Computer Science

Part 1
Hexadecimal system

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Lesson Objectives

Students will learn about:

- Hexadecimal numbers and its representation
- How to convert binary and denary numbers to their hexadecimal equivalents and vice versa
- What are the applications of the hexadecimal number system?

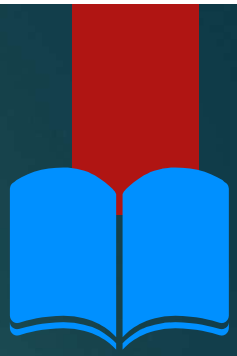
1.

Content

Introduction

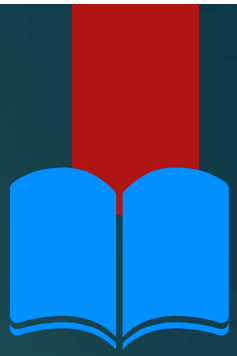
- Hexadecimal (or hex) is a system with base 16.
- The 16 digits used in the hexadecimal system and their equivalent value in binary and in denary systems are shown in the table.

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



Hexadecimal system

- Each nibble (a group of 4 bits) can be represented with 1 digit in hexadecimal system.
- It is very convenient to write in numbers in hex when compared to a binary system.
- It is helpful for programmers coding in low-level languages. Instead of 4 bits, it is enough if they type a single character.

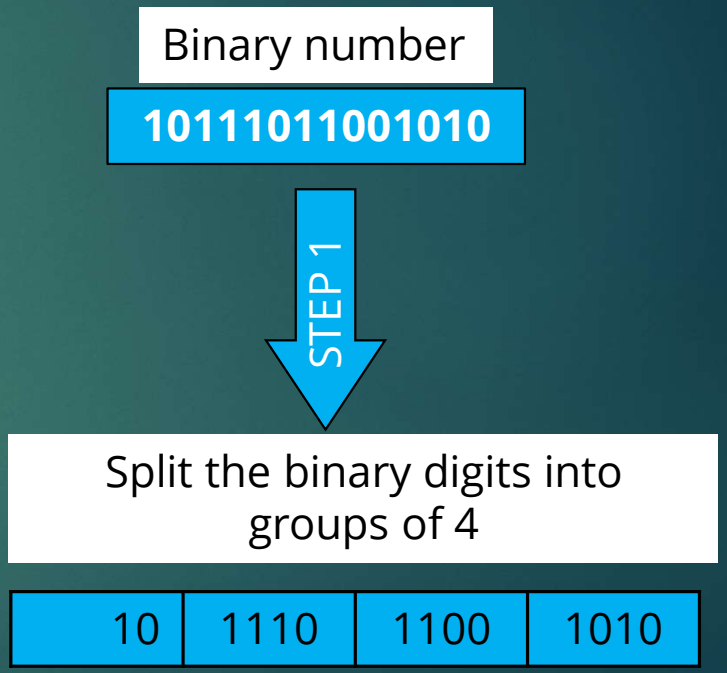


Hexadecimal system

- The memory location in a computer is also stated in hexadecimal form. This makes the address more readable.
- Consider a memory address A3F581. Is represented in binary, it would be:
- 1010| 0011| 1111| 0101| 0100| 0001

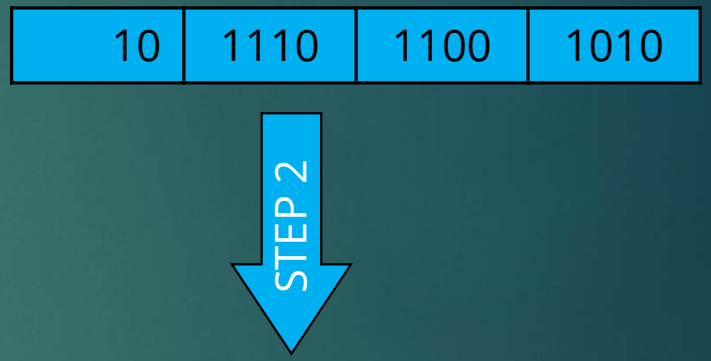
Converting binary to hexadecimal: Step 1

- Starting from right to left, the binary numbers are split into a group of 4 bits.
- If the group has less than 4 bits, zeros are added to the left.
- Each nibble is then converted to its equivalent hexadecimal number.



Converting binary to hexadecimal: Step 2

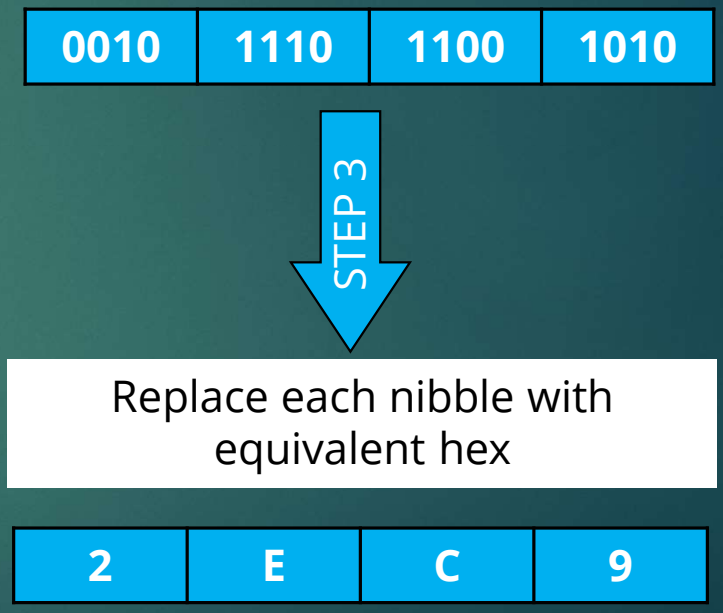
- Starting from right to left, the binary numbers are split into a group of 4 bits.
- If the group has less than 4 bits, zeros are added to the left.
- Each nibble is then converted to its equivalent hexadecimal number.



As the leftmost group has only two bits, add extra zeros to the left

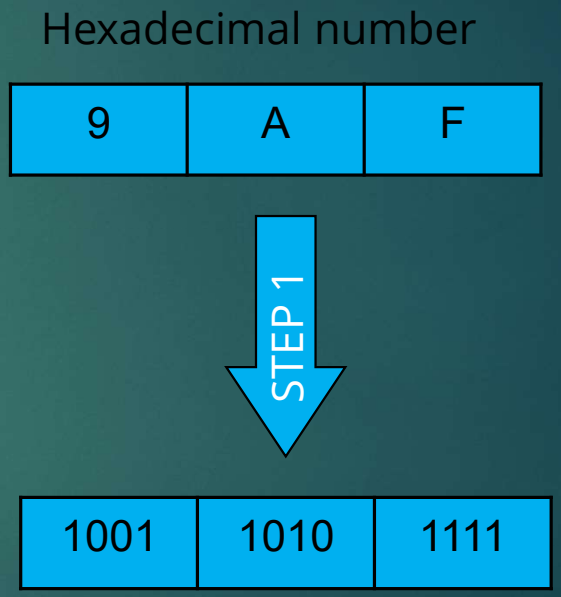
Converting binary to hexadecimal: Step 3

- Starting from right to left, the binary numbers are split into a group of 4 bits.
- If the group has less than 4 bits, zeros are added to the left.
- Each nibble is then converted to its equivalent hexadecimal number.



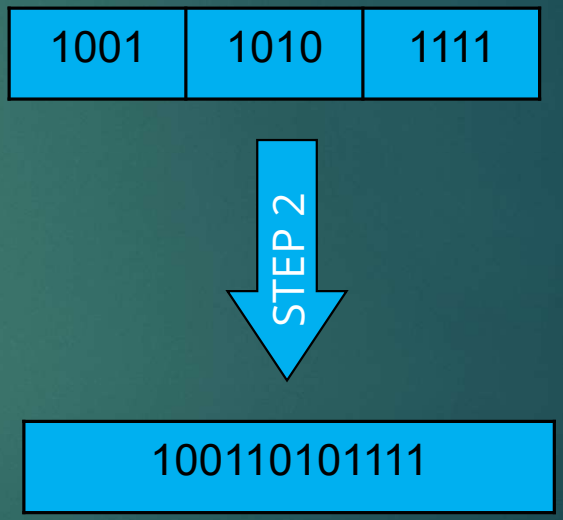
Converting hexadecimal to binary: Step 1

- Hexadecimal numbers are converted to binary by finding the 4-bit code.
- Write the nibbles together.



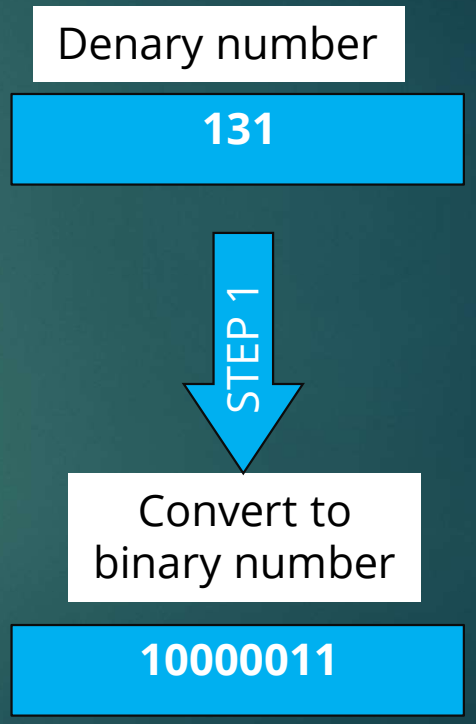
Converting hexadecimal to binary: Step 2

- Hexadecimal numbers are converted to binary by finding the 4-bit code.
- Write the nibbles together.



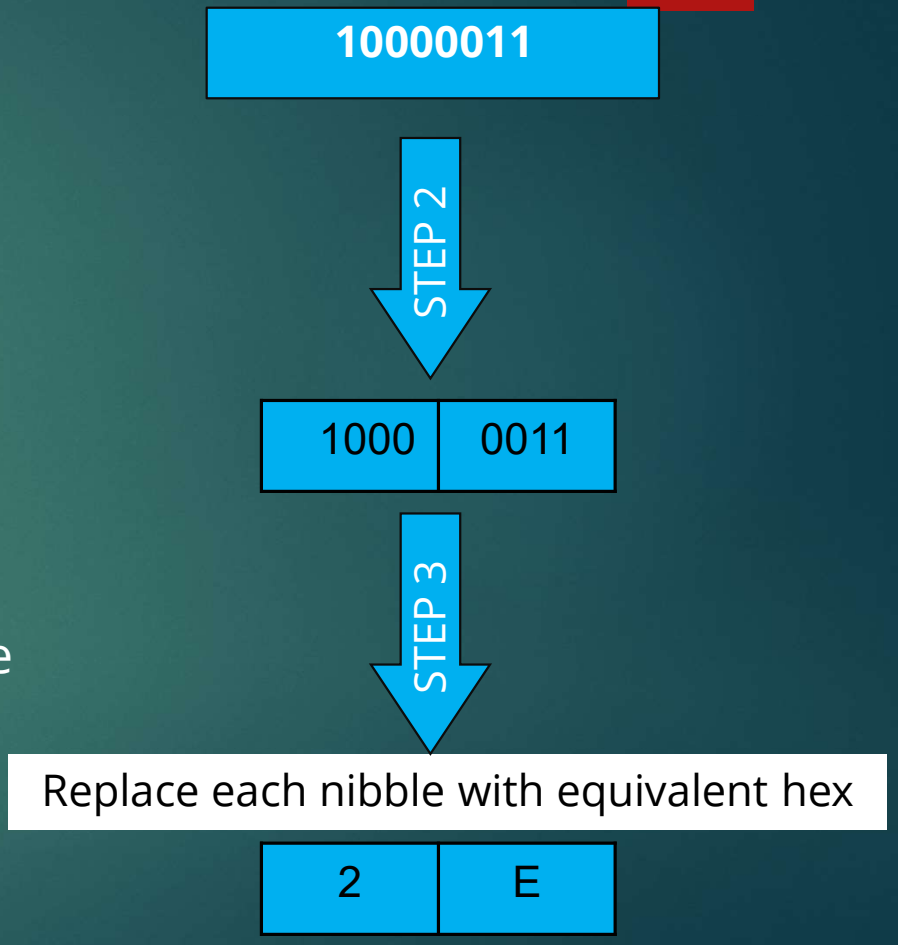
Converting denary to hexadecimal: Step 1

- To convert a denary number to hexadecimal, the number is converted to binary.
- The binary number is converted to a hexadecimal system.
- Ex: Converting the number 14 to hex. The binary form is 1110, which is E in the hexadecimal system.



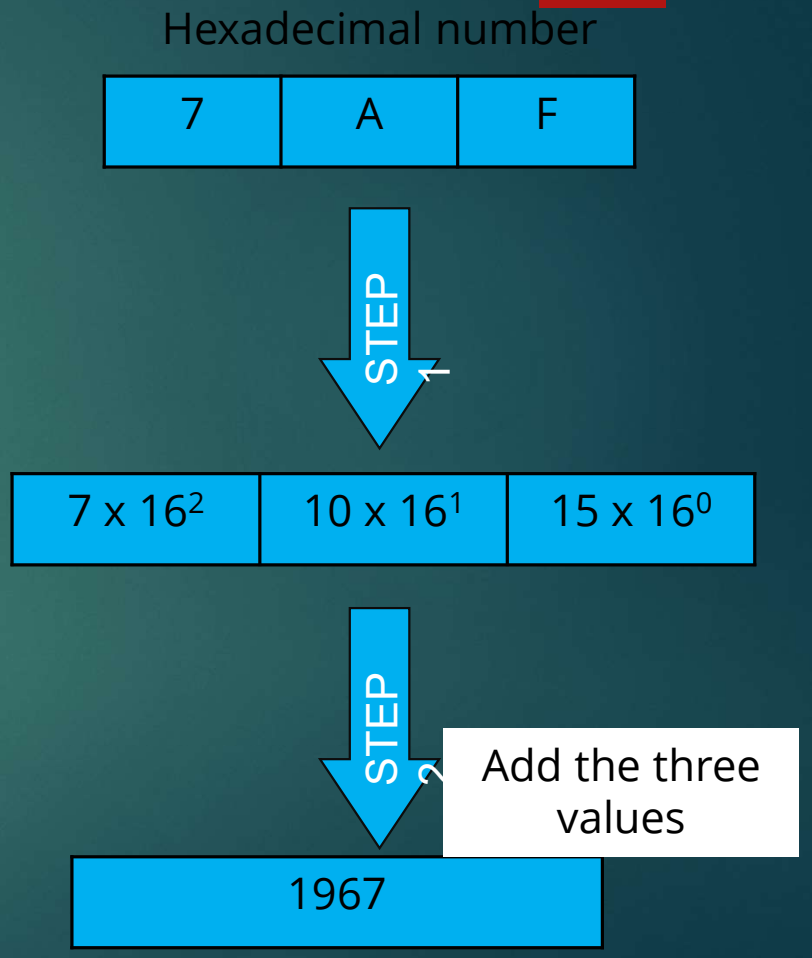
Converting denary to hexadecimal: Step 2 & 3

- To convert a denary number to hexadecimal, the number is converted to a binary.
- The binary number is converted to hexadecimal system.
- Ex: Converting the number 14 to hex. The binary form is 1110, which is E in the hexadecimal system.



Converting hexadecimal to denary

- Hexadecimal numbers can be converted to the denary system by using the place values.
- The place value is in the powers of 16.
- The value of each digit is multiplied with the place value and the values are added to find the denary equivalent.



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Computer Science

Part 2
Hexadecimal system
Applications

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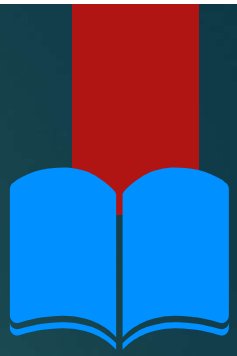
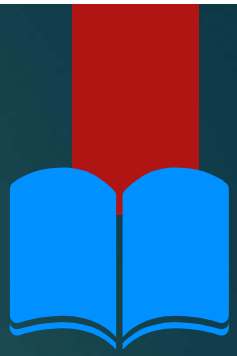
Applications of hexadecimal system



A few applications of hex system are explained below:

- Colours
- RGB Colour Model
- Errors
- MAC address
- URL
- Assembly code and machine code



Colours

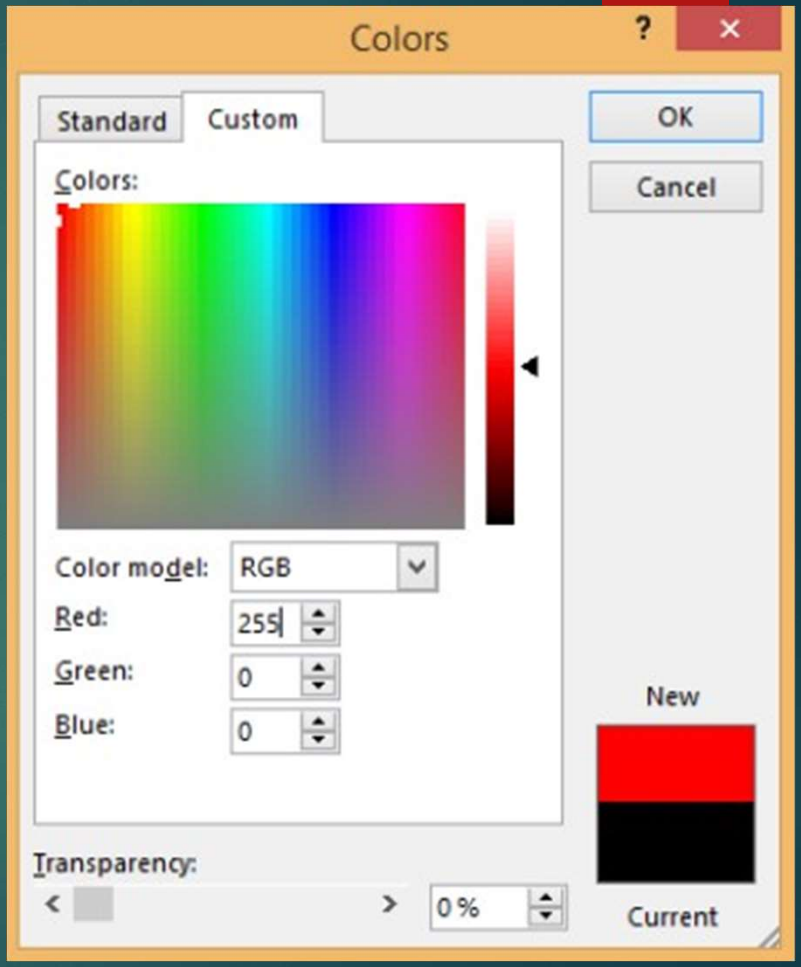
- Hexadecimal numbers are used to represent colours in various software tools.
- A colour is represented in #RRGGBB format. RR, GG and BB represent the hex number of red, green and blue colours.
- A pure blue colour is #0000FF, white is #FFFFFF and black is #0000000.
- Using this method, 256 variants of each colour can be made, hence making a total of 256 reds × 256 greens × 256 blues.
- A shade of yellow is represented in hex format as #FEF65B.

Colours

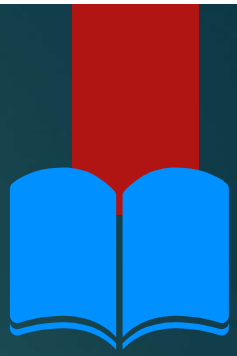
	#0000FF (Blue)		#0000000 (Black)
	#FFFFFFF (White)		#FFFF00 (Yellow)

RGB Colour Model

- Colours can also be represented using the RGB colour model.
- This system is similar to hex system but each colour has a value between 0 to 255.
- Hence, a shade of pink represented in hex format as #FEF65B have R value of 254, G value of 246 and B value of 91.



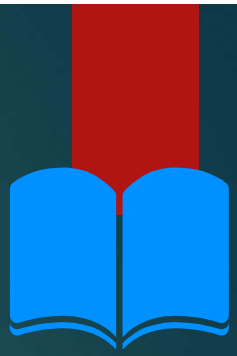
Errors



- Error message contains a hex number that represents the memory location of the error.
- This information is very useful to programmers.
- The error can be easily rectified by verifying the code in that particular location.
- The process in which the contents of memory is displayed or stored in a storage drive in case of a system crash is called a memory dump.

Location	Contents					
A0B8F10	89	20	A0	B1	C2	F3
A0B8F11	1A	3D	F4	56	F7	9A
A0B8F12	AB	C2	D1	9D	4F	5D

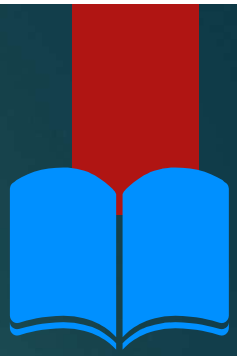
Errors



- Using this information, a programmer can identify the exact location where the error lies.
- Compared to binary, this is easier to understand. The binary form of DEF6B2C3 is: 11011110111101101011001011000011.
- Even though, using the hexadecimal system improves readability of errors, the programmer must have knowledge about the computer architecture to interpret the results.

Location	Contents					
A0B8F10	89	20	A0	B1	C2	F3
A0B8F11	1A	3D	F4	56	F7	9A
A0B8F12	AB	C2	D1	9D	4F	5D

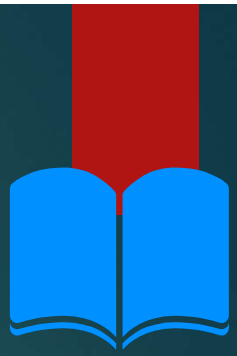
MAC addresses



- A media access control address refers to the number on the Internet that uniquely identifies a device on the Internet.
- This is the address of the network interface card (NIC).
- A MAC address is made up of 48 bits, which are shown as a six-group of hexadecimal digits.

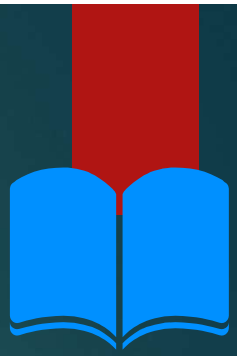
  NN-NN-NN-DD-DD-DD or NN: NN: NN: DD: DD: DD
- The first half of the address represents the identification number of the manufacturer and the second half of the number represents the serial number of the device. For example: 00: 14: 22: 34: AC: 4F refers to a device made by Dell with a serial number of 34AC4F.

MAC addresses



- There are two types of MAC address: Universally Administered MAC Address (UAA) and Locally Administered MAC Address (LAA).
- The UAA is set by manufacturer and is most commonly used.
- This address is not changed most of the times.
- In case the UAA of a device is changed, it is important to make sure that the UAA is unique.

MAC addresses



A user or organisation may change their UAA due to:

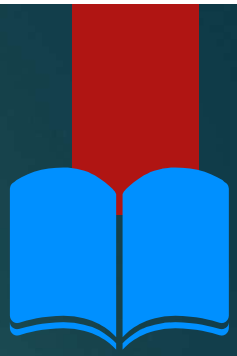
- Some software applications used on mainframe systems requires the systems to use a MAC address that follows a strict format. To ensure that all devices have MAC address that obey this format, it may be changed.
- A router or firewall may allow MAC addresses with certain format only. In order to bypass them, MAC address of device may be changed.
- Some networks may restrict certain MAC addresses. In order to use the network, certain devices may have their MAC addresses changed.

URL

- Hexadecimal values are used to represent web addresses or URL (Uniform Resource Locator). The ASCII codes are used to represent the web address.
- For example: www.google.com becomes: (using the ASCII codes)

w	w	w	.	g	o	o	g	l	e	.	c	o	m
%77	%77	%77	%2E	%67	%6F	%6F	%67	%6C	%65	%2E	%63	%6F	%6D

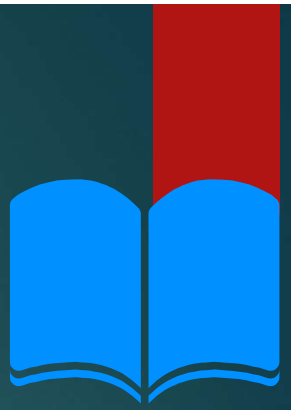
URL



- % denotes that hexadecimal values are used.
- Hexadecimal values are used to represent addresses of files and web pages to improve security.
- A user is protected from accessing a fake website when he is asked to use a hexadecimal URL rather than a URL with letters that could be misleading.

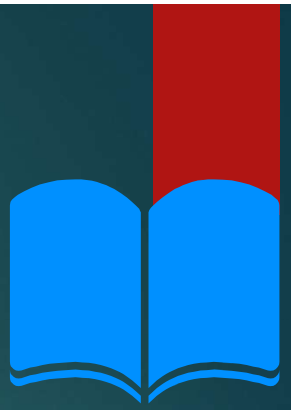
w	w	w	.	g	o	o	g	l	e	.	c	o	m
%77	%77	%77	%2E	%67	%6F	%6F	%67	%6C	%65	%2E	%63	%6F	%6D

Assembly code and machine code



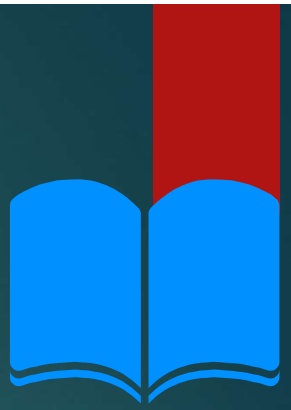
- Machine code and assembly code can be used to refer the computer memory directly.
- Use of hexadecimal numbers makes low-level language coding easier, faster and reduces errors when compared to the binary system.
- For example: An assembly code instruction ADD is translated to machine code as 0100, which is equivalent to 4 in hexadecimal. It is enough for the programmer to type a single digit ‘4’ when compared to four digits ‘0100’.

Hypertext Markup language (HTML)



- HTML is a markup language, widely used in developing web pages.
- It is used to define the attributes of text such as colour. Tags are used to define objects in a web-page.
- For example: The tag is used to define a paragraph. The tag represents its end. The contents between the two are codes.

Hypertext Markup language (HTML)



- The colour codes are also used in html to define objects.

For example:

Welcome to my website.

The colour code FF8000 represents orange colour. The paragraph looks like this:

Welcome to my website.

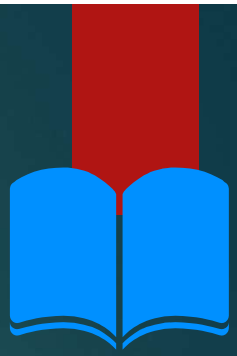
Error-checking methods

- Data is transmitted through a channel, could get corrupted or changed.
- Hence, it's very important to implement error-checking methods in computer technologies. These methods are used to detect and correct errors.
- Types of error-checking methods:
  - ✓ Parity checking
  - ✓ Check digits

Parity checking

- Parity checking uses a parity bit in each byte of data. This bit is allocated before transmission.
- An even parity has an even number of bit 1s in a byte. An odd parity has an odd number of bit 1s in a byte.
- Systems may use even or odd parity.
- The sender and receiver make an agreement prior to the transmission about the type of parity.

Parity checking: Example 1



- In this data, there are 5 bits of 1.

Even parity	1	1	0	1	0	1	1	1
Odd parity	0							
	Parity bit	Data						

- Hence, to make the number of 1 bits even, parity bit is assigned bit 1. The number of bits is odd and hence, the parity bit in odd parity is 0.

Parity checking: Example 2

- Let us consider the following byte of data, which uses even parity, received by a receiver.

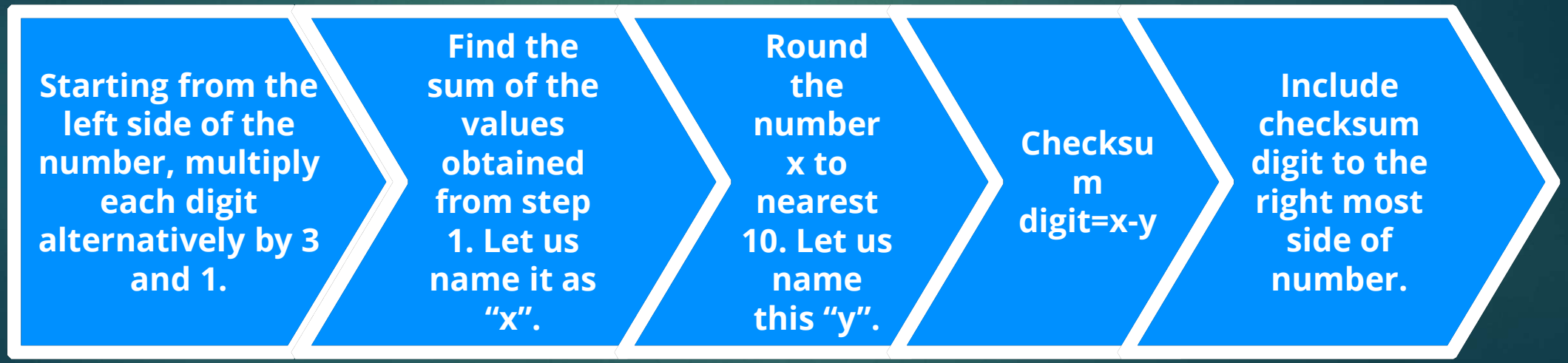
1	0	1	0	1	1	1	0
Parity bit	Data						

- The number of bit 1s is 5 and this indicates transmission error. Some bits have changed during transmission.

Check digits

- In this method, an additional digit is included for every seven digits.
- This bit is calculated using a standard algorithm and is called as checksum digit.

Calculating chemsum digit

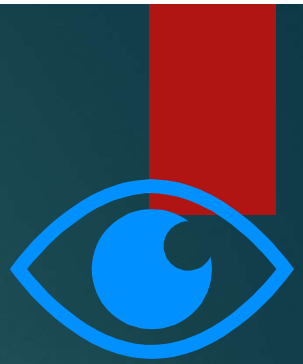


Check digits

- 7 digit code + checksum digit = EAN 8
- EAN is the European Article Numbers and is used for finding checksum digit for barcodes of various products.
- Let us find the EAN 8 form of the number 7325931.

Multiplying digits by 3 and 1	7×3 =21	3×1= 3	2×3= 6	5×1= 5	9×3= 27	3×1= 3	1×3= 3
Sum of the numbers	x= 21 + 3 + 6 + 5 + 27 + 3 + 3 = 68						
Round x to nearest 10	y = 70						
Finding check digit	y – x = 70 – 68 = 2						
EAN 8 number	7	3	2	5	9	3	1	2

Let's review some concepts



Hexadecimal number system

Hexadecimal (or hex) is a system with base 16. Numbers 0-9 and letters A-F are used.

Converting binary to hexadecimal

Split the digits into groups of 4. Add zeros to the leftmost group if necessary. Convert nibbles to hex equivalents.

Converting hexadecimal to binary

Find the 4-bit code for hex digits and write the nibbles together.

Converting denary to hexadecimal

Convert denary number to binary first. Follow necessary steps to find hex equivalent.

Converting hexadecimal to denary

The value of each digit is multiplied with the place value (16^) and the values are added to find the denary equivalent.

Format for representing colours

A colour is represented in #RRGGBB format.

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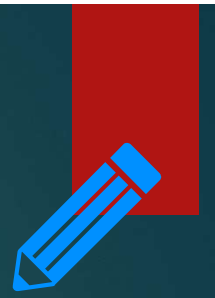
Activities

Activity-1

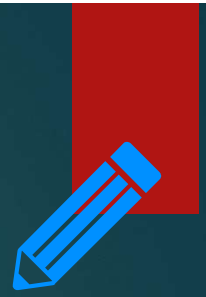
Duration: 15 minutes



1. Convert the denary number 248 to hexadecimal. Show your working.
2. Convert the hexadecimal number A39 to denary. Show your working.

Activity-2

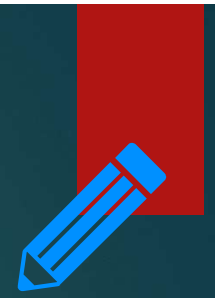
Duration: 10 minutes



1. Calculate the EAN 8 for the number 542 8118. In the table below, specify the steps taken.

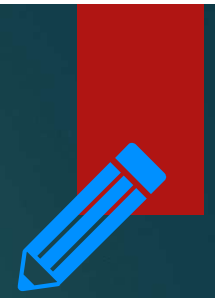
3.

End of topic questions



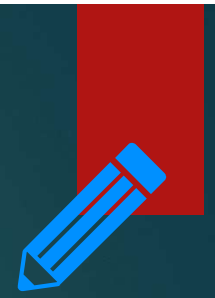
End of topic questions

1. Convert the following binary numbers to hexadecimal.
   a) 10111100
   b) 110011
   c) 1010111001
2. Convert the following hexadecimal numbers to binary.
   a) C5
   b) 34
   c) 1F3
3. What are the advantages of hexadecimal representation of numbers when compared to binary system?



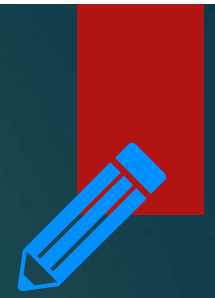
End of topic questions

4. What is MAC address? How can a computer be identified using MAC address?
5. Two number in hexadecimal format are 4A and F6. What is the sum of these numbers?
6. Data sent through a channel is: 1011000. What is the parity bit for this data, if:
   a) Even parity is used?
   b) Odd parity is used?



End of topic questions

7. How is hexadecimal number system used to represent colours? How is this useful in designing HTML web pages?
8. What are the advantages of using hexadecimal addresses for files and web pages?



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