COUNTING

1 2 3

$$\frac{1 \qquad 2 \qquad 3}{10^2 \qquad 10^1 \qquad 10^0}$$

$$1 \quad 2 \quad 3$$

$$10^2 \qquad 10^1 \qquad 10^0$$

$= 1 \text{ x } 10^2 + 2 \text{ x } 10^1 + 3 \text{ x } 10^0$

$= 1 \text{ x } 100 + 2 \text{ x } 10 + 3 \text{ x } 1$

$= 123$

4	1	2	3
?	10^2	10^1	10^0

$$4 \quad 1 \quad 2 \quad 3$$

$$? \qquad 10^2 \qquad 10^1 \qquad 10^0$$

$$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

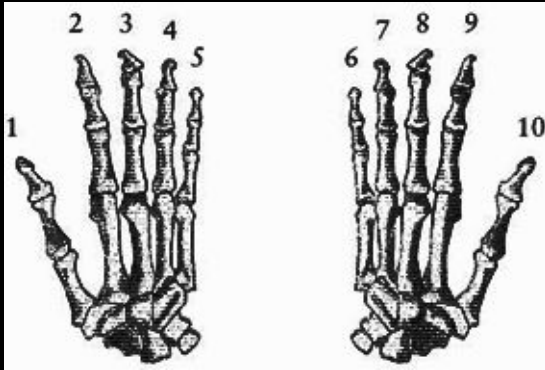$$4 \quad 1 \quad 2 \quad 3$$

? 10^2 10^1 10^0

$$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

$$= 4 \times 1000 + 1 \times 100 + 2 \times 10 + 3 \times 1$$

$$4 \quad 1 \quad 2 \quad 3$$

$$? \qquad 10^2 \qquad 10^1 \qquad 10^0$$

$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$
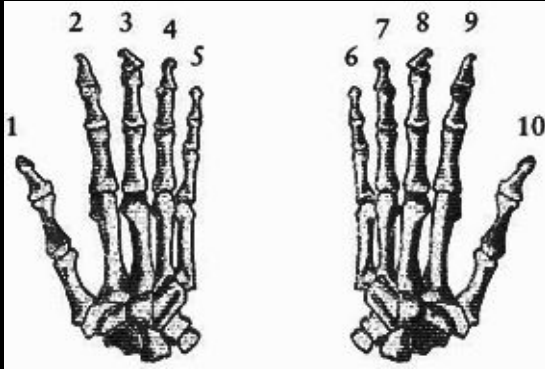
$= 4 \times 1000 + 1 \times 100 + 2 \times 10 + 3 \times 1$

$= 4123$

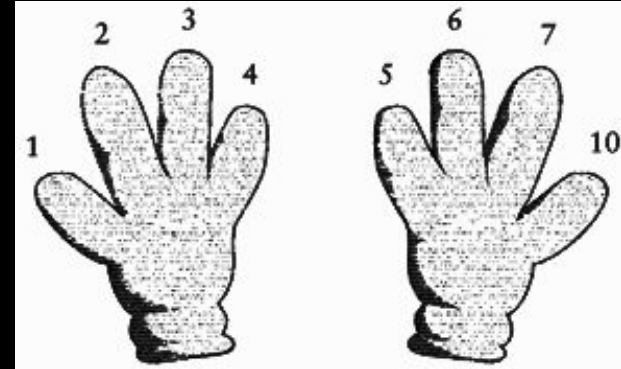human hand

human hand   cartoon character's hand

1   2   3   (octal)

$$1 \qquad 2 \qquad 3 \qquad \text{(octal)}$$

$$8^2 \qquad\qquad 8^1 \qquad\qquad 8^0$$

1   **2**   **3**   (octal)

8^2 8^1 8^0

$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$

1   2   3   (octal)

8^2 8^1 8^0

$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$

$= 1 \times 64 + 2 \times 8 + 3 \times 1$

$$1 \qquad 2 \qquad 3 \qquad \text{(octal)}$$

$$8^2 \qquad\qquad 8^1 \qquad\qquad 8^0$$

$$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$$

$$= 1 \times 64 + 2 \times 8 + 3 \times 1$$

$$= 83 \text{ (decimal)}$$

decimal   octal

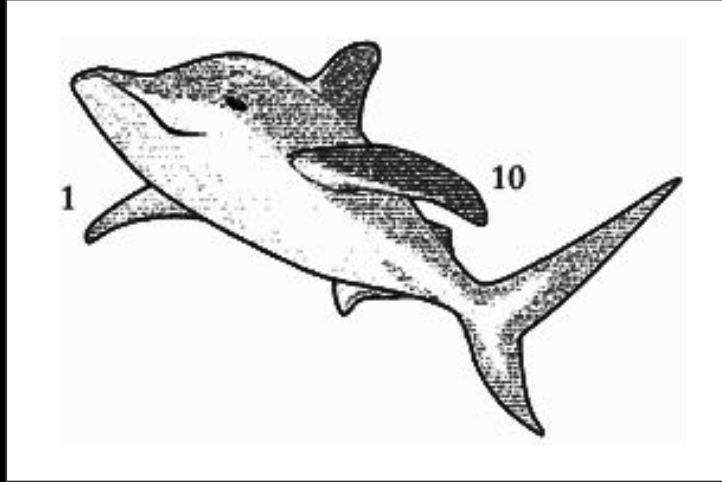8   ⟶   ?

decimal   octal

?   ⟵————————   7

decimal   octal

16   ⟶   ?

decimal   octal

? $\longleftarrow$ 100

what now?

Image source: Petzold, Charles. Code: The Hidden Language of Computer Hardware and Software. 2nd ed., Microsoft Press, 2022.

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0, 1, …

0, 1, 10, …

0, 1, 10, 11, …

0, 1, 10, 11, 100, …

0, 1, 10, 11, 100, 101, …

0, 1, 10, 11, 100, 101, 110

1   1   0   (binary)

$$1 \quad 1 \quad 0 \quad \text{(binary)}$$

$$2^2 \qquad 2^1 \qquad 2^0$$

1   1   0   (binary)

$$2^2 \qquad\qquad 2^1 \qquad\qquad 2^0$$

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

$$1 \quad 1 \quad 0 \quad \text{(binary)}$$

$$2^2 \qquad\qquad 2^1 \qquad\qquad 2^0$$

$$= 1 \text{ x } 2^2 + 1 \text{ x } 2^1 + 0 \text{ x } 2^0$$

$$= 1 \text{ x } 4 + 1 \text{ x } 2 + 0 \text{ x } 1$$

1   1   0   (binary)

2^2 2^1 2^0

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

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

$= 6$ (decimal)

$$2 \quad 3 \quad 4 \quad 5 \quad 6$$

0, 1, 10, 11, 100, 101, 110

place value systems

$$N = d_n * R^{n-1} + \ldots + d_2 * R^1 + d_1 * R^0$$

$$d \in \{ 0, 1, \ldots R-1 \}$$

n = number of digits

R = base

$$R \geq 2$$