Workbook

Exercise 1 LINK PAGE 1

Ask students to complete Exercise 1 in the workbook by competing the table with binary and Boolean values that correspond to the natural language expression.

AO1: Demonstrate knowledge and understanding of the principles and concepts of computer science

Answers LINK PAGE 000

All answers to questions in the Workbook are available at resource.marshallcavendish.com/teacher

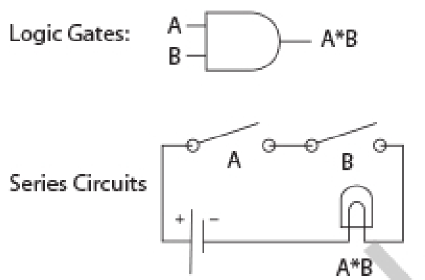
Students can check the answers to Let's Practice at resource.marshallcavendish.com/student. xxxxx xxxxxx

Types of logic gates

Before or after explaining each gate, use the suggested activities below to showcase how Boolean operations can be applied in the switching circuits and how these are illustrative of the different logic gates.

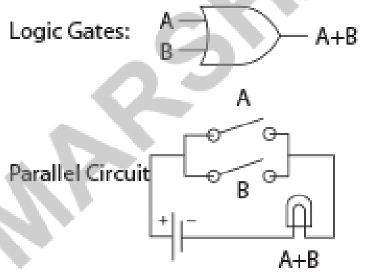
Get students engaged in hands-on activities like building switching circuits to illustrate the different types of logic gates. These activities can be done in a school science lab.

AND



A	B	A•B
0	0	0
0	1	0
1	0	0
1	1	1

OR



A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

Students can record their results using a truth table, where 1 and 0 denote the states when the switches are on and off. Ask the students to discuss the results and reflect on how these relate to the logic gates they are learning about.

You might use role-playing to understand the function of the logic gates, e.g.:

- a group project needs both students A and B to agree on something so that the project can proceed (AND gate)
- a different group project will be able to proceed if either students A or B or both agree (OR gate)

Support students by giving more real-life examples:

- **AND** gate: in a bank vault, two keys must be turned together by the manager and the senior clerk to open the safe doors
- **OR** gate: a parent promises pocket money if their child completes either a car washing chore or a housework chore: whichever chore they complete will result in the same outcome, which is pocket money

Challenge more able students by explaining that pocket money will be given if they do either chore or both. This is called an 'inclusive-OR' situation, because if either input includes a true condition or both inputs are true then the output is true. Ask if they can think of a scenario where this is not the case, i.e. if both conditions are true then the output is not true.

Be on the lookout for possible misconceptions that may arise due to the unusual notation, especially the AND ('.' not '+') gate.

Extension ideas

Students can create an informative leaflet that includes a range of logic gates and their rules.

Students can test their peers by creating and exchanging logic gate and truth table questions, such as fill in the blanks.

Worked example

Go through the worked example about a security light.

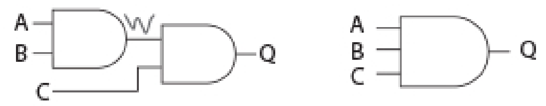
Activity

Encourage students to attempt to do the same as the worked example for the scenario in question 1.

Support students by encouraging them to do all the steps:

- make a table in normal language
- make a table in Boolean and binary values
- make the resulting truth table
- choose the logic gate that will make this happen

Challenge more able students to skip steps and invent another scenario for the AND, OR or NOT gate.



3 input AND				
Input			Intermediate Output	Output
A	B	C	W	Q
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

In question 2, remind students that this is not math, and in this case 'one and one is one'.

Support students by pointing out that:

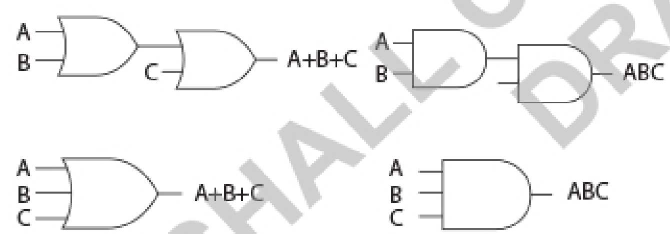
- the first table has only **one** input so there can only be one possible answer
- the second table has a positive output only if both inputs A **AND** B are true
- the third table has a positive output if A **OR** B are true

Challenge more able students to discuss what happens when there are more than two inputs into the AND or OR gate, and the resulting truth tables. This could be done by searching for the answers on the Internet and giving feedback to the class. They could then team teach the concept with the teacher.

Example

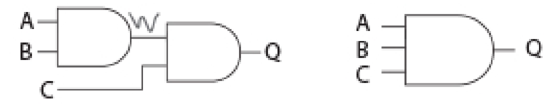
n-input Gates

- Because + and • are binary operations, they can be cascaded together to OR or AND multiple inputs.



You can also ask these students to draw logic gates with three inputs and their corresponding truth tables.

Example



3 input AND				
Input			Intermediate Output	Output
A	B	C	W	Q
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

Additional logic gates

Ask students what they think happens if they add a NOT gate to an AND or OR gate. Explain that these gates already exist: with a NAND gate, the output is simply the opposite of the AND gate, and the same goes for a NOR gate. The 'N' means 'NOT'.

Support students as you explain each gate by asking them to imagine the AND or OR gate and simply reverse the output.

Challenge more able students to discuss the corresponding logic notation and Boolean algebra form for each logic gate.

Be sure to guide students as to how the truth table relates to each of the logic gates.

Challenge higher-ability students to discuss what happens when there are more than two inputs into the NAND or NOR gate and the resulting truth tables. This could be done by searching the answers on the internet and feeding back to the class. They could then team teach the concept with the teacher.

These students can also be asked to draw logic gates containing three line inputs and the corresponding truth tables. Ask them to give examples of when three inputs are used in the real world and share these real-life links with the class.

For the XOR gate, explain that at a fast food restaurant you can choose either a hot dog, or cheeseburger. It has to be one or the other; it cannot be both. This is called an 'exclusive-OR' because it doesn't allow both – the output is false if both inputs are true.

Worked example

Go through the worked example of two people walking along a corridor.

It is sometimes difficult to find examples of XOR gates in real life. The corridor metaphor works well here. Ensure students understand that the gate only works if A OR B are near the windows. If they are both near the windows, then they will crash into each other.

Support students by explaining that Anne AND John can't ride the bike at the same time.

Challenge more able students to think of other 'exclusive-OR' scenarios.

Activity

1 Question 1 describes the NAND gate. If either input is true then the output is false.

Support students by asking them to imagine the scenario with a normal AND gate. If both the window and the door are closed, then the output will be true.

1, 1, 1 = if both the window and the door are closed there is current to the alarm

1, 0, 0 = if only the window is closed there is no current to the alarm

0, 1, 0 = if only the door is closed there is no current to the alarm

0, 0, 0 = if both the window and the door are open there is no current to the alarm

But in this case the output is reversed:

1, 1, 0 = if both the window and the door are closed there is no current to the alarm

1, 0, 1 = if only the window is closed there is current to the alarm

0, 1, 1 = if only the door is closed there is current to the alarm

0, 0, 1 = if both the window and the door are open there is current to the alarm

(The solutions can be found in the Teacher Guide portal online and at the back of the Teacher's Guide.)

2 The tables represent the XNOR and NAND gates.

Workbook

Exercises 2 and 3 LINK PAGE 1–2

Ask students to complete Exercise 2 in the workbook by labelling the gates and Exercise 3 by filling in the truth tables for each gate.

AO1: Demonstrate knowledge and understanding of the principles and concepts of computer science

AO3: Provide solutions to problems by evaluating computer systems

Answers LINK PAGE 000

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10.2 Combining logic gates

Warmup

Revise how an AND or OR gate followed by a NOT makes a NAND gate and explain that we can also represent this as a logic circuit, as there is more than one gate involved.

Logic circuits

Guide the students through breaking down logic circuits into two parts and show how the truth tables of logic gates in the previous sections relate to logic circuits. Allow students to review and reflect on the previous exercises and see how circuits are simply chains of two gates. Each stage has its own output that feeds into the next stage. Help students with the construction of the truth tables with two or more possible inputs by introducing the intermediate inputs in the truth table – make sure they understand the significance of the intermediate column in the table. Explain how we try to give a truth table for the entire circuit without the intermediate outputs, so we can remove these once we have worked them out.

Worked example

Go through the truth table for the logic circuit.

Support students by taking them though the steps. For example, inputs A and B have an output, but it is not the final output of the circuit. So, we begin again at 'P'. P inputs into the last gate, resulting in X. It is useful to show:

- the initial inputs
- the intermediate output
- the final output

Challenge higher-ability students to try out more complicated variations of the circuits, or to draw all known logic gates on individual cards and create their own combined logic gates to test a friend. For example, one student may combine an AND and a NOT gate. This would then require the friend to create the truth table for all the possible combinations, including the intermediate inputs.

Activity

Support only those students that require help by explaining that the name 'NOR' tells us that this is an OR gate and a NOT gate, so the missing gate is an OR gate. The intermediate outputs at P are simply those of a normal inclusive-OR gate:

0 = neither A nor B is true

1 = A is true

1 = B is true

1 = A and B are true

The NOT gate then reverses this:

0 = neither A nor B is true but is reversed by the NOT gate so 1

1 = A is true but is reversed by the NOT gate so 0

1 = B is true but is reversed by the NOT gate so 0

1 = A and B is true but is reversed by the NOT gate so 0

Challenge more able students to express the circuit in a logic statement or Boolean algebra.

Workbook

Exercise 4 LINK PAGE 3

Ask students to complete Exercise 4 in the workbook by completing the truth tables with inputs and intermediate and final outputs.

AO1: Demonstrate knowledge and understanding of the principles and concepts of computer science

AO2: Apply knowledge and understanding of the principles and concepts of computer science to a given context

AO3: Provide solutions to problems by evaluating computer systems

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Logic circuits with more than two inputs

Take students step-by-step through the two parts of the circuit to obtain the intermediate outputs and then use these to calculate the inputs and output of the last gate. Encourage them to fill out a truth table for each stage as they go.

Ask students to check with their peers to verify the initial inputs, intermediate outputs and final outputs.

Worked example

Make sure the students understand the scenario and can explain it back to you before starting.

Activity

1 Ask students to follow exactly the same steps as the worked example and the presentation in their book. This problem is slightly more challenging as it is abstract – there is no real-life scenario to accompany it.

2 Writing a logic statement may seem a little daunting. Support only those students that need it by helping them to work backwards from X.

Workbook

Exercise 5 LINK PAGE 4

Ask students to complete Exercise 5 in the workbook by completing the truth tables with inputs, intermediate and final outputs.

AO1: Demonstrate knowledge and understanding of the principles and concepts of computer science

AO2: Apply knowledge, and understanding of the principles and concepts of computer science to a given context

AO3: Provide solutions to problems by evaluating computer systems

Answers LINK PAGE 000

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Writing logic circuit statements

Students have already seen logic circuit statements in the previous section, where the intermediate outputs were expressed as P = (A = 1 AND B = 0) and Q = (C = 1 AND B = 0). Revise this and go on to explain that in the previous example the final statement would be:

X = (A = 1 AND B = 0) AND (C = 1 AND B = 0).

Chapter 10