PIAF – Pedagogical Scenario

(PIAF= Développement de la pensée informatique et algorithmique dans l'enseignement fondamental – **Development of computational and algorithmic thinking in basic education**)

Title

Logic Gates

Practical Information

(Ideal) Number of students: 16
Age of the students: 12 – 15 years
Duration of the scenario: 3 sessions of 45 minutes each

Main discipline of the Scenario

C 2.3 Create a sequence of actions to reach a simple goal
C 2.4 Create a sequence of actions to reach a complex goal
C 3.3 Integrate a simple condition into a sequence of actions

Description

Students learn about Boolean Logic and Logic gates that are used in digital circuits. At first, they are given simple goals such as making a simple logic "if" statement by relating two images and ideating an outcome. Later on, using visual representations of logic gates and basic circuits where students need to indicate the correct input, output, and/or logic gate. Simple and complex goals consist of simple and complex circuits using multiple logic gates. For reaching those goals, students must identify, understand, and execute the correct sequence of actions.

PIAF-specific competencies/goals

Specific PIAF Competencies:	
C1	Competency 2: Compose/decompose a sequence of actions > C 2.3 Create a sequence of actions to reach a simple goal > Students are given a set of action sequences that they need to identify, evaluate, and select for reaching the simple goal. The simple goal consists of logic statements with 1 logic operator (AND, OR, NOT)..
C2	Competency 2: Compose/decompose a sequence of actions > C 2.4 Create a sequence of actions to reach a complex goal > Students combine the action sequences from single logic operators (AND, OR, NOT) to complete complex goals. The complex goal consists of logic statements with multiple logic operators.
C3	Competency 3: Control a sequence of actions > C3.3 Integrate a simple condition into a sequence of actions > Students identify and use simple conditions (i.e. if…then statements) to understand and complete simple and complex logic statements.

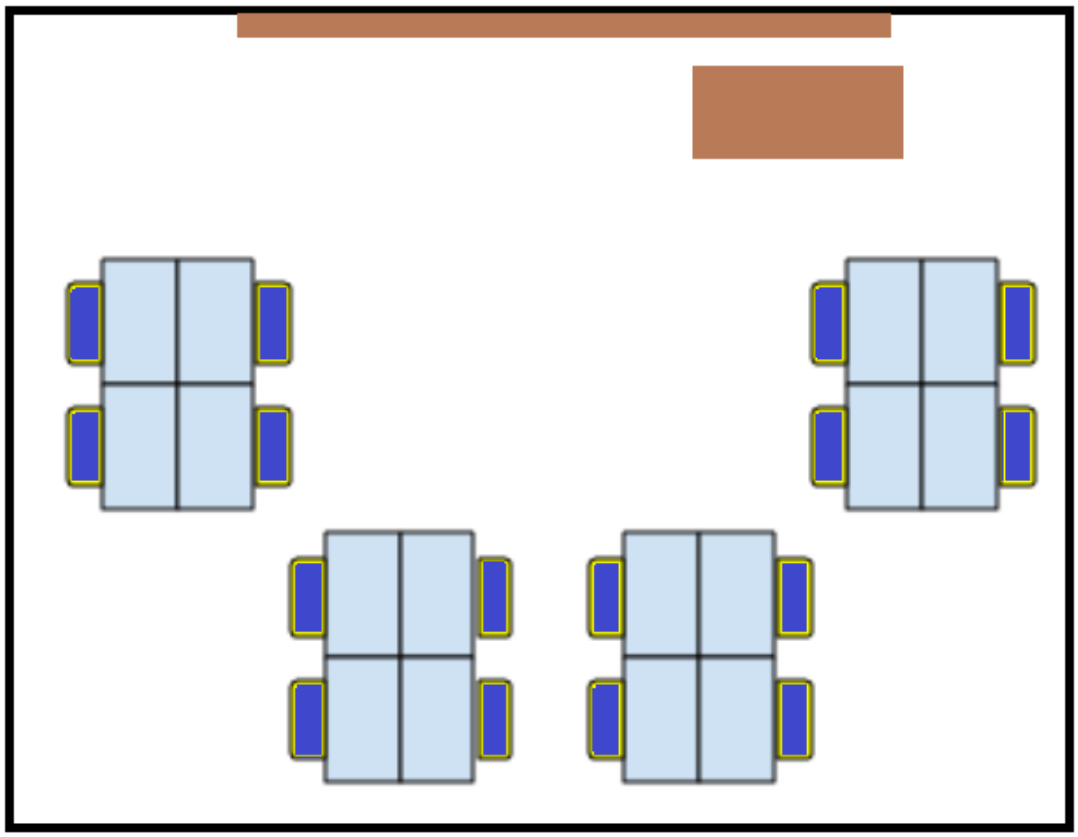
Pre-requisite for the activities

Read, write, and follow instructions

Digital Resources

Technical	**Didactic**
None	Course notes and attachments
	Per group: 2 batteries, 2 wires, 1 light bulb, 2 switches

Organization of the classroom



Scenario (Sequence of the Activities)

Activity 1: Boolean Logic		
1. Introduction (5')	Group Format: Whole class Document: Attachment A for teachers Instruction: "*Boolean logic is a special form of algebra (a branch of mathematics) where values can either be either True or False, it is named after George Boole who introduced it. True and False can also be represented in binary as 0 and 1. False = 0 and True= 1. Can you state whether this is True or False? Is today Monday (ask actual day of the week)? Are you 20 years old? Does Earth revolve around the sun?"* Students task: Students should respond the questions Instructors role: Encourage students to interact through asking some more similar questions	
2. Topic Elaboration (5')	Group Format: Whole class Instruction: "*Boolean logic performs some logic operations using three basic logic operators AND, OR and NOT. We can use them in a statement to understand e.g. If you are a student AND 10 years old, raise your hand. If your favorite sport is Football OR Basketball, raise your hand. If you are a girl AND have a younger brother, raise your hand."* Students task: Students should respond to the teacher through raising their hands Instructors role: Make sure all students are participating in the activity. Ask them to make some more statements beginning with "if" Expected response: Students should make some similar statements	
3. Activity (30')	Group Format: Groups of 2-3 students Document: Attachment A for teachers; Attachment 1 for students Instruction: *"Form small groups and I will give each group an exercise sheet where you need to create logic statements. Firstly, you will need to determine the steps for creating any logical statement and*	2.3 3.3

	then you will follow those steps to create them. You will do the logic statement using pictures and logic operators." Students task: Students should work in groups Instructors role: Distribute worksheets. Go to each group, check the actions sequence and logic statements they have created. Ask them to describe the actions sequence they have created to achieve the goal. Provide them feedback accordingly. If students finish all the tasks before time's up, ask them to present and compare results with other groups. Anticipation of difficulties: If some student(s)/ groups struggle with creating outputs for the pairs of images, ask them to think about how could those 2 images be (un)related. You can present them with the following statement: "If I do … and /or …, then … can be done" where the first 2 gaps need to be covered with the images and the third gap is the consequence/ result/ outcome of those 2 images.	
4. End of session: finalize activity and summarize (5')	Group Format: Whole class Instruction: "*What did we learn today?*" Students task: Verbal description of what has been learned during this session Instructors role: Guide the students with questions for obtaining the expected answers Covered topics: ● Boolean Logic ● Boolean Logic Operators	
Activity 2: Logic Gates		
1. Revision (5')	Group Format: Whole class Instruction: "*Do you remember Boolean logic and logic operators?"* Students task: Students interact through responding Instructors role: Ask some further linked questions to revise the lesson (if required) Expected response: -Created Boolean logic statements -Created statements and segregated each to the logic gate used	

2.Topic introduction (10‘)	Group Format: whole class Document: Attachment B for teachers Instruction: "*Today we will learn how this Boolean logic is used in logic gates. Logic gates are a special kind of gates that are used in digital circuits. These circuits are used in electronic devices e.g. computers and mobiles. Each circuit has input, gate and output. Can you think of any example of circuit?"* Students task: Students give some examples of circuits or things with circuits Instructors role: Draw logic gate simple circuit diagram on the board. Respond to the examples they give. Give them the example of light circuit	
3. Elaboration (5‘)	Group Format: whole class Document: Attachment B for teachers Instruction: *"As you see, we have three logic gates OR, AND, and NOT gates drawn on the board. Do you find any similarities or differences among them?"* Students task: Prompted by the teacher, students describe the similarities and differences Expected response: Similarities and differences in terms of inputs and output. Instructors role: Guide the students through some target questions to obtain the expected response. Give example for each logic gate	
4. Activity (20´)	Group Format: small groups (2-3 students) Document: Attachment B for teachers; Attachment 2 for students Instruction: *"Now I will distribute worksheets to you. Now that we have learned about the three main logic gates, we will do some exercises with them."* Students task: Solve the worksheet Instructors role: Check if they are working correctly, understand the problem statements for inputs and output combinations.	2.3 3.3
5. End of session: finalize activity and summarize (5’)	Group Format: Whole class Instruction: *“What did we learn today?”* Students task: Verbal description of what has been learned during this session Instructors role: Guide the students with questions for obtaining the expected answers	

	Covered topics: ● Logic Gates: types, shapes (i.e. graphical representation), input(s) and output, and characteristics	
Activity 3: Logic Circuits		
1. Revision (5')	Group Format: Whole class Instruction: *"Can someone remind me of what we did last time?"* Students task: Students should respond the question Instructors role: Remind students through questions to obtain expected answers	
2. Recap activity: Simple goals and conditionals (25')	Group Format: Individually Document: Attachment C for teachers; Attachment 3 for students Instruction: *"Today we will continue with the logic gates topic that we learned last session. First, we will do a recap activity by answering the following worksheet"* Students task: Answer the worksheet Anticipation of difficulties: If students don't remember the logic gates or how they work, support them by reviewing what was done on the last session	2.3 3.3
3. Activity: Complex goals and conditionals (10´)	Group Format: Individually Document (optional): Attachment C for teachers; Attachment 4 for students Instruction: "*Now let's solve a couple of more complex logic circuits."* Students task: Solve the worksheet Instructors role: Check the progress of every student. If there's enough time, review the answers with all students.	2.4 3.3
4. End Session (10´)	Group Format: Whole class Instruction: *"To review what we did today, I will pick some volunteers to come to the front to explain the steps they did to complete the logic circuits"* Covered Topics: -Simple and complex logic gate circuits	2.4

Assessment

Competencies/ PIAF-Goals	Activities for the assessment	Assessment criteria
C 2.3 Creating an action sequence to achieve a simple goal	Describe and execute the action sequence correctly to reach the goal	Create and perform the correct action sequence to reach the goals of completing a simple logic circuit
C 2.4 Creating an action sequence to achieve a complex goal	Make and describe the action sequence to create the circuit using logic gates	Create and perform the correct action sequence to reach the goals of completing a complex logic circuit
C3.3 Create a sequence of actions which relies on simple conditions	Define conditions to create a sequence of actions to reach the goals by using sequence cards and a set of pictures	Identify the conditional statement of the logic circuits

Received Feedback on the created Scenario

If you have had the opportunity to experiment with the scenario presented here, suggest some feedback on it: what worked well, the obstacles encountered, the learner's feedback, your feelings, possible ways to improve it.

Bibliography

- All photos used in activity1 are taken from https://www.pexels.com/. These photos are free to use, can be edited or modified. Giving attribution or credit is not required. More information on their license page: https://www.pexels.com/license/

Attachments

Attachments Overview

Activity	Teacher Attachment	Student Attachment
1.1	A	
1.3	A	1
2.2	B	
2.3	B	
2.4	B	2
3.2	C	
3.3	C	3

Teacher's Attachments

Teacher's Attachment: A

Used in activity:	1.1: Introduction 1.3: Activity
Along with Student's Attachment(s):	1

Activity 1.1:

For topic introduction you can ask some questions to students where students can give True or False as an answer. Make the questions begin with "if" e.g. *"if you have a pet?", "if you like sports?"* etc.

Activity 1.3:

Give to each group an activity sheet (Attachment 1), scissors, and glue. The activity sheet contains seven pairs of images but groups only need to create four logical statements with 4 pairs of images. Students will cut and paste pictures into the input column to create logic statements.

Go to each group and ensure that they have correctly organized the four steps in the correct action sequence. Once they have done it, they must follow that sequence every time, for each pair of images they use. Check if they have made statements correctly. Scaffold the half statement to students if they find it difficult to make statements. Allow them to make statements without pictures if they face difficulty or finish early.

General criteria for checking the logic statements:

1. The logic statements make sense when read using the following formula: "if (image-1 and/or image-2), then (consequence/ result/ action)*".*
2. Other language and grammatical issues can be handled as per need.

Solution for Attachment 1:

- Your goal is to **make logic statements.**

1. Create an action sequence to achieve the goal.
    a. For that, reorganize the steps below into the correct 4-step sequence.
2. Once you have the correct sequence of steps, follow those steps to fill the last table. You can cut and paste the pictures

- Make at least 1 statement for each logic operator.
- The logic operators you can use are: AND, OR, or NOT
- Remember: Logic statements begin with “if”.

Select logic operator	Use input column to paste selected pictures	Use output column to write logic statement	Pick input picture(s)

Step 1	Step 2	Step 3	Step 4
Pick input picture(s)	Select logic operator	Use input column to paste selected pictures	Use output column to write logic statement

Possible logic statements for the pictures:

Below, there are examples of one logic statement for each pair of images. These are not the unique answers. What matters is that the logic statements indicate a cause and effect relationship where the images, connected by a logical operator, act as a cause, and the effect is related to the images. Logic statements that use NOT use two logical operators.

1. If you have sweater AND boots, then you can go play outside
2. If you go to school by (school) bus OR by car, then you will pass the bridge
3. If the food is cold AND you have a microwave oven, then reheat the food
4. If you have water AND coffee, you can prepare a coffee
5. If you are a girl OR a boy, then you need to study for the final exam
6. If it is NOT cold AND you are on the beach, then you don’t need to use a jacket
7. If you use a mask AND sanitizer, you will prevent getting flu

Teacher's Attachment: B

Used in activity:	2.2: Topic Introduction 2.3: Elaboration 2.4: Activity
Along with Student's Attachment(s):	2

Activity 2.2:

Introduce the topic "Logic gates" with definition, importance and usage in electric devices e.g. in computers, mobile etc.

You can draw this simple logic gate circuit diagram or print and paste on the board to show the students.

Possible explanation:

The possible explanation for the diagram can be: *"Input passes through the gate (i.e. the arrow) where a logic operation performs and creates an output. The input and output can be True or False or 1 and 0, respectively"*

Lamp example:

You can give this light example to students and explain working of the circuit:

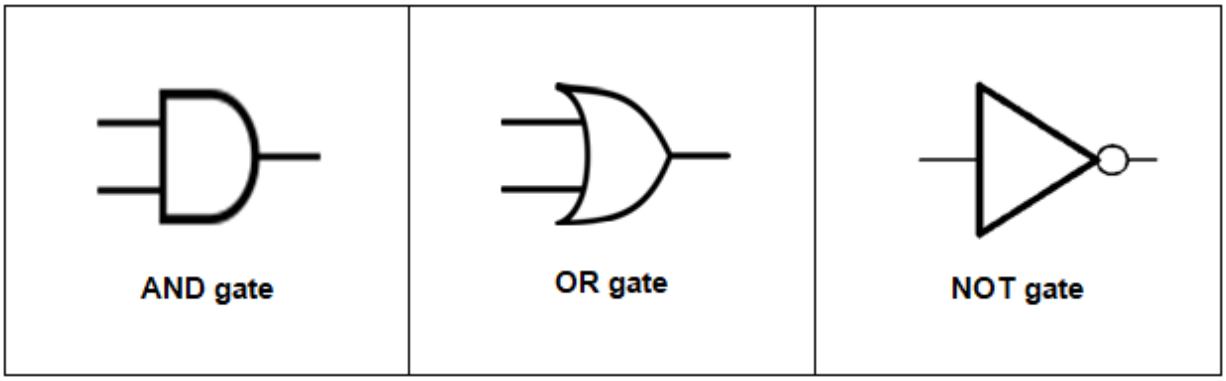
"A very simple logic circuit you may know and have used is a lamp.
A lamp has a switch, which is the input, that allows two possible states or options which are ON or OFF, or 1 or 0, or True or False. A lamp has an output which in this case is the lightbulb that can be either turned on or off.
As you can see, the logic circuit of a lamp is very simple and straightforward. If the switch is ON, then the lightbulb is on. If we want the lightbulb to be off then we turn the switch OFF.

Later we will see more complex circuits that, for instance, have two inputs and the combination of them generates a single output.
What matters now is that when talking about logic circuits, each individual input and output can only have two states or options: ON or OFF, 1 or 0, or True or False.

Activity 2.3:

AND, OR and NOT Gates:

You can draw the picture of logic gates on the board. The picture of logic gates: OR, AND, NOT are as follows:



You can explain them to students like: *"In each gate prongs on the left side are for input and on the left side is for output. Each logic gate processes inputs differently and therefore can generate different outputs. Please note that the AND and OR gates take 2 inputs whereas the NOT gate only takes 1 input. All three gates produce only 1 output"*

Questions for students:

Q: Do you see any pattern here?
A: On all 3 gates all the inputs are located on the left side of the gates and the outputs on the right side. All gates “produce” only 1 output

Q: How many inputs and outputs for each gate?
A: 2 inputs for AND and OR, 1 input for NOT. All 3 gates have 1 output

Q: How many combinations are possible for two inputs of 0 and 1?
A: Four: 0-1, 1-0, 0-0, 1-1

Possible examples

To explain working of each gate, you can give these examples to students.

AND gate example:

If you want to make banana and strawberry smoothie. What do you need? Banana AND Strawberry.

Statement: 'If you have Banana AND Strawberry, then you can do a smoothie'

The AND gate indicates that only if the two inputs are true, then the output can be true.
If one of the 2 inputs are false, then the output can only be false.

We will refer to the fact of having a banana as 'True' or as 1. In case we do NOT have a banana, we can refer to that as 'False' or 0.

Logic statements:
If you have banana AND strawberry, can you make smoothie? Yes.
1 AND 1 = 1

If you have banana AND no strawberry, can you make smoothie? No
1 AND 0 = 0

If you have no banana AND only strawberry, can you make smoothie? No.
0 AND 1 = 0

If you have no banana AND no strawberry, can you make smoothie? No.
0 AND 0 = 0

OR gate example:

If you want to make orange juice, what do you need? Oranges. One orange is enough but if we have two oranges, that's better.

Statement: 'If you have an Orange OR an (another) Orange, then you can do orange juice'

Logic statements:

If you have orange OR orange, can you make juice? Yes.
1 OR 1 = 1

If you have orange OR no orange, can you make juice? Yes. (Because we only need at least 1 orange)
1 OR 0 = 1

If you have no orange OR orange, can you make juice? Yes.
0 OR 1 = 1
If you have no orange OR no orange, can you make juice? No.
0 OR 0 = 0

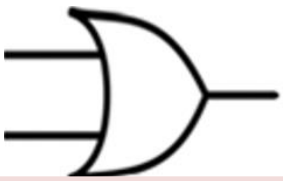
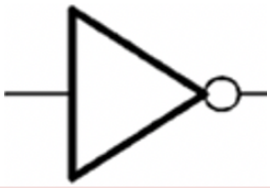
NOT gate example:

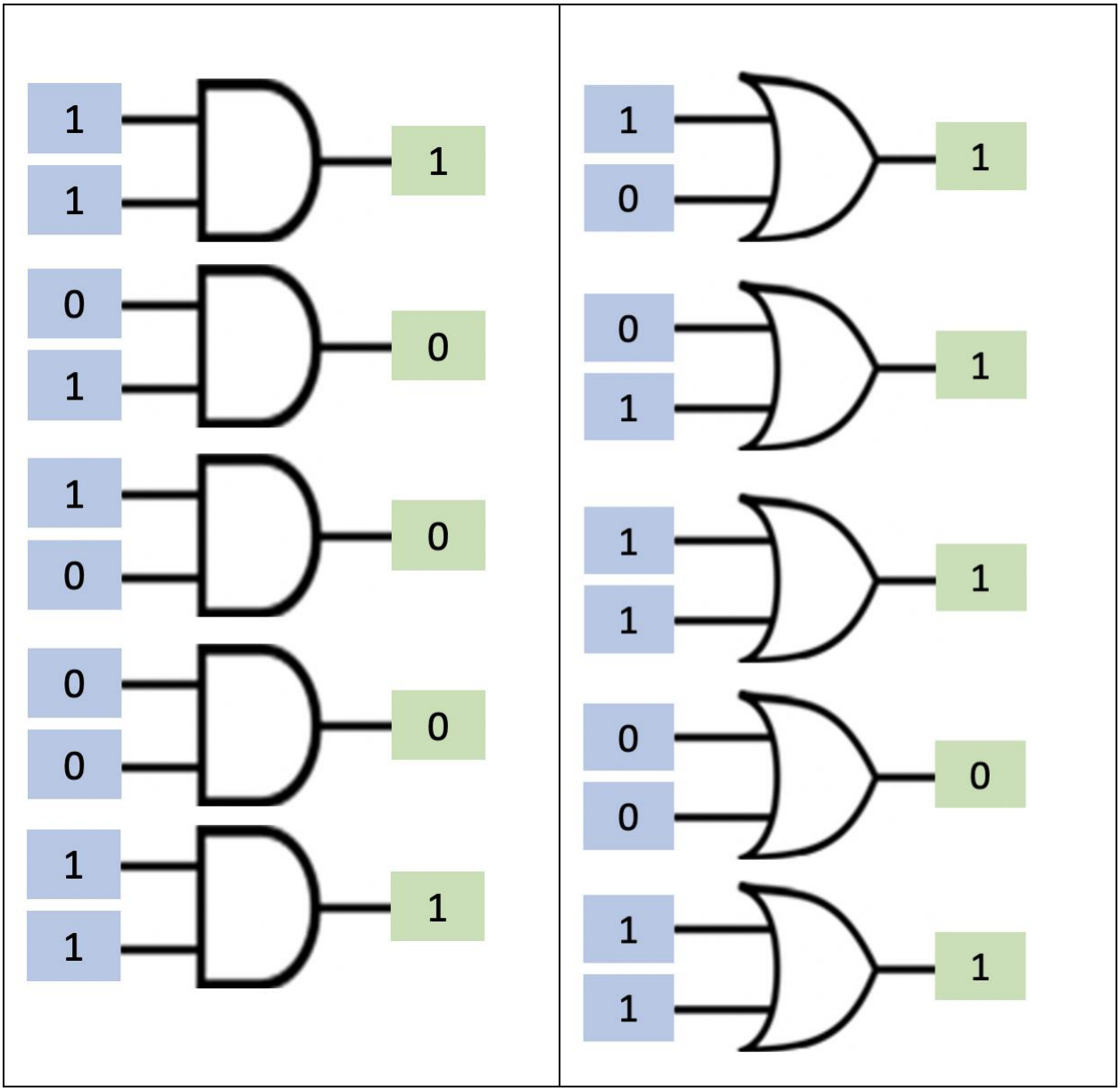
"Thee NOT gate is a little bit different than the previous 2 gates. This gate only takes 1 input. Remember when we said that each input can only have 2 states? ON or OFF, 1 or 0, True or False? What the NOT gate does is invert an input before it goes to a AND or OR gate.

For example, if an input is ON, then after passing through a NOT gate it will turn into OFF."

Activity 2.4:

Instructions: Now that you have learned about the logic gates, first identify each of the three gates by writing their name in the orange boxes. Then, complete the green and blue boxes with the correct input or output

		
Logic gate: AND	Logic gate: OR	Logic gate: NOT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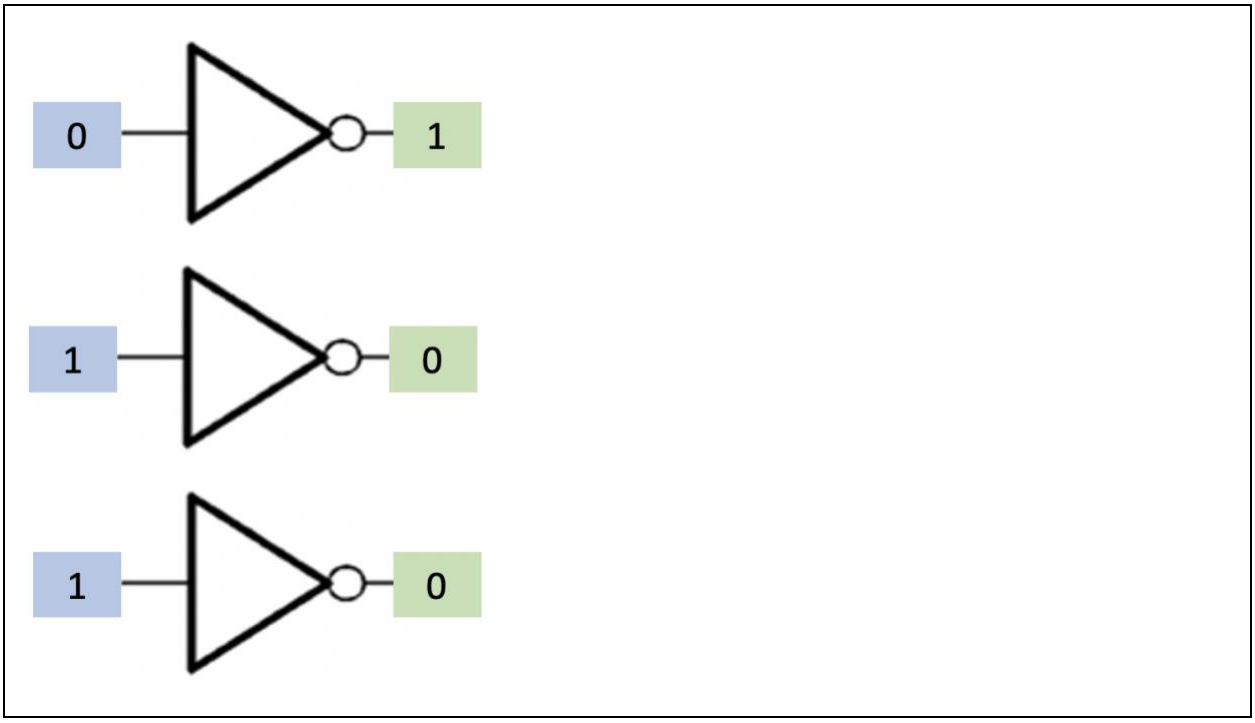
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Teacher's Attachment: C

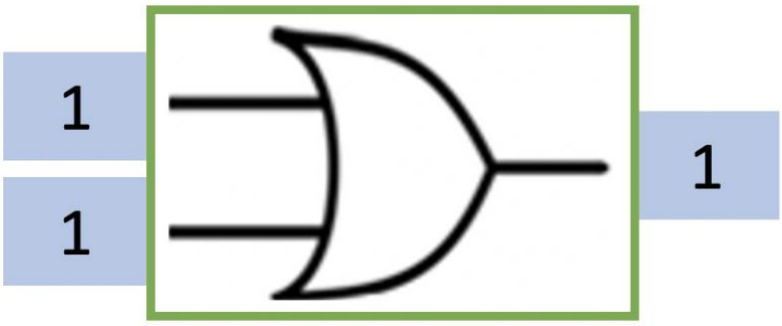
Used in activity:	3.2. Recap activity: Simple goals and conditionals 3.3. Activity: Complex goals and conditionals
Along with Student's Attachment(s):	3 and 4

Attachment 3:
Read the following statements and complete the tasks.

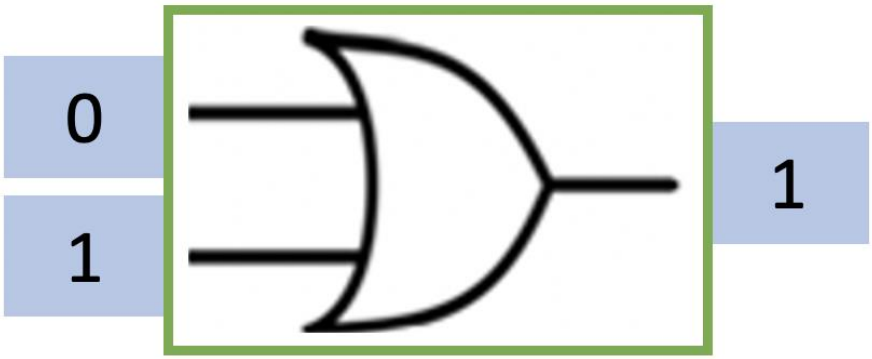
Statement: "If you have cake and flour, then you can bake a cake"
Task: From the 3 options below, select the correct logic operator that should go in the green box

Statement: "If you have cake and no flour, then you can/cannot bake a cake"
Task: Select again the correct logic operator that should go in the green box and fill in the correct values of the green boxes according to the information of this new statement

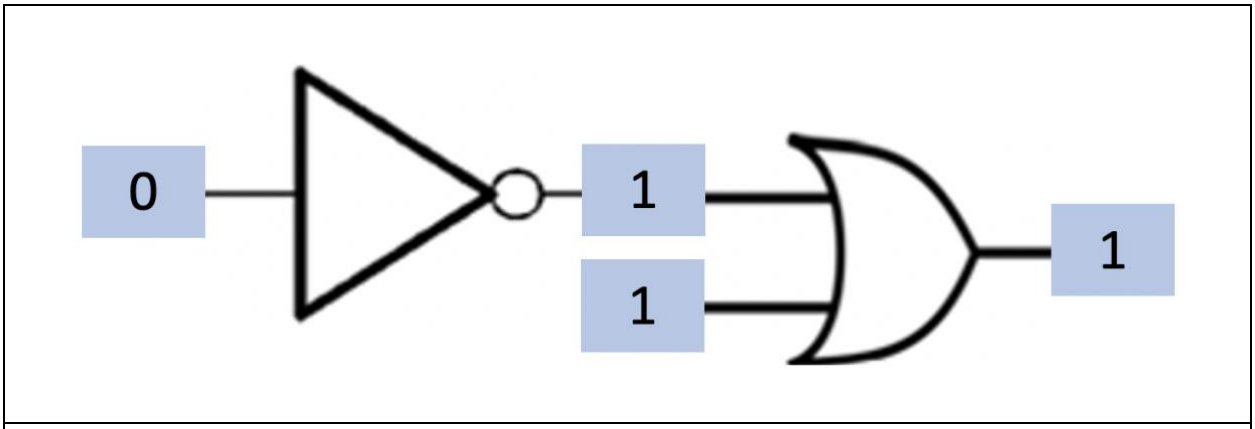
Statement: “If you have strawberry or mango, then you can drink a fruit smoothie”
Task: From the 3 options below, select the correct logic operator that should go in the green box

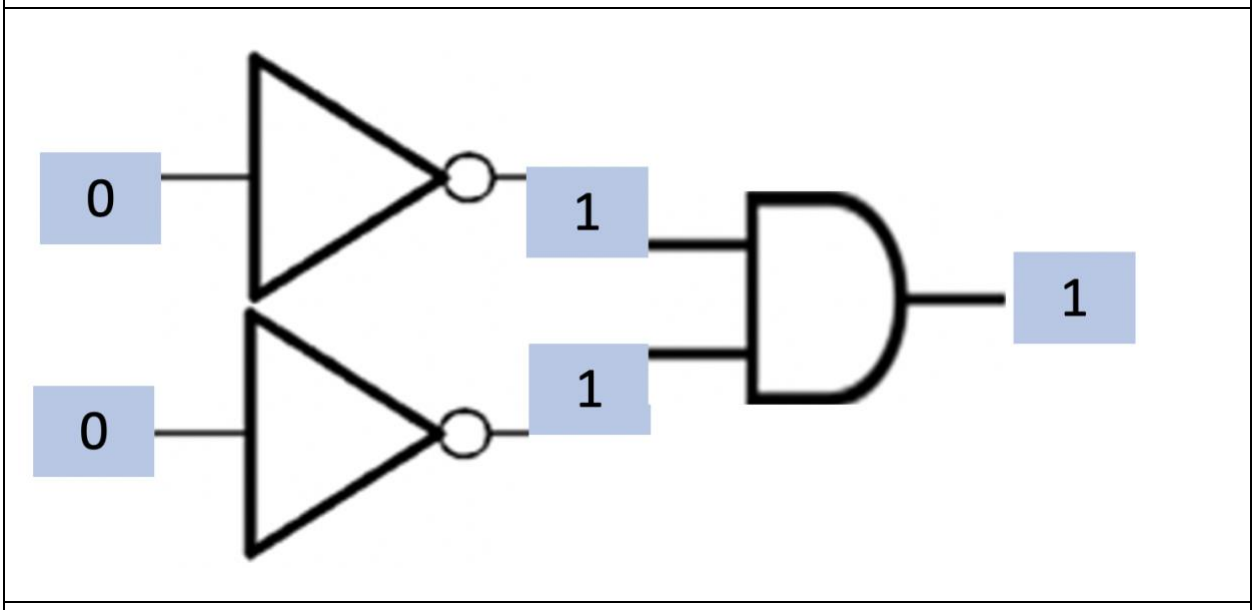


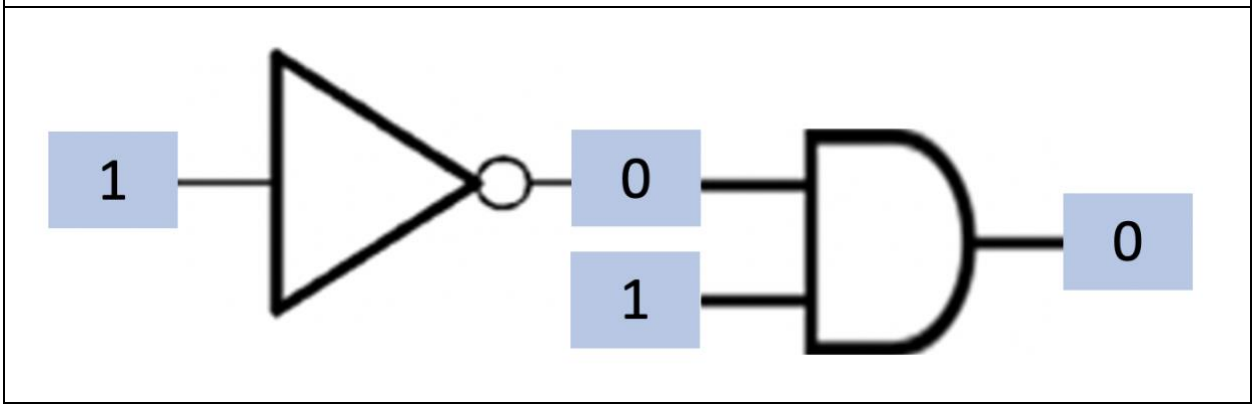
Statement: “If you have no strawberry and mango, then you can/cannot drink a fruit smoothie”
Task: Select again the correct logic operator that should go in the green box and fill in the correct values of the green boxes according to the information of this new statement



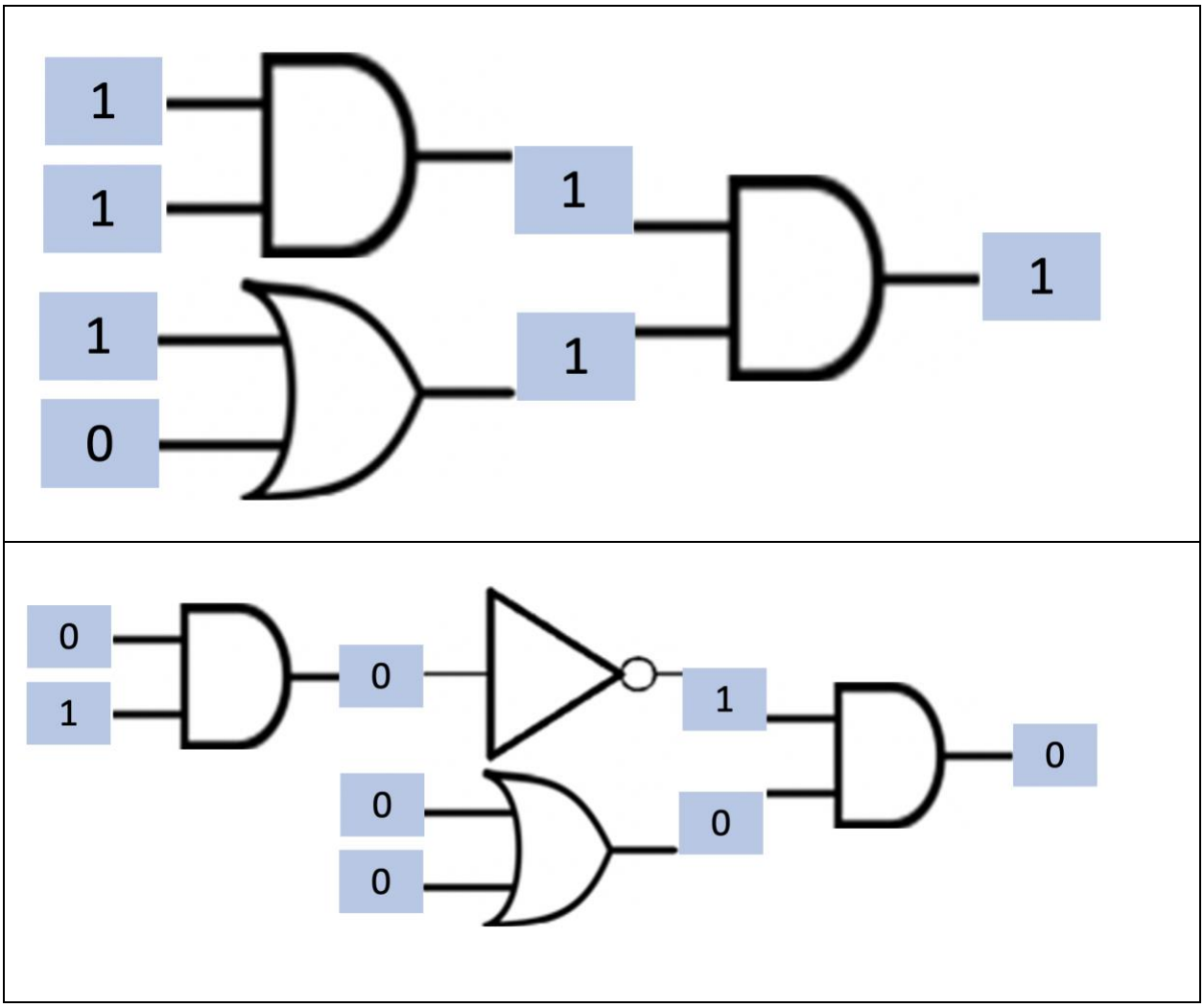
Task: Complete the following logic circuits







Attachment 4:
Task: Complete the following complex logic circuits



Student’s Attachments

Attachment 1:

- Your goal is to **make logic statements.**

1. Create an action sequence to achieve the goal.
    a. For that, reorganize the steps below into the correct 4-step sequence.
2. Once you have the correct sequence of steps, follow those steps to fill the last table. You can cut and paste the pictures

- Make at least 1 statement for each logic operator.
- The logic operators you can use are: AND, OR, or NOT
- Remember: Logic statements begin with “if”.

Select logic operator	Use input column to paste selected pictures	Use output column to write logic statement	Pick input picture(s)

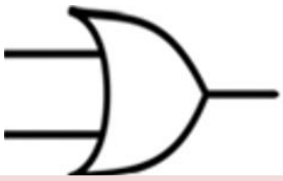
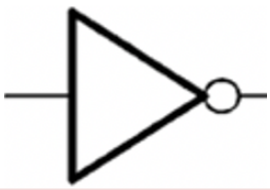
Step 1	Step 2	Step 3	Step 4

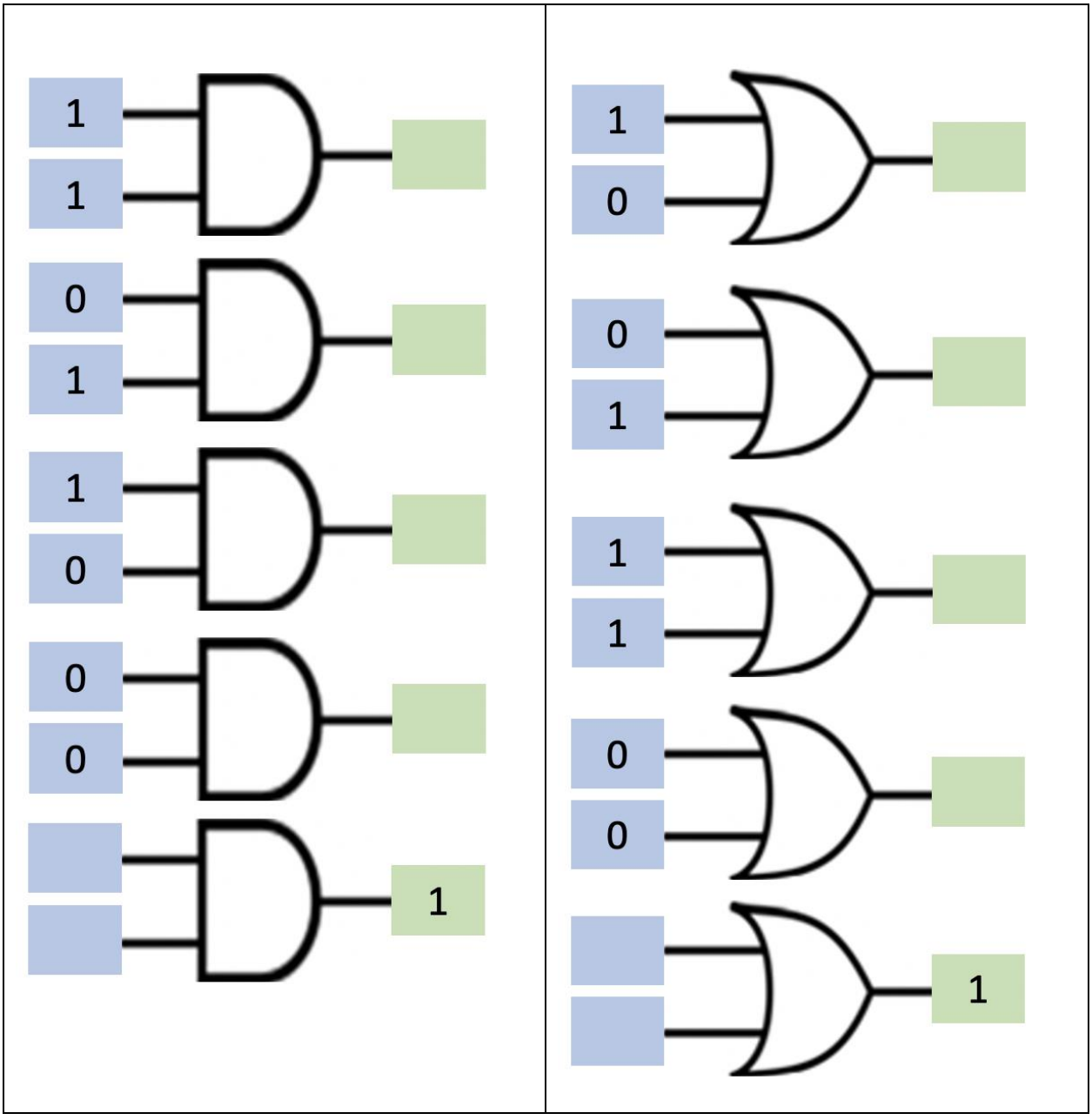
	INPUTS	LOGIC OPERATOR	OUTPUT
IF…			
IF…			
IF…			

IF…			

Attachment 2:

Instructions: Now that you have learned about the logic gates, first identify each of the three gates by writing their name in the orange boxes. Then, complete the green and blue boxes with the correct input or output

		
Logic gate:	Logic gate:	Logic gate: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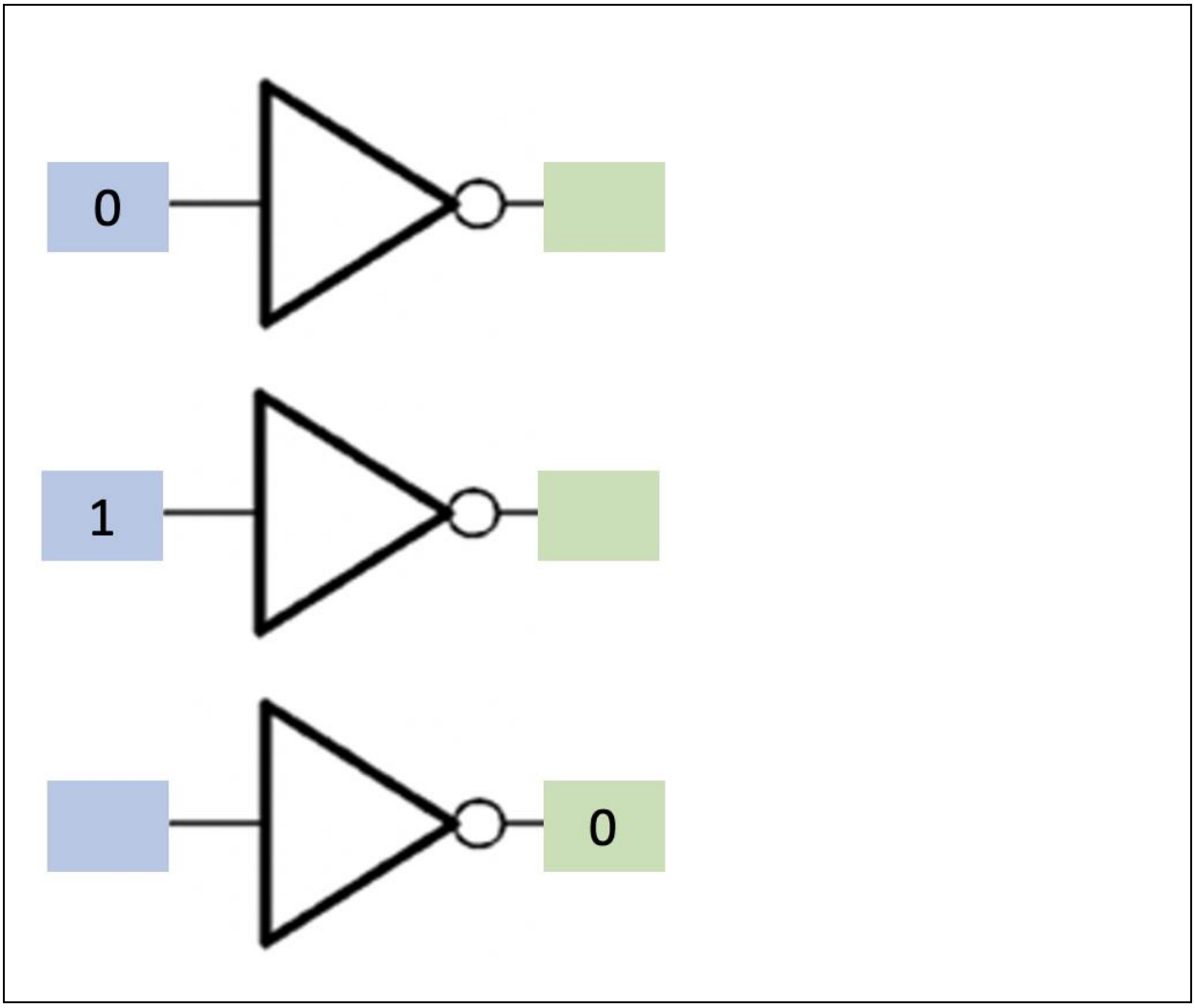
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Attachment 3:

Read the following statements and complete the tasks.

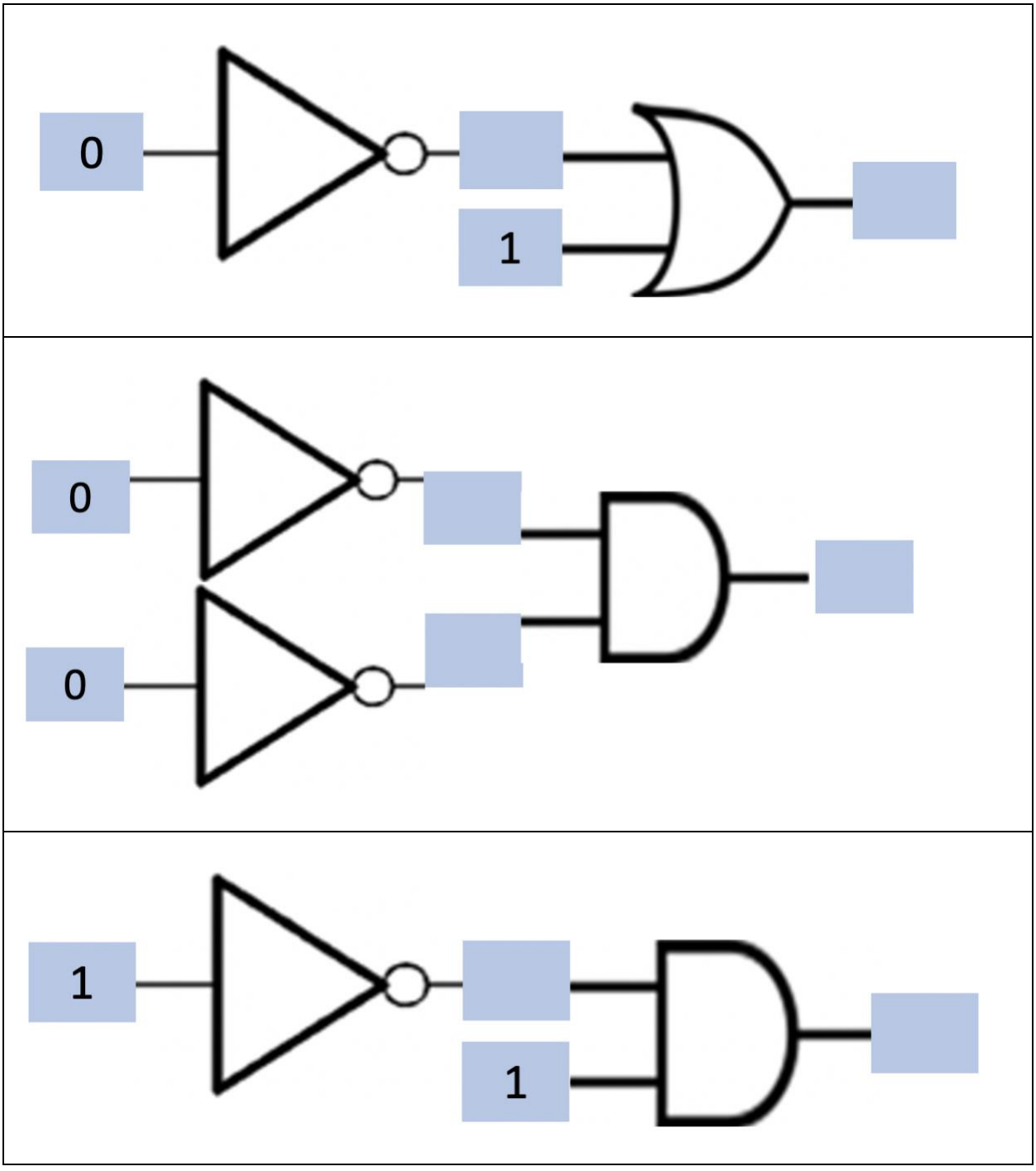
Statement: “If you have cake and flour, then you can bake a cake” **Task:** From the 3 options below, select the correct logic operator that should go in the green box

Statement: “If you have cake and no flour, then you can/cannot bake a cake” **Task:** Select again the correct logic operator that should go in the green box and fill in the correct values of the green boxes according to the information of this new statement


Statement: “If you have strawberry or mango, then you can drink a fruit smoothie”
Task: From the 3 options below, select the correct logic operator that should go in the green box

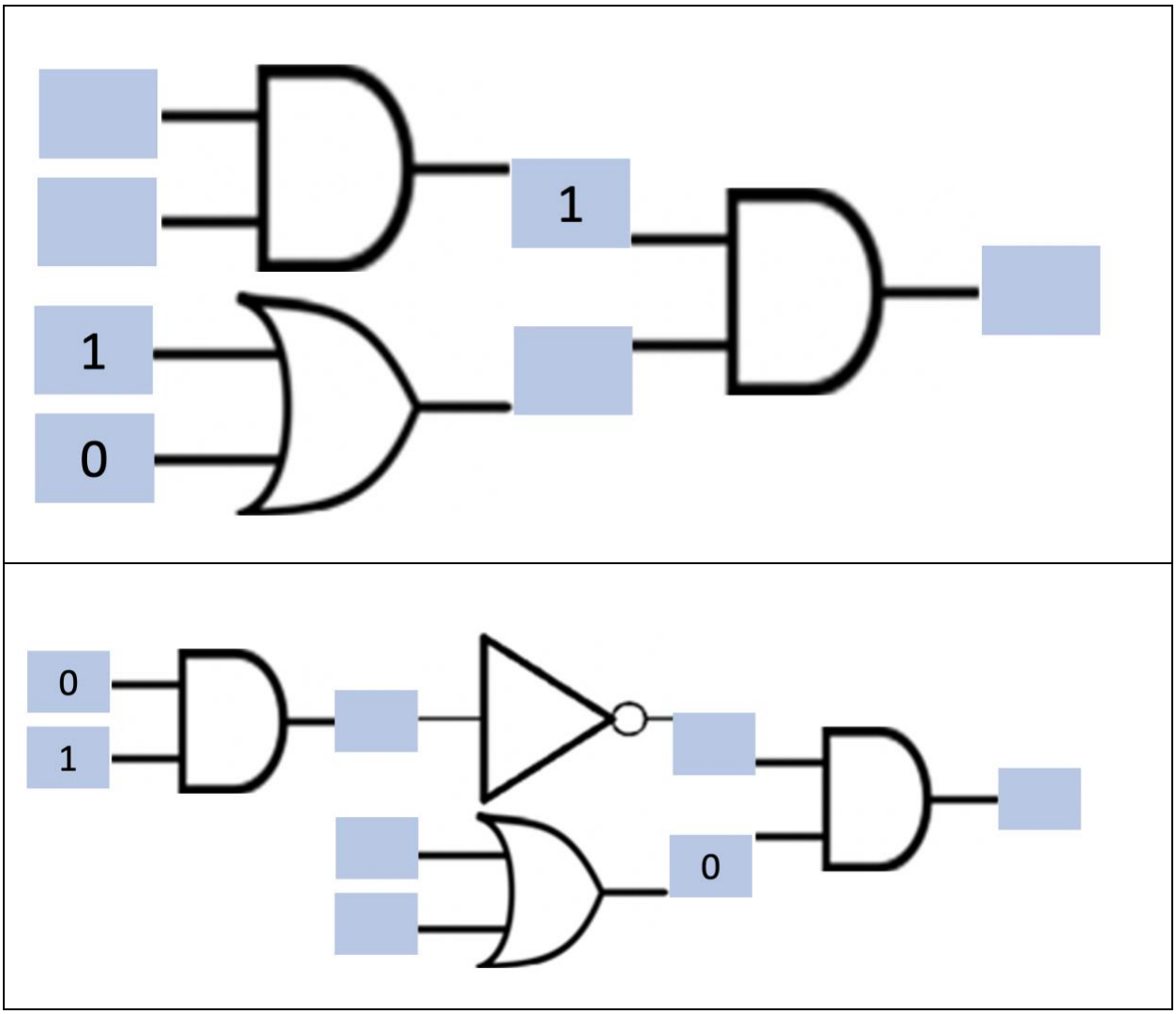
Statement: “If you have no strawberry and mango, then you can/cannot drink a fruit smoothie”
Task: Select again the correct logic operator that should go in the green box and fill in the correct values of the green boxes according to the information of this new statement

Task: Complete the following logic circuits



Attachment 4:

Task: Complete the following complex logic circuits



Evaluation

From the steps in the box below, identify the correct ones required for solving the following logic circuit and place the steps in the correct order.

Add up the amount of TRUE inputs and subtract them from the added amount of TRUE outputs.

For the missing logic gate on the right, pick the correct logic gate based on the amount of inputs and outputs it can take.

Replace all AND gates with NOT gates.

Once all logic gates are defined, fill out the blue boxes from left to right.

For the missing logic gate on the left, pick the correct logic gate based on the already filled inputs and outputs.

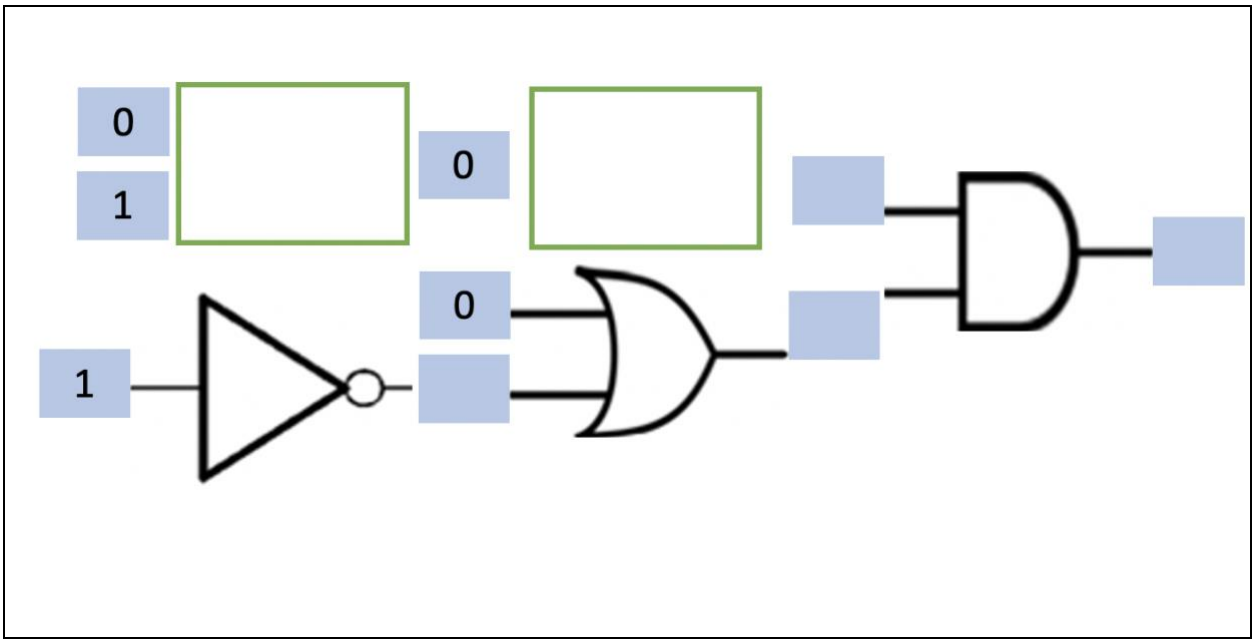
Identify the existing logic gates.

Once all logic gates are defined, fill out the blue boxes from right to left.

Replace all OR gates with AND gates.

Order	Step
1	
2	
3	
4	

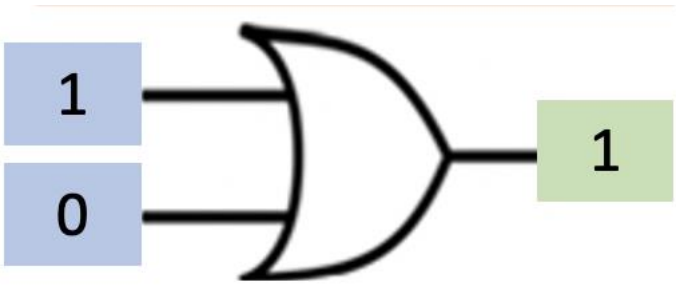
Follow the sequence of steps you identified above to fill the missing logic gates, inputs and outputs



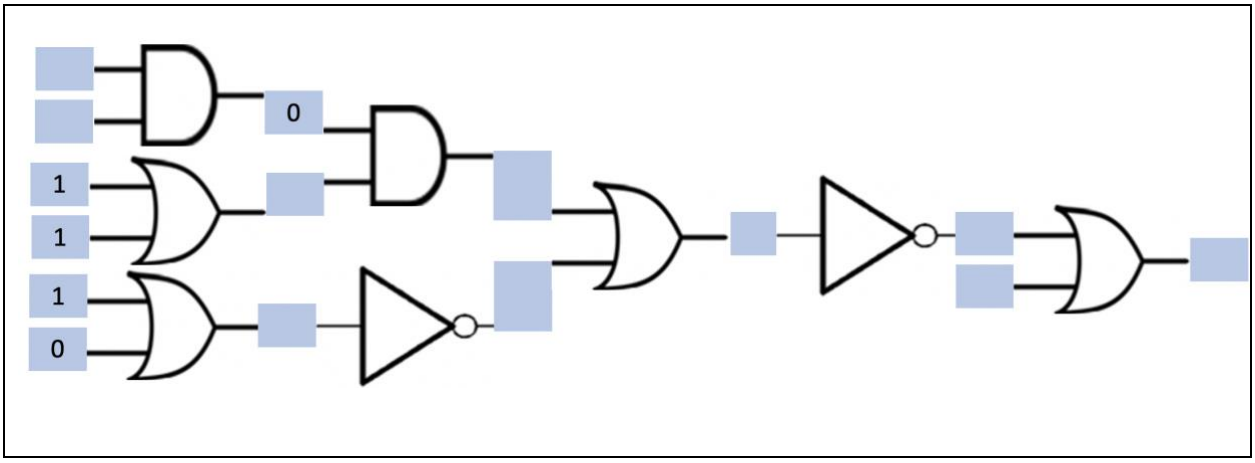
For the following logic circuits and using the provided words, write down a "if… then" sentence that matches the corresponding circuit.

Logic circuit

Words to use: "plane ticket", "no plane ticket", "passport", "no passport", "fly", "not fly"
"If … then" sentence
If I have a "_____" ___ "_____", then I can "_____"

Logic circuit

Words to use: "pencil", "no pencil", "pen", "no pen", "write", "not write"
"If … then" sentence
If I have a "_____" ___ "_____", then I can "_____" "_

Complete the following logic circuit



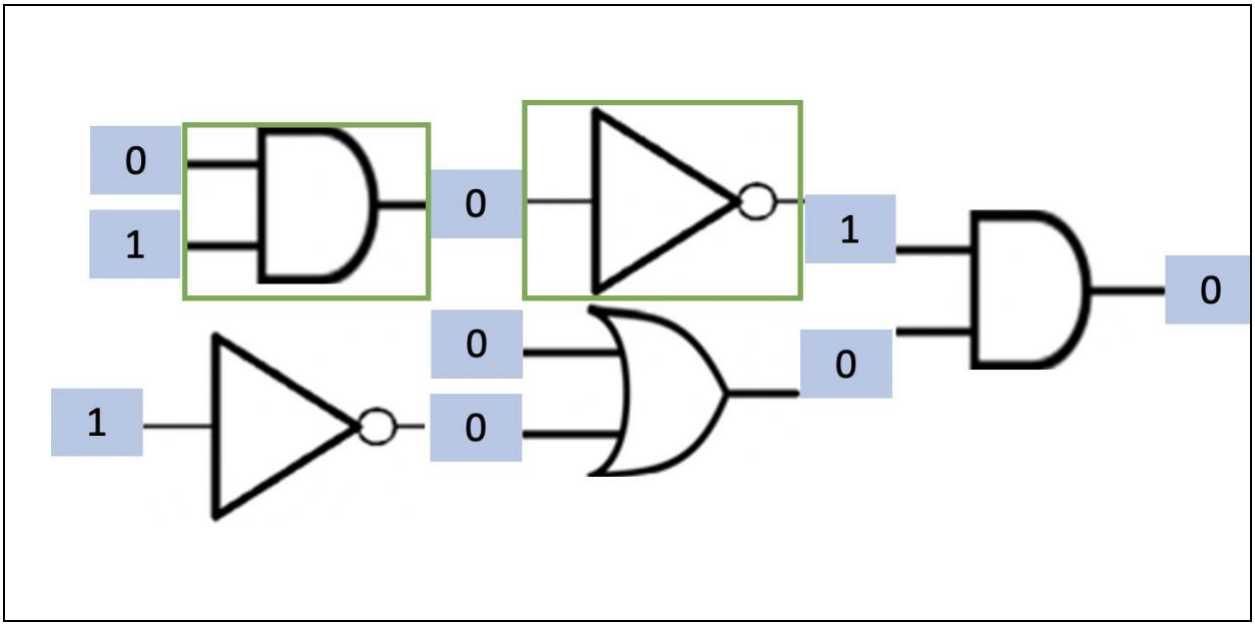
Evaluation (ANSWERS)

From the steps in the box below, identify the correct ones required for solving the following logic circuit and place the steps in the correct order.

Add up the amount of TRUE inputs and subtract them from the added amount of TRUE outputs. For the missing logic gate on the right, pick the correct logic gate based on the amount of inputs and outputs it can take. Replace all AND gates with NOT gates. Once all logic gates are defined, fill out the blue boxes from left to right. For the missing logic gate on the left, pick the correct logic gate based on the already filled inputs and outputs. Identify the existing logic gates. Once all logic gates are defined, fill out the blue boxes from right to left. Replace all OR gates with AND gates.

Order	Step
1	Identify the existing logic gates
2	For the missing logic gate on the left, pick the correct logic gate based on the already filled inputs and outputs
3	For the missing logic gate on the right, pick the correct logic gate based on the amount of inputs and outputs it can take
4	Once all logic gates are defined, fill out the blue boxes from left to right

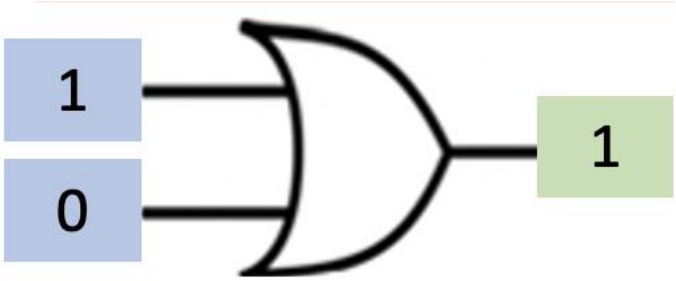
Follow the sequence of steps you identified above to fill the missing logic gates, inputs and outputs



For the following logic circuits and using the provided words, write down a "if… then" sentence that matches the corresponding circuit.

Logic circuit

Words to use: "plane ticket", "no plane ticket", "passport", "no passport", "fly", "not fly"
"If … then" sentence
Possible answer 1: If I have a "plane ticket" AND "no passport", then I can "not fly" Possible answer 2: If I have a "no plane ticket" AND "passport", then I can "not fly"

Logic circuit

Words to use: "pencil", "no pencil", "pen", "no pen", "write", "not write"
"If … then" sentence
Possible answer 1: If I have a "pencil" OR "no pen", then I can "write" Possible answer 2: If I have a "no pencil" OR "pen", then I can "write"

Complete the following logic circuit