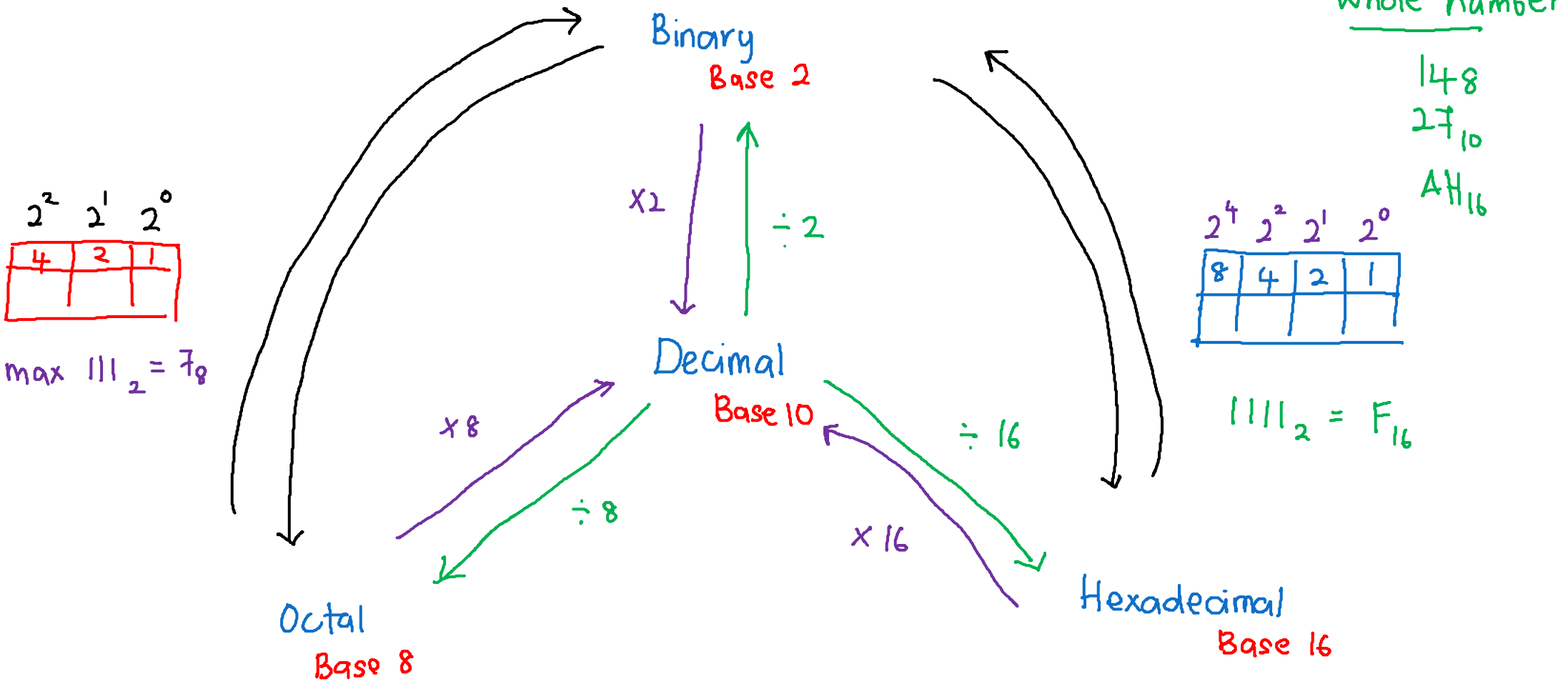
MMU
MULTIMEDIA UNIVERSITY

TUTORIAL 2
NUMBER SYSTEM, OPERATIONS AND CODES

PDS0101: INTRODUCTION TO DIGITAL SYSTEMS
TRI 2, 2022-2023



Whole number

148

27_{10}

AH_{16}

75.12_8 → hexa

octal → binary → hexa

octal → decimal → hexa

Binary to octal

Group from LSB

Example $111\ 101_2$ convert to octal

$7\ 5_8$ ※

4	2	1
1	1	1

4	2	1
1	0	1

$4+1=5$

$1\times2^2+0\times2^1+1\times2^0$

$=1\times4+0\times2+1\times1$

$=4+0+1$

$=5$ ※

THEORY BASED QUESTIONS : BINARY NUMBER

Perform the conversions from BINARY to DECIMAL number

a. $1011_2 = 8+2+1=11$

b. $110101101_2 = 256 + 128 + 32 + 8 + 4 + 1 = 429$

c. $0.1101_2 = 0.5 + 0.25 + 0.0625 = 0.8125$

d. $0.00111_2 = 0.125+0.0625+0.03125 = 0.21875$

e. $101101.101_2 = 32 + 8 + 4 + 1 + 0.5 + 0.125 = 45.625$

f. $10111.1101_2 = 16 + 4 + 2 + 1 + 0.5 + 0.25 + 0.0625$
$= 23.8125$

THEORY BASED QUESTIONS : BINARY NUMBER

Perform the conversions from BINARY to DECIMAL number

Whole fraction

$e.\ 1\ 0\ 1\ 1\ 0\ 1\ .\ 1\ 0\ 1_{\ 2}$

$1\times2^5+0\times2^4+1\times2^3+1\times2^2+0\times2^1+1\times2^0+1\times2^{-1}+0\times2^{-2}+1\times2^{-3}$

$= 32+0+8+4+0+1+0.5+0+0.125$

$= 45.625_{10}$ ※

Positive Powers of Two (Whole Numbers)

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
512	256	128	64	32	16	8	4	2	1
				1	0	1	1	0	1

$32+8+4+1 = 45$

Negative Powers of Two (Fractional Numbers)

2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^6
1/2	1/4	1/8	1/16	1/32	1/64
0.5	0.25	0.125	0.0625	0.03125	0.015625
1	0	1			

$0.5+0.125 = 0.625$

THEORY BASED QUESTIONS : BINARY NUMBER

Perform the conversions from BINARY to DECIMAL number

f. 10111.1101_2 $= 23 + 0.8125$

$= 23.8125_{10}$

$1\times2^4 + 0\times2^3 + 1\times2^2 + 1\times2^1 + 1\times2^0 + 1\times2^{-1} + 1\times2^{-2} + 0\times2^{-3} + 1\times2^{-4}$

$16 + 0 + 4 + 2 + 1 + 0.5 + 0.25 + 0 + 0.0625$

$= 23.8125_{10}$ ✱

Positive Powers of Two (Whole Numbers)

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
512	256	128	64	32	16	8	4	2	1
					1	0	1	1	1

$16 + 4 + 2 + 1 = 23$

Negative Powers of Two (Fractional Numbers)

2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^6
1/2	1/4	1/8	1/16	1/32	1/64
0.5	0.25	0.125	0.0625	0.03125	0.015625
1	1	0	1		

$0.5 + 0.25 + 0.0625 = 0.8125$

THEORY BASED QUESTIONS : BINARY NUMBER

Perform the conversions from DECIMAL to BINARY number ÷ 2

g. $24_{10} = \mathbf{11\ 000_2}$

h. $15_{10} = \mathbf{1111_2}$

i. $0.246_{10} = \mathbf{0.00\ 11111_2}$

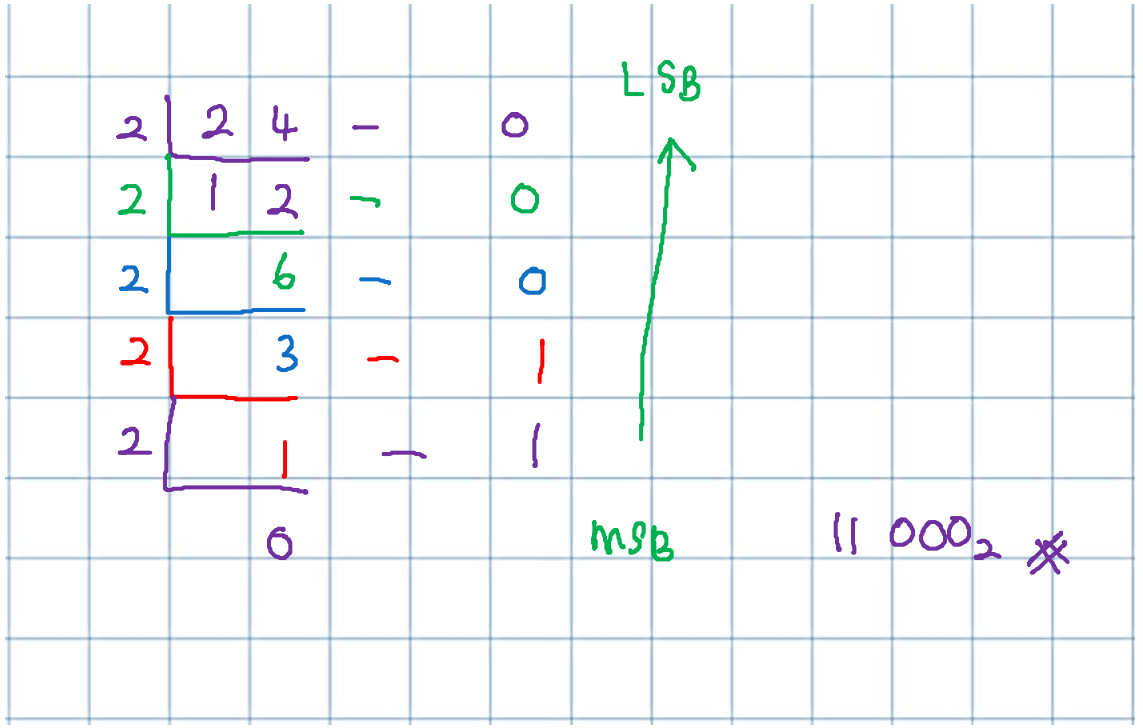
j. $0.0981_{10} = \mathbf{0.000\ 11001_2}$

k. $56.625_{10} = \mathbf{111\ 000.101_2}$

l. $110.75_{10} = \mathbf{1\ 101\ 110.11_2}$

Positive Powers of Two (Whole Numbers)

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
512	256	128	64	32	16	8	4	2	1
					1	1	0	0	0



THEORY BASED QUESTIONS : BINARY NUMBER

Perform the conversions from DECIMAL to BINARY number

whole fraction

k. 56.625_{10} = **$111\ 000.101_2$**

÷2 ← x2 →

x fraction number only

32	16	8	4	2	1
1	1	1	0	0	0

32 + 16 + 8 = 56

2	56	– 0
2	28	– 0
2	14	– 0
2	7	– 1
2	3	– 1
2	1	– 1
	0	

LSB

MSB

$111\ 000_2$

0.625

x 2

MSB 1.25

x 2

0.5

x 2

LSB 1.0

THEORY BASED QUESTIONS : BINARY NUMBER

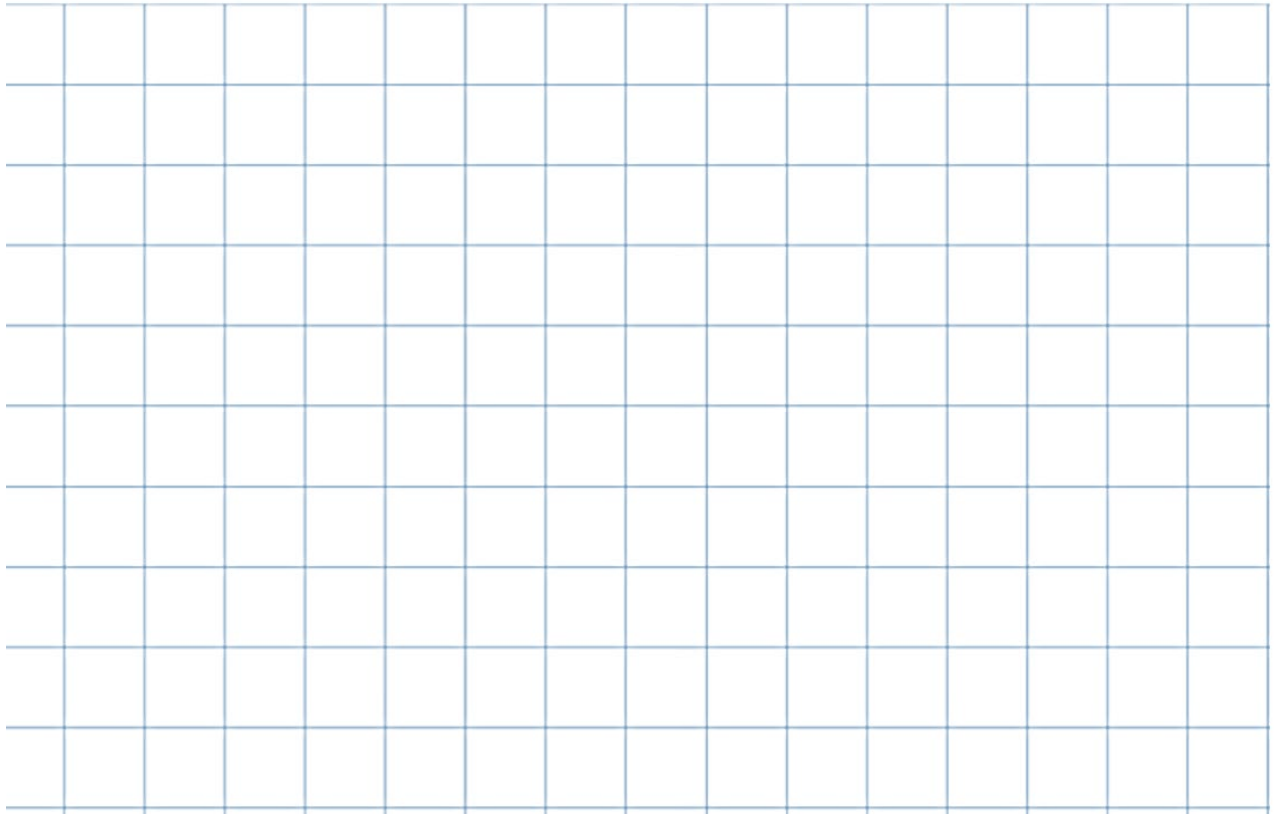
Perform the conversions from DECIMAL to BINARY number

I. 110.75_{10} = **1 101 110.11**$_2$

÷2 ← x2 →

Positive Powers of Two (Whole Numbers)

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
512	256	128	64	32	16	8	4	2	1



THEORY BASED QUESTIONS

What is the HIGHEST DECIMAL NUMBER that can be represented by each of the following NUMBER OF BITS

$2^n - 1$

a. 3 = $2^3 - 1 = 7$

b. 4 = $2^4 - 1 = 15$

c. 7 = $2^7 - 1 = 127$

d. 8 = $2^8 - 1 = 255$

Positive Powers of Two (Whole Numbers)

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
512	256	128	64	32	16	8	4	2	1
							1	1	1
						1	1	1	1
			1	1	1	1	1	1	1
		1	1	1	1	1	1	1	1

4 + 2 + 1 = 7

8 + 4 + 2 + 1 = 15

64 + 32 + 16 + 8 + 4 + 2 + 1 = 127

128 + 64 + 32 + 16 + 8 + 4 + 2 + 1 = 255

THEORY BASED QUESTIONS

What is the MINIMUM NUMBER OF BITS required to represent the following DECIMAL numbers?

10001

a. 17 = 5

100011

b. 35 = 6

1100 1101

c. 205 = 8

1000 0100

d. 132 = 8

Positive Powers of Two (Whole Numbers)

2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
512	256	128	64	32	16	8	4	2	1

THEORY BASED QUESTIONS

Perform the following arithmetic operations on binary numbers (unsigned)

a. 101 + 11 = 1000_2 ✻

b. 1001 + 101 = 1110_2 ✻

a)

```
  1 1 0 1
+     1 1
-------------
  1 0 0 0   ✻
```

```
  1
+ 1
-----
 10
```

b)

```
    1 0 0 1
+     1 0 1
-------------
  1 1 1 0
```

```
  1
+ 1
-----
 10
```

THEORY BASED QUESTIONS

Perform the following arithmetic operations on binary numbers (unsigned)

c. 1100 - 1001 = 11_2

d. 110 – 101

Binary number

0 — 0
1 — 1
10 — 2
11 — 3

↖ Decimal

c.

$$\begin{array}{r} {\scriptstyle 1}\ {\scriptstyle 0}\ {\scriptstyle 10}\ {\scriptstyle 10} \\ 1\ 1\ 0\ 0 \\ -\ 1\ 0\ 0\ 1 \\ \hline 0\ 1\ 1 \end{array}$$

$$\begin{array}{r} 10 \\ -\ 1 \\ \hline 1 \end{array}$$

$$\begin{array}{r} 2 \\ -\ 1 \\ \hline 1 \end{array}$$

THEORY BASED QUESTIONS

Perform the following arithmetic operations on binary numbers (unsigned)

e. 11 x 11 = 1001

$$
\begin{array}{r}
11 \\
\times\ 11 \\
\hline
11 \\
+\ 11 \\
\hline
1001
\end{array}
$$

THEORY BASED QUESTIONS

Perform the following arithmetic operations on binary numbers (unsigned)

f. 1001 x 110 = $110\ 110_2$

```
  1001
x  110
------
  0000
 1001
+1001
------
110110
```

THEORY BASED QUESTIONS

Perform the following arithmetic operations on binary numbers (unsigned)

g. 111 x 101 = 100011_2

```
  111
x 101
-----
  111
 000
+111
------
100011
```

THEORY BASED QUESTIONS

Perform the following arithmetic operations on binary numbers (unsigned)

9 ÷ 3 = 3

h. 1001 ÷ 11 = **11**

i. 1100 ÷ 100 = **11**

h.

```
        1 1
   11 | 1 0 0 1
      - 1 0 0
      -------
          1
        - 1
        ---
          0   #
```

OCTAL NUMBERS

Perform the conversions from OCTAL to DECIMAL

a. $12_8 = 1 \times 8^1 + 2 \times 8^0 = 1010$

b. $73_8 = 7 \times 8^1 + 3 \times 8^0 = 5910$

c. $56_8 = 5 \times 8^1 + 6 \times 8^0 = 4610$

d. $163_8 = 1 \times 8^2 + 6 \times 8^1 + 3 \times 8^0 = 11510$

e. $1024_8 = 1 \times 8^3 + 0 \times 8^2 + 2 \times 8^1 + 4 \times 8^0 = 53210$

OCTAL NUMBERS

Perform the conversions from DECIMAL to OCTAL

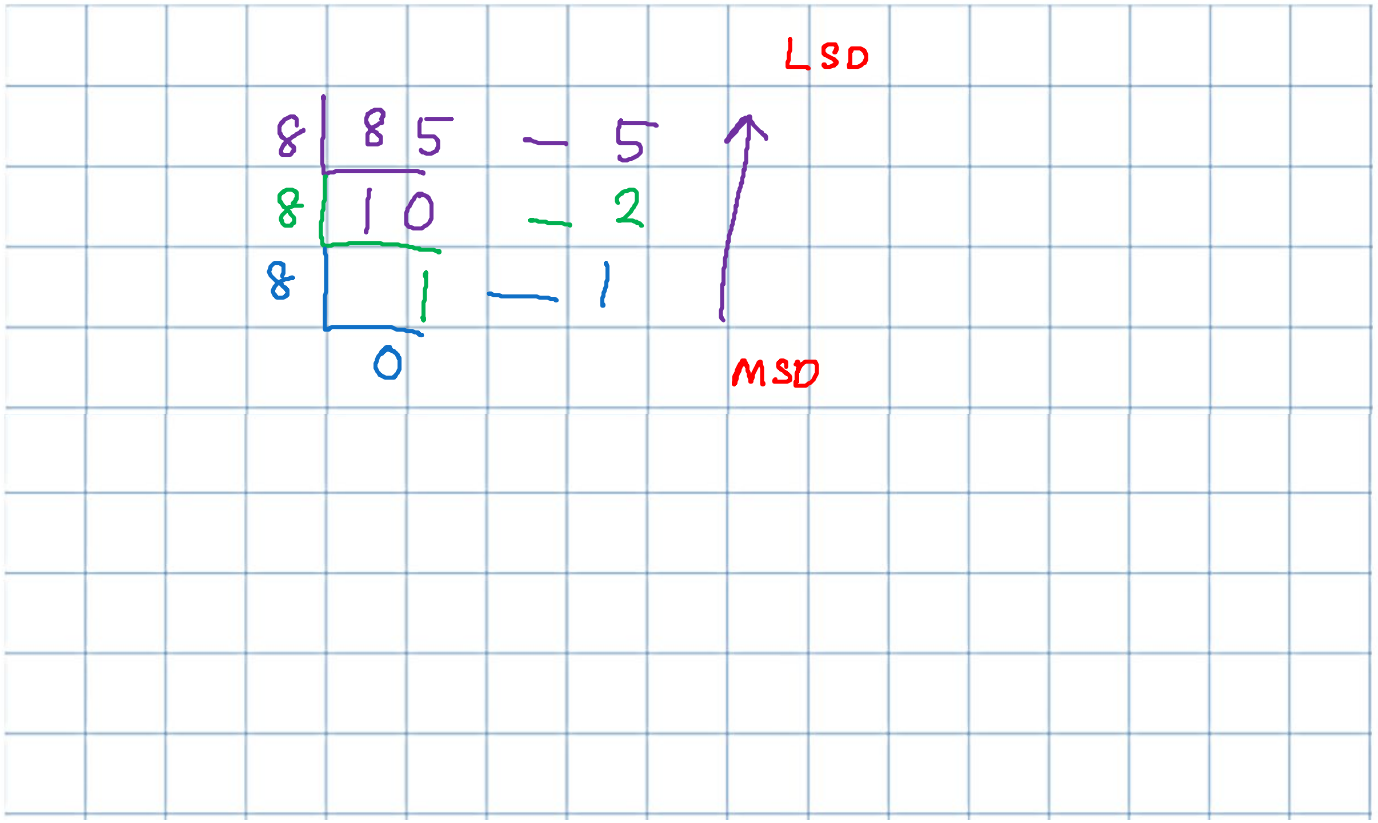
f) $85 = 125_8$

g) $103 = 147_8$

h) $1024 = 2000_8$

i) $98 = 142_8$

j) $999 = 1747_8$



OCTAL NUMBERS

Perform the conversions from DECIMAL to OCTAL

f) $85 = 125_8$

8	85	
8	10	remainder 5 (LSD)
8	1	remainder 2
	0	remainder 1 (MSD)

g) $103 = 147_8$

8	103	
8	12	remainder 7 (LSD)
8	1	remainder 4
	0	remainder 1 (MSD)

OCTAL NUMBERS

Perform the conversions from DECIMAL to OCTAL

h) $1024 = 2000_8$

8	1024	
8	128	remainder 0(LSD)
8	16	remainder 0
8	2	remainder 0
	0	remainder 2(MSD)

i) $98 = 142_8$

8	98	
8	12	remainder 2(LSD)
8	1	remainder 4
	0	remainder 1(MSD)

OCTAL NUMBERS

Perform the conversions from DECIMAL to OCTAL

j) 999 = 1747_8

8	999	
8	124	remainder 7 (LSD)
8	15	remainder 4
8	1	remainder 7
	0	remainder 1 (MSD)

OCTAL NUMBERS

Convert the following DECIMAL FRACTIONS to its OCTAL FRACTION equivalents

whole fractions

a) $28.175 = 34.13146_8$

b) $59.080 = 73.05075_8$

c) $88.888 = 130.70651_8$

OCTAL NUMBERS

Convert the following DECIMAL FRACTIONS to its OCTAL FRACTION equivalents

a) $28.175 = 34.13146_8$

÷ 8 ← 28.175 → × 8

		remainder
8	28	
8	3	4
	0	3

LSD ↑ MSD

fraction

0.175 × 8 = 1.4

0.4 × 8 = 3.2

0.2 × 8 = 1.6

0.6 × 8 = 4.8

0.8 × 8 = 6.4

MSD ↓ LSD

OCTAL NUMBERS

Convert the following DECIMAL FRACTIONS to its OCTAL FRACTION equivalents

b) 59.080 = **73.05075_8**

8	59	remainder
8	7	3
	0	7

0. 080
x 8
0.64
x 8
5.12
x 8
0.96
x 8
7.68
x 8
5.44

OCTAL NUMBERS

Convert the following DECIMAL FRACTIONS to its OCTAL FRACTION equivalents

c) 88.888 = 130.70651_8

8	88	remainder
8	11	0
8	1	3
	0	1

0. 888
x 8
7.104
x 8
0.832
x 8
6.656
x 8
5.248
x 8
1.984

OCTAL NUMBERS

Convert the following OCTAL FRACTION to its DECIMAL FRACTIONS equivalents

highest number = 7 for octal

d. 180.01_8 = **INVALID**

e. 407.304_8 = **263.3828125**

f. 345.135_8 = **229.1816406**

OCTAL NUMBERS

Convert the following OCTAL FRACTION to its DECIMAL FRACTIONS equivalents

e. 407.304_8

$\times 8^n$ $\times 8^{-n}$

$= 4 \times 8^2 + 0 \times 8^1 + 7 \times 8^0 + 3 \times 8^{-1} + 0 \times 8^{-2} + 4 \times 8^{-3}$

$= 4 \times 64 + 0 \times 8 + 7 \times 1 + 3 \times 0.125 + 0 \times 0.015625$

$+ 4 \times 0.001953125$

$= 256 + 7 + 0.375 + 0.0078125$

$= 263.3828125$

OCTAL NUMBERS

Convert the following OCTAL FRACTION to its DECIMAL FRACTIONS equivalents

f. 345.135_8

$= 3 \times 8^2 + 4 \times 8^1 + 5 \times 8^0 + 1 \times 8^{-1} + 3 \times 8^{-2} + 5 \times 8^{-3}$

$= 3 \times 64 + 4 \times 8 + 5 \times 1 + 1 \times 0.125 + 3 \times 0.015625$

$+ 5 \times 0.001953125$

$= 192 + 32 + 5 + 0.125 + 0.046875 + 0.009765625$

$= 229.1816406$

OCTAL NUMBERS

Convert each OCTAL below to BINARY

a) $13_8 = 1\ 011_2$

001 011

001 011_2

b) $13\ 271_8 = 1\ 011\ 010\ 111\ 001_2$

001 011 010 111 001

Octal \ binary	4	2	1
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

OCTAL NUMBERS

Convert each BINARY below to OCTAL

c) $1100_2 = 14_8$

1 4

one group 3 bit ; group from LSB

d) $111\ 100\ 010\ 111_2 = 7427_8$

7 4 2 7

octal \ Binary	4	2	1
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

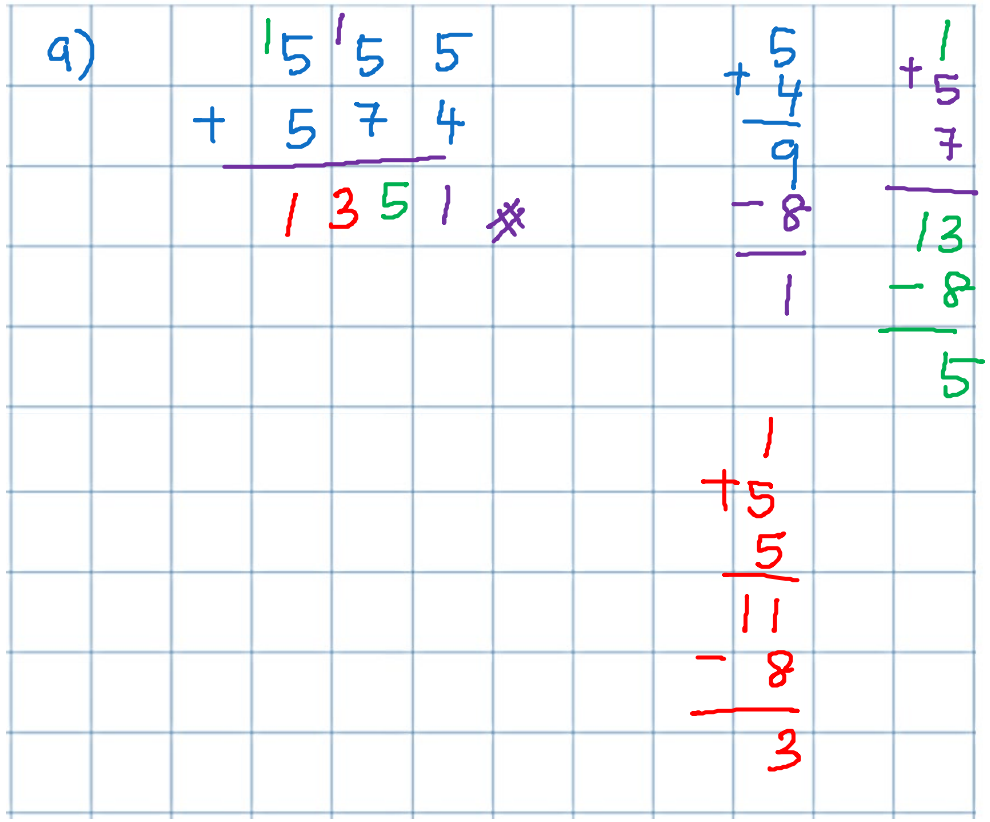
OCTAL NUMBERS

Perform the calculations for the following octal values as shown below

a) $555_8 + 574_8 = 1351_8$

b) $456_8 + 123_8 = 601_8$

c) $77714_8 + 76_8 = 100012_8$



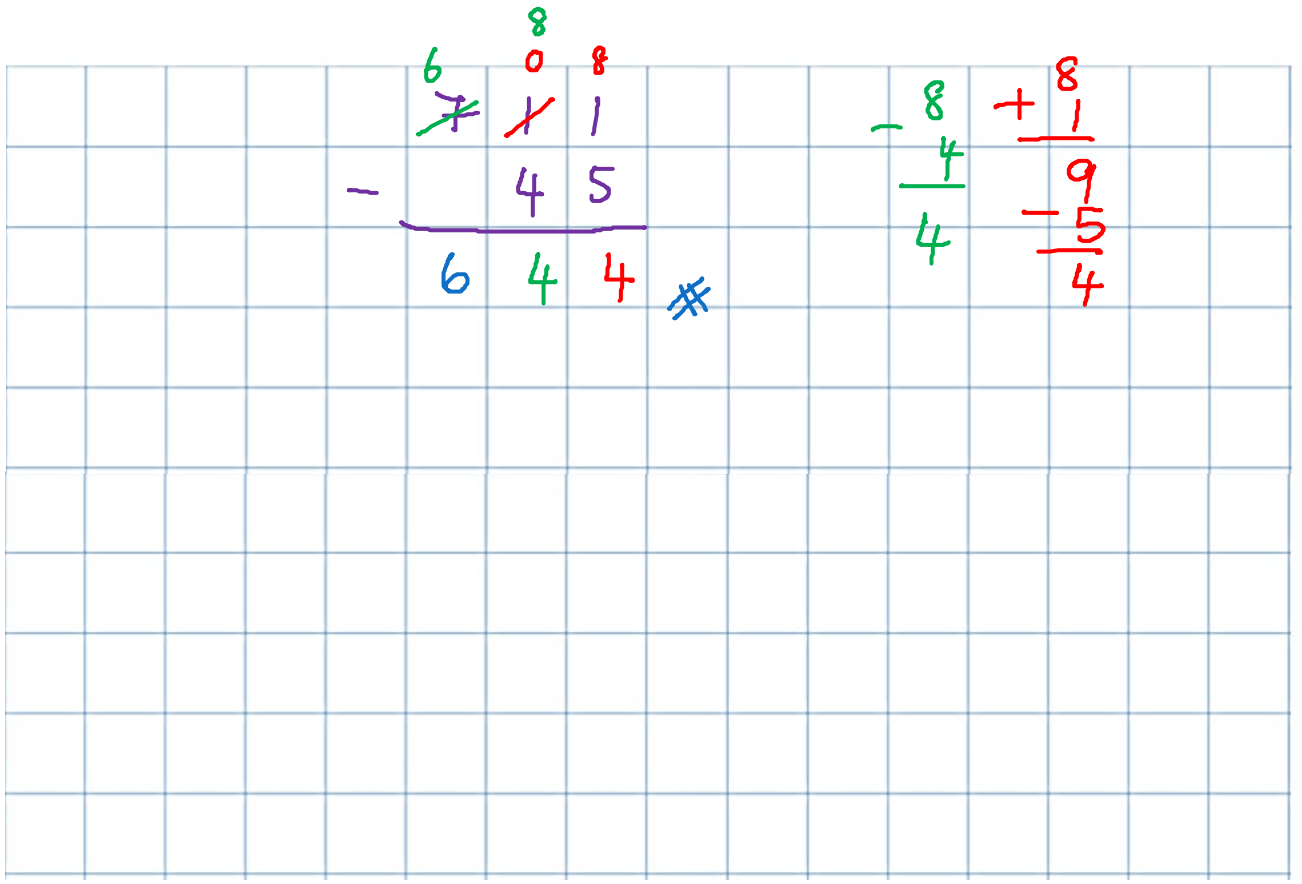
OCTAL NUMBERS

Perform the calculations for the following octal values as shown below

a) $711_8 - 45_8 = 644_8$

b) $765_8 - 444_8 = 321_8$

c) $44_8 - 6_8 = 36_8$



HEXADECIMAL NUMBERS

Perform the following conversions from HEXADECIMAL to DECIMAL

a) $A034B_{16} = A \times 16^4 + 0 \times 16^3 + 3 \times 16^2 + 4 \times 16^1 + B \times 16^0 = 656203_{10}$

b) $666FA_{16} = 6 \times 16^4 + 6 \times 16^3 + 6 \times 16^2 + F \times 16^1 + A \times 16^0 = 419578_{10}$

c) $66_{16} = 6 \times 16^1 + 6 \times 16^0 = 102_{10}$

d) $191_{16} = 1 \times 16^2 + 9 \times 16^1 + 1 \times 16^0 = 401_{10}$

HEXADECIMAL NUMBERS

Perform the following conversions from HEXADECIMAL to BINARY

a) $A034B_{16} = 1010\ 0000\ 0011\ 0100\ 1011_2$

b) $666FA_{16} = 0110\ 0110\ 0110\ 1111\ 1010_2$

c) $66_{16} = 0110\ 0110_2$

d) $191_{16} = 0001\ 1001\ 0001_2$

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

HEXADECIMAL NUMBERS

Perform the following conversions from HEXADECIMAL to OCTAL

hexadecimal → decimal → octal
hexadeeimal → binary → octal

a) $A034B_{16}$

b) $666FA_{16}$

c) 66_{16}

d) 191_{16}

HEXADECIMAL NUMBERS

Perform the following conversions from HEXADECIMAL to OCTAL

a) $A034B_{16}$

$= 1010\ 0000\ 0011\ 0100\ 1011_2$

$= 10\ 100\ 000\ 001\ 101\ 001\ 011_2$

$= 2401513_8$

hexa ⟶ binary ⟶ octal

regroup
one group 3 bit
group from LSB

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

HEXADECIMAL NUMBERS

Perform the following conversions from HEXADECIMAL to OCTAL

b) $666FA_{16}$

$= 0110\ 0110\ 0110\ 1111\ 1010_2$

$= 01\ 100\ 110\ 011\ 011\ 111\ 010_2$

$= 1463372_8$

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

HEXADECIMAL NUMBERS

Perform the following conversions from HEXADECIMAL to OCTAL

c) $66_{16} = 01\ 100\ 110_2$

$= 146_8$

	4	2	1
6	1	1	0
4	1	0	0
1	0	0	1

HEXADECIMAL NUMBERS

Perform the following conversions from HEXADECIMAL to OCTAL

d) $191_{16} = 000\ 110\ 010\ 001_{2}$

$= 621_{8}$

	4	2	1
1	0	0	1
2	0	1	0
6	1	1	0
0	0	0	0

HEXADECIMAL NUMBERS

Perform the calculation for the following data as shown below:

a) $15h + 32h = 47h$

b) $12h + EBh = FDh$

$$\begin{array}{r} 12 \\ +\ EB \\ \hline FD \end{array}$$

$$\begin{array}{r} {}^{2} \\ +\ B \\ \hline D \end{array} \qquad \begin{array}{r} 2 \\ 11 \\ \hline 13 \end{array}$$

$$\begin{array}{r} {}^{1} \\ +\ E \\ \hline F \end{array} \qquad \begin{array}{r} 1 \\ 14 \\ \hline 15 \end{array}$$

c) $AAA_{16} + 111_{16} = BBB_{16}$

d) $DDF_{16} + 11_{16} = DF0_{16}$

e) $16Fh + 4A2h = 611h$

f) $9EFh + 9EFh = 13DEh$

HEXADECIMAL NUMBERS

Perform the calculation for the following data as shown below:

g) $C_{16} - 2_{16} = A_{16}$

h) $BB_{16} - C1_{16} = -6_{16}$

i) $1586h - 243h = 1343h$

j) $576A_{16} - AB_{16} = 56BF_{16}$

k) $1234_{16} - 4321_{16} = -30ED_{16}$

l) $FD19_{16} - AC_{16} = FC6D_{16}$

END PART 1

(UNSIGNED NUMBERS)

ANY QUESTIONS ??