

BST 234: Lab - 1

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Python usage

- For command prompt: Python in the terminal or script
- For interactive use: IPython notebook (Jupyter etc.)

Quick tips on Python

- Zero-based indexing
- `math`, `numpy`, `scipy` are useful modules for scientific computing and `matplotlib` is useful for visualization
- Several data structures available such as: lists, dictionaries, tuples, arrays etc.

Normalized Floating Point Representation

$$x = \pm m * b^{\pm e}$$

- base $b \in \mathbb{N}$ and $b > 1$
- mantissa $m = m_1 b^{-1} + \dots + m_r b^{-r} \in \mathbb{R}$
- exponent $e = e_{s-1} b^{s-1} + \dots + e_0 b^0 \in \mathbb{N}$
- digits $m_i, e_i \in 0, \dots, b-1$
- significant digits $s \in \mathbb{N}$ and $r \in \mathbb{N}$

Practice: Normalized Floating Point Representation

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$$2^3 \leq 10 \leq 2^4$$

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- Factor x into b^k, b^{k-1}, \dots

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

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- Add terms and factor out b^{k+1}

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

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- Answer: $x = (.101)_2 * 2^4$

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Express the number $x = 100$ in normalized floating point format for the base $b = 3$:

- Find k such that $b^k \leq x \leq b^{k+1}$
- Factor x into b^k, b^{k-1}, \dots
- Add terms and factor out b^{k+1}
- Answer: $x = (.10201)_3 * 3^5$

Machine Precision

Definition:

$$eps := \frac{1}{2}b^{-r+1}$$

For the IEEE-format:

$$eps_{IEEE} \leq \frac{1}{2}2^{-51}$$

- *Python demonstration*

Floating point arithmetic

- Since floating point arithmetic is inherently approximate and not exact following symbols are used: $\oplus, \ominus, \otimes, \oslash$
- $(x \oplus y) \oplus z \neq x \oplus (y \oplus z)$ (Associative law doesn't hold)
- $(x \oplus y) \otimes z \neq (x \otimes z) \oplus (y \otimes z)$ (Distributive law doesn't hold)
- $x \oplus y = x$ for $|y| \leq \frac{|x|}{b} \text{eps}$
- *Python demonstration*

Practice: Prove the identity

Prove that $u \ominus v = -(v \ominus u)$ based on the following identities:

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$$u \oplus v = v \oplus u$$

$$u \oplus 0 = u$$

$$u \ominus v = u \oplus -v \tag{1}$$

$$= -v \oplus u \tag{2}$$

$$= -(v \oplus -u) \tag{3}$$

$$= -(v \ominus u) \tag{4}$$