Introduction to Computing for Engineers 050IU

Symbolic Mathematics

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Symbolic

- Expand or simplify symbolic expressions.
- Find symbolic roots, limits, minima, maxima, etc.
- Solving differentiate and integrate.
- Solve simultaneous equations (even some nonlinear).
- Laplace transforms.
- in linear algebra, including symbolic methods for obtaining determinants, matrix inverses, and eigenvalues….

Creating Symbolic Variables

- To create one symbolic variable, type **sym**:

```
x = sym('x'); x=str2sym('x');
```

You can also use the **syms** command:

```
syms x;
```

- To create multiple symbolic variables, use the **syms** command as follows:

```
syms x y z T0;
```

Creating a Symbolic Expression with Symbolic Variables

- To create an expression using existing symbolic variables, using **syms** command:

```
>>   syms P K T P0;
     P = P0*exp(K*T);
```

- Or

```
>>    P = str2sym('P0*exp(K*T)');
```

Symbolic Function()

- numden()
- expand()
- factor()
- simplify()
- poly2sym()
- solve()
- subs()
- ezplot()
- diff()
- int()

numden()

- numden(): separate the numerator and denominator.
- Example:

```
>>   syms x
     y = 2*((x+3)^2+1)/(x^2+6*x+9)
     [Numerator, Denominator]=numden(y)

>>   Numerator = 2*x^2 + 12*x + 20
     Denominator = x^2 + 6*x + 9
```

expand()

- expand(): expand the products of factors in an expression.
- Example:

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

>> ans = 2*x^2 + 12*x + 18
```

factor()

- The factor(): factor an expression into a product of terms.
- Example:

```
>>   syms x
     y = x^2 + 6*x + 9
     factor(y)

>> ans = (x+3)^2
```

simplify()

- simplify(): uses the Maple simplification algorithm to simplify each part of an expression.
- Example:

```
>>  syms x
      y = sin(x)^2 + cos(x)^2
     simplify(y)
>>    ans = 1;
```

poly2sym() & sym2poly()

- poly2sym(): uses an array of coefficients to create a polynomial.
- Example

```
>> a = [1,3,2]
    b = poly2sym(a)
>>  b = x^2 + 3*x + 2
```

- The function sym2poly() is the inverse of poly2sym().

```
>> c = sym2poly(b)
>> c =  1     3     2
```

solve()

- The solve() function sets an expression equal to zero, then solves the equation for its roots.
- Example

```
>>  syms x
    y = x^2 - 9
    solve(y)
>>  ans =
    3
    -3
```

solve()

```
>> syms x a b c
     y = a*x^2 + b*x + c
     solve(y)

ans =
 -(b+(b^2-4*a*c)^(1/2))/(2*a)
 -(b-(b^2-4*a*c)^(1/2))/(2*a)
```

solve()

```
>> syms x a b c
    y = a*x^2 + b*x + c
    solve(y,a)
>> ans =
    -(c + b*x)/x^2
```

Note that this solves the expression for “a”.

solve()
Systems of Equations

```
>> syms x y z
    one = 3*x + 2*y - z == 10
    two = -x + 3*y + 2*z == 5
    three = x - y - z == -1
    [x y z] = solve(one,two,three)

>> x = -2    y = 5    z = -6
```

Or:

```
>>   one = str2sym('3*x+2*y-z=10')
    two = str2sym('-x+3*y+2*z=5')
    three = str2sym('x-y-z=-1')
    [x y z] = solve(one,two,three)
```

subs()

- The subs(): substitute a symbol with another symbol or assign a number to a variable.

```
>>   syms a b c x y
     quandratic = a*x^2 + b*x + c
     yquandratic = subs(quandratic,x,y)
>>   yquadratic =
     a*y^2 + b*y + c
```

subs()
Multiple substitutions

subs(symbolic_funct,{substitutant},{substitute})

```
>> subs(quadratic,{a,b,c},{1,2,3})
    ans = x^2 + 2*x + 3
```

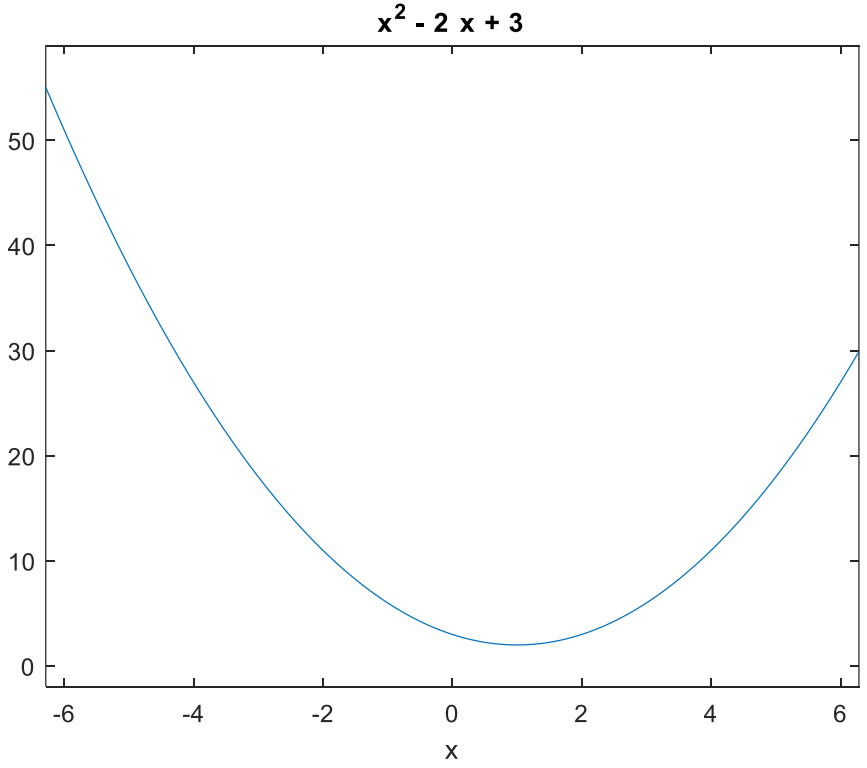
Or

```
>> subs(quadratic,{a,b,c,x},{1,2,3,4})
    ans = 27
```

ezplot()

- ezplot(): Plotting symbolic function

```
syms x
y = x^2 - 2*x + 3
ezplot(y)
```



diff()
Differentiation

- diff(): take derivative symbolic functions

  `diff(f,x,n)`

  - n: the order of the derivative
- Example:

```
>>   syms x
     y = x^2 - 2*x + 3
     diff(y,x,1)
>> ans =
  2*x - 2
```

int()
Integration

- int(): take integral symbolic functions

int(y,x,a,b) or int(y,x)

- Example:

```
>>   syms x
     y = x^2 - 2*x + 3
     int(y,x)
>>   ans =
     (x*(x^2 - 3*x + 9))/3
>>   int(y,x,1,2)
>>   ans = 7/3
```

int()
Integration Constant

- Display constant

```
>>  syms x a
    y = 2*x;
    int(y,a,x)
>>  ans =
    x^2 - a^2
```

Summary

- Creating Symbolic Expressions
  - sym('x'), syms x, expressions i.e. e=str2sym('m*c^2')
- Manipulation
  - numden, expand, factor, simplify, poly2sym
- Solutions
  - solve, subs
- Plotting
  - ezplot
- Differentiation
  - diff(y,x, n)
- Integration
  - int(y, x, a, b)

Quiz

- P1: Use the symbolic toolbox to solve the following system of equations:

  $x + 2y - z = 4$

  $3x + 8y + 7z = 20$

  $2x + 7y + 9z = 23$

- P2: The velocity of a car is v = t^2 - 3t + 5. Find the displacement for 1<t<5 and the acceleration at t=1.5. Plot the equations for distance, velocity, and acceleration on one graph.