HISTORY OF COMPUTING

How do computers represent text data?

ASCII and Hexadecimal

Overview:

This lesson looks at how computer systems use text data (binary ASCII). In the second half, hexadecimal system is explained as a shorthand for binary. NB Hexadecimal is often abbreviated to Hex.

Computing National Curriculum Attainment Target:

- KS3: Explain how data of various types can be represented and manipulated in the form of binary digits including numbers or text and be able to carry out some such manipulations by hand
- KS3: Explain how instructions are stored and executed within a computer system

- KS4: Develop knowledge in computer science,
- KS4: Develop computational thinking skills.

- KS5: Be able to convert between decimal, binary and hex
- KS5: Understand the advantages and limitations of ASCII code and compare with alternatives (such as Unicode).

Lesson Objectives:

- Understand how computers represent text characters as ASCII codes in binary
- Know that hexadecimal is a number system which can be used as a shorthand for binary
- Be able to convert between binary and hex

Lesson Outcomes:

- All: Be able to write their names in 8 bit ASCII code
- Most: Be able to explain why ASCII is used and how to simplify it into hexadecimal (8 bit binary becomes 2 hex characters)
- Some: Be able to explain the advantages and limitations of ASCII code and compare with alternatives (such as Unicode).

Lesson Resources:

- How do computers represent text? - **Video**
- **Binary to Hex Worksheet**
- **ASCII Challenge!**

Technical Background

Each keyboard character has its own unique 8 bit ASCII code. When a user types a letter on the keyboard the 1s and 0s of its ASCII code enter the computer and are made available on the data bus to be processed by the CPU or saved into RAM.

Hexadecimal is a complete number system – mathematically this is base 16 (just like binary which is base 2).

Binary uses place value column headings which are powers of 2:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	U
0	1	1	0	0	0	0	1

In decimal this would be 97.

Hexadecimal uses place value column heading which are powers of 16:

16^3	16^2	16^1	16^0
4094	256	16	U
0	1	A	C

In decimal this would be $(0 \times 16^3) + (1 \times 16^2) + (10 \times 16^1) + 12 = 256 + 160 + 12 = 428$

The Video keeps away from this as most often programmers just need to convert between binary and hex (so it rarely gets converted into decimal)

Keywords

- ASCII – American Standard for Information Interchange
- Hexadecimal

Lesson Summary:

This lesson will concentrate on modelling what happens in the CPU and RAM when a computer is running a program. It works in binary.

Main/Development:

1. Show **Video 6 – KS5 S6 - How do Computers show text**?

2. Display the ASCII table (keyboard characters showing their 8 bit binary equivalents). Ask the students to write their own names in ASCII on a scrap of paper. Swap the names and get them to decode them.

3. **Show the video KS5 S6 - Hexidemical**.

   Ask for a volunteer to demonstrate on the whiteboard how to convert HELLO is ASCII back into hexadecimal. Ask the students to write their own names in hexadecimal and then in decimal (pretending the binary ASCII code for each character is a decimal number). Again swap and see if the students can figure out each name.

4. Discuss limitations of ASCII – can it represent French OK?

   (answer: yes as there are enough codes to allow acute accents etc)

   Can it represent all global languages (including Chinese and Japanese)?

   (answer: no because there will be more than 256 global characters to represent each alphabet around the world).

5. Hand out the **Binary to Hex Worksheet** and **ASCII Challenge!** allow time for students to complete the tasks, then go through the answers.

Extension Tasks:

Research Unicode as a solution to be able to represent more than 256 characters.

Is it backwards compatible with ASCII? (answer yes – Unicode is at least 16 bit so allows a minimum of $2^{16} = 65536$ possible characters and is enough for all global alphabets and languages)