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# Graph Representation

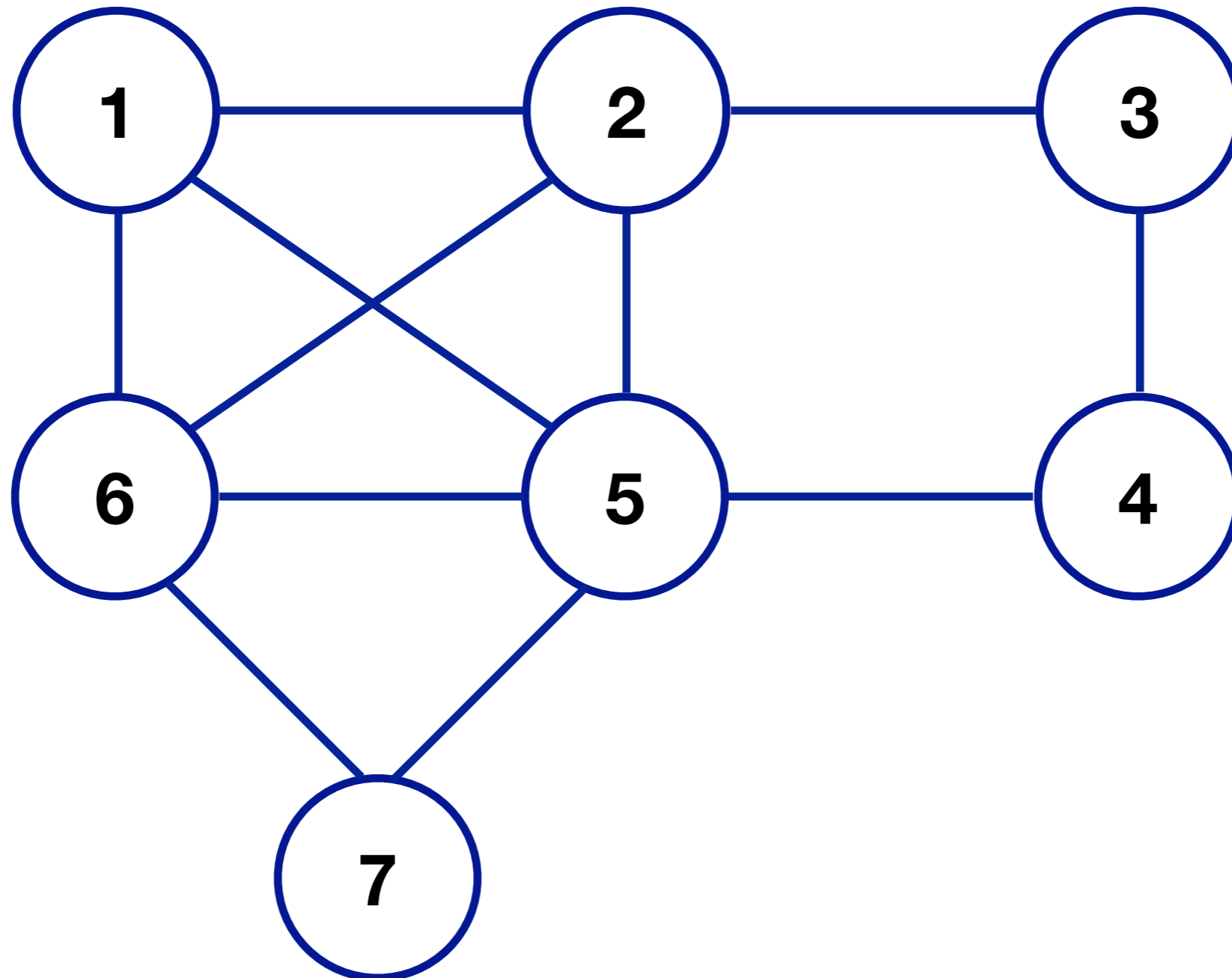
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Alan.Labouseur@Marist.edu

# Graphs

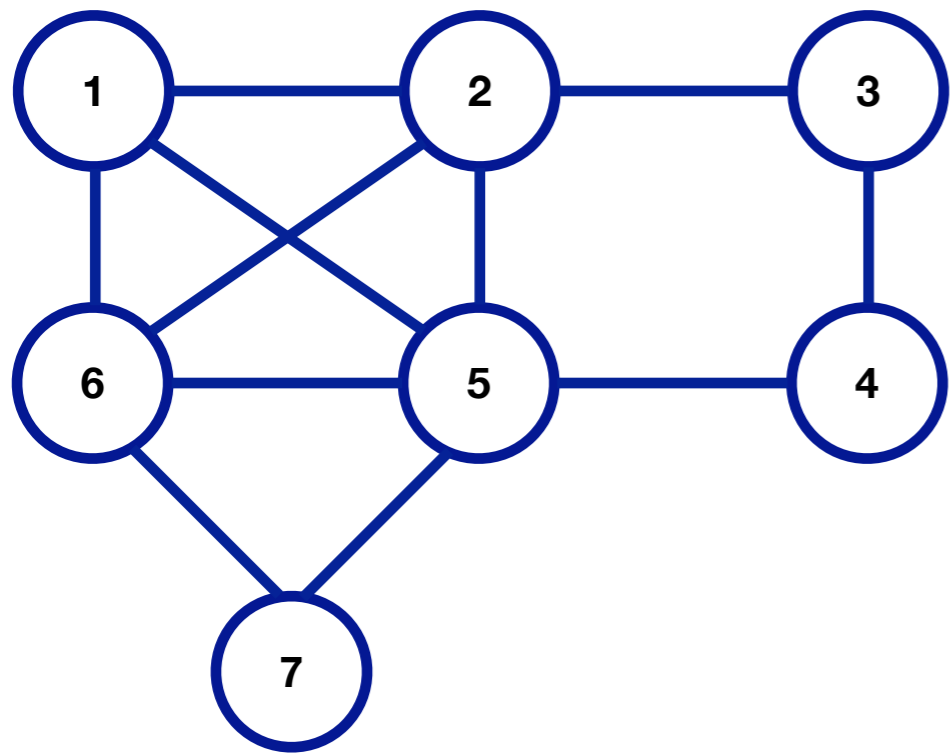
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# Graphs

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Graph . . .



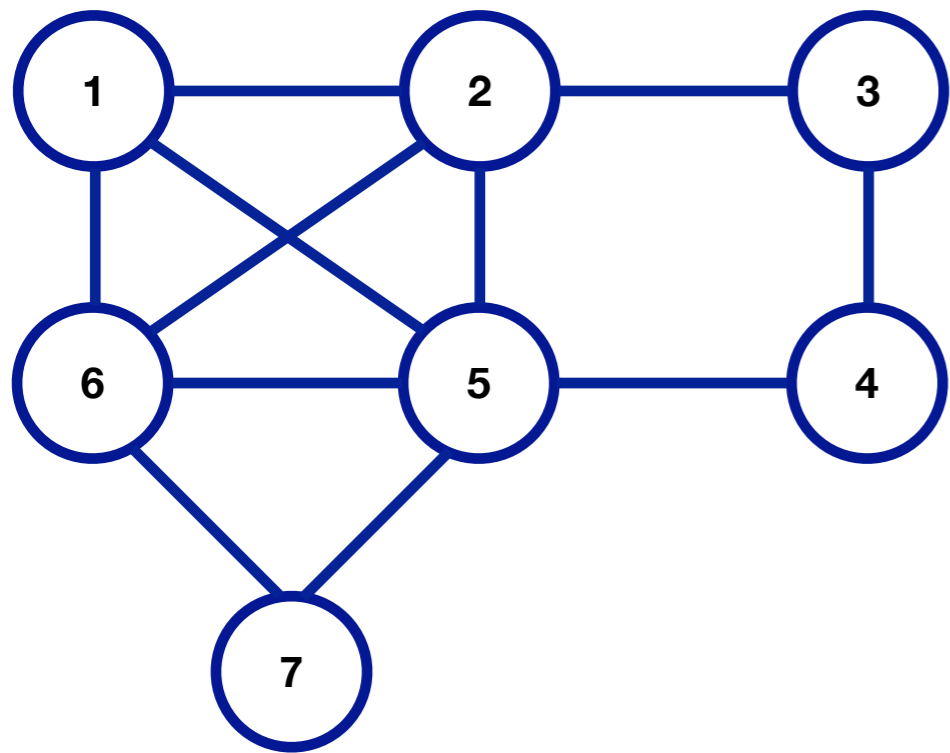
as Matrix

	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>
<i>1</i>	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
<i>2</i>	<b>1</b>	.	<b>1</b>	.	<b>1</b>	<b>1</b>	.
<i>3</i>	.	<b>1</b>	.	<b>1</b>	.	.	.
<i>4</i>	.	.	<b>1</b>	.	<b>1</b>	.	.
<i>5</i>	<b>1</b>	<b>1</b>	.	<b>1</b>	.	<b>1</b>	<b>1</b>
<i>6</i>	<b>1</b>	<b>1</b>	.	.	<b>1</b>	.	<b>1</b>
<i>7</i>	.	.	.	.	<b>1</b>	<b>1</b>	.

# Graphs

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Graph . . .



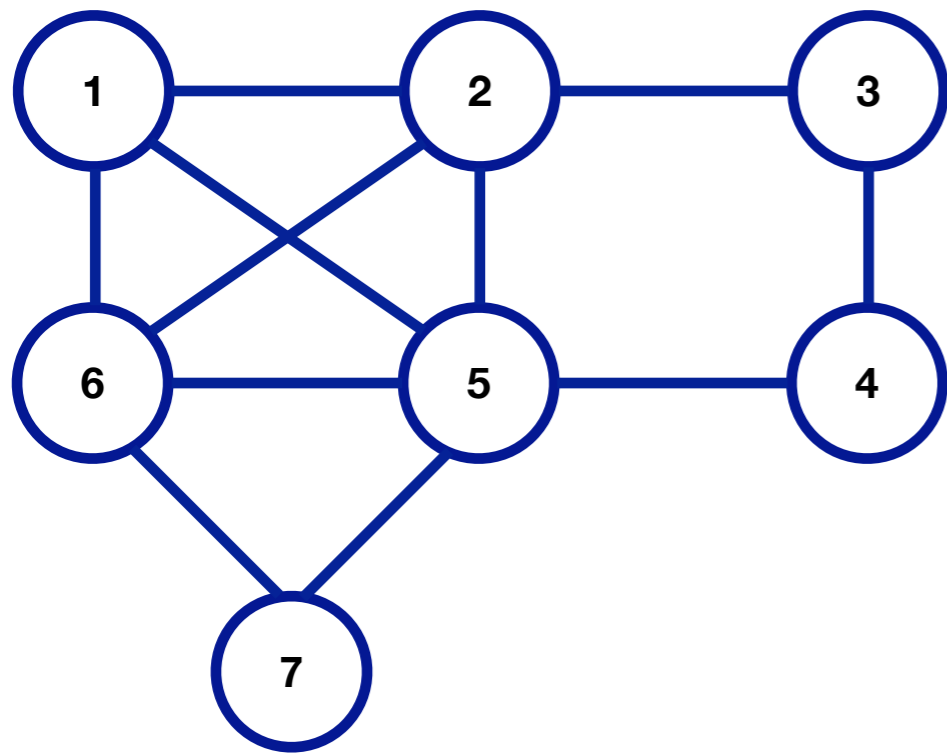
as Adjacency List

```
[1] 2 5 6
[2] 1 3 5 6
[3] 2 4
[4] 3 5
[5] 1 2 4 6 7
[6] 1 2 5 7
[7] 5 6
```

# Graphs

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Graph . . .



as Linked Objects

Vertex

```
int      id  
boolean processed  
Vertex[] neighbors
```

# Graphs

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Graph . . .

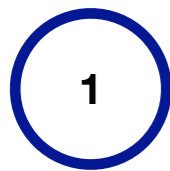
as Linked Objects

```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

# Graphs

---

Graph . . .



as Linked Objects

<i>id</i>	1
<i>processed</i>	false
<i>neighbors</i>	[]

```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

Matrix

$\begin{matrix} & 1 \\ 1 & \cdot \end{matrix}$

# Graphs

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Graph . . .



as Linked Objects

<i>id</i>	1
<i>processed</i>	false
<i>neighbors</i>	[]

<i>id</i>	2
<i>processed</i>	false
<i>neighbors</i>	[]

```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

Matrix

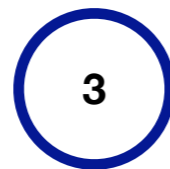
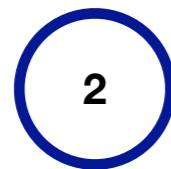
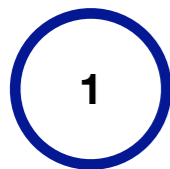
$$\begin{matrix} & 1 & 2 \\ 1 & \cdot & \cdot \\ 2 & \cdot & \cdot \end{matrix}$$



# Graphs

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Graph . . .



as Linked Objects

```
id      1
processed false
neighbors []
```

```
id      2
processed false
neighbors []
```

```
id      3
processed false
neighbors []
```

```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

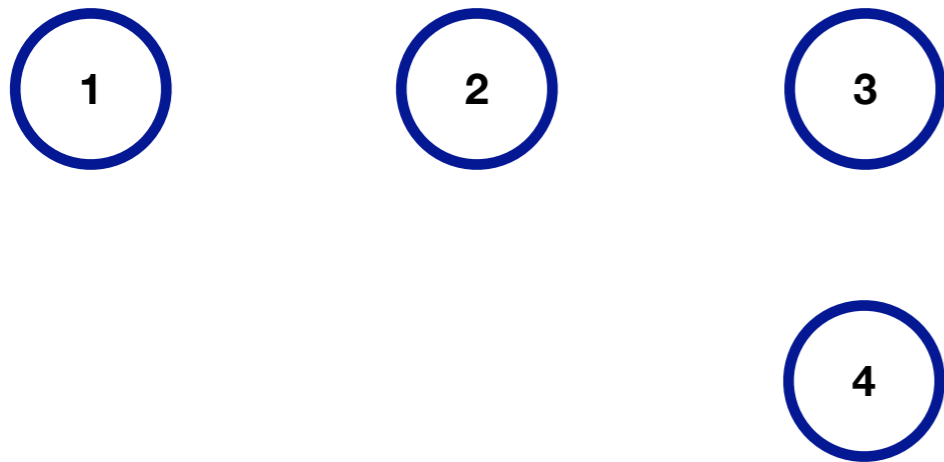
## Matrix

```
      1 2 3
1  . . .
2  . . .
3  . . .
```

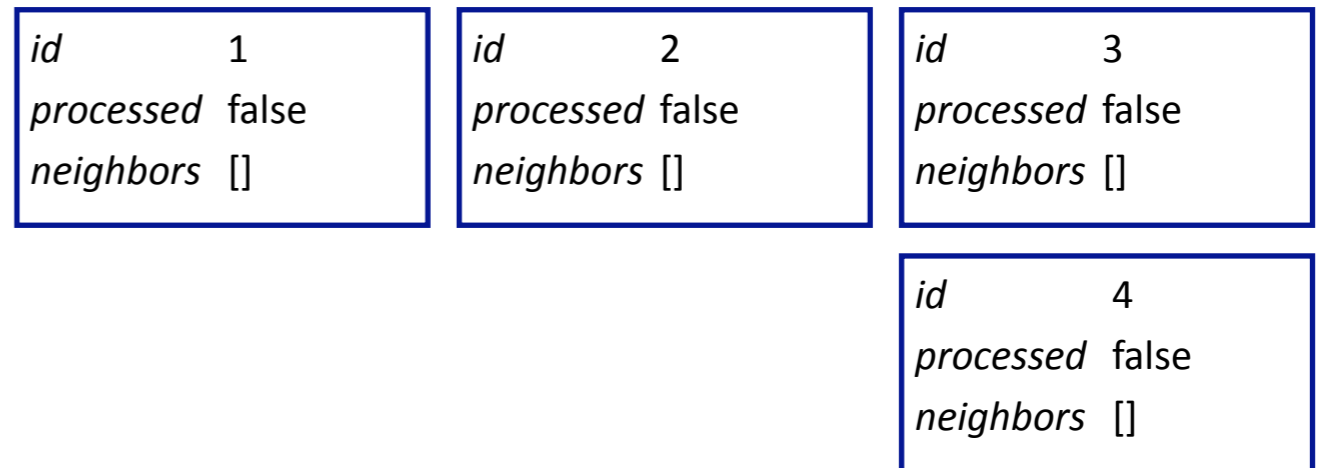
# Graphs

---

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

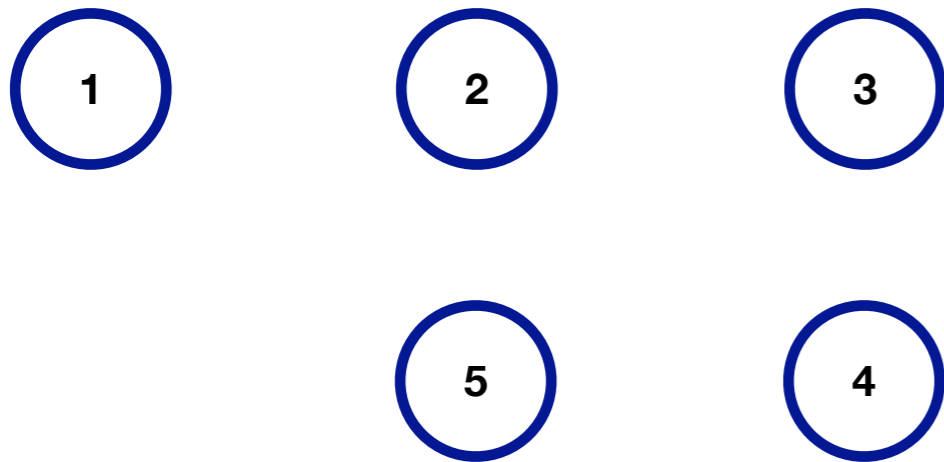
## Matrix

	1	2	3	4
1	.	.	.	.
2	.	.	.	.
3	.	.	.	.
4	.	.	.	.

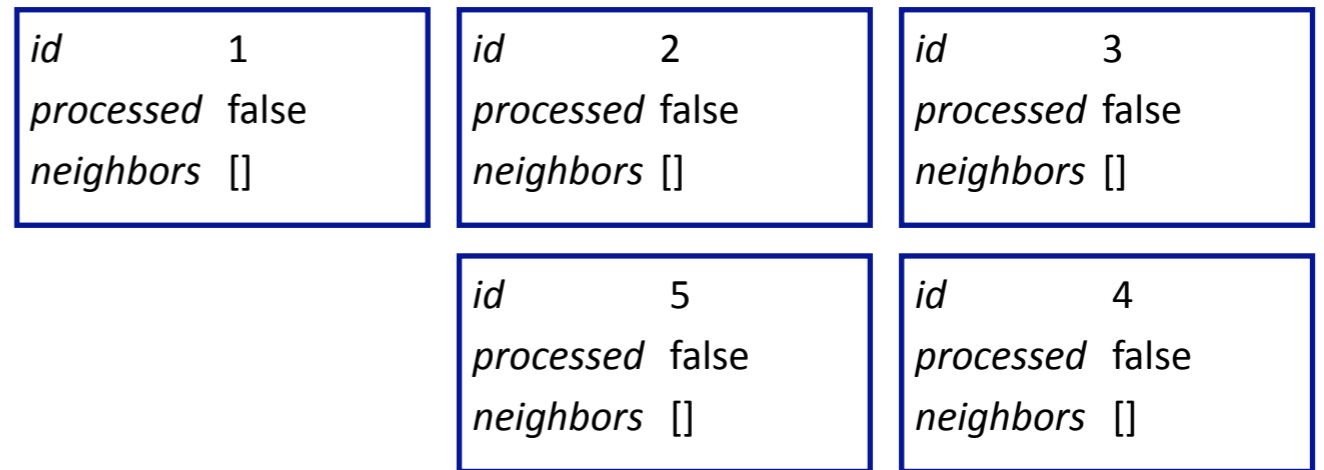
# Graphs

---

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

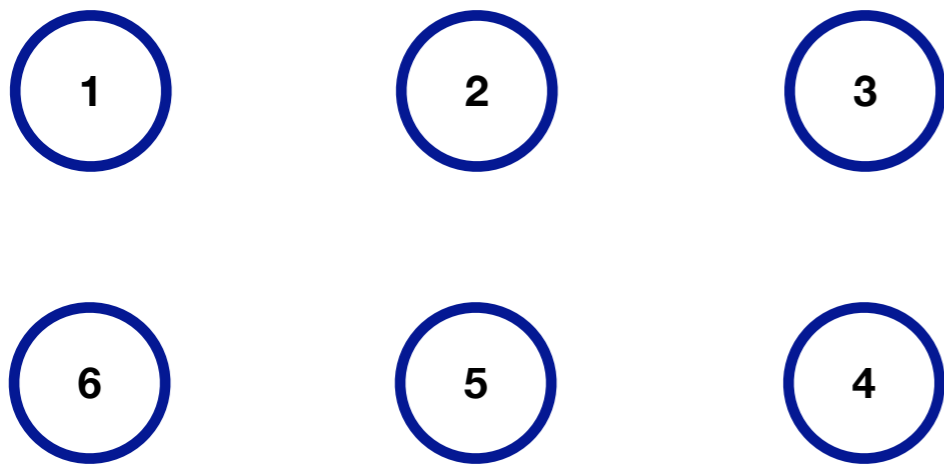
## Matrix

	1	2	3	4	5
1	.	.	.	.	.
2	.	.	.	.	.
3	.	.	.	.	.
4	.	.	.	.	.
5	.	.	.	.	.

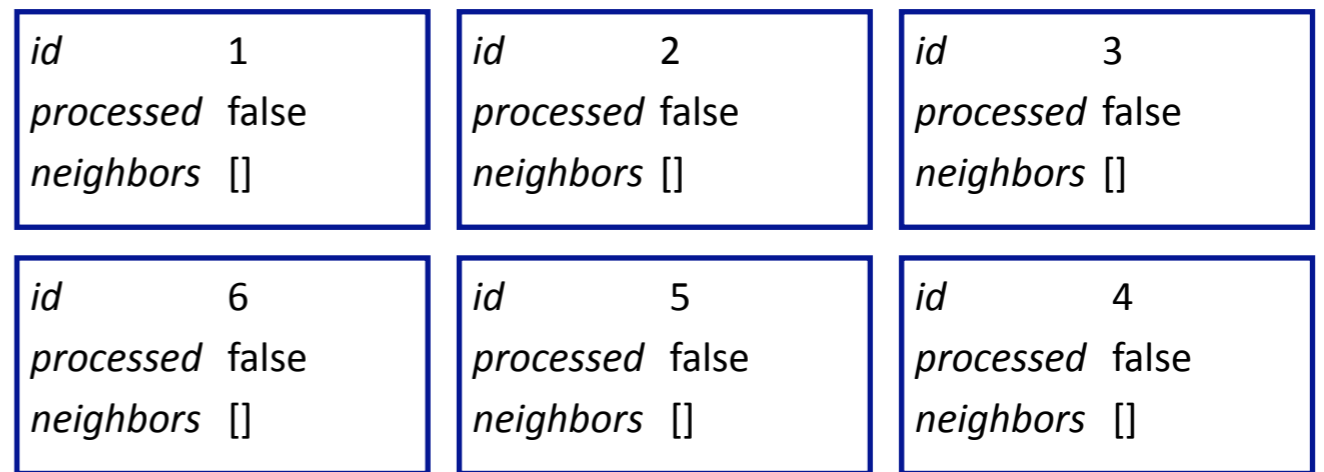
# Graphs

---

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

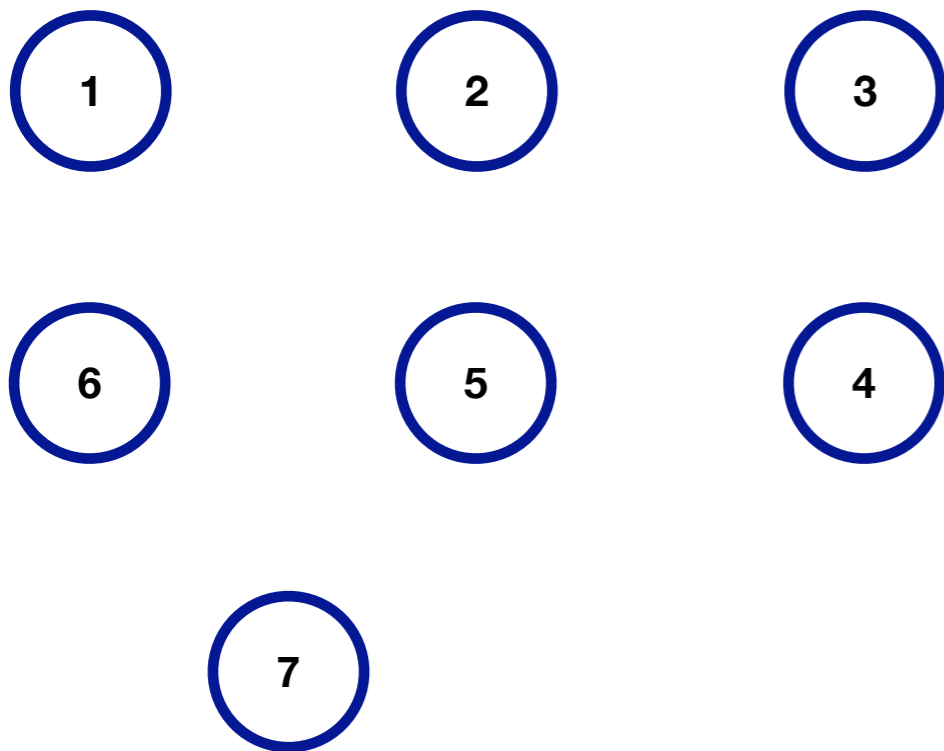
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

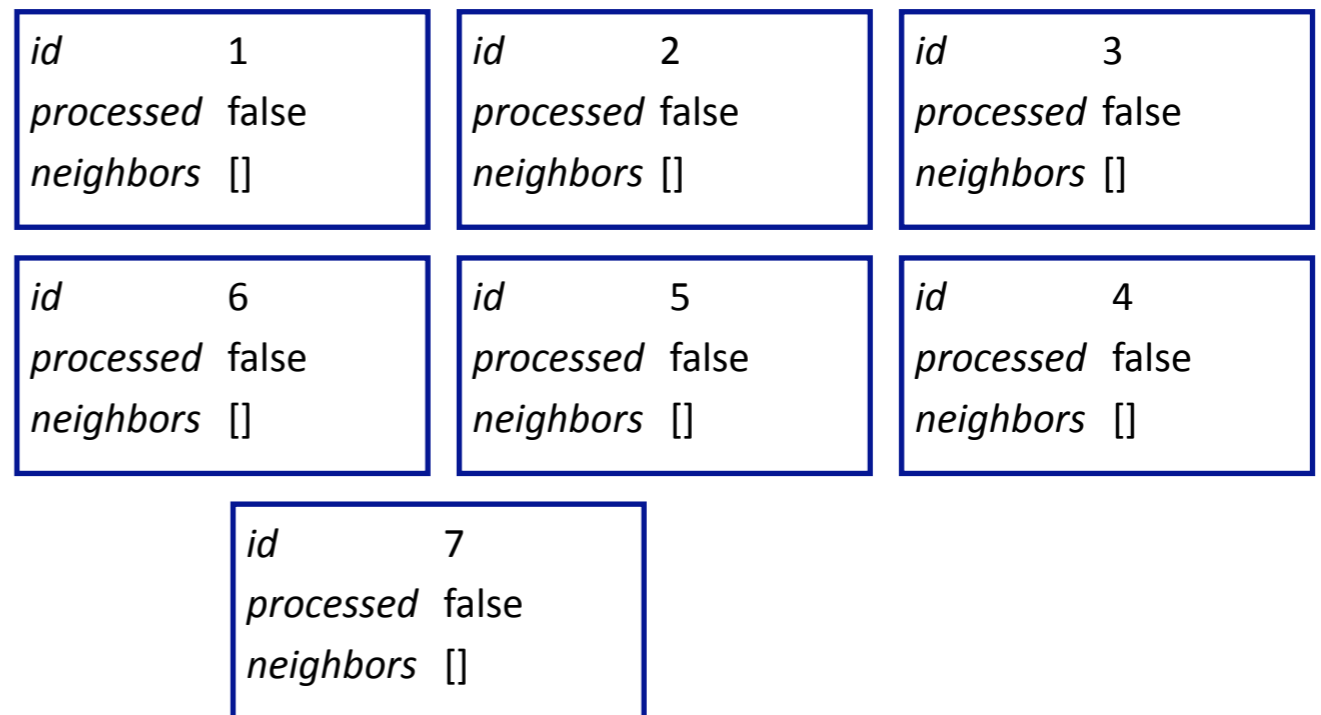
	1	2	3	4	5	6
1	.	.	.	.	.	.
2	.	.	.	.	.	.
3	.	.	.	.	.	.
4	.	.	.	.	.	.
5	.	.	.	.	.	.
6	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

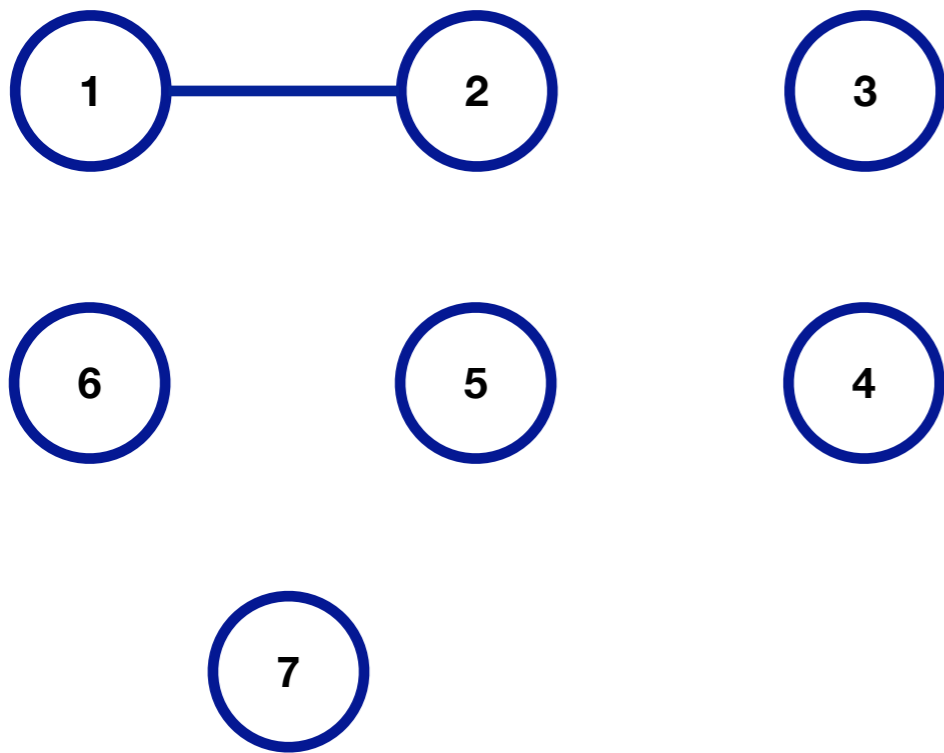
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

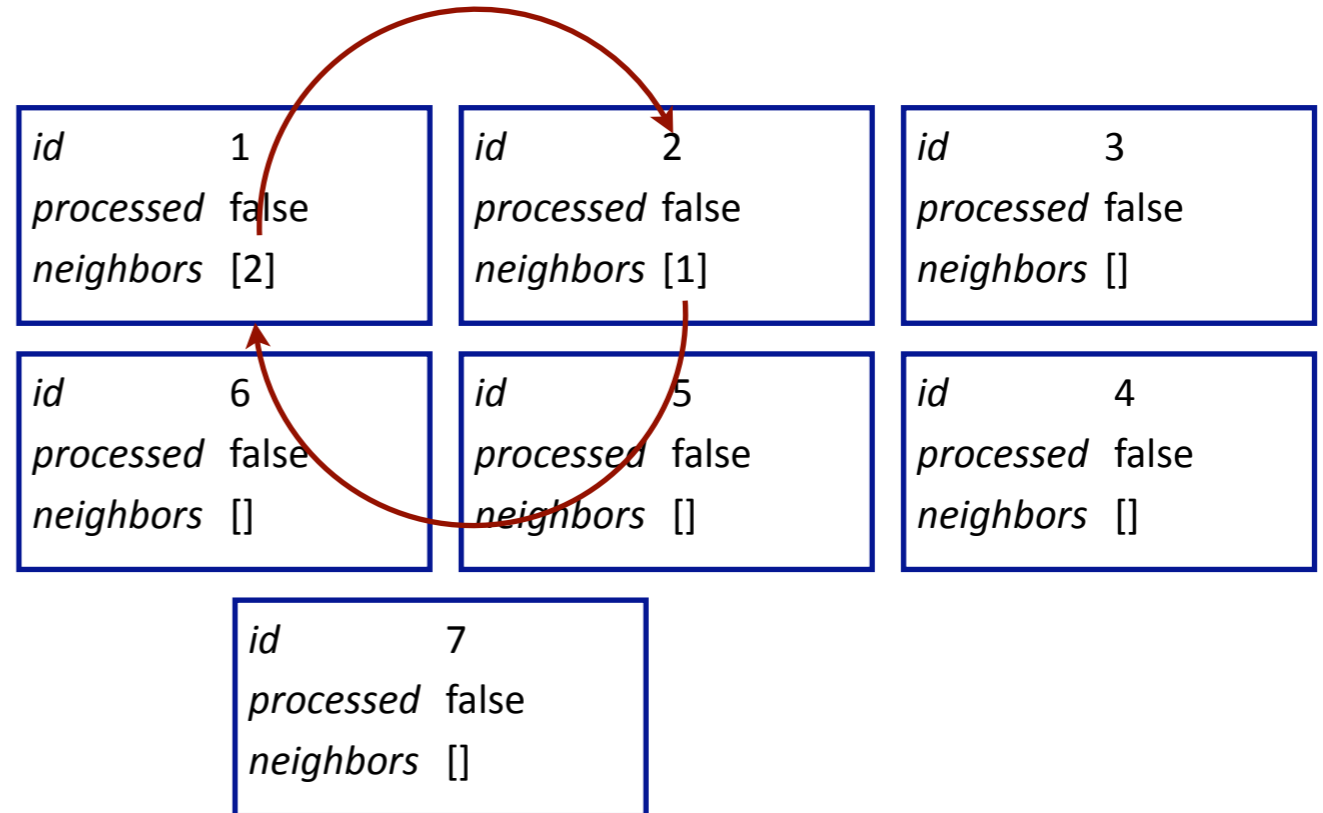
	1	2	3	4	5	6	7
1	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

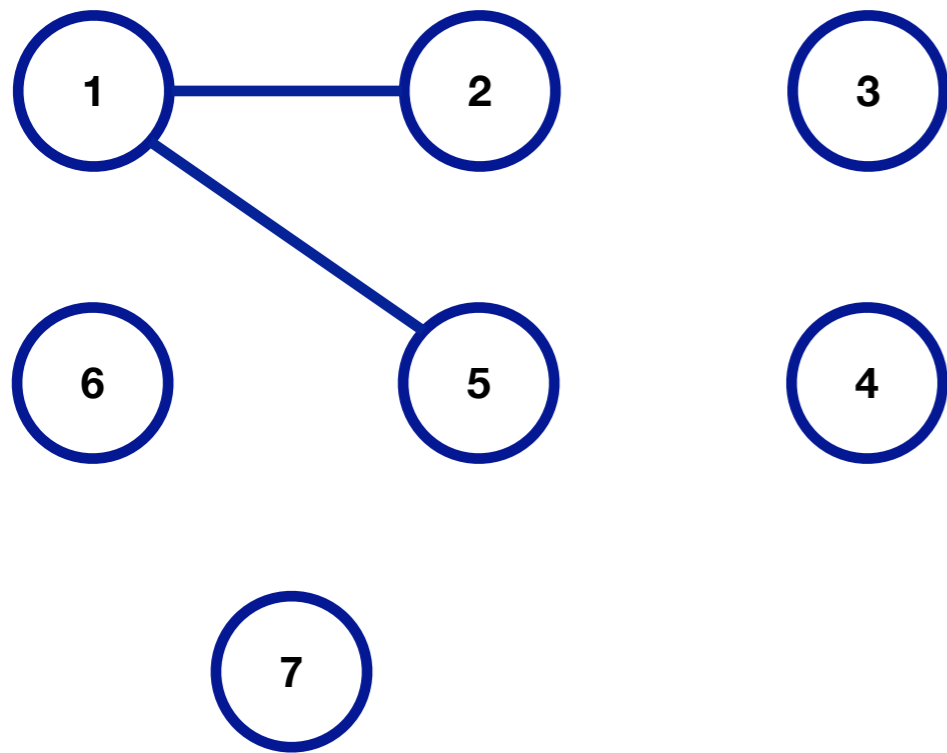
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

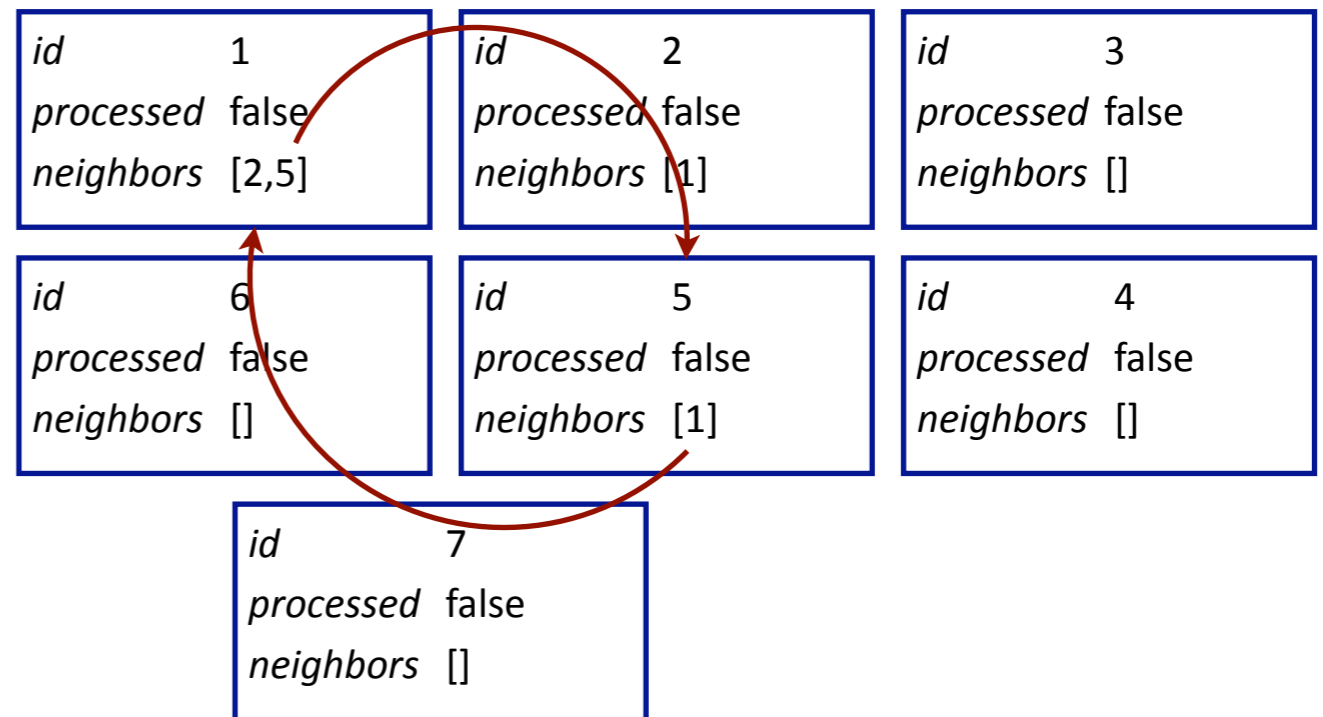
	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	.	.	.
2	<b>1</b>	.	.	.	.	.	.
3	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

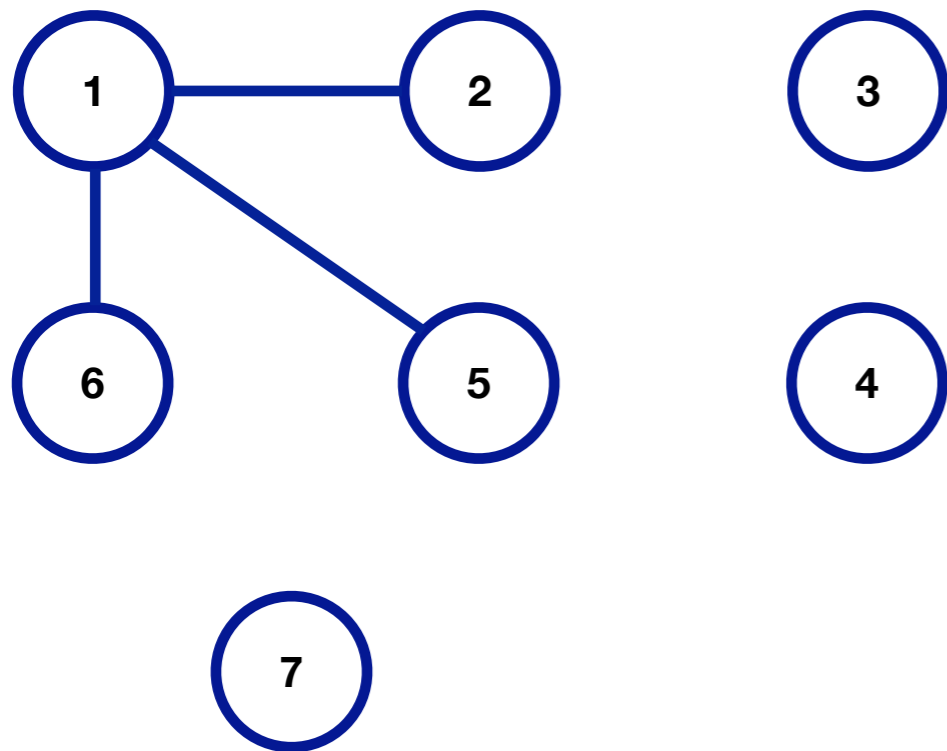
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

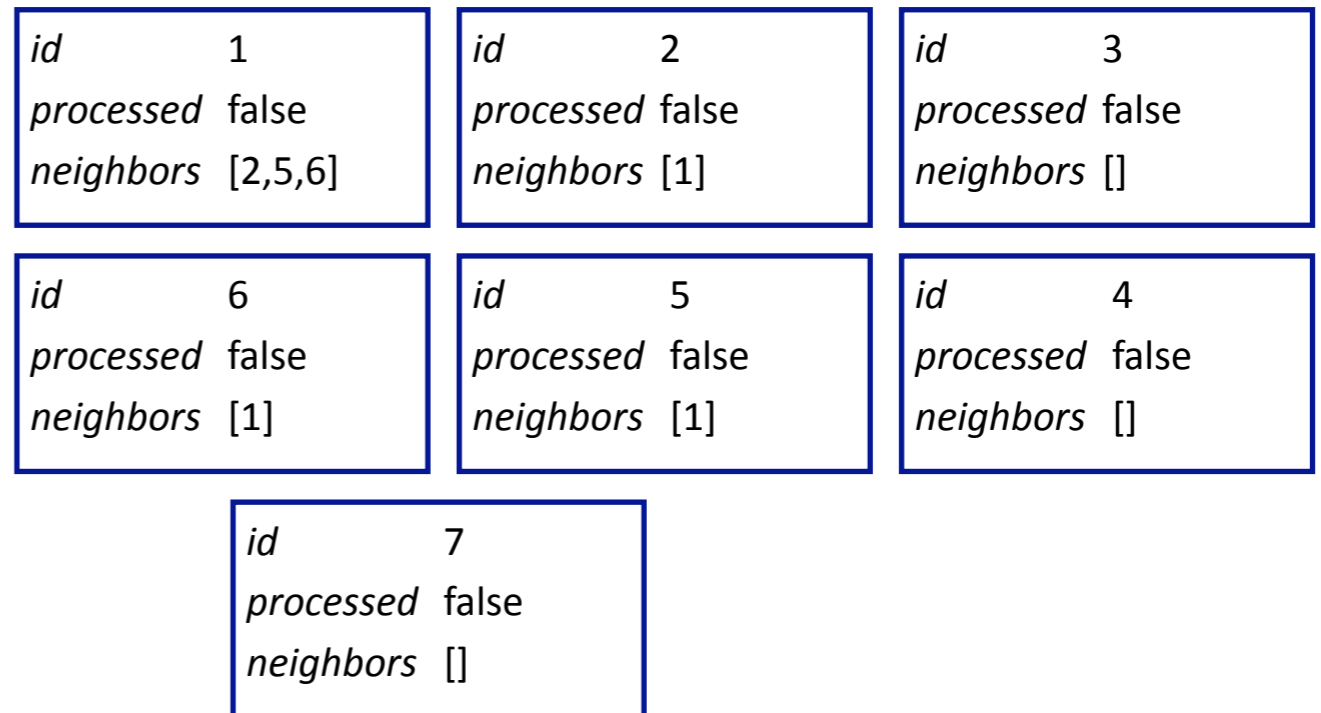
	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	.	.
2	<b>1</b>	.	.	.	.	.	.
3	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
5	<b>1</b>	.	.	.	.	.	.
6	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

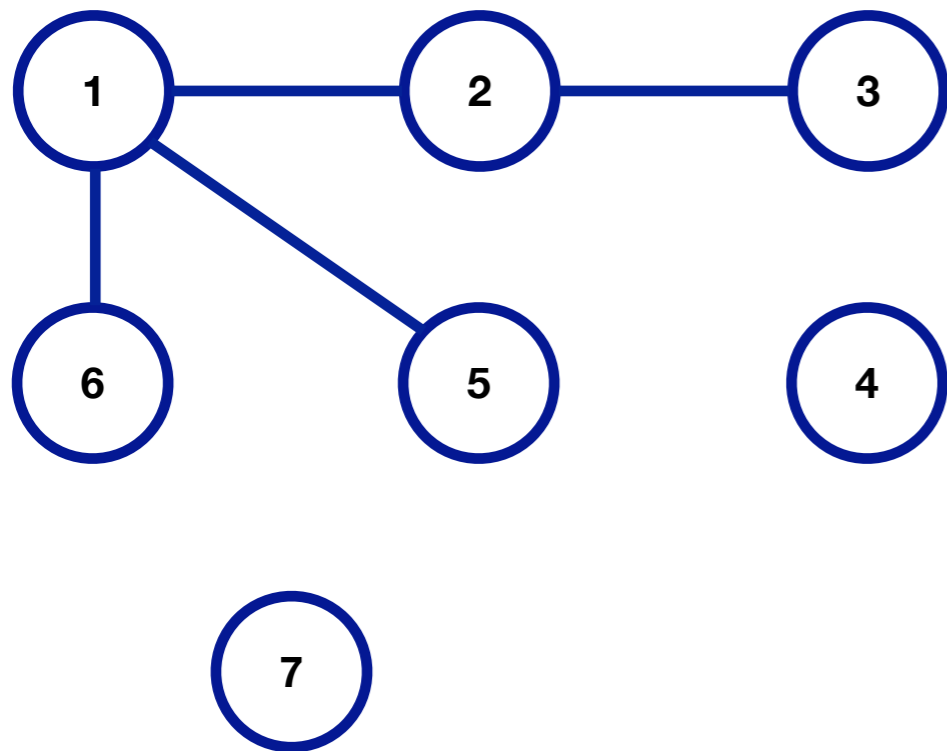
## Matrix

	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
2	<b>1</b>	.	.	.	.	.	.
3	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.
5	<b>1</b>	.	.	.	.	.	.
6	<b>1</b>	.	.	.	.	.	.
7	.	.	.	.	.	.	.

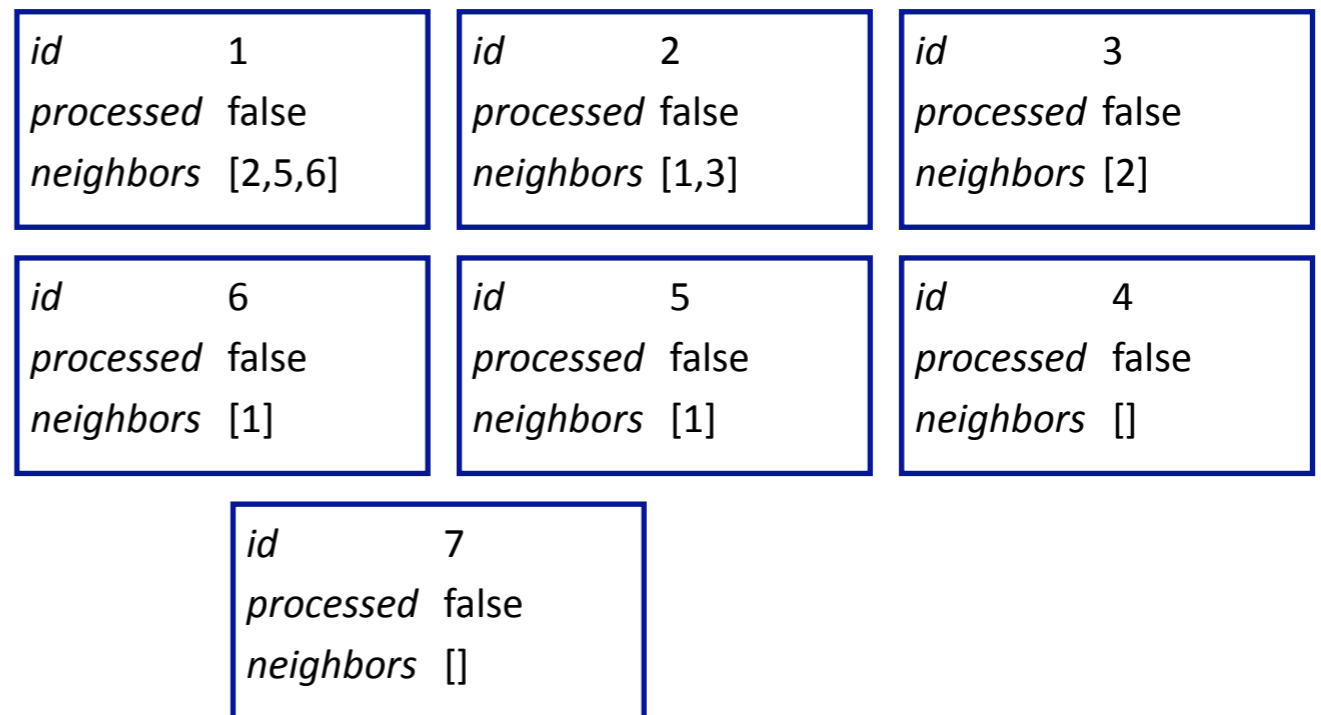


# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

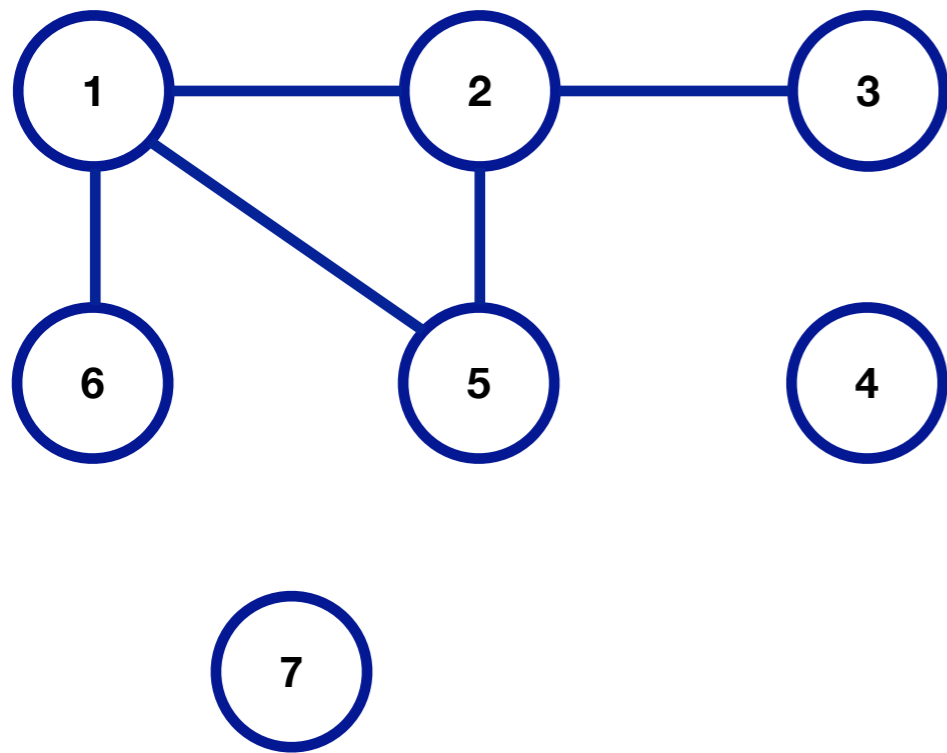
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

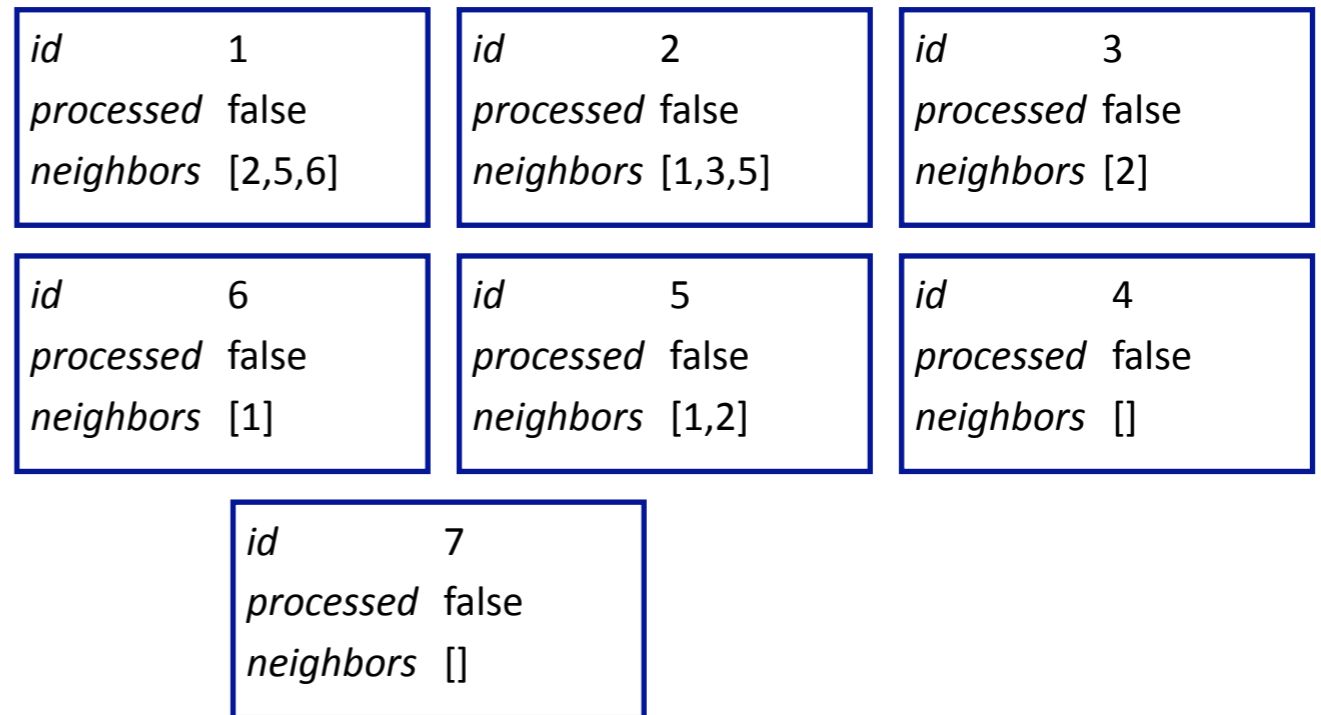
	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
2	<b>1</b>	.	<b>1</b>	.	.	.	.
3	.	<b>1</b>	.	.	.	.	.
4	.	.	.	.	.	.	.
5	<b>1</b>	.	.	.	.	.	.
6	<b>1</b>	.	.	.	.	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

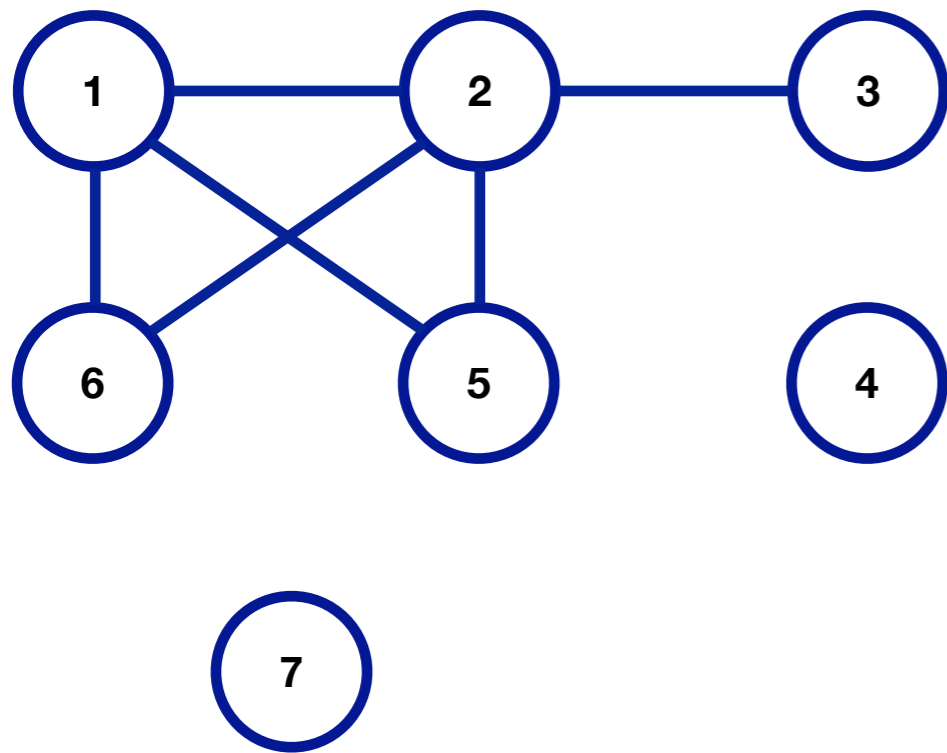
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

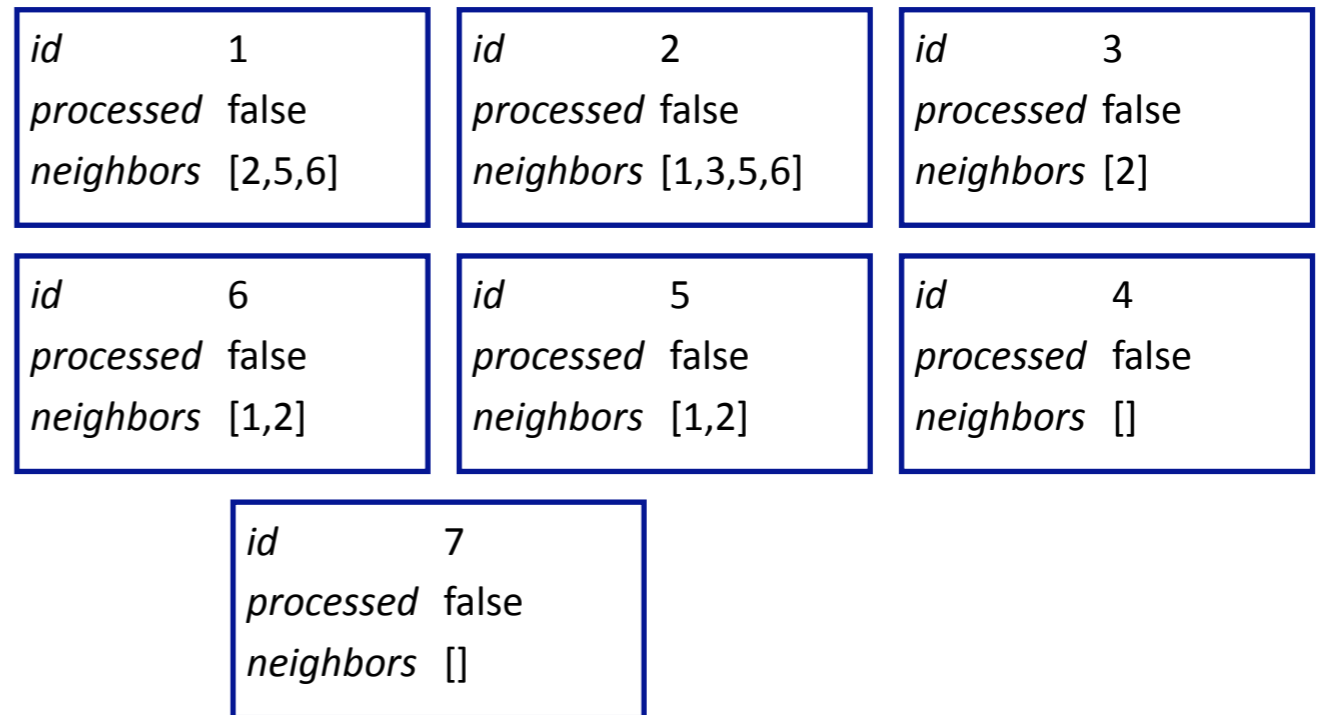
	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
2	<b>1</b>	.	<b>1</b>	.	<b>1</b>	.	.
3	.	<b>1</b>	.	.	.	.	.
4	.	.	.	.	.	.	.
5	<b>1</b>	<b>1</b>	.	.	.	.	.
6	<b>1</b>	.	.	.	.	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
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```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
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add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

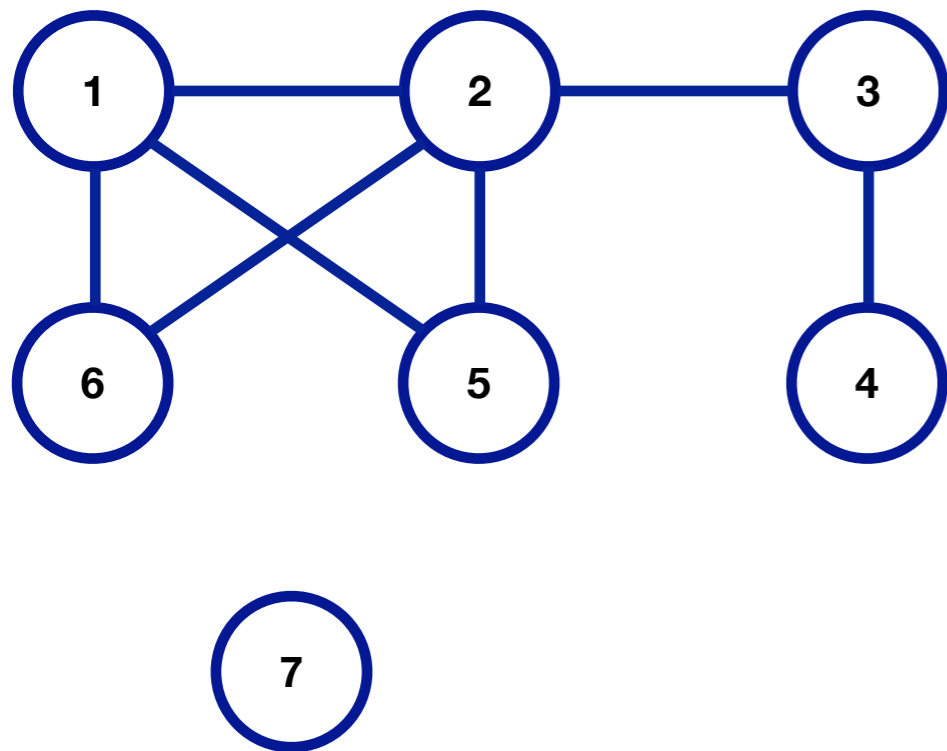
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

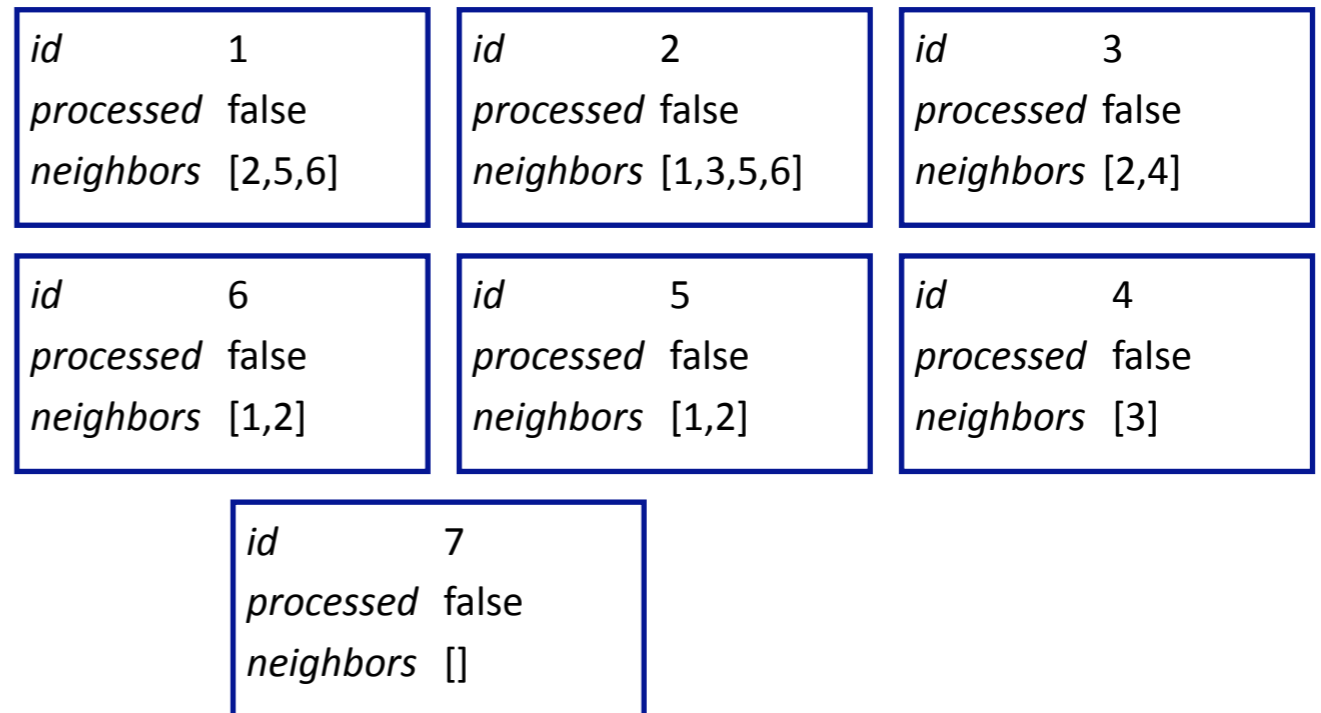
	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
2	<b>1</b>	.	<b>1</b>	.	<b>1</b>	<b>1</b>	.
3	.	<b>1</b>	.	.	.	.	.
4	.	.	.	.	.	.	.
5	<b>1</b>	<b>1</b>	.	.	.	.	.
6	<b>1</b>	<b>1</b>	.	.	.	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

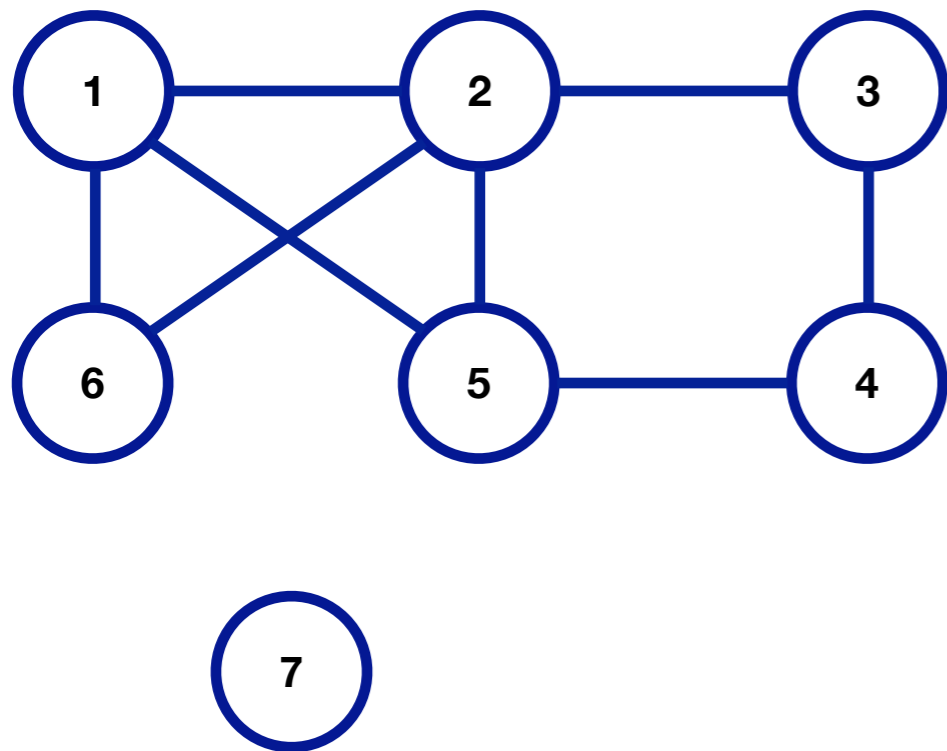
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

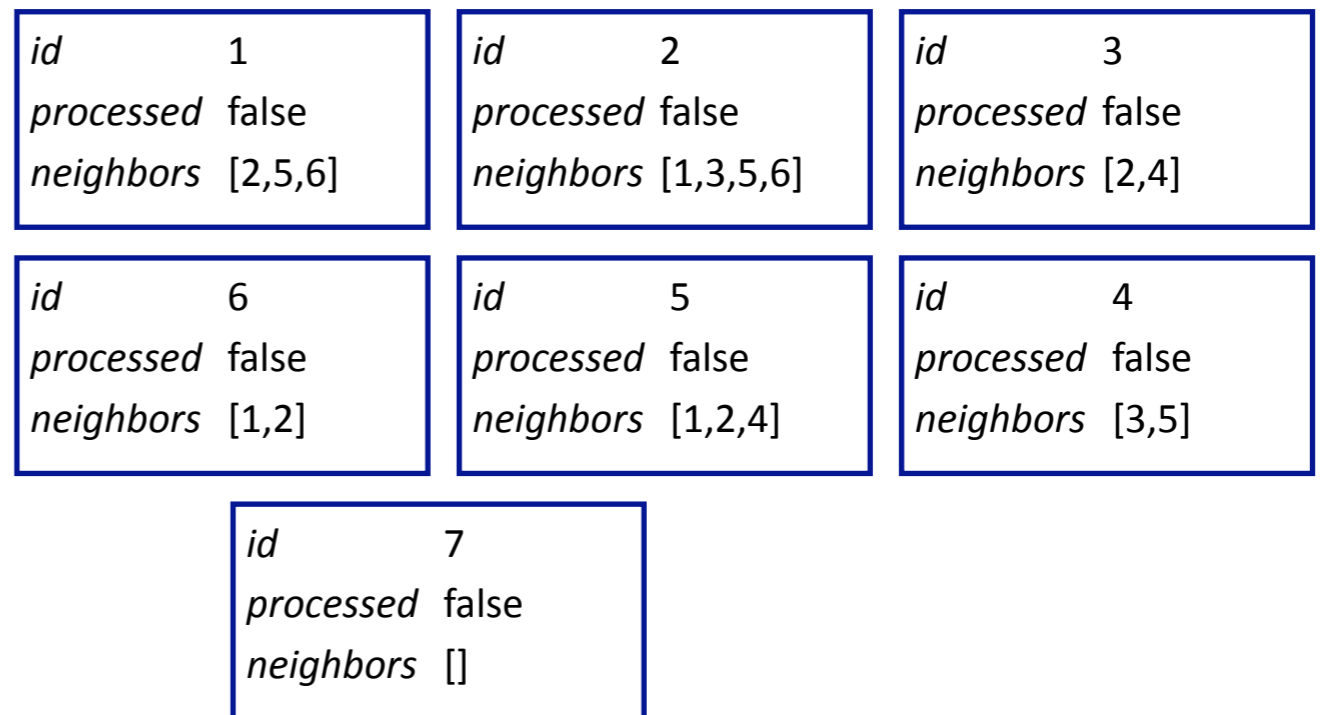
	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
2	<b>1</b>	.	<b>1</b>	.	<b>1</b>	<b>1</b>	.
3	.	<b>1</b>	.	<b>1</b>	.	.	.
4	.	.	<b>1</b>	.	.	.	.
5	<b>1</b>	<b>1</b>	.	.	.	.	.
6	<b>1</b>	<b>1</b>	.	.	.	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
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add vertex 5
add vertex 6
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```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

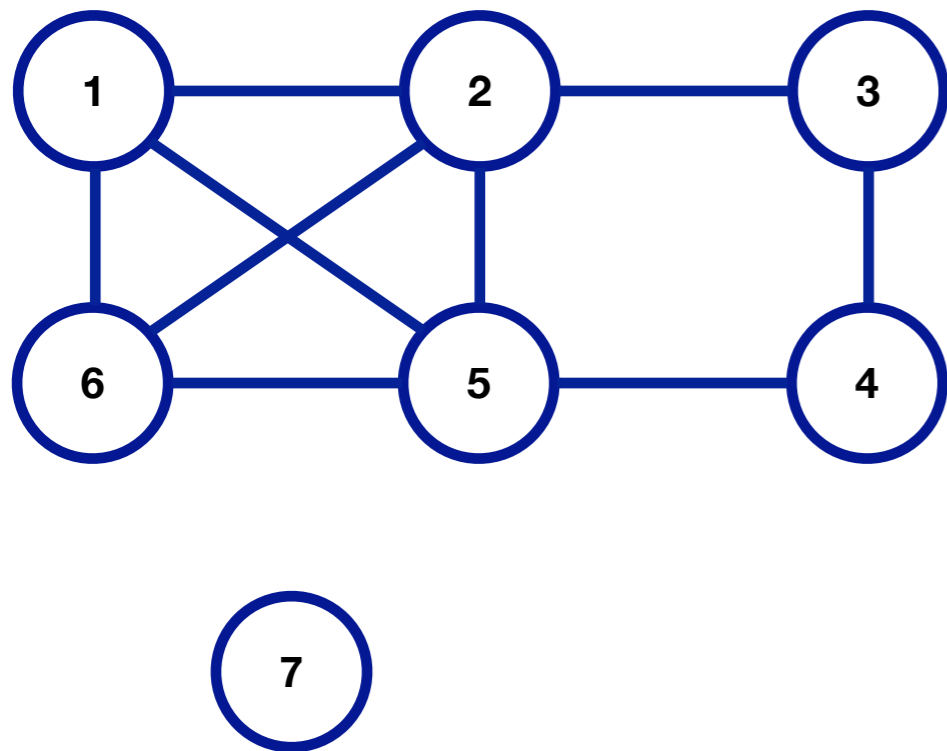
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

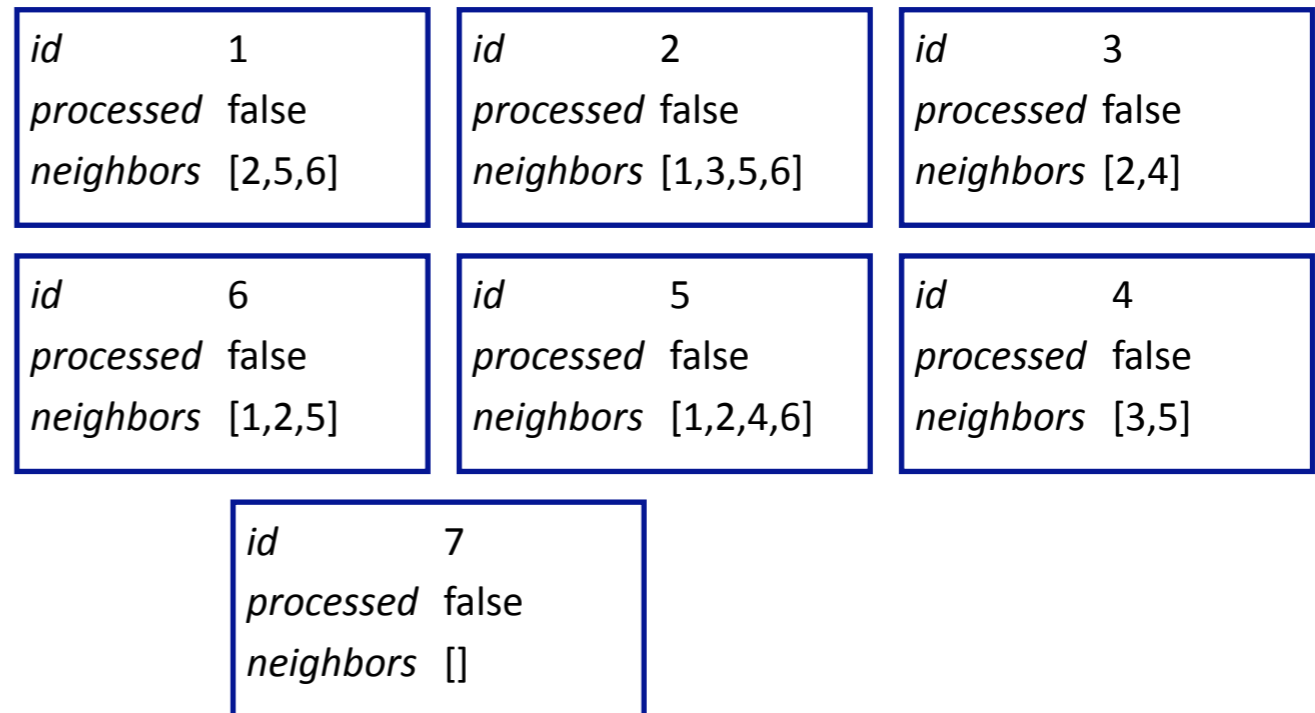
	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
2	<b>1</b>	.	<b>1</b>	.	<b>1</b>	<b>1</b>	.
3	.	<b>1</b>	.	<b>1</b>	.	.	.
4	.	.	<b>1</b>	.	<b>1</b>	.	.
5	<b>1</b>	<b>1</b>	.	<b>1</b>	.	.	.
6	<b>1</b>	<b>1</b>	.	.	.	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
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add vertex 7
add edge 1 - 2
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add edge 2 - 6
```

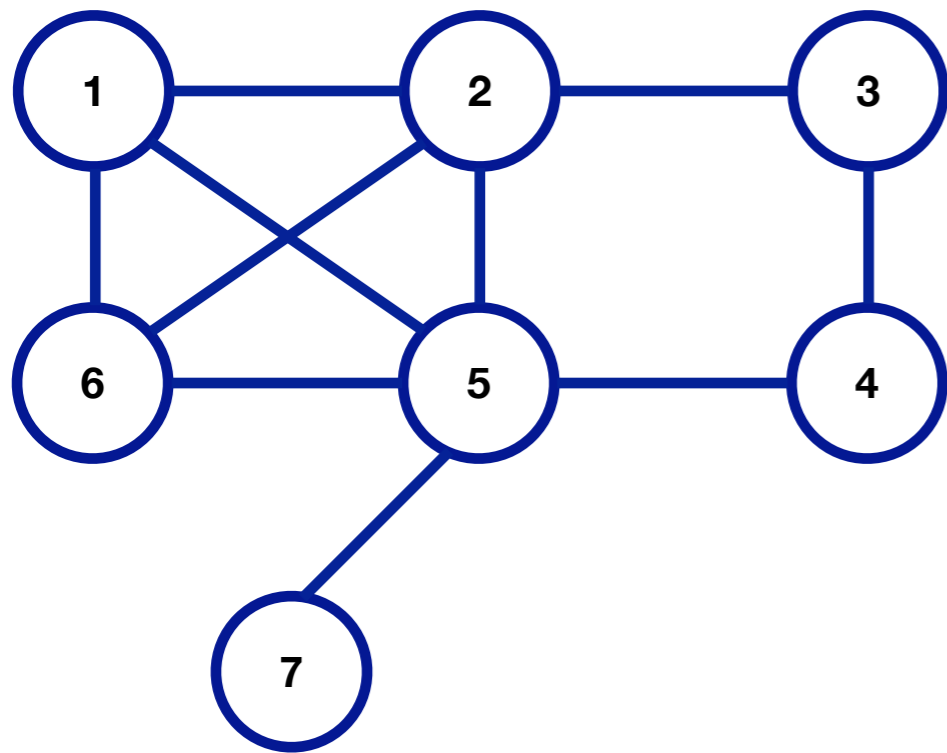
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

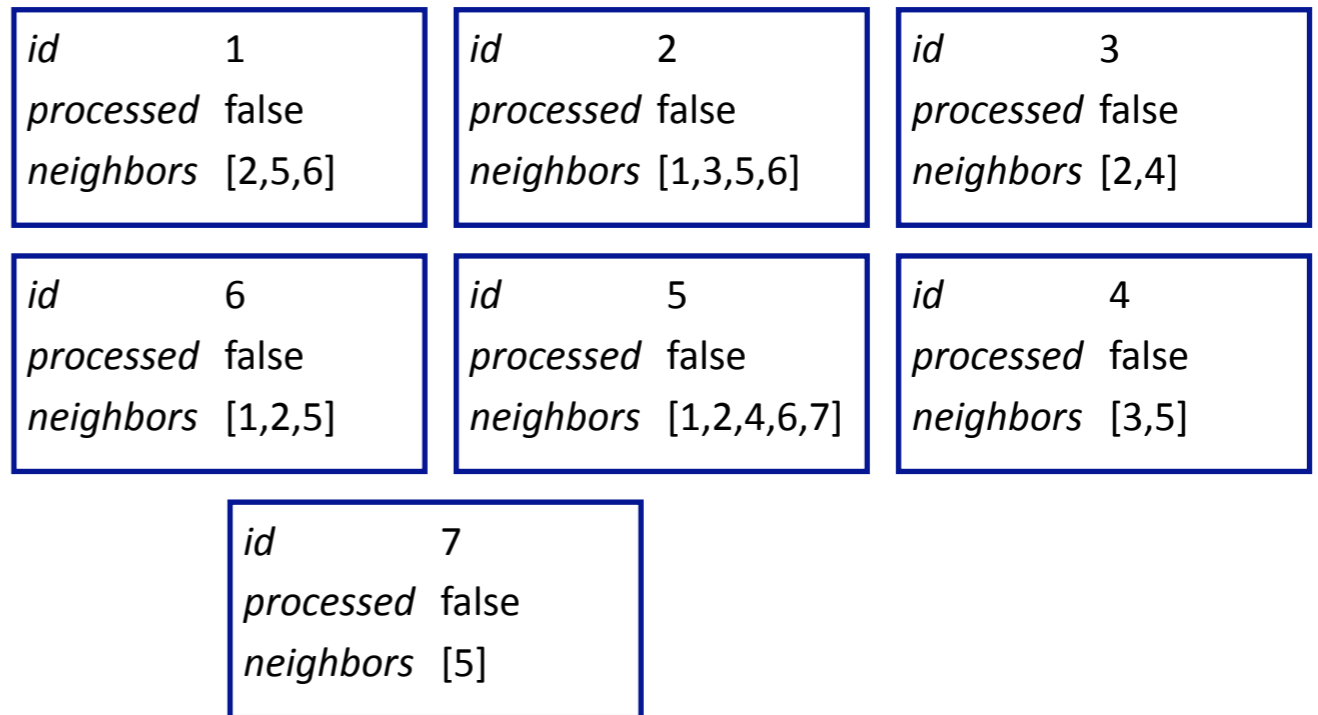
	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
2	<b>1</b>	.	<b>1</b>	.	<b>1</b>	<b>1</b>	.
3	.	<b>1</b>	.	<b>1</b>	.	.	.
4	.	.	<b>1</b>	.	<b>1</b>	.	.
5	<b>1</b>	<b>1</b>	.	<b>1</b>	.	<b>1</b>	.
6	<b>1</b>	<b>1</b>	.	.	<b>1</b>	.	.
7	.	.	.	.	.	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

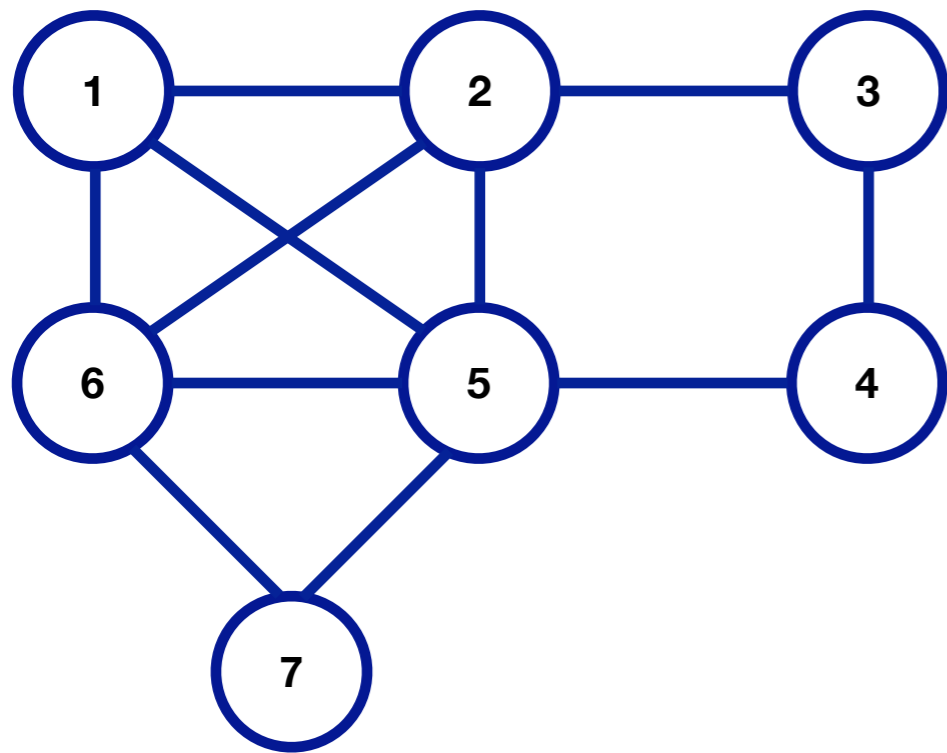
```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

## Matrix

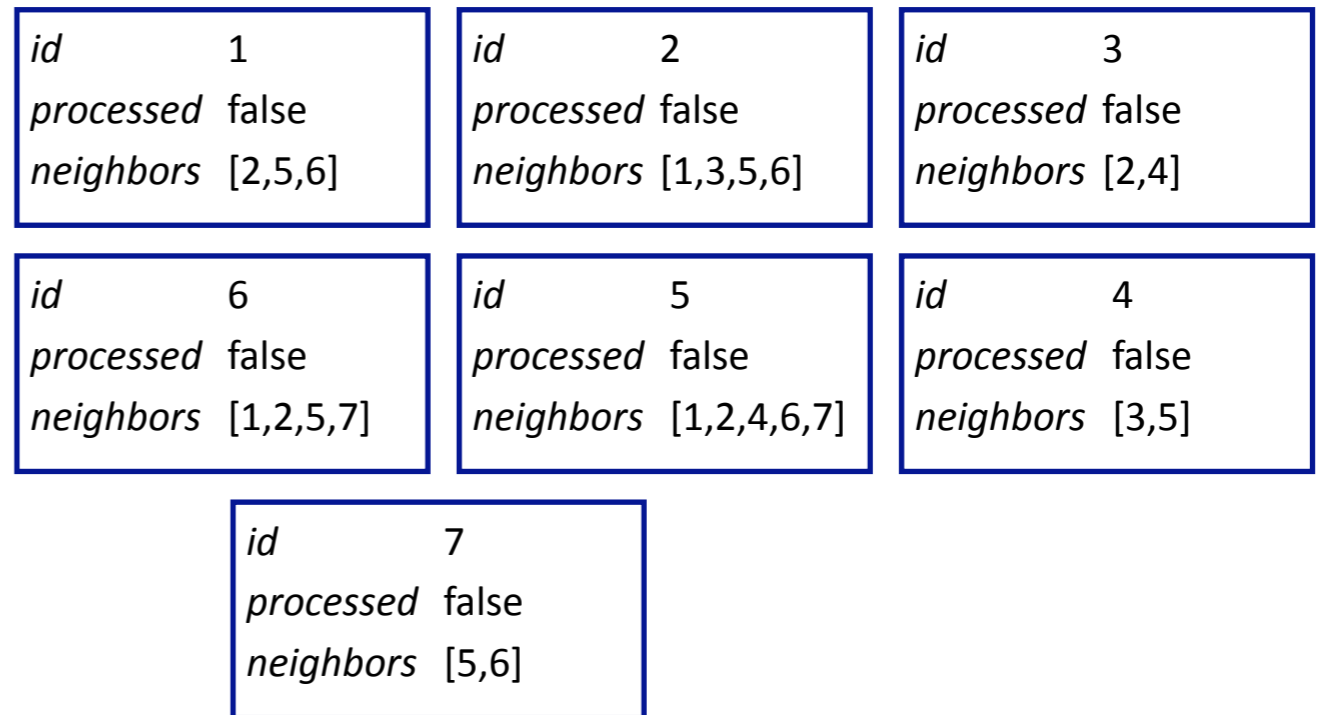
	1	2	3	4	5	6	7
1	.	1	.	.	1	1	.
2	1	.	1	.	1	1	.
3	.	1	.	1	.	.	.
4	.	.	1	.	1	.	.
5	1	1	.	1	.	1	1
6	1	1	.	.	1	.	.
7	.	.	.	.	1	.	.

# Graphs

Graph . . .



as Linked Objects



```
new graph
add vertex 1
add vertex 2
add vertex 3
add vertex 4
add vertex 5
add vertex 6
```

```
add vertex 7
add edge 1 - 2
add edge 1 - 5
add edge 1 - 6
add edge 2 - 3
add edge 2 - 5
add edge 2 - 6
```

```
add edge 3 - 4
add edge 4 - 5
add edge 5 - 6
add edge 5 - 7
add edge 6 - 7
```

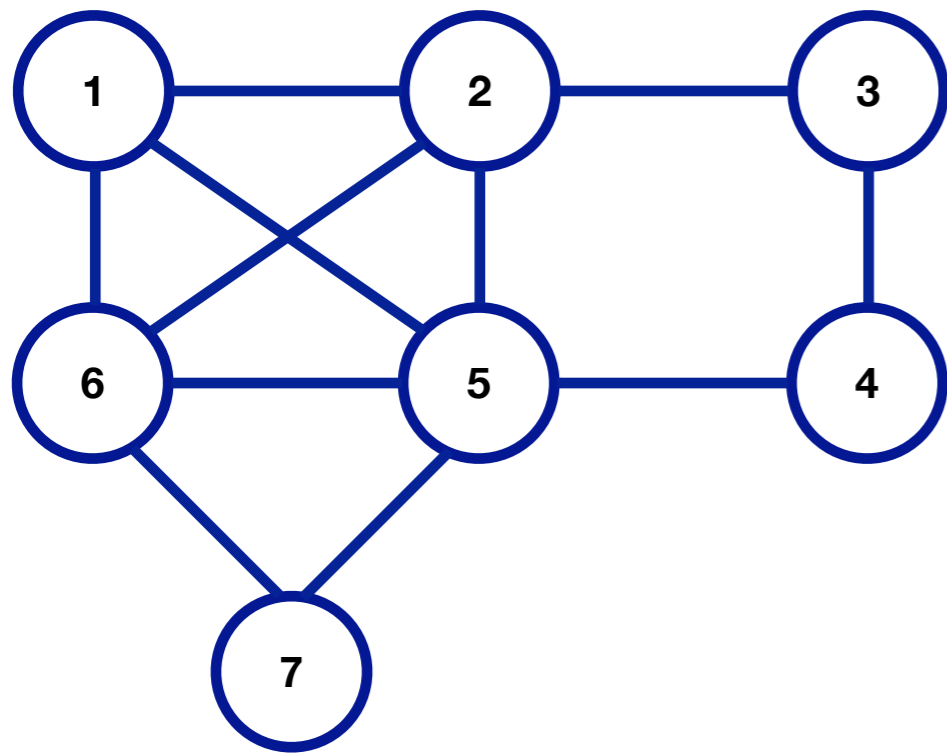
## Matrix

	1	2	3	4	5	6	7
1	.	1	.	.	1	1	.
2	1	.	1	.	1	1	.
3	.	1	.	1	.	.	.
4	.	.	1	.	1	.	.
5	1	1	.	1	.	1	1
6	1	1	.	.	1	.	1
7	.	.	.	.	1	1	.

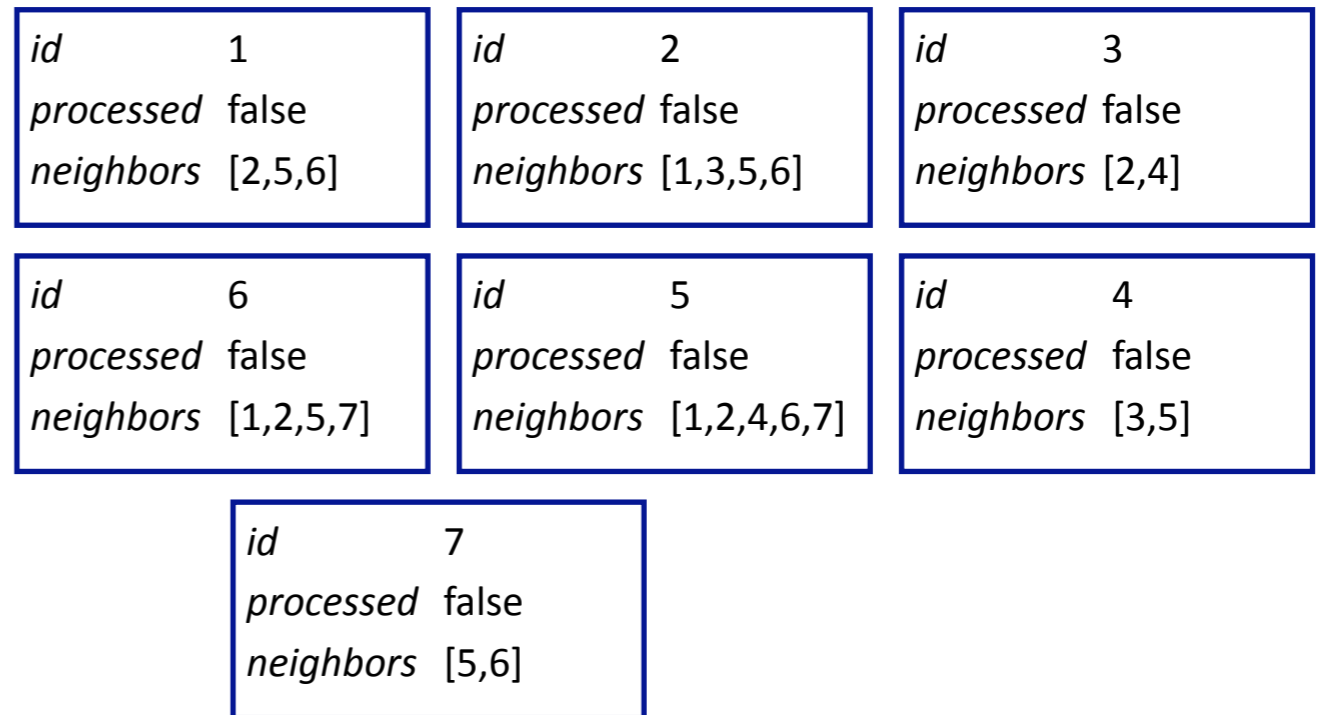


# Graphs

Graph . . .



as Linked Objects

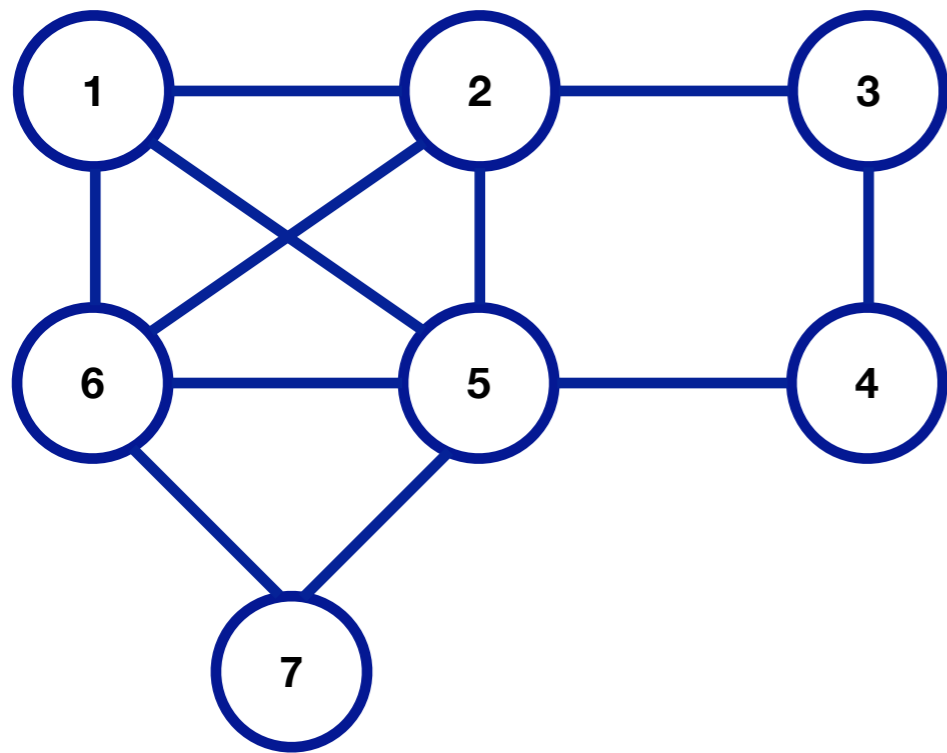


Matrix

	1	2	3	4	5	6	7
1	.	<b>1</b>	.	.	<b>1</b>	<b>1</b>	.
2	<b>1</b>	.	<b>1</b>	.	<b>1</b>	<b>1</b>	.
3	.	<b>1</b>	.	<b>1</b>	.	.	.
4	.	.	<b>1</b>	.	<b>1</b>	.	.
5	<b>1</b>	<b>1</b>	.	<b>1</b>	.	<b>1</b>	<b>1</b>
6	<b>1</b>	<b>1</b>	.	.	<b>1</b>	.	<b>1</b>
7	.	.	.	.	<b>1</b>	<b>1</b>	.

# Graphs

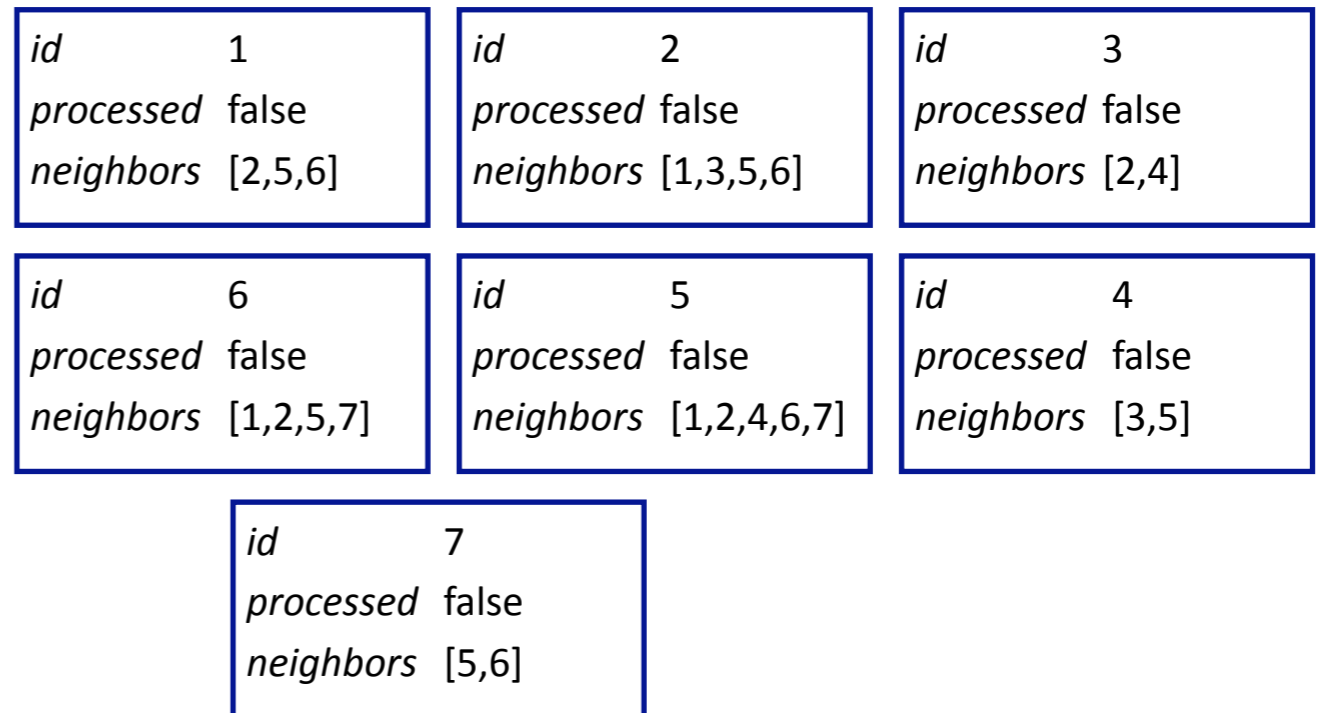
Graph . . .



Adjacency  
List

```
[1] 2 5 6
[2] 1 3 5 6
[3] 2 4
[4] 3 5
[5] 1 2 4 6 7
[6] 1 2 5 7
[7] 5 6
```

as Linked Objects

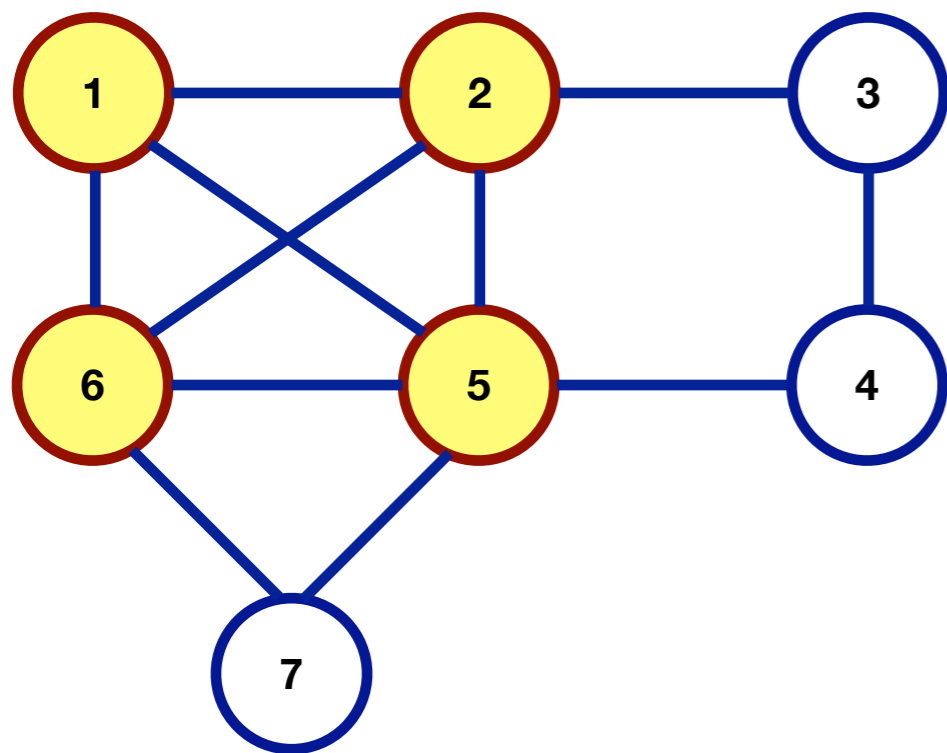


Matrix

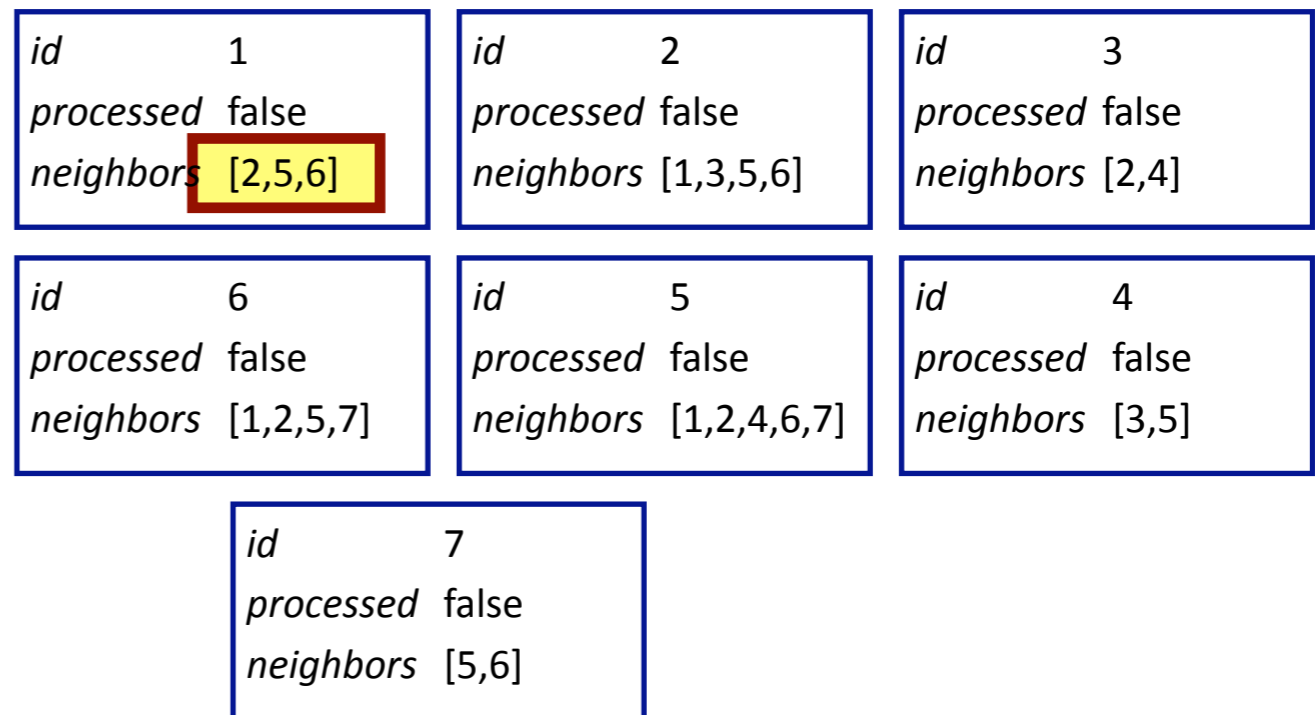
```
  1 2 3 4 5 6 7
1  . 1 . . 1 1 .
2  1 . 1 . 1 1 .
3  . 1 . 1 . . .
4  . . 1 . 1 . .
5  1 1 . 1 . 1 1
6  1 1 . . 1 . 1
7  . . . . 1 1 .
```

# Graphs

Graph . . .



as Linked Objects



Adjacency List

```
[1] 2 5 6  
[2] 1 3 5 6  
[3] 2 4  
[4] 3 5  
[5] 1 2 4 6 7  
[6] 1 2 5 7  
[7] 5 6
```

Matrix

	1	2	3	4	5	6	7
1	1	1	0	0	1	1	0
2	1	1	0	0	1	1	0
3	0	1	0	1	0	0	0
4	0	0	1	0	1	0	0
5	1	1	0	1	0	1	1
6	1	1	0	0	1	0	1
7	0	0	0	0	1	1	0