Computer Programming with MATLAB

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Lesson 2: Matrices and Operators

by

Akos Ledeczi and Mike Fitzpatrick

Introduction to Arrays and Matrices

- Array
  - Any set of numbers arranged in a rectangular pattern.

Example—

A page with six rows of four numbers each is a two-dimensional array

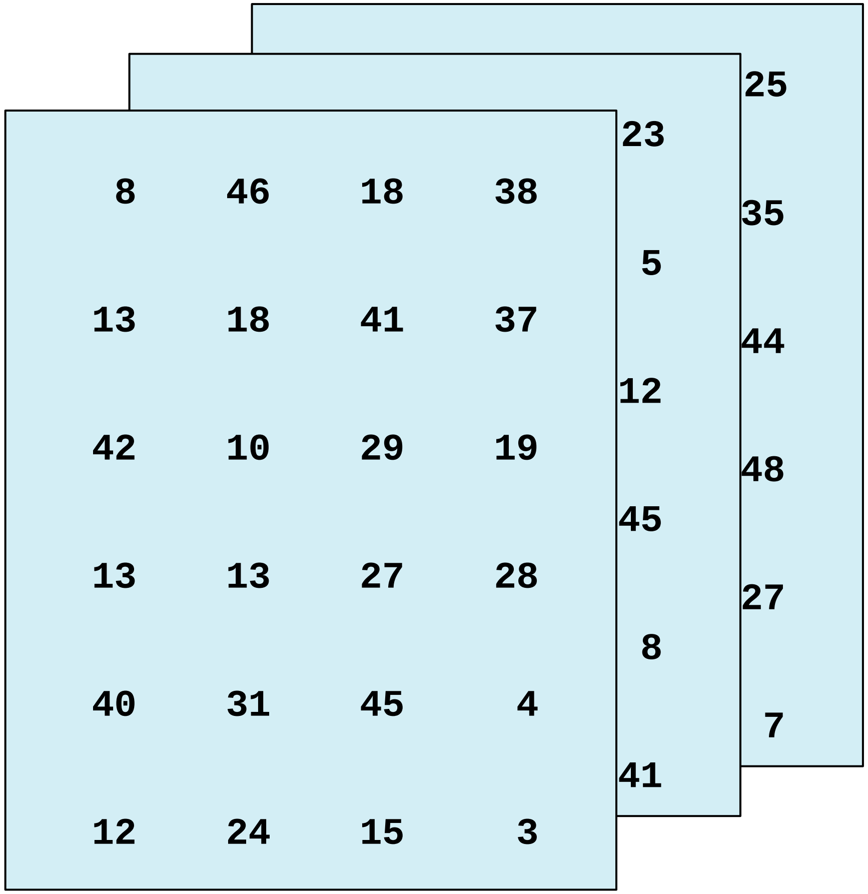
10	14	48	25
24	34	17	35
22	33	29	44
32	8	11	48
35	6	37	27
37	25	13	7

Introduction to Arrays and Matrices

- Array
  - Any set of numbers arranged in a rectangular pattern.

Three-dimensional Example—

A stack of such pages



8	46	18	38
13	18	41	37
42	10	29	19
13	13	27	28
40	31	45	4
12	24	15	3

Introduction to Arrays and Matrices

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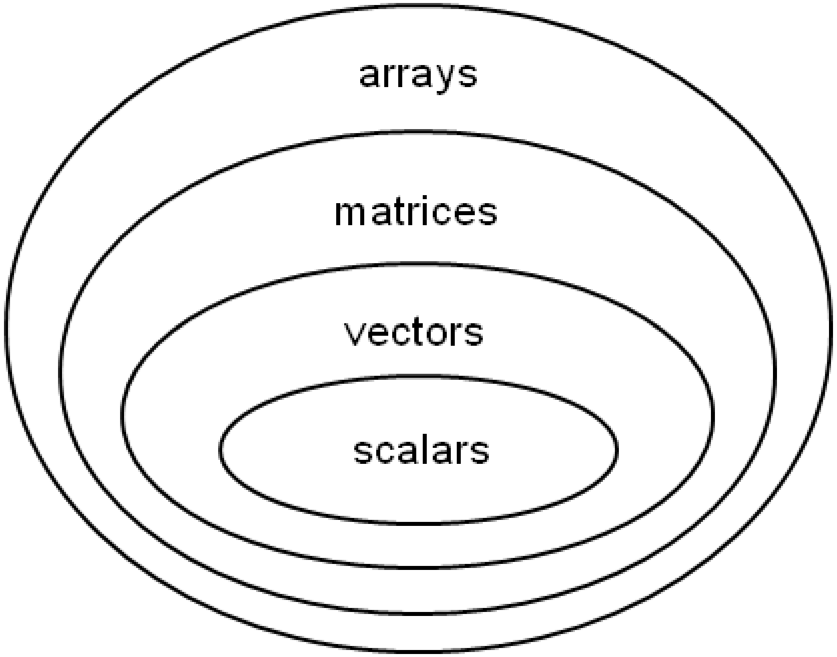
- Higher dimensions are uncommon
- The most common have special names:
  - 2D array = “matrix” (plural is “matrices”)
  - 1D array = “vector”
- Most ingenious part of Cleve Moler’s invention of MATLAB was the way he set it up to deal with matrices.
- MATLAB stands for “Matrix Laboratory”!

Arrays and Matrices



arrays

matrices

vectors

scalars

Rows and Columns

```
>> X = [1:4; 5:8; 9:12];
```

$$\begin{array}{r|cccc|} 1: & 1 & 2 & 3 & 4 \\ 2: & 5 & 6 & 7 & 8 \\ 3: & 9 & 10 & 11 & 12 \end{array}$$

rows

Rows and Columns

```
>> X = [1:4; 5:8; 9:12];
```

$$\begin{array}{cccc} 1: & 2: & 3: & 4: \\ \hline 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{array}$$

columns

Indexing

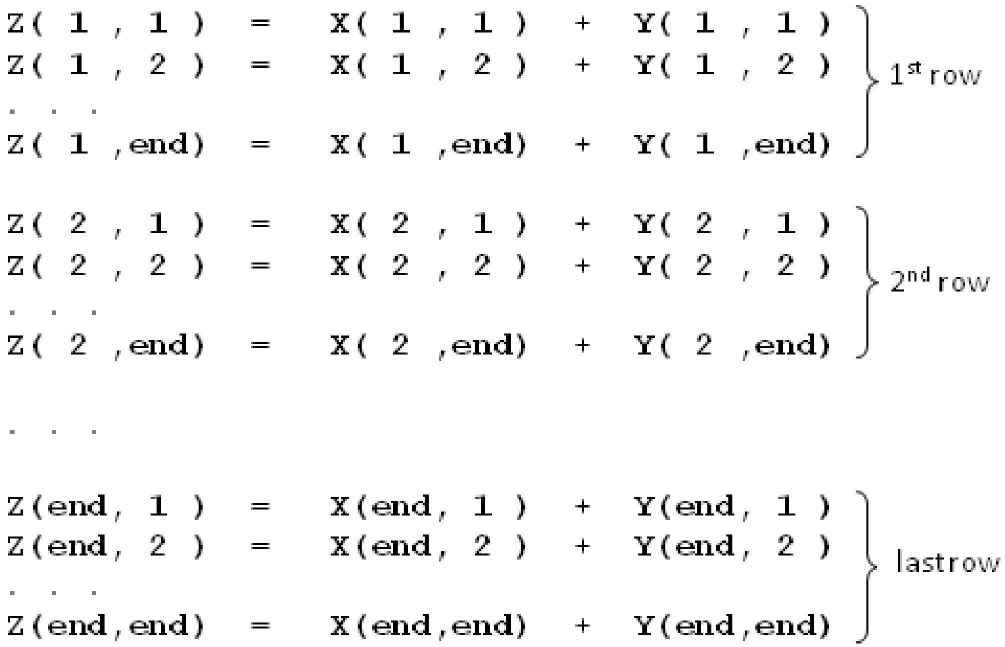
```
>> X = [1:4; 5:8; 9:12];
>> X(2,3)
```

$$\begin{array}{cc} & \begin{array}{cccc} & & 3: & \end{array} \\ 2: & \left[\begin{array}{cccc} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{array}\right] \end{array}$$

```
>> ans =

        7
```

Array Addition

- Z = X + Y means
  - Z(m,n) = X(m,n) + Y(m,n) for all valid m and n



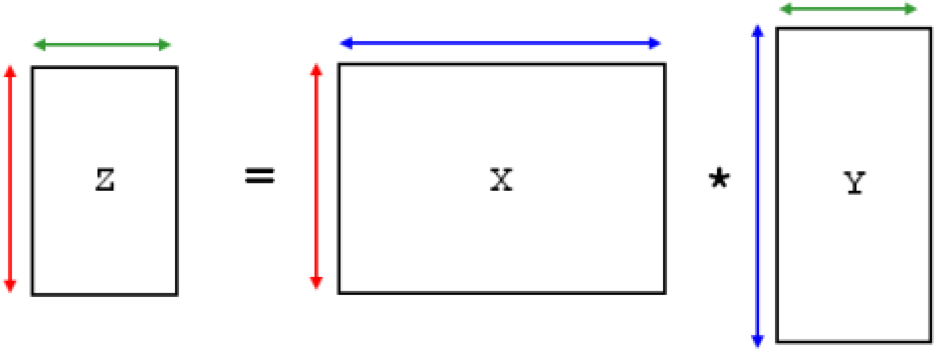
```
Z( 1 , 1 )  =   X( 1 , 1 )  +  Y( 1 , 1 )
Z( 1 , 2 )  =   X( 1 , 2 )  +  Y( 1 , 2 )    1st row
 .  .  .
Z( 1 ,end)  =   X( 1 ,end)  +  Y( 1 ,end)

Z( 2 , 1 )  =   X( 2 , 1 )  +  Y( 2 , 1 )
Z( 2 , 2 )  =   X( 2 , 2 )  +  Y( 2 , 2 )    2nd row
 .  .  .
Z( 2 ,end)  =   X( 2 ,end)  +  Y( 2 ,end)


 .  .  .


Z(end, 1 )  =   X(end, 1 )  +  Y(end, 1 )
Z(end, 2 )  =   X(end, 2 )  +  Y(end, 2 )    lastrow
 .  .  .
Z(end,end)  =   X(end,end)  +  Y(end,end)
```

Matrix Multiplication

- Different from Array Multiplication!
- **Z = X * Y** means that for all valid m and n

$$Z(m,n) = \sum_{k} X(m,k)\,Y(k,n)$$

- Not always legal:
  - Inner dimensions of X and Y must be the same

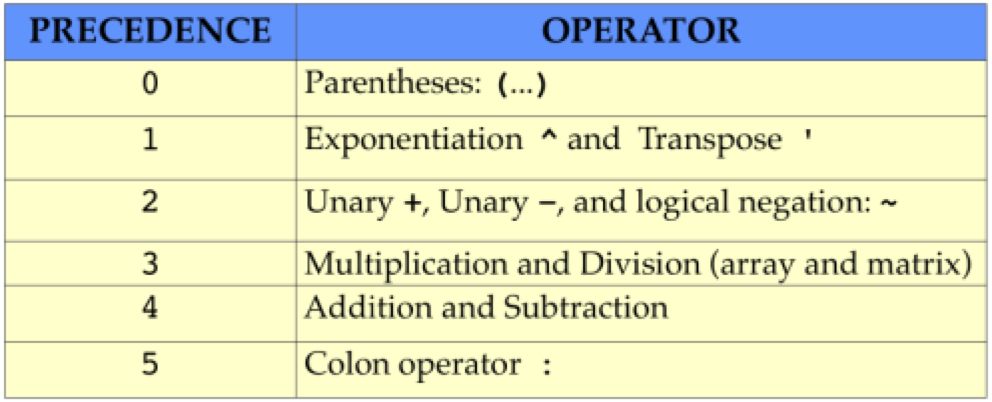


Array Division

- `Z = X./Y`
  - means that for each m and n, Z(m,n) = X(m,n)/Y(m,n)
- `Z = X.\Y`
  - means that for each m and n, Z(m,n) = Y(m,n)/X(m,n)
- Try these out in MATLAB on your own!
- Matrix division is a complicated concept in linear algebra, so we are not covering it here
  - But you can check out the advanced concepts of the textbook for detailed explanation

Precedence

- x = a + b + c
  - order does not matter with addition
- y = c + a * b is not the same as
- y = (c + a) * b
- Multiplication has priority over addition
  - In programming, this is called *precedence*



PRECEDENCE	OPERATOR
0	Parentheses: (...)
1	Exponentiation ^ and Transpose '
2	Unary +, Unary −, and logical negation: ~
3	Multiplication and Division (array and matrix)
4	Addition and Subtraction
5	Colon operator :

Precedence Table

Associativity

- `x = a + b + c`
- `x = a * b * c`
  - order does not matter with addition or multiplication
- `y =  a ^(b ^ c)` is not the same as
- `y = (a ^ b)^ c`
- In programming, the order in which operators of the same precedence are executed is called ***associativity***
- In MATLAB, it is left to right
- `y =  a ^ b  ^ c` is the same as
- `y = (a ^ b) ^ c`