Arithmetic, Logical and Matrix operations in R

#### In this lecture

- Arithmetic
- Logical
- Matrix operations

# Arithmetic operations in R

### Arithmetic operations in R

Symbols	Operation	
=, < -	Assignment	
+	Addition	
-	Subtraction	
*	Multiplication	
/	Division	
^,**	Exponent	
%%	Remainder	
%/%	Integer division	

<sup>\*</sup>In R only '< -' is valid for assignment operation where as in R Studio both = and < -' will work

# Hierarchy of operations

$$A = 7 - 2x \frac{27}{3^2} + 4$$

Order of Precedence	Operation
Bracket	( )
Exponent	^,**
Division	/
Multiplication	*
Addition and subtraction	+,-

# Logical operations in R

# Logical operations in R

Symbols	Operation	Examples
<	Less than	> 2>3 [1] FALSE
<=	Less than equal to	> > 2<3 [1] TRUE > > 2>=3
>	Greater than	
>=	Greater than equal to	[1] FALSE
==	Exactly equal to	> 2<=3 [1] TRUE
!=	Not equal to	> > 2==3 [1] FALSE
!	Not	> > !2
	Or	[1] FALSE >
&	And	> 2!=3 [1] TRUE
isTRUE	Test if variable is TRUE	<u>&gt;</u> I

# Matrix operations in R

#### **Matrices**

A matrix is a rectangular arrangement of numbers in rows and columns

Rows run horizontally and columns run vertically

$$\begin{bmatrix}
 1 & 5 & 3 \\
 4 & 9 & 2 \\
 5 & 6 & 7
 \end{bmatrix}
 \begin{bmatrix}
 1 \\
 2
 \end{bmatrix}
 \begin{bmatrix}
 1 & 4 & 5
 \end{bmatrix}$$

#### Creating matrices

#### Follow these steps to create a matrix

1. Open a curve bracket,

$$A = matrix()$$

2. Enter the sequence of elements,

```
A = matrix(c(1,2,3,4,5,6,7,8,9))
```

3. Specify the parameters nrow, ncol, byrow

```
A= matrix(c(1,2,3,4,5,6,7,8,9), nrow =3, ncol=3, byrow=TRUE)
```

This parameter decides how values in the vector would be assigned i.e. "by row" or not

### Creating special matrices

#### **Different ways of creating matrices:**

- a. Matrix where all rows and columns are filled by a single constant 'k'.
  - For k=3, with 'm' rows & 'n' columns

Command:matrix(3,m,n)

- b. Diagonal matrix:
  - Values in diagonal, similar to 'matrix()'.
  - Mention 'k' as constant/array in first parameter.
  - Command: diag(k,m,n)
- c. Identity matrix:
  - Use 'diag()' command with k=1

```
Console ~/ 🖒
     [,1] [,2] [,3] [,4]
 diag(c(4,5,6),3,3)
     [,1] [,2] [,3]
                   0
                   6
```

```
>diag(1,3,3)
[,1] [,2] [,3]
[1,] 1 0 0
[2,] 0 1 0
[3,] 0 0 1
```

### Exercise: Creating matrices

#### Create the following matrices in R

$$\begin{bmatrix} 3 & 5 \\ -2 & 0 \end{bmatrix} , \begin{bmatrix} 1 & 10 \\ 3 & -1 \\ 7 & 5 \end{bmatrix}$$
 and

$$\begin{bmatrix} 2 & 3 & 4 \\ 0 & 1 & 2 \\ -1 & -2 & -3 \\ 5 & 4 & 3 \end{bmatrix}$$

#### Matrix metrics

```
# create a matrix A
A = matrix(c(1,2,3,4,5,6,7,8,9), nrow = 3,
ncol=3, byrow=TRUE )
Finding the size of the matrix, A:
dim(A) will return the size of the matrix
nrow(A) will return the number of rows
ncol(A) will return the number of
columns
prod(dim(A)) or length(A) will return
the number of elements
```

```
Console ~/ 🖒
> dim(A)
[1] 3 3
> nrow(A)
[1] 3
> ncol(A)
  length(A)
```

#### Accessing, editing, deleting in elements in matrices

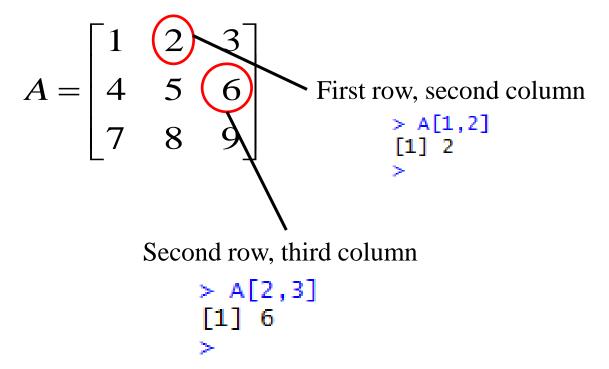
# They follow the same convention as dataframes such as

- Array/value before "," for accessing rows
- Array/value before "," for accessing columns
- use of '-' for removing rows/columns
- Strings can be assigned as names of rows and columns using:
  - rownames() and Colnames()

```
A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 8 & 9 & 1 \end{bmatrix}_{3 \times 3}
```

```
3,3,byrow = T
 colnames(A) <- c("a","b","c")</pre>
 rownames(A) <- c("d", "e", "f")
 a b c
> A[,1:2]
 A[,c("a","c")]
 A[c("d", "f"),]
 8 9 1
```

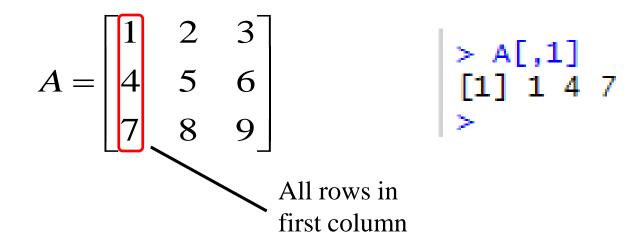
# Accessing an entry of a matrix



The part before the comma should be the row number
The part after the comma should be the column number

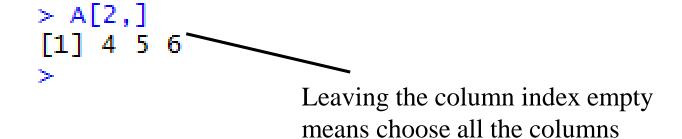
## Accessing a column

- Specify the column index
- Leave the rows index unspecified
- This means accessing all row elements of the given column index



## Accessing a row

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$



How do you access the last row? A[nrow(A), ]

#### Accessing everything but one column

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- Access the column that has to be avoided and then put a '-' sign in front of it
  - For example: A[,-2]
  - This will fetch all the columns except the 2nd column

### Accessing everything but one row

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- Access the row that has to be avoided and then put a '-' sign in front of it
  - For example: A[-2, ]
  - This will fetch all the row except the 2nd row

### Exercise: Accessing elements of a matrix

#### Do the following in R

Assign the following matrix

$$A = \begin{bmatrix} 1 & 7 & 3 \\ 4 & 4 & 6 \\ 4 & 7 & 12 \end{bmatrix}$$

- Change the element 12 to 13
- Access the second row and the third column
- List all the elements in the second column and third row

## Colon operator

Colon operator can be used to create a row matrix

```
> 1:10

[1] 1 2 3 4 5 6 7 8 9 10

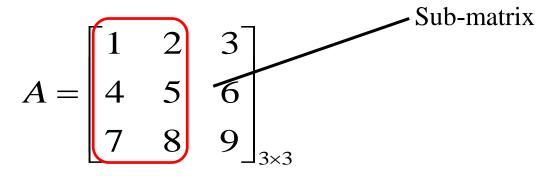
> 10:1

[1] 10 9 8 7 6 5 4 3 2 1

>
```

#### Colon operator: sub matrices selection

The colon notation can also be used to pick sub-matrices



The sub-matrix occupies the **first three rows** and the **first two columns** 

# Accessing submatrices: Example 2

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 2 \\ 7 & 8 \end{bmatrix}$$

# Exercise: Accessing sub-matrices

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

How do you access this sub-matrix  $\begin{bmatrix} 1 & 3 \\ 4 & 6 \end{bmatrix}$ 

#### Matrix concatenation

- Matrix concatenation refers to merging of a row or column to a matrix
  - Concatenation of a row to a matrix is done using **rbind()**
  - Concatenation of a column to a matrix is done using cbind()
  - Consistency of the dimensions between the matrix and the vector should be checked before concatenation

# Matrix concatenation – rbind()

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} \qquad B = \begin{bmatrix} 10 & 11 & 12 \end{bmatrix}$$

$$B = \begin{bmatrix} 10 & 11 & 12 \end{bmatrix}$$

Use rbind() to append B row vector to the rows of A

$$C = \begin{bmatrix} A \\ B \end{bmatrix}$$

## Matrix concatenation — cbind()

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} \qquad B = \begin{bmatrix} 10 \\ 11 \\ 12 \end{bmatrix}$$

$$B = \begin{bmatrix} 10 \\ 11 \\ 12 \end{bmatrix}$$

Use cbind() to append B column vector to the columns of A

$$C = \begin{bmatrix} A & B \end{bmatrix}$$

# Dimension inconsistency –cbind()

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} \qquad B = \begin{bmatrix} 10 & 11 & 12 \end{bmatrix}$$

Can these two matrices be merged to give

$$C = \begin{bmatrix} A & B \end{bmatrix}$$

```
> D = cbind(A,B)
Error in cbind(A, B) : number of rows of matrices must match (see arg 2)
```

### Fixing the dimension inconsistency

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$
 > C = cbind(A,B)

$$B = \begin{bmatrix} 10 \\ 11 \\ 12 \end{bmatrix}$$

$$C = \begin{bmatrix} A & B \end{bmatrix}$$

```
> C = cbind(A,B)
>
> C
     [,1] [,2] [,3] [,4]
[1,] 1 2 3 10
[2,] 4 5 6 11
[3,] 7 8 9 12
> |
```

### Deleting a column

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- Access the column that has to be deleted and then put a '-' sign in front of it
  - For example: A=A[,-2]
  - This will fetch all the columns except the 2nd column

#### Deleting a row

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- Access the row that has to be deleted and then put a '-' sign in front of it
  - For example: A=A[-2, ]
  - This will fetch all the rows except the 2nd row

```
> A[-2,]

[,1] [,2] [,3]

[1,] 1 2 3

[2,] 7 8 9

>
```

# Matrix algebra

- Addition/subtraction
- Multiplication
- Matrix Operations in R
- Matrix Division

#### Matrix addition/subtraction & multiplication

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 8 & 9 & 1 \end{bmatrix}_{3 \times 3}$$

$$B = \begin{bmatrix} 3 & 1 & 3 \\ 4 & 2 & 1 \\ 5 & 1 & 2 \end{bmatrix}_{3 \times 3}$$

Element-wise multiplication is based on multiplication between corresponding elements of two matrices.

```
Console ~/ 🙈
    [,1] [,2] [,3]
    [,1] [,2] [,3]
 A%*%B # Regular matrix multiplication
     [,1] [,2] [,3]
  A*B # element-wise multiplication
     [,1] [,2] [,3]
          10
```

#### Matrix division



#### **WARNING:**

The following operation is not inverse of a matrix but element wise division between matrices A & B.

$$A = \begin{bmatrix} 4 & 9 \\ 16 & 25 \end{bmatrix} \quad B = \begin{bmatrix} 2 & 3 \\ 4 & 5 \end{bmatrix}$$

$$A/B = \frac{a_{ij}}{b_{ij}}$$