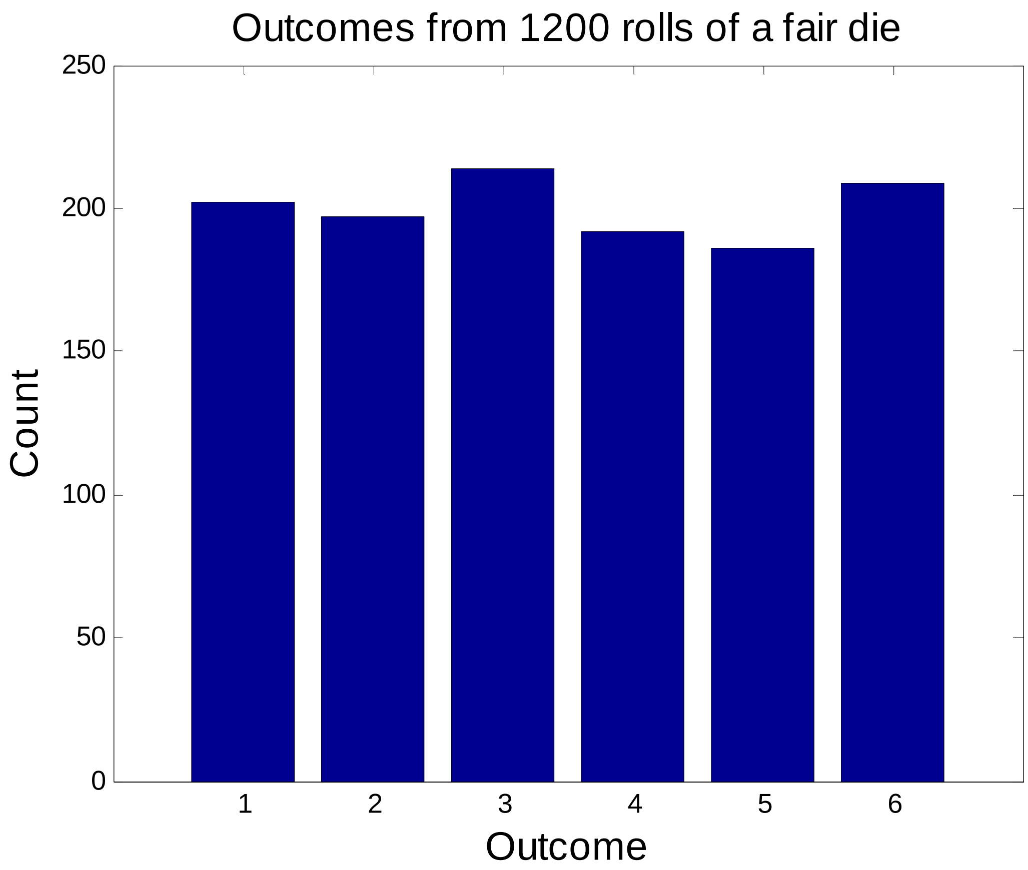
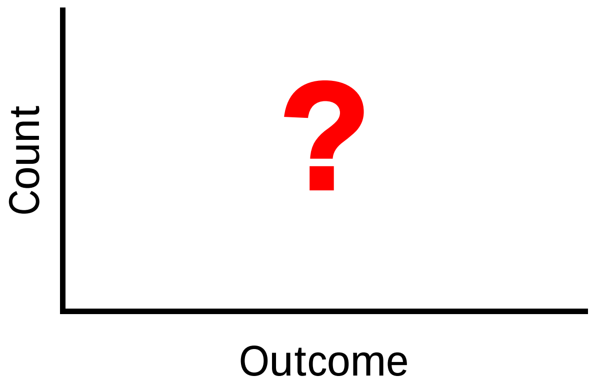
- Previous Lecture:
  - Executing a user-defined function
  - Function scope

- Today's Lecture:
  - Subfunction
  - 1-d array—vector
  - Probability and random numbers
  - Simulation using random numbers, vectors

- Announcement:
  - Project 3 due Friday 10/3 at 11pm

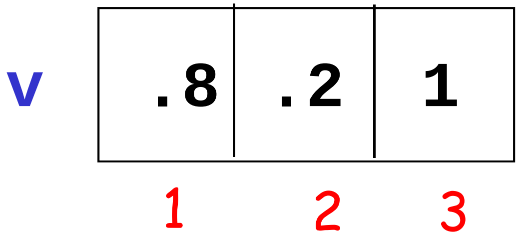


Roll 2 fair dice



1-d array: **vector**

- An array is a named collection of like data organized into rows or columns
- A 1-d array is a row or a column, called a *vector*
- An *index* identifies the position of a value in a vector



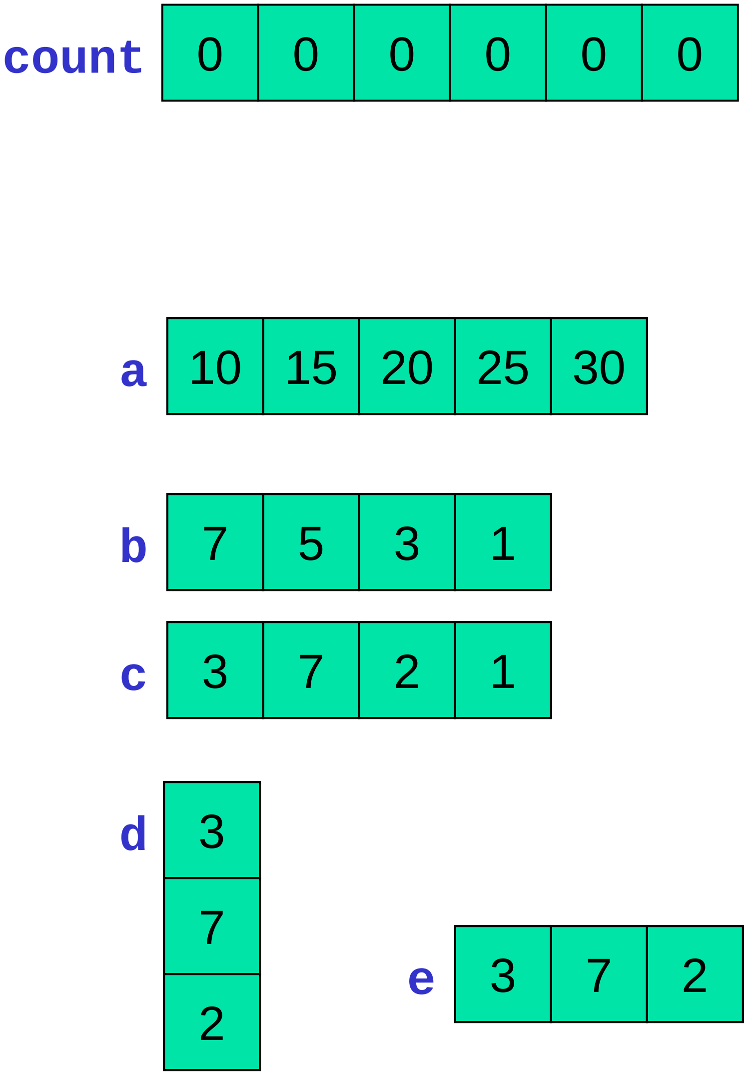
v	.8	.2	1
	1	2	3

Here are a few different ways to create a vector

```
count= zeros(1,6)
```

Similar functions: **`ones`**, **`rand`**

```
a= linspace(10,30,5)

b= 7:-2:0

c= [3 7 2 1]

d= [3; 7; 2]

e= d’
```



count

0	0	0	0	0	0

a

10	15	20	25	30

b

7	5	3	1

c

3	7	2	1

d

3
7
2

e

3	7	2

Start with drawing a single line segment

```
a= 0;   % x-coord of pt 1
b= 1;   % y-coord of pt 1
c= 5;   % x-coord of pt 2
d= 3;   % y-coord of pt 2
plot([a c], [b d], ‘-*’)
```

x-values
(a vector)

y-values
(a vector)

Line/marker
format

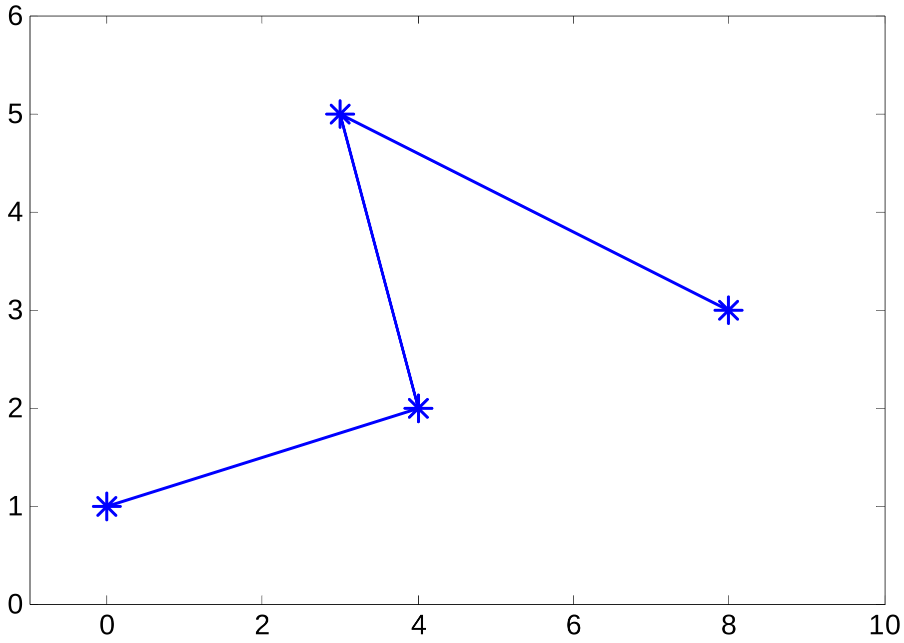
Making an x-y plot

```
a= [0 4 3 8];   % x-coords
b= [1 2 5 3];   % y-coords
plot(a, b, '-*')
```

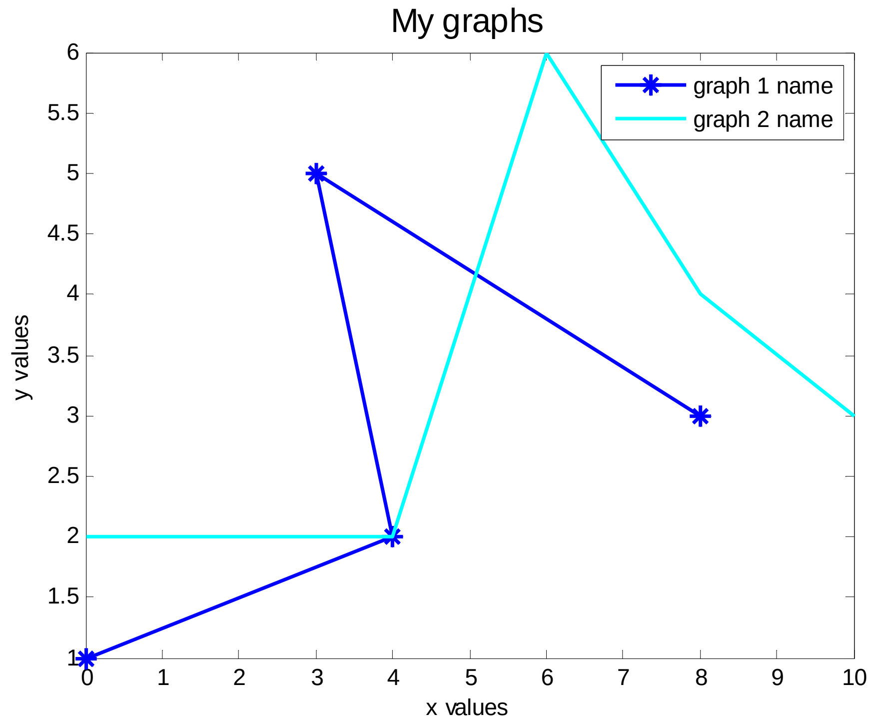
x-values
(a vector)

y-values
(a vector)

Line/marker
format

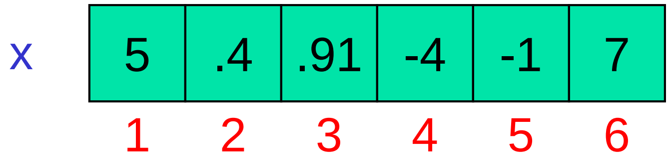


Making an x-y plot with multiple graphs (lines)



```
a= [0 4 5 8];
b= [1 2 5 3];
f= [0 4 6 8 10];
g= [2 2 6 4  3];
plot(a,b,'-*',f,g,'c')
legend('graph 1 name', 'graph 2 name')
xlabel('x values')
ylabel('y values')
title('My graphs', 'Fontsize',14)
```

Array index starts at 1



x	5	.4	.91	-4	-1	7
	1	2	3	4	5	6

Let k be the index of vector x, then

- k must be a positive integer
- 1<= k <= length(x)
- To access the k^{th} element: x(k)

Accessing values in a vector

score	93	92	87	0	90	82
	1	*2*	*3*	*4*	*5*	*6*

Given the vector **`score`** …

Accessing values in a vector

`score`	**93**	99	**87**	80	85	**82**
	1	*2*	*3*	*4*	*5*	*6*

Given the vector **`score`** …

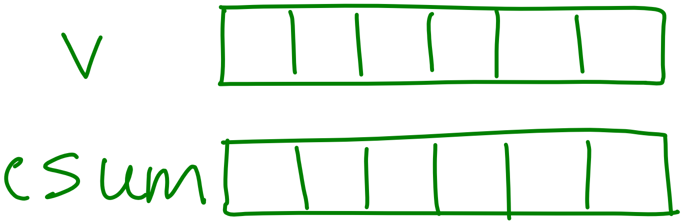
```
score(4)= 80;
score(5)= (score(4)+score(5))/2;
k= 1;
score(k+1)= 99;
```

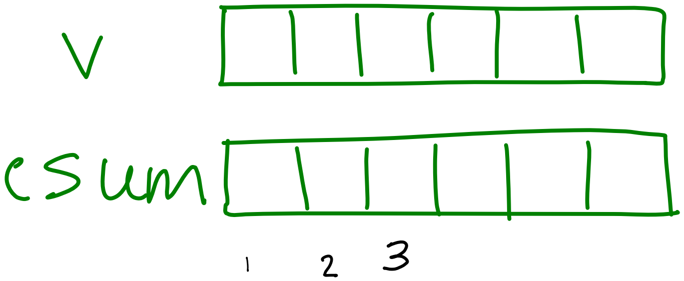
See **`plotComparison2.m`**

Example

- Write a program fragment that calculates the cumulative sums of a given vector **v**.
- The cumulative sums should be stored in a vector of the same length as **v**.

1, 3, 5, 0	**v**
1, 4, 9, 9	cumulative sums of **v**


v
csum



$$\mathrm{csum}(k) = \mathrm{csum}(k-1) + v(k)$$

$$\mathrm{csum}(3) = v(1) + v(2) + v(3)$$

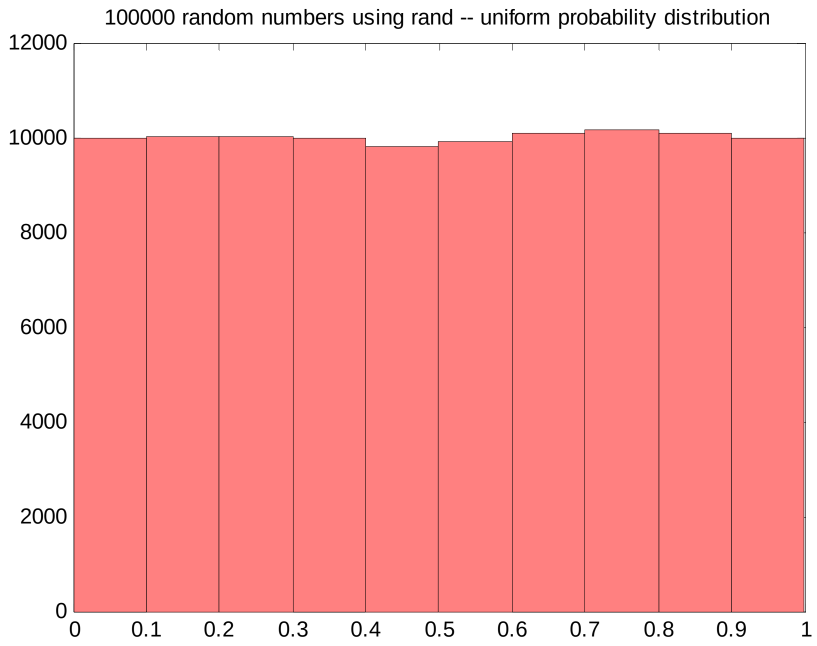
$$\mathrm{csum}(4) = \underbrace{v(1) + v(2) + v(3)}_{\mathrm{csum}(3)} + v(4)$$

```
csum (1) = v (1);
for   k  =  2 : length(v)
        csum(k) =  csum(k-1) + v(k);
end
```

Random numbers

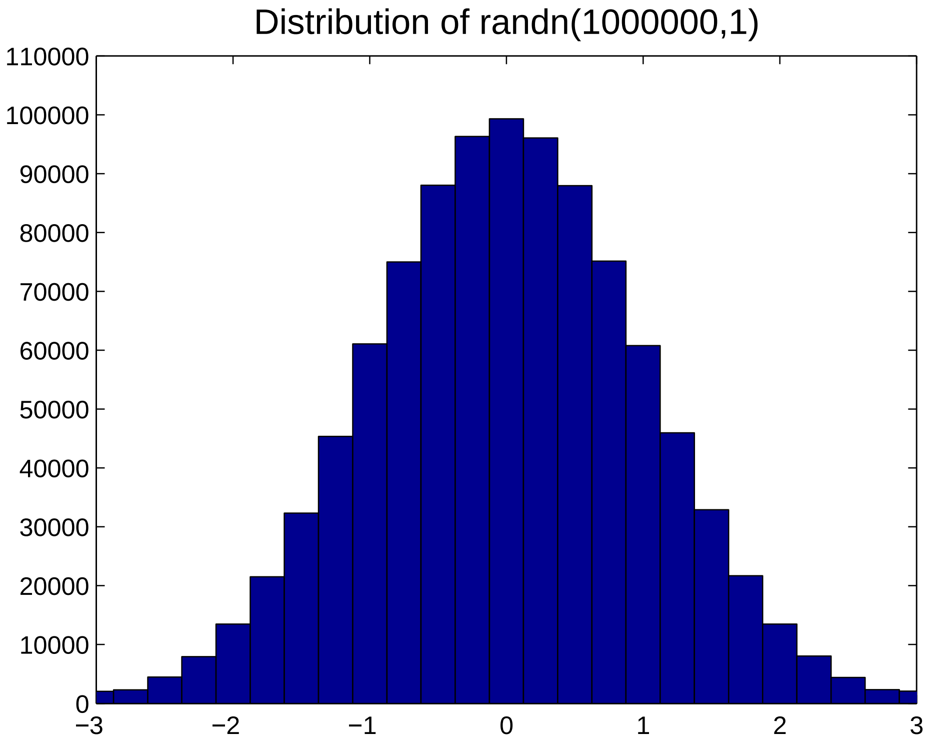
- *Pseudorandom* numbers in programming
- Function `rand(…)` generates random real numbers in the interval (0,1). All numbers in the interval (0,1) are equally likely to occur—uniform probability distribution.
- Examples:

`rand(1)`	one random # in (0,1)
`6*rand(1)`	one random # in (0,6)
`6*rand(1)+1`	one random # in (1,7)



Normal distribution with zero mean and unit standard deviation

`randn`



Uniform probability distribution in (0,1)

`rand`

Simulate a fair 6-sided die

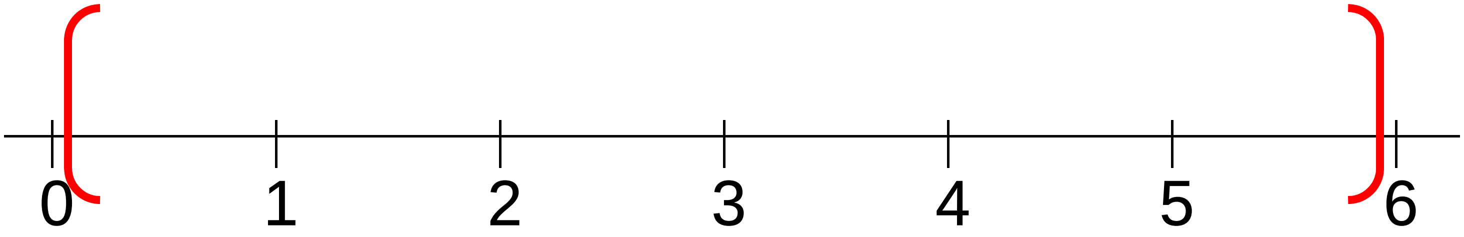
Which expression(s) below will give a random *integer* in [1..6] with equal likelihood?

A `round(rand*6)`

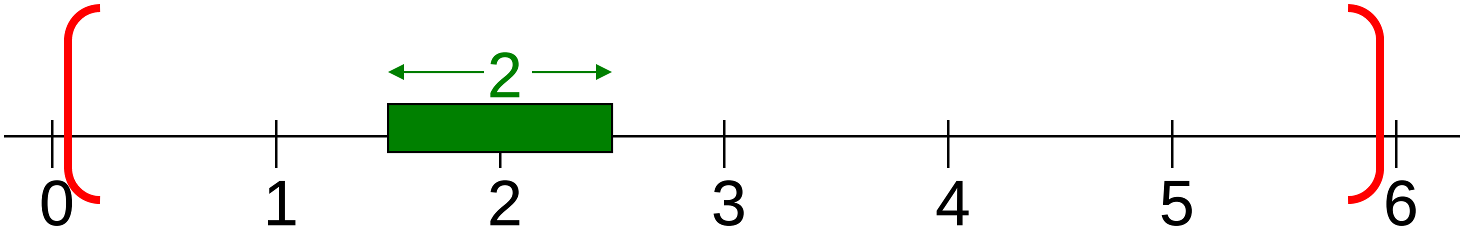
B `ceil(rand*6)`

C *Both expressions above*

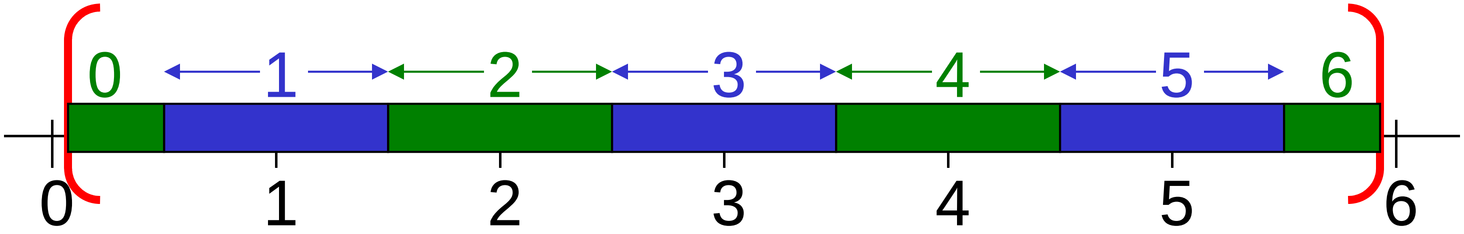
`(rand*6)`



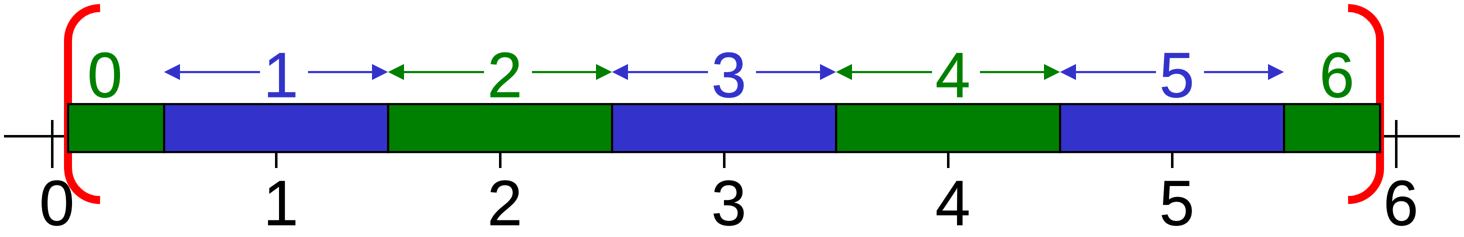
`round(rand*6)`



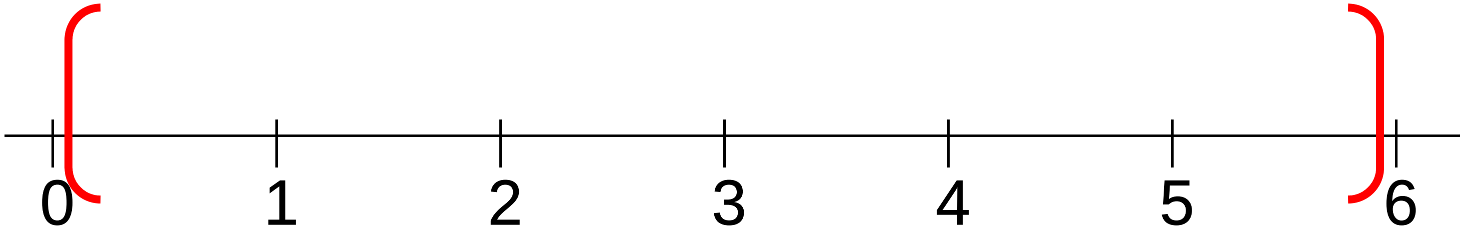
`round(rand*6)`



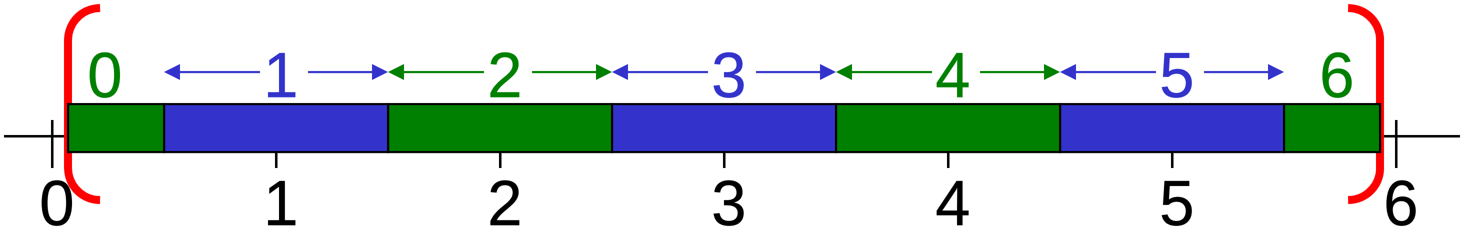
`round(rand*6)`



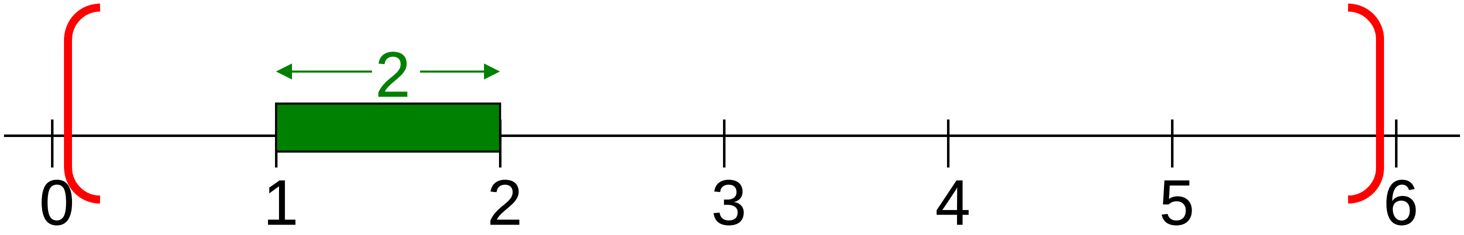
`(rand*6)`



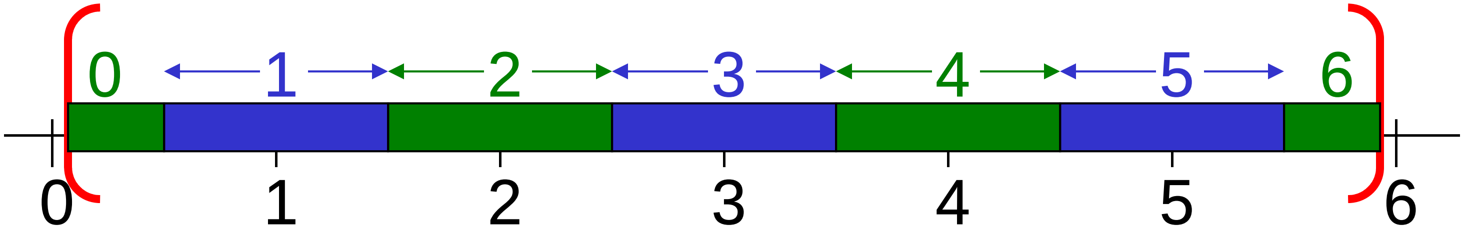
`round(rand*6)`



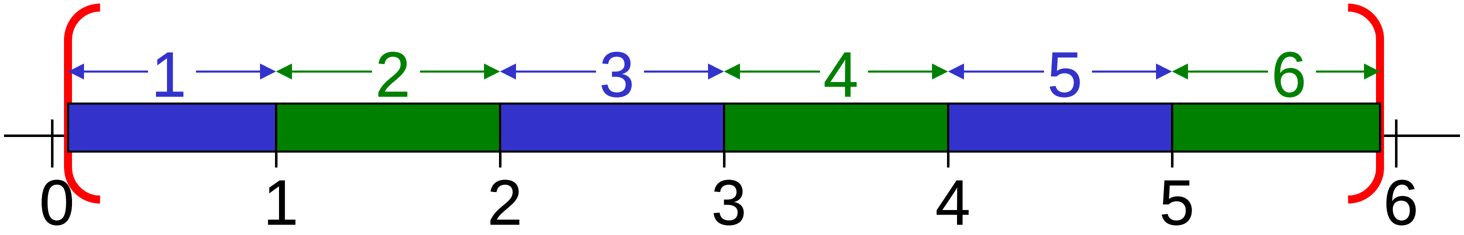
`ceil(rand*6)`



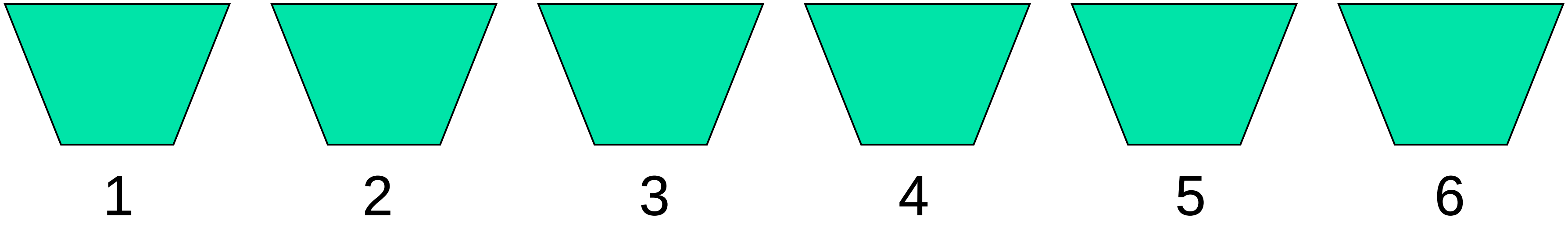
`round(rand*6)`



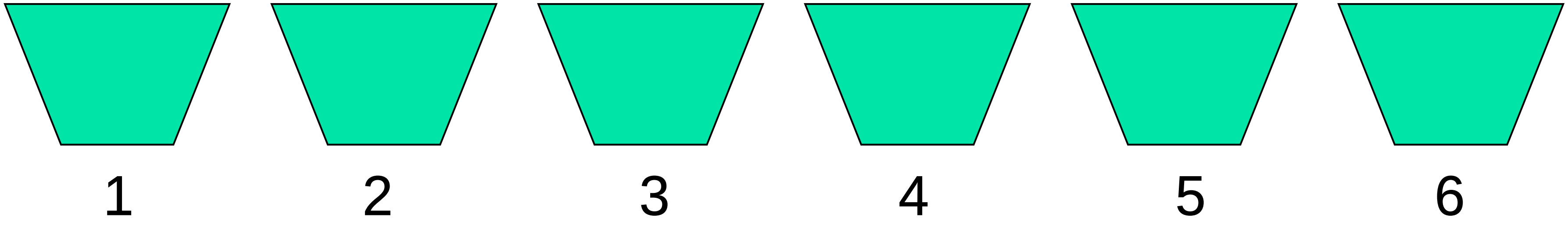
`ceil(rand*6)`



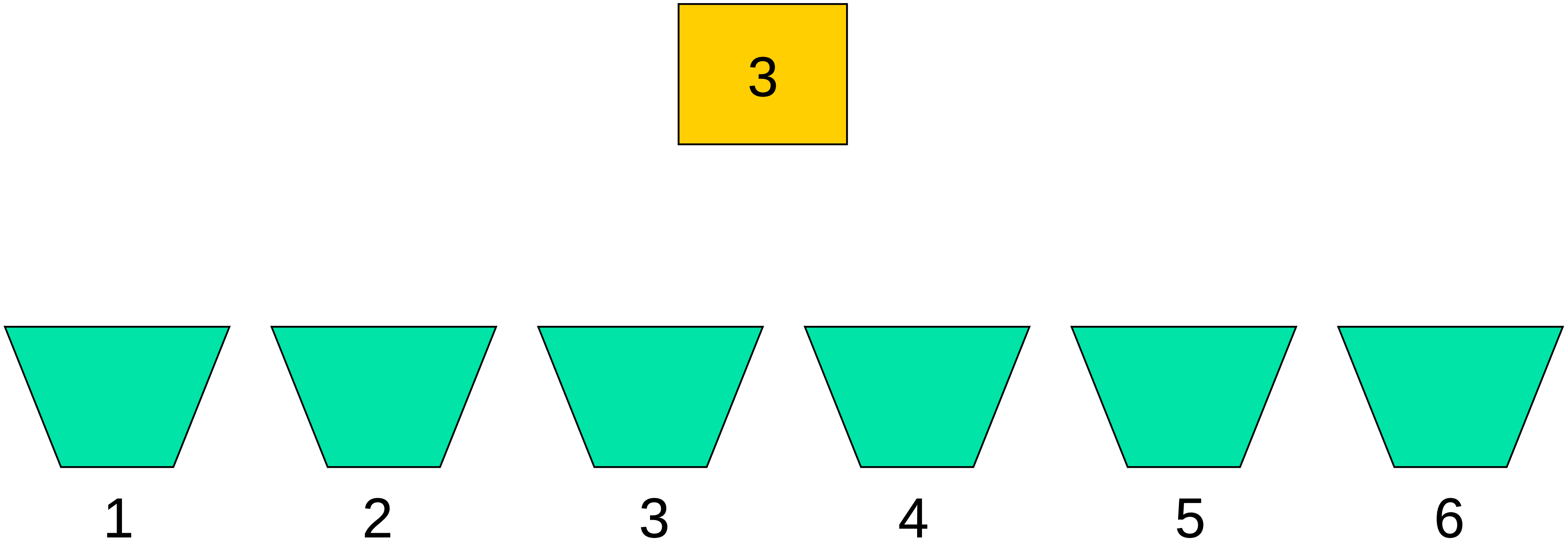
Possible outcomes from rolling a fair 6-sided die



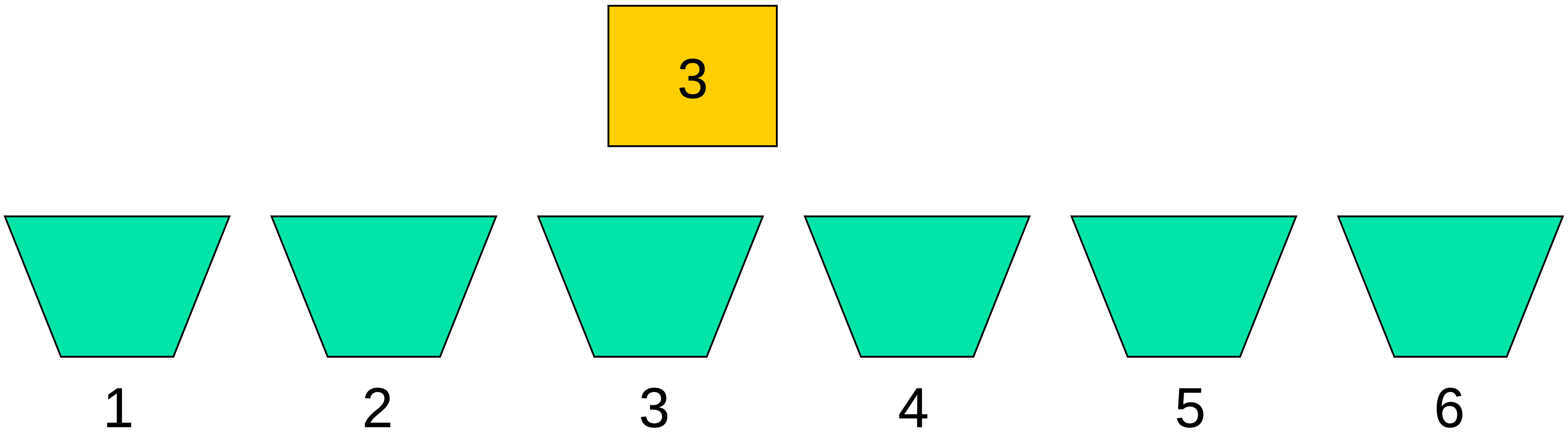
Simulation



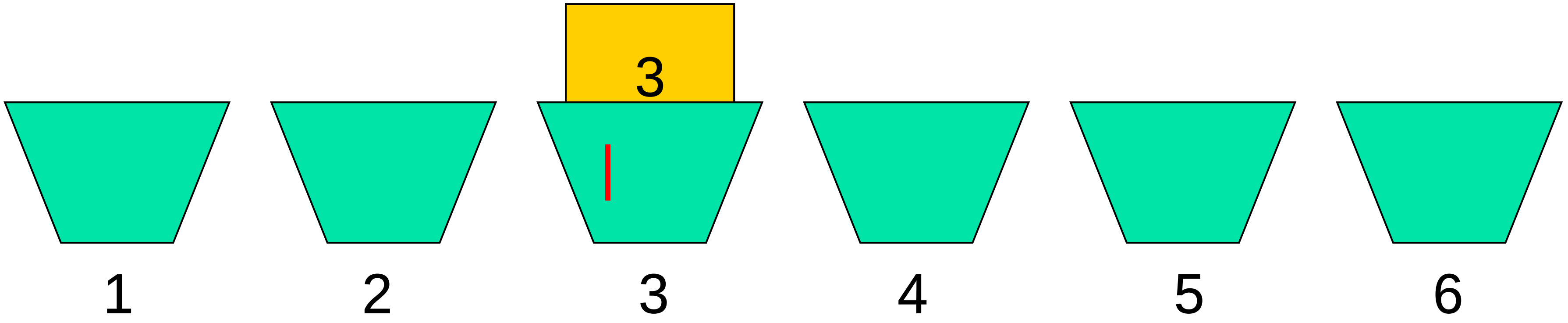
Simulation



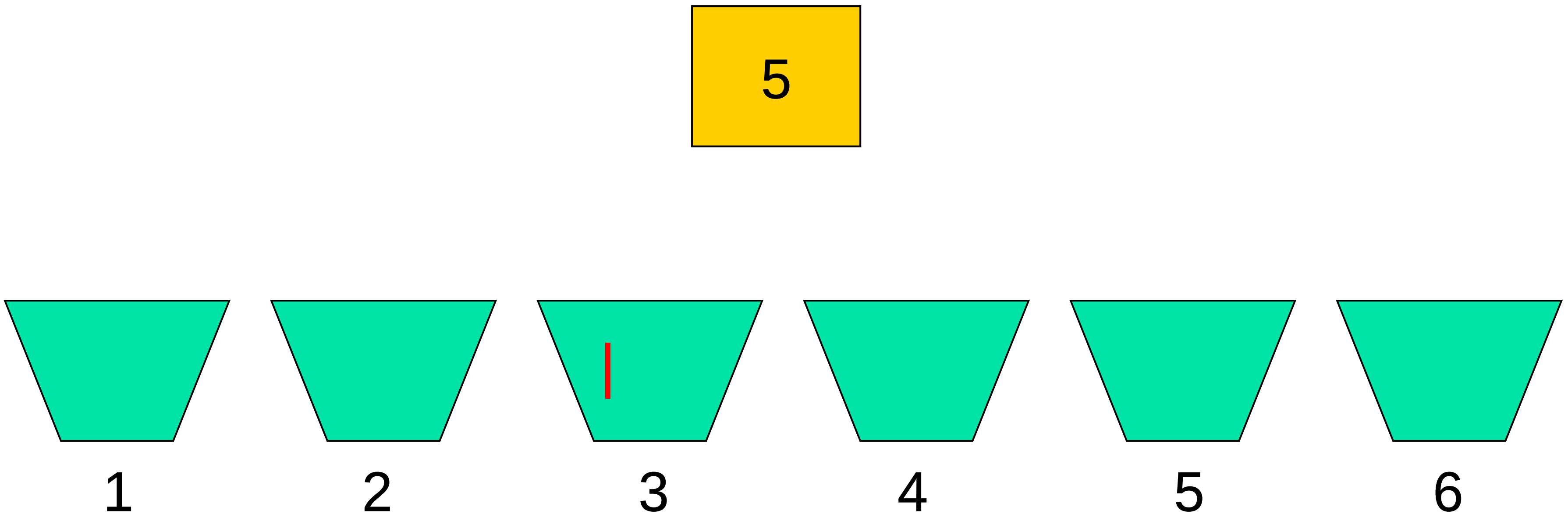
Simulation



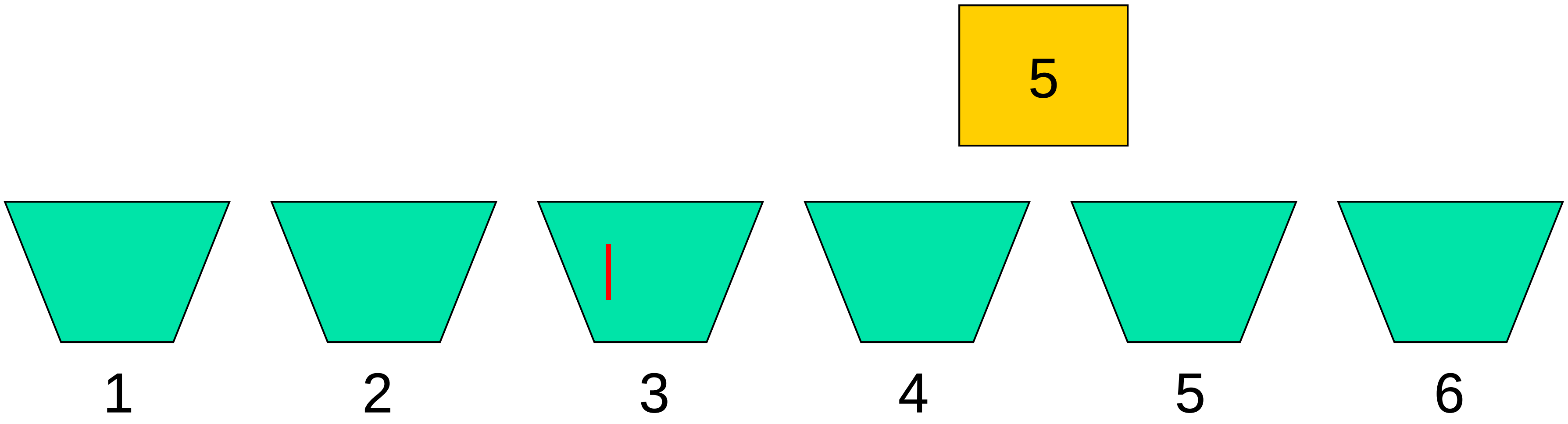
Simulation



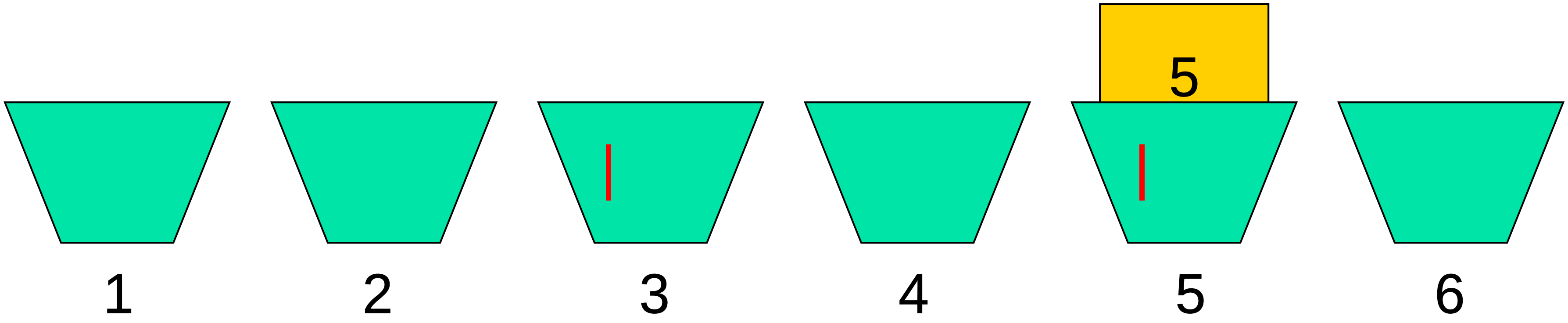
Simulation



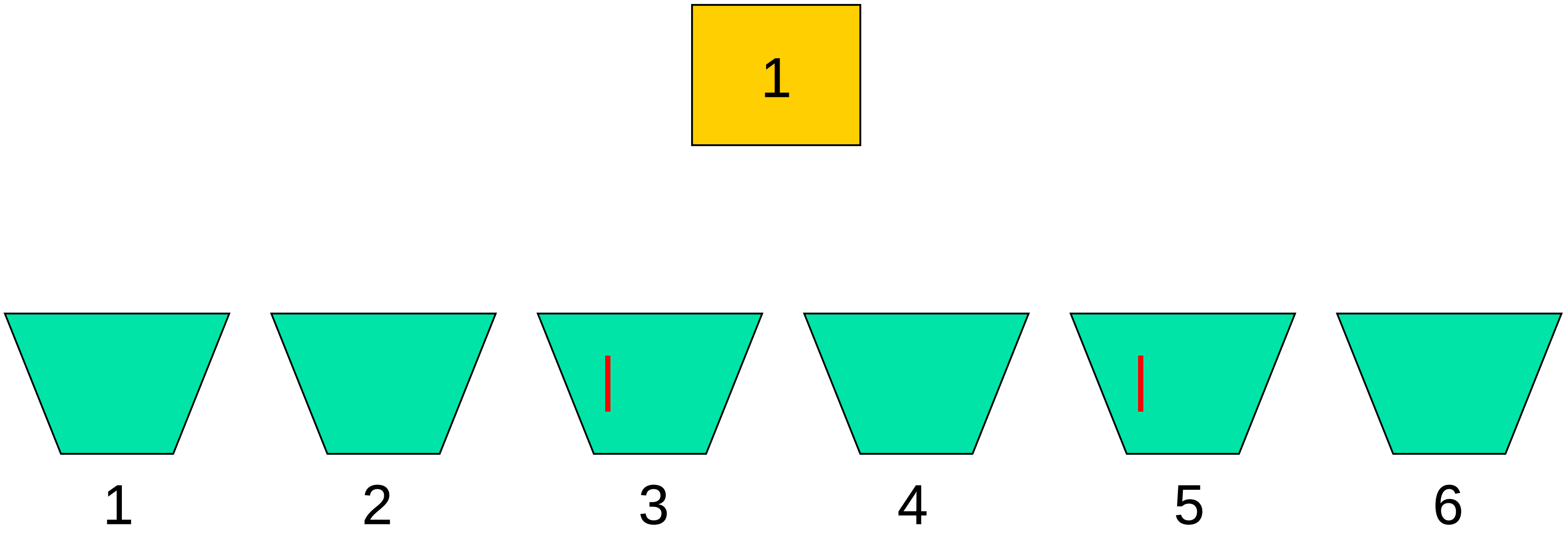
Simulation



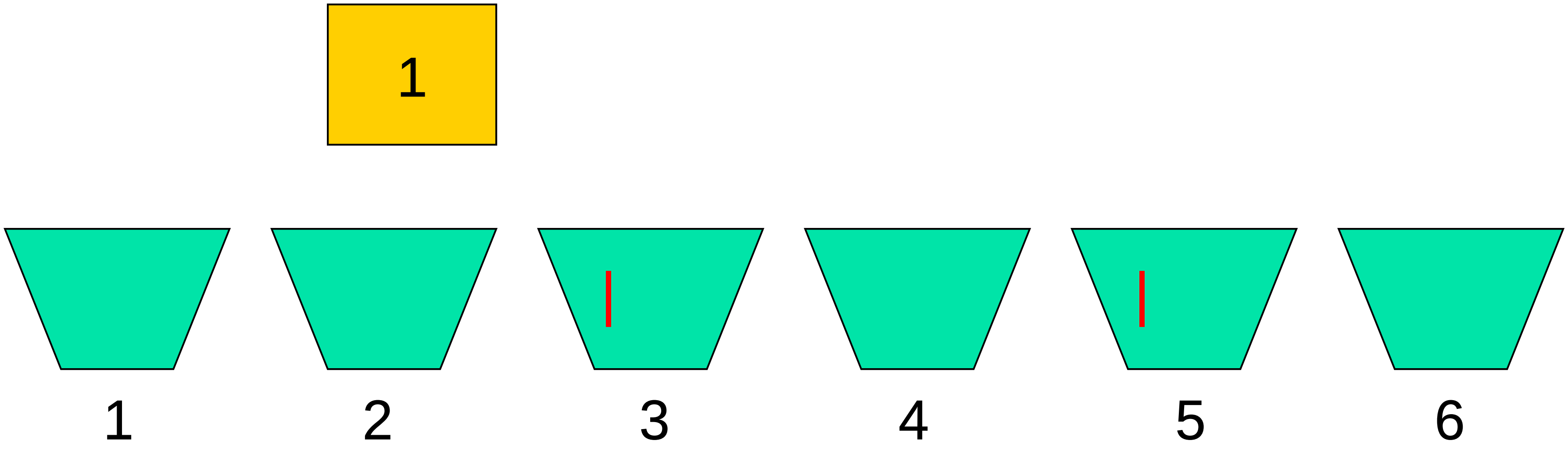
Simulation



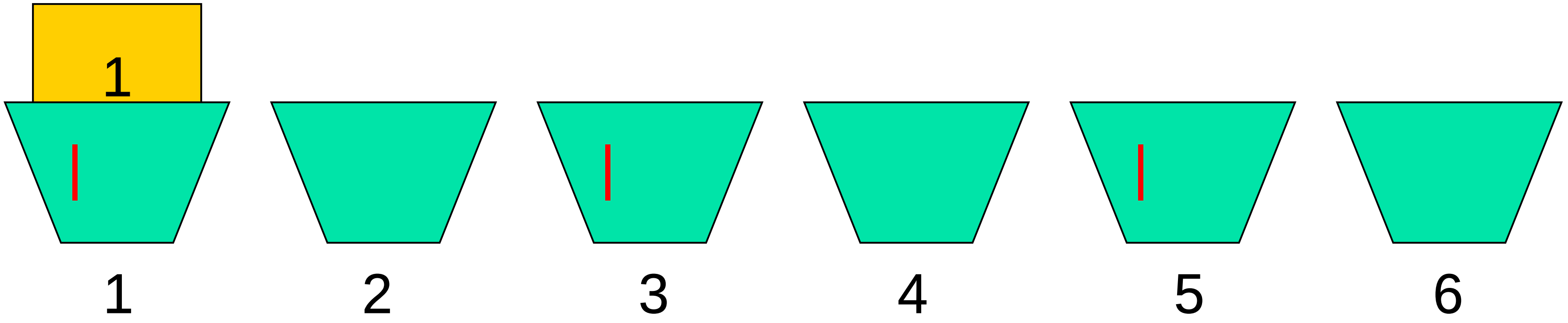
Simulation



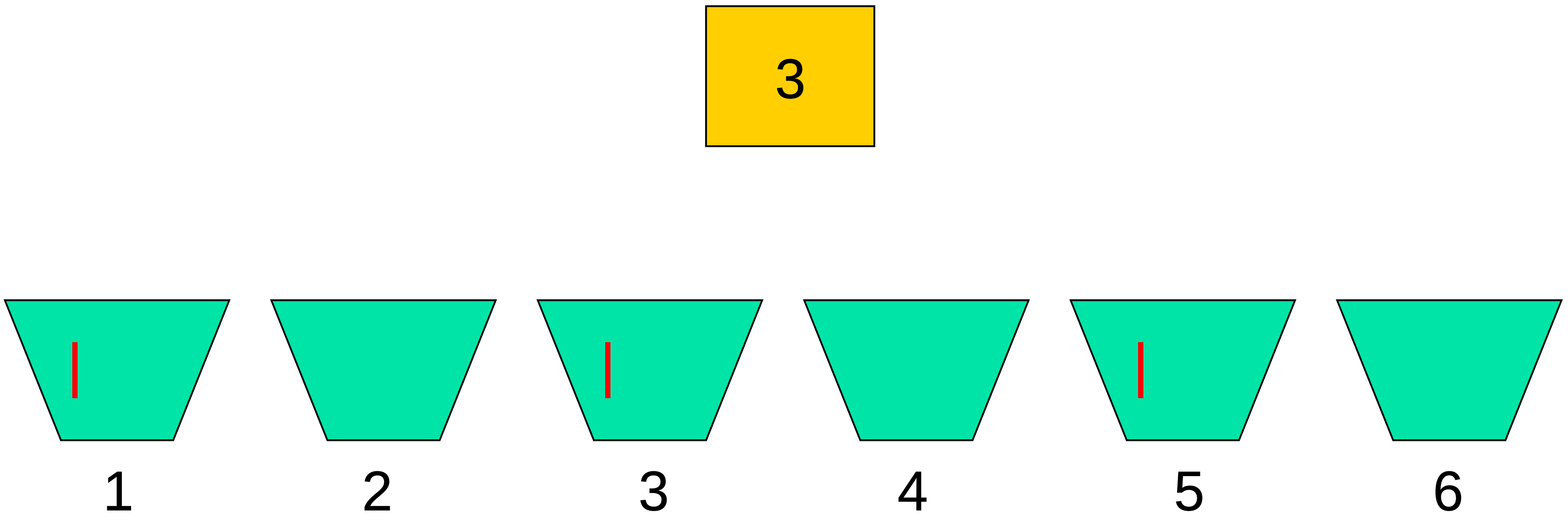
Simulation



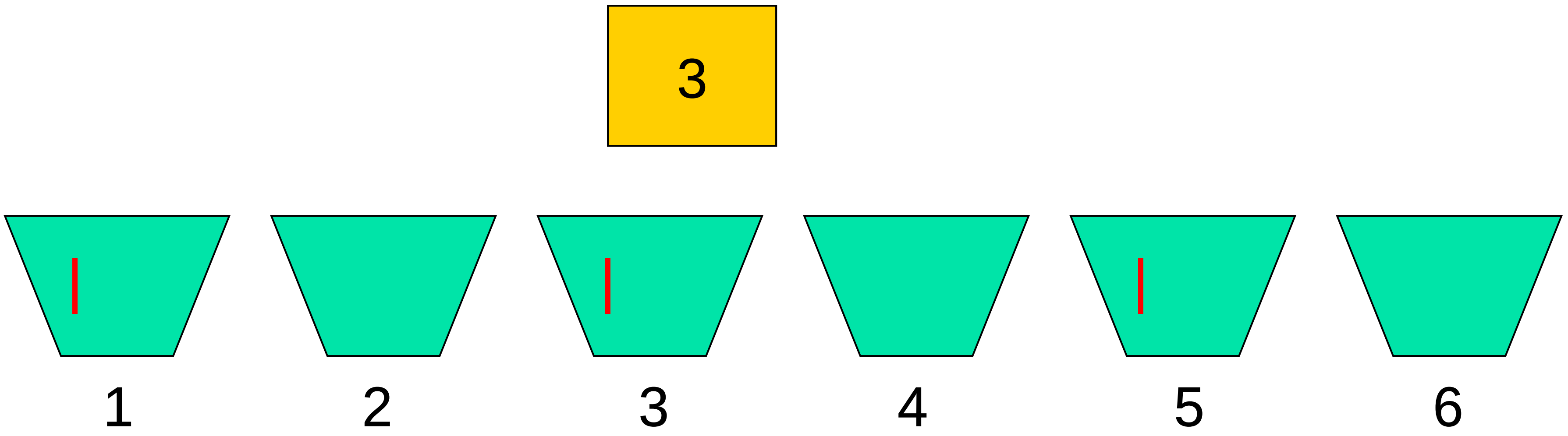
Simulation



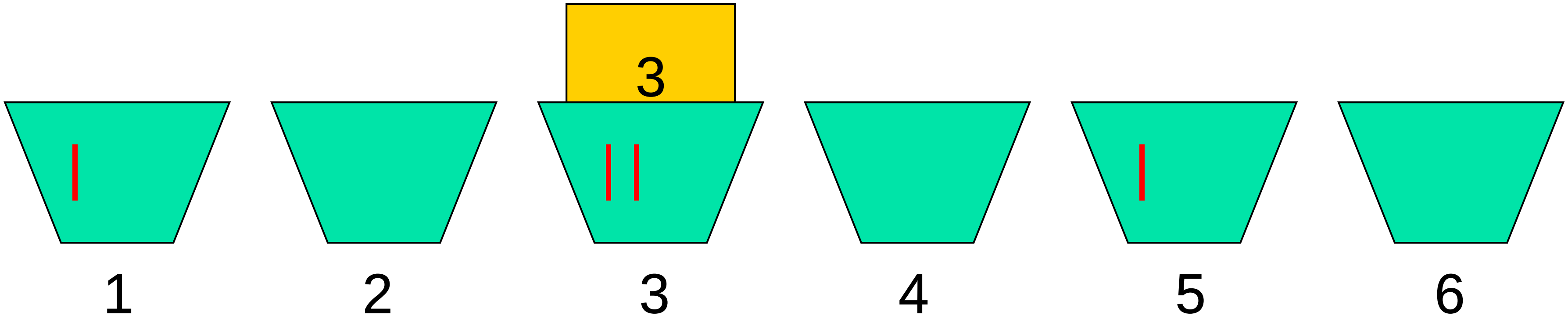
Simulation



Simulation



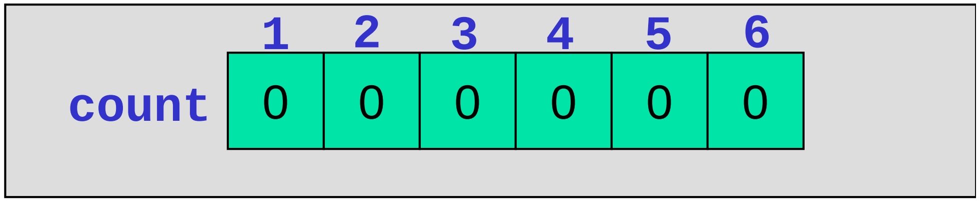
Simulation



Keep tally on repeated rolls of a fair die

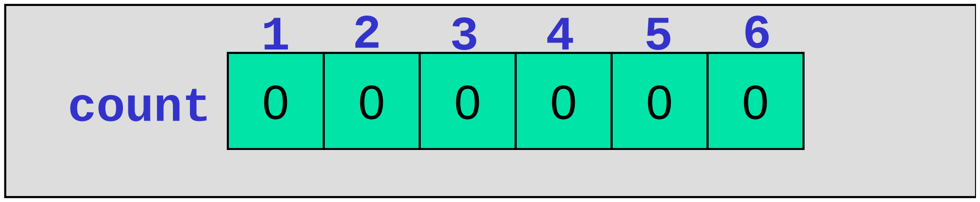
```
Repeat the following:

    % roll the die

    % increment correct “bin”
```

```
function count = rollDie(rolls)

FACES= 6;                % #faces on die
count= zeros(1,FACES);

% Count outcomes of rolling a FAIR die
for k= 1:rolls
    % Roll the die

    % Increment the appropriate bin

end

% Show histogram of outcome
```



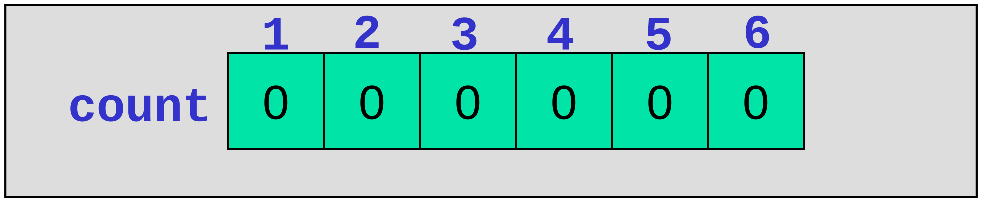
	1	2	3	4	5	6
count	0	0	0	0	0	0

```
function count = rollDie(rolls)

FACES= 6;               % #faces on die
count= zeros(1,FACES);

% Count outcomes of rolling a FAIR die
for k= 1:rolls
    % Roll the die
    face= ceil(rand*FACES);
    % Increment the appropriate bin

end

% Show histogram of outcome
```



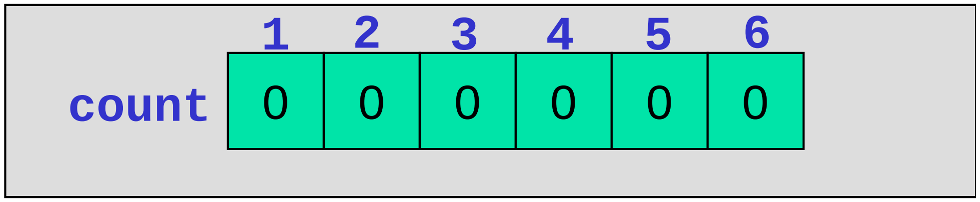
rollDieV1.m

```
% Count outcomes of rolling a FAIR die
count= zeros(1,6);
for k= 1:100
    face= ceil(rand*6);
    if face==1
        count(1)= count(1) + 1;
    elseif face==2
        count(2)= count(2) + 1;
    ⋮
    elseif face==5
        count(5)= count(5) + 1;
    else
        count(6)= count(6) + 1;
    end
end
```



	1	2	3	4	5	6
count	0	0	0	0	0	0

```
function count = rollDie(rolls)

FACES= 6;               % #faces on die
count= zeros(1,FACES);

% Count outcomes of rolling a FAIR die
for k= 1:rolls
    % Roll the die
    face= ceil(rand*FACES);
    % Increment the appropriate bin
    count(face)= count(face) + 1;
end

% Show histogram of outcome
```



	1	2	3	4	5	6
count	0	0	0	0	0	0