UNIT –III

1	**a**	Discuss various number systems of a computer.	[L2][CO6]	**[8M]**

Answer:

Explanation – 6M

When we type some letters or words, the computer translates them in numbers as computers can understand only numbers. A computer can understand the positional number system where there are only a few symbols called digits and these symbols represent different values depending on the position they occupy in the number.

The value of each digit in a number can be determined using −

- The digit
- The position of the digit in the number
- The base of the number system (where the base is defined as the total number of digits available in the number system)

Decimal Number System

The number system that we use in our day-to-day life is the decimal number system. Decimal number system has base 10 as it uses 10 digits from 0 to 9. In decimal number system, the successive positions to the left of the decimal point represent units, tens, hundreds, thousands, and so on.

Each position represents a specific power of the base (10). For example, the decimal number 1234 consists of the digit 4 in the units position, 3 in the tens position, 2 in the hundreds position, and 1 in the thousands position. Its value can be written as

(1 x 1000)+ (2 x 100)+ (3 x 10)+ (4 x l)

$(1 \times 10^3)+ (2 \times 10^2)+ (3 \times 10^1)+ (4 \times l0^0)$

1000 + 200 + 30 + 4

1234

Binary Number System

Characteristics of the binary number system are as follows −

- Uses two digits, 0 and 1
- Also called as base 2 number system
- Each position in a binary number represents a **0** power of the base (2). Example 2^0
- Last position in a binary number represents a **x** power of the base (2). Example 2^x where **x** represents the last position - 1.

Example

Binary Number: 10101_2

Calculating Decimal Equivalent −

Step	Binary Number	Decimal Number
Step 1	10101_2	$((1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0))_{10}$
Step 2	10101_2	$(16 + 0 + 4 + 0 + 1)_{10}$
Step 3	10101_2	21_{10}

Octal Number System

Characteristics of the octal number system are as follows −

- Uses eight digits, 0,1,2,3,4,5,6,7
- Also called as base 8 number system
- Each position in an octal number represents a **0** power of the base (8). Example 8^0
- Last position in an octal number represents a **x** power of the base (8). Example 8^x where **x** represents the last position - 1

Example

Octal Number: 12570_8

Calculating Decimal Equivalent –

Step	Octal Number	Decimal Number
Step 1	12570_8	$((1 \times 8^4) + (2 \times 8^3) + (5 \times 8^2) + (7 \times 8^1) + (0 \times 8^0))_{10}$
Step 2	12570_8	$(4096 + 1024 + 320 + 56 + 0)_{10}$
Step 3	12570_8	5496_{10}

Hexadecimal Number System

Characteristics of hexadecimal number system are as follows −

- Uses 10 digits and 6 letters, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- Letters represent the numbers starting from 10. A = 10. B = 11, C = 12, D = 13, E = 14, F = 15
- Also called as base 16 number system
- Each position in a hexadecimal number represents a **0** power of the base (16). Example, 16^0
- Last position in a hexadecimal number represents a **x** power of the base (16). Example 16^x where **x** represents the last position - 1

Example

Hexadecimal Number: $19FDE_{16}$

Calculating Decimal Equivalent –

Step	Binary Number	Decimal Number
Step 1	$19FDE_{16}$	$((1 \times 16^4) + (9 \times 16^3) + (F \times 16^2) + (D \times 16^1) + (E \times 16^0))_{10}$
Step 2	$19FDE_{16}$	$((1 \times 16^4) + (9 \times 16^3) + (15 \times 16^2) + (13 \times 16^1) + (14 \times 16^0))_{10}$
Step 3	$19FDE_{16}$	$(65536 + 36864 + 3840 + 208 + 14)_{10}$
Step 4	$19FDE_{16}$	106462_{10}

	b	Tabulate the numbers up to 15 which can be represented in base-2, base-8, base 10 and base -16.	[L2][CO4]	**[4M]**

Answer:

Table -4M

Base - 2	Base - 8	Base - 10	Base - 16
0000	0	0	0
0001	1	1	1
0010	2	2	2
0011	3	3	3
0100	4	4	4
0101	5	5	5
0110	6	6	6
0111	7	7	7
1000	10	8	8
1001	11	9	9
1010	12	10	A
1011	13	11	B
1100	14	12	C
1101	15	13	D
1110	16	14	E
1111	17	15	F

2	**a**	Compute the power of each digit for five-digit numbers in base 6.	[L3][CO4]	**[2M]**

Answer:

Calculation – 2M

The power of each digit in any number of base 6 is depending on their positions. Traverse each digit from right to left.

5th Digit	4th Digit	3rd Digit	2nd Digit	1st Digit
6^4 = 1296	6^3 = 216	6^2 = 36	6^1 = 6	6^0 = 1

	b	Use your results from part (a) to convert the base 6 number $(24531)_6$ to decimal.	[L3][CO4]	**[4M]**

Answer:

Calculation -2M
Result -2M

$(2\ 4\ 5\ 3\ 1)_6$

$1x6^0=1$

$3x6^1=18$

$5x6^2=180$

$4x6^3=864$

$2x6^4=2592$

$(3655)_{10}$

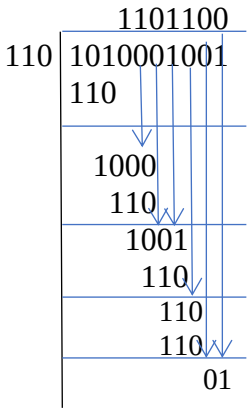
	c	Some older computers used an 18-bit word to store numbers. Calculate, what is the decimal range for this word size?	[L3][CO4]	**[2M]**
	Answer: **Result -2M** 18 Binary digits have decimal range 2^{18} = $(262144)_{10}$ or $(1000000)_8$ or $(40000)_{16}$			
	d	Calculate how many bits will it take to represent the decimal number 3,175,00 and how many bytes will it take to store this number?	[L3][CO4]	**[4M]**
	Answer: **Explanation -1M** **Calulation & Result – 3M** Divide the number 3,175,000 by the base of 2. **(Do the division and write the answer)** The binary bits are $(11\ 0000\ 0111\ 0010\ 0101\ 1000)_2$ As we know that 8 binary bits = 1 byte and $(11\ 0000\ 0111\ 0010\ 0101\ 1000)_2$ has 22 bits. Hence it requires minimum 3 bytes to store this number			
3	**a**	Infer the values after multiplying the following binary numbers: (i) 1101 × 101 (ii) 11011 × 1011	[L4][CO6]	**[6M]**
	Answer: **Calulation & Result (each 4M) – 8M** (i) 1101 × 101 = 1101, 0000x, 1101xx = **1000001** Result: $(1000001)_2$ (ii) 11011 × 1011 = 11011, 11011x, 00000xx, 11011xxx = **100101001** Result: $(100101001)_2$			

	b	Show the results after performing the following binary divisions: (i). 1010001001 by 110 (ii). 11000000000 by 1011	[L3][CO6]	**[6M]**

Answer:

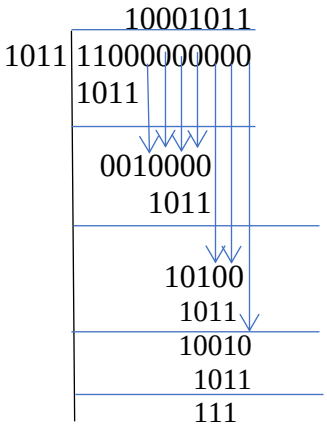
Caluation 2M each
Result 1M each

(i).1010001001 by 110



Quotient: $(1101100)_2$
Remainder: $(01)_2$

(ii). 11000000000 by 1011



Quotient: $(10001011)_2$
Reminder : $(111)_2$

4	**a**	Create addition and multiplication tables for base 12 arithmetic. Use alphabetic characters to represent digits 10 and larger	[L6][CO4]	**[4M]**

Answer:

EACH TABLE – 2M

(i).Multiplication Table for Base 12

*	0	1	2	3	4	5	6	7	8	9	A	B
0	0	1	2	3	4	5	6	7	8	9	A	B
1	0	1	2	3	4	5	6	7	8	9	A	B
2	0	2	4	6	8	A	10	12	14	16	18	1A
3	0	3	6	9	10	13	16	19	20	23	26	29
4	0	4	8	10	14	18	20	24	28	30	34	38
5	0	5	A	13	18	21	26	2A	34	39	42	47
6	0	6	10	16	20	26	30	36	40	46	50	56
7	0	7	12	19	24	2B	36	41	48	53	5A	65
8	0	8	14	20	28	34	40	48	54	60	68	74
9	0	9	16	23	30	39	46	53	60	69	76	83
A	0	A	18	26	34	42	50	5A	68	76	84	92
B	0	B	1A	29	38	47	56	65	74	83	92	A1

(ii). Addition Table for Base 12

+	0	1	2	3	4	5	6	7	8	9	A	B
0	0	1	2	3	4	5	6	7	8	9	A	B
1	1	2	3	4	5	6	7	8	9	A	B	10
2	2	3	4	5	6	7	8	9	A	B	10	11
3	3	4	5	6	7	8	9	A	B	10	11	12
4	4	5	6	7	8	9	A	B	10	11	12	13
5	5	6	7	8	9	A	B	10	11	12	13	14
6	6	7	8	9	A	B	10	11	12	13	14	15
7	7	8	9	A	B	10	11	12	13	14	15	16
8	8	9	A	B	10	11	12	13	14	15	16	17
9	9	A	B	10	11	12	13	14	15	16	17	18
A	A	B	10	11	12	13	14	15	16	17	18	19
B	B	10	11	12	13	14	15	16	17	18	19	1A

b	Apply the values from part (a) tables, and calculate the results for the following addition: $(25A84)_{12}$ $+ (70396)_{12}$	[L4][CO6]	**[4M]**

Answer:

RESULT – 4M

$(25A84)_{12}$
$+ (70396)_{12}$
$9625A$

Result : $(9625A)_{12}$

c	Apply the values from part (a) tables, and calculate the results for the following multiplication: $(2A6)_{12}$ $x (B1)_{12}$	[L4][CO6]	**[4M]**

Answer:

RESULT – 4M

$(2\ A\ 6)_{12}$
$x (B\ 1)_{12}$

2 A 6
2 7 7 6 x

2 7 A 4 6

Result: $(27A46)_{12}$

5	**a**	Show the results after performing the following binary additions: (i) 101101101 + 10011011 (ii) 110111111 + 110111111 (iii) 11010011 + 10001010 (iv) 1101, 1010, 111, + 101	[L3][CO6]	**[8M]**

Answer:

EACH RESULT – 2M

(i)

101101101
+ 10011011
1000001000 Result : $(1000001000)_2$

(ii)

110111111
+ 110111111
1101111110 Result : $(1101111110)_2$

(iii)

11010011
+ 10001010
101011101 Result : $(101011101)_2$

(iv)

1101
1010
111
+ 101
100011 Result : $(100011)_2$

	b	Use the results obtained from (i), (ii), (iii) & (iv) of 5(a) part and convert them to hexadecimal and decimal numbers.	[L2][CO4]	**[4M]**

Answer:

EACH RESULT – 1M

(i). $(10\ 0000\ 1000)_2 = (2\ 0\ 8)_{16} = (520)_{10}$

(ii). $(11\ 0111\ 1110)_2 = (3\ 7\ E)_{16} = (894)_{10}$

(iii). $(1\ 0101\ 1101)_2 = (1\ 5\ D)_{16} = (349)_{10}$

(iv). $(100011)_2 = (23)_{16} = (35)_{10}$

6	**a**	Using the powers of each digit in base 8, convert the decimal number $(6026)_{10}$ to octal.	[L2][CO4]	**[3M]**

Answer:

RESULT – 3M

Step1: convert the decimal number to octal by dividing the base 8

8 | 6026
8 | 753 -2
8 | 94 -1
8 | 11 -6
8 | 1 -3

Step2: Read the remainders from bottom to get answer

Answer**: $(13612)_8$**

	b	Using the powers of each digit in hexadecimal, convert the decimal number $(6026)_{10}$ to hexadecimal.	[L2][CO4]	**[3M]**

Answer:

RESULT – 3M

Step1: convert the decimal number to Hexadecimal number by dividing base 16

16 | 6026
16 | 376 -10
16 | 23 -8
1 -7

Step2: Read the remainders from bottom to get answer

Answer : **$(178\ 10)_{16}$ = $(178A)_{16}$**

	c	Calculate the decimal value of the following binary numbers (i) $(1100101.1)_2$ (ii) $(1110010.11)_2$ (iii) $(11100101.1)_2$	[L4][CO4]	**[6M]**

Answer:

EACH RESULT – 2M

Convert the Binary number to decimal number by multiplying base 2 power of each digits

i). $(1100101.1)_2$

$=1*2^6+ 1*2^5+ 0*2^4+ 0*2^3+ 1*2^2+ 0*2^1+ 1*2^0+ 1*2^{-1}$

$= 64 + 32 + 4 + 1 + 0.5$

$= \mathbf{(101.5)_{10}}$

(ii) $(1110010.11)_2$

$=1*2^6+ 1*2^5+ 1*2^4+ 0*2^3+ 0*2^2+ 1*2^1+ 0*2^0+ 1*2^{-1}+1*2^{-2}$
$= 64 +32 +16 + 2 +0.5 + 0.25$
$=$ **$(114.75)_{10}$**

(iii) $(11100101.1)_2$

$=1*2^7+1*2^6+ 1*2^5+ 0*2^4+ 0*2^3+ 1*2^2+ 0*2^1+ 1*2^0+ 1*2^{-1}$
$= 128 +64 + 32 + 4 + 1 + 0.5$
$=$ **$(229.5)_{10}$**

7	**a**	Using the division method, convert the following decimal numbers: (i) $(13750)_{10}$ to base 12 (ii) $(6026)_{10}$ to hexadecimal (iii) $(3175)_{10}$ to base 5	[L2][CO4]	**[6M]**

Answer:

EACH RESULT – 2M

(i) $(13750)_{10}$ to base 12

Step1: convert the decimal number to Duo binary number by dividing base 12

12	13750	
12	1145	-10
12	95	-5
12	7	-11

Answer : $(7\ 11\ 5\ 10)_{12}$

(ii) $(6026)_{10}$ to hexadecimal

Step1: convert the decimal number to Hexadecimal number by dividing base 16

16	6026	
16	376	-10
16	23	-8
	1	-7

Answer : $(178\ 10)_{16} = (178A)_{16}$

(ii) $(3175)_{10}$ to base 5

Step1: convert the decimal number to Base 5 number by dividing base 5

5	3175	
5	635	-0
5	127	-0
5	25	-2
	5	-0
	1	-0

Answer : $(100200)_5$

	b	Convert the following numbers from their given base to decimal: (i) $(0.1001001)_2$ (ii) $(0.3A2)_{16}$ (iii) $(0.2A1)_{12}$	[L2][CO4]	**[6M]**

Answer:

EACH RESULT – 2M

(i) $(0.1001001)_2$

Step1: convert the Binary number to decimal number by multiplying base 2 power of each digits

$$= 1*2^{-1} +0*2^{-2} +0*2^{-3} +1*2^{-4}+0*2^{-5} +0*2^{-6}+1*2^{-7}$$
$$= 0.5 + 0.0625 + 0.007$$
$$= (0.5703125)_{10}$$

(i) $(0.3A2)_{16}$

Step1: convert the Hexadecimal number to decimal number by multiplying base 16 power of each digits

$$= 3 * 16^{-1} + A(10) * 16^{-2} + 2 * 16^{-2}$$
$$= 3 * 0.025 + A * 0.03906 + 2 * 0.0002441$$
$$= (0.22704)_{10}$$

(ii) $(0.2A1)_{12}$

Step1: convert the Duo binary number to decimal number by multiplying base 12 power of each digits

$$= 2 * 12^{-1} + A(10) * 12^{-2} + 1 * 12^{-2}$$
$$= 2 * 0.0833 + A * 0.006944 + 1 * 0.0005787$$
$$= (0.2366187)_{10}$$

8	**a**	Convert the following numbers from decimal to binary and then to hexadecimal: (i) $(27.625)_{10}$ (ii) $(4192.37761)_{10}$	[L2][CO4]	**[8M]**

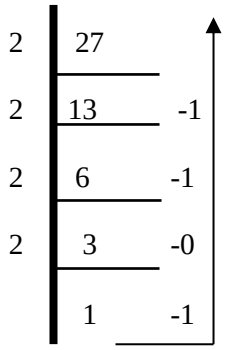
Answer:

EACH RESULT – 4M

(i) $(27.625)_{10}$

Step 1: convert the decimal number to binary by dividing base 2 for integer and for decimal fraction by multiplying with the base 2 of each fractions

$(27.625)_{10}$



Integer Answer $(11011)_2$

Fraction	Fraction * 2	Reminder New Fraction	Integer
0.625	0.625 * 2 = 1.250	0.250	1 (MSB)
0.250	0.250 * 2 = 0.500	0.500	0
0.500	0.500 * 2 = 0.000	0.000	1(LSB)

Fractional Answer is - $(101)_2$

Therefore the final Answer is $(11011.101)_2$

Step 2:convert the binary number to Hexadecimal by splitting into 4 digits from LSB onwards

$(11011.101)_2$

For integers, splitting starts from LSB and For decimal fraction splitting starts from MSB onwards

0001 1011 . 1010 = $(1\ B\ .\ A\ )_{16}$

(ii) $(4192.37761)_{10}$

Step 1: convert the decimal number to binary by dividing base 2 for integer and for decimal fraction by multiplying with the base 2 of each fractions

Integer Answer $(1000001100000)_2$

Fraction	Fraction * 2	Reminder New Fraction	Integer
0.37761	0.37761 * 2 = 0.75522	0.7552	0
0.75522	0.75522 * 2 = 1.51044	0.51044	1
0.51044	0.51044 * 2 = 1.02088	0.02088	1
0.02088	0.02088 * 2 = 0.04176	0.04176	0

Fractional Answer $(0110)_2$

Therefore the Answer is $(1000001100000.011000)_2$

Step 2:convert the binary number to Hexadecimal by splitting into 4 digits from LSB onwards

$(1000001100000.011000)_2$

For integers, splitting starts from LSB and For decimal fraction splitting starts from MSB onwards

0001 0000 0110 0000 . 0110 0000 = $(1\ 0\ 6\ 0\ .\ 6\ 0\ )_{16}$

b	Convert the octal number $(27745)_8$ to hexadecimal without using decimal as an intermediary for the conversion.	[L2][CO4]	**[2M]**

Answer:

RESULT – 2M

Step1 : convert the given octal to binary number by assigning 3 equivalent binary bits for each decimal digit.

$(27745)_8$ = (010 111 111 010 101) 2

Step 2: convert the obtained binary numbers to octal by splitting the 3bits from LSB onwards to decimal equivalent

(010 111 111 010 101) 2 = 2 15 14 5 = (2 F E 5)16

c	Convert the base 3 number $(210102)_3$ to octal.	[L2][CO4]	**[2M]**

Answer:

RESULT – 2M

Step 1: convert the base 3 number to decimal by multiplying with base 3 power of each digit and then decimal to octal by dividing by base 8

$210102 = 2 * 3^5 + 1 * 3^4 + 0 * 3^3 + 1 * 3^2 + 0 * 3^1 + 2 * 3^0 = 486 + 81 + 9 + 2 = 578$

8 | 578

8 | 72 -2

8 | 9 -0

8 1 -0

Answer = $(1002)_8$

9

a	Convert the following hexadecimal numbers to binary: (i) $(4F6A)_{16}$ (ii) $(9902)_{16}$ (iii) $(A3AB)_{16}$	[L2][CO4]	**[6M]**

Answer:

EACH RESULT – 2M

Step : convert the given Hexadecimal number to binary by assigning 4 equivalent binary bits for each Hexa decimal digit.

(i) $(4F6A)_{16}$ = (0100 1111 0110 1010)2

(ii) $(9902)_{16}$ = (1001 1001 0000 0010)2

(iii) $(A3AB)_{16}$ = (1010 0011 1010 1011)2

	b	Convert the following binary numbers directly to hexadecimal: (i) $(101101110111010)_2$ (ii) $(1111111111110001)_2$ (iii) $(110001100011001)_2$	[L2][CO4]	**[6M]**

Answer:

EACH RESULT – 2M

Step :Splitting the given binary numbers of 4 digits from LSB onwards to the hexa deicmal equivalent

(i) $(101\ 1011\ 1011\ 1010)_2$ = $(5\ B\ B\ A)_{16}$

(ii) $(1111\ 1111\ 1111\ 0001)_2$ = $(\ F\ F\ F\ 1)_{16}$

(iii). $(110\ 0011\ 0001\ 1001)_2$ = $(6\ 3\ 1\ 9\ )_{16}$

10

	a	Using the multiplication method, convert the following numbers to decimal: (i) $(1100010100100001)_2$ (ii) $(C521)_{16}$ (iii) $(3ADF)_{16}$ (iv) $(24556)_7$	[L2][CO4]	**[8M]**

Answer:

EACH RESULT – 2M

Convert the given binary number to decimal by multiplying the base 2 power of each digit

(i) $(1100010100100001)_2$ = $1*2^{15} + 1*2^{14} + 0*2^{13} + 0*2^{12} + 0*2^{11} + 1*2^{10} + 0*2^9 + 1*2^8 + 0*2^7 + 0*2^6 + 1*2^5 + 0*2^4 + 0*2^3 + 0*2^2 + 0*2^1 + 1*2^0$ = **$(50465)_{10}$**

Convert the given number to decimal by multiplying the base 16 power of each digit

(ii) $(C521)_{16}$ = $C(12)*16^3 + 5*16^2 + 2*16^1 + 1*16^0$

= $(50465)_{10}$

Convert the given number to decimal by multiplying the base 16 power of each digit

(iii). $(3ADF)_{16}$ = $3*16^3 + A(10)*16^2 + D(13)*16^1 + F*16^0$

= $(15071)_{10}$

Convert the number to decimal by multiplying the base 7 power of each digit

(iv) $(24556)_7$ = $2*7^4 + 4*7^3 + 5*7^2 + 5*7^1 + 6*7^0$

= $(6460)_{10}$

	b	Convert $(0.12201)_3$ to base 10.	[L2][CO4]	**[2M]**

Answer:

RESULT – 2M

Convert the given number to decimal of base 10 by multiplying the each given digit with power of 3

$0.12201 = 1*3^{-1} + 2*3^{-2} + 2*3^{-3} + 0*3^{-4} + 1*3^{-5}$ = $(\ 0.63374\ )_{10}$

	c	Convert $(0.828125)_{10}$ to base 2.	[L2][CO4]	**[2M]**

Answer:

RESULT – 2M

Convert the decimal fraction by multiplying with the base 2 of each fractions

Fraction	**Fraction * 2**	**Reminder New Fraction**	**Integer**
0.828125	1.65625	0.65625	1
0.65625	1.3125	0.315	1
0.315	0.6875	0.6875	0
0.6875	1.350	0.3750	1
0.3750	0.7500	0.7500	0
0.7500	1.5000	0.5000	1
0.5000	1.0000	0.0000	1

Answer $(0.1101011)_2$