DYALOG

APL Standards

Karta Kooner

DYALOG

- Introduction to APL

DYALOG

- Introduction to APL
- About Dyalog

DYALOG

- Introduction to APL
- About Dyalog
- Differences in APL implementations

DYALOG

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- Omissions in the standard

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DYALOG

```
xpower←{
  xt←{(0,⍺)xtimes 0,⍵}
  b←⍞2⊥⍣¯1+10⊥⍵
  ↑,/xt/b/{xt⍨⍵}\(⊂,10⊥⍣¯1+⍺)⍴⍨⍴b
}
```

DYALOG

+ − × ÷ ⋆ ← > ⍨ ⍤ ≠ ⊆ ⊂ ∩ ⍋ ⍒ ⌿ ∘ ⍤ ⍨ ⍣

DYALOG

Array programming language

DYALOG

Array programming language (interpreted)

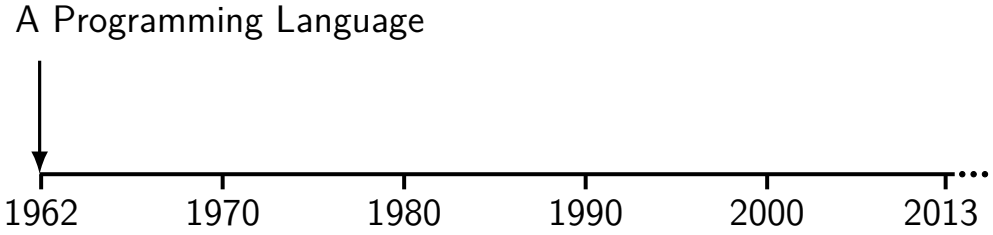
DYALOG

Array programming language (interpreted)

Developed by Kenneth Iverson, 1960s

DYALOG

DYALOG



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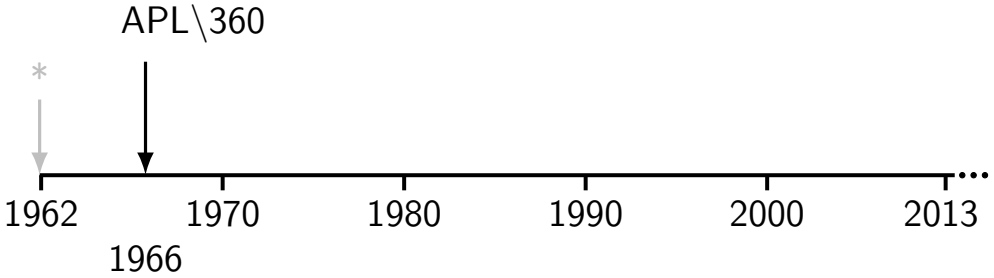

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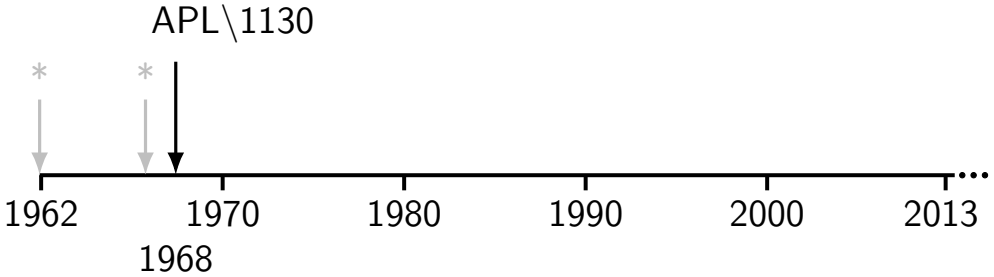

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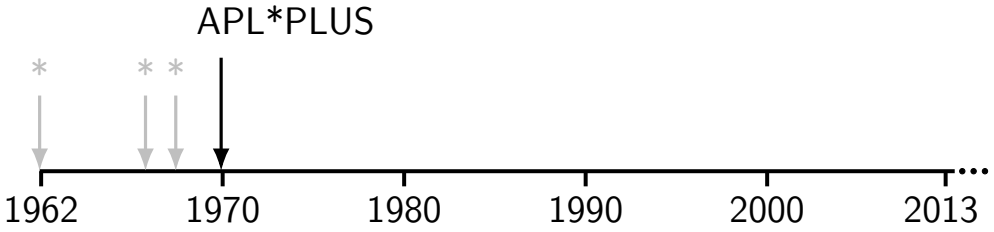
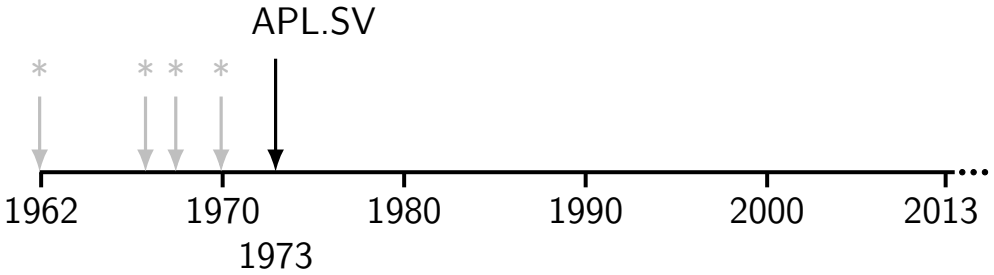
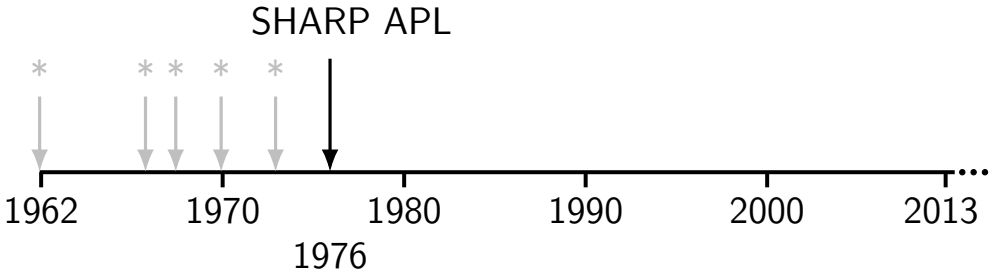


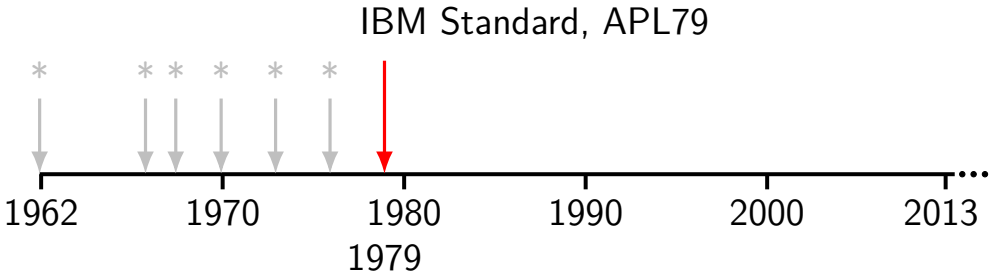
DYALOG



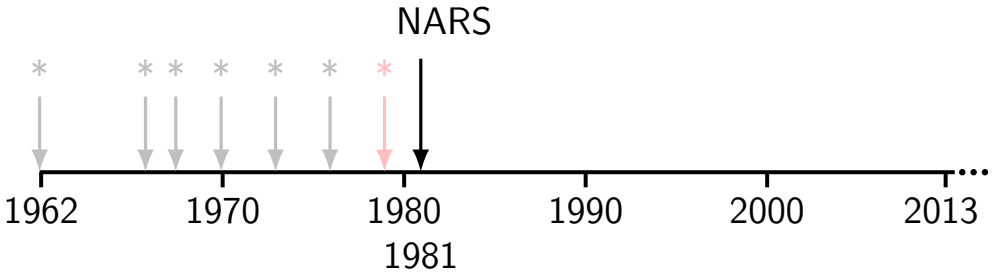
DYALOG



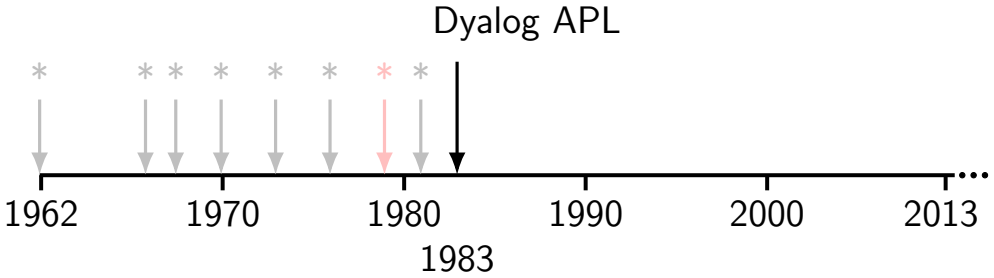
DYALOG



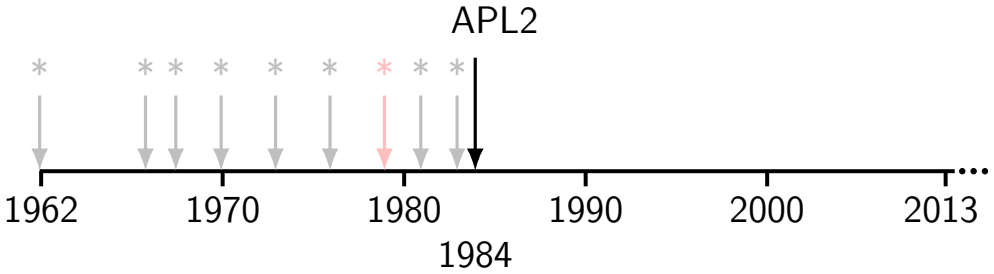
DYALOG



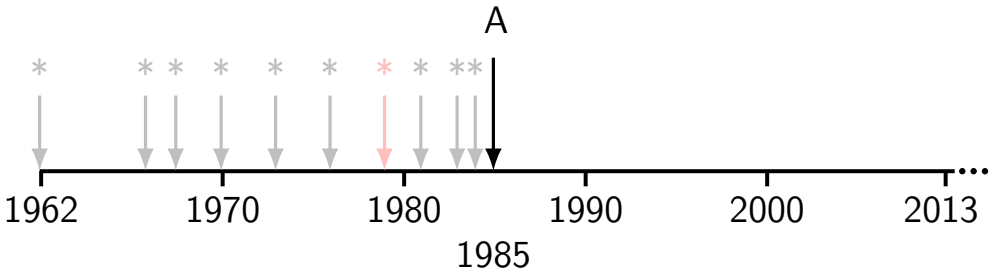
DYALOG



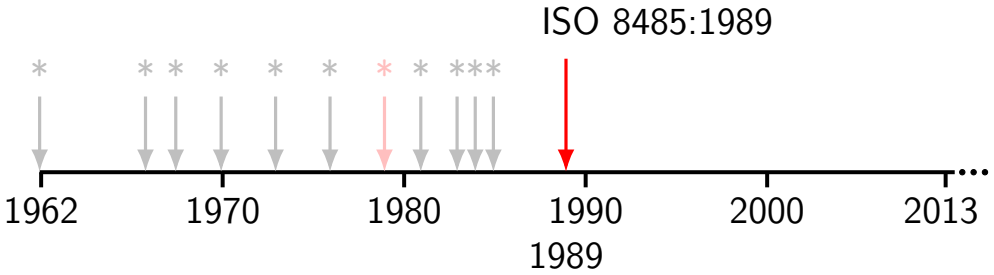
DYALOG



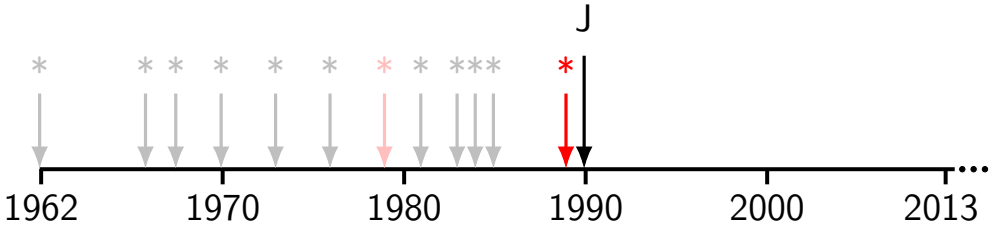
DYALOG



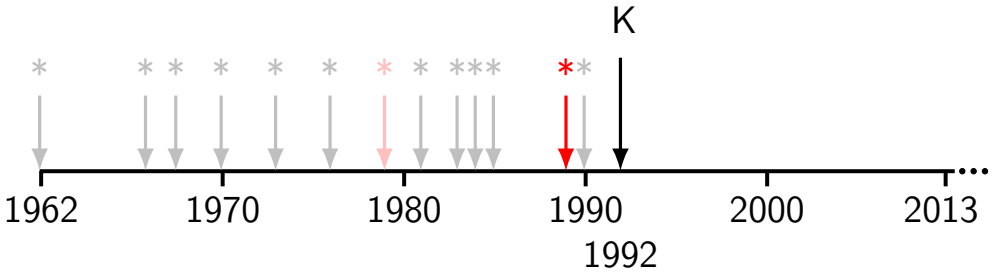
DYALOG



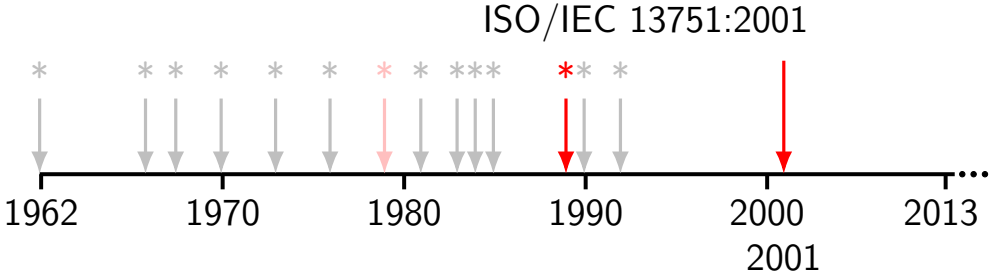
DYALOG



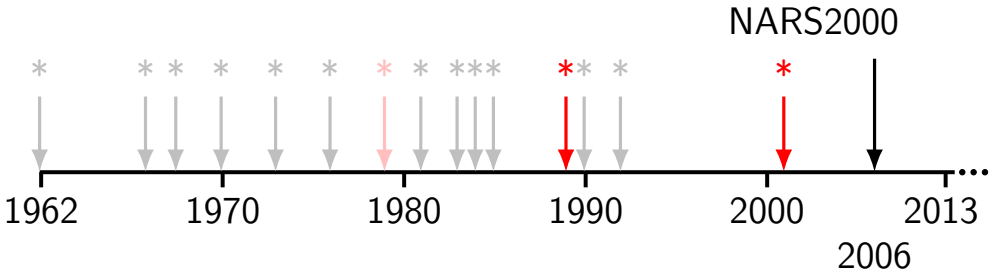
DYALOG



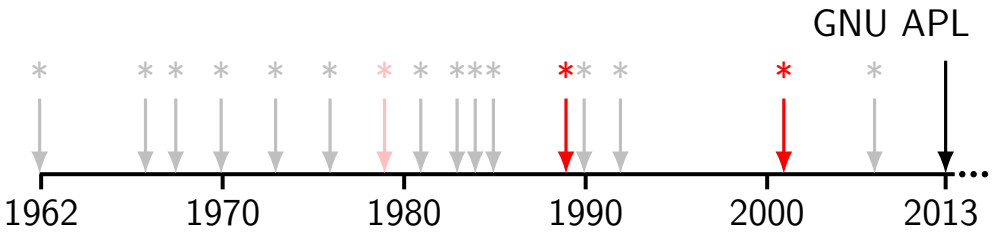
DYALOG



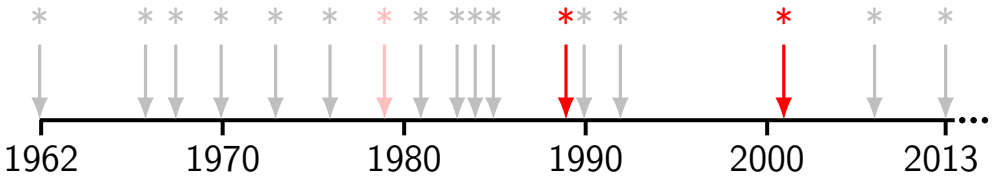
DYALOG



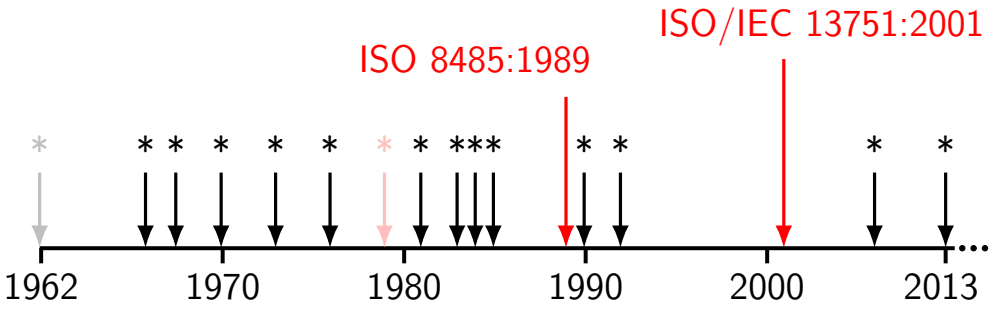
DYALOG



DYALOG



DYALOG


ISO/IEC 13751:2001
ISO 8485:1989
1962
1970
1980
1990
2000
2013

DYALOG

Dyalog APL

DYALOG

Dyalog APL
(that's us)

DYALOG

Dyalog APL
(that's us)

APL2

DYALOG

Dyalog APL
(that's us)

APL2

APL64

DYALOG

Dyalog APL
(that's us)

APL2 APL64 APL+Win

DYALOG

Dyalog APL
(that's us)

APL2
NARS2000

APL64

APL+Win

DYALOG

Dyalog APL
(that's us)

APL2
NARS2000

APL64
GNU APL

APL+Win

DYALOG

Dyalog APL
(that's us)

APL2
NARS2000

APL64
GNU APL

APL+Win
dzaima/APL

DYALOG

Dyalog APL
(that's us)

APL2
NARS2000

APL64
GNU APL
...

APL+Win
dzaima/APL

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DYALOG

```
x ← 1 2 3
```

DYALOG

```
x ← 1 2 3

x + 2 3 4
```

DYALOG

```
x ← 1 2 3

x + 2 3 4
3 5 7
```

DYALOG

```
x ← 1 2 3

x + 2 3 4
3 5 7

10 + x
```

DYALOG

```
x ← 1 2 3

x + 2 3 4
3 5 7

10 + x
11 12 13
```

DYALOG

```
1 2 3 (4 5)
```

DYALOG

```
1 2 3 (4 5)
```

```
1 2 3 (4 5) + 1 2 3 4 5
```

DYALOG

```
      1 2 3 (4 5)


      1 2 3 (4 5) + 1 2 3 4 5
LENGTH ERROR
  1 2 3(4 5)+1 2 3 4 5
            ^
```

DYALOG

```
10 20 30[2]
```

DYALOG

```
10 20 30[2]
20
```

DYALOG

```
      10 20 30[2]
20

      10 20 30 (40 50)[2]
```

DYALOG

```
      10 20 30[2]
20

      10 20 30 (40 50)[2]
```

Dyalog

```
20
```

DYALOG

```
      10 20 30[2]
20

      10 20 30 (40 50)[2]
```

Dyalog

```
20
```

NARS2000

```
10 20 30 50
```

DYALOG

```
successor ← +∘1
```

DYALOG

```
successor ← +∘1

successor 2
```

DYALOG

```
successor ← +∘1

successor 2
3
```

DYALOG

```
successor ← +∘1

successor 2
3

successor 1 2 3 4 5
```

DYALOG

```
successor ← +∘1

successor 2
3

successor 1 2 3 4 5
2 3 4 5 6
```

DYALOG

```
+∘1
```

DYALOG

```
+∘1
```

```
+∘1 2 3
```

DYALOG

```
      +∘1

      +∘1 2 3

+∘(1 2 3)
```

DYALOG

```
      +∘1

      +∘1 2 3

+∘(1 2 3)          (+∘1) 2 3
```

DYALOG

```
+∘1
```

```
+∘1 2 3
```

```
+∘(1 2 3)
```

```
(+∘1) 2 3
```

Dyalog

```
+∘ 1 2 3
```

DYALOG

```
+∘1
```

```
+∘1 2 3
```

```
+∘(1 2 3)
```

Dyalog

```
+∘ 1 2 3
```

```
(+∘1) 2 3
```

NARS2000

```
3 4
```

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DYALOG

```
[ 4 2
  1 3 ]
```

DYALOG

```
[ 4 2
  1 3 ]
4 2
1 3
```

DYALOG

```
[ 4 2
  1 3 ]
```

```
4 2
1 3
```

```
⍈ [ 4 2
    1 3 ]
```

DYALOG

```
[ 4 2
  1 3 ]
4 2
1 3

⌹ [ 4 2
     1 3 ]
 0.3 ¯0.2
¯0.1  0.4
```

DYALOG

```
⍸ [ 1 3
    1 2
    1 3 ]
```

DYALOG

```
⌹ [ 1 3
    1 2
    1 3 ]
 ¯1     3 ¯1
  0.5 ¯1  0.5
```

DYALOG

```
⎕ [ 1 3
    1 2
    1 3 ]
¯1     3 ¯1
 0.5 ¯1  0.5
```

Moore-Penrose Pseudoinverse, M^+

$$MM^+M = M$$

DYALOG

```
⎕ [ 1e6  0
    0    1e¯6 ]
```

DYALOG

```
⌹ [ 1e6  0
      0   1e¯6 ]
1e¯6  0
0     1e6
```

DYALOG

```
⌹ [ 1e6 0
    0   1e¯6 ]
1e¯6 0
0    1e6

⌹ [ 1e7 0
    0   1e¯7 ]
```

DYALOG

```
⌹ [ 1e6 0
      0   1e¯6 ]
1e¯6 0
0    1e6

⌹ [ 1e7 0
      0   1e¯7 ]
DOMAIN ERROR
```

DYALOG

10.2.13 Matrix Divide

```
Z ← A ⌹ B
```

DYALOG

10.2.13 Matrix Divide

```
Z ← A ⌹ B
```

If the rank of `A` or the rank of `B` is greater-than two, signal rank-error.

DYALOG

10.2.13 Matrix Divide

```
Z ← A ⌹ B
```

If the rank of `A` or the rank of `B` is greater-than two, signal rank-error.

...

Use the implementation-algorithm matrix-divide to generate an array `Z`

DYALOG

5.2.4 Implementation Algorithms

DYALOG

5.2.4 Implementation Algorithms

An Implementation-Algorithm is an algorithm

DYALOG

5.2.4 Implementation Algorithms

An Implementation-Algorithm is an algorithm used in this International Standard

DYALOG

5.2.4 Implementation Algorithms

An Implementation-Algorithm is an algorithm used in this International Standard whose behaviour is implementation-defined.

DYALOG

```
⌹ [ 1e7  0
    0    1e¯7 ]
```

DYALOG

```
⌹ [ 1e7  0
      0   1e¯7 ]
```

Dyalog

```
DOMAIN ERROR
```

DYALOG

```
⌹ [ 1e7  0
    0    1e¯7 ]
```

Dyalog

```
DOMAIN ERROR
```

NARS2000

```
1e¯7  0
0     1e7
```

DYALOG

```
⊡[ 0 0
     0 0 ]
```

DYALOG

```
⎕ [ 0 0
    0 0 ]
```

Dyalog

```
DOMAIN ERROR
```

DYALOG

```
⌹ [ 0 0
    0 0 ]
```

Dyalog

```
DOMAIN ERROR
```

NARS2000

```
0 0
0 0
```

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DYALOG

```
1 = 0.99999999999999
```

DYALOG

```
      1 = 0.99999999999999
1
```

DYALOG

```
      1 = 0.99999999999999
1

      1 = 1 - 1e¯14
```

DYALOG

```
      1 = 0.99999999999999
1

      1 = 1 - 1e¯14
1
```

DYALOG

```
      1 = 0.99999999999999
1

      1 = 1 - 1e¯14
1

      0.3 = 0.1 + 0.2
```

DYALOG

```
      1 = 0.99999999999999
1

      1 = 1 - 1e¯14
1

      0.3 = 0.1 + 0.2
1
```

DYALOG

$$x \approx y \quad \text{iff} \quad |x - y| \leq \varepsilon \cdot \max(\,|x|, |y|\,)$$

DYALOG

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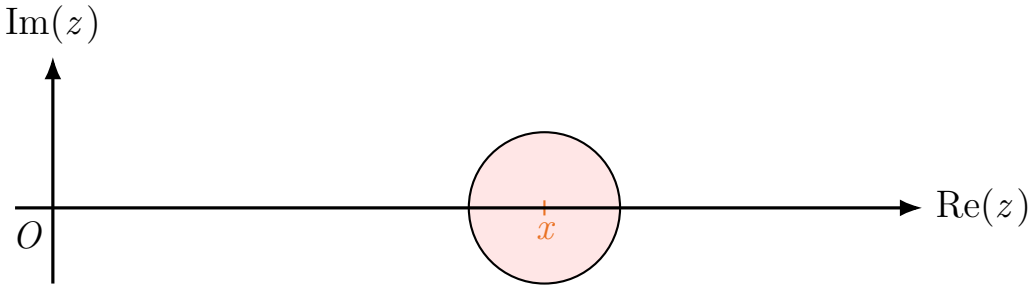
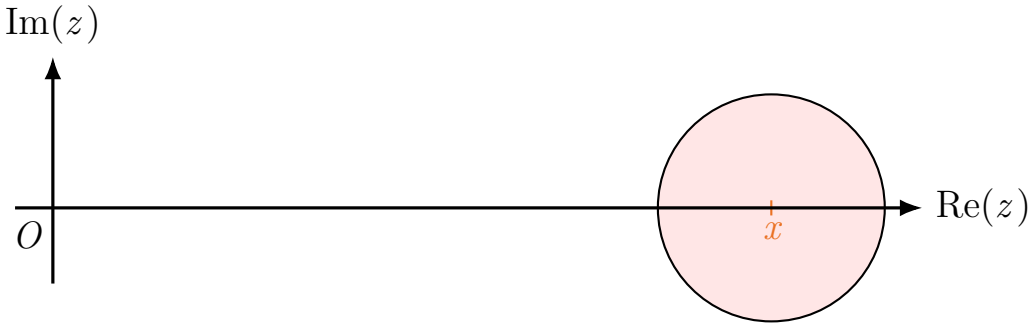


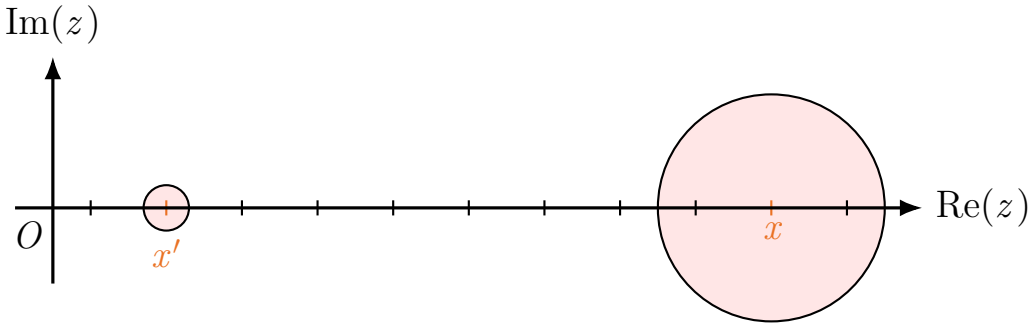
DYALOG

$$x \approx y \quad \text{iff} \quad |x - y| \leq \varepsilon \cdot \max(\,|x|, |y|\,)$$



DYALOG

$$x \approx y \quad \text{iff} \quad |x - y| \leq \varepsilon \cdot \max(\,|x|, |y|\,)$$



DYALOG

$$x \approx y \quad \text{iff} \quad |x - y| \leq \varepsilon \cdot \max(\,|x|, |y|\,)$$

DYALOG

$$x \approx y \quad \text{iff} \quad |x - y| \leq \varepsilon \cdot \max(\,|x|, |y|\,)$$

⎕CT

DYALOG

$$x \approx y \quad \text{iff} \quad |x - y| \leq \varepsilon \cdot \max(\,|x|, |y|\,)$$

```
⎕CT
1e¯14
```

DYALOG

$$x \approx y \quad \text{iff} \quad |x - y| \leq \varepsilon \cdot \max(\,|x|, |y|\,)$$

```
⎕CT
1e¯14

1e14 = 1e14 + 1
```

DYALOG

$$x \approx y \quad \text{iff} \quad |x - y| \leq \varepsilon \cdot \max(\,|x|, |y|\,)$$

```
⎕CT
1e¯14

1e14 = 1e14 + 1
1
```

DYALOG

```
⌊ 1.5
```

DYALOG

```
⌊ 1.5
1
```

DYALOG

```
⌊ 1.5
1

⌊ 0.99999999999999
```

DYALOG

```
⌊ 1.5
1

⌊ 0.99999999999999
1
```

DYALOG

7.1.5 Floor

```
Z ← ⌊ B
```

DYALOG

7.1.5 Floor

```
Z ← ⌊ B
```

For real-numbers, `Z` is

DYALOG

7.1.5 Floor

```
Z ← ⌊ B
```

For real-numbers, `Z` is the greatest integer

DYALOG

7.1.5 Floor

```
Z ← ⌊ B
```

For real-numbers, `Z` is the greatest integer tolerantly less than or equal to `B`.

DYALOG

7.1.5 Floor

```
Z ← ⌊ B
```

For real-numbers, `Z` is the greatest integer tolerantly less than or equal to `B`. Uses comparison-tolerance.

DYALOG

```
⌊ 1e14
```

DYALOG

```
⌊ 1e14

1e14 = 1e14 + 1
1
```

DYALOG

```
⌊ 1e14

1e14 = 1e14 + 1
1
```

ISO/IEC 13751:2001

```
1e14 + 1
```

DYALOG

```
⌊ 1e14

1e14 = 1e14 + 1
1
```

ISO/IEC 13751:2001

```
1e14 + 1
1.00000000000001e14
```

DYALOG

```
⌊ 1e14

1e14 = 1e14 + 1
1
```

ISO/IEC 13751:2001

```
1e14 + 1
1.00000000000001e14
```

Dyalog

```
1e14
```

- Existence: every number has a floor

- Existence: every number has a floor
- Uniqueness: every number has only one floor

DYALOG

- Existence: every number has a floor
- Uniqueness: every number has only one floor
- Idempotency: floor acts as a projection operation `(⌊x) = ⌊⌊x`

DYALOG

- Existence: every number has a floor
- Uniqueness: every number has only one floor
- Idempotency: floor acts as a projection operation `(⌊x) = ⌊⌊x`
- Integer Translation: `(n+⌊x) = ⌊n+x`

DYALOG

- Existence: every number has a floor
- Uniqueness: every number has only one floor
- Idempotency: floor acts as a projection operation `(⌊x) = ⌊⌊x`
- Integer Translation: `(n+⌊x) = ⌊n+x`
- `(⌊-x) = -⌈x`, and `(⌈-x) = -⌊x`

DYALOG

- Existence: every number has a floor
- Uniqueness: every number has only one floor
- Idempotency: floor acts as a projection operation `(⌊x) = ⌊⌊x`
- Integer Translation: `(n+⌊x) = ⌊n+x`
- `(⌊-x) = -⌈x`, and `(⌈-x) = -⌊x`
- ...

DYALOG

Summary

DYALOG

- Differences to other implementations (historical reasons)

DYALOG

- Differences to other implementations (historical reasons)
- Where the standard could be more explicit

DYALOG

- Differences to other implementations (historical reasons)
- Where the standard could be more explicit
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DYALOG

Thank you

DYALOG

Thank you

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