**TRINITY INTERNATIONAL SS & COLLEGE**

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**CASE STUDY # 2: Boolean Gates**

**(COMPUTER SCIENCE)**

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# **Logic Gates — AND gate**

**What is the name of the gate?** ‘AND’, sometimes written ‘&’ or ‘∧’

**What does the gate do?** If both inputs are true, the output is true, else the output is false.

**Truth table and symbol**:

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q = A AND B** |
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

**Where might you see this gate in everyday life?** On a high powered device like a lawnmower you have to press two buttons at the same time to switch it on. If both buttons (the first button AND the second button) are ‘on’, it will switch on. Otherwise it will be off.

**What is it doing?** The output is only true when both of the inputs are true.

**What else might you see this gate in everyday life?** What other systems require you to press two buttons at the same time to work? Why might they be designed like that?

# **Logic Gates — OR gate**

**What is the name of the gate?** ‘OR’, sometimes written ‘|’ or ‘∨’

**What does the gate do?** If either input is true, or both inputs are true, the output is true, else the output is false.

**Truth table and symbol**:

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q = A OR B** |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

**Where might you see this gate in everyday life?** In a TV game show, where several people can press a buzzer to claim a question for their team. If one or more buttons are pressed, the buzzer will sound. If none are pressed, it will not.

**Where might this gate be used in an integrated system?** The buzzer system for this type of team game.

**What is it doing?** The output is true when either of the inputs are true. The output is also true when both inputs are true.

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# **Logic Gates — NOT gate**

**What is the name of the gate?** ‘NOT’, sometimes written ‘!’ or ‘¬’

**What does the gate do?** It inverts the input, so true becomes false and false becomes true.

**Truth table and symbol**:

|  |  |
| --- | --- |
| **A** | **Q = NOT A** |
| 0 | 1 |
| 1 | 0 |

**Where might you see this gate in everyday life?** A fridge light. There is a switch in the fridge which is pressed when the door closes. If this button is pressed ‘on’, the light will be off. When you open the door, the switch is released (‘off’) and the light comes on. Did you realise you use a NOT gate every day?

**Where might this gate be used in an integrated system?** NOT gates are most commonly used in conjunction with AND and OR gates, as you will see later.

**What is it doing?** It produces the opposite signal of the input.

# **Logic Gates — NAND gate**

**What is the name of the gate?** ‘NAND’ (or ‘NOT-AND’)

**What does the gate do?** The same as an AND gate followed by a NOT gate, that is, if both inputs are true, the output is false, else the output is true.

**Truth table and symbol**:

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q = NOT(A AND B)** |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**Where might you see this gate in everyday life?** In a burglar alarm system with two door sensors. If both doors are closed, both sensors are pressed (‘on’), and there is no alarm, if one or both doors are opened, their sensor(s) will be off, and the alarm is triggered. In reality, this gate will be connected to another circuit, which sounds the alarm until a code is entered to switch it off - otherwise a burglar could just close each door behind them to turn the alarm off.

**Where might this gate be used in an integrated system?** A NAND gate is a universal gate, meaning that combinations of them can be formed to represent any other gate. Solid state hard drives are essentially a large set of NAND gates storing all your files as binary data! A lot of microchips are made up of lots of tiny NAND gates connected together.

**What is it doing?** The output is only false when both of the inputs are true.

# **Logic Gates — NOR gate**

**What is the name of the gate?** ‘NOR’ (or ‘NOT-OR’)

**What does the gate do?** The same as an OR gate followed by a NOT gate, that is, if either or both inputs are true, the output is false, else the output is true.

**Truth table and symbol**:

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q = NOT(A OR B)** |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

**Where might you see this gate in everyday life?** In a fail-safe system with more than one trip wire, a light will shine if everything is connected, and the light will go out if any of the trip wires are broken or if the power fails.

**Where might this gate be used in an integrated system?** A NOR gate is a universal gate, meaning that combinations of them can be formed to represent any other gate. They are common in computer integrated circuit (IC) chips.

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# **Logic Gates — XOR gate**

**What is the name of the gate?** ‘Exclusive OR’, ‘XOR’, or ‘EOR’, pronounced ‘eks or’, sometimes written as ‘⊕’

**What does the gate do?** If either one input is true, the output is true.

If both inputs are the same (true or false), the output is false.

In other words, the output is true either but not both inputs are true.

**Truth table and symbol**:

|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q = A XOR B** |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**Where might you see this gate in everyday life?** Two light switches which control the same bulb (e.g. often found at the bottom and top of stairs in a house). If one is on (the switches are different), the light is on. If the switches are the same, the light is off.

It seems complex but if you think about it, it means that you can switch the light on and off with either switch, whatever the other switch is set to. If you used an OR gate or AND gate you might have to flick both switches to turn the light on or off - involving a pointless trip up/downstairs!

**Where might this gate be used in an integrated system?** XOR gates are used in a half adder, which you may come across later in this session.

**What is it doing?** The output is true when either of the inputs are true. The output is false when both inputs are true or both inputs are false.

# **Logic Gates — XNOR gate**

**What is the name of the gate?** ‘Exclusive NOR’, ‘XNOR’, or ‘ENOR’, pronounced ‘eks nor’

**What does the gate do?** The same as an XOR gate followed by a NOT. If either one input is true, the output is false. If both inputs are the same (true or false), the output is true. Sometimes it is called an equivalence gate, because it tells you if the inputs are the same.

**Truth table and symbol**:

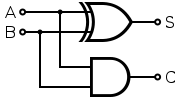
|  |  |  |
| --- | --- | --- |
| **A** | **B** | **Q = NOT(A XOR B)** |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

**Where might you see this gate in everyday life?** One example (thanks to JoelKatz on Yahoo Answers!) is that children will be happy (1) unless only one of them is given a treat. If neither is given a treat, they probably won’t be upset. If both are given a treat, they will probably be happy. If only one is given a treat, the other one may get upset.

# **Logic Gates — Half Adder**

**What is the name of this gate?** Actually it is a combination of two gates, called a half adder. It sends the input to an XOR gate and an AND gate.

**What does the gate do?** It takes two inputs but has two outputs called sum (S) and carry (C). The combination of these outputs can be considered as one output with two binary digits, or one decimal digit.

**Truth table and symbols**:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **A** | **B** | **C = A AND B** | **S = A XOR B** | **Decimal Q = 2C + S** |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 2 |

**Where might this gate be used in an integrated system?** There are more complicated adders formed from more logic gates that can count higher than 2! It is more likely you will see those.

**What is it doing?** The output is 0 when both of the inputs are false.The output is 1 when either of the inputs are true. The output is 2 when both inputs are true.