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Lecture 3
Vectors and Matrices

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3.1 Vectors

- A **vector** is an ordered list of numbers.
- You can enter a vector of any length in MATLAB by typing a list of numbers, separated by **commas** and/or **spaces**, inside square brackets.
- For example: **>> z = [1,4,7,18]** **>> y = [4 -3 5 -2 8 1]**
- Vector of values running from 1 to 9:

>> x = 1:9 X = 1 2 3 4 5 6 7 8 9

- The increment can be specified as the **middle** of three argument:

>> x = 0:2:10 x = 0 2 4 6 8 10

- Increments can be **fractional or negative**, for example,

>> 0:0.1:1 or **100:-1:0**.

- **linspace(0,10,6)** ans = 0 2 4 6 8 10

3.1 Vectors

- The elements of the vector **x** can be **extracted** as **x(1)**, **x(2)**, etc. For example: >> x = 0: 7;

>> x(3) **>> x(4:7)** **>> x([4,7])**

- To **change** the vector **x** from a row vector to a column vector, put a **prime** (') after **x**: **>> x'**

>> x1=[5,3,1,23,11], min(x1), max(x1), mean(x1), sort(x1), sum(x1).

- You can perform **mathematical operations** on vectors.

for example, to **square** the elements of the vector **x**,

>> $x = 0: 2: 10$

>> x.^2 ans = 0 4 16 36 64 100;

- The **period(.)** in this expression says that the numbers in **x** should be squared individually, or *element-by-element*.

3.1 Vectors

- Typing **x^2** would tell MATLAB to use matrix multiplication to multiply **x** by itself and would produce an **error** message in this case.

- Similarly, you must type **.*** or **./** if you want to multiply or divide vectors element-by-element.

```
>> x.*y          ans =  0  -6  20  -12  64  10
```

- Most MATLAB operations are, by **default**, performed element-by-element. **For example**, you do not type a period**(.)** before: **addition, subtraction** and **exp(x)** (the **matrix exponential** function is **expm**).

Example

The Redlich-Kwong equation of state is given by:

$$\boldsymbol{P = \frac{RT}{v - b} - \frac{a}{v(v + b)\sqrt{T}}}$$

Where $R = 8.31\ J \cdot mol^{-1} \cdot K^{-1}, T = 171, 181, 191\ K, the\ value\ of\ a\ from\ 0.1\ to\ 1.9, b = 0.086, and\ v = 5 \times 10^{-2}. Find\ the\ pressure\ P.$

3.2 Matrices

❖ A **matrix** is a rectangular array of numbers. Row and column vectors are examples of matrices.

❖ **Example 1**: Write the following Matrix: $\boldsymbol{a} = \begin{pmatrix} \mathbf{1} & \mathbf{2} & \mathbf{3} & \mathbf{4} \\ \mathbf{5} & \mathbf{7} & \mathbf{15} & \mathbf{3} \\ \mathbf{12} & \mathbf{9} & \mathbf{6} & \mathbf{3} \end{pmatrix}$

Ans: $a = [1:4; 5,7,15,3; 12:-3:3];$

Note The "[]" defines the matrix in MATLAB. The matrix *elements* in any row are separated by **commas**, and the rows are separated by **semicolons**.

❖ The elements in a row can also be separated by **spaces**.

Example 2: Extract: a(7), a(3,2), a(2,:), a(1:3,2:3), a([2 3],[1 3])

❖ If two matrices **A** and **B** are the same size:

sum: A+B **add a scalar** (a single number): **A + c**

difference: A-B **subtracts: A - c**

3.2 Matrices

❖ Here are some commands:

zeros(1,3), ones(2,4), rand(3,5), randn(2,5), eye(n,m), det(A),
size (A), Length (A).

Example: If v=[1, 2, 4, 5], w=[1;2;4;5], and A = [1,2,3;4,-5,6;5,-6,7], try to do the following steps:

>> v+2 >>B=A' >> A*B >>A+B >> B=A.'

>> A(2,3) >> A([2 3],[1 2]) >> B(:,2) = [ ]

>> B=A([3 2],[2 1])

>> B=[A(3,2);A(3,1);A(2,2);A(2,1)]

3.2 Matrices

Transpose	B = A'
Identity Matrix	eye(n) ➔ returns an n x n identity matrix eye(m,n) ➔ returns an m x n matrix with ones on the main diagonal and zeros elsewhere.
Addition and subtraction	C = A + B C = A – B
Scalar Multiplication	B = αA, where α is a scalar.
Matrix Multiplication	C = A*B
Matrix Inverse	B = inv(A), A must be a square matrix in this case. rank (A) ➔ returns the rank of the matrix A.
Matrix Powers	B = A.^2 ➔ squares each element in the matrix C = A * A ➔ computes A*A, and A must be a square matrix.
Determinant	det (A), and A must be a square matrix.

3.3 MATLAB Functions

❖ Functions @ sign:

g = @(x, y) xˆ2 + yˆ2; **g = g(1, 2) ;** g = 5

Example: Use built in functions at the points (1:5,*2*) and (1:5,2:6) for the function of $g = x^2 + y^2$.

Ans: **g = @(x, y) x.^2 + y^2;** **g(1:5, 2) ;**

3.4 Solving Equations

- You can solve algebraic equations, differential equations and solve equations involving variables with **solve** or **fzero**.
- The command **solve** can solve:

1. Higher-degree polynomial equations.
2. Equations involving more than one variable

- The input to solve can be **symbolic** expression
- Solve **algebraic equations** to get either exact analytic solutions or high-precision numeric solutions.

Examples about analytic solutions

1. Solve the following equations:

>> syms x solve(x^2 - 2*x - 4 == 0); ans = 5^(1/2)+1 1-5^(1/2).

- ❖ The answer is the exact (symbolic) solutions.
- ❖ To get numerical solutions, type **double (ans)**, or **vpa(ans)** to display more digits.

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2. Solve $x^2 - 3x = -7$; **syms x solve(x^2 - 3*x + 7)**

ans=
```
3/2+1/2*i*19^(1/2)
3/2-1/2*i*19^(1/2)
```

- ❖ To get numerical solutions, type **double(ans)**, or **vpa(ans).**

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3. Solve $(2x - \ln y = 1$ for y in terms of $x)$,

type: **syms x y**

solve(2*x - log(y) – 1, y)

Examples

4. Solve these two equations: $x^2 - y = 2,\ y - 2x = 5$

Ans: **syms x y [x,y]=solve(x^2-y-2,y-2*x-5);**

```
x =                 y =
 1+2*2^(1/2)         7+4*2^(1/2)
 1-2*2^(1/2)         7-4*2^(1/2)
```

❖ You can **extract** the first x and y values by typing:

>> **x(1)** ans = 1+2*2^(1/2) >> **y(1)** ans = 7+4*2^(1/2)

❖ Some equations **cannot** be solved symbolically, and in these cases **solve** tries to find a numerical answer.

5. syms x solve(sin(x) ==2 - x)