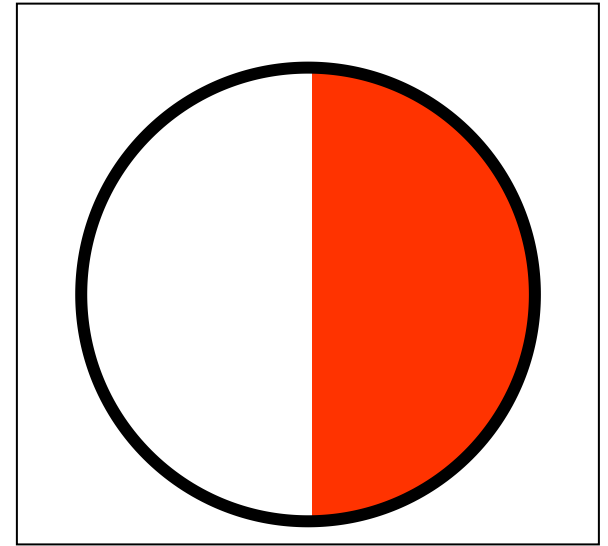


# **HEXADECIMAL NUMBERS**

# Memory Test

30 Seconds



**End**

**01011011010110110101101101011011**

# Which is easier to remember?

**01011011010110110101101101011011**

**or**

**5B5B5B5B**

- Humans are not good at remembering long strings of numbers
- Binary numbers are often long and unwieldy

# OBJECTIVES

- Know what a **hexadecimal** number is
- Understand how to convert **Denary 0 - 255** to **hexadecimal** and vice versa
- Know how to convert **Hexadecimal** to **Binary** and **Binary** to **Hexadecimal (up to 4 bits)**
- Understand **why** we use **hexadecimal**

# Binary Numbers

- Here are the first 16 binary numbers (using decimal equivalents).

**What do you think the Hex equivalent might be?**

Binary	Denary	Hex	Binary	Denary	Hex
0000	0		1000	8	
0001	1		1001	9	
0010	2		1010	10	
0011	3		1011	11	
0100	4		1100	12	
0101	5		1101	13	
0110	6		1110	14	
0111	7		1111	15	

# Activity

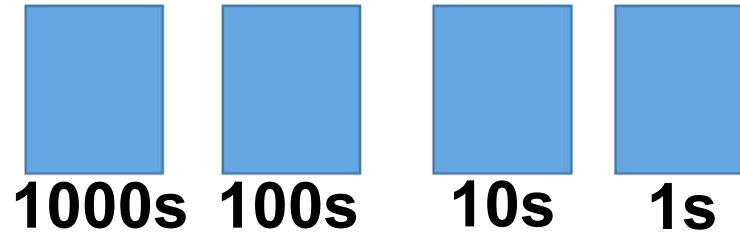
- Complete the chart by writing the first numbers (beginning with 0)

**How many bits  
do you need to  
represent the  
first 16  
hexadecimal  
numbers?**

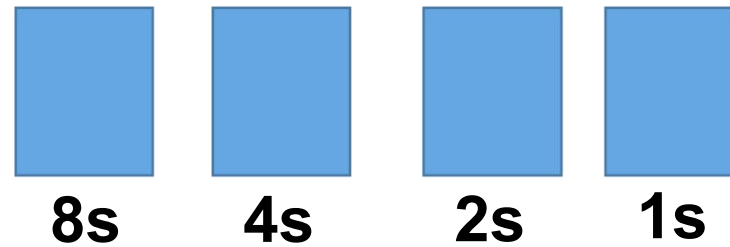
Binary	Denary	Hex	Binary	Denary	Hex
0000	0	0	1000	8	8
0001	1	1	1001	9	9
0010	2	2	1010	10	A
0011	3	3	1011	11	B
0100	4	4	1100	12	C
0101	5	5	1101	13	D
0110	6	6	1110	14	E
0111	7	7	1111	15	F

# Number Systems

**Decimal  
Values**



**Binary  
Values**



**Hexadecimal  
Values**



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

# Converting Hex to Denary

- We naturally understand denary numbers
- We know that  $1089 = (1 \times 10^3) + (0 \times 10^2) + (8 \times 10) + (9 \times 1)$
- For hexadecimal it is the same but for base 16

- For example:

**A9**

**Step 1** Work out the value of the Hex number in Denary

**10**

**9**

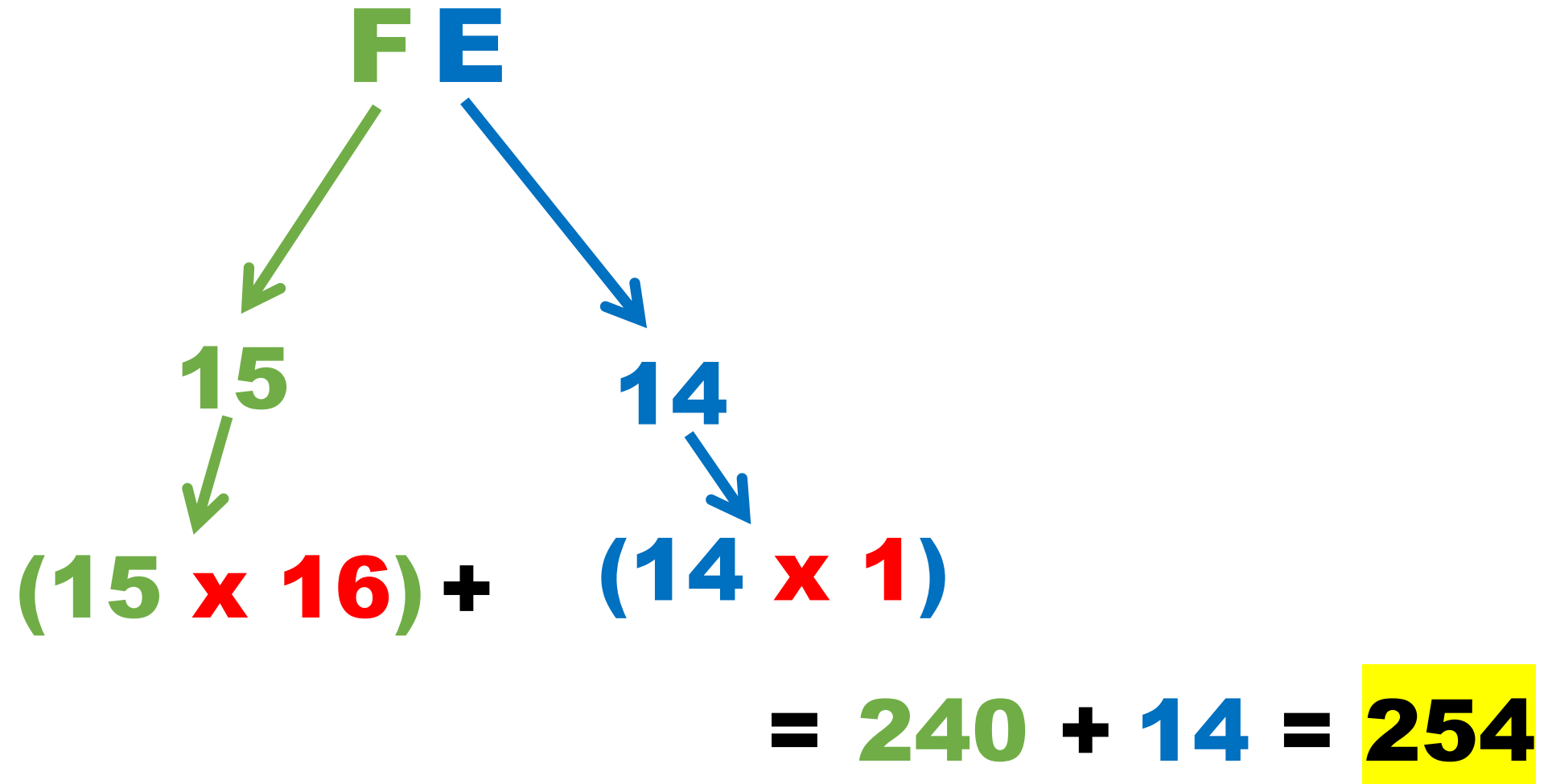
**Step 2** Multiply the value of the Hex Number by its power of 16

$$(10 \times 16) + (9 \times 1) = 160 + 9 = 169$$

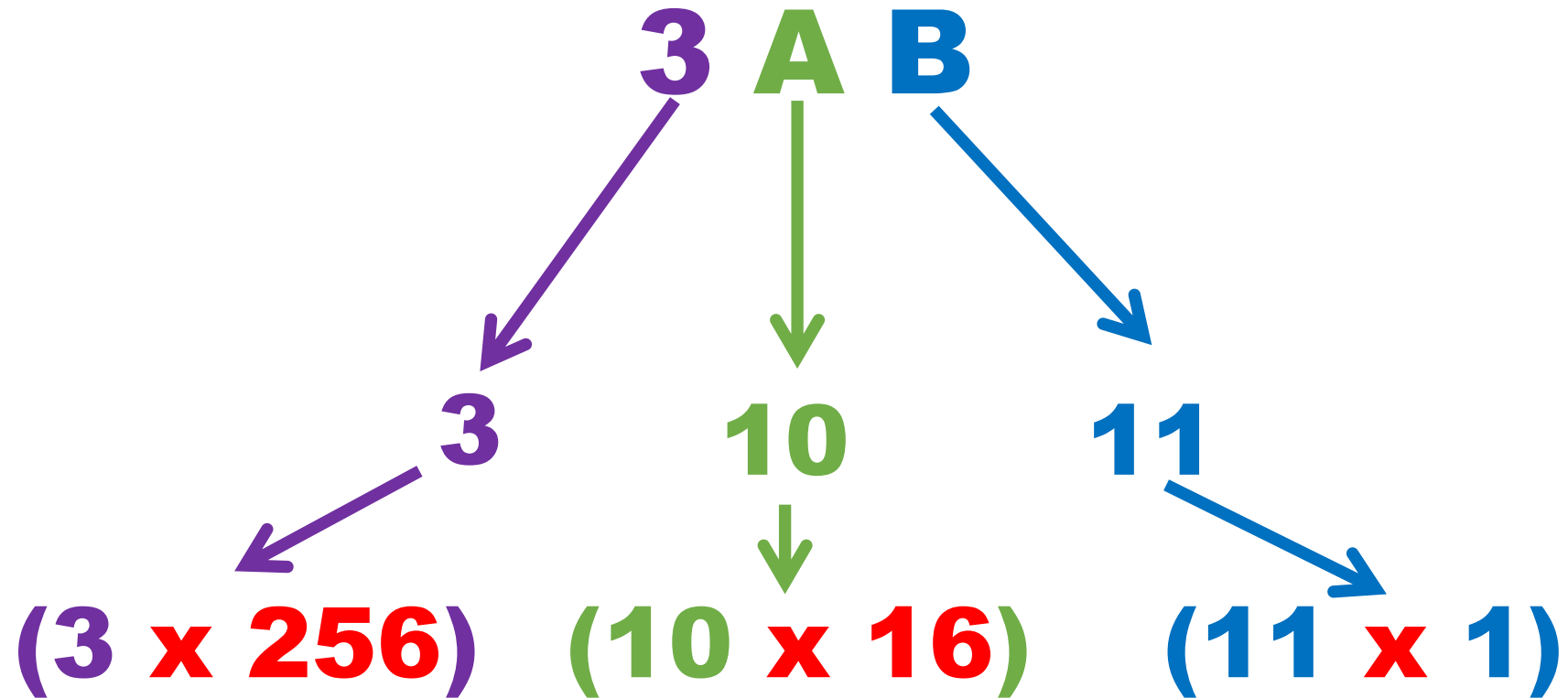
**Step 3** Add the values together



# Example



# A more difficult example



$$= 768 + 160 + 11 = \mathbf{939}$$

# Convert these denary – show

## EXTRA CHALLENGE – TRY THESE:

- FFF
- EF4

• FF	$(15 \times 16) + (15 \times 1)$	$240 + 15$	<b>255</b>
• AC	$(10 \times 16) + (12 \times 1)$	$160 + 12$	<b>172</b>
• 8D	$(8 \times 16) + (13 \times 1)$	$128 + 13$	<b>141</b>
• 99	$(9 \times 16) + (9 \times 1)$	$144 + 9$	<b>153</b>
• EE	$(14 \times 16) + (14 \times 1)$	$224 + 14$	<b>238</b>
• 42	$(4 \times 16) + (2 \times 1)$	$64 + 2$	<b>66</b>

# Extension

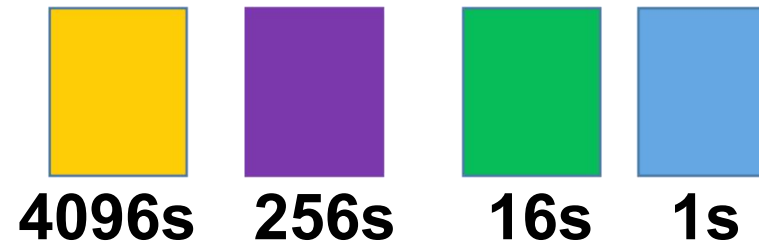
- **FFF**     $(15 \times 256) + (15 \times 16) + (15 \times 1)$   
 $(3,840) + (240) + (15) = 4,095$
- **EF4**     $(14 \times 256) + (15 \times 16) + (4 \times 1)$   
 $(3,584) + (240) + (4) = 3,828$

# **Converting Hex to Decimal**

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

# Denary to Hexadecimal

Example: Convert 200 denary to hexadecimal:

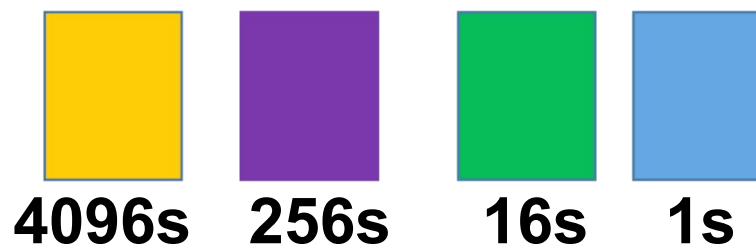


1. Find the placeholder smaller > the number = 16
2. Divide 200 by 16 = 12 (lots of 16) = 192
3. Calculate the remainder =  $200 - 192 = 8$  (units)
4. and 8 in Decimal is 8 in Hex
5. Answer is C8

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

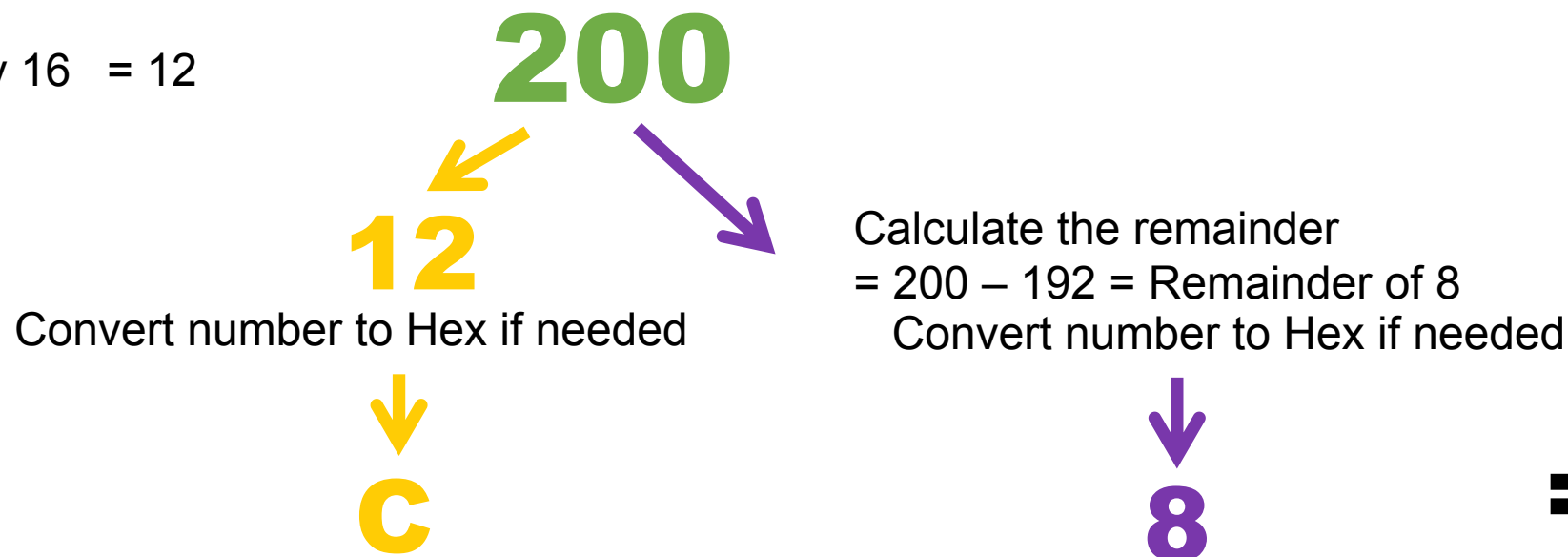
# Denary to Hexadecimal

Example: Convert **200** denary to hexadecimal:



1. Find the placeholder < the number (**200**) = 16

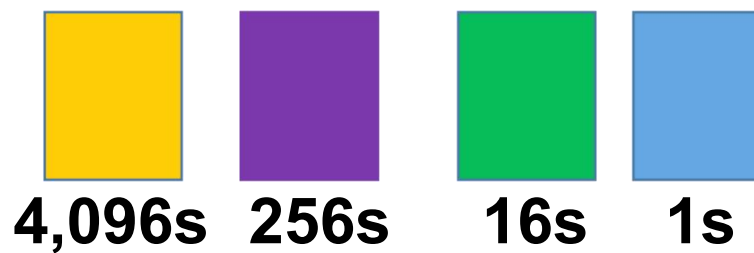
Divide 200 by 16 = 12



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

# Denary to Hexadecimal

**Difficult Example:** Convert 8,000 denary to hexadecimal...



1. Find the placeholder < the number (8,000) = 16

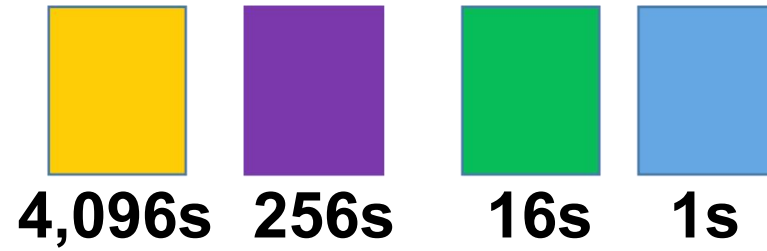
This is 4,096

**8,000**   Divide 8,000 by 4,096 = 1 = 1 in Hex

**1**

Calculate the remainder = Remainder of 3,904  
 = 8,000 - 4,096





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

Find the placeholder < the remainder (**3,904**)

This is 256

**8,000**

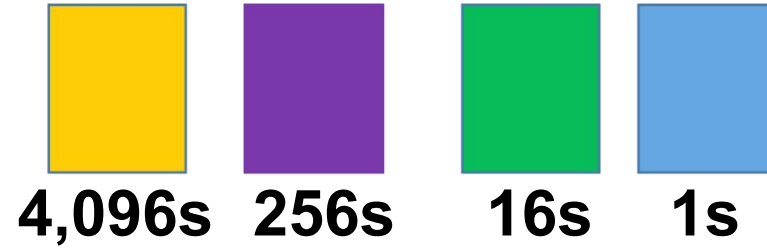
Divide **3,904** by 256 = 15 = F in Hex

**1**

**F**



Calculate the remainder  
= 3904 – 3840 = Remainder of 64



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

Find the placeholder < the remainder (64)

This is 16

8,000

Divide 64 by 16 = 4 = 4 in Hex

1 F 4 0

Calculate the remainder  
= 64 - 64 = Remainder of 0

= 1F40

# Convert these denary to hexadecimal

a) 32      20

b) 255      FF

c) 59      3B

d) 159      9F

e) 230      E6

f) 256      100

# **Converting Binary to Hex**

# Binary to Hexadecimal

- Hexadecimal groups binary bits into groups of 4 bits
- Each group of 4 Bits (nibble) is assigned a hex digit value.
  - Digits are the same as for decimal up to 9
  - Letters A through F are used for 10 - 15

**Thus the 8-bit binary number**

**1011 0010**

**converted to hex is**

**B2**

**0000 = 0**

**0001 = 1**

**0010 = 2**

**0011 = 3**

**0100 = 4**

**0101 = 5**

**0110 = 6**

**0111 = 7**

**1000 = 8**

**1001 = 9**

**1010 = A**

**1011 = B**

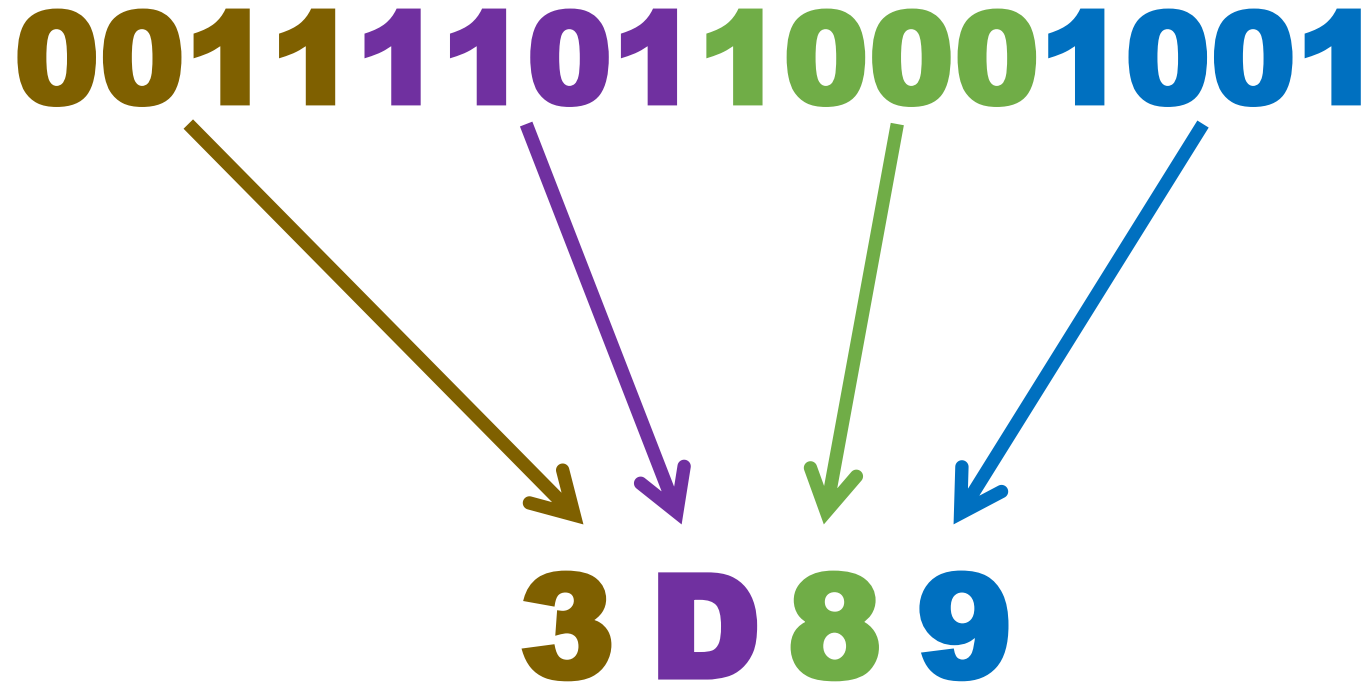
**1100 = C**

**1101 = D**

**1110 = E**

**1111 = F**

# Binary to Hexadecimal



0000 = 0

0001 = 1

0010 = 2

0011 = 3

0100 = 4

0101 = 5

0110 = 6

0111 = 7

1000 = 8

1001 = 9

1010 = A

1011 = B

1100 = C

1101 = D

1110 = E

1111 = F

# What would these Binary numbers be as Hexadecimal?

- |              |     |
|--------------|-----|
| a) 11111111  | FF  |
| b) 00000101  | 05  |
| c) 10101010  | AA  |
| d) 01011111  | 5F  |
| e) 11110000  | F0  |
| f) 100111111 | 13F |
| g) 111101110 | 1EE |

**Extension** – write the proof by converting each to denary

# Binary to Hex

- 111111110111
- 111000011
- 1111100001



# 111111110111

- Split into groups of 4 bits (Nibbles)

•           1111   1111   0111

**D**

**F**

**7**

<b>0000 = 0</b>	<b>1000 = 8</b>
<b>0001 = 1</b>	<b>1001 = 9</b>
<b>0010 = 2</b>	<b>1010 = A</b>
<b>0011 = 3</b>	<b>1011 = B</b>
<b>0100 = 4</b>	<b>1100 = C</b>
<b>0101 = 5</b>	<b>1101 = D</b>
<b>0110 = 6</b>	<b>1110 = E</b>
<b>0111 = 7</b>	<b>1111 = F</b>

# 111000011

- Split into groups of 4 bits (Nibbles)

•                    1    1100    0011

**1**            **C**            **3**

<b>0000 = 0</b>	<b>1000 = 8</b>
<b>0001 = 1</b>	<b>1001 = 9</b>
<b>0010 = 2</b>	<b>1010 = A</b>
<b>0011 = 3</b>	<b>1011 = B</b>
<b>0100 = 4</b>	<b>1100 = C</b>
<b>0101 = 5</b>	<b>1101 = D</b>
<b>0110 = 6</b>	<b>1110 = E</b>
<b>0111 = 7</b>	<b>1111 = F</b>

# 1111100001

- Split into groups of 4 bits (Nibbles)

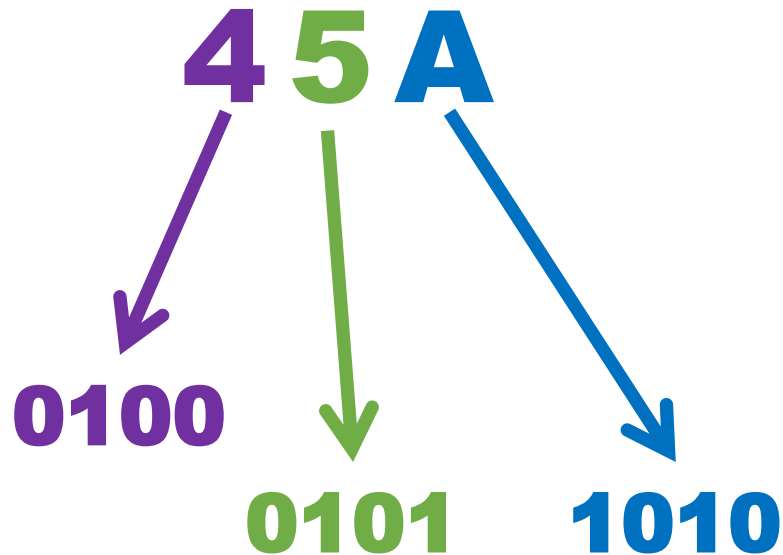
•                    11   1110   0001

**3**   **E**   **1**

<b>0000 = 0</b>	<b>1000 = 8</b>
<b>0001 = 1</b>	<b>1001 = 9</b>
<b>0010 = 2</b>	<b>1010 = A</b>
<b>0011 = 3</b>	<b>1011 = B</b>
<b>0100 = 4</b>	<b>1100 = C</b>
<b>0101 = 5</b>	<b>1101 = D</b>
<b>0110 = 6</b>	<b>1110 = E</b>
<b>0111 = 7</b>	<b>1111 = F</b>

# Hexadecimal to Binary

- Find the four bit code for each digit



**0000 = 0**

**0001 = 1**

**0010 = 2**

**0011 = 3**

**0100 = 4**

**0101 = 5**

**0110 = 6**

**0111 = 7**

**1000 = 8**

**1001 = 9**

**1010 = A**

**1011 = B**

**1100 = C**

**1101 = D**

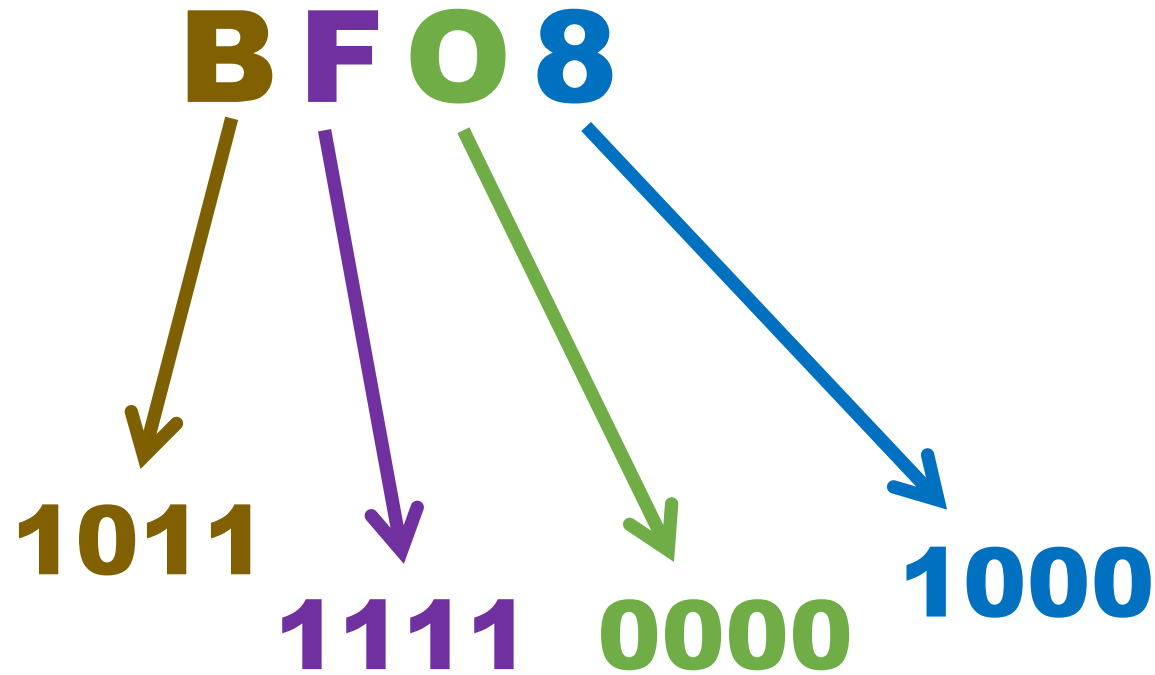
**1110 = E**

**1111 = F**

**010001011010**

# Another Example

- Find the four bit code for each digit



**0000 = 0**

**1000 = 8**

**0001 = 1**

**1001 = 9**

**0010 = 2**

**1010 = A**

**0011 = 3**

**1011 = B**

**0100 = 4**

**1100 = C**

**0101 = 5**

**1101 = D**

**0110 = 6**

**1110 = E**

**0111 = 7**

**1111 = F**

**1011111100001000**

# Convert the following into Binary

a) 6C		0110	1100	
b) 59		0101	1001	
c) AA		1010	1010	
d) A01	1010	0000	0001	
e) 40E	0100	0000	1110	
f) BA6	1011	1010	0110	
g) 9CC	1001	1100	1100	
h) 40AA	0100	0000	1010	1010

# Why hexadecimal?

- Hex numbers are shorter/more memorable than equivalent binary numbers..
- ... and can easily be converted to and from binary...
- ... as each hexadecimal digit corresponds to 4 binary digits

# Challenge – Write an Algorithm for...

## Six Groups

- Decimal to hex
- Hex to decimal
- Binary to hex
- Hex to binary
- Binary to decimal
- Decimal to binary

## Three Groups

- Decimal to hex
- Hex to decimal
- Binary to hex
- Hex to binary
- Binary to decimal
- Decimal to binary



# HEXADECIMAL BINGO

- Highlight the decimal equivalent of the hexadecimal number given

B	I	N	G	O
43	80	123	170	233
1	76	149	178	229
38	58	111	187	213
B	I	N	G	O
11	60	112	168	203
48	63	139	190	222
40	55	147	176	223
B	I	N	G	O
5	80	141	151	254
11	68	128	180	244
50	71	117	166	223

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Hex	Binary	Hex	Binary
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

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

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

Hex	Binary	Hex	Binary
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111