G.C.E. O/L Grade 10 ICT · Lesson 3

3.2 Decimal to Binary, Octal and Hexadecimal

Computers use binary, but long strings of 1s and 0s are hard for people to read. So programmers also use **octal (base 8)** and **hexadecimal (base 16)**. In this note you will learn the four number systems, their **place values**, and how to convert a decimal number to any of them using **repeated division**.

1. Four number systems

System	Base	Digits used	Example
Binary	2	0, 1	1011_2
Octal	8	0 – 7	157_8
Decimal	10	0 – 9	249_{10}
Hexadecimal	16	0 – 9, A – F	$3F_{16}$

The **base** tells you how many digits the system has. The biggest digit is always **base − 1** (1 in binary, 7 in octal, 9 in decimal, F in hex).

2. Hexadecimal digits A–F

Hex needs 16 single digits, so after 9 it uses letters:

Hex	A	B	C	D	E	F
Decimal	10	11	12	13	14	15

3. Place values

In every system the right-most place is worth 1 (base^0). Each place to the left is worth **base times** more.

Base	4th place	3rd place	2nd place	1st place
2	$2^3 = 8$	$2^2 = 4$	$2^1 = 2$	$2^0 = 1$
8	$8^3 = 512$	$8^2 = 64$	$8^1 = 8$	$8^0 = 1$
10	$10^3 = 1000$	$10^2 = 100$	$10^1 = 10$	$10^0 = 1$
16	$16^3 = 4096$	$16^2 = 256$	$16^1 = 16$	$16^0 = 1$

💡 Example: in 234_8 the 2 is worth 2 × 64, the 3 is worth 3 × 8 and the 4 is worth 4 × 1.

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4. Repeated division method

- Divide the decimal number by the **new base** (2, 8 or 16).
- Write down the **remainder**.
- Divide the **quotient** again; repeat until the quotient is 0.
- Read the remainders from **bottom to top**. In hex, change 10–15 to A–F.

Worked example 1: 47_{10} → binary

Division	Quotient	Remainder
47 ÷ 2	23	1
23 ÷ 2	11	1
11 ÷ 2	5	1
5 ÷ 2	2	1
2 ÷ 2	1	0
1 ÷ 2	0	1

💡 47_{10} = **101111_2**

Worked example 2: 156_{10} → octal

Division	Quotient	Remainder
156 ÷ 8	19	4
19 ÷ 8	2	3
2 ÷ 8	0	2

💡 156_{10} = **234_8**. Check: 2×64 + 3×8 + 4×1 = 128 + 24 + 4 = 156.

Digit	2	3	4
Place value	$8^2 = 64$	$8^1 = 8$	$8^0 = 1$
Digit × place value	2 × 64 = 128	3 × 8 = 24	4 × 1 = 4

Worked example 3: 500_{10} → hexadecimal

Division	Quotient	Remainder
500 ÷ 16	31	4
31 ÷ 16	1	15 = F
1 ÷ 16	0	1

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💡 Reading bottom to top: 1, F, 4 → 500_{10} = **$1F4_{16}$**. Check: 1×256 + 15×16 + 4 = 500.

💡 **Exam trick:** always check your answer by multiplying each digit by its place value and adding. If you get the original number, you are right!

5. Comparing the same number

Decimal	Binary	Octal	Hex
8	1000	10	8
10	1010	12	A
15	1111	17	F
16	10000	20	10
64	1000000	100	40
100	1100100	144	64
255	11111111	377	FF

NEW 2026 **Where you see hex today:** web colours (#FF0000 is red), MAC addresses on Wi-Fi routers (e.g. 3C:5A:B4:...), IPv6 addresses and error codes on your phone or PC.

Key Words

Octal – Number system with base 8 using digits 0–7.

Hexadecimal – Number system with base 16 using 0–9 and A–F.

Base – The number of digits in a number system (2, 8, 10, 16).

Place value – Value of a position: a power of the base (base^0, base^1 ...).

Quotient – The whole-number answer of a division.

Remainder – The amount left over after a division; always smaller than the base.

Repeated division – Method of dividing by the new base until the quotient is 0.

Subscript – Small number after a value showing its base, e.g. 75_8.

Hex digit A–F – Letters that stand for 10–15 in hexadecimal.

Power of the base – The base multiplied by itself, e.g. $16^2 = 256$.

Decimal – The base-10 system people use every day.

Colour code – A 6-digit hex value for a colour on a screen, e.g. #00FF00.

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Sample Q&A

1. What is the base of the octal number system and which digits does it use?

> **Answer:** Base 8; digits 0, 1, 2, 3, 4, 5, 6, 7.

2. What do the letters A to F stand for in hexadecimal?

> **Answer:** A=10, B=11, C=12, D=13, E=14, F=15.

3. Convert 100_{10} to octal.

> **Answer:** 100÷8=12 r4; 12÷8=1 r4; 1÷8=0 r1 → 144_8.

4. Convert 250_{10} to hexadecimal.

> **Answer:** 250÷16=15 r10(A); 15÷16=0 r15(F) → FA_{16}.

5. What are the first four place values in hexadecimal?

> **Answer:** 1, 16, 256, 4096 (16^0 to 16^3).

6. Why do programmers use hexadecimal?

> **Answer:** It is much shorter than binary and easy to convert (one hex digit = 4 bits), e.g. colour codes and memory addresses.

MCQ

1. What is the base of the hexadecimal system?

A. 6
B. 16
C. 8
D. 10

2. Which digit is NOT used in the octal system?

A. 0
B. 7
C. 5
D. 8

3. In hexadecimal, the letter D stands for:

A. 13
B. 11
C. 14
D. 12

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4. What is 156_{10} in octal?

A. 243
B. 234
C. 324
D. 432

5. What is 250_{10} in hexadecimal?

A. FA
B. AF
C. F10
D. FB

6. What is 47_{10} in binary?

A. 110111
B. 101101
C. 101111
D. 111101

7. The place value of the 3rd digit from the right in octal is:

A. 64
B. 512
C. 16
D. 24

8. The place value of the 3rd digit from the right in hexadecimal is:

A. 32
B. 48
C. 4096
D. 256

9. What is 255_{10} in hexadecimal?

A. 100
B. FF
C. F5
D. EF

10. What is 64_{10} in octal?

A. 100
B. 010
C. 80
D. 64

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11. What is 200_{10} in hexadecimal?

A. 8C
B. 128
C. C8
D. C2

12. When converting to hexadecimal, a remainder of 11 is written as:

A. 11
B. C
C. B
D. A

13. Which of these is a valid hexadecimal number?

A. 1H
B. 2E9
C. G5
D. Z0

14. 16_{10} written in hexadecimal is:

A. 16
B. F
C. G
D. 10

15. A web colour #FF0000 uses which number system?

A. Octal
B. Binary
C. Hexadecimal
D. Roman

Structured Questions

1. Copy and complete the table:
System | Base | Digits
Binary | ? | ?
Octal | ? | ?
Hexadecimal | ? | ? (4 marks) *(4 marks)*

> Binary – 2 – 0, 1
> Octal – 8 – 0 to 7
> Hexadecimal – 16 – 0 to 9 and A to F

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2. Convert 83_{10} to octal using repeated division. Show working. (3 marks) *(3 marks)*

> 83÷8=10 r3; 10÷8=1 r2; 1÷8=0 r1 → 123_8. Check: 64+16+3=83.

3. Convert 175_{10} to hexadecimal. Show working. (3 marks) *(3 marks)*

> 175÷16=10 r15(F); 10÷16=0 r10(A) → AF_{16}. Check: 10×16+15=175.

4. Convert 29_{10} to (i) binary (ii) octal (iii) hexadecimal. (3 marks) *(3 marks)*

> (i) 11101_2 (ii) 35_8 (iii) $1D_{16}$

5. (i) Write the place values of the first four positions in octal. (2 marks)
(ii) What is the largest single digit in base 8 and base 16? (2 marks) *(4 marks)*

> (i) 1, 8, 64, 512 (ii) base 8 → 7; base 16 → F (15)

6. A web designer wants the colour with red = 200, green = 30, blue = 255. Colour codes are written as #RRGGBB in hex. (i) Convert 200, 30 and 255 to hex. (3 marks) (ii) Write the colour code. (1 mark) *(4 marks)*

> (i) 200 = C8, 30 = 1E, 255 = FF (ii) #C81EFF

Summary

- Four number systems: binary (2), octal (8), decimal (10), hexadecimal (16).
- The largest digit in a system is base − 1.
- Hex uses A–F for 10–15.
- Place values are powers of the base: 1, base, base^2, base^3 …
- Octal place values: 1, 8, 64, 512. Hex: 1, 16, 256, 4096.
- Decimal → any base: divide by the base repeatedly, read remainders upward.
- Always check by multiplying digits by place values and adding.
- Hex is used for colour codes, MAC and IPv6 addresses.

MCQ answer key – 3.2

1. **B** – Hexa (6) + decimal (10) = 16.
2. **D** – Octal digits are 0–7.
3. **A** – A10 B11 C12 D13.
4. **B** – Remainders 4, 3, 2 read upward → 234_8.
5. **A** – 250 = 15×16 + 10 → FA.
6. **C** – 32 + 8 + 4 + 2 + 1 = 47.
7. **A** – 8^0=1, 8^1=8, 8^2=64.
8. **D** – 16^2 = 256.
9. **B** – 255 = 15×16 + 15 → FF.
10. **A** – 64 = 1×8^2 → 100_8.

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11. **C** – 200 = 12×16 + 8 → C8.
12. **C** – B = 11.
13. **B** – Hex digits are 0–9 and A–F only.
14. **D** – 16 = 1×16 + 0 → 10_{16}.
15. **C** – Colour codes are 6 hex digits (RRGGBB).

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