Basic MATLAB commands II

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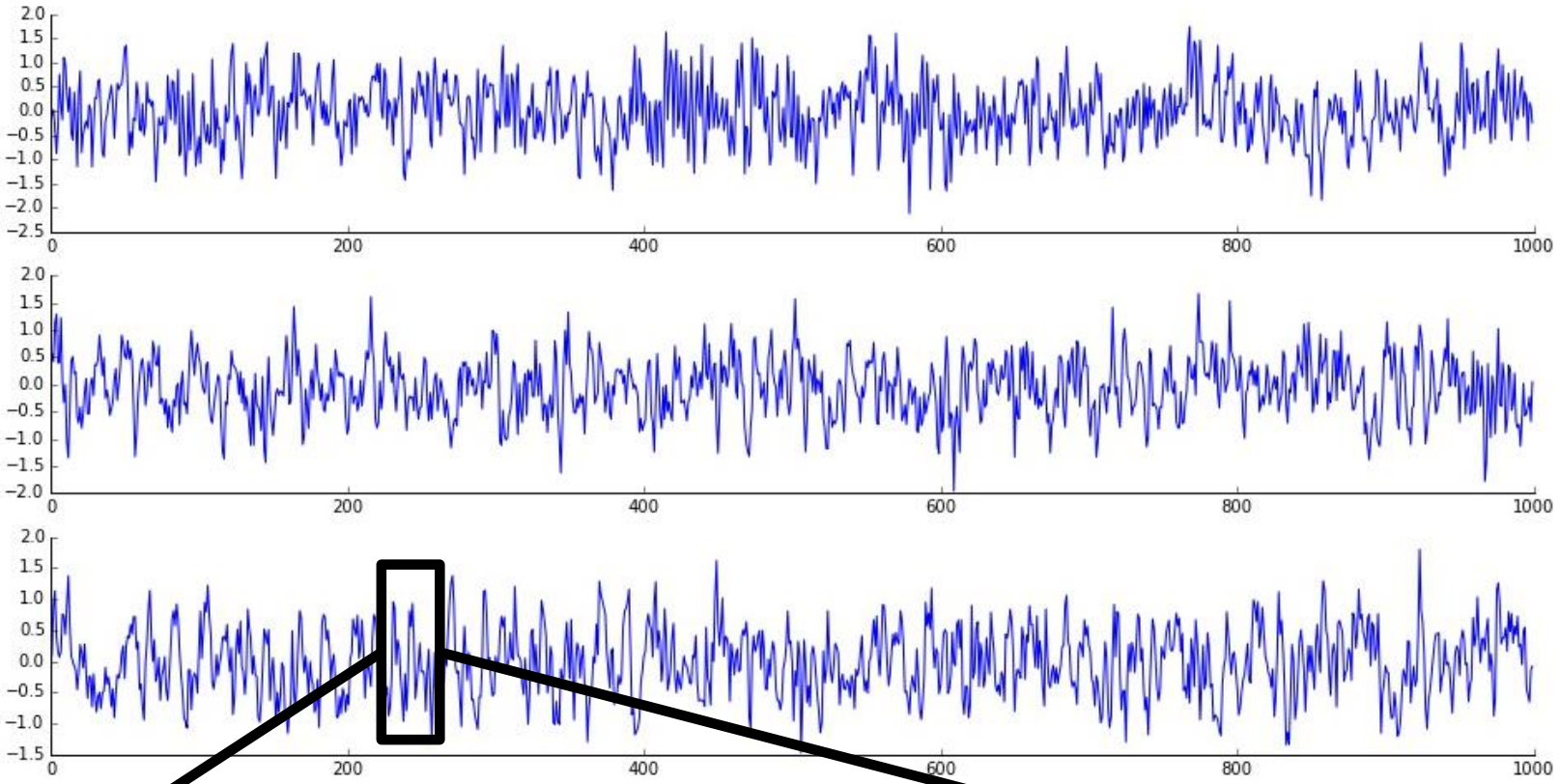
With some snapshots from Olaf Hauk’s previous slides

MATLAB = Matrix Laboratory

- All your data in MATLAB will be in the format of a matrix

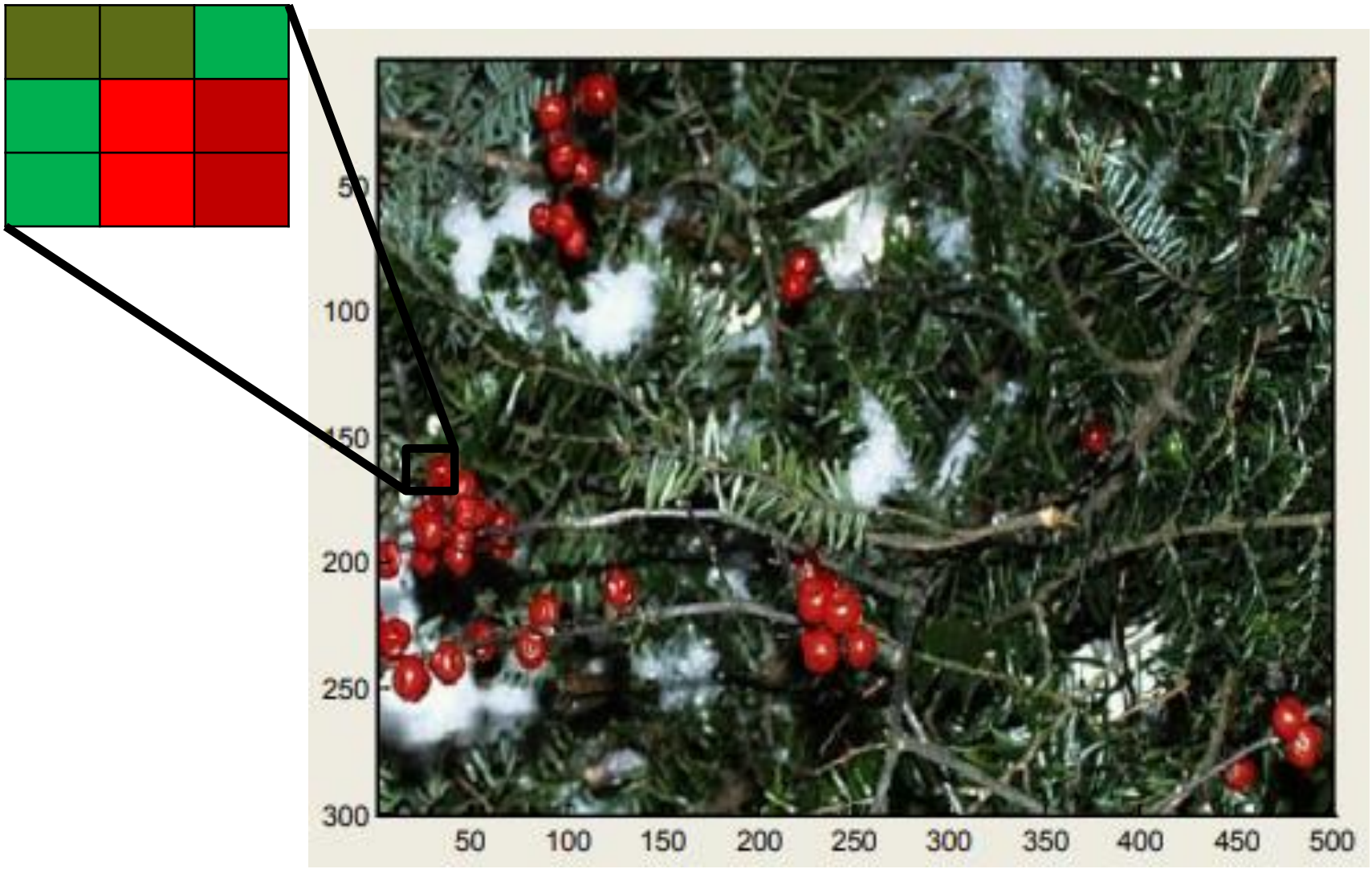
	Column 1	Column 2	Column 3	Column 4
Row 1				
Row 2				
Row 3				
Row 4				

	IQ	RT	accuracy	gender
subj 1	110	0.41	90	1
subj 2	90	0.53	80	1
subj 3	150	0.38	92	2
subj 4	100	0.40	85	2



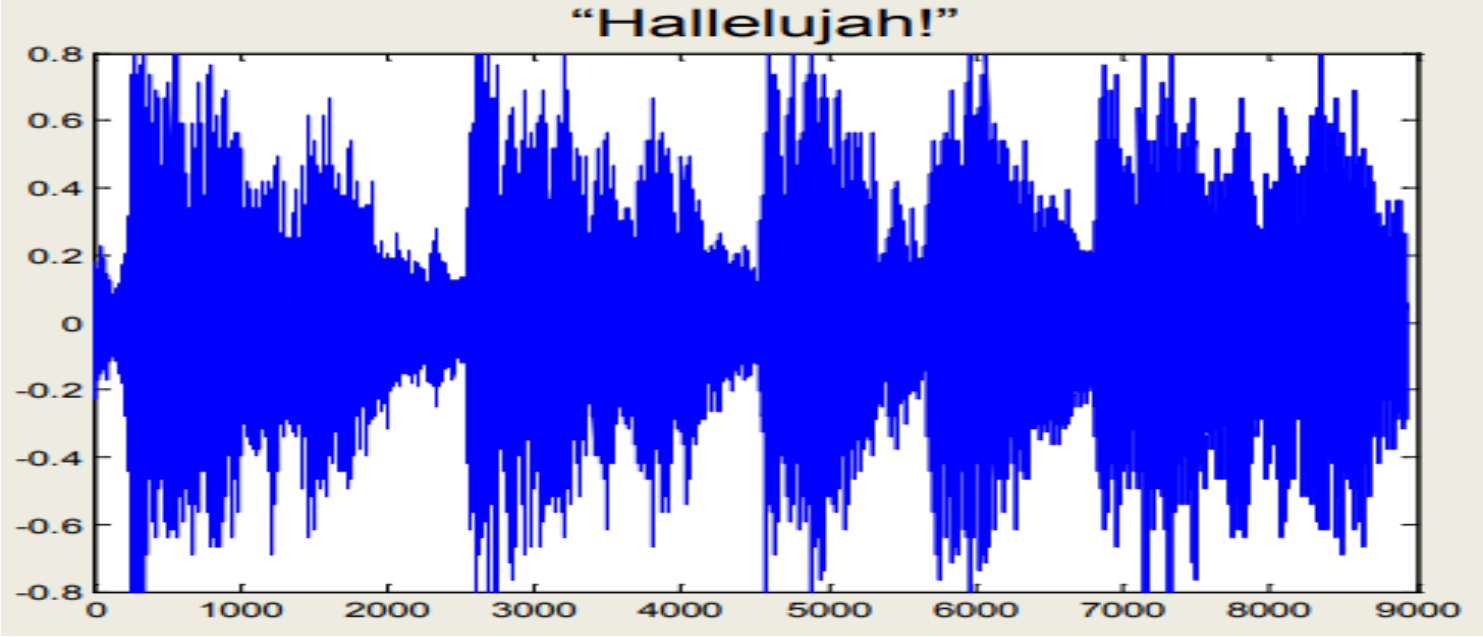
1.5	1.3	0.7	-0.1	-0.6	-1.3	-0.9	-0.2	0.3	0.7

	Time point 1	Time point 2	Time point 3	Time point 4
Brain region 1	1.11336	1.46548	1.7325	1.96574
Brain region 2	0.36547	0.58962	0.12547	0.35478
Brain region 3	2.36987	1.25896	1.32569	0.85421


50
100
150
200
250
300
50
100
150
200
250
300
350
400
450
500

	Time point 1	Time point 2	Time point 3	Time point 4
Brain region 1	1.11336	1.46548	1.7325	1.96574

A row vector = 1 row x 4 columns



A sound file = 1 row x 9000 columns

Column vector
4 rows x 1 column

	IQ
subj 1	110
subj 2	90
subj 3	150
subj 4	100

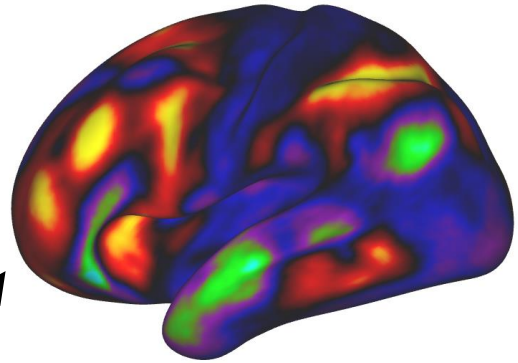
A scalar
1 row x 1 column

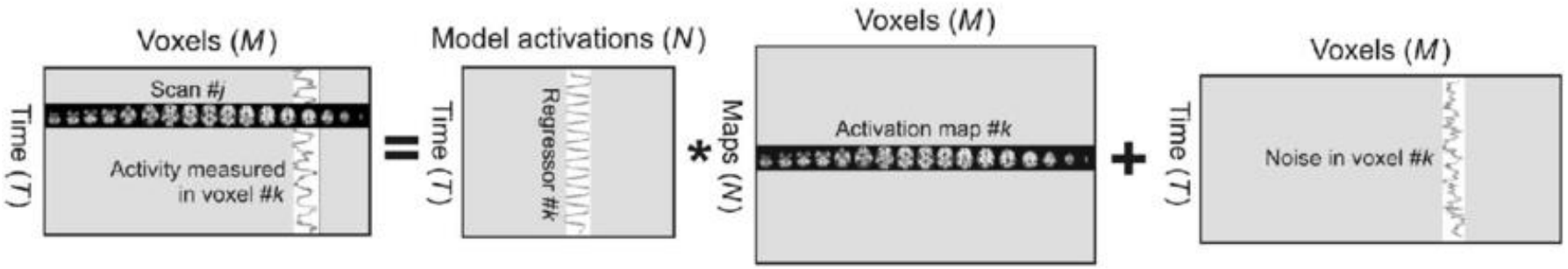
10

- To analyse your data, you will need to be able to handle matrices
- To handle matrices, you need to follow some mathematical rules

Results = data * matrix

fMRI GLM analysis





Observed data $\mathbf{Y}$ $(T \times M)$ = Design matrix $\mathbf{X}$ $(T \times N)$ * Model parameters β $(N \times M)$ + Noise ϵ $(T \times M)$

Scalars

```
> a = 10
> b = 2

> a + b = 12
> a – b = 8
> a * b = 20
> a / b  = 5
> a + a + b = 22
```

Scalars & Vectors

```
> a = 2
> b = [ 1  2 ]    %row 1x2 vector

> a + b
```

$$2 + [1 \quad 2] = [3 \quad 4]$$

```
> a * b
```

$$2 * [1 \quad 2] = [2 \quad 4]$$

```
> a / b = Matrix dimensions must agree.
```

what about

b / a

a./b $\quad 2 ./ \begin{bmatrix} 1 & 2 \end{bmatrix} = [2 \quad 1]$

Vectors & vectors

In addition/subtractions: dimensions **must** match!

```
> b = [ 1   2 ]    %row 1x2 vector

> b + [ 1  0 ]
```

$$[1 \quad 2] + [0 \quad 1] = [1 \quad 3]$$

Vectors multiplication

> b = [1 2] %row 1x2 vector

> c = [1 ; 2] %column 2x1 vector $\begin{bmatrix}1\\2\end{bmatrix}$

> b * b or c * c = Inner matrix dimensions must agree.

> dot (scalar) product: b * c ≠ c * b

$$[1 \quad 2] * \begin{bmatrix}1\\2\end{bmatrix} = [1 * 1 + \quad 2 * 2] = 5$$

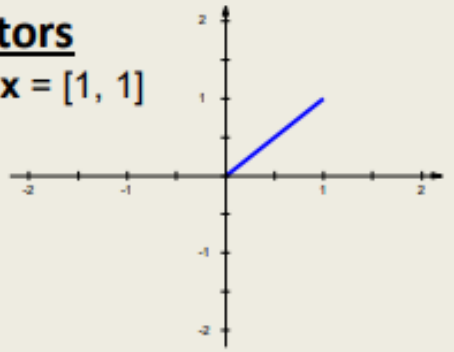
$$\begin{bmatrix}1\\2\end{bmatrix} * \quad [1 \quad 2] = \begin{bmatrix}1 * 1 & 1 * 2\\2 * 1 & 2 * 2\end{bmatrix} = \begin{bmatrix}1 & 2\\2 & 4\end{bmatrix}$$

Vectors in geometric space

2D Visualisation of Vectors

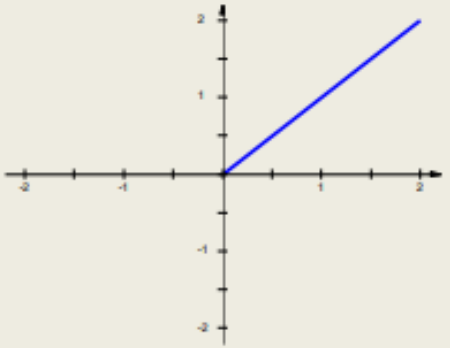
A “vector” is a list of numbers, e.g.: **x** = [1, 1]

x =



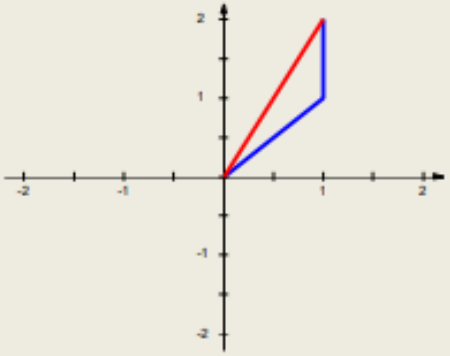
Multiplication with a scalar:

2*x = [2 2]

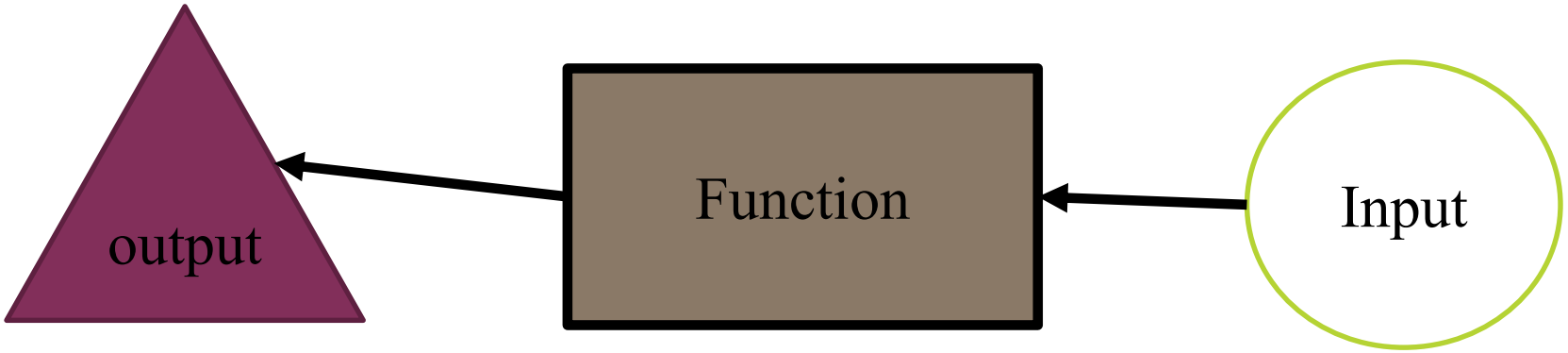


Vector addition/subtraction:

[1 1] + [0 1] = [1 2]



EXERCISE 1



Output = function(input)

Y = mean(x)

Matrices operations

- Addition/subtraction
  - Both matrices **must** be the same size
  - The result has the same dimensions

$$\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} + \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

$$\begin{bmatrix} 1 \\ 1 \end{bmatrix} + \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

Matrix dimensions must agree.

Matrices operations

- Multiplication/division
  - Inner dimensions must be the same
  - The result dimensions are the outward dimensions

$$\begin{bmatrix}1 & 1\\ 1 & 1\end{bmatrix} * \begin{bmatrix}1 & 2\\ 3 & 4\end{bmatrix}$$

$$\begin{bmatrix}1 & 1\\ 1 & 1\end{bmatrix} .* \begin{bmatrix}1 & 2\\ 3 & 4\end{bmatrix}$$

$$\begin{bmatrix}1\\ 1\end{bmatrix} * \begin{bmatrix}1 & 2\\ 3 & 4\end{bmatrix} =$$ Inner matrix dimensions must agree.

$$\begin{bmatrix}1 & 1\end{bmatrix} * \begin{bmatrix}1 & 2\\ 3 & 4\end{bmatrix}$$

Matrix/vector transpose

$$\mathbf{M} \rightarrow \mathbf{M}^T \ (\mathbf{M} \rightarrow \mathbf{M}' \text{ in Matlab})$$

Rows of **M** become columns of **M**

Dimension changes from *R*x*C* to *C*x*R*

$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{pmatrix} \rightarrow \begin{pmatrix} 1 & 4 \\ 2 & 5 \\ 3 & 6 \end{pmatrix}$$

(2x3) *(3x2)*

Special matrices

Identity Matrix

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Diagonal Matrix

$$\begin{pmatrix} a & 0 & 0 \\ 0 & c & 0 \\ 0 & 0 & b \end{pmatrix}$$

Upper Triagonal Matrix

$$\begin{pmatrix} a & d & f \\ 0 & c & e \\ 0 & 0 & b \end{pmatrix}$$

Symmetric Matrix

$$\begin{pmatrix} a & d & e \\ d & b & f \\ e & f & c \end{pmatrix}$$

A “square” matrix has the same number of rows and columns (C=R)

MORE EXERCISES!