

# 11 Chapter 1 From Morris Mori's book

## Problem

| <u>1-1</u> | <u>Decimal</u> | <u>base 3</u> |
|------------|----------------|---------------|
| 0          | 0              | 0             |
| 1          | 1              | 1             |
| 2          | 2              | 2             |
| 3          | 10             | 10            |
| 4          | 11             | 11            |
| 5          | 12             | 12            |
| 6          | 20             | 20            |
| 7          | 21             | 21            |
| 8          | 22             | 22            |
| 9          | 100            | 100           |
| 10         | 101            | 101           |
| 11         | 102            | 102           |
| 12         | 110            | 110           |
| 13         | 111            | 111           |
| 14         | 112            | 112           |
| 15         | 120            | 120           |
| 16         | 121            | 121           |
| 17         | 122            | 122           |
| 18         | 200            | 200           |
| 19         | 201            | 201           |

Just to check

$$\begin{array}{r} 3 \mid 19 \\ 3 \quad \boxed{6} \uparrow \\ 3 \quad \boxed{2} \uparrow \\ 0 \quad 2 \end{array}$$

as it is correct for the last value; the table must be correct.

## 1-2

a1

$$\begin{array}{r} (1\overset{1}{2}30)_4 \\ + (23)_{41} \\ \hline 1313 \end{array}$$

$$\begin{array}{r} 4 \mid 5 \\ 4 \quad \boxed{1} \uparrow \\ 0 \quad 1 \end{array}$$

$$\begin{array}{r} 1 \overset{1}{1} \\ 2 \overset{1}{2} \\ (1230)_4 \\ (23)_4 \\ \hline 11010 \\ 3120 \times \\ \hline 102210 \end{array}$$

$$\begin{array}{r} 4 \mid 4 \\ 4 \quad \boxed{1} \\ 0 \end{array}$$

$$\begin{array}{r} 4 \mid 6 \\ 4 \quad \boxed{1} \uparrow \\ 0 \end{array}$$

$$\begin{array}{r} 4 \mid 8 \\ 4 \quad \boxed{2} \\ 0 \end{array}$$

$$\begin{array}{r} 4 \mid 9 \\ 4 \quad \boxed{2} \\ 0 \end{array}$$

b1

$$\begin{array}{r} 111 \\ (135.4)_6 \\ (43.2)_6 \\ \hline (223.0)_6 \end{array}$$

$$\begin{array}{r} 6 \boxed{122} & 6 \boxed{16} \\ 6 \boxed{34} \uparrow & 6 \boxed{204} \uparrow \\ 6 \boxed{03} & 6 \boxed{02} \\ 6 \boxed{6} & \\ 6 \boxed{01} & \\ \hline 6 \boxed{9} & 6 \boxed{8} \\ 6 \boxed{13} \uparrow & 6 \boxed{12} \uparrow \\ 0 \boxed{1} & 0 \boxed{1} \end{array}$$

$$\begin{array}{r} 232 \\ 141 \\ (135.4)_6 \\ (43.2)_6 \\ \hline 3152 \\ 4550 \times \\ 10244 \times \\ \hline (1121452)_6 \end{array}$$

$$\begin{array}{r} 6 \boxed{17} \\ 6 \boxed{25} \uparrow \\ 0 \boxed{2} \\ 6 \boxed{12} \\ 6 \boxed{20} \uparrow \\ 0 \boxed{2} \\ \hline 6 \boxed{11} \\ 6 \boxed{15} \uparrow \\ 6 \boxed{7} \\ 6 \boxed{11} \uparrow \end{array}$$

c1

$$\begin{array}{r} (367)_8 \\ (715)_8 \\ \hline (1304)_8 \end{array}$$

$$\begin{array}{r} (367)_8 \\ \times (715)_8 \\ \hline 2323 \\ 367 \times \\ 3301 \times \times \\ \hline (336313)_8 \end{array}$$

$$\begin{array}{r} 8 \boxed{9} \\ 8 \boxed{11} \uparrow \\ 0 \boxed{1} \\ 8 \boxed{13} \uparrow \\ 0 \boxed{1} \end{array}$$

d1

$$\begin{array}{r} 11 \\ (296)_{12} \\ (57)_{12} \\ \hline (331)_{12} \end{array}$$

$$\begin{array}{r} 12 \boxed{13} \\ 12 \boxed{1} \uparrow \\ 0 \boxed{1} \\ 12 \boxed{15} \\ 12 \boxed{13} \uparrow \\ 0 \boxed{1} \end{array}$$

$$\begin{array}{r} 32 \\ 53 \\ (296)_{12} \\ \times (57)_{12} \\ \hline 1766 \\ 1196 \times \\ \hline (13506)_{12} \end{array}$$

$$\begin{array}{r} 12 \boxed{42} \\ 12 \boxed{36} \uparrow \\ 0 \boxed{3} \end{array}$$

e1

$$\begin{array}{r} 12 \boxed{17} \\ 12 \boxed{15} \uparrow \\ 12 \boxed{1} \\ 12 \boxed{45} \\ 12 \boxed{39} \uparrow \\ 12 \boxed{03} \\ 12 \boxed{30} \\ 12 \boxed{26} \uparrow \\ 12 \boxed{02} \\ 12 \boxed{19} \\ 12 \boxed{17} \uparrow \\ 12 \boxed{01} \\ 12 \boxed{66} \\ 12 \boxed{56} \uparrow \\ 0 \boxed{5} \end{array}$$

1-3

$(250.5)_{10}$

$$\begin{array}{r} 3 | 250 \\ \hline 3 | 83 \quad 1 \\ \hline 3 | 27 \quad 2 \\ \hline 3 | 9 \quad 0 \\ \hline 3 | 3 \quad 0 \\ \hline 3 | 1 \quad 0 \\ \hline 0 \quad 1 \end{array}$$

$$\begin{array}{r} .5 \\ \times 3 \\ \hline 1 \quad .5 \\ \times 3 \\ \hline 1 \quad .5 \\ \times 3 \\ \hline 1 \quad .5 \end{array}$$

$$= (100021.1111)_3 \text{ (Approx)}$$

$$\begin{array}{r} 4 | 250 \\ \hline 4 | 62 \quad 2 \\ \hline 4 | 15 \quad 2 \\ \hline 4 | 3 \quad 3 \\ \hline 0 \quad 3 \end{array}$$

$$\begin{array}{r} 0.5 \\ \times 4 \\ \hline 2.0 \end{array}$$

$$= (3322.2)_4$$

$$\begin{array}{r} 7 | 250 \\ \hline 7 | 355 \\ \hline 7 | 50 \\ \hline 0 \quad 5 \end{array}$$

$$\begin{array}{r} 0.5 \\ \times 7 \\ \hline 3 \quad .5 \\ \times 7 \\ \hline 3 \quad .5 \\ \times 7 \\ \hline 3 \quad .5 \end{array}$$

$$\underline{\underline{= (505)}} = (505.33333)_7 \text{ (Approx)}$$

$$\begin{array}{r} \overline{1-3} \\ 8 \Big| 250 \\ 8 \quad \Big| 31 \quad 2 \\ 8 \quad \Big| 3 \quad 7 \uparrow \\ 0 \quad 3 \end{array} \qquad \begin{array}{r} 0.5 \\ \times 8 \\ \hline 4.0 \end{array}$$

$$= (372.4)_8$$

$$\begin{array}{r} 16 \Big| 250 \\ 16 \quad \Big| 15 \quad 10 \uparrow \\ 0 \quad 15 \end{array} \qquad \begin{array}{r} 0.5 \\ \times 16 \\ \hline 8.0 \end{array}$$

$$= (FA.8)_{16}$$

1-4

$$(12.0625)_{16} = (1100.0001)_2$$

$$\begin{array}{r} 2 \Big| 12 \\ 2 \quad \Big| 6 \quad 0 \\ 2 \quad \Big| 3 \quad 0 \uparrow \\ 2 \quad \Big| 1 \quad 1 \\ 0 \quad 1 \end{array}$$

$$\begin{array}{r} 0.0625 \\ \times 2 \\ \hline 0.125 \\ \times 2 \\ \hline 0.25 \\ \times 2 \\ \hline 0.5 \\ \times 2 \\ \hline 1.0 \end{array}$$

\*\*

1-4

$$(10^4 \cancel{10})(1000)_{10} = (1111101000)_2$$

|   |       |
|---|-------|
| 2 | 1000  |
| 2 | 500 0 |
| 2 | 250 0 |
| 2 | 125 0 |
| 2 | 62 1  |
| 2 | 31 0  |
| 2 | 15 1  |
| 2 | 7 1   |
| 2 | 3 1   |
| 2 | 1 1   |
|   | 0 1   |

$$(673.23)_{10} = (1010100001.00111)_2 \text{ (Approx)}$$

|   |       |
|---|-------|
| 2 | 6 73  |
| 2 | 336 1 |
| 2 | 168 0 |
| 2 | 84 0  |
| 2 | 42 0  |
| 2 | 21 0  |
| 2 | 10 1  |
| 2 | 5 0   |
| 2 | 2 1   |
| 2 | 1 0   |
|   | 0 1   |

$$\begin{array}{r}
 0.23 \\
 \times 2 \\
 \hline
 0.46 \\
 \times 2 \\
 \hline
 0.82 \\
 \times 2 \\
 \hline
 1.64 \\
 \times 2 \\
 \hline
 3.28 \\
 \times 2 \\
 \hline
 0.72
 \end{array}$$

1-4

$$\begin{array}{r}
 2 | 1998 \\
 \hline
 2 | 990 \\
 \hline
 2 | 491 \\
 \hline
 2 | 241 \\
 \hline
 2 | 121 \\
 \hline
 2 | 60 \\
 \hline
 2 | 30 \\
 \hline
 2 | 15 \\
 \hline
 2 | 71 \\
 \hline
 2 | 31 \\
 \hline
 2 | 11 \\
 \hline
 0 & 1
 \end{array}$$

$$(1998)_0 = (111001110)_2$$

1-5

$$\begin{array}{r}
 (10.10001)_2 = (1 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-5})_{10} \\
 = 2.53125
 \end{array}$$

$$\begin{array}{r}
 10110.0101 = 2^1 + 2^2 + 2^3 + 2^5 + 2^3 + 2^2 + 2^1 + 2^{-2} + 2^{-4} \\
 = 46.3125
 \end{array}$$

$$\begin{array}{r}
 1110101.110 = 2^6 + 2^5 + 2^4 + 2^2 + 2^0 + 2^{-1} + 2^{-2} \\
 = 117.75
 \end{array}$$

$$\begin{array}{r}
 1101101.111 = 2^6 + 2^5 + 2^3 + 2^2 + 2^0 + 2^{-1} + 2^{-2} + 2^{-3} \\
 = 109.875
 \end{array}$$

$$\underline{\text{a) } \left( \begin{smallmatrix} 2 & 0 \\ 225 & 225 \end{smallmatrix} \right)_{10} = (E1.399)_{16} \text{ (Approx)} = (11100001.00111001)_2}$$

~~2 | 225      2x16^2 +~~

$$16 \overline{)225} \\ 16 \overline{)14 \quad 1} \\ 0 \quad 14$$

$$\begin{array}{r} .225 \\ \times 16 \\ \hline 9.6 \\ \times 16 \\ \hline 9.6 \\ \times 16 \\ \hline 9.6 \end{array}$$

$$\begin{array}{c} E1.39 \\ \downarrow \quad \downarrow \\ 01110 \quad 0601.0011 \quad 10010 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ (3 \quad 4 \quad 1 \quad . \quad 1 \quad 6 \quad 2)_8 \end{array}$$

$$\underline{\text{b) } \left( \begin{smallmatrix} 0 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 10 \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \end{smallmatrix} \right)_2 = (3 \quad 2 \quad 7 \quad . \quad 6)_8}$$

$$\begin{array}{c} (11010111.1100)_2 \\ \downarrow \quad \downarrow \quad \downarrow \\ (D \quad 7 \quad . \quad C)_{16} \end{array}$$

$$\begin{aligned} &= (13 \times 16^1 + 7 \times 16^0 + 12 \times 16^{-1})_{10} \\ &= (215.75)_{10} \end{aligned}$$

c1

$$(623.77)_8$$

↓      ↓      ↓      ↓      ↓  
 $(100110\ 010\ 011 \cdot 111\ 1100)_2$   
 ↓      ↓      ↓      ↓      ↓  
 $(1, 9, 3, F, C)_{16}$

$$\begin{aligned}
 &= (6 \times 16^2 + 9 \times 16^1 + 3 \times 16^0 + 15 \times 16^{-1} + 12 \times 16^{-2})_{10} \\
 &= (659.984375)_{10}
 \end{aligned}$$

d1

$$(2A\ C5.D)_{16}$$

↓      ↓      ↓      ↓      ↓  
 $(010\ 1011000101 \cdot 110100)_2$   
 ↓      ↓      ↓      ↓      ↓  
 $(2\ 5\ 3\ 0\ 5 \cdot 6\ 4)_8$

$$(2\overset{3}{A}\overset{2}{C}\overset{1}{5}.\overset{0}{D})$$

$$\begin{aligned}
 &\approx (2 \times 16^3 + 10 \times 16^2 + 12 \times 16^1 + 5 \times 16^0 + 13 \times 16^{-1})_{10} \\
 &= (10949.8125)_{10}
 \end{aligned}$$

1-7

$$\underline{a)} \quad (1001001.011)_2$$

$$= (2^6 + 2^3 + 2^0 + 2^{-2} + 2^{-3})_{10} = (73.375)_{10}$$

$$\underline{b)} \quad (12121)_3$$

$$= (1 \times 3^4 + 2 \times 3^3 + 1 \times 3^2 + 2 \times 3^1 + 1 \times 3^0)_{10} = (151)_{10}$$

$$\underline{c)} \quad (1032.2)_4$$

$$= (1 \times 4^3 + 3 \times 4^1 + 2 \times 4^0 + 2 \times 4^{-1})_{10} = (78.5)_{10}$$

$$\underline{d)} \quad (4310)_5$$

$$= (4 \times 5^3 + 3 \times 5^2 + 1 \times 5^1)_{10} = (580)_{10}$$

$$\underline{e)} \quad (0.\overset{-2-3}{342})_6$$

$$= (3 \times 6^{-1} + 4 \times 6^{-2} + 2 \times 6^{-3})_{10} = (0.6203703702)_0$$

$$\underline{f)} \quad (50)_7$$

$$= (5 \times 7^1)_{10} = (35)_{10}$$

$$\underline{g)} \quad (8.3)_9$$

$$= (8 \times 9^0 + 3 \times 9^{-1})_{10} = (72.33333)_{10} \text{ (Approx)}$$

$$\underline{h)} \quad (198)_{12}$$

$$= 1 \times 12^2 + 9 \times 12^1 + 8 \times 12^0 = (260)_{10}$$

2.1

$$\underline{a1} \quad (01101011)_2$$

$$\downarrow \quad \downarrow$$

$$(6 \quad B)_{16}$$

b1

$$(17 \quad 4003)_8$$

$$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow$$

$$(1111100000000011)_2$$

$$\underline{c1} \quad (10110111)_2$$

$$\downarrow \quad \downarrow$$

$$(B \quad 7)_{16}$$

d1

$$(67.24)_8$$

$$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$$

$$(110111.010100)_2$$

$$\underline{e1} \quad (00010100.1101)_2$$

$$\downarrow \quad |$$

$$(1 \quad 4 \quad . \quad D)_{16}$$

f1

$$(F \quad 3 \quad A \quad 5)_{16}$$

$$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$$

$$(1111001110100101)_2$$

$$\underline{g1} \quad (011011001)_2$$

$$\downarrow \quad \downarrow \quad \downarrow$$

$$(3 \quad 3 \quad 1)_8$$

$$\begin{array}{r} \underline{\underline{2.1}} \\ \text{hl} \\ (AB3D)_{16} \\ \swarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ (1010\ 1011\ 0011\ 1101)_2 \end{array}$$

$$\begin{array}{r} \underline{|x|} \\[0.5ex] \begin{array}{r} 101110 \\ \downarrow \quad \downarrow \quad \downarrow \\ (5 \quad 7 \quad .3 \quad )_8 \end{array} \cdot \begin{array}{r} 011 \\ \downarrow \\ 100 \end{array} \end{array}$$

$$\begin{array}{c} \text{y1} \\ (15 \text{ C. } 38)_{16} \\ \swarrow \quad \swarrow \quad \swarrow \quad \downarrow \quad \downarrow \\ (10101100, 00111000)_2 \end{array}$$

$$\begin{array}{r}
 \text{2.2} \\
 \underline{\text{a1}} \\
 \begin{array}{c}
 (1023)_8 \\
 \downarrow \quad \downarrow \quad \downarrow \\
 (001\overset{0}{0}00010011)_2 \\
 \hline
 \downarrow \quad \downarrow \quad \downarrow \\
 (2 \quad 1 \quad 3)_{16}
 \end{array}
 \end{array}$$

~~(1111 1100 0110 1010)~~  
 (7 E G A)<sub>16</sub>  
~~(1111 1100 0110 1010)~~<sub>2</sub>  
 (7 E G A)<sub>16</sub>

$$\begin{array}{c}
 \cancel{S1} \\
 \diagdown \quad \downarrow \quad \downarrow \quad \downarrow \\
 (ABCD)_{16} \\
 \cancel{(001010\ 101\ 1100\ 1101)}_2 \\
 \cancel{\underline{\quad\quad\quad\quad\quad\quad}} \\
 \begin{array}{c}
 \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\
 (1 \ 2 \ 5 \ 7 \ 1 \ 5)_8
 \end{array}
 \end{array}$$

2.2

b1  $(761302)_8$

$$\begin{array}{r} 11000101100001010 \\ \hline 1001111000101100001010 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ 3 \quad E \quad 2 \quad C \quad 2 \end{array} (3E2C2)_8$$

c1

c1  $(163417)_8$

$$\begin{array}{r} 1110011100001111 \\ \hline 1110011100001111 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ E \quad 7 \quad 0 \quad F \end{array} (E70F)_{16}$$

d1

d1  $(552273)_8$

$$\begin{array}{r} 101101010010111011 \\ \hline 101101010010111011 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ 204B\ B \end{array} (204B\ B)_{16}$$

e1

e1  $(5436.15)_8$

$$\begin{array}{r} 10110001110.00110100 \\ \hline 10110001110.00110100 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ B\ 1\ E\ .\ 3\ 4 \end{array} (B1E.34)_{16}$$

$$\underline{2.2} \underline{f1} \quad (13707.207)_8$$

$$\begin{array}{r} 0001 \ 011110000111,010000110 \\ \hline 1000 \end{array}$$

$$(17C7.438)_{16}$$

$$\underline{2.3} \underline{a1} \quad (1023)_{16}$$

$$\begin{array}{r} 001 \ 000000100011 \\ \hline 10043 \end{array}$$

$$(10043)_8$$

$$\underline{b1} \quad (7EGA)_{16}$$

$$\begin{array}{r} 11111001101010 \\ \hline 77152 \end{array}$$

$$(77152)_8$$

$$\underline{c1} \quad (ABCD)_{16}$$

$$\begin{array}{r} 00101010111001101 \\ \hline 125715 \end{array}$$

$$(125715)_8$$

d)  $(C350)_{16}$

$$\begin{array}{ccccccc}
 & \swarrow & \downarrow & \downarrow & \downarrow \\
 & 0 & 0 & 1 & 1 & 0 & 0 0 0 1 1 0 1 0 1 0 0 0 0 \\
 \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
 (1 & 4 & 1 & 5 & 2 & 0) & _8
 \end{array}$$

e)  $(9E36.7A)_{16}$

$$\begin{array}{ccccccc}
 & \swarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
 & 0 & 0 & 1 & 0 & 0 1 1 1 1 0 0 0 1 1 0 1 0 . 0 & 1 1 1 1 0 1 0 0 \\
 \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
 (1 & 1 & 7 & 0 & 6 & 6 & . 3 & 6 & 4) & _8
 \end{array}$$

f)  $(DEAD.BEEF)_{16}$

$$\begin{array}{ccccccc}
 & \swarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
 & 0 & 0 & 1 & 0 & 1 1 1 0 1 0 1 0 1 1 0 1 . 1 & 0 1 1 1 0 1 1 1 0 1 1 1 0 0 \\
 \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\
 (1 & 5 & 7 & 2 & 5 & 5 . 5 & 7 & 5 & 6 & 7 & 4) & _8
 \end{array}$$

2.4

$(12345670123)_{8}$

$$\begin{array}{ccccccccccccc}
 & \swarrow & \searrow \\
 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1
 \end{array}$$

If we write them in four 8 bit bytes we get

01010011 10010111 01110000 01010011

2.5

$$\underline{a} \quad (1101011)_2 = (2^6 + 2^5 + 2^3 + 2^1 + 1 \times 2^0)_{10} = (107)_{10}$$

$$\underline{b} \quad (174003)_8 = (1 \times 8^5 + 7 \times 8^4 + 4 \times 8^3 + 3 \times 8^0)_{10} = (63491)_{10}$$

$$\underline{c} \quad (10110111)_2 = (2^7 + 2^5 + 2^4 + 2^2 + 2^1 + 2^0)_{10} = (183)_{10}$$

$$\underline{d} \quad (67.24)_8 = (6 \times 8^1 + 7 \times 8^0 + 2 \times 8^{-1} + 4 \times 8^{-2})_{10} = (55.3125)_{10}$$

$$\underline{e} \quad (10100.1101)_2 = (2^4 + 2^2 + 2^{-1} + 2^{-2} + 2^{-4})_{10} = (20.8125)_{10}$$

$$\underline{f} \quad (F3A5)_{16} = (15 \times 16^3 + 3 \times 16^2 + 10 \times 16^1 + 5 \times 16^0)_{10} = (62373)_{10}$$

$$\underline{g} \quad (12010)_3 = (1 \times 3^4 + 2 \times 3^3 + 1 \times 3^1)_{10} = (138)_{10}$$

$$\underline{h} \quad (\bar{A}\bar{B}3D)_{16} = (10 \times 16^3 + 11 \times 16^2 + 3 \times 16^1 + 13 \times 16^0)_{10} = (43837)_{10}$$

$$\underline{i} \quad (7156)_8 = (7 \times 8^3 + 1 \times 8^2 + 5 \times 8^1 + 6 \times 8^0)_{10} = (3694)_{10}$$

$$\underline{j} \quad (15C.38)_{16} = (1 \times 16^2 + 5 \times 16^1 + 12 \times 16^0 + 3 \times 16^{-1} + 8 \times 16^{-2})_{10} = (348.21875)_{10}$$

2.6

$$\underline{a} \quad (125)_{10} = (1111101)_2$$

$$\begin{array}{r} 2 | 125 \\ 2 | 62 \ 1 \\ 2 | 31 \ 0 \\ 2 | 15 \ 1 \\ 2 | 7 \ 1 \\ 2 | 3 \ 1 \\ 2 | 1 \ 1 \\ 0 \end{array} \uparrow$$

$$\underline{2.6} \quad \underline{b1} \quad (3485)_{10} = (6641)_8$$

$$\begin{array}{r} 8 | 3485 \\ 8 | 436 \quad 1 \\ 8 | 54 \quad 4 \\ 8 | 6 \quad 6 \\ \hline 0 \quad 6 \end{array}$$

$$\underline{c1} \quad (209)_{10} = (11010001)_2$$

$$\begin{array}{r} 2 | 209 \\ 2 | 104 \quad 1 \\ 2 | 52 \quad 0 \\ 2 | 26 \quad 0 \\ 2 | 13 \quad 0 \\ 2 | 6 \quad 1 \\ 2 | 3 \quad 0 \\ \hline 1 \quad 1 \end{array}$$

$$\underline{d1} \quad (9714)_{10} = (22762)_8$$

$$\begin{array}{r} 8 | 9714 \\ 8 | 1214 \quad 2 \\ 8 | 151 \quad 6 \\ 8 | 18 \quad 7 \\ 8 | 2 \quad 2 \\ \hline 0 \quad 2 \end{array}$$

$$\underline{e1} \quad (132)_{10} = (10000100)_2$$

$$\begin{array}{r} 2 | 132 \\ 2 | 66 \quad 0 \\ 2 | 33 \quad 0 \\ 2 | 16 \quad 1 \\ 2 | 8 \quad 0 \\ 2 | 4 \quad 0 \\ 2 | 2 \quad 0 \\ \hline 1 \quad 0 \end{array}$$

2.6 E1  $(23851)_{10} = (5D2B)_{16}$

$$\begin{array}{r} 16 \mid 23851 \\ 16 \quad \boxed{1490 \quad 11} \\ 16 \quad \boxed{93 \quad 2} \uparrow \\ 16 \quad \boxed{5 \quad 13} \\ \hline 0 \quad 5 \end{array}$$

2.1  $(727)_{10} = (10402)_5$

$$\begin{array}{r} 5 \mid 727 \\ 5 \quad \boxed{145 \quad 2} \\ 5 \quad \boxed{29 \quad 0} \\ 5 \quad \boxed{5 \quad 4} \\ 5 \quad \boxed{1 \quad 0} \uparrow \\ \hline 0 \quad 1 \end{array}$$

h1  $(57190)_{10} = (DE66)_{16}$

$$\begin{array}{r} 16 \mid 57190 \\ 16 \quad \boxed{3574 \quad 6} \\ 16 \quad \boxed{223 \quad 6} \uparrow \\ 16 \quad \boxed{13 \quad 15} \\ \hline 0 \quad 13 \end{array}$$

i1  $(1435)_{10} = (2633)_8$

$$\begin{array}{r} 8 \mid 1435 \\ 8 \quad \boxed{179 \quad 3} \\ 8 \quad \boxed{22 \quad 3} \uparrow \\ 8 \quad \boxed{2 \quad 6} \\ \hline 0 \quad 2 \end{array}$$

$$j) (65113)_{10} = (FE59)_{16}$$

$$\begin{array}{r} 16 | 65113 \\ \hline 16 | 4069 \ 9 \\ \hline 16 | 254 \ 5 \\ \hline 16 | 15 \ 14 \\ \hline 0 \ 15 \end{array}$$

2.7 a)

$$\begin{array}{r} (110101)_2 \\ + (11001)_2 \\ \hline (1001110)_2 \end{array}$$

$$\begin{array}{r} b) (101110)_2 \\ (100101)_2 \\ \hline (1010011)_2 \end{array}$$

$$\begin{array}{r} c) (11011101)_2 \\ (1100011)_2 \\ \hline (101000000)_2 \end{array}$$

$$\begin{array}{r} d) (1110010)_2 \\ + (1101101)_2 \\ \hline (11011111)_2 \end{array}$$

2.8

$$\begin{array}{r} a) (110101)_2 \\ - (11001)_2 \\ \hline (11100)_2 \end{array}$$

$$\begin{array}{r} b) (101110)_2 \\ - (100101)_2 \\ \hline (1001)_2 \end{array}$$

$$\begin{array}{r} c) (11011101)_2 \\ - (1100011)_2 \\ \hline (111010)_2 \end{array}$$

$$\begin{array}{r} d) (1110010)_2 \\ - (1101101)_2 \\ \hline (0101)_2 \end{array}$$

2.9

a)

$$\begin{array}{r} 8 \\ \times 8 \\ \hline 64 \\ + 0 \\ \hline 64 \end{array}$$

$$\begin{array}{r} 11 \\ (1372)_8 \\ + (4631)_8 \\ \hline (6223)_8 \end{array}$$

c)

$$\begin{array}{r} 11 \\ (175214)_8 \\ + (152405)_8 \\ \hline (347621)_8 \end{array}$$

$$\begin{array}{r} 1 \\ (47135)_8 \\ + (5125)_8 \\ \hline (54262)_8 \end{array}$$

$$\begin{array}{r} 8 \\ \times 8 \\ \hline 64 \\ + 0 \\ \hline 64 \end{array}$$

$$\begin{array}{r} 8 \\ \times 8 \\ \hline 64 \\ + 0 \\ \hline 64 \end{array}$$

2.10

a)

$$\begin{array}{r} (1372)_{16} \\ + (4631)_{16} \\ \hline (59A3)_{16} \end{array}$$

$$\begin{array}{r} 11 \\ (4F1A5)_{16} \\ + (B8D5)_{16} \\ \hline (5AA7A)_{16} \end{array}$$

$$\begin{array}{r} 13 \\ + 10 \\ \hline 23 \\ 16 \boxed{1} 7 \\ 16 \quad 1 \\ 0 \end{array}$$

c)

$$\begin{array}{r} 11 \\ (F35B)_{16} \\ + (27E6)_{16} \\ \hline (11B41)_{16} \end{array}$$

$$\begin{array}{r} 11 \\ (1B90F)_{16} \\ + (C44E)_{16} \\ \hline (27D5D)_{16} \end{array}$$

$$\begin{array}{r} 11 \\ + 6 \\ \hline 17 \\ 16 \boxed{1} 1 \\ 16 \quad 1 \\ 0 \end{array}$$

$$\begin{array}{r} 15 \\ + 14 \\ \hline 29 \\ 16 \boxed{1} 13 \\ 16 \quad 1 \\ 0 \end{array}$$

$$\begin{array}{r} 6 \\ + 14 \\ \hline 20 \\ 16 \boxed{1} 4 \\ 16 \quad 1 \\ 0 \end{array}$$

31

a1 Number of atoms in a sample of a material - Digital

b1 Altitude of an aircraft - Analog

c1 Grains of sand in a beach - Digital

d1 Volume through a loud speaker - Analog

e1 Time setting on a microwave oven - Digital

f1 Temperature of a room - Analog

(41) How many bits would be needed to represent  $(15768)_{10}$  in binary format?

$$\begin{array}{r} 2 | 15768 \\ \hline 2 | 7884 \quad 0 \\ \hline 2 | 3942 \quad 0 \\ \hline 2 | 1971 \quad 0 \\ \hline 2 | 985 \quad 1 \\ \hline 2 | 492 \quad 1 \\ \hline 2 | 246 \quad 0 \\ \hline 2 | 123 \quad 0 \\ \hline 2 | 61 \quad 1 \\ \hline 2 | 30 \quad 1 \\ \hline 2 | 15 \quad 0 \\ \hline 2 | 7 \quad 1 \\ \hline 2 | 3 \quad 1 \\ \hline 2 | 1 \quad 1 \\ \hline & 0 \quad 1 \end{array}$$

So if there is no sign then we need at least 14 bits to represent the number.

If there is a sign ~~best~~ bit then we need at least 15 bits.

5.

|    | Hexadecimal           | Decimal               | Octal                   | Binary                              |
|----|-----------------------|-----------------------|-------------------------|-------------------------------------|
| a) | 1C A C                | 7340                  | 16254                   | 1110010101100                       |
| b) | 315                   | 789                   | <del>1025</del><br>1425 | <del>1100010101</del><br>1100010101 |
| c) | <del>281</del><br>119 | <del>119</del><br>281 | 431                     | 100011001                           |
|    | 476                   | 1142                  | 2166                    | 010001110110                        |

a)

$$\begin{array}{r}
 (1C\ A\ C)_{16} \\
 / \quad | \quad \backslash \\
 1 \ 0 \ 0 \ 1 \quad 1 \ 0 \ 0 \ 1 \ 0 \ 0 \\
 \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\
 (1 \ 6 \ 2 \ 5 \ 4)_8
 \end{array}$$

$$\begin{aligned}
 \text{Decimal: } & 1 \times 16^3 + 12 \times 16^2 + 10 \times 16^1 + 12 \times 16^0 \\
 = & 7340
 \end{aligned}$$

- |     |      |
|-----|------|
| 0   | 1    |
| 1   | 10   |
| 2   | 11   |
| 3   | 100  |
| 4   | 101  |
| 5   | 110  |
| 6   | 111  |
| 7   | 1000 |
| 8   | 1001 |
| 9   | 1010 |
| (A) | 1011 |
| (B) | 1100 |
| (C) | 1101 |
| (D) | 1110 |
| (E) | 1111 |
| (F) | 1010 |

b)

$$\begin{array}{r}
 2 \Big| 789 \\
 2 \overline{)394} \quad 1 \\
 2 \Big| 197 \quad 0 \\
 2 \overline{)98} \quad 1 \\
 2 \Big| 49 \quad 0 \\
 2 \Big| 24 \quad 1 \\
 2 \Big| 12 \quad 0 \\
 2 \Big| 6 \quad 0 \\
 2 \Big| 3 \quad 0 \\
 2 \Big| 1 \quad 1 \\
 \hline & 0 \quad 1
 \end{array}$$

$$\begin{array}{r}
 (601000010101)_2 \\
 \downarrow \quad \downarrow \quad \downarrow \\
 (3 \quad 1 \quad 5)_{16} \\
 \hline
 001 \quad 1000 \quad 10 \quad 10 \quad 1 \\
 \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\
 (1 \quad 4 \quad 2 \quad 5)_{10} \\
 \hline
 \end{array}$$

51  
c1

$$\begin{array}{r} (431)_8 \\ \downarrow \quad \downarrow \quad \downarrow \\ 00(100 \ 011 \ 001)_2 \\ \hline (1 \quad 1 \quad 9)_{16} \end{array}$$

$$\begin{aligned} & (1 \times 16^2 + 1 \times 16 + 9 \times 16^0)_{10} \\ & = (281)_{10} \end{aligned}$$

d1

$$\begin{array}{r} (010001110110)_2 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\ (2 \quad 1 \quad 6 \quad 6)_8 \end{array}$$

$$\begin{array}{r} 010001110110 \\ \downarrow \quad \downarrow \quad \downarrow \\ (4 \quad 7 \quad 6)_{16} \end{array}$$

$$\begin{aligned} & (010001110110)_2 \\ & = (1 \times 2^{10} + 2^6 + 2^5 + 2^4 + 2^2 + 2^1 + 2^0)_{10} \\ & = \cancel{1143} = (1142)_{10} \end{aligned}$$

a)

a)

$$(1346.6)_8$$
$$(101100110.110)_2$$

b)

$$(\overline{00010111101.1010})_2$$
$$(17D.A)_{16}$$

c)

$$(5703.4)_8$$
$$(\overline{10111000011.1000})_2$$
$$(B.C3.8)_{16}$$

d)

$$(8AD.9)_{16}$$
$$(\overline{100010101101.100100})_2$$
$$(4255.44)_{10}$$