

## Rules of logic

### How does a computer add? (Logic Gates)

#### Computing National Curriculum Attainment Target:

- KS3: understand simple Boolean logic [for example, AND, OR and NOT] and some of its uses in circuits and programming; understand how numbers can be represented in binary, and be able to carry out simple operations on binary numbers [for example, binary addition, and conversion between binary and decimal]
- KS4: Develop knowledge in computer science
- KS4: Develop computational thinking skills
- KS5: Combine logic gates and derive truth tables
- KS5: Apply problem-solving by using Boolean algebra

#### Lesson Objectives:

- Understand how to do binary addition (including carry bits)
- Know the common logic gates AND OR NOT XOR
- Know why logic gates are important

#### Lesson Outcomes:

- All: Be able to explain why logic gates are important in a computer (answer: as they can be used to process binary – enabling binary addition subtraction etc)
- Most: Be able to perform accurate binary addition calculations with and without carry bits. Recognise and use logic gate symbols and be able to write a truth table for a given gate
- Some: Have been able to combine logic gates to derive the resulting composite truth table. Have researched NAND and NOR gates (extension tasks)

#### Lesson Resources:

- How Computers Work – KS5 S2 - **Part 1**
- **Logic Gates** – PowerPoint
- **Logic Gate Worksheet**
- **Logic Gate ANSWERS**
- <http://ncalculators.com/digital-computation/binary-addition-calculator.htm>

#### Technical Background

Video KS5 S2 - Part 2 links into Video KS5 S2 - Part 3, which is conceptually much harder to grasp. A computer uses logic gates in its central processor chip to perform operations on the binary (such as add / subtract). The 3 simplest logic gates are AND, NOT, OR. Students should be able to relate this to Internet advanced searches – eg search for “recipe for cookies” AND “chocolate chip” OR “caramel chips” NOT “fish and chips”

## Keywords

- AND OR NOT XOR
- Logic Gate
- Truth Table

**Lesson Summary:** This lesson will concentrate on binary addition and Boolean logic.

**Starter:** Show **Video 2**

Ask students to explain why computers have to work in binary.

Discuss the binary number system – what happens if we need to represent a number bigger than 31?

## Main/Development:

1. Demonstrate examples of binary addition. Using 5 bits ask students to volunteer to show how to add 9 and 10 in binary. Repeat with 7 + 11 (harder).

2. Remind students of the common logic gates and discuss / explain their truth tables. Ask for everyday examples of combining logical OR and logical NOT (e.g. I want steak AND chips OR pie and chips, NOT cabbage for tea.). Hand out the Logic Gate Worksheet then go through and explain the answers.

3. Relate Boolean logic to search engines. Demonstrate and discuss Google advanced search. What logic do they use in search if you just type some keywords only? (Answer: most use logical OR to widen the results).

4. Logic gates – how would you use Google advanced search to find any trains leaving Birmingham (not the Birmingham in the USA) between 10am and 1pm but not on a Saturday or Sunday travelling to either London Euston or York?

Extension: 1) Research truth tables for NAND and NOR. Investigate whether it is correct that adding a NOT to an AND makes a NOR gate and whether adding a NOT gate to an OR gate makes a NOR gate.

5) Research and explain the liar paradox (eg <http://www.logicalparadoxes.info/liar/>). Research other logical paradoxes and explain them in your own words.

**Plenary:** How do you think a computer can use logic gates to actually add in binary? (Answer is in the next Video).