

## Learning Launch



Use the chat to enter reasons why humans may find it difficult to work with binary




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## Representation of numbers

Bit shifting and Hexadecimal

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## Learning Outcomes

**By the end of this 90-minute session, you will:**

- Be able to perform left and right binary shifts
- Recap number systems used in computing and be able to perform basic arithmetic operations
- Know why hexadecimal is used and its advantages
- Know how to convert between the number systems, binary, denary and hexadecimal




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## Confidence Check-In

- Please take time to anonymously share your confidence in today's topics



## Number Systems – Binary

Computers operate with electronic circuits using transistors as switches, which are either 'on' (1) or 'off' (0).



Place Values	128	64	32	16	8	4	2	1
	1	0	1	1	1	0	1	1
MSB								LSB

## Recap Number Bases

A number base is the number of digits or combination of digits that a system uses to represent numbers.

Binary (base 2)

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

Denary (base 10)

$10^3$	$10^2$	$10^1$	$10^0$
1000	100	10	1
1	3	4	5

More on number bases later with hexadecimal (base 16)

### Binary Shift – LEFT

32	16	8	4	2	1	Dec
0	0	0	0	0	1	1
0	0	0	0	1	0	2
0	0	0	1	0	0	4
0	0	1	0	0	0	8

What is happening to the **1**?

The **1** is **SHIFTING** 1 place to the left




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### Binary Shift – LEFT

32	16	8	4	2	1	Dec
0	0	0	0	1	1	3
0	0	0	1	1	0	6
0	0	1	1	0	0	12
0	1	1	0	0	0	24

Each place moved to the left multiplies the number by 2




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### Binary Shift – LEFT

- Shift the following binary number 3 places to the left

**11001101**

10011010 (1 shift left (x2))

00110100 (2 shift left (x4))

01101000 (3 shift left (x8))

After shifting, how has the number changed?  
(comment in the chat)




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## Binary Shift – RIGHT

32	16	8	4	2	1	Dec
0	1	1	0	0	0	24
0	0	1	1	0	0	12
0	0	0	1	1	0	6
0	0	0	0	1	1	3

Right shift represents division.  
Each shift right is Divide by 2



## Why binary shifts are used

- Direct hardware support in the CPU
- CPUs have specific instructions for bit shifting
- Efficient use of resources (fewer steps than other methods)
- Many operations such as binary multiplication or data handling use bit shifting



## Activity

- Complete Task 1 in Handout1



You have  
5 minutes

### Representation of numbers in GCSE computer science

#### Handout 1 – Converting between number types

##### Task 1 – Binary Shifting (Left and Right)

Q1 () Complete a 2 place right shift on the binary number 11001000.

Q1 What is the effect of the binary shift.

Q2 () Complete a 3 place left shift on the binary number 11001011.

Q2 What is the effect of the binary shift.

Q3 () Complete a 1 place left shift on the binary number 01001001.

Q3 What is the effect of the binary shift.

Q4 Explain the effect of performing a 2 place shift to the right on the binary number 11001101.

Q5 A binary shift can be performed on a binary integer. Identify which shift will multiply a number by 8.



## Task 1 – answers

Q1.

Complete a 1 place left shift on the binary number 01001001.

**10010010**

ii) What is the effect of the binary shift:

- **Multiplying the number by 2**  
 $73 \times 2 = 146$




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## Task 1 – answers

Q2.

i) Complete a 3 place left shift on the binary number 11001011.

**01011000**

ii) What is the effect of the binary shift:

- **Multiplying the number by 8 or  $2^3$  or  $2 \times 2 \times 2$**   
(\*2 for each place moved to the right)
- **Loss of precision due to binary overflow**




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## Task 1 – answers

Q3.

i) Complete a 2 place right shift on the binary number 11001000.

**00110010**

ii) What is the effect of the binary shift:

- **Dividing the number by 4**  
(/2 for each place moved to the right)




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## Task 1 – answers

**Q4.** Divide the binary number 00010000 by 4 using a binary shift operation.

Each right shift is  $/2$ , so  $16/2 = 8$  then  $8/2 = 4$

	128	64	32	16	8	4	2	1
before	0	0	0	1	0	0	0	0
after	0	0	0	0	0	1	0	0

**Q5.** A binary shift can be performed on a binary integer. Identify which shift will multiply a number by 8

**LEFT 3 Places**




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## Hexadecimal

We know base 2 is **binary** and base 10 is **denary**.  
Base 16 is known as **hexadecimal**.

'Hex' has 16 possible values for each column(place).

											A	B	C	D	E	F
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

• Only 2 place values are needed for exams

$16^1$	$16^0$
16	1
A	6




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## Back to number bases

Exam questions will either tell you the number base, or use a smaller number in **subscript** at the end

Base	2 (binary)	10 (denary)	16 (hexadecimal)
Example	$10101_2$	$238_{10}$	$AC_{16}$

**Let's Play "What's the Number Base?"**

- a.  $01011100_2$       **2**  
 b.  $43_{10}$               **10**  
 c.  $85_{16}$                **16**  
 d.  $FF_{16}$                **16**



Use the chat  
to respond




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## Hexadecimal

The numbers below are all equivalent to denary 252

16	1
F	C

HEX

100	10	1
2	5	2

Denary

128	64	32	16	8	4	2	1
1	1	1	1	1	1	0	0

Binary



What differences do you notice, comment in the chat



## Hexadecimal

Binary is difficult for humans to work with!  
Converting between binary and hex is simple for computers



Image Generated by OpenAIs DALL-E

A MAC address is made up of 12 hex characters  
The equivalent binary number is 48 bits



## Hexadecimal

One common example of hex usage is in color codes.



#6DD533



#CF39AF

11001111100111001 10101111



Image Generated by OpenAIs DALL-E

Other places where we see hexadecimal numbers used:

- Memory Addresses
- In error codes, whilst debugging



## Hexadecimal

Let's summarise why we use hex instead of binary

- Easier and quicker to communicate (enter, write, read)
- Less chance of inputting errors
- Easier to find errors
- They are shorter so easier to remember
- Easy to convert between binary and hexadecimal




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## Binary to Hex conversion

### Method

- Step 1: Split the binary number into two nibbles
- Step 2: Draw the table
- Step 3: Add numbers with 1s in

### Example 1

8	4	2	1	6	8	4	2	1
1	0	1	0	0	0	1	1	1
$8 + 2 = 10$						$4 + 2 + 1 = 7$		
answer =						7		




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## Binary to Hex conversion

### Method

- Step 1: Split the binary number into two nibbles
- Step 2: Draw the table
- Step 3: Add numbers with 1s in

### Example 2

8	4	2	1	6	8	4	2	1
0	0	1	1	1	1	1	1	1
$2 + 1 = 3$						$8 + 4 + 2 + 1 = 15$		
answer =						F		




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## Exam tip!

Before tackling questions using hexadecimal

- Write the number range (0-15 in a line)
- Place characters A-F from 10-15

											<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	

											<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>
										0-9	10	11	12	13	14	15

or simpler

This will help prevent errors when converting




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## Activity

- Complete **Task 2** in Handout1



**You have  
5 minutes**

### Task 2 – Binary to Hexadecimal

Q1 Give **two** reasons why computer scientists use hexadecimal to represent numbers instead of binary.

Q2 Convert the binary number 11101001 to Hexadecimal

Q3 Convert the binary number 11001010 to Hexadecimal

Q4 Convert the binary number 10110011 to Hexadecimal




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## Task 2 – answers

**Q1.** Give **two** reasons why computer scientists use hexadecimal to represent numbers instead of binary.

- Easier and quicker to communicate (enter, write, read)
- Less chance of inputting errors
- Easier to find errors
- They are shorter so easier to remember
- Easy to convert between binary and Hexadecimal




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## Task 2 - answers

Q2. Convert the binary number 11101001 to Hexa decimal

8	4	2	1					8	4	2	1				
1	1	1	0					1	0	0	1				

=14 (E)      =9

answer = **E9**

Q3. Convert the binary number 11001010 to Hexa decimal

8	4	2	1					8	4	2	1				
1	1	0	0					1	0	1	0				

=12 (C)      =A

answer = **CA**

A B C D E F  
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Task 2 - answers

Q4. Convert the binary number 10110011 to Hexa decimal

8	4	2	1					8	4	2	1				
1	0	1	1					0	0	1	1				

=11 (B)      =3

answer = **B3**

A B C D E F  
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Hex to Binary conversion

### Method

- Step 1: Split the Hex digits
- Step 2: Draw 2 nibble tables
- Step 3: Convert to binary

A B C D E F  
0-9 10 11 12 13 14 15

### Example 1

6				C			
8	4	2	1	8	4	2	1
0	1	1	0	1	1	0	0

answer = **01101100**

## Hex to Binary conversion

### Method

- Step 1: Split the Hex digits
- Step 2: Draw 2 nibble tables
- Step 3: Convert to binary

	A	B	C	D	E	F
0-9	10	11	12	13	14	15

### Example 2

A				D			
8	4	2	1	8	4	2	1
1	0	1	0	1	1	0	1

answer = 10101101




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## Activity

- Complete Task 3 in Handout1



You have  
5 minutes

### Task 3 – Hexadecimal to Binary

Q1 Convert the Hexadecimal number 0F to Binary

Q2 Convert the Hexadecimal number 3A to Binary

Q3 Convert the Hexadecimal number 96 to Binary




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## Task 3 – answers

Q1. Convert the Hexadecimal number 0F to Binary

8	4	2	1		8	4	2	1
0	0	0	0	= 0	1	1	1	1

00001111

Q2. Convert the Hexadecimal number 3A to Binary

8	4	2	1		8	4	2	1
0	0	1	1	= 3	1	0	1	0

00111010

	A	B	C	D	E	F
0-	1	1	1	1	1	1
9	0	1	2	3	4	5




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### Task 3 - answers

Q3. Convert the Hexadecimal number 96 to Binary

8	4	2	1		8	4	2	1	
1	0	0	1	= 9	0	1	1	0	=6

**10010110**

A B C D E F  
0-9 10 11 12 13 14 15




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### Denary to Hex to conversion

**Method 1 - Using denary to binary**

Convert denary 187 into hex

- Step 1: Convert into 8 bit binary as normal!
- Step 2: Split the binary number into two nibbles
- Step 3: Convert nibbles into Denary
- Step 4: Convert the denary values into hex.

8	4	2	1	8	4	2	1
1	0	1	1	1	0	1	1
8 + 2 + 1 = 11				8 + 2 + 1 = 11			

Answer =

**B**




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### Denary to Hex to conversion

**Method 2 - Division by 16**

Convert denary 231 into hex

**Step 1** - Divide the number of 16

Integer part goes in the left column, remainder in the right

**Step 2:** Convert to hex value if needed (10 or greater)

231 / 16 = 14 remainder 7

Answer = **E 7**

16	1
14	7
E	7

A B C D E F  
0-9 10 11 12 13 14 15




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## Activity

- Complete **Task 4** in Handout1



**You have  
5 minutes**

### Task 4 – Denary to Hexadecimal

Q1 Convert the Denary number 62 to Hexadecimal

Q2 Convert the Denary number 250 to Hexadecimal

Q3 Convert the Denary number 128 to Hexadecimal



## Task 4 – answers

**Q1.** Convert the denary number 62 to hexadecimal

$$62/16 = 3 \text{ r } 14 = 3\text{E}$$

**Q2.** Convert the denary number 250 to hexadecimal

$$250 / 16 = 15 \text{ r } 10 = \text{FA}$$

**Q3.** Convert the denary number 128 to hexadecimal

$$128 / 16 = 8 \text{ r } 0 = 80$$

A B C D E F  
0-9 10 11 12 13 14 15



## Hex to Denary conversion

### Method 1 - Table method

Convert the Hex number **AB** into denary.

Step 1: Draw the table

Step 2: Add the Hex digits to the table

Step 3: Multiply the denary equivalent by column value

Step 4: Add results together

16	1
A	B

$$A = 10$$

$$B = 11$$

$$10 * 16 = 160$$

$$11 * 1 = 11$$

$$\text{Answer} = 171$$



## Activity

- Complete **Task 5** in Handout1



**You have  
5 minutes**

**Task 5 – Hexadecimal to Denary**  
Q1 Convert the hexadecimal number 3E into a Denary.

Q2 Convert the hex number 62 to Denary

Q3 Convert the hexadecimal number A3 to Denary

### Extension

Complete the table below

Denary	8 bit Binary	Hexadecimal
12	00110000	66
255		




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## Task 5 – answers

**Q1.** Convert the hexadecimal number **3E** into a denary number.

$$(3 * 16) + 14 = 62 \text{ or}$$

$$0011\ 1110 = 62$$

**Q2.** Convert the hex number **62** to denary

$$(6 * 16) + 2 = 98 \text{ or}$$

$$0110\ 0010 = 98$$




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## Task 5 – answers

**Q3.** Convert the hexadecimal number **A3** to denary

$$(10 * 16) + 3 = 163$$

or

$$10100011 = 163$$




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## All together – Isaac Gameboard

Representation of numbers in GCSE computer science - Booster 2

Step 2 place values	Answer	0 0 0
Exponential to binary	Answer	0 0 0
Binary shifts	Answer	0 0 0
Exponential to binary	Answer	0 0 0
From binary to hex	Answer	0 0 0
Find the hexadecimal	Answer	0 0 0
Binary to hexadecimal 2	Answer	0 0 0
Hexadecimal to binary 2	Answer	0 0 0
Binary to hexadecimal conversion 1	Answer	0 0 0
Why hex?	Answer	0 0 0



You have  
5  
minutes

[ncce.io/isc-binary](https://ncce.io/isc-binary)



## Learning Outcomes

By the end of this 90-minute session, you will:

- Be able to perform left and right binary shifts
- Recap number systems used in computing and be able to perform basic arithmetic operations
- Know why hexadecimal is used and its advantages
- Know how to convert between the number systems, binary, denary and hexadecimal

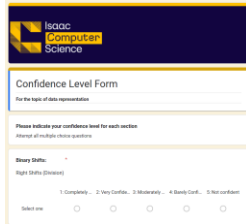


## Check for more ISAAC boosters

Keep an eye out for more student booster events

## Confidence Check-In

- Please take time to anonymously share your confidence in today's topics



"Computers are incredibly fast, accurate, and stupid. Human beings are incredibly slow, inaccurate, and brilliant. Together they are powerful beyond imagination."

Albert Einstein  
Physicist



# Thank You

