Symbolic computation

creating symbolic variables, expressions, math functions

Symbolic Math Toolbox

- In computation mathematics, there is **numeric** computation and **symbolic** computation

- MATLAB provides functions for solving, plotting, and manipulating symbolic math equations

- Ordinary Differential Equations
- Calculus
- Linear Algebra
- Equation Manipulation
- Equation Simplification

Numeric or Symbolic Arithmetic

- In **numeric** arithmetic, you represent numbers in **floating-point** format using either **double precision** or **variable precision**.
- In **symbolic** arithmetic, you represent **numbers in their exact form**.

Double-Precision Arithmetic

```
>>x = 10001/1001
>> y = pi
>> z = sqrt(2)
```

The results are converted to double-precision values.

x = 9.9910
y = 3.1416
z = 1.4142

Speed – **Fast**, Memory Usage - **Least**

Symbolic Arithmetic

```
x = sym(pi)
y = sqrt(sym(2))
```

Express the irrational numbers π and √2 in symbolic form.

x =pi

y = 2^(1/2)

Speed – **Slow**, Memory Usage - **Greatest**

Create Symbolic Numbers

>> sym(1/3) - **1/3**

Creating a Symbolic Expression

```
>> phi = (1 + sqrt(sym(5)))/2

phi = 5^(1/2)/2 + 1/2
```

Creating a Symbolic Matrix

```
>> syms a b c
>> A = [a b c; b c a; c a b]

A =

[a, b, c]
[b, c, a]
[c, a, b]
```

Create Matrix of Symbolic Numbers

```
A= [ 0.5 0.25;0.75 0.5]
sym(A)
```

$$\begin{pmatrix} \frac{1}{2} & \frac{1}{4} \\ \frac{3}{4} & \frac{1}{2} \end{pmatrix}$$

Create Symbolic Variables

```
syms x   or syms a b c  or y=sym('y')
```

Creating Symbolic Math Functions

```
syms x y z
r = sqrt(x^2 + y^2 + z^2)
t = atan(y/x)
f = sin(x*y)/(x*y)
```

$$r = \sqrt{x^2 + y^2 + z^2}$$

$$t = \operatorname{atan}\left(\frac{y}{x}\right)$$

$$f = \frac{\sin(x\,y)}{x\,y}$$

Create Symbolic Functions

```
syms f(x,y)
f(x,y) = x^2*y
f(3,2)
```

f(x, y) = $x^2 y$

Ans=18

Solve systems of equations

Solve Algebraic Equations with One Symbolic Variable

```
syms x
solve(x^3 - 6*x^2 == 6 - 11*x)
```

$$\begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$$

To solve the equation, $5x^2 + 6x + 3 = 10$

```
syms x
solve(5*x^2+6*x-7,0)
```

$$\begin{pmatrix} -\frac{2\sqrt{11}}{5} - \frac{3}{5} \\ \frac{2\sqrt{11}}{5} - \frac{3}{5} \end{pmatrix}$$

OR

```
syms x
e2= sym(5*x^2 + 6*x + 3== 10)
solve(e2)
```

```
syms a b c x
S = a*x^2 + b*x + c;
solve(S)
```

$$\begin{pmatrix} -\frac{b+\sqrt{b^2-4ac}}{2a} \\ -\frac{b-\sqrt{b^2-4ac}}{2a} \end{pmatrix}$$

Solve Systems of Algebraic Equations

```
syms x y z
one = sym(3*x + 2*y - z == 10);
two = sym(-x + 3*y + 2*z == 5);
three = sym(x - y - z == -1);
answer = solve(one,two,three)
answer.x
answer.y
answer.z

OR

[x y z]=solve(one, two, three)
```

X = -2
Y =5
Z = -6

factor(S)- Factors the expression or equation

```
syms x
factor(x^3-1)
```

$$(x-1 \quad x^2+x+1)$$

```
syms x
 g = x^3 + 6*x^2 + 11*x + 6;
factor(g)
```

$$(x+3 \quad x+2 \quad x+1)$$

expand(f)-rewrite a polynomial in the standard form

```
syms x
n= (x+ x^2+ 2* x+ 2)*(x+3)
expand(n)
```

n= $(x+3)\ (x^2+3x+2)$

$$x^3+6x^2+11x+6$$

subs-Substitutions in Symbolic Expressions

```
syms x
f = 2*x^2 - 3*x + 1;
subs(f, 1/3)
```

$$\frac{2}{9}$$

simplify(y)- Simplify Symbolic Expressions

```
syms x
n= (x+ x^2+ 2* x+ 2)*(x+3)
simplify(n)
```

$$(x+3)\ (x^2+3x+2)$$

Compare the programs

```
clc, clear
syms x
y1=(x+1)^2
y2=x^2+2*x+1
if(y1==y2)
disp('equal')
else
disp('notequal')
end
```

notequal

```
clc, clear
syms x
y1=(x+1)^2
simplify(y1)
y2=x^2+2*x+1
simplify(y2)
if(simplify(y1)==simplify(y2))
disp('equal')
else
disp('notequal')
end
```

equal