CIS 1102N PORTFOLIO #3

# INTRODUCTION TO NUMBER SYSTEMS

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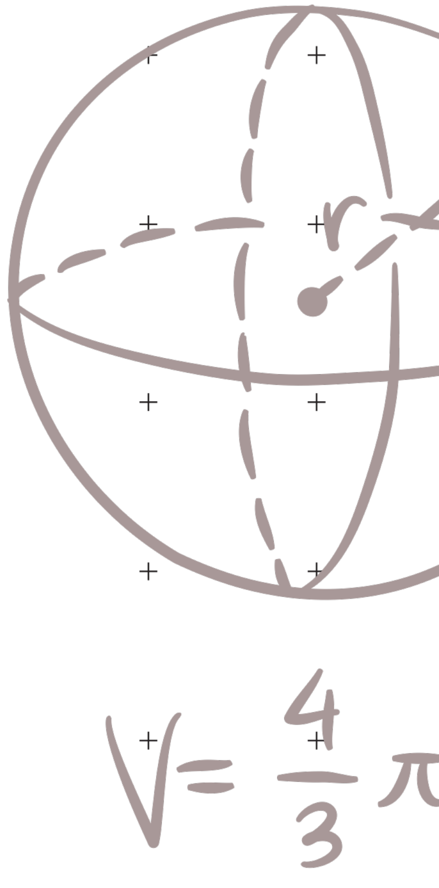
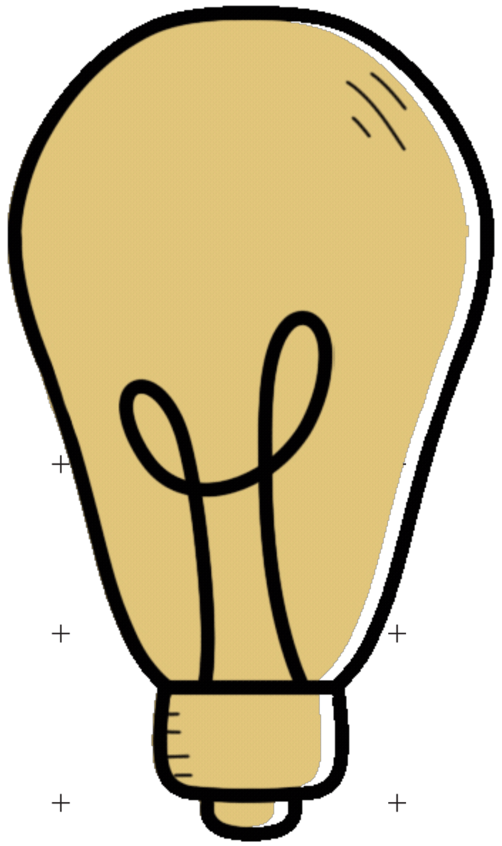
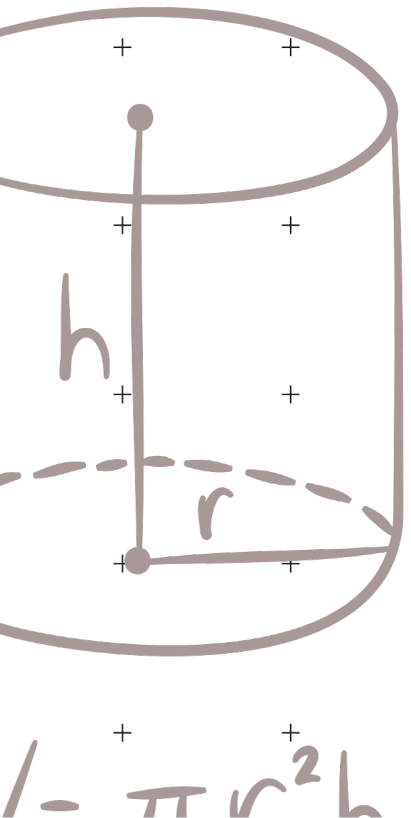
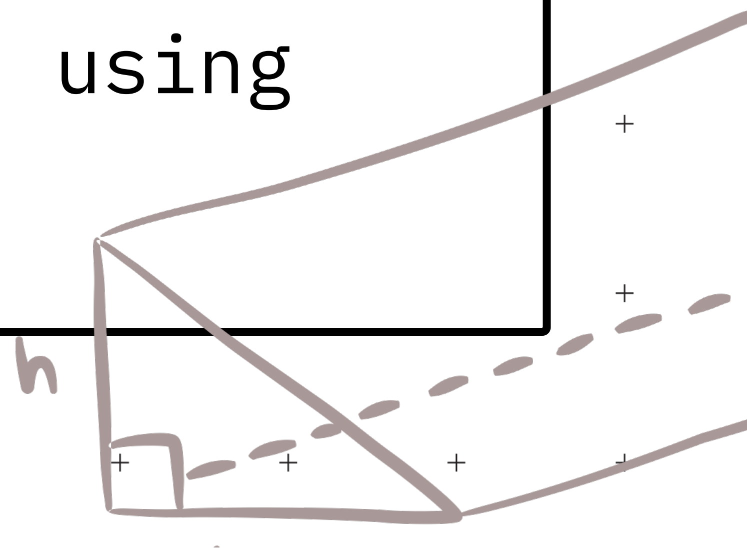




# WHAT ARE NUMBER SYSTEMS?

- A number system is a set of **rules and symbols** used to **represent numbers**
- It encompasses the ways humans reason about numbers, including speech representation, written notation, and the concept of a **number base or radix**
- Mathematically, a numeration system is defined as a **set of integers (basis elements)** that allows unique representation of every integer using bounded-size integer digits
- Various number systems exist beyond the familiar **decimal system**, **including binary, octal, and hexadecimal**, each using different numbers of digits



# WHAT ARE NUMBER SYSTEMS?

- Number systems play a crucial role in **mathematics, computing, and understanding the universe.**
- These systems differ in their base and number of digits, but all build upon the fundamental concept of the decimal system.
- The total number of digits used in a number system is called its **base or radix**. The base is written after the number as subscript; for instance $1000110_2$ (1000110 base 2), $56_{10}$ (56 to base of 10), $71_8$ (71 base 8) etc.
- Understanding different number systems, their representations, arithmetic operations, and interconversion is crucial for **digital device programming and comprehension**.

# TYPES OF NUMBER SYSTEMS

- Binary number system (Base 2)
- Octal number system (Base 8)
- Decimal number system (Base 10)
- Hexadecimal number system (Base 16)

$$x = \frac{-b \pm \sqrt{b^2 -}}{2a}$$

# DECIMAL NUMBER SYSTEM

- “**decimus**” (Latin) => **tenth**
- It uses ten digits **(0-9)** to represent numbers
- The base of decimal number system is 10 ($N_{10}$), because it has only 10 digits.

0 1 2 3 4 5 6 7 8 9

Positional :

$$2945 \neq 2495$$

$$2945 = (2*10^3) + (9*10^2) + (4*10^1) + (5*10^0)$$

# BINARY NUMBER SYSTEM

- “**binarius**” (Latin) => consisting of **two**
- A Binary number system has only two digits, which are **0 and 1**
- The base of binary number system is 2 ($N_2$), because it has only two digits.
- The number system form which the **system/machine accepts**.

**0 1**

Positional : $1010_2 \neq 1100_2$

# BINARY-DECIMAL CONVERSION

- Positional notation: (BINARY TO DECIMAL)

$$1011 = (1*2^3) + (0*2^2) + (1*2^1) + (1*2^0)$$

$$= 8 + 0 + 2 + 1$$

$$= 11$$

# DECIMAL-BINARY CONVERSION

- Determine largest power of 2 ≤ number

$$37 = (?*2^5)+(?*2^4)+(?*2^3)+(?*2^2)+(?*2^1)+(?*2^0)$$

$$37 = (1*2^5)+(0*2^4)+(0*2^3)+(1*2^2)+(0*2^1)+(1*2^0)$$

$$\begin{array}{r} \underline{-32} \\ 5 \\ \underline{-4} \\ 1 \\ \underline{-1} \\ 0 \end{array}$$

# DECIMAL-BINARY CONVERSION

Convert Decimal $13_{10}$ to Binary (Division Method

Divide the decimal number (13) by 2 and record the remainder:

13 ÷ 2 = 6, remainder 1
6 ÷ 2 = 3, remainder 0
3 ÷ 2 = 1, remainder 1
1 ÷ 2 = 0, remainder 1

**Read the remainders from bottom to top: 1101**

**$13_{10}$ = $1101_2$ in binary**

# HEXADECIMAL NUMBER SYSTEM

- **"hexa"** (Greek) => six and **"decimus"** (Latin) => tenth
- The base is 16 ($N_{16}$) because it has 16 alphanumeric values from 0 to 9 and A to F.

**0 1 2 3 4 5 6 7 8 9**
**A B C D E F**

Positional:

$A13D_{16} \neq 3DA1_{16}$

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

# DECIMAL TO HEXADECIMAL

- Hexadecimal to decimal: expand using positional notation

$$
\begin{aligned}
25_{16} &= (2*16^{1}) + (5*16^{0}) \\
&= 32 + 5 \\
&= 37_{10}
\end{aligned}
$$

- Decimal to hexadecimal: use the shortcut

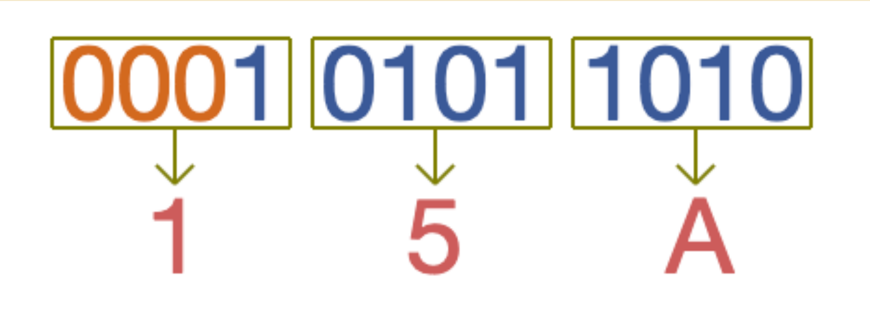
37 / 16 = 2 Remainder: 5

2 / 16 = 0 Remainder: 2

**Read the remainders from bottom to top: $25_{10}$**

# BINARY TO HEXADECIMAL

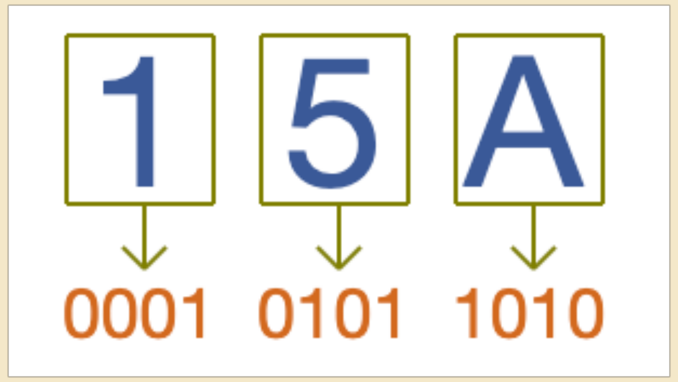
- Every 1 hexadecimal digit corresponds to 4 binary digits
    - $(101011010)_2 = (15A)_{16}$
    - $(0001)_2 = (1)_{16}$
    - $(0101)_2 = (5)_{16}$
    - $(1010)_2 = (A)_{16}$




- Starting from the least significant bit, divide the binary number into groups of four bits and proceed to the left. To complete the leftmost group of bits, we append three zeros to the left.

# HEXADECIMAL TO BINARY

- $(15A)_2 = (000101011010)_8$




- To convert a hexadecimal number to binary, write 4 bit binary equivalent of each hexadecimal digit in the same order.

# DECIMAL NUMBER SYSTEM

- “octo” (Latin) => eight
- The base of octal number system is 8 ($N_8$), because it has only 8 digits from 0 to 7

**0 1 2 3 4 5 6 7**

Positional:

$$1743_8 \neq 7314_8$$

# DECIMAL-OCTAL CONVERSION

Octal to decimal: expand using positional notation

$$37 = (3*8^1) + (7*8^0)$$
$$= 24 + 7$$
$$= 31$$

Decimal to octal: use the shortcut

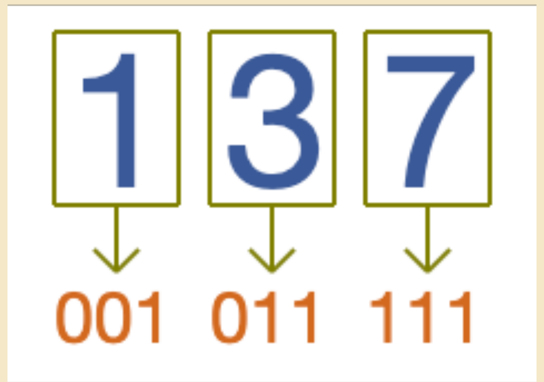
31 / 8 = 3 Remainder: 7
3 / 8 = 0 Remainder: 3

Read from bottom to top:
**37**

# BINARY-OCTAL CONVERSION

- Every 1 octal digit corresponds to 3 binary digits

$$(137)_2 = (001011111)_8$$




To convert an octal number to binary, we write 3 bit binary equivalent of each octal digit in the same order.

**Octal to Binary Table**

MATH MONKS

| Octal (Base 8) | Binary (Base 2) | Octal (Base 8) | Binary (Base 2) |
|---|---|---|---|
| 0 | 000 | 4 | 100 |
| 1 | 001 | 5 | 101 |
| 2 | 010 | 6 | 110 |
| 3 | 011 | 7 | 111 |

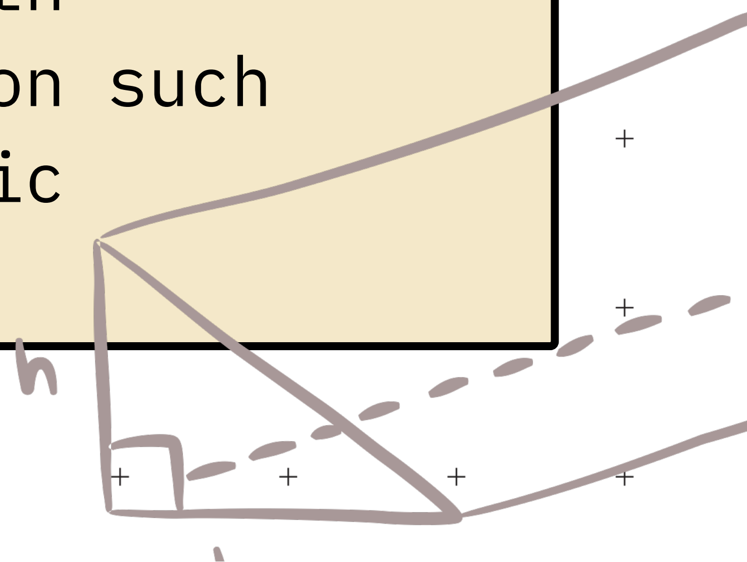
# THEIR USES AND SIGNIFICANCE

## DECIMAL NUMBER SYSTEM

- used in everyday life
- It is the numerical base most widely used by modern civilization
- The decimal number system is the fundamental concept underlying various other number systems used in digital devices.

## BINARY NUMBER SYSTEM

- The binary number system has significant applications in modern computing and digital processing.
- It is widely used for in-machine representation of information and conversion of decimal numbers for digital applications
- Binary codes are employed to represent analog data, with methods for error detection such as parity checks and cyclic redundancy



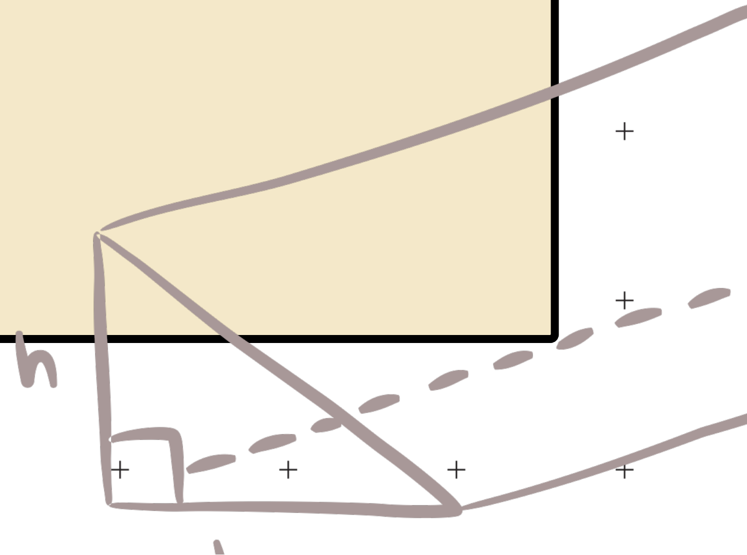
# THEIR USES AND SIGNIFICANCE

## HEX NUMBER SYSTEM

- Used to define locations in memory.
- To define colours on web pages.
- It makes life easier as it allows grouping of binary numbers which makes it easier to read, write and understand.
- It is more human-friendly, as humans are used to grouping together numbers and things for easier understanding.

## OCTAL NUMBER SYSTEM

- Widely used in computer application sectors and digital numbering systems.
- The octal number is also used in the aviation sector in the form of a code.
- It uses fewer digits than the decimal and hexadecimal number system. So, it has fewer computations and less computational errors.



# ANALYSIS/REACTION

As a first-year BS IT student, researching number systems has opened my eyes to how essential these systems are in computing. Before diving into the topic, I had only a vague understanding of what number systems were. Now, I realize that there are multiple types—binary, octal, decimal, and hexadecimal—and each plays a critical role in how computers function.

I've learned that number systems were created specifically to suit computers, which operate differently from how humans use the decimal system in daily life. What fascinates me is how computers, in a way, feel like magic. Behind the scenes, everything from storing data to running programs is all about numbers and math, something I didn't appreciate as much before. Each system is used because it is suited to specific tasks computers need to perform, and slowly, I started to get the hang of it. Another thing that stood out to me is how important math is when it comes to computers. This realization has made me see the importance of mathematics in computing. It made me realize that without understanding these systems, it would be hard to grasp how computers work behind the scenes.

I now understand that every piece of code, every program, is a direct translation of number systems that computers understand. At first, I found the topic confusing and even a bit overwhelming. Converting between binary, octal, and hexadecimal systems felt tricky, but with practice, I started to grasp their significance. I believe learning about these systems will be incredibly useful as I continue my academic journey in BS IT, helping me better understand how computers process and manage data.

# SOURCES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