

Lecture 1

Polynomial Roots:

$$f(x) = x^2 - (5 + i)x + (8 + i)$$

```
EDU>> r=[1 -(5+i) (8+i)];
```

```
EDU>> roots(r)
```

```
ans =
```

```
3.0000 + 2.0000i
```

```
2.0000 - 1.0000i
```

More general method to solve for the zero's of a nonlinear equation:

```
EDU>> syms x
```

```
EDU>> solve(x^2-(5+i)*x+8+i,x)
```

```
ans =
```

```
3 + 2*i
```

```
2 - i
```

The “expand” command:

```
EDU>> syms x;
```

```
EDU>> expand((x-(3+2*i))*(x-(2-i)))
```

```
ans =
```

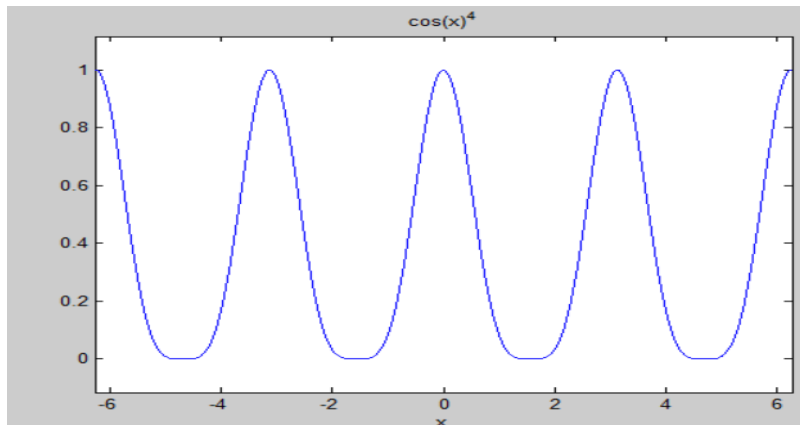
```
x*(- 5 - i) + x^2 + 8 + i
```

Lecture 2

Various representations of $\cos^4(x)$:

```
EDU>> syms x
EDU>> simple(cos(x)^4)
simplify:
cos(x)^4
radsimp:
cos(x)^4
simplify(Steps = 100):
cos(x)^4
combine(sincos):
cos(2*x)/2 + cos(4*x)/8 + 3/8
combine(sinhcosh):
cos(x)^4
combine(ln):
cos(x)^4
factor:
cos(x)^4
expand:
cos(x)^4
combine:
cos(x)^4
rewrite(exp):
(exp(-x*i)/2 + exp(x*i)/2)^4
rewrite(sincos):
cos(x)^4
rewrite(sinhcosh):
cosh(x*i)^4
rewrite(tan):
(tan(x/2)^2 - 1)^4/(tan(x/2)^2 + 1)^4
mwcos2sin:
(sin(x)^2 - 1)^2
collect(x):
cos(x)^4
ans =
cos(x)^4
```

```
EDU>> syms x
ezplot(cos(x)^4)
```



Calculating $\tan^{-1}\left(\frac{3}{-2}\right)$:

```
EDU>> atan(3/-2)
ans =
    -0.9828
EDU>> atan2(3,-2)
ans =
    2.1588
```

The `atan2` provides the correct answer when the denominator is negative.

Cartesian $\leftrightarrow$ Polar transformations:

```
EDU>> [r,theta]=cart2pol(-2,1)
r =
    2.6779
theta =
    2.2361
EDU>> [a,b]=pol2cart(r,theta)
a =
    -2
b =
    1.0000
```

Alternative method for computing magnitude and angle of $z=-2+i$

```
EDU>> z=-2+i
z =
    -2.0000 + 1.0000i
EDU>> abs(z), angle(z)
ans =
    2.2361
ans =
    2.6779
```

More examples of complex algebra:

```
EDU>> z1=2*exp(i)
z1 =
    1.0806 + 1.6829i
EDU>> z2=exp(-2*i)
z2 =
    -0.4161 - 0.9093i
EDU>> z1*z2
ans =
    1.0806 - 1.6829i
EDU>> z1/z2
ans =
    -1.9800 + 0.2822i
EDU>> z1^z2
ans =
    0.9315 - 1.6105i

EDU>> j^j
ans =
    0.2079
EDU>> exp(j*pi/2)^j
ans =
    0.2079
```

Computing limits:

$$\lim_{x \rightarrow 2} \frac{x-2}{x^2-4} \text{ and } \lim_{x \rightarrow 0} \frac{\sin(x)}{x}$$

```
EDU>> syms x
EDU>> limit((x-2)/(x^2-4))
ans =
1/2
EDU>> limit((x-2)/(x^2-4), 2)
ans =
1/4
EDU>> limit(sin(x)/x, 0)
ans =
1
```

Lecture 3

Finite sum:

$$\sum_{k=1}^n (2k-1)^2$$

```
EDU>> syms n k
EDU>> symsum((2*k-1)^2,1,n)
ans =
(4*n^3)/3 - n/3
EDU>> factor(ans)
ans =
(n*(2*n - 1)*(2*n + 1))/3
EDU>> pretty(ans)
```

$$\frac{n(2n-1)(2n+1)}{3}$$

Infinite sum:

$$\sum_{k=0}^{\infty} \frac{x^k}{k!}$$

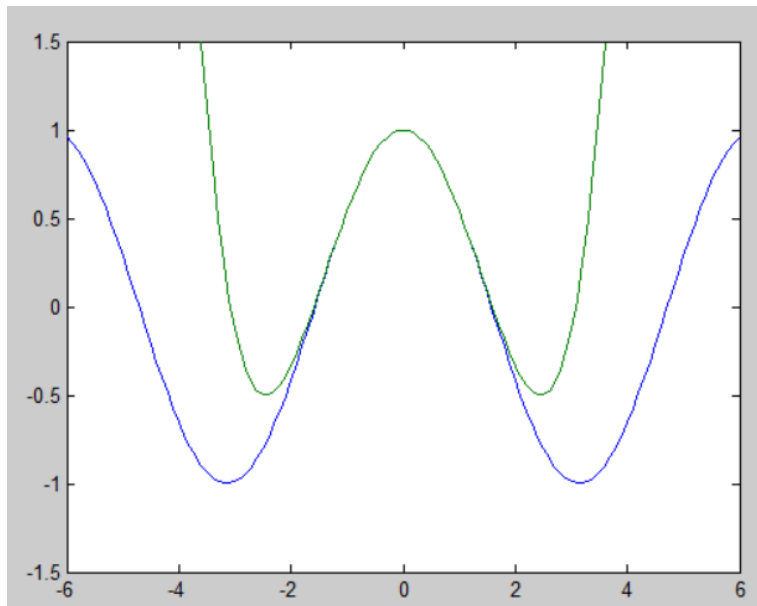
```
EDU>> syms x k
EDU>> symsum(x^k/factorial(k),k,0,inf)
ans =
exp(x)
```

Taylor series expansion:

```
EDU>> syms x
EDU>> taylor(cos(x),x)
ans =
x^4/24 - x^2/2 + 1
EDU>> taylor(cos(x),x,pi/2)
ans =
pi/2 - x - (pi/2 - x)^3/6 + (pi/2 - x)^5/120
EDU>> taylor(cos(x),x,'order',8)
ans =
- x^6/720 + x^4/24 - x^2/2 + 1
```

Plotting $\cos(x)$ vs its Taylor series expansion of order 4:

```
EDU>> y=@(x) cos(x);  
EDU>> y1=@(x) x.^4/24 - x.^2/2 + 1;  
EDU>> x=-6:0.1:6;  
EDU>> plot(x,y(x),x,y1(x))  
EDU>> axis([-6 6 -1.5 1.5])
```



Partial Fraction Expansion:

$$\frac{3x^2+9x-20}{x^2+x-6} = \frac{4}{x+3} + \frac{2}{x-2} + 3$$

```
EDU>> [R,P,K]=residue([3 9 -20],[1 1 -6])  
R =  
    4  
    2  
P =  
   -3  
    2  
K =  
    3
```

Integration (symbolic):

$$\int \sin(ax) dx$$

```
EDU>> syms a x
EDU>> int(sin(a*x),x)
ans =
-cos(a*x)/a
EDU>> pretty(ans)
```

$$-\frac{\cos(ax)}{a}$$

Integration (numeric):

$$\int_0^{\pi/2} \sin(x) dx$$

```
EDU>> f=@(x) sin(x);
EDU>> quad(f,0,pi/2)
ans =
1.0000
```

Differentiation:

$$\frac{d}{dx} \sin(x^2)$$

```
EDU>> syms x
EDU>> diff(sin(x^2))
ans =
2*x*cos(x^2)
```

$$\frac{d}{dx} \sin(ax^2)$$

```
EDU>> syms x a
EDU>> diff(sin(a*x^2),x)
ans =
2*a*x*cos(a*x^2)
```

$$\frac{d^2}{dx^2} \sin(x^2)$$

```
EDU>> diff(sin(x^2),2)
ans =
2*cos(x^2) - 4*x^2*sin(x^2)
```

Here is a method that allows the evaluation of the derivative at a given value for x:

$$\frac{d}{dx} \sin(x^2) \text{ at } x = 1.2$$

```
EDU>> syms x
EDU>> f=matlabFunction(diff(sin(x^2)))
f =
    @(x)x.*cos(x.^2).*2.0
EDU>> f(1.2)
ans =
    0.3130
```

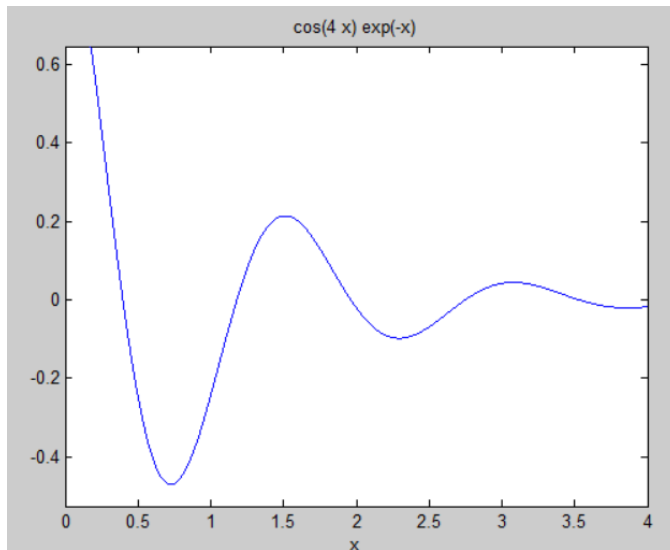
Lecture 4

Plotting of symbolically defined functions:

$$f(x) = e^{-x} \cos(4x)$$

```
EDU>> syms x
```

```
EDU>> ezplot(exp(-x)*cos(4*x), 0, 4)
```



Plotting two signals on the same graph:

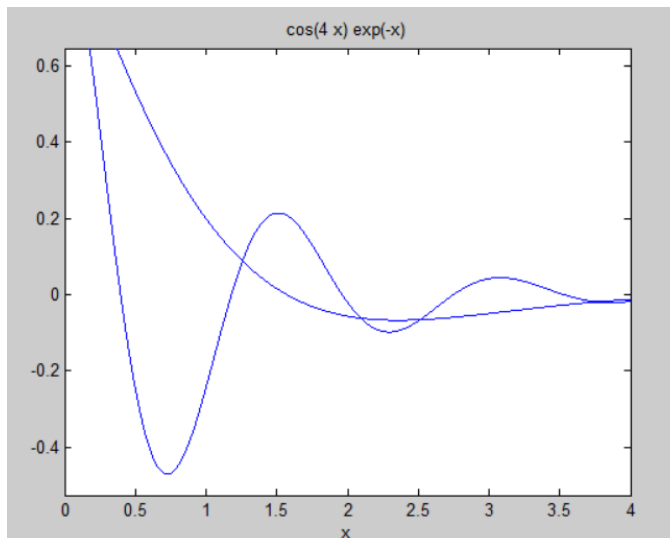
```
EDU>> syms x
```

```
EDU>> ezplot(exp(-x)*cos(x), 0, 4)
```

```
EDU>> hold
```

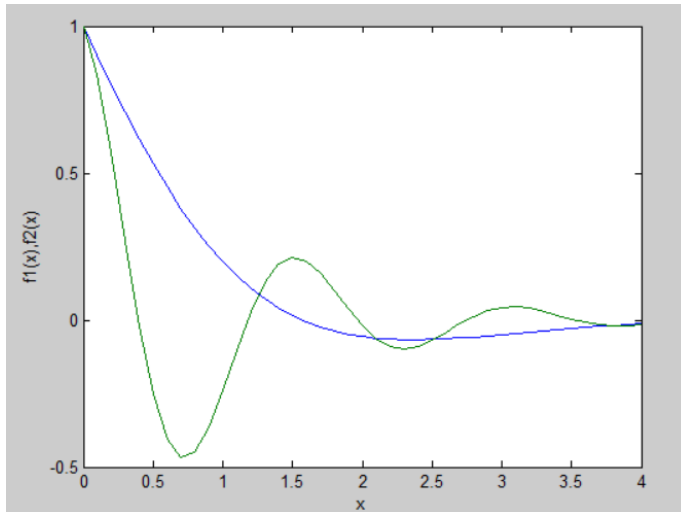
Current plot held

```
EDU>> ezplot(exp(-x)*cos(4*x), 0, 4)
```



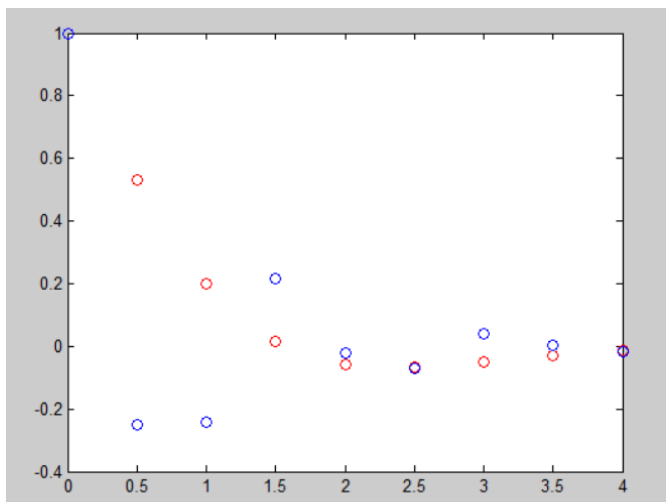
Plotting of signals defined as anonymous functions:

```
EDU>> x=0:0.1:4;  
EDU>> f1=@(x) exp(-x).*cos(x);  
EDU>> f2=@(x) exp(-x).*cos(4*x);  
EDU>> plot(x,f1(x),x,f2(x))  
EDU>> xlabel('x'),ylabel('f1(x),f2(x)')
```



Plotting samples:

```
EDU>> x=0:0.5:4;  
EDU>> f1=@(x) exp(-x).*cos(x);  
EDU>> f2=@(x) exp(-x).*cos(4*x);  
EDU>> plot(x,f1(x),'ro',x,f2(x),'bo')
```



Lecture 6

Piecewise functions. Develop a function that computes y as a function of t for the following piecewise function. Use the output vector y to generate a graph for y vs t , for $t = -5$ to 50 .

$$y(t) = \begin{cases} 11t^2 - 5t & 0 \leq t \leq 10 \\ 1100 - 5t & 10 \leq t \leq 20 \\ 50t + 2(t - 20)^2 & 20 \leq t \leq 30 \\ 1520e^{-0.2(t-30)} & t > 30 \\ 0 & \text{otherwise} \end{cases}$$

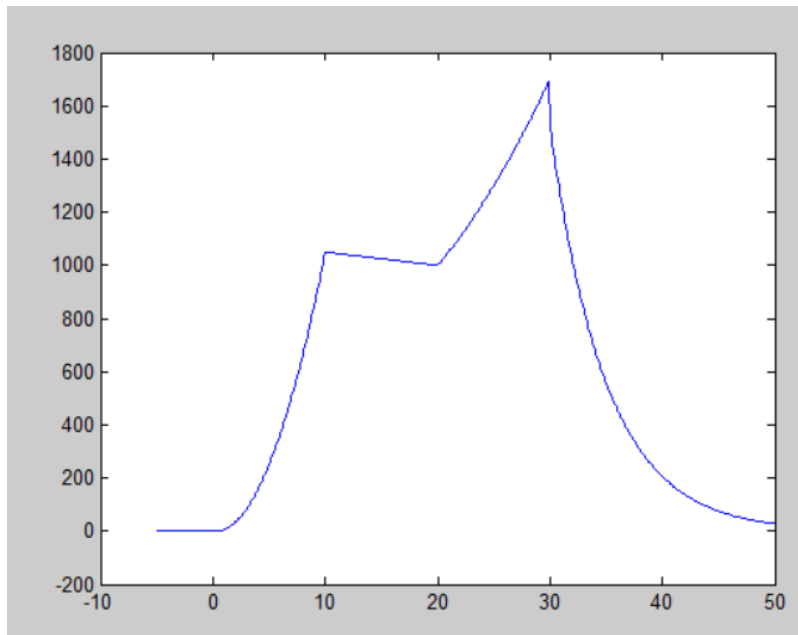
Solution:

```
pwf.m x
1 function y=pwf(t)
2 % Generates data vector y for a piecewise function
3 % given input vector t.
4 m=length(t);
5 for n=1:m
6     if t(n) >= 0 && t(n) <= 10
7         y(n)=11*t(n)^2-5*t(n);
8     end
9     if t(n) >= 10 && t(n) <= 20
10        y(n)=1100-5*t(n);
11    end
12    if t(n) >= 20 && t(n) <= 30
13        y(n)=50*t(n)+2*(t(n)-20)^2;
14    end
15    if t(n) >= 30
16        y(n)=1520*exp(-0.2*(t(n)-30));
17    end
18    if t(n) < 0
19        y(n)=0;
20    end
21 end
```

```
EDU>> t=-5:0.1:50;
```

```
EDU>> y=pwf(t);
```

```
EDU>> plot(t,y)
```



Lecture 7

Symbolic solution of linear ordinary differential equations:

$$\frac{d^2}{dt^2}y(t) + 5\frac{d}{dt}y(t) + 6y(t) = 4e^{-t}, \quad t > 0.$$

$$\text{with } \frac{d}{dt}y(0) = -2 \text{ and } y(0) = 10$$

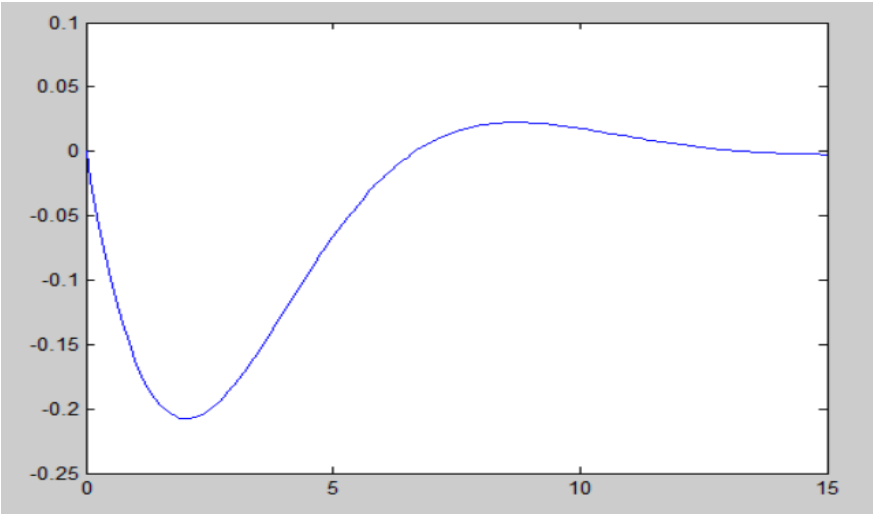
```
EDU>> dsolve('D2y+5*Dy+6*y=4*exp(-t)', 'Dy(0)=-2', 'y(0)=10')
ans =
2*exp(-t) + 24*exp(-2*t) - 16*exp(-3*t)
```

Matlab symbolic solution of linear ordinary differential equations:

$$3\frac{d^2}{dt^2}y(t) + 2\frac{d}{dt}y(t) + y(t) = 0, \quad t > 0.$$

$$\text{with } \frac{d}{dt}y(0) = -\frac{\sqrt{2}}{6} \text{ and } y(0) = 0$$

```
EDU>> y=dsolve('3*D2y+2*Dy+y=0', 'Dy(0)=-sqrt(2)/6', 'y(0)=0')
y =
-(exp(-t/3)*sin((2^(1/2)*t)/3))/2
EDU>> pretty(y)
      / 1/2 \
      /  t \ | 2  t |
exp| - - | sin| ----- |
      \ 3 /  \ 3  /
-----
      2
EDU>> f=matlabFunction(y)
f =
@(t)exp(t.*(-1.0./3.0)).*sin(sqrt(2.0).*t.*(1.0./3.0)).*(-1.0./2.0)
EDU>> t=0:0.1:15;
EDU>> plot(t,f(t))
```



Lecture 11

Laplace and inverse Laplace Transforms:

(note: Matlab implements the one-sided Laplace transform. The unit-step function is "heaviside(t)")

```
EDU>> syms t s
EDU>> laplace(heaviside(t))
ans =
1/s
EDU>> laplace(t)
ans =
1/s^2
EDU>> laplace(exp(-3*t))
ans =
1/(s + 3)
EDU>> syms b
EDU>> laplace(cos(b*t))
ans =
s/(b^2 + s^2)
```

```
EDU>> syms s b
EDU>> ilaplace(1/s)
ans =
1
EDU>> ilaplace(1/(s-1))
ans =
exp(t)
EDU>> ilaplace(b/(s^2+b^2))
ans =
sin(b*t)
```

Lecture 17

The Fourier Transform:

```
EDU>> syms t w
```

```
EDU>> fourier(exp(-t)*heaviside(t))
```

```
ans =
```

```
1/(w*i + 1)
```

```
EDU>> fourier(dirac(t))
```

```
ans =
```

```
1
```

```
EDU>> fourier(cos(t))
```

```
ans =
```

```
pi*(dirac(w - 1) + dirac(w + 1))
```

```
EDU>> ifourier(heaviside(t)+heaviside(-t))
```

```
ans =
```

```
dirac(x)
```

```
EDU>> ifourier(pi*(dirac(w - 1) + dirac(w + 1)))
```

```
ans =
```

```
exp(-x*i)/2 + exp(x*i)/2
```

Lecture 20

Z-Transform:

```
EDU>> syms n a z
EDU>> ztrans(2^n)
ans =
z/(z - 2)
EDU>> ztrans(sin(a*n))
ans =
(z*sin(a))/(z^2 - 2*cos(a)*z + 1)
EDU>> ztrans(a^n)
ans =
-z/(a - z)
EDU>> iztrans(z/(z-2))
ans =
2^n
EDU>> iztrans(exp(a/z), z, n)
ans =
a^n/factorial(n)
```