G.C.E. O/L Grade 10 ICT · Lesson 3

3.1 Binary – Representing Data with Two States

Inside a computer, everything – numbers, letters, photos, songs and videos – is stored using only two symbols: **1 and 0**. In this note you will learn why computers use two states, what the **binary number system** is, and how to write a positive decimal number in binary.

1. Data and two states

A computer is made of millions (even billions) of tiny electronic switches called **transistors**. Each switch can be in only **two states**: ON or OFF. We write ON as **1** and OFF as **0**. Because there are only two states, it is easy and reliable to store and send them.

State 1	State 0	Where you see it
ON	OFF	Switch / transistor
TRUE / YES	FALSE / NO	Logic, decisions
High voltage	Low voltage	Circuits, wires
Magnetised one way	Magnetised other way	Hard disk
Light reflected / pit	No change	CD / DVD
Charge stored	No charge	SSD, USB flash, memory card

💡 **Digital** data = data stored as separate values 0 and 1. A single 0 or 1 is called a **bit** (binary digit).

2. Why do computers use binary?

- Electronic switches have only two states – ON/OFF fits perfectly.
- Two states are easy to tell apart, so there are fewer errors (even with electrical noise).
- Circuits are simpler, cheaper and faster to build.
- All kinds of data (text, images, sound, video) can be turned into patterns of 1s and 0s.

3. The binary number system

We normally use the **decimal** system (base 10) with ten digits 0–9. The **binary** system has **base 2** and only two digits: **0 and 1**. Each place is worth **2 times** the place on its right: 1, 2, 4, 8, 16, 32, 64, 128 …

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

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To show which system a number belongs to, write the base as a small number: 1101_2 (binary), 13_{10} (decimal). Without a base, 10 could mean ten or two!

4. Writing a positive decimal integer in binary

Method 1 – place values: find the biggest place value that fits, put 1 there, subtract, and continue. Example: 13 = 8 + 4 + 1.

8	4	2	1
1	1	0	1

💡 So 13_{10} = **1101_2**. Check: 8 + 4 + 0 + 1 = 13.

Method 2 – repeated division by 2: divide by 2, write the remainder, keep dividing the quotient until it becomes 0. Read the remainders from **bottom to top**. Example: 25_{10}.

Division	Quotient	Remainder
25 ÷ 2	12	1
12 ÷ 2	6	0
6 ÷ 2	3	0
3 ÷ 2	1	1
1 ÷ 2	0	1

💡 Reading remainders bottom to top: 25_{10} = **11001_2**. (16 + 8 + 1 = 25)

5. How many values can n bits hold?

With **n bits** you can make **2^n** different patterns. 1 bit → 2, 2 bits → 4, 3 bits → 8, 8 bits → 256 (0 to 255). The largest number with n bits is **$2^n - 1$**.

Bits (n)	Patterns (2^n)	Range
1	2	0 – 1
2	4	0 – 3
3	8	0 – 7
4	16	0 – 15
8	256	0 – 255

NEW 2026 **2026 link:** a photo on your phone is millions of tiny dots (pixels), each stored as bits for red, green and blue. A 12-megapixel photo is about 36 million bytes before compression!

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Key Words

Binary – Number system with base 2 using only digits 0 and 1.

Bit – A single binary digit, 0 or 1 – the smallest unit of data.

Two-state system – A system with only two conditions such as ON/OFF or TRUE/FALSE.

Transistor – A tiny electronic switch inside a chip that is ON (1) or OFF (0).

Decimal – Number system with base 10 using digits 0–9.

Base (radix) – The number of different digits a number system uses.

Place value – The value of a digit's position, e.g. 1, 2, 4, 8 in binary.

Repeated division – Dividing by the base again and again and reading the remainders upward.

Remainder – What is left after dividing; in base 2 it is 0 or 1.

Digital data – Data stored as separate (discrete) values such as 0 and 1.

MSB – Most Significant Bit – the left-most bit with the highest place value.

LSB – Least Significant Bit – the right-most bit with place value 1.

Sample Q&A

1. Why do computers use the binary system?

> **Answer:** Electronic switches (transistors) have only two states, ON and OFF, which map to 1 and 0. Two states are easy to detect reliably and circuits are simpler.

2. Give three pairs of two states that can represent 1 and 0.

> **Answer:** ON/OFF, TRUE/FALSE, high voltage/low voltage (also YES/NO, magnetised/not).

3. Convert 13_{10} to binary.

> **Answer:** $13 = 8 + 4 + 1 \rightarrow 1101_2$.

4. What is a bit?

> **Answer:** A binary digit – a single 0 or 1, the smallest unit of data.

5. How many different values can 8 bits represent?

> **Answer:** $2^8 = 256$ values (0 to 255).

6. In repeated division, in which order are the remainders read?

> **Answer:** From the last remainder (bottom) to the first (top). The last remainder is the MSB.

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MCQ

1. How many digits does the binary number system use?

A. 2
B. 8
C. 16
D. 10

2. Which pair best describes the two states used in a computer?

A. Red and blue
B. ON and OFF
C. Up, down and middle
D. 0 to 9

3. A single binary digit is called a:

A. Word
B. Nibble
C. Bit
D. Byte

4. What is 13_{10} in binary?

A. 1101
B. 1001
C. 1110
D. 1011

5. What is 25_{10} in binary?

A. 11001
B. 10101
C. 11010
D. 10011

6. What is the place value of the 5th bit from the right in binary?

A. 5
B. 32
C. 16
D. 10

7. How many different patterns can 4 bits make?

A. 15
B. 16
C. 8
D. 4

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8. The largest number that can be stored in 8 bits is:

A. 256
B. 128
C. 8
D. 255

9. Which decimal number is the same as 1010_2?

A. 12
B. 5
C. 10
D. 1010

10. When converting by repeated division by 2, the answer is read:

A. Remainders from top to bottom
B. Only the last quotient
C. Quotients from top to bottom
D. Remainders from bottom to top

11. Why is binary reliable for electronic circuits?

A. Only two states are easy to tell apart
B. It is the base used by humans
C. It uses ten voltage levels
D. It needs no electricity

12. Which number CANNOT be a binary number?

A. 1001
B. 1021
C. 10
D. 1111

13. In the binary number 10110_2, the MSB is in the place worth:

A. 32
B. 1
C. 2
D. 16

14. How many bits are needed at minimum to write 6_{10} in binary?

A. 2
B. 3
C. 6
D. 4

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Structured Questions

1. (i) What is meant by a two-state system? (1 mark)
(ii) Give two examples of two states used to represent 1 and 0. (2 marks) *(3 marks)*

> (i) A system that has only two possible conditions.
> (ii) ON/OFF, TRUE/FALSE, high/low voltage, magnetised/not magnetised (any two).

2. Give three reasons why computers use the binary number system. *(3 marks)*

> Transistors have only two states; two states are easy to detect with fewer errors; circuits are simpler/cheaper/faster; all data types can be coded as 0s and 1s.

3. Convert 45_{10} to binary using repeated division. Show your working. (3 marks) *(3 marks)*

> 45÷2=22 r1; 22÷2=11 r0; 11÷2=5 r1; 5÷2=2 r1; 2÷2=1 r0; 1÷2=0 r1. Read upward: $45_{10} = 101101_2$.

4. Write 100_{10} in binary using place values. (3 marks) *(3 marks)*

> 100 = 64 + 32 + 4 → 64 32 16 8 4 2 1 = 1 1 0 0 1 0 0 → 1100100_2.

5. (i) How many different values can be stored in 5 bits? (1 mark)
(ii) What is the largest decimal number that can be stored in 5 bits? (1 mark)
(iii) Write that number in binary. (1 mark) *(3 marks)*

> (i) $2^5 = 32$ (ii) 31 (iii) 11111_2

6. A smart bulb in a classroom is controlled by an app. (i) How can the bulb's ON/OFF state be stored as one bit? (1 mark) (ii) Eight bulbs are in a row. How many different ON/OFF patterns are possible? (2 marks) *(3 marks)*

> (i) ON = 1, OFF = 0. (ii) Each bulb is 1 bit, 8 bits → $2^8 = 256$ patterns.

Summary

- Computers store all data using two states: 1 and 0.
- Two states: ON/OFF, TRUE/FALSE, high/low voltage.
- A bit is one binary digit; it is the smallest unit of data.
- Binary has base 2; place values 1, 2, 4, 8, 16, 32, 64, 128.
- Decimal → binary: place values or repeated division by 2.
- Read the remainders from bottom to top.
- n bits give 2^n patterns; the largest value is $2^n - 1$.
- Write the base as a subscript, e.g. $1101_2 = 13_{10}$.

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MCQ answer key – 3.1

1. **A** – Binary has base 2: digits 0 and 1.
2. **B** – A switch is either ON (1) or OFF (0).
3. **C** – Bit = binary digit.
4. **A** – 13 = 8 + 4 + 1 = 1101_2.
5. **A** – 25 = 16 + 8 + 1 = 11001_2.
6. **C** – Place values 1, 2, 4, 8, 16 → $2^4 = 16$.
7. **B** – $2^4 = 16$.
8. **D** – $2^8 - 1 = 255$ (11111111_2).
9. **C** – 8 + 2 = 10.
10. **D** – The last remainder is the MSB, so read upward.
11. **A** – Two levels are easy to detect even with noise.
12. **B** – Binary uses only 0 and 1; '2' is not allowed.
13. **D** – 5 bits: 16, 8, 4, 2, 1 → MSB place = 16.
14. **B** – 6 = 110_2 → 3 bits.

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