**Module A.5 – Binary Numbers**

**Level 1: Presentation Notes**

1. Number systems used in Computer Science
   1. List the main features of the Decimal System

Digits: 0,1,2,3,4,5,6,7,8,9

Used for communicating with humans

Base 10

* 1. List the main features of the Binary System  
      Digits: 0,1,2 (On or Off)  
      Binary 10 == 2

Used by internal CPU and Memory Circuits

Base 2

* 1. List the main features of the Octal System  
      Digits: 0,1,2,3,4,5,6,7 (No 8 or 9)  
      Octal 10 == Decimal 8

Used by computer scientists for grouping 3 binary digits

Base 8

* 1. List the main features of the Hexadecimal System  
      Digits: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F (Uses extra digits)

Hex F == Decimal 15

Hex 10 == Decimal 16

Used by computer scientists for groupings of 4 binary digits

Base 16

1. Compare and contrast the Decimal and Binary systems

|  |  |  |
| --- | --- | --- |
| **Criteria** | **Decimal System** | **Binary System** |
| Digits  Used | 0,1,2,3,4,5,6,7,8,9 | 0,1  (True or False)  (= or -) |
| Addition Example | 0+1=1  1+1 = 2  99+=100 | 0+1=1  1+1 = 10  11+=100 |
| Powers of  Base | 100=1  101=10  102=100 | 20=1  21=10 2 Decimal  22=100 4 Decimal |
| Value of  111 | 111 = 102+101+100 | 111 = 22 + 21 +20 |

1. Convert the following binary numbers to decimal:
   1. 11 = 3
   2. 101 = 5
   3. 1010 = 10
2. Convert the following decimal numbers to binary:
   1. 6 = 110
   2. 13 = 1101
3. Add the following binary numbers. (verify your answers using decimal)

|  |  |
| --- | --- |
| a)  0101 5  +0010 +2  --------- ------  0111 7 | b)  0101 5  +1010 +01  --------- ------  1111 15 |
| c)  0011 3  +0010 +2  --------- ------  0101 5 | d)  0110 6  +0011 +3  --------- ------  1001 9 |

1. List the main features of the following Computer Memory Structures:
   1. Bit  
       1 binary digit  
       Used for Boolean data type

Building block for all computer data and memory

* 1. Byte  
      8 binary digit  
      Used for char(character) data type

Largest values is 1111 1111 binary 255 decimal

* 1. Word  
      16 binary digit  
      Largest Value is 1111 1111 1111 1111 65535 Decimal
  2. Integer Data Type  
      1 word  
      But must represent both positive and negative  
      Range (+)32767 to (-)32768
  3. Double Word

32 binary digit (4 bytes or 2 words)

largest value is 4 billion digit

f. Integer data type long

larger range for positive and negative numbers

g. Double Word Memory Accessing

Provides access to 4gb of memory max

**Level 2: Research Questions**

1. The Intel 8085 microprocessor was a first generation processor that was used in many early game systems and personal computers. Google “8085 microprocessor architecture” to answer these questions.
   1. Year Introduced

The Intel 8085 came out in 1976

* 1. Size of data bus (in bits)

8-bit

* 1. Largest data number (in binary and decimal)

1111 1111 binary 255 decimal

* 1. Size of address bus (in bits)

16-bit address bus

* 1. Largest memory address (in binary and decimal)

1111 1111 1111 1111 binary 65536 decimal

1. The Intel 8086 microprocessor was the processor used in the first IBM PCs running the DOS operating system. Google “8086 microprocessor architecture” to answer these questions.
   1. Year Introduced

The 8086 released in 1978

* 1. Size of data bus (in bits)

8-bit

* 1. Largest data number (in decimal)

255 decimal

* 1. Size of address bus (in bits)

20-bit address bus

* 1. Largest memory address (in decimal)

1048576 decimal

1. The Intel 80286 microprocessor a common processor used in IBM PCs running the Windows operating system. Google “80286 microprocessor architecture” to answer these questions.
   1. Year Introduced
   2. 1982
   3. Size of data bus (in bits)

16-bit data bus

* 1. Largest data number (in decimal)

65536 decimal

* 1. Size of address bus (in bits)

24-bit address bus

* 1. Largest memory address (in decimal)

16777216 decimal

1. The modern PCs run either a 32 bit or 64 bit Windows operating system. Google “32 vs 64 bit” to answer these questions.
   1. How do these systems differ in data capacity? (explain using bits)

A 32-bit register can store 232 different values. A 64-bit register can store 264 different values.

* 1. How do these systems differ in memory capacity? (explain using bits)

A 32 bit processor holds 4gb of memory at maximum. A 64 bit processor can hold up to 2TB of memory.

* 1. How do these systems differ in hardware requirements?

32 bit operating systems require 32 bit processors and to install a 64 bit operating system requires a 64 bit processor.

1. Research and explain how negative (-) numbers are represented using bits and how they are stored in computer memory.  
    Negative numbers are stored using complement.
2. Research and explain how floating point (decimal) numbers are represented using bits and how they are stored in computer memory.

The computer memory is organized into strings of bits called words of same length. Decimal numbers are first converted into their binary equivalents and then are represented in either integer or floating point form.

**Level 3: Sample Program**

number = input("Enter a 4 digit decimal number:")

index = 0

for char in number :

index += 1

print("Digit ", index, " is : ", char)

1. Modify the following sample Python program to print out the digits in:
   1. Binary

number = input("Enter a 4 digit decimal number:")

index = 0

for char in number :

index += 1

bin(index)

print("Digit ", bin(index), " is : ", char)

* 1. Octal

number = input("Enter a 4 digit decimal number:")

index = 0

for char in number :

index += 1

oct(index)

print("Digit ",oct(index), " is : ", char)

* 1. Hexadecimal

number = input("Enter a 4 digit decimal number:")

index = 0

for char in number :

index += 1

hex(index)

print("Digit ", hex(index), " is : ", char)