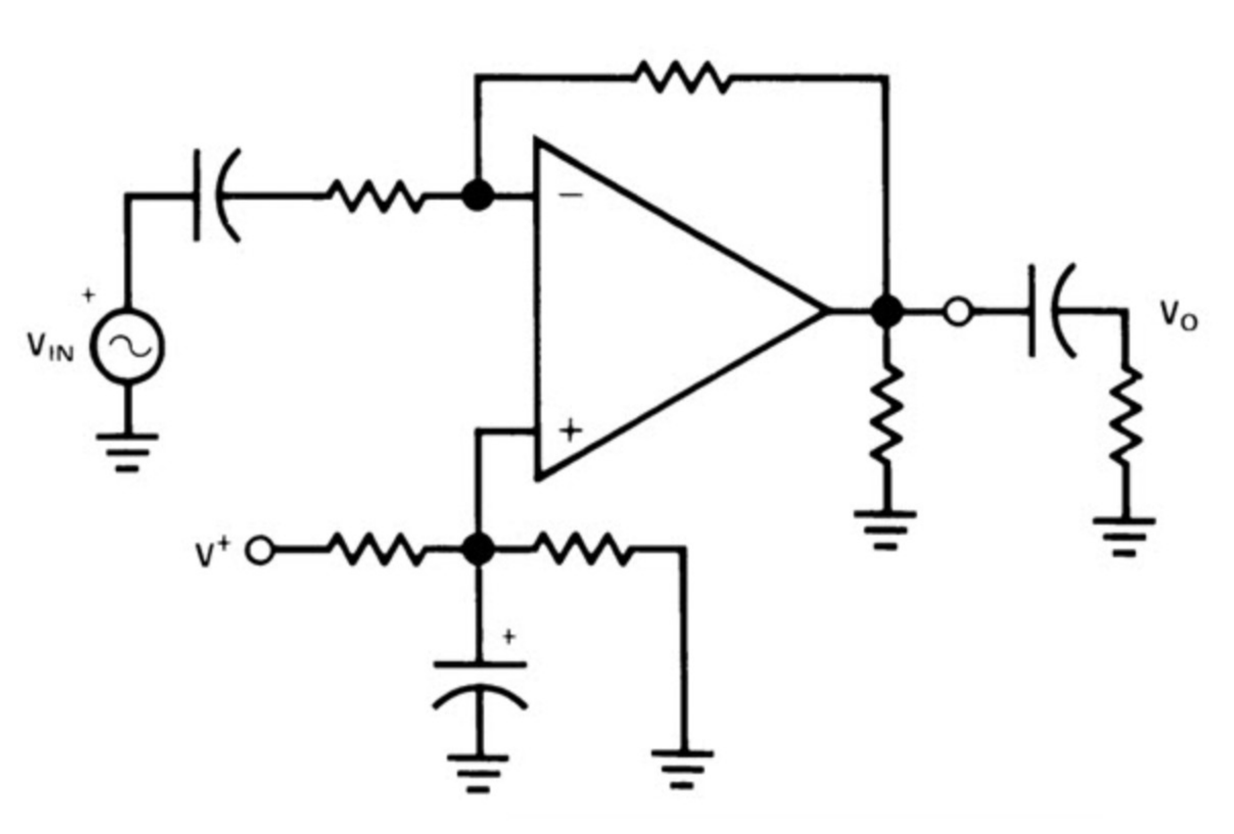
Logic Gates

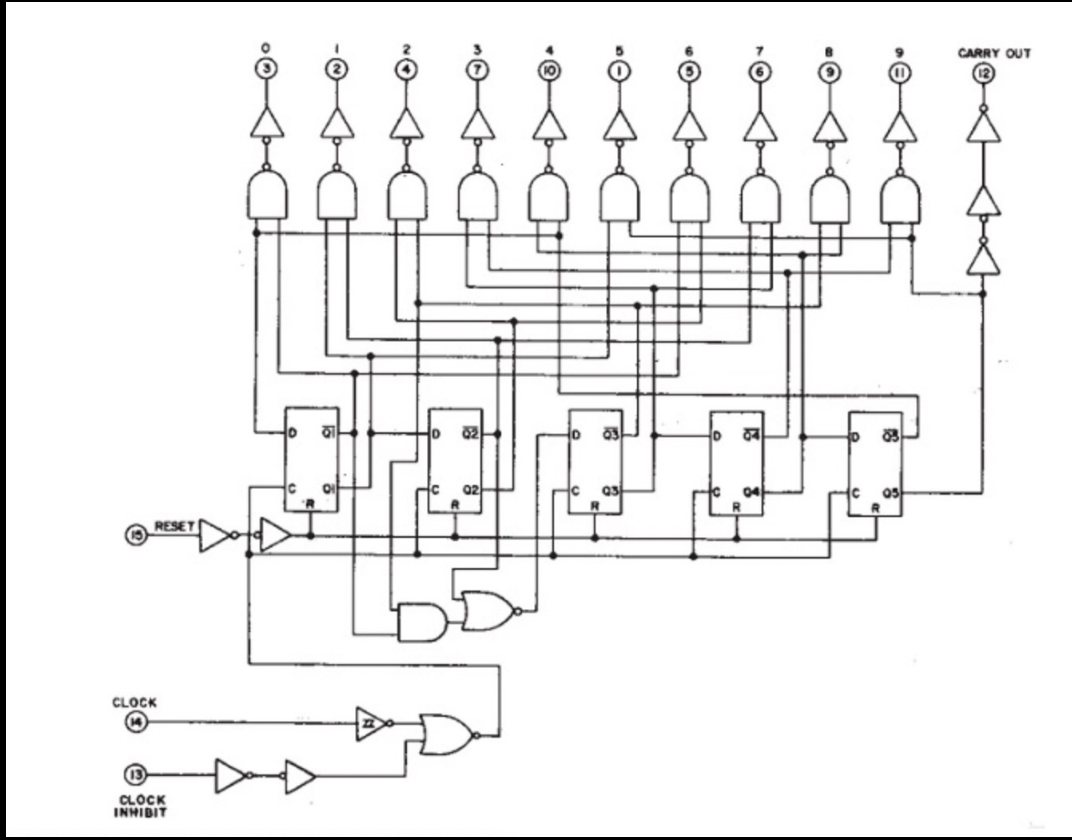
Supplemental module

electronic circuits

analog

digital





digital circuits

consist of logic gates

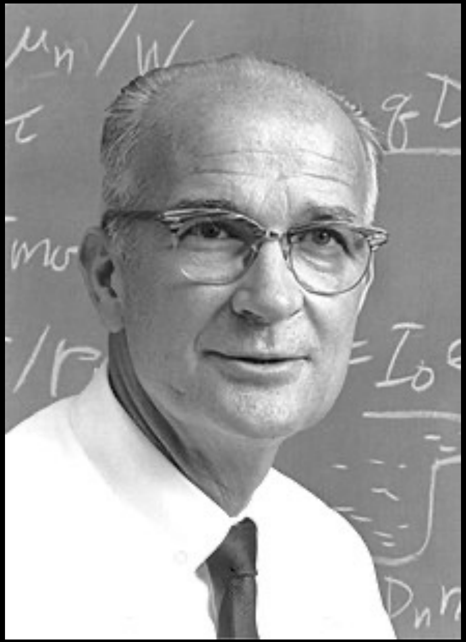
constructed from transistors.

Learning objective: be able to translate between combinations of logic gates and wffs of SL.

digital circuits

consist of logic gates

constructed from transistors.



William
Shockley

supervised

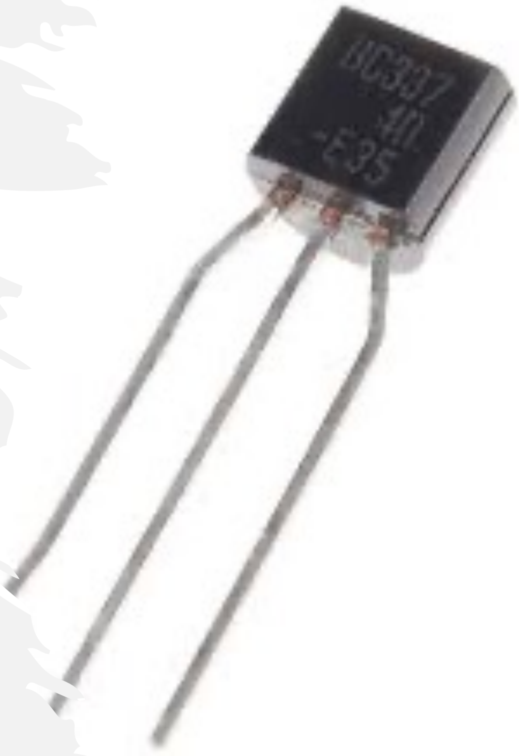
Walter
Brattain

and

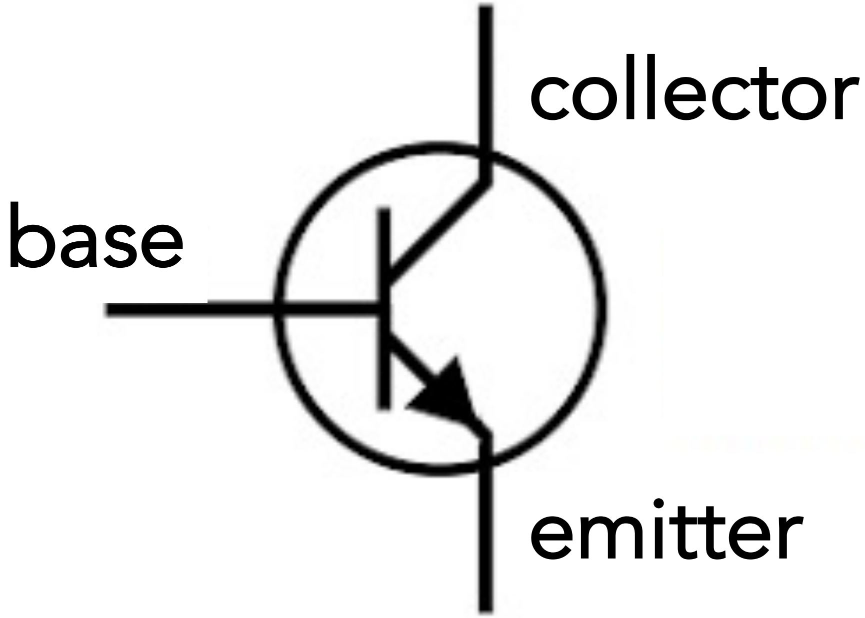
John
Bardeen

who invented the transistor in 1948 at Bell labs
and won the Nobel Prize in Physics in 1956.

transistor

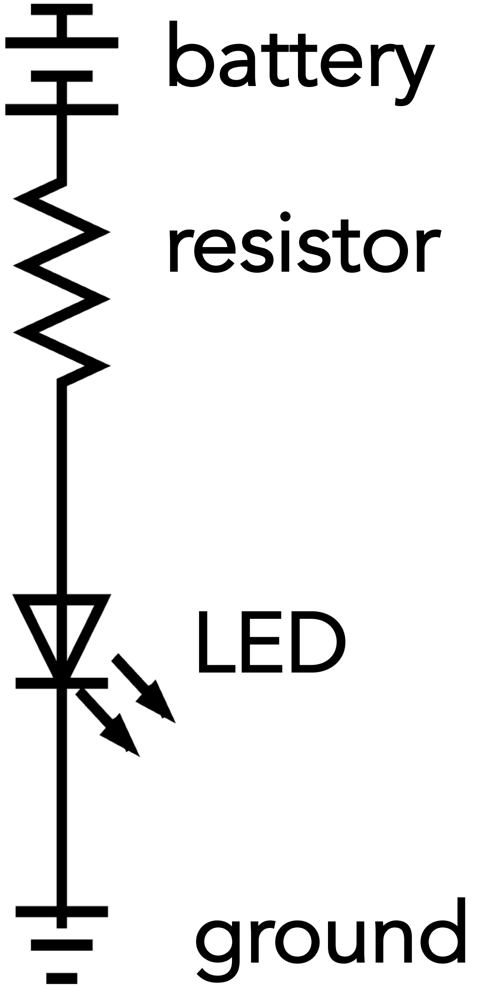


(Negative-Positive-Negative)

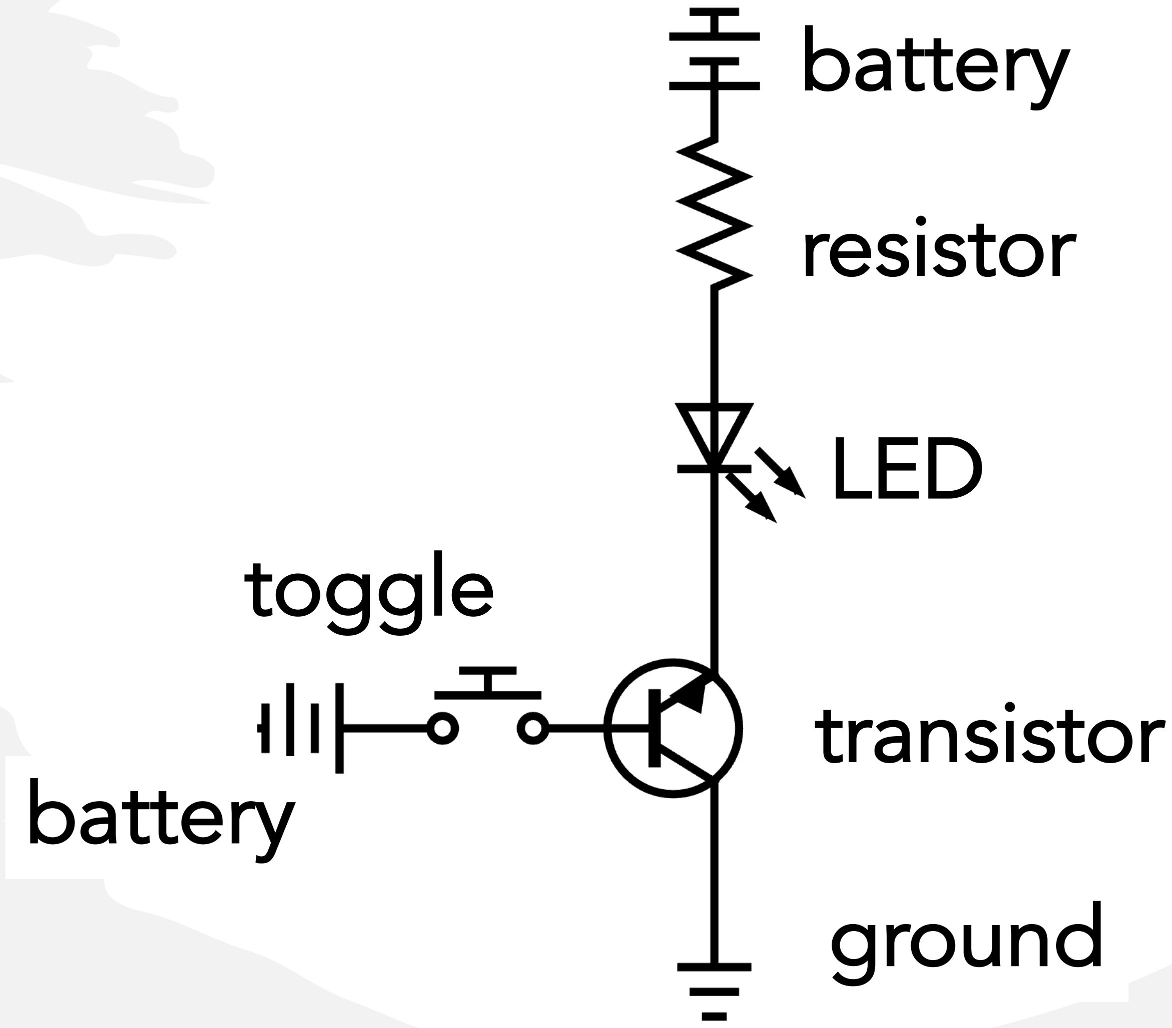


we can only go so far….

for more on transistors,
you can watch this video:


battery
resistor
LED
ground

transistor

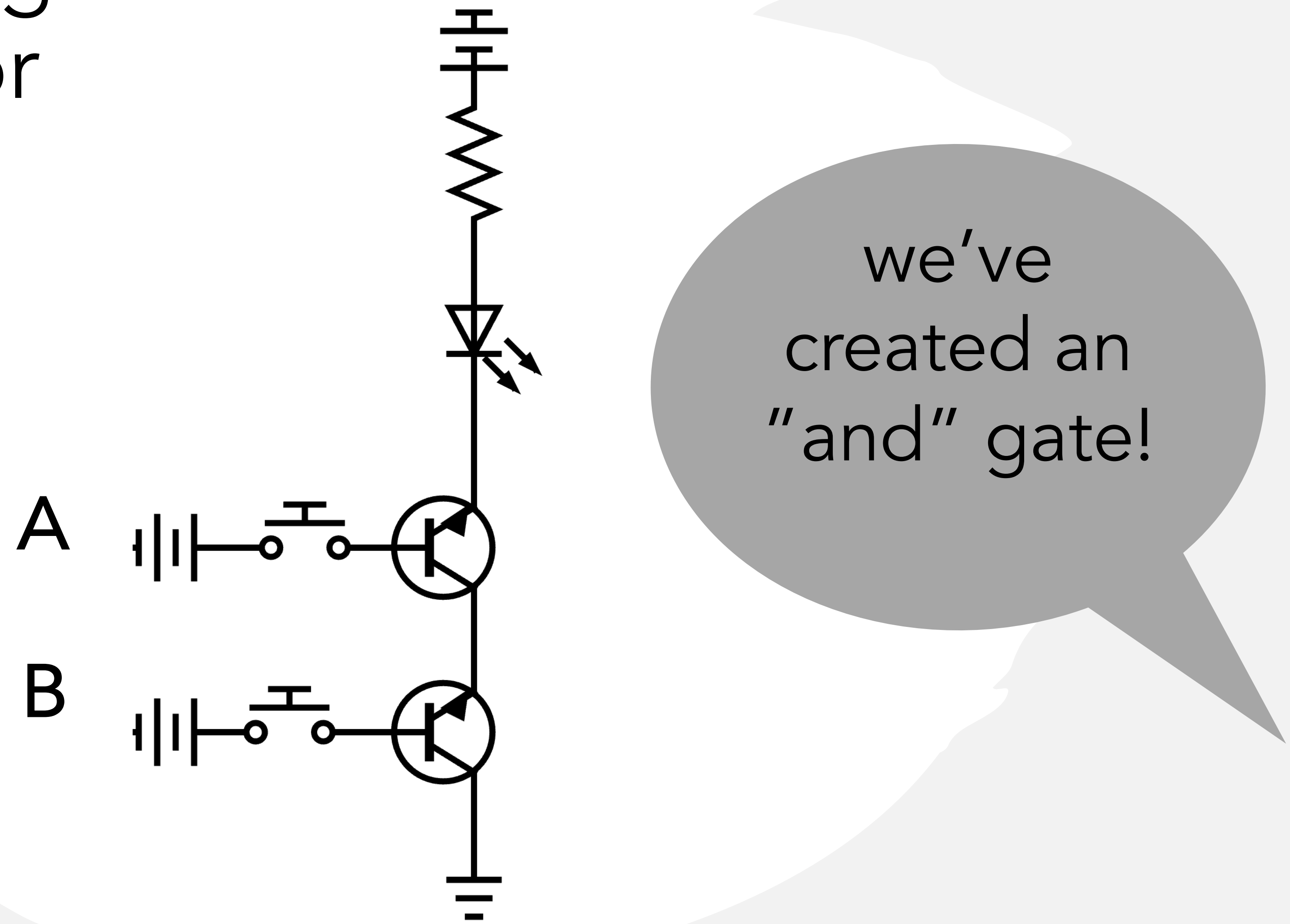


digital circuits

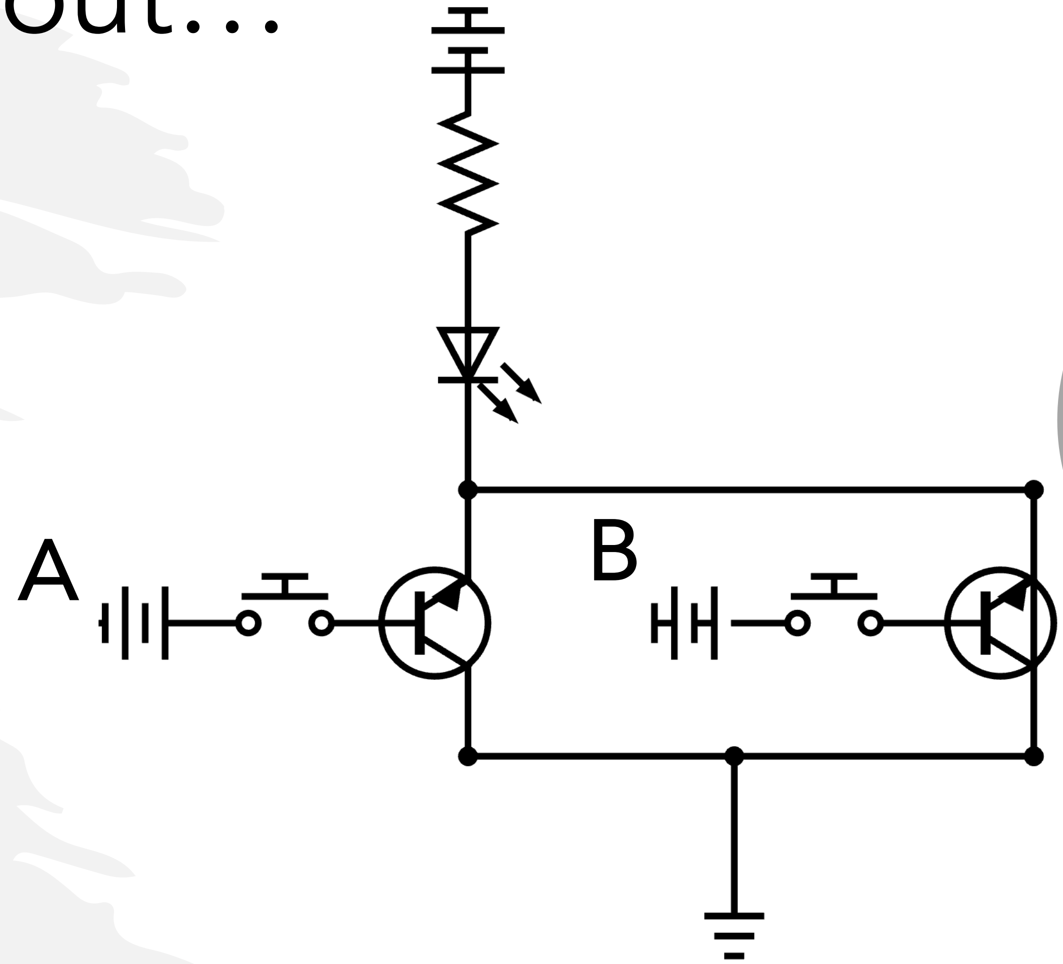
consist of logic gates

constructed from transistors.

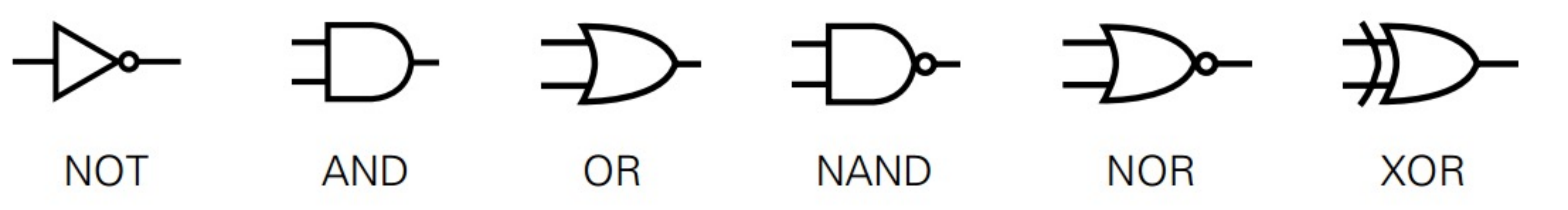
making a logic gate from a transistor



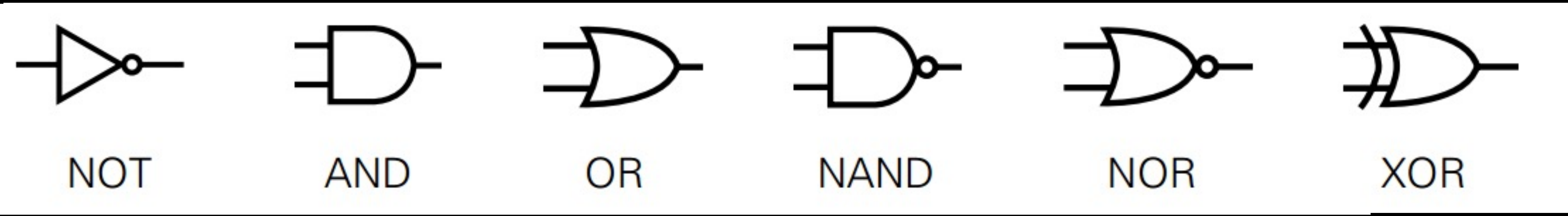
what about…



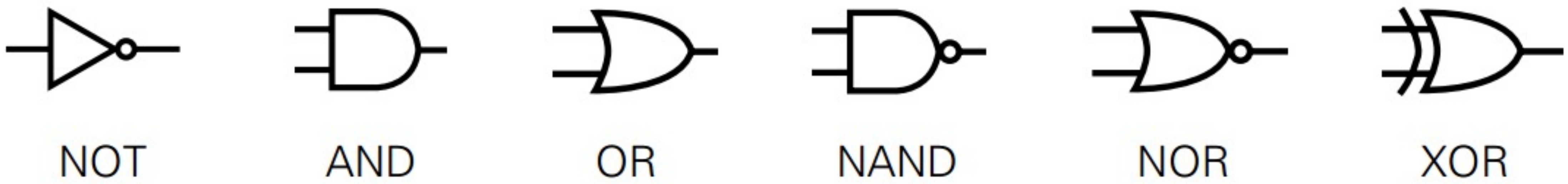
it’s an “or” gate



A	B	$\neg A$	$A \land \mathrm{B}$	$A \lor \mathrm{B}$	$\neg(A \land \mathrm{B})$	$\neg(A \lor \mathrm{B})$	$(A \lor \mathrm{B}) \land \neg(A \land \mathrm{B})$
T	T						
T	F						
F	T						
F	F						



A	B	$\neg A$	$A \land \mathrm{B}$	$A \lor \mathrm{B}$	$\neg(A \land \mathrm{B})$	$\neg(A \lor \mathrm{B})$	$(A \lor \mathrm{B}) \land \neg(A \land \mathrm{B})$
T	T	F	T	T	F	F	F
T	F	F	F	T	T	F	T
F	T	T	F	T	T	F	T
F	F	T	F	F	T	T	F



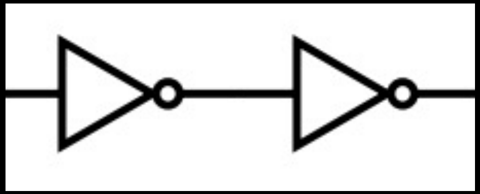
A	B	$\neg A$	$A \land \mathrm{B}$	$A \lor \mathrm{B}$	$\neg(A \land \mathrm{B})$	$\neg(A \lor \mathrm{B})$	$(A \lor \mathrm{B}) \land \neg(A \land \mathrm{B})$
1	1	0	1	1	0	0	0
1	0	0	0	1	1	0	1
0	1	1	0	1	1	0	1
0	0	1	0	0	1	1	0

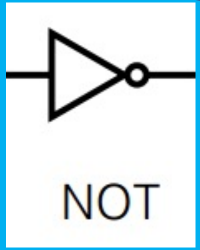
digital circuits

consist of logic gates

constructed from transistors.

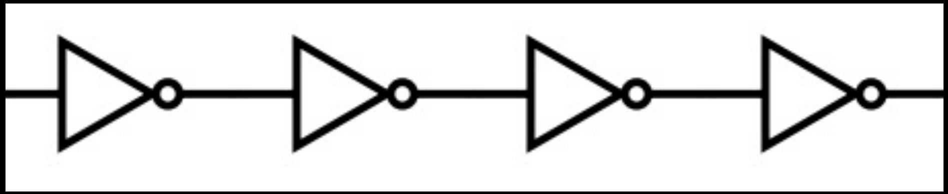
can you translate this into a wff of SL?



Recall: 

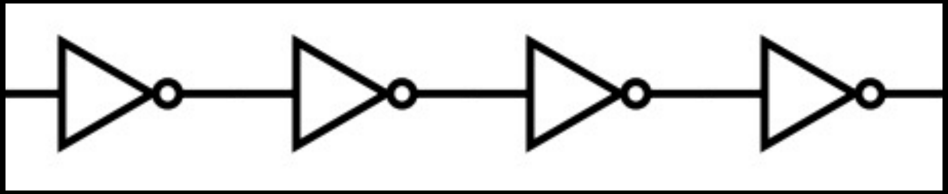
So we have $\neg\neg a$

can you translate this into a wff of SL?



$\neg\neg\neg\neg a$

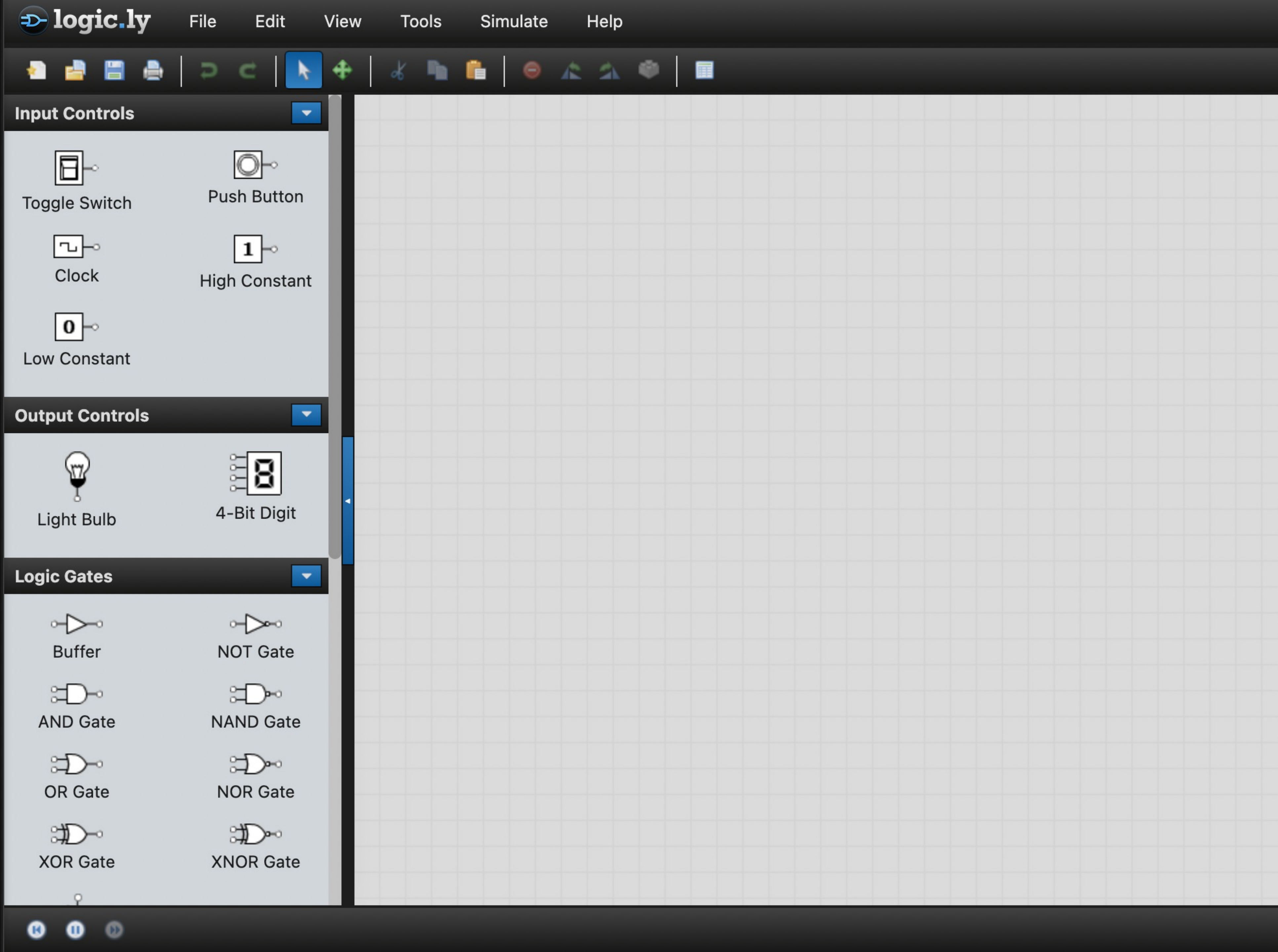
What is the output if the input at point *(a)* is a 0 bit?



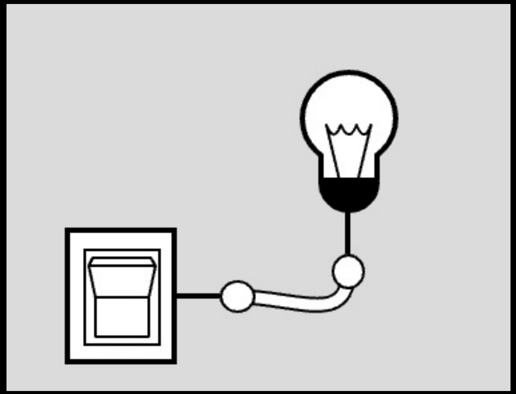
$0 \rightarrow \quad 1 \rightarrow \quad 0 \rightarrow \quad 1 \rightarrow \quad 0 \rightarrow$

a	$\neg a$	$\neg\neg a$	$\neg\neg\neg a$	$\neg\neg\neg\neg a$
0	1	0	1	0

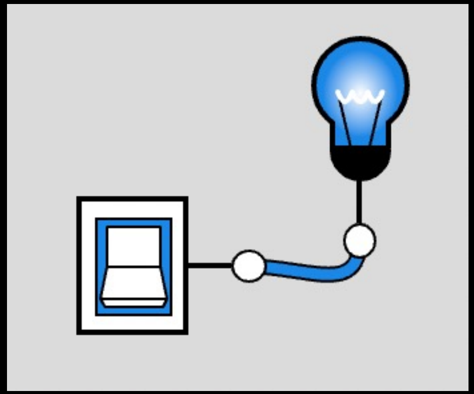
we'll use this tool to construct our logic gates.



we'll use this tool to construct our logic gates.

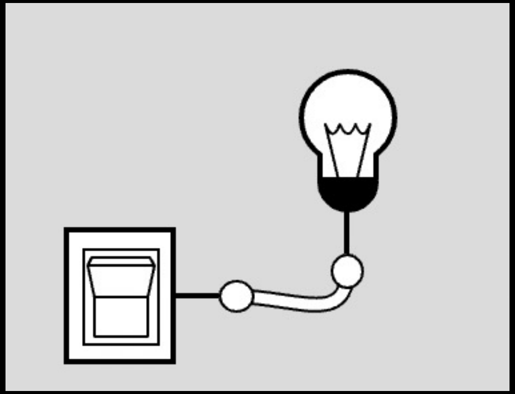


a is false, light is off

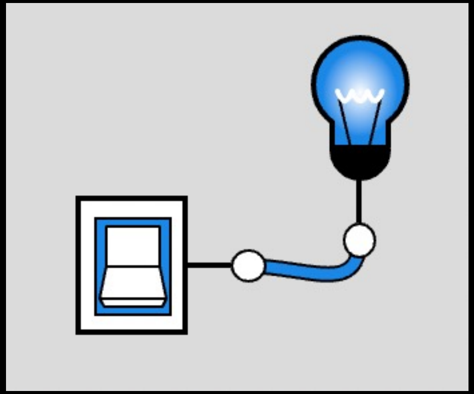


a is true, light is on

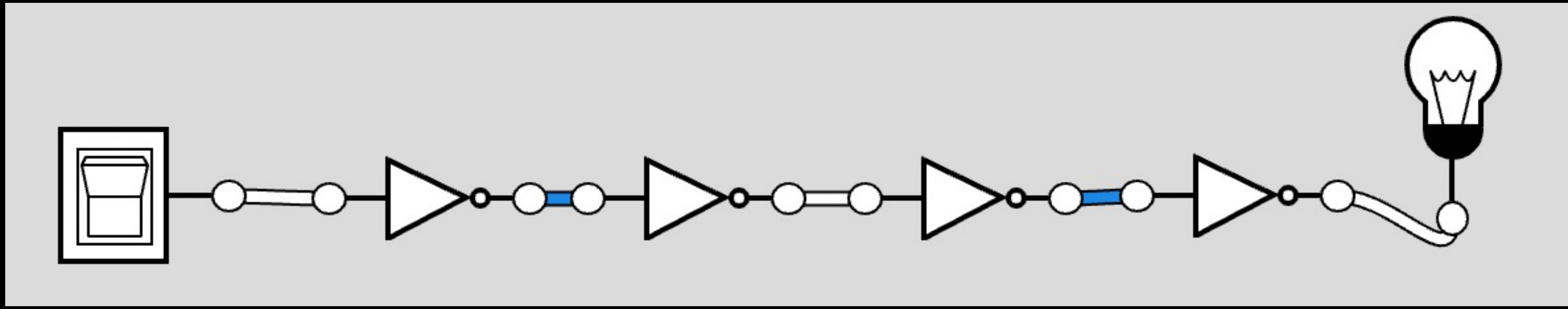
we'll use this tool to construct our logic gates.



a is false, light is off

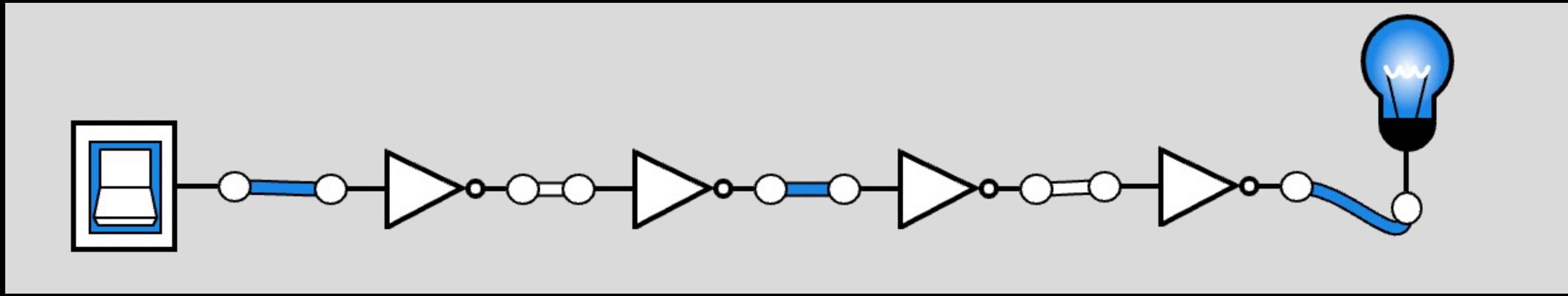


a is true, light is on



$a \text{ is } false$

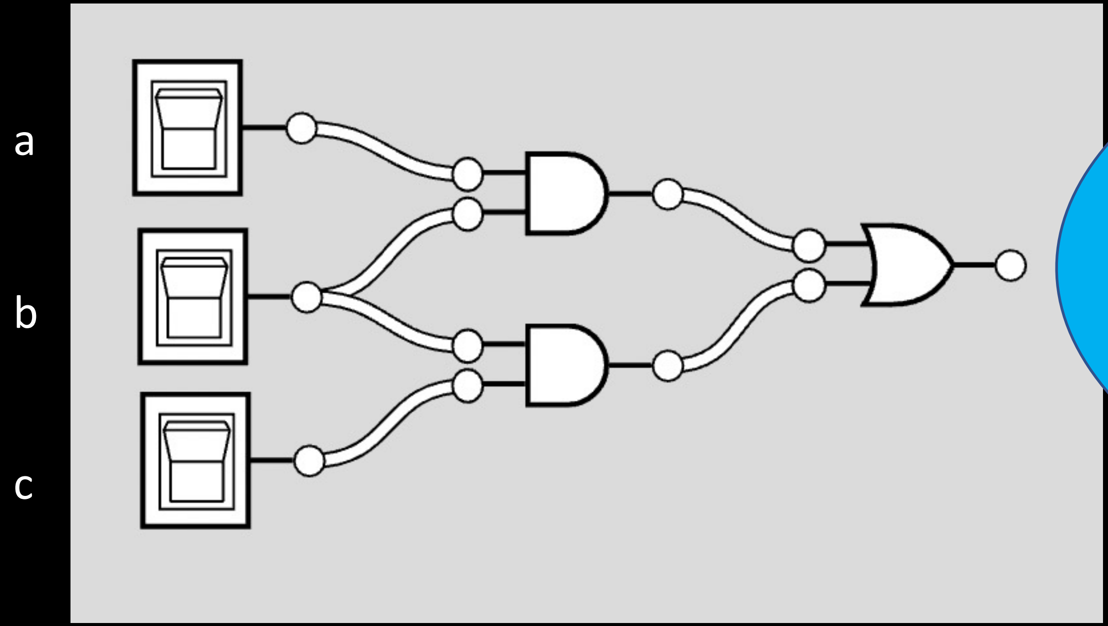
$\neg\, \neg\neg\neg a \text{ is } false, light \text{ is } off$



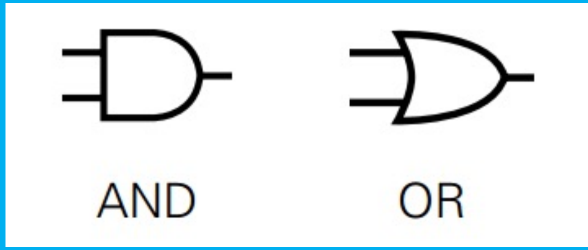
$a \text{ is } true$

$\neg\, \neg\neg\neg a \text{ is } true, light \text{ is } on$

can you translate this into a wff of SL?



Recall:



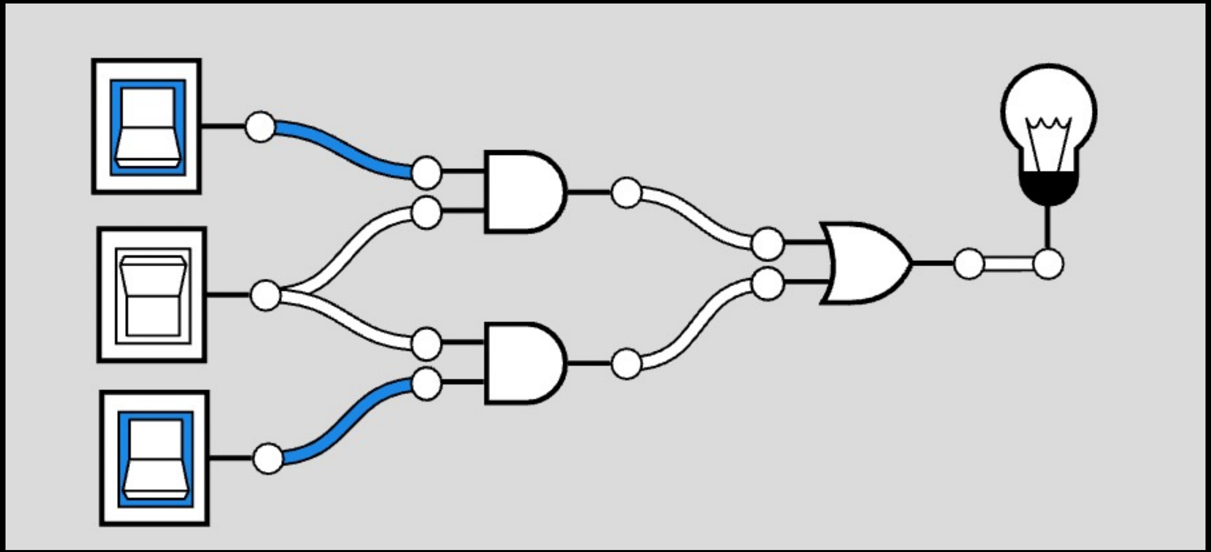
$(a \wedge b) \vee (b \wedge c)$

If I connected a light, would it be on or off?

a

b

c



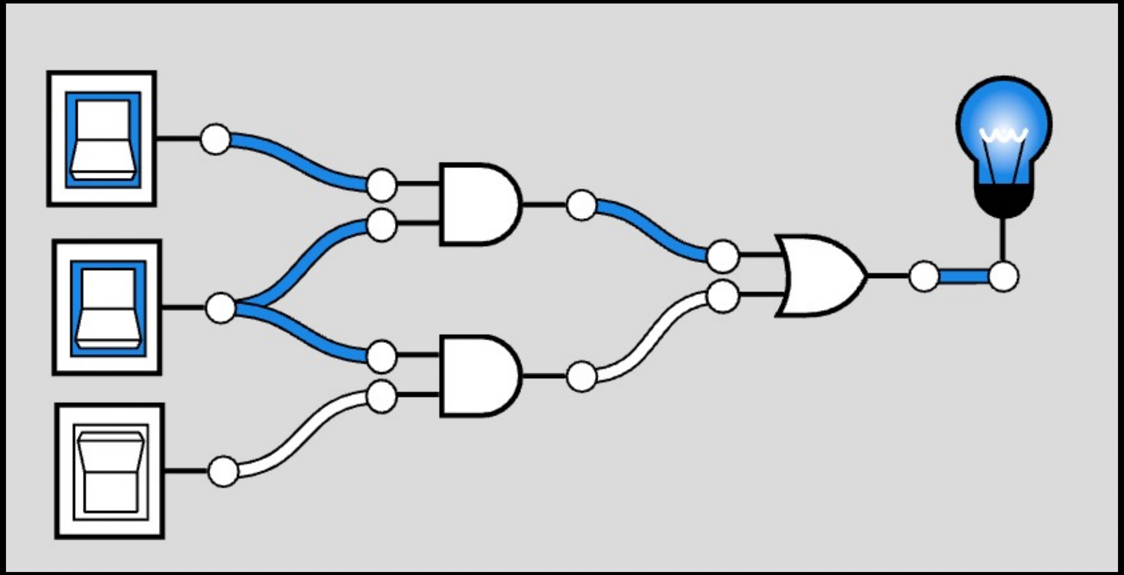
a	b	c	$(a \wedge b)$	$\vee$	$(b \wedge c)$
1	0	1	0	0	0

If I connected a light, would it be on or off?

a

b

c



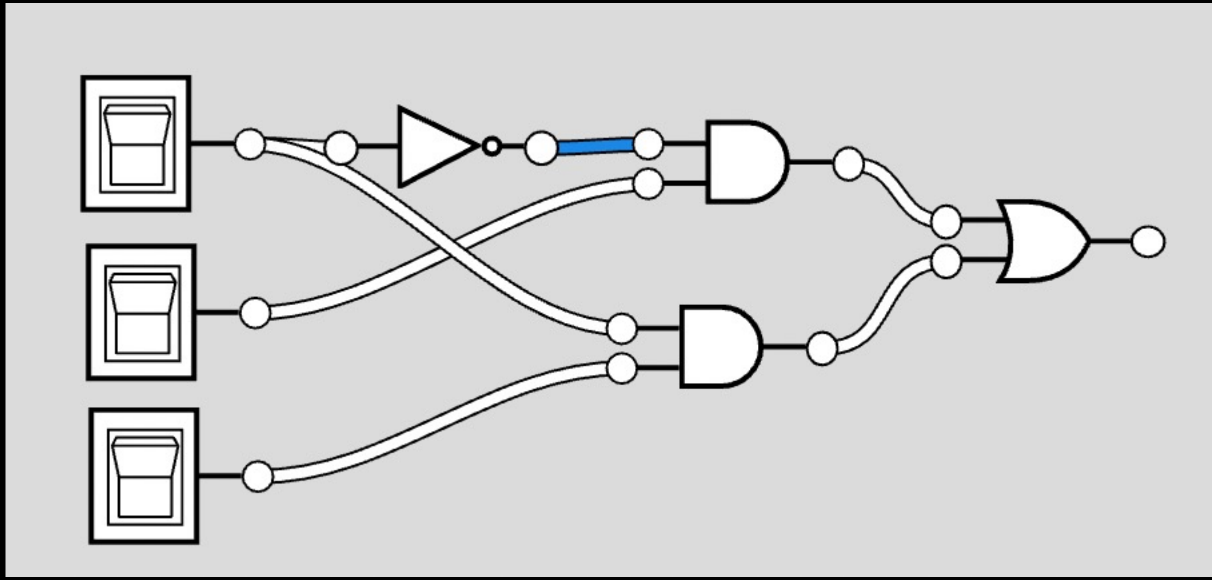
a	b	c	$(a \wedge b)$	$\vee$	$(b \wedge c)$
1	1	0	1	1	0

can you translate this into a wff of SL?

a

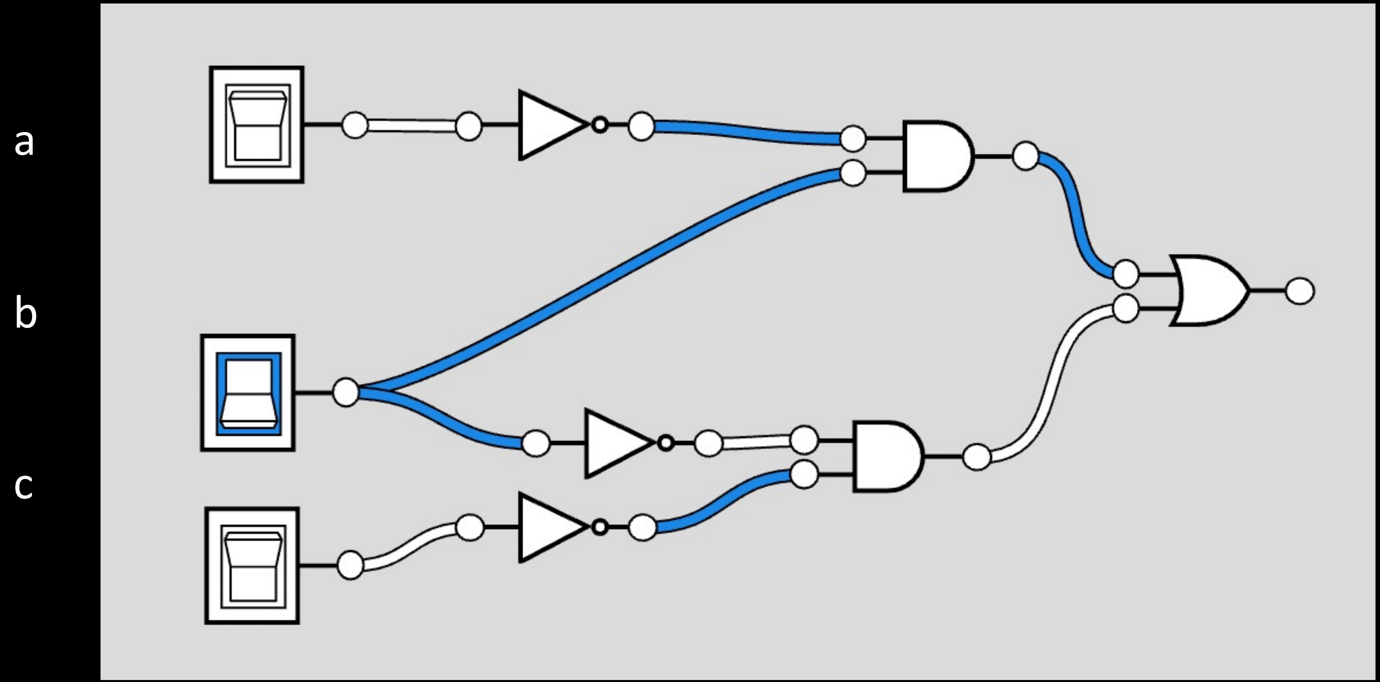
b

c

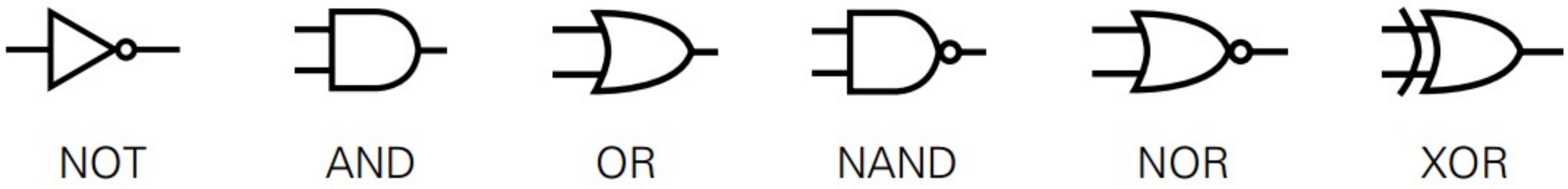


$(\neg a \wedge b) \vee (a \wedge c)$

can you translate this into a wff of SL?



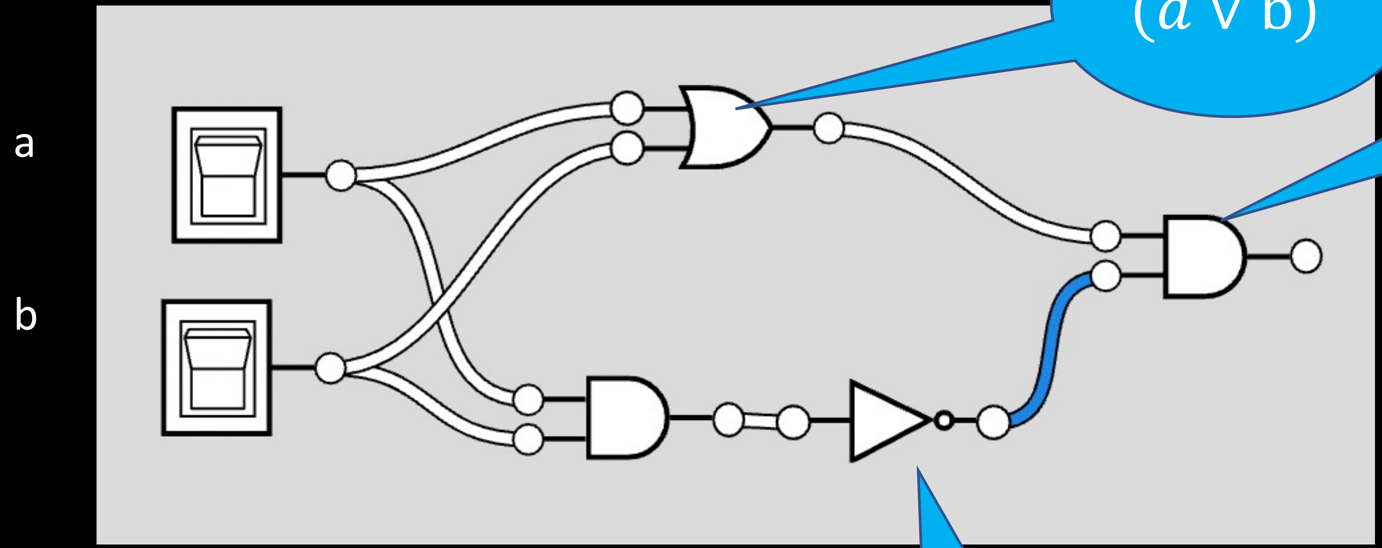
$(\neg a \wedge b) \vee (\neg b \wedge \neg c)$



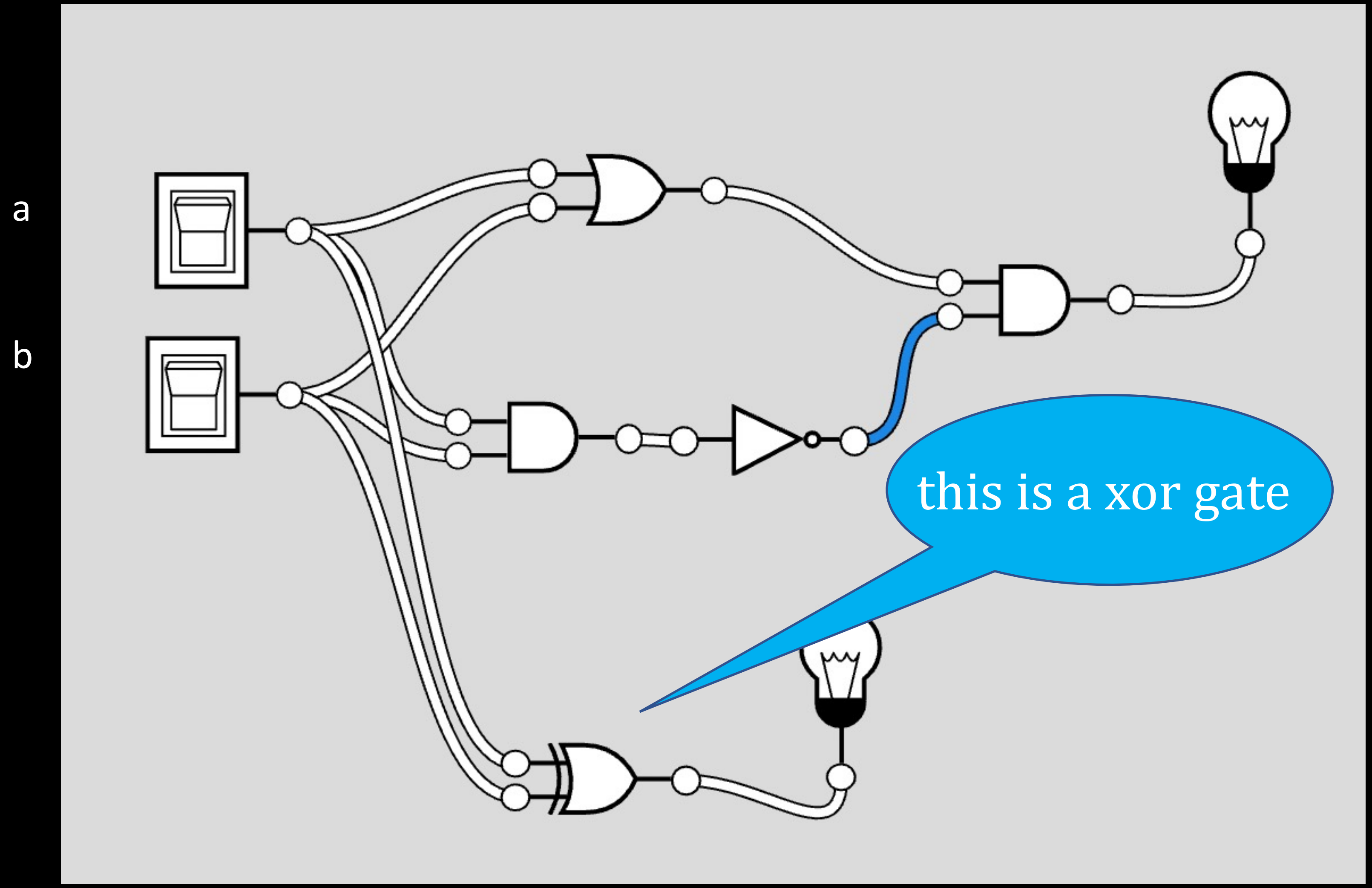
A	B	$\neg A$	$A \wedge \mathrm{B}$	$A \vee \mathrm{B}$	$\neg(A \wedge \mathrm{B})$	$\neg(A \vee \mathrm{B})$	$(A \vee \mathrm{B}) \wedge \neg(A \wedge \mathrm{B})$
1	1	0	1	1	0	0	0
1	0	0	0	1			
0	1	1	0	1			
0	0	1	0	0	1		0

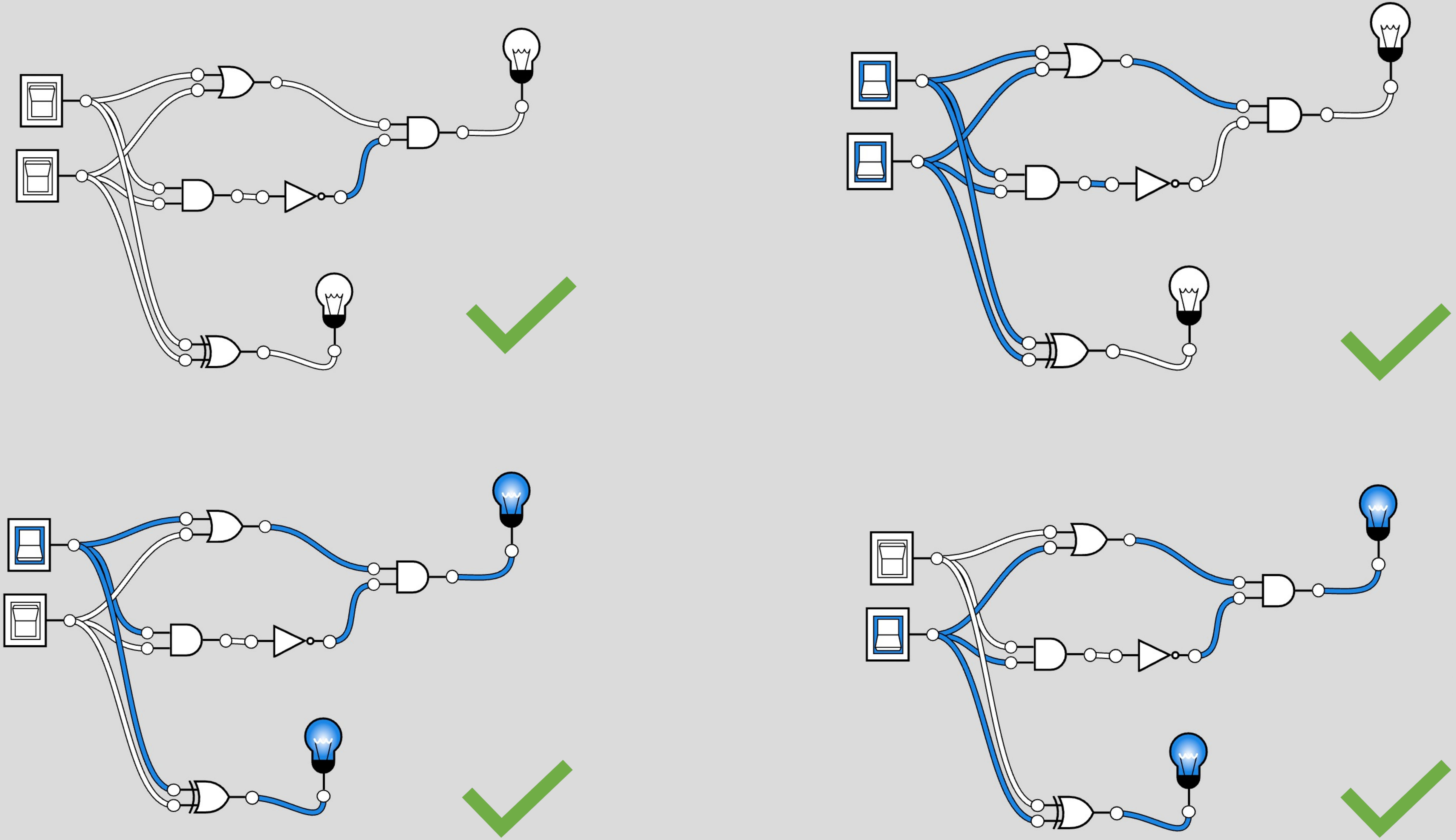
We can make the rest
from the basic logic gates

can you make xor?



does it work?

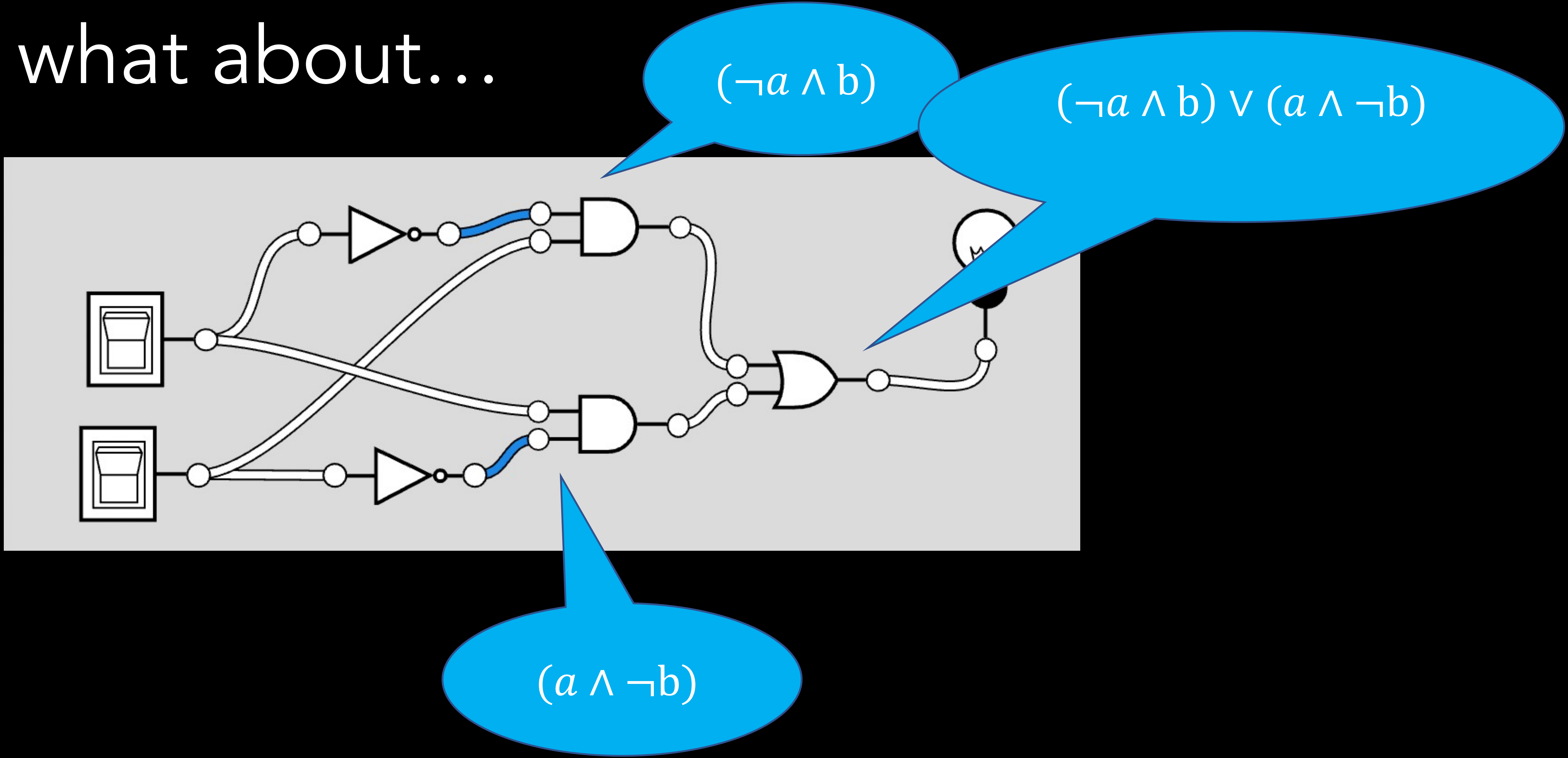




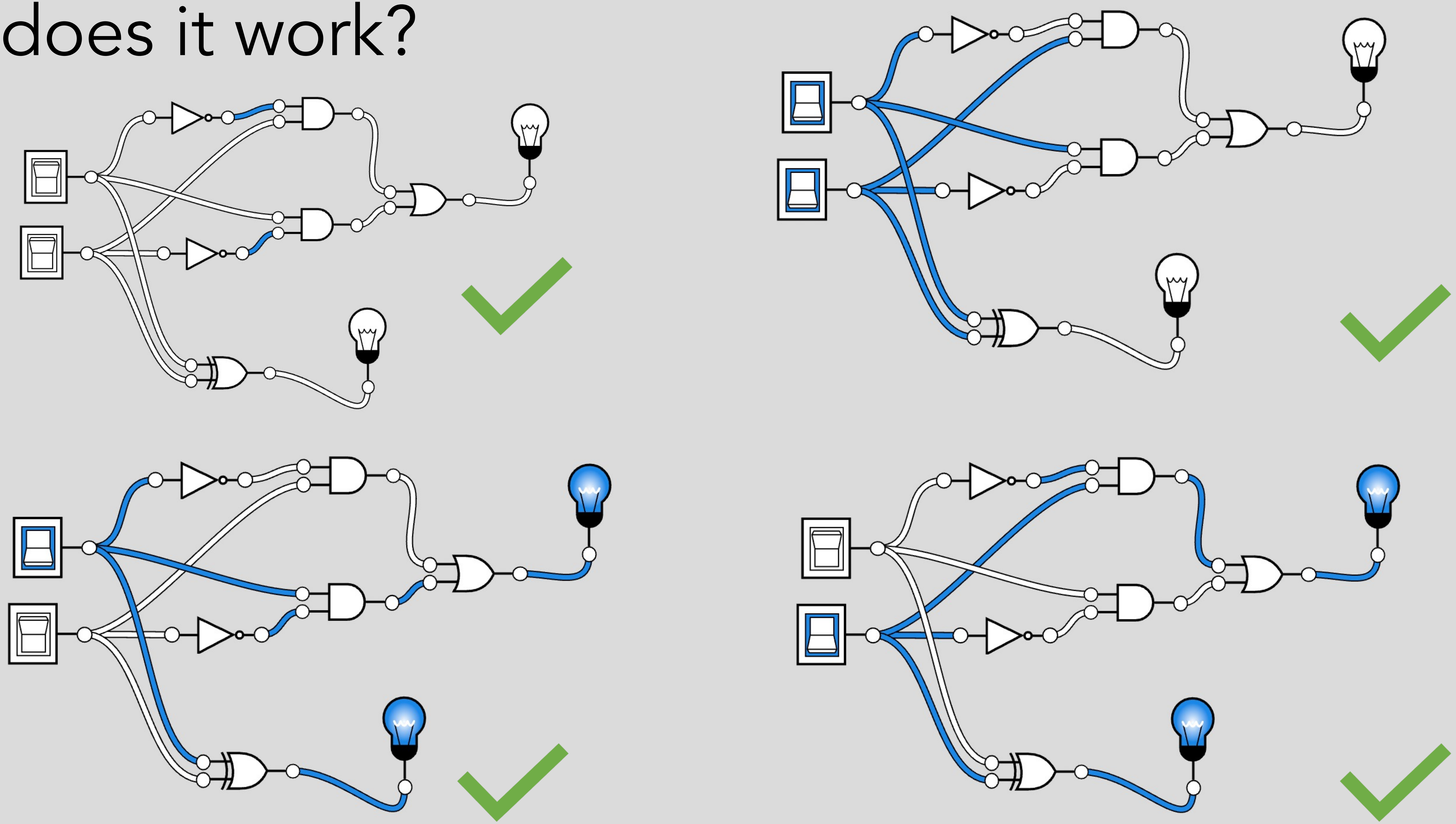
what about…

a

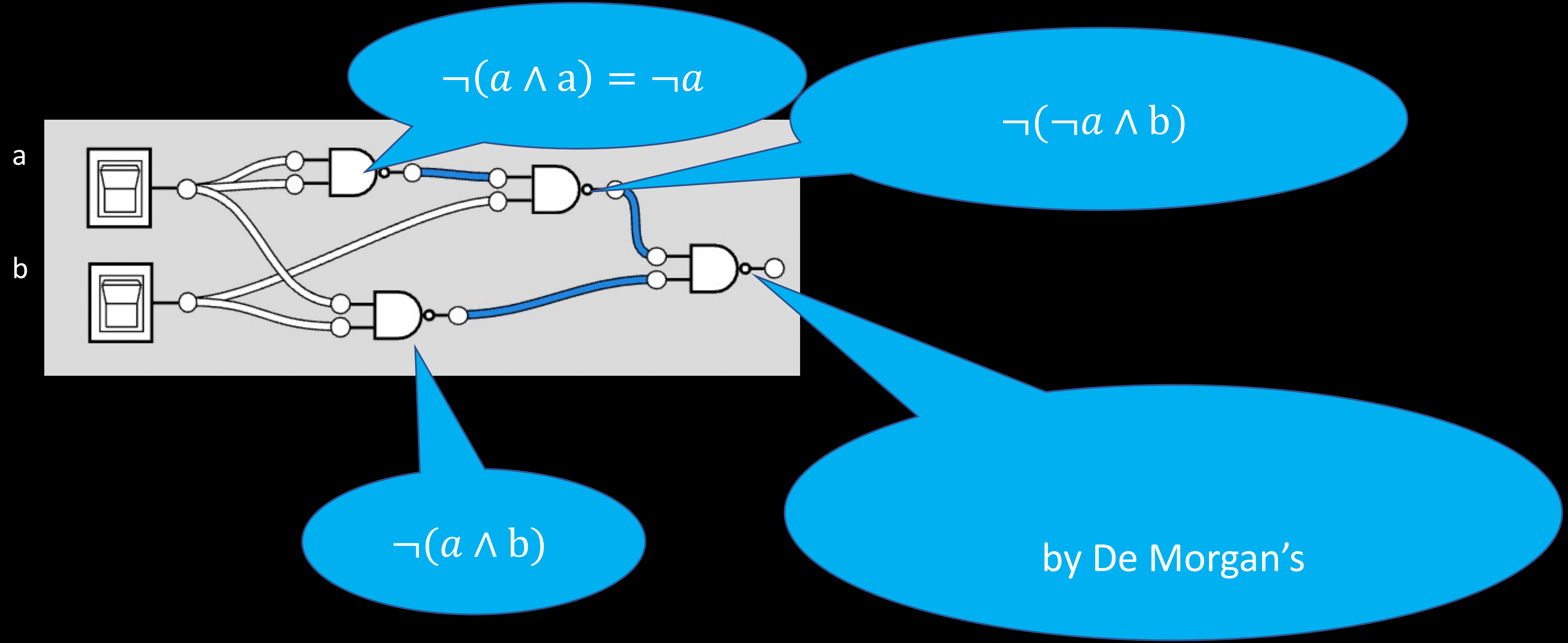
b



does it work?



what's going on here?

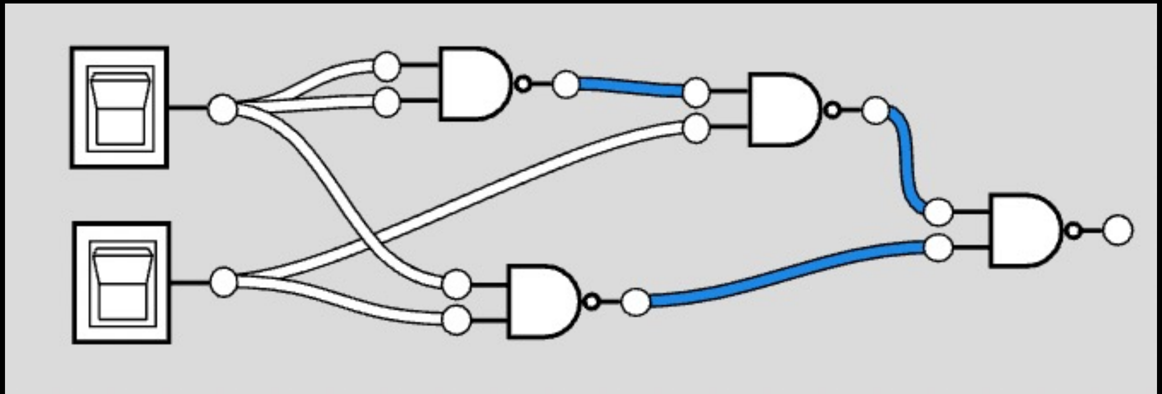


why make it so complex?

Both represent
$(\neg a \land b) \lor (a \land b)$
but the top one uses a single gate (NAND) whereas the bottom one uses 3 different gates (NOT, OR, and AND).

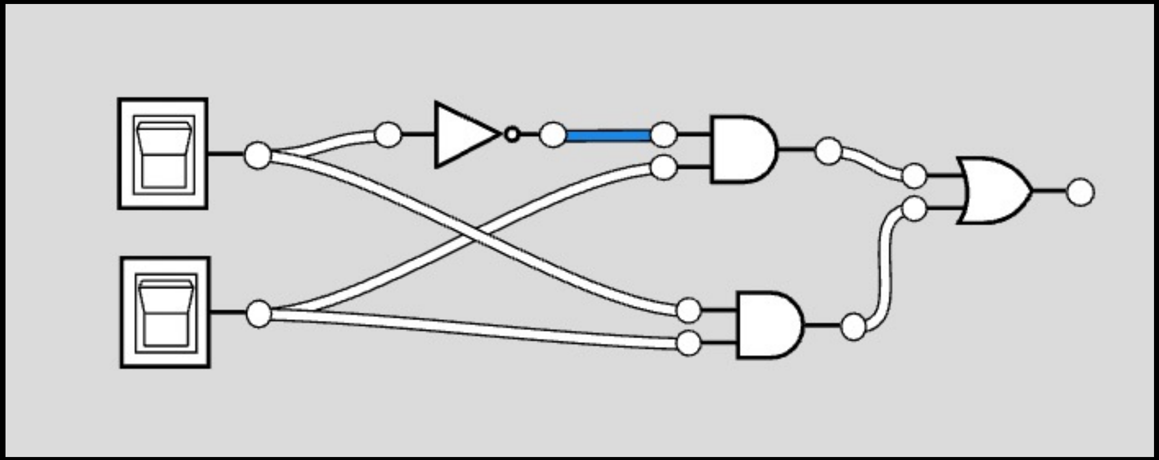
a

b



a

b



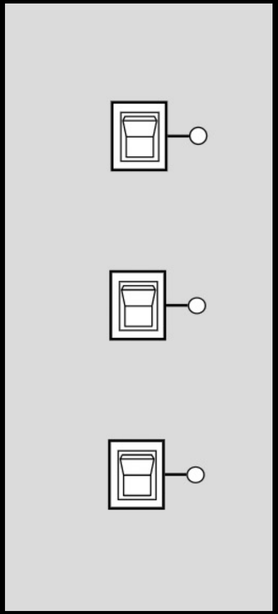
can you construct a logic gate diagram representing this wff of SL?:

$$(\neg a \wedge b) \vee (a \vee (\neg b \wedge c))$$

a

b

c



can you construct a logic gate diagram representing this wff of SL?:

$$(\neg a \wedge b) \vee (a \vee (\neg b \wedge c))$$

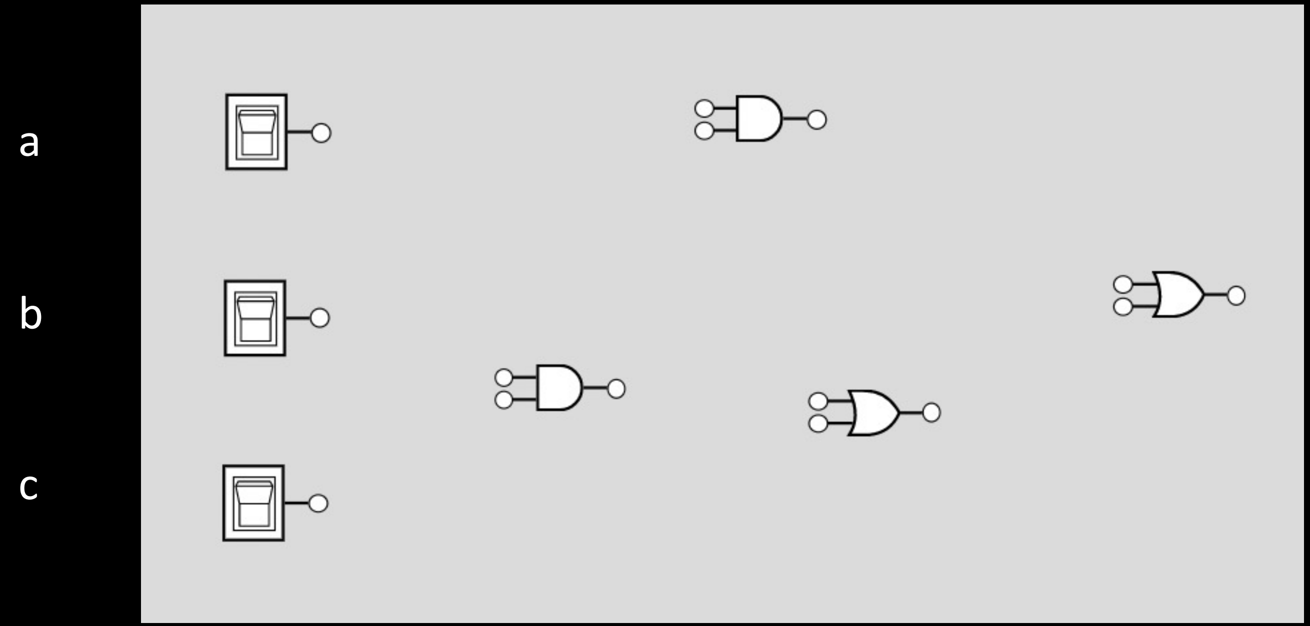
a

b

c

can you construct a logic gate diagram representing this wff of SL?:

$$(\neg a \land b) \lor (a \lor (\neg b \land c))$$



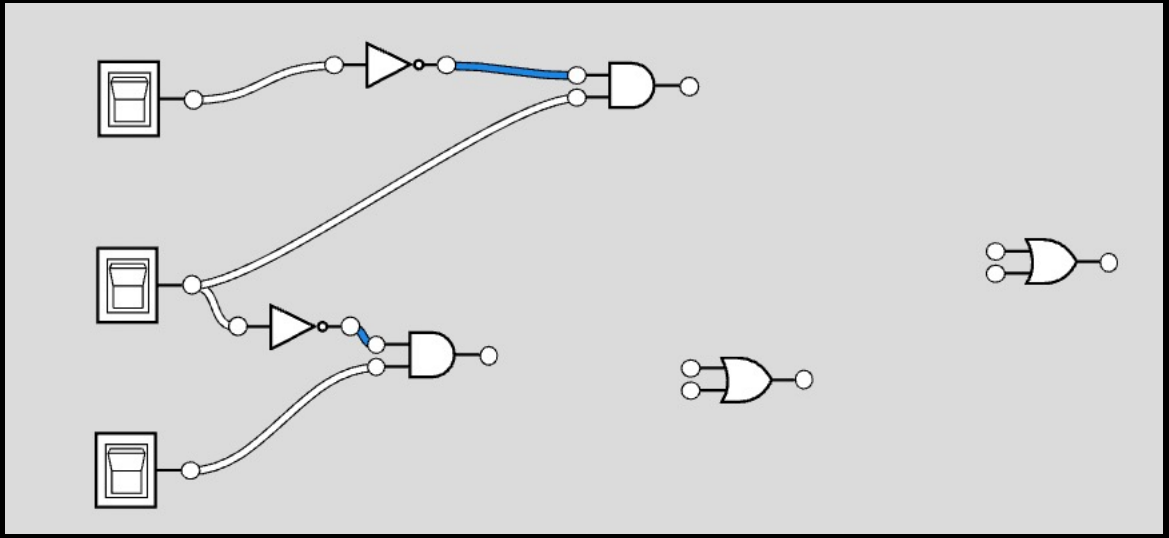
can you construct a logic gate diagram representing this wff of SL?:

$$(\neg a \land b) \lor (a \lor (\neg b \land c))$$

a

b

c



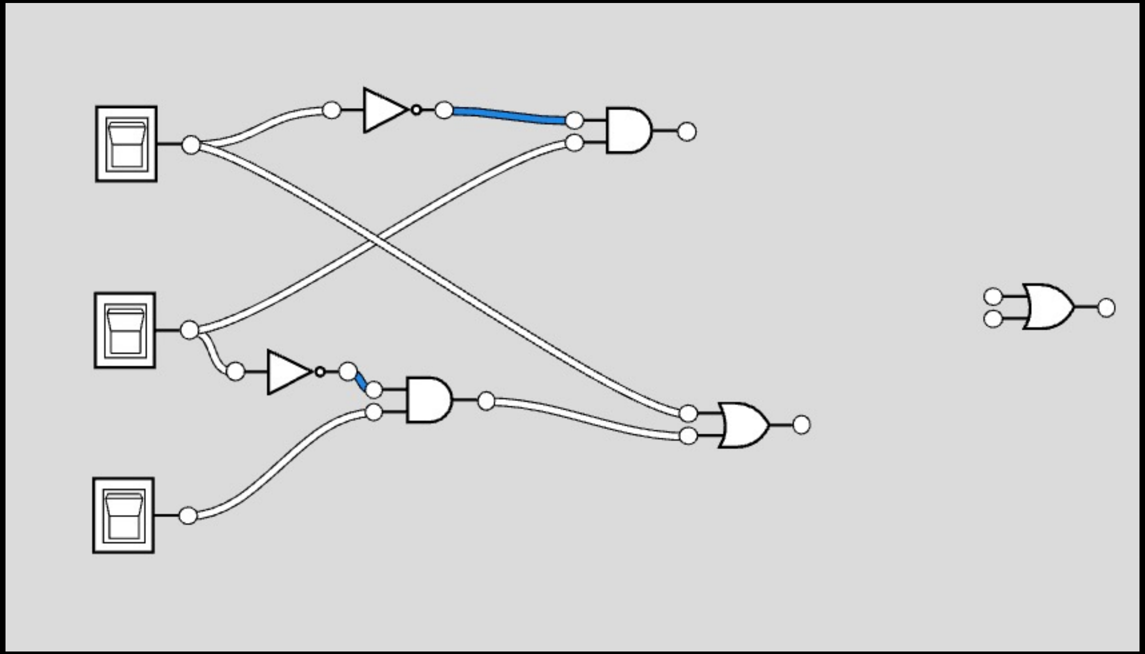
can you construct a logic gate diagram representing this wff of SL?:

$$(\neg a \wedge b) \vee (a \vee (\neg b \wedge c))$$

a

b

c



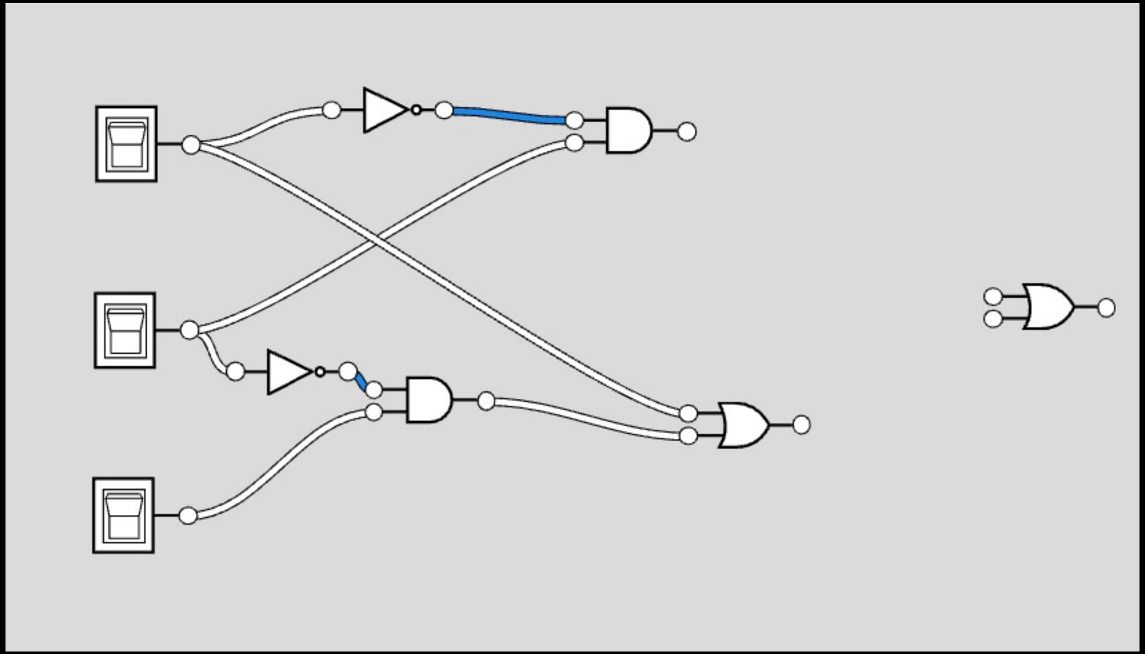
can you construct a logic gate diagram representing this wff of SL?:

$$(\neg a \wedge b) \vee (a \vee (\neg b \wedge c))$$

a

b

c



can you construct a logic gate diagram representing this wff of SL?:

$$(\neg a \wedge b) \vee (a \vee (\neg b \wedge c))$$

a

b

c