Unit 1 Section 1 : Binary Numbers

We normally work with numbers in base 10. In this section we consider numbers in *base 2*, often called *binary numbers*.

In *base 10* we use the digits 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9.

In *base 2* we use only the digits 0 and 1.

Binary numbers are at the heart of all computing systems since, in an electrical circuit, 0 represents *no* current flowing whereas 1 represents a current flowing.

In *base 10* we use a system of place values as shown below:

1000	100	10	1		
4	2	1	5	$\rightarrow$	$4 \times 1000 + 2 \times 100 + 1 \times 10 + 5 \times 1$
3	1	0	2	$\rightarrow$	$3 \times 1000 + 1 \times 100 + 2 \times 1$

Note that, to obtain the place value for the next digit to the left, we multiply by 10. If we were to add another digit to the front (left) of the numbers above, that number would represent 10 000s.

In *base 2* we use a system of place values as shown below:

64	32	16	8	4	2	1		
1	0	0	0	0	0	0	$\rightarrow$	$1 \times 64 = 64$
1	0	0	1	0	0	1	$\rightarrow$	$1 \times 64 + 1 \times 8 + 1 \times 1 = 73$

Note that the place values begin with 1 and are multiplied by 2 as you move to the left.

Once you know how the place value system works, you can convert binary numbers to base 10, and vice versa.

Example 1

Convert the following binary numbers to base 10:

(a) 111 **4 + 2 + 1 = 7**

(b) 101 **4 + 1 = 5**

(c) 1100110 — 64 + 32 + 4 + 2 = 102

Example 2

Convert the following base 10 numbers into binary numbers:

(a) 3 — 3 = 2 + 1 → 1 1

(b) 11 — 11 = 8 + 2 + 1 → 1 0 1 1

(c) 140 — 140 = 128 + 8 + 4 → 1 0 0 0 1 1 0 0

Question 1

Convert the following binary numbers to base 10:

(a) 110

(b) 1111

(c) 1001

(d) 1101

(e) 10001

(f) 11011

(g) 1111111

(h) 1110001

(i) 10101010

(j) 11001101

(k) 111000111

(l) 1100110

Question 2

Convert the following base 10 numbers to binary numbers:

(a)	9	
(b)	8	
(c)	14	
(d)	17	
(e)	18	
(f)	30	
(g)	47	
(h)	52	
(i)	67	
(j)	84	
(k)	200	
(l)	500	

Question 3

Convert the following base 10 numbers to binary numbers:

(a) 5

(b) 9

(c) 17

(d) 33

What will be the next base 10 number that will fit this pattern?

Question 4

Convert the following base 10 numbers to binary numbers:

(a) 3

(b) 7

(c) 15

(d) 31

What is the next base 10 number that will continue your binary pattern?

Question 5

A particular binary number has 3 digits.

(a) What are the *largest* and *smallest* possible binary numbers?

largest: smallest:

(b) Convert these numbers to base 10.

largest: smallest:

Question 6

When a particular base 10 number is converted it gives a 4-digit binary number. What could the original base 10 number be?

Write the numbers as a list. e.g. 21, 22, 23, etc

Question 7

A 4-digit binary number has 2 zeros and 2 ones.

List the numbers separated by commas. e.g. 21, 22, 28, 30

(a) List all the possible binary numbers with these digit

(b) Convert these numbers to base 10

Question 8

A binary number has 8 digits and is to be converted to base 10.

(a) What is the *largest* possible base 10 answer?

(b) What is the *smallest* possible base 10 answer?

Question 9

The base 10 number 999 is to be converted to binary. How many more digits does the binary number have than the number in base 10?

Question 10

Calculate the difference between the base 10 number 11111 and the binary number 11111, giving your answer in base 10.