

Vectorized Code

Operations on Vectors and Matrices

- "Vectorized code": using a function that can apply itself to each element of a vector or matrix.
- Most Matlab operators and functions can operate on vectors and matrices.
- E.g.: $m = m * 3;$
 - Works if m is a scalar
 - Also works if m is a vector or matrix; each element of m is multiplied by 3.

Matlab functions support vectors/matrices

- `v=-3:4`

`v =`

`-3 -2 -1 0 1 2 3 4`

- `abs(v)`
- `m=round(rand(3,4)*10)`
- `sin(m)`

Matrix vs. Arithmetic operations

- Multiplication, division, and power operators have special conventions when applied to matrices. They will typically do **matrix operations** rather than **arithmetic operations**.
- Matrix operations are topics of Linear Algebra. In this class, we work with arithmetic operations; so you need to make sure matrix operations are not used.

Matrix vs. Arithmetic operations

- When using an operator, Matlab gets to decide whether it will apply matrix vs. arithmetic operation, based on the size of the operands.
- Let $A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$, $B = \begin{bmatrix} 10 & 20 \\ 30 & 40 \end{bmatrix}$

First Arg	Operator	Second Arg	Operation	Example
Scalar	* / ^	Scalar	Arithmetic	5/3, 1/2, 5^2
Matrix	* /	Scalar	Arithmetic	A*2, A/2
Scalar	*	Matrix	Arithmetic	2*A
Scalar	/ ^	Matrix	Matrix	2/A
Matrix	^	Scalar	Matrix	A^2
Matrix	* /	Matrix	Matrix	A*B, A/B

Element-wise operators

- You can force arithmetic operations on matrices by using "element-wise" operators.
- Place a period before the operator to make it element-wise.
- Whereas the meaning of $X*Y$ depend on the size of X and Y , $X.*Y$ is always arithmetic.
- To be safe, you may choose to always use element-wise operators.

Matrix vs. Element-wise operations

```
>> A=[1 2; 4 5]
      1   2
      4   5
```

```
>> B = [10 20; 30 40]
      10   20
      30   40
```

- Matrix multiplication

```
>> A * B
      70   100
      190  280
```

- Element-wise multiplication

```
>> A .* B
      10   40
      120  200
```

Matrix vs. Element-wise operations

```
>> A=[1 2; 4 5]
      1   2
      4   5
```

- Matrix division

```
>> 1 / A
```

**Error using /
Matrix dimensions
must agree.**

- Element-wise division

```
>> 1 ./A
```

```
1.0000    0.5000
0.2500    0.2000
```

- Matrix power

```
>> A ^ 2
```

```
9    12
24   33
```

- Element-wise power

```
>> A .^ 2
```

```
1    4
16   25
```

Exercise: Vectorized Code

- Let n be a positive integer.
- Calculate the sum:

$$\frac{1}{1^1} + \frac{1}{2^2} + \frac{1}{3^3} + \dots + \frac{1}{n^n}$$
$$\text{sum} \left(\begin{bmatrix} 1 & 1 & 1 & \dots & 1 \\ 1^1 & 2^2 & 3^3 & \dots & n^n \end{bmatrix} \right)$$

$$1 \quad ./ \quad [1^1 \quad 2^2 \quad 3^3 \quad \dots \quad n^n]$$

$$[1 \quad 2 \quad 3 \quad \dots \quad n] \quad .^{\wedge} \quad [1 \quad 2 \quad 3 \quad \dots \quad n]$$

$$1:n \quad .^{\wedge} \quad 1:n \quad ??$$

Exercise

- Let n be an even positive integer.
- Calculate the sum:

$$1 - 2^3 + 3^4 - 4^5 + 5^6 \dots - n^{n+1}$$