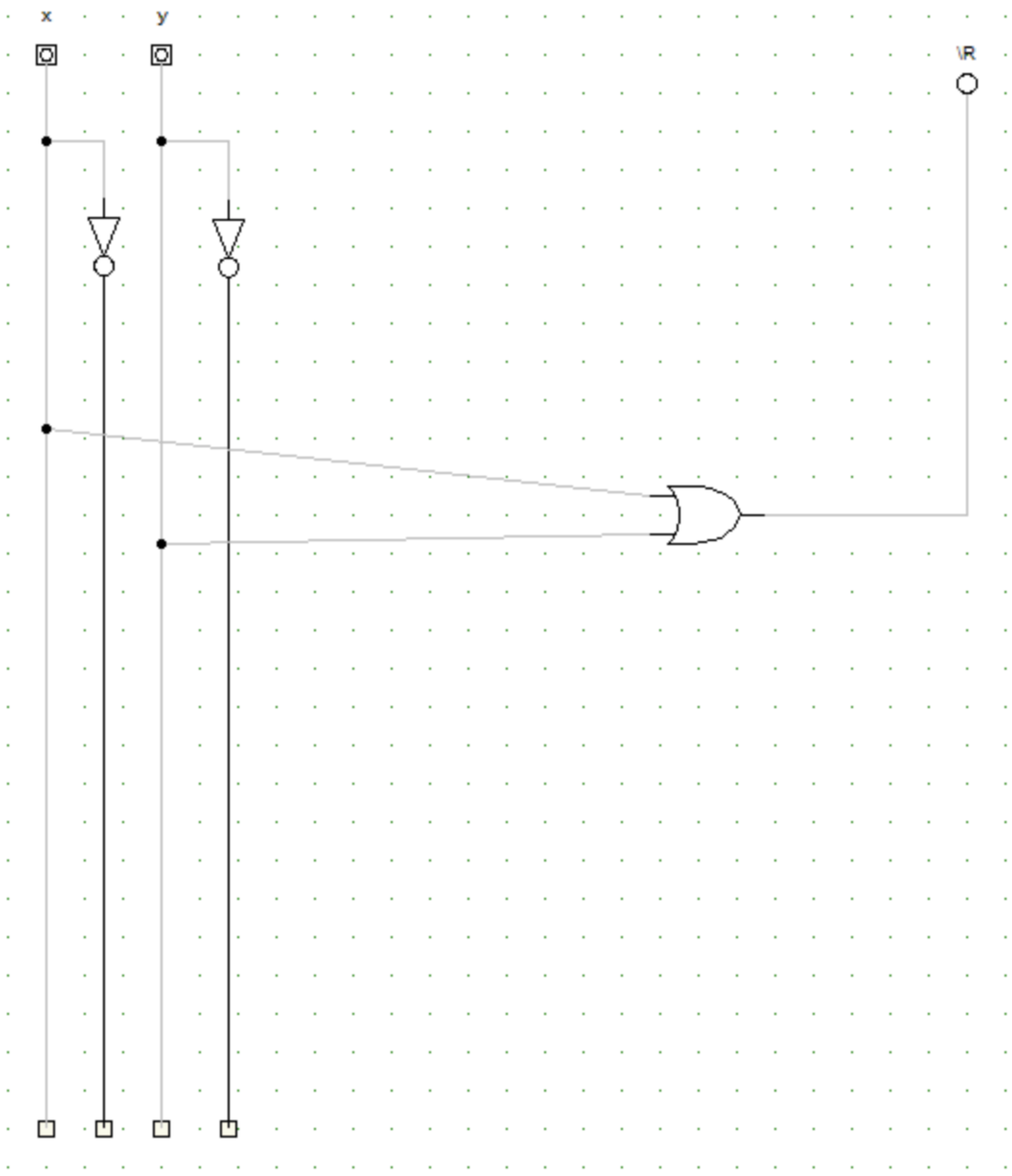


- We then would want to create a light for our output



- Based on our equation x+y we can now connect x and y to the light using an OR gate
- Again, this is saying that if x or y is on then the R will be 1 and the light will be on



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ALL DONE

- Now in digital works click on your switches to test each scenario
- In this case we have four different possibilities for the inputs
- This means that we have four test cases that must be satisfied
- If X is off and Y is off the light should stay off
- For this example, in all other cases the light should stay on