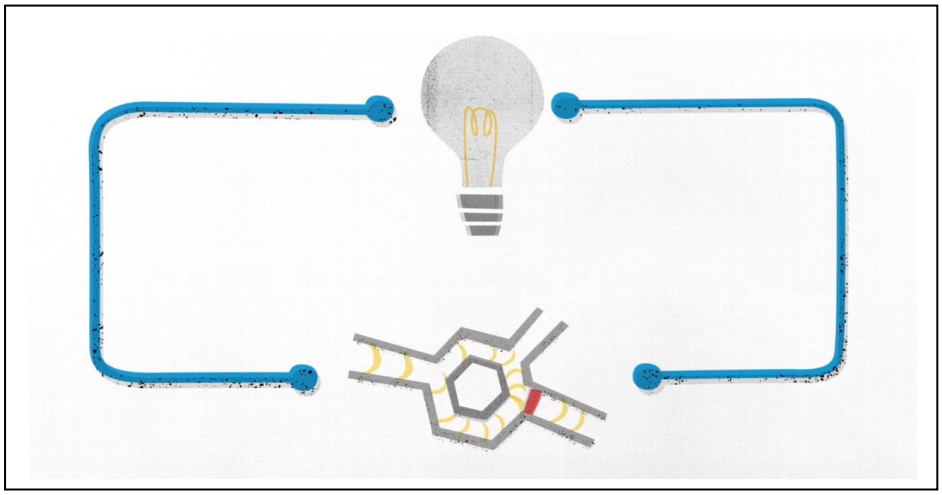
Key Stage 4 – Logically Speaking

Notes for teachers

At a glance

Currently, electronic switches in the form of transistors and diodes are the building blocks for computers and other electronic devices. Scientists at the University of Oxford are researching how electricity flows in nanoscale electronics. In the future it may be possible to create electronic switches that are based on individual molecules. In this lesson students find out a bit more about the development of electronic components over the years and are introduced to logic gates and truth tables.



Learning Outcomes

- Students are able to recall that computers are made up of components that have become smaller and more efficient over time.
- Students are able to predict the outputs of basic logic gates given specific inputs.
- Students are able to create and interpret truth tables for simple logic gates.

Each student will need

- Student worksheet

Lesson Activities

1. **Starter activity**
    - Ask the students to watch the Oxford Sparks 'How does electricity flow through small objects?' animation. Right at the end the video mentions potential future benefits. Ask the students if they can remember what they were.
    - The main benefit mentioned is that it may be possible to build a simple energy efficient switch

and potentially other highly energy efficient molecular components. The specific electronic components mentioned are conductive wire, insulators and transistors.

2. Main activity: A brief History

- Ask the students to read the first page of the student worksheet ('a brief history'). This briefly outlines the development of computers from using thermionic valves (vacuum tubes) through transistors to Integrated Circuits (ICs).
- Ask the students to discuss in pairs how computers and electronics have changed over the course of their lifetime. Possible things to consider might include mobile phones, computers, televisions, etc.
- Changes that have made these items more powerful, smaller or more energy efficient are often down to the increasing number of components that can be built into individual ICs.

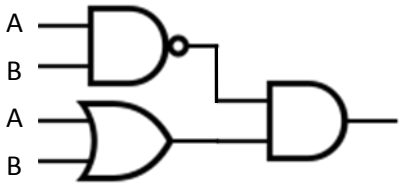
3. Main activity: Logic Gates

- The second and third pages of the student worksheet describe logic gates and truth tables.
- Ask the students to work their way through the worksheets.
- The answers to the worksheet questions are as follows:

OR gate	Input A	Input B	Output
	0	0	0
	0	1	1
	1	0	1
	1	1	1

XOR definition – This should be something similar to the description below:
An XOR gate gives an output of 1 if **either** A or B are 1 but not if they are both 1 (or 0).

- Although logic gates are usually constructed from electronic components, they can be created in a variety of other ways (e.g., mechanical or pneumatic systems).
- Show the students one or both of the videos in the weblinks relating to building individual gates or a computer capable of adding two binary numbers out of dominoes.
- [OPTIONAL for more able students] Often logic gates are made using combinations of other logic gates (particularly NAND and NOR gates). Ask the students if they can work out which of the gates described on their worksheets can be created using the combination of gates below. [ANSWER = XOR Gate]. They may find it useful to construct a truth table to verify their answer.



4. Plenary

- If we could build components for computers that were highly energy efficient and based on molecules what would be the advantages? Are there any disadvantages?
    - Possible advantages :
        - Less energy consumption (cheaper to run, better for the environment)
        - We could potentially build far more powerful computers (this has happened every time we've made components smaller)
        - The computers would be much smaller so we could carry more powerful computers with us (in phones, wearable technology etc)
        - Computers might become cheaper
    - Possible disadvantages:
        - More complicated technology would be even harder for people to fix themselves so it would encourage buying new stuff
        - People might become more reliant on computers if they carry them with them all the time
        - Parts of the world with the latest technology may have an advantage over parts still using older technology
        - Initially the new computers might be expensive

Weblinks

- Oxford Sparks 'How does electricity flow through small objects' animation: https://youtu.be/wF13tGIrzA8
- Domino computer and logic gate videos
  https://www.youtube.com/watch?v=lNuPy-r1GuQ
  &
  https://www.youtube.com/watch?v=OpLU__bhu2w