$(d_n . d_{n-1} \text{ -- } d_1)_{10}$

$= d_1 \times 10^0 + d_2 \times 10^1 + \cdots + d_{n-1} \times 10^{n-2} + d_n \times 10^{n-1}$

---

10 1 2 |

Octal — 8

hexa-decimal — 16

Octal numbers

0 = 0	10 = 8	20 = 16	70	100
1 = 1	11 = 9			
2 = 2	12 = 10			
3 = 3	13 = 11			
4 = 4	14 = 12			
5 = 5	15 = 13			
6 = 6	16 = 14			
7 = 7	17 = 15	27	77	

One digit octal number

$$\boxed{\begin{array}{c} 0-7 \\ \hline 6 \end{array}}$$

$\times 8^0 = 6 \times 1 = 6$

---

two digit octal number

1-7	0-7
6	4

$$\times 8^0 = 4 \times 1 = 4$$

$$\times 8^1 = 6 \times 8 = 48$$

$$+ \quad \overline{52}$$

$$(64)_8 = (52)_{10}$$

---

three digit octal number

d_3	d_2	d_1
1-7	0-7	0-7
2	7	4

$$\times 8^0 = 4 \times 1 = 4$$

$$\times 8^1 = 7 \times 8 = 56$$

$$\times 8^2 = 2 \times 64 = 128$$

$$\overline{188}$$

$$(274)_8 = (188)_{10}.$$

Any number in octal form.

1-7	0-7	0-7		0-7	0-7	0-7
d_n	d_{n-1}	d_{n-2}	• • •	d_3	d_2	d_1

$$\times 8^0 = d_1 \times 8^0$$

$$\times 8^1 = d_2 \times 8^1$$

$$\times 8^2 = d_3 \times 8^2$$

$\times 8^{n-3} = d_{n-2} \times 8^{n-3}$

$\times 8^{n-2} = d_{n-1} \times 8^{n-2}$

$\times 8^{n-1} = d_n \times 8^{n-1}$

After addition,

$$(d_n d_{n-1} d_{n-2} \cdots d_3 d_2 d_1)_8 = d_1 \times 8^0 + d_2 \times 8^1 + d_3 \times 8^2 + \cdots + d_{n-2} \times 8^{n-3} + d_{n-1} \times 8^{n-2} + d_n \times 8^{n-1}$$

= least significant digit

= most significant digit

Decimal to Octal Conversion

20, Divide 20 by 8, and find the quotient and the remainder

$q = 2, \quad r = 4.$

$$20 = \underset{Q}{2} \times 8 + \underset{R}{4}$$

$$= 2 \times 8^1 + 4 \times 1$$

$$= 2 \times 8^1 + 4 \times 8^0$$

0-7	0-7
2	4

4×8^0

2×8^1

$$= 2 \times 8^1 + 4 \times 8^0 = (20)_{10}$$

$$(24)_8 = (20)_{10}$$

167

Stage-1: Divide 167 by 8.

$Q = 20 \qquad R = 7.$

$167 = \underline{\underline{20}} \times 8 + 7.$

Stage 2: Divide 20 by 8.

$Q = 2, \quad R = 4.$

$20 = 2 \times 8 + 4$

$167 = 20 \times 8 + 7$ ... Stage-1

$167 = [2 \times 8 + 4] \times 8 + 7$ ... substituting 20 by $2 \times 8 + 4$.
:- Stage-2

$= 2 \times 8 \times 8 + 4 \times 8 + 7$

$= 2 \times 8^2 + 4 \times 8^1 + 7 \times 1$

$= 2 \times 8^2 + 4 \times 8^1 + 7 \times 8^0$

0-7	0-7	0-7
2	4	7

$\times 8^0 = 7 \times 8^0$

$\times 8^1 = 4 \times 8^1$

$\times 8^2 = 2 \times 8^2$

$(247)_8 = 7 \times 8^0 + 4 \times 8^1 + 2 \times 8^2 = (167)_{10}$

Conversion of decimal to octal.

1) Divide target number by 8
   find out the quotient & the remainder

2) keep dividing the quotient by 8 until it falls down to 0. and for each division of quotient, register a remainder.

3) when the quotient is zero write down all remainder from left to write in the reverse order of their generation (LIFO)

- Hexa-decimal number system.

0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f.
10	11	12	13	14	15	16	17	18	19	1a	1b	1c	1d	1e	1f
20	21	22	23	24	25	26	27	28	29	2a	2b	2c	2d	2e	2f

$(a)_{16} = (10)_{10}$ $\quad$ $(d)_{16} = (13)_{10}$

$(b)_{16} = (11)_{10}$ $\quad$ $(e)_{16} = (14)_{10}$

$(c)_{16} = (12)_{10}$ $\quad$ $(f)_{16} = (15)_{10}$.

Single digit hexa-decimal number

0-f
c

$\rightarrow \times 16^0 = c \times 1 = c = (12)$.

Two digit hexa-decimal number.

1-f	0-f
d	8

$8 \times 16^0 = 8 \times 16^0 = 8 \times 1 = 8$

$d \times 16^1 = d \times 16^1 = 13 \times 16 = 208$

$$(d8)_{16} = (216)_{10}$$

Three digit hexa-decimal number

1-f	0-f	0-f
2	f	a

$a \times 16^0 = a \times 16^0 = 10 \times 1$

$f \times 16^1 = f \times 16^1 = 15 \times 16$

$2 \times 16^2 = 2 \times 16^2 = 2 \times 256$

$$\begin{array}{rcl} 10 \times 1 & = & 10 \\ 15 \times 16 & = & 240 \\ 2 \times 256 & = & 512 \\ \hline & & 762 \end{array}$$

$$(2fa)_{16} = (762)_{10}$$

Any number in hexa-decimal format

1-f	0-f	0-f		0-f	0-f	0-f
d_n	d_{n-1}	d_{n-2}	. . .	d_3	d_2	d_1

$d_1 \times 16^0$

$d_2 \times 16^1$

$d_3 \times 16^2$

$d_{n-2} \times 16^{n-3}$

$d_{n-1} \times 16^{n-2}$

$d_n \times 16^{n-1}$

$$(d_n d_{n-1} d_{n-2} \ldots d_3 d_2 d_1)_{16}$$
$$= \left(d_1 \times 16^0 + d_2 \times 16^1 + d_3 \times 16^2 + \ldots + d_{n-2} \times 16^{n-3} + d_{n-1} \times 16^{n-2} + d_n \times 16^{n-1}\right)_{10}$$

$$(189)_{10} \longrightarrow (??)_{16}.$$

Divide 189 by 16.

$Q = 11 \quad R = 13$

$$189 = 11 \times 16 + 13$$
$$= b \times 16 + d$$
$$= b \times 16^1 + d \times 16^0$$

b	d

$\times 16^0 = d \times 16^0 = 13 \times 1 = 13$
$\times 16^1 = b \times 16^1 = 11 \times 16 = 176 \quad = (189)_{10}$

Conversion of decimal to hexa-decimal.

1) Divide target number by 16
   find out the quotient & the remainder

2) keep dividing the quotient by 16 until it falls down to 0. and for each division of quotient, register a remainder.
3) when the quotient is zero write down all remainder from left to write in the reverse order of their generation (LIFO)

[Additional Activity in Decimal – hex Conversion]

After dividing the target number in step-1 or the quotient in step-2, the remainder will fall between 0 to 15.

If remainder is between 10 to 15 then while writing the hexa-decimal form in step-3

replace $10 \xrightarrow{by} a$

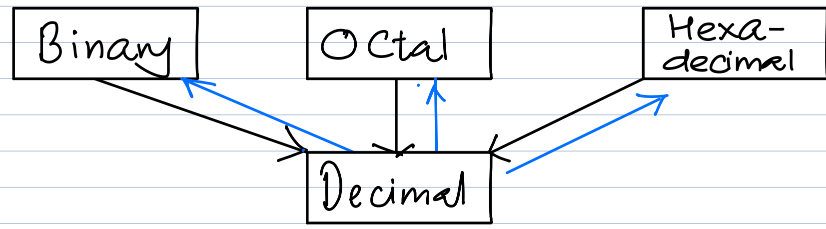
$11 \xrightarrow{by} b$

$12 \xrightarrow{by} c$

$13 \xrightarrow{by} d$

$14 \xrightarrow{\text{by}} e$

$15 \xrightarrow{\text{by}} f$



Versatile computer vs. Non-versatile traditional devices → While shipping Mechanisms & interface given to combine mechanisms

While shipping Mechanism + Policy

While shipping Mechanisms & interface given to combine mechanisms → Programmable device

Act of combining mechanism under some policy by end user using given interface → Programming.

Doer of the act → Programmer.

Computer = the CPU + RAM

Mechanisms
[ALU, trigonometric,
inverse trigonometric,
exponential, logarithmic,
hyperbolic, inverse
hyperbolic, data
movement, control
flow management
] + Interface
to combine
mechanisms.

$\therefore$ a computer == a programmable
device

Memory = Any device capable of exhibiting
more than one state and does
not undergo a state transition
without explicit command

How to represent numbers in memory?
[to answer the question $\rightarrow$ how CPU
mechanisms are combined in memory]
STOP.

fundamental principle of counting (simple version)
fundamental principle of counting (generalised version)

Division theorem.

Exponential & log function (log to base 10, 2), floor & ceiling funcs.

Decimal, binary, octal & Hexa-decimal number system & inter-conversions

RESUME