

How does a computer represent numbers?

Computing National Curriculum Attainment Target:

- KS3: understand how instructions are stored and executed within a computer system; understand how data of various types (including text, sounds and pictures) can be represented and manipulated digitally, in the form of binary digits
- KS4: Develop knowledge in computer science
- KS4: Develop computational thinking skills

Lesson Objectives:

- Understand that computer chips can only work with binary (on or off) data
- Know how numbers are represented in a computer system
- Understand how to convert between binary and decimal numbers (integers)
- Be able to perform mental arithmetic in binary (extension tasks)

Lesson Outcomes:

- All: Be able to explain why computer chips have to work in binary. Be able to give the 5 bit binary for any number up to 31
- Most: Be able to explain why computer chips have to work in binary
- Some: Be able to calculate any number in 8 bit binary up to 255

Lesson Resources:

- How Computers Work - **Video 1**
- **Binary Numbers** PowerPoint
- **Binary Worksheet**
- **Binary Worksheet ANSWERS**
- **1s and 0s sheets**
- Counting in binary **Video 2 & 3**

Technical Background

Although a tablet or smart phone is powerful, the way it works is hidden away from the user. Digital machines can only detect if electricity exists at a certain point or not (on or off). Computers therefore have to represent *everything* in binary data (1s and 0s). Text, numbers, pictures, sounds or video – all are represented in binary by the chips (processors) inside a computer, tablet or smart phone.

How does a computer represent numbers?

The operating system and program software convert program data into binary data so that the hardware can process it correctly and make it all work correctly. When a user saves a file on a computer the data that gets saved is all binary.

Place values in *decimal* are all the powers of 10 (mathematically this is base 10).

Place values in *binary* are all the powers of 2 (mathematically this is number base 2).

Therefore column headings double as you move left and half as you move right.

Keywords

- Binary
- Bits

Lesson Summary: This lesson will concentrate on how integers are represented in a computer.

Starter: Show Video 1

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. Hand out the 1s and 0s in teams of 5. Ask the groups to come up with 1, 2 or 3 three-digit whole numbers and show how they could represent them in binary.
2. What is the largest number you can represent?
3. Repeat 1 and 2 but in teams of 8. Then try counting from 0 to 255.
4. If you placed one grain of rice on a chess board on the first square in the corner and then 2 on the next square and then 4 on the next (doubling each time) and end up filling the chess board, what is the total grains of rice you have? (answer $2^{64} + 2^{63} + 2^{62}$ etc – LOTS!)

Extension: Research how you could represent fractions in binary (Search for fixed point binary).

Plenary: What are the advantages and disadvantages of working in binary? Why do we count in 10s normally? (Answer - because we have 10 fingers)