LAB 1

1. Convert the following numbers from the base shown to base 10.

a. 1100101112

=1\*28 + 1\*27 + 0\*26 + 0\*25 + 1\*24 + 0\*23 + 1\*22 + 1\*21 + 1\*20

=256 + 128 + 0 + 0 + 16 + 0 + 4 +2 +1

=40710

b. 110110101012

= 1\*210 + 1\*29 + 0\*28 + 1\*27 + 1\*26 + 0\*25 + 1\*24 + 0\*23 + 1\*22 + 0\*21 + 1\*20

= 1024 + 512 + 128 + 64 + 16 + 4 + 1

= 174910

c. 35718

= 3\*83 + 5\*82 + 7\*81 + 1\*80

= 1536 + 320 + 56 + 1

= 191310

d. 124748

= 1\*84 + 2\*83 + 4\*82 +7\*81 + 4\*80

= 4096 + 1024 + 256 + 56 +4

= 543610

e. A89114

= 10\*143 + 8\*142 +9\*141 + 1\*140

= 27440 + 1568 + 126 + 1

= 2913510

f. 278D16

= 2\*163 + 7\*162 + 8\*161 + 13\*160

= 4096 + 1792 + 128 + 13

=602910

2. Convert the following numbers from decimal to binary, octal, and hexadecimal. Show the quotient and remainder at each step of the division algorithm for octal and hexadecimal. For binary, you may use the shortcut method.

a. 87010

* In Binary

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Power of 2 | 512 | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Quotient | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| Remainder | 358 | 102 | 102 | 38 | 6 | 6 | 6 | 2 | 0 |  |
| Number in Binary |  | 11011001102 | | | | | | | | |

* In octal

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Quotient | 108 | 13 | 1 | 0 |
|  | 8|870 | 8|108 | 8|13 | 8|5 |
| Remainder | 6 | 4 | 5 | 5 |

Number in octal becomes 55468

* In Hexadecimal

|  |  |  |  |
| --- | --- | --- | --- |
| Quotient | 54 | 3 | 0 |
|  | 16|870 | 16|54 | 16|3 |
| Remainder | 6 | 6 | 3 |

Number in hexadecimal becomes 36616

b. 383410

* In Binary

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Power of 2 | 2048 | 1024 | 512 | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Quotient | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 |
| Remainder | 1786 | 762 | 250 | 250 | 122 | 58 | 26 | 10 | 2 | 2 | 0 |  |
| Number in Binary | 1110111110102 | | | | | | | | |  | | |

* In Octal

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Quotient | 479 | 59 | 7 | 0 |  |
|  | 8|3834 | 8|479 | 8|59 | 8|7 |
| Remainder | 2 | 7 | 3 | 7 |

Number in Octal becomes 73728

* In Hexadecimal

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Quotient | 239 | 14 | 0 |  |
|  | 16|3834 | 16|239 | 16|14 |
| Remainder | 10 | 15 | 14 |

Number in hexadecimal becomes EFA16

3. Convert the following numbers from the base shown to binary.

a. 43628

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number in octal | 4 | 3 | 6 | 2 |
| Equivalent in binary | 100 | 011 | 110 | 010 |
| Number in Binary | 1000111100102 | | | |

b. C3B816

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Number in hex | C | 3 | B | 8 |  |
| Equivalent in binary | 1100 | 0011 | 1011 |  |
| Number in Binary | 1100001110112 | | | |

4. Convert the following numbers from binary to octal and hexadecimal.

a. 10101011102

* To octal

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number in binary | 10101011102 | | | |
| Group of 3 digits | 001 | 010 | 101 | 110 |
| Equi. In Decimal | 1 | 2 | 5 | 6 |
| Number in octal | 12568 | | | |

* To hexadecimal

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number in binary | 10101011102 | | |  |
| Group of 4 digits | 10 | 1010 | 1110 |
| Equi. In Decimal | 2 | A | E |
| Number in hex | 2AE16 | | |

b. 1010100111002

* To octal

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Number in binary | 1010100111002 | | | | |
| Group of 3 digits | 101 | 010 | 011 | 100 |  |
| Equi. In Decimal | 5 | 2 | 3 | 4 |  |
| Number in octal | 52348 | | | | |

* To hexadecimal

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number in binary | 1010100111002 | | |  |
| Group of 3 digits | 1010 | 1001 | 1100 |
| Equi. In Decimal | A | 9 | C |
| Number in octal | A9C16 | | |

5. Convert the following numbers from octal to hexadecimal.

a. 746128

=7\*84 + 4\*83 + 6\*82 + 1\*81 + 2\*80 = 28672+2048+384+8+2 = 3111410

To hexadecimal

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Quotient | 1944 | 121 | 7 | 0 |
|  | 16|31114 | 16|1944 | 16|121 | 16|7 |
| Remainder | A | 8 | 9 | 7 |

Number in hexadecimal is 798A16

b. 2746358

=2\*85 + 7\*84 + 4\*83 + 6\*82 + 3\*81 + 5\*80 = 65536+28672+2048+384+24+5 = 9666910

To hexadecimal

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Quotient | 6041 | 377 | 23 | 1 | 0 |
|  | 16|96669 | 16|6041 | 16|377 | 16|23 | 16|1 |
| Remainder | D | 9 | 9 | 7 | 1 |

Number in hexadecimal is 1799D16

6. Convert the following numbers from hexadecimal to octal.

a. 34AFE16

Firstly I will convert it into binary:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Number in hex | 3 | 4 | A | F | E |  |
| Equivalent in binary | 0011 | 0100 | 1010 | 1111 | 1110 |
| Number in Binary | 1101001010111111102 | | | | |

Now converting binary to octal:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Number in binary | 1101001010111111102 | | | | | |  |
| Group of 3 digits | 110 | 100 | 101 | 011 | 111 | 110 |  |
| Equi. In Decimal | 6 | 4 | 5 | 3 | 7 | 6 |  |
| Number in octal | 6453768 | | | | | |  |

So the number in octal is 6453768

b. BC246D016

Converting hexadecimal to binary

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Number in hex | B | C | 2 | 4 | 6 | D | 0 |  |
| Equivalent in binary | 1011 | 1100 | 0010 | 0100 | 0110 | 1101 | 0000 |
| Number in Binary | 10111100001001000110110100002 | | | | | | |

Now converting binary to octal

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Number in binary | 10111100001001000110110100002 | | | | |  |  |  |  |  |
| Group of 3 digits | 001 | 011 | 110 | 000 | 100 | 100 | 011 | 011 | 010 | 000 |
| Equi. In Decimal | 1 | 3 | 6 | 0 | 4 | 4 | 3 | 3 | 2 | 0 |
| Number in octal | 1360443328 | | | | | | | | | |

7. Perform the following binary calculations. Show the sequence of carry bits or borrowed bits in addition to the final result.

a. 1010111012 + 001101012 = 1100100102

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carries |  | 1 | 1 | 1 | 1 | 1 |  | 1 |  |
|  | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
|  |  | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| Sum | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
|  |  | 1+0+0=1 | 1+1=10 | 1+1=10 | 1+1+1=11 | 1+1+0=10 | 1+1=10 | 0+0+1=1 | 1+1=10 |

b.10110111112 + 110101012 = 11101101002

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Carries |  |  | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 |  |
|  |  | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
|  | + |  |  | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| Sum |  | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
|  |  |  | 1+0=01 | 1+1+1=11 | 1+1=10 | 1+0+0=1 | 1+1+1=11 | 1+1=10 | 1+1+1=11 | 1+1+0=10 | 1+1=10 |

c.10101000112 – 101110102 = 1111010012

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Borrowing |  |  | 1 | 0+2 | 1 | 0+2 | 1 |  |  |  |  |
|  | 0 | 0+2 | 0 | 0+2 | 0 | 0+2 | 0+2 |  |  |  |
| Numbers |  | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| - |  |  | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| Result |  | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |

d.10001000112 – 1110102 = 1111010012

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Borrowing |  |  | 1 | 1 | 1 | 0+2 | 1 |  |  |  |  |
|  |  | 0 | 0+2 | 0+2 | 0+2 | 0 | 0+2 | 0+2 |  |  |  |
| Numbers |  | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
|  |  |  |  |  |  | 1 | 1 | 1 | 0 | 1 | 0 |
| Result |  | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |

8. Perform the following octal calculations. Show the sequence of carry bits or borrowed bits in addition to the final result.

a.730258 + 347138 =1277408

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carries | 1 |  |  |  | 1 |  |
|  |  | 7 | 3 | 0 | 2 | 5 |
|  |  | 3 | 4 | 7 | 1 | 3 |
| Sum | 1 | 2 | 7 | 7 | 4 | 0 |
|  |  | 7+3=10=8+2 |  |  | 1+2+1=4 | 5+3=8+0 |

b.1264748 + 3056268 = 4344228

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Carries |  | 1 | 1 | 1 | 1 |  |
|  | 1 | 2 | 6 | 4 | 7 | 4 |
|  | 3 | 0 | 5 | 6 | 2 | 6 |
| Sum | 4 | 3 | 4 | 4 | 2 | 2 |
|  |  |  | 1+6+5=8+4 | 1+4+6=11=8+4 | 1+7+2=10=8+2 | 4+6=10=8+2 |

c. 652108 – 264078 =366018

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Borrowing |  |  | 12 |  |  |  |
|  |  | 5 | 5+8=13 | 2+8=10 | 0 | 0+8 |
| Numbers |  | 6 | 5 | 2 | 1 | 0 |
|  |  | 2 | 6 | 4 | 0 | 7 |
| Result |  | 3 | 6 | 6 | 0 | 1 |

d. 7462718 – 531548 = 6731158

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Borrowing |  |  |  |  |  |  |  |
|  |  | 6 | 4+8=12 |  |  | 6 | 1+8=9 |
| Numbers |  | 7 | 4 | 6 | 2 | 7 | 1 |
|  |  |  | 5 | 3 | 1 | 5 | 4 |
| Result |  | 6 | 7 | 3 | 1 | 1 | 5 |

9. Perform the following hexadecimal calculations. Show the sequence of carry bits or borrowed bits in addition to the final result.

a. 2580E16 + AFBC516 = D53D316

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Carries | 1 | 1 |  | 1 |  |
|  | 2 | 5 | 8 | 0 | E |
|  | A | F | B | C | 5 |
| Sum | D | 5 | 3 | D | 3 |
|  | 1+2+10=13 | 1+5+15=21=16+5 | 8+11=19=16+3 |  | 14+5=19=16+3 |

b. 79A8DE16 + BC745316 = 1361D3116

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Carries | 1 | 1 | 1 |  | 1 | 1 |  |
|  |  | 7 | 9 | A | 8 | D | E |
|  |  | B | C | 7 | 4 | 5 | 3 |
| Sum | 1 | 3 | 6 | 1 | D | 3 | 1 |
|  |  | 1+7+11=19=16+3 | 1+9+12=22=16+6 | 10+7=17=16+1 | 13=D | 1+13+5=16+3 | 14+3=17=16+1 |

c. 80BC116 – 2786316 = 5936E16

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Borrowing |  |  |  |  |  |  |
|  |  | 7 | 0+16 |  |  | 1+16=17 |
| Numbers |  | 8 | 0 | B | C | 1 |
|  |  | 2 | 7 | 8 | 6 | 3 |
| Result |  | 5 | 9 | 3 | 6 | E |

d. 79D8AE16 - BC45316 = 6E145B16

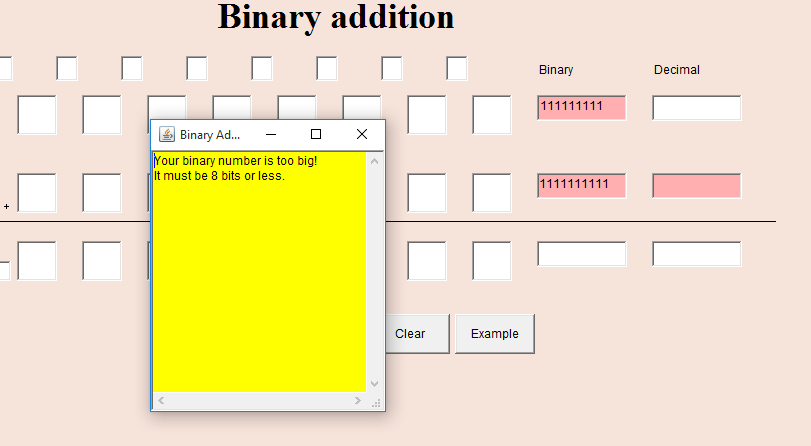
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Borrowing |  |  |  |  |  |  |  |
|  |  | 6 | 9+16=25 |  |  |  |  |
| Numbers |  | 7 | 9 | D | 8 | A | E |
|  |  |  | B | C | 4 | 5 | 3 |
| Result |  | 6 | E | 1 | 4 | 5 | B |

10. Write your answer to question 9 for Exercise 1 in "Lab 2 Exploring Number Systems" (Lab2\_Manual.pdf). Explain how you found these answers.

ANS: The limits of Binary Addition app are (0 to 255) in decimal number system and (00000000 to 11111111) in binary system which means 0 to 8 bits.

Largest Number it can add: 255(decimal) 11111111(binary)

Largest result it can produce: 510(decimal) 11111110(binary)

When I typed any number greater than 255 or 8 bits, there was a pop-up message (screenshot shared below) that shows that the no. Must be less than 256 which can only be 255 and when I added 255 to 255, I got 510 which shows that 510 becomes the largest sum. 

11. Calculate the equivalent binary of powers of 2 (20, 21, 22 , 23 , …). Explain the pattern that relates these values.

ANS: The binary of powers of 2 is as follows:

20 = 1

21 = 10

22 = 100

23 = 1000

24 = 10000

25 = 100000

:

:

2n = 10n

It follows a very clear pattern that the digit at the number of power of 2 becomes 1 and the other digits remain 0. If we summarize the overall trend then we can estimate it as 2n = 10n.