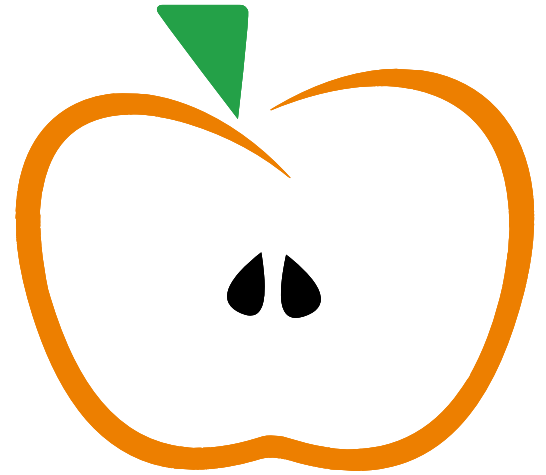


# DIALOG

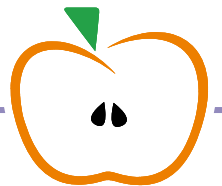
APL Seeds 2022

Easy to Learn,  
Worth Mastering

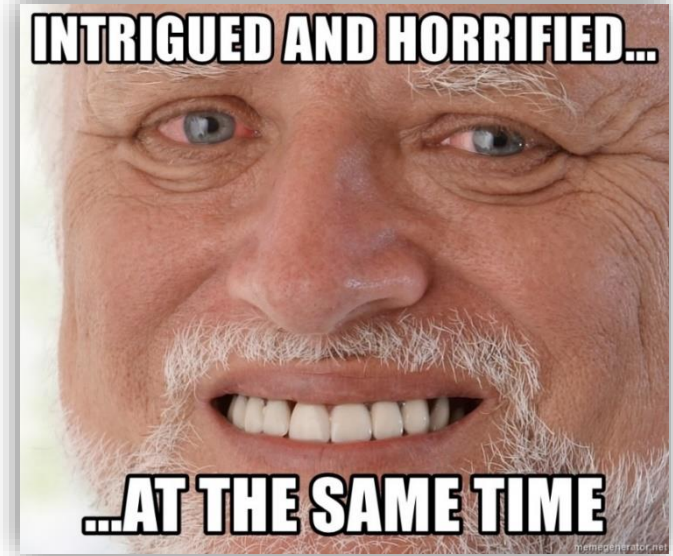
*Rich Park*



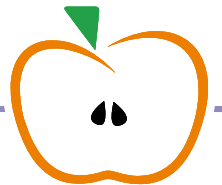
# First Impressions



# First Impressions



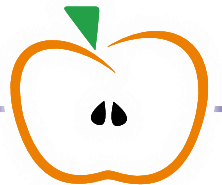
Life ← {↑1 ω∨.∧3 4=+/, -1 0 1◦.θ-1 0 1◦.φ<ω}



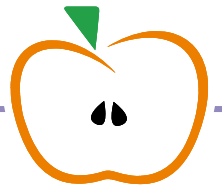




# A Tale of Two Castles



# A Tale of Two Castles



# Versatile Building Blocks

## Mathematics

+ - × ÷ [ ] \* ! | ⊗ ○ ⊞ ⊥ τ ?

## Logic and Comparison

~ ^ v ã ã < > ≤ ≥ = ≠ ≡ ≠

## Structural

ρ , , ϕ θ ϑ ↑ ↓ ⊆ ⊇ ≡ ∈

## Selection and Set Operations

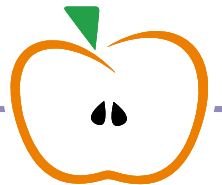
□ ⊃ / ≠ \ ≠ ~ ≠ ∪ ∩ → ←

## Search and Ordering

⊂ ⊆ ∈ ⊆ ⊆ ⊆

## Operators

.. ~ \* . ° / \ ≠ ≠ ≠ ≠ ≠ ≠ ≠ ≠ ≠

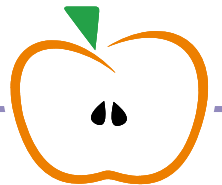


# Suggestive Symbols

A + B + C + ...

P ^ Q ^ R ^ ...

P and Q and R and ...



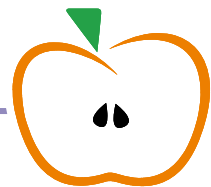


# Suggestive Symbols

+ / A B C ...

^ / P Q R ...

a l l ( P Q R ... )



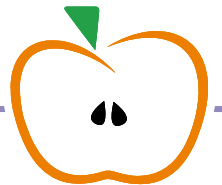
# Suggestive Symbols

Arithmetic             $+$     $-$     $\times$     $\div$     $!$

Numerics             $|x|$     $\lfloor x \rfloor$     $\lceil x \rceil$

Comparison            $<$     $\leq$     $=$     $>$     $\geq$

Sets & Logic            $\cap$     $\cup$     $\in$     $\wedge$     $\vee$



# Suggestive Symbols

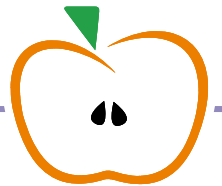
φ

∅

┌

└

≠



# Suggestive Symbols

reverse

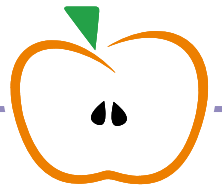
φ

∅

┌

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# Suggestive Symbols

9279v97

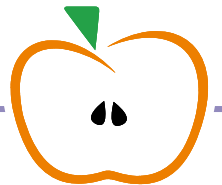
φ

ϕ

┌

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# Suggestive Symbols

9279v97

φ

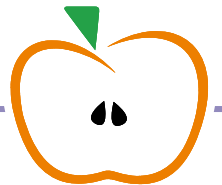
∅

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~~T R A  
N S P  
O S E~~



# Suggestive Symbols

9279v97

φ

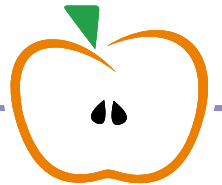
∅

┌

└

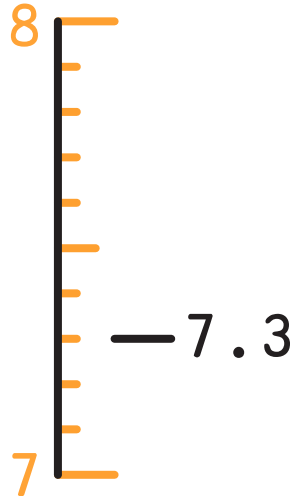
≠

~~ART  
MRO  
EPA~~



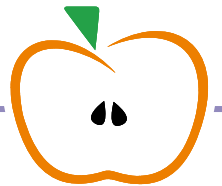
# Suggestive Symbols

9279v91



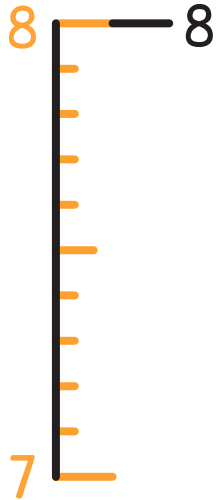
$\phi$   
 $\emptyset$   
┌  
└  
 $\neq$

1  
M  
A  
2  
R  
3  
E  
B  
O



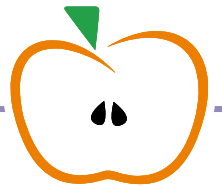
# Suggestive Symbols

9279v91



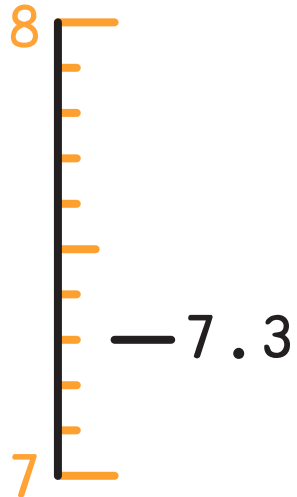
φ  
∅  
┌  
└  
≠

1  
M  
O  
2  
R  
E  
A  
B



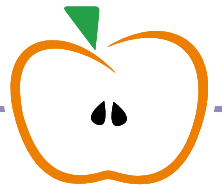
# Suggestive Symbols

9279v91



$\phi$   
 $\emptyset$   
┌  
└  
 $\neq$

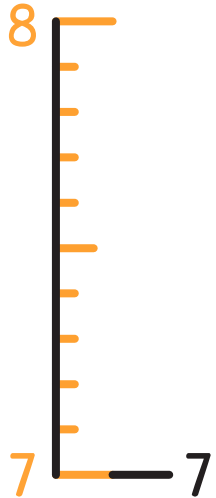
1  
M  
O  
2  
R  
E  
A  
B





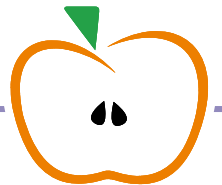
# Suggestive Symbols

9279v97



φ  
∅  
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≠

1  
M  
O  
2  
R  
E  
A  
B



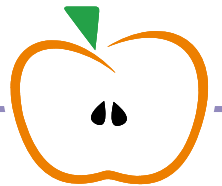
# Suggestive Symbols

9279v97



φ  
∅  
┌  
└  
≠

1  
M  
A  
2  
R  
B  
3  
E  
O



# Suggestive Symbols

9279v97



'list'

φ

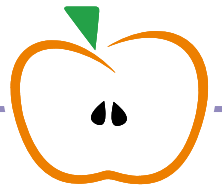
∅

┌

└

≠

NO  
M2  
TR  
E  
B  
A



# Suggestive Symbols

9279v97



'list'  
-

φ

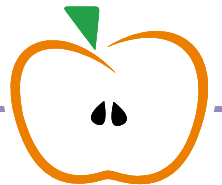
∅

┌

└

≠

ONR  
M2B  
T R A



# Suggestive Symbols

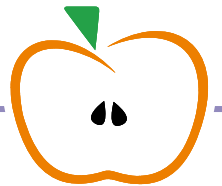
9279v97



'list'  
=

φ  
∅  
┌  
└  
≠

NO  
MR  
E  
B  
A





# Suggestive Symbols

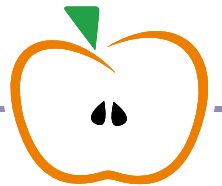
9279v91



'list'  
≡

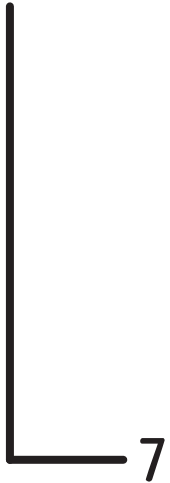
∅  
∅  
┌  
└  
≠

ONR  
TMR  
A2B



# Suggestive Symbols

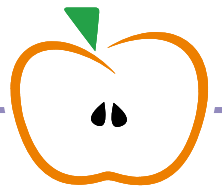
9279v91



'list'  
≠

φ  
∅  
┌  
└  
≠

ONR  
TMR  
A2B



# Simple syntax

two-argument, infix: **dyadic** functions

$$3 \times 5$$

15

$$3 - 5$$

-2

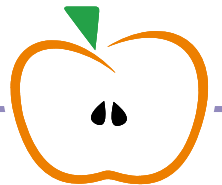
one-argument, prefix: **monadic** functions

$$- 6 \quad 3 \quad 0 \quad -12$$

-6   -3   0   12

$$\iota \quad 7$$

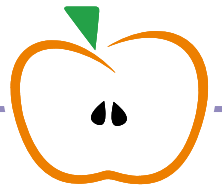
1   2   3   4   5   6   7



# Simple syntax

Short left scope; long right scope

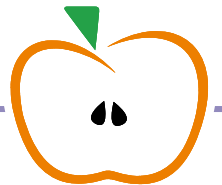
							ι	7
1	2	3	4	5	6	7		
					2	×	ι	7
2	4	6	8	10	12	14		
			-1	+	2	×	ι	7
1	3	5	7	9	11	13		



# Simple syntax

Short left scope, long right scope

`-1 + 2 * 7`

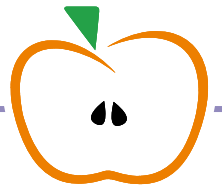




# Simple syntax

Short left scope, long right scope

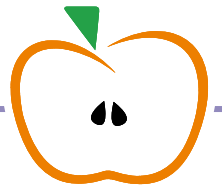
$-1 + 2 \times 7$



# Simple syntax

Short left scope, long right scope

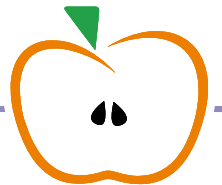
$-1 + 2 \times 1 2 3 4 5 6 7$



# Simple syntax

Short left scope, long right scope

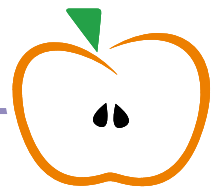
$-1 + 2 4 6 8 10 12 14$



# Simple syntax

Short left scope, long right scope

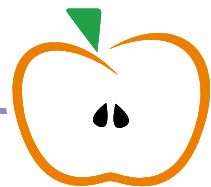
1 3 5 7 9 11 13



# Operators

How to sum a list

$$2 + 5 + 8 + -4 + 6$$



# Operators

How to sum a list

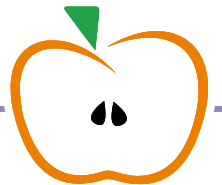
$$2 + 5 + 8 + -4 + 6$$

$$2 + 5 + 8 + 2$$

$$2 + 5 + 10$$

$$2 + 15$$

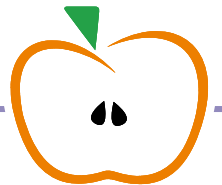
$$17$$



# Operators

How to find the maximum value in a list

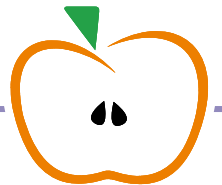
2 | 5 | 8 | -4 | 6



# Operators

How to find the maximum value in a list

```
2 | 5 | 8 | -4 | 6
2 | 5 | 8 |   |
2 | 5 | 8 |   |
2 | 8 |   |   |
8 |   |   |   |
```





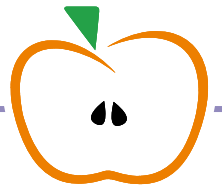
# Operators

How to find the maximum value in a list

```
nums ← 2 5 8 -4 6
```

```
17 +/nums      A sum
8   [/nums     A max
-4  [/nums     A min
-1920 ×/nums    A product
```

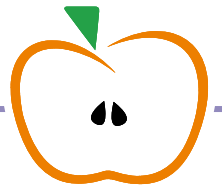
```
2 7 15 + \nums
2 5 8 8 8 [/nums
2 2 2 -4 -4 [/nums
2 10 80 -320 -1920 × \nums
```



# Operators

Outer Product

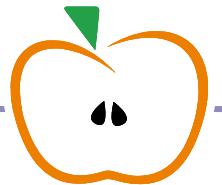
```
      nums ← 1 7
      nums ◦ . ×  nums
1      2      3      4      5      6      7
2      4      6      8     10     12     14
3      6      9     12     15     18     21
4      8     12     16     20     24     28
5     10     15     20     25     30     35
6     12     18     24     30     36     42
7     14     21     28     35     42     49
```



# Operators

Outer Product

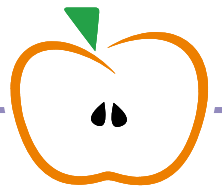
```
      nums ← 1 7
      nums ◦ . + nums
2     3     4     5     6     7     8
3     4     5     6     7     8     9
4     5     6     7     8     9    10
5     6     7     8     9    10    11
6     7     8     9    10    11    12
7     8     9    10    11    12    13
8     9    10    11    12    13    14
```



# Operators

Outer Product

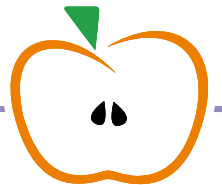
```
nums ← i 7
nums ◦ . | nums
1 2 3 4 5 6 7
2 2 3 4 5 6 7
3 3 3 4 5 6 7
4 4 4 4 5 6 7
5 5 5 5 5 6 7
6 6 6 6 6 6 7
7 7 7 7 7 7 7
```



# Operators

Outer Product

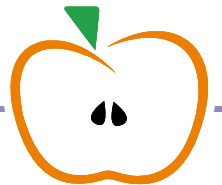
```
nums ← ι 7
nums ◦ . = nums
1 0 0 0 0 0 0
0 1 0 0 0 0 0
0 0 1 0 0 0 0
0 0 0 1 0 0 0
0 0 0 0 1 0 0
0 0 0 0 0 1 0
0 0 0 0 0 0 1
```



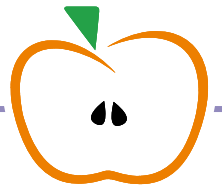
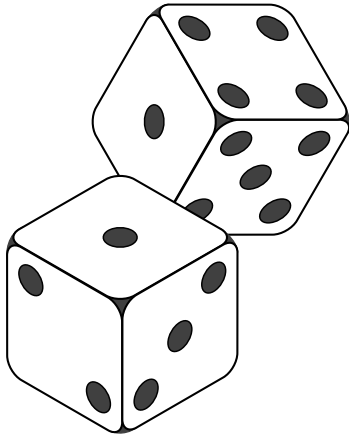
# Operators

Outer Product

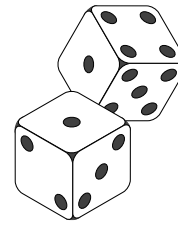
```
nums ← 1 7
nums ◦ . ≥ nums
1 0 0 0 0 0 0
1 1 0 0 0 0 0
1 1 1 0 0 0 0
1 1 1 1 0 0 0
1 1 1 1 1 0 0
1 1 1 1 1 1 0
1 1 1 1 1 1 1
```



# Distribution of Dice Throws



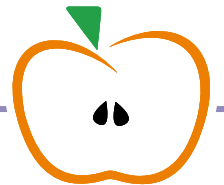
# Distribution of Dice Throws



throws  $\leftarrow$  1 6

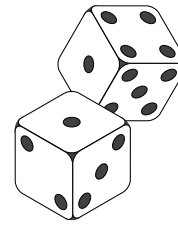
throws  $\circ$  . + throws

2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10
6	7	8	9	10	11
7	8	9	10	11	12

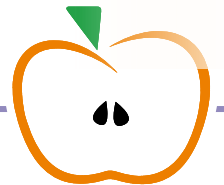




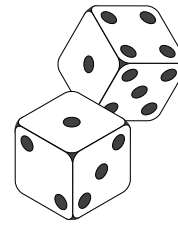
# Distribution of Dice Throws



```
2 3 4 5 6 7 3 4 5 6 7 8 4 5 6 7 8 9 5 6 7 8 9 10 6 7
, throws ◦.+ throws
all ← , throws ◦.+ throws
∪ all
2 3 4 5 6 7 8 9 10 11 12
unique ← ∪ all
unique ◦.= all
```

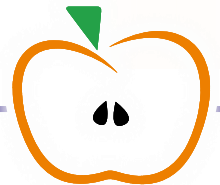


# Distribution of Dice Throws

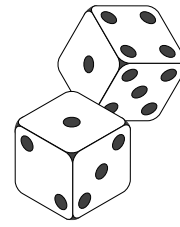


unique ◦.= all

1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

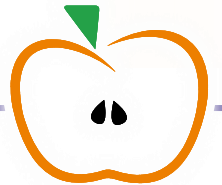


# Distribution of Dice Throws

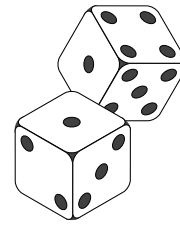


unique ◦. = all

2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
6	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0
7	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0
8	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



# Distribution of Dice Throws



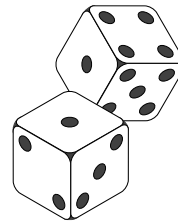
unique ◦ . = all

2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	
7	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	
8	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	2	3	4	5	6	7	3	4	5	6	7	8	4	5	6	7	8	9	5	6	7	8	9	10	6	7	8	9	10

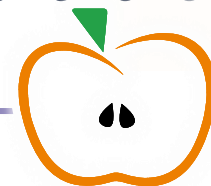




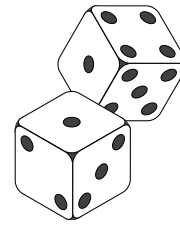
# Distribution of Dice Throws



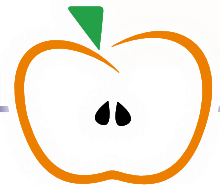
	+ /		unique					° . =					all																
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0



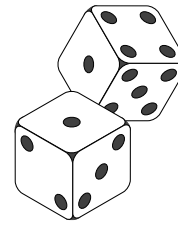
# Distribution of Dice Throws



	+	/	unique				°	.	=	all																												
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0		
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0		
0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



# Distribution of Dice Throws



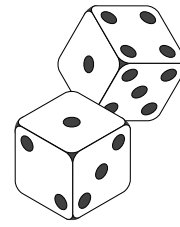
+ / unique ◦ . = all

1  
2  
3  
4  
5  
6  
5  
4  
3  
2  
1

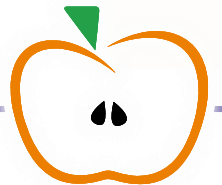




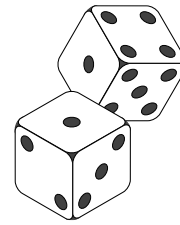
# Distribution of Dice Throws



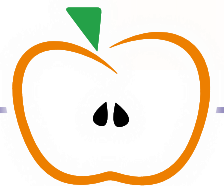
+ / unique ° . = all  
1 2 3 4 5 6 5 4 3 2 1



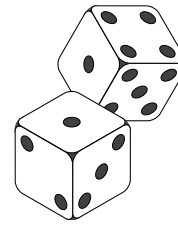
# Distribution of Dice Throws



```
counts ← +/ unique o.= all
|/ counts
6
  |/ counts
1 2 3 4 5 6
```



# Distribution of Dice Throws

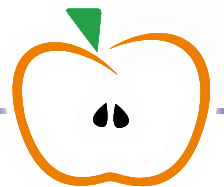


```
counts ← +/ unique o.= all  
[ / counts
```

6

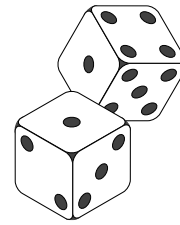
```
counts o.≥ 1 [ / counts
```

```
1 0 0 0 0 0  
1 1 0 0 0 0  
1 1 1 0 0 0  
1 1 1 1 0 0  
1 1 1 1 1 0  
1 1 1 1 1 1  
1 1 1 1 1 0  
1 1 1 1 0 0  
1 1 1 0 0 0  
1 1 0 0 0 0  
1 0 0 0 0 0
```

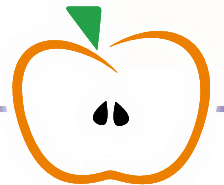


# Distribution of Dice Throws

aside: indexing arrays

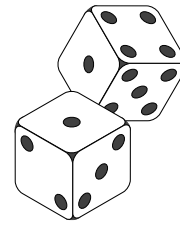


```
C 'LE CHAT'[4]
```

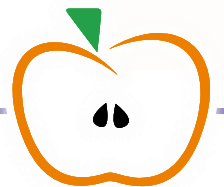


# Distribution of Dice Throws

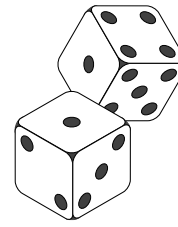
aside: indexing arrays with arrays



```
'LE CHAT'[4]
C
'LE CHAT'[7 5 2 3 4 6 7]
THE CAT
2 3p7 5 2 4 6 7
7 5 2
4 6 7
'LE CHAT'[2 3p7 5 2 4 6 7]
THE
CAT
```



# Distribution of Dice Throws

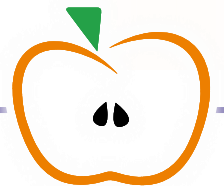


```
counts ← +/ unique ◦.= all  
⌈/ counts
```

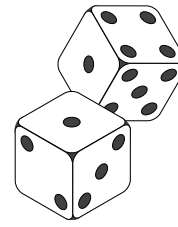
6

```
counts ◦.≥ 1 ⌈/ counts
```

```
1 0 0 0 0 0  
1 1 0 0 0 0  
1 1 1 0 0 0  
1 1 1 1 0 0  
1 1 1 1 1 0  
1 1 1 1 1 1  
1 1 1 1 1 0  
1 1 1 1 0 0  
1 1 1 0 0 0  
1 1 0 0 0 0  
1 0 0 0 0 0
```



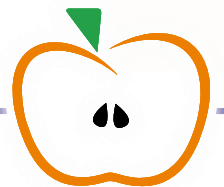
# Distribution of Dice Throws



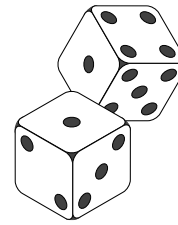
```
counts ← +/ unique ◦.= all  
[ / counts
```

6

```
1 + counts ◦.≥ 1 [ / counts  
1 0 0 0 0 0  
1 1 0 0 0 0  
1 1 1 0 0 0  
1 1 1 1 0 0  
1 1 1 1 1 0  
1 1 1 1 1 1  
1 1 1 1 1 0  
1 1 1 1 0 0  
1 1 1 0 0 0  
1 1 0 0 0 0  
1 0 0 0 0 0
```



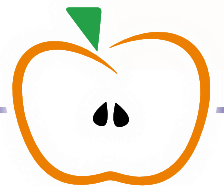
# Distribution of Dice Throws



```
counts ← +/ unique ◦.= all  
[ / counts
```

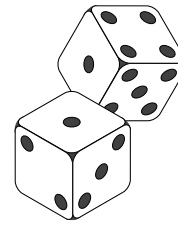
6

```
1 + counts ◦.≥ 1 [ / counts  
2 1 1 1 1 1  
2 2 1 1 1 1  
2 2 2 1 1 1  
2 2 2 2 1 1  
2 2 2 2 2 1  
2 2 2 2 2 2  
2 2 2 2 2 1  
2 2 2 2 1 1  
2 2 2 1 1 1  
2 2 1 1 1 1  
2 1 1 1 1 1
```



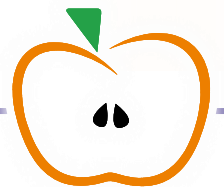


# Distribution of Dice Throws

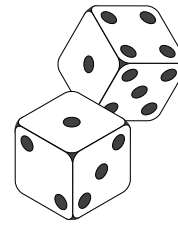


```
counts ← +/ unique ◦.= all  
[ / counts
```

```
6  
' ◦ ' [ 1 + counts ◦.≥ 1 [ / counts ]  
2 1 1 1 1 1  
2 2 1 1 1 1  
2 2 2 1 1 1  
2 2 2 2 1 1  
2 2 2 2 2 1  
2 2 2 2 2 2  
2 2 2 2 2 1  
2 2 2 2 1 1  
2 2 2 1 1 1  
2 2 1 1 1 1  
2 1 1 1 1 1
```

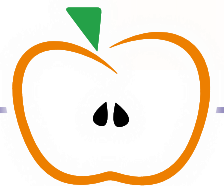


# Distribution of Dice Throws

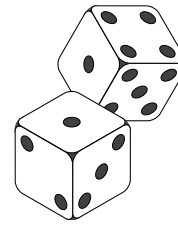


```
counts ← +/ unique o.= all  
[ / counts
```

```
6  
' o ' [ 1 + counts o.≥ 1 [ / counts ]  
2 1 1 1 1 1  
2 2 1 1 1 1  
2 2 2 1 1 1  
2 2 2 2 1 1  
2 2 2 2 2 1  
2 2 2 2 2 2  
2 2 2 2 2 1  
2 2 2 2 1 1  
2 2 2 1 1 1  
2 2 1 1 1 1  
2 1 1 1 1 1
```

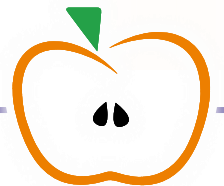
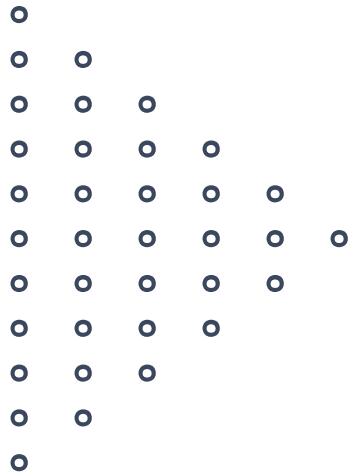


# Distribution of Dice Throws

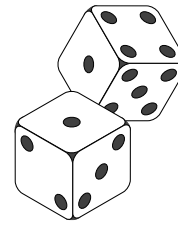


```
counts ← +/ unique o.= all  
[ / counts
```

```
6  
' o '[ 1 + counts o.≥ 1 [ / counts ]
```



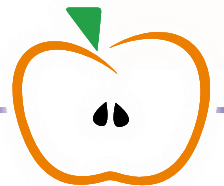
# Distribution of Dice Throws



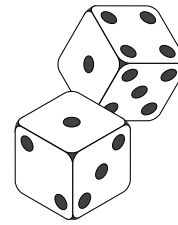
```
counts ← +/ unique o.= all  
[ / counts
```

```
6  
' o '[ 1 + counts o.≥ ι [ / counts ]
```

```
o  
oo  
ooo  
oooo  
ooooo  
oooooo  
oooooo  
ooooo  
oooo  
ooo  
oo  
o
```



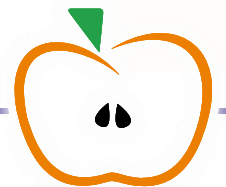
# Distribution of Dice Throws



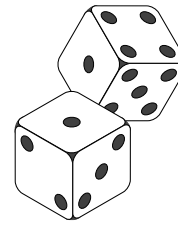
```
counts ← +/ unique ◦.= all  
[ / counts
```

6

```
unique , ' ◦ '[ 1 + counts ◦.≥ 1 [ / counts ]
```



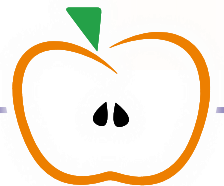
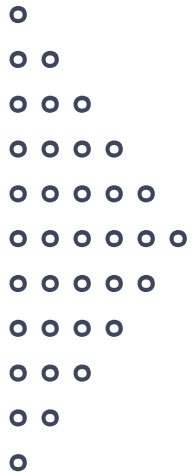
# Distribution of Dice Throws



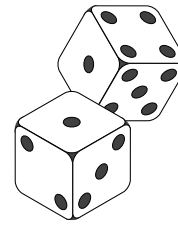
```
counts ← +/ unique ◦.= all  
[ / counts
```

6

```
unique , ' ◦ '[ 1 + counts ◦.≥ 1 [ / counts ]
```



# Distribution of Dice Throws

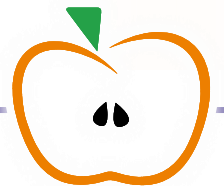


```
counts ← +/ unique o.= all  
[/ counts
```

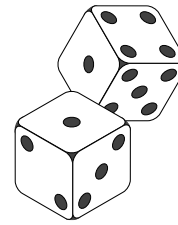
6

```
unique , ' o' [ 1 + counts o.≥ 1 [/ counts ]
```

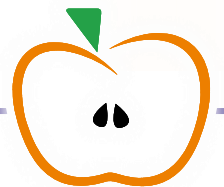
```
2  o  
3  oo  
4  ooo  
5  oooo  
6  ooooo  
7  oooooo  
8  oooooo  
9  oooo  
10 ooo  
11 oo  
12 o
```



# Distribution of Dice Throws

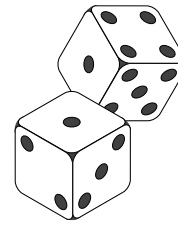


```
throws <- r 6  
all <- , throws o.+ throws  
unique <- v all  
counts <- +/ unique o.= all  
unique , ' o'[ 1 + counts o.≥ r [/ counts ]
```





# Distribution of Dice Throws



```
Dist ← {  
  throws ← 1 ω  
  all ← , throws ◦.+ throws  
  unique ← v all  
  counts ← +/ unique ◦.= all  
  unique , ' ◦'[ 1 + counts ◦.≥ 1 [ / counts ]  
}
```

Dist 3

```
2 ◦  
3 ◦◦  
4 ◦◦◦  
5 ◦◦  
6 ◦
```

