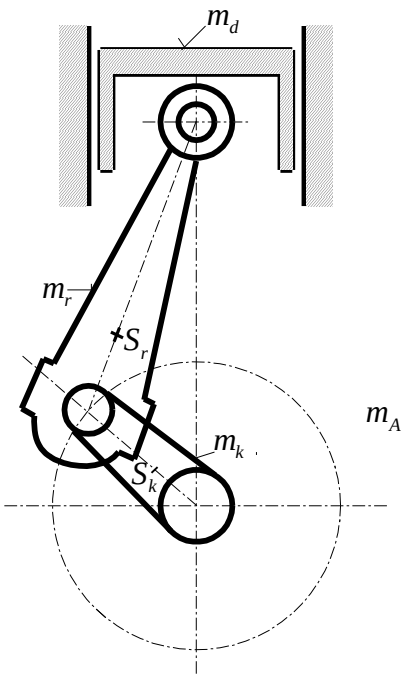
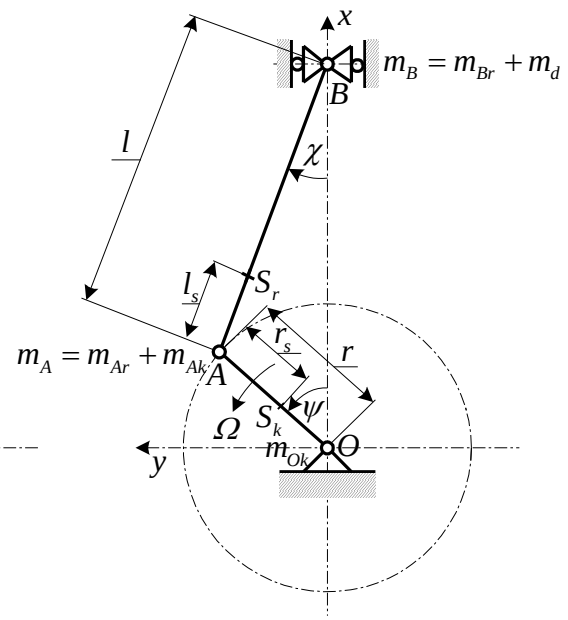
Dynamics of Machines Week 6 –1st and 2nd Exercises

6/1 Exercise – Unbalanced Forces and Moments of a Crank Mechanism



Crank Mechanism



Mechanical Model

$$F_x(t) = \Omega^2 \left[(Q_A + Q_B)\cos(\psi) + Q_B(+A_2\cos(2\psi) - A_4\cos(4\psi) + A_6\cos(6\psi) - \ldots\ldots\ldots\ldots \right] \ (N)$$

$$F_y(t) = \Omega^2 Q_A \sin(\psi) \ \ (N)$$

$$M_{Oz} = (J_{Srz} - \tilde{J}_{Srz})\,\lambda\,\Omega^2 \left[+C_1\sin(\psi) - C_3\sin(3\psi) + C_5\sin(5\psi) - \ldots\ldots\ldots\ldots \right] \ (Nm)$$

Where:

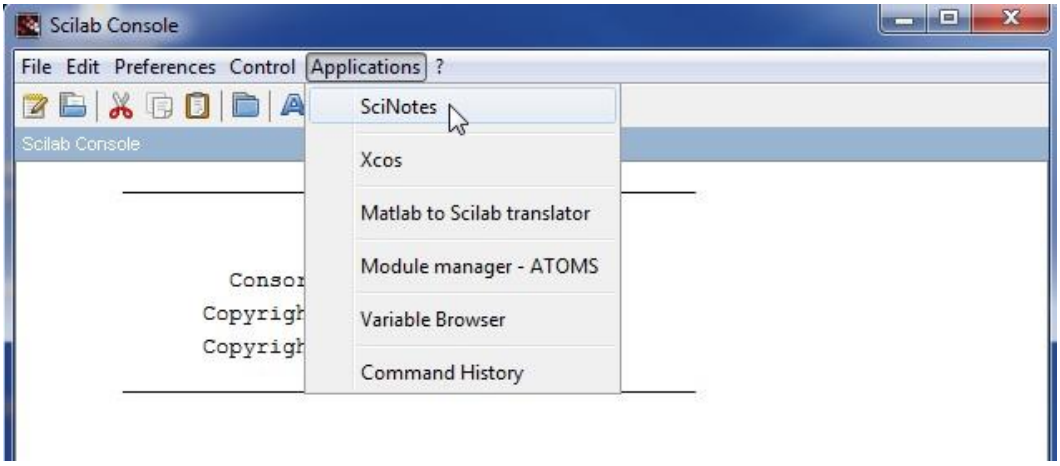
$$Q_A = m_A r_A \ , \ \ Q_B = m_B r_B \ , \ \ \lambda = \frac{r}{l} \ , \ \ \tilde{J}_{Srz} = m_r l_S (l - l_S) \ , \ \ \Omega = \frac{2\pi n}{60} \ , \ \ \psi = \Omega t$$

Constants:

$$A_2 = 0{,}3431 \ , \ A_4 = 0{,}0101 \ , \ A_6 = 0{,}003 \ , \ C_1 = 1{,}014 \ , \ C_3 = 0{,}044 \ , \ C_5 = 0{,}002$$

Data:

$$m_r = 0{,}5\ kg \ , \ J_{Srz} = 0{,}002\ kgm^2 \ , \ l = 0{,}15\ m \ , \ l_S = 0{,}06\ m \ , \ n = 6000\ rev/min \ ,$$
$$r = 0{,}05\ m$$

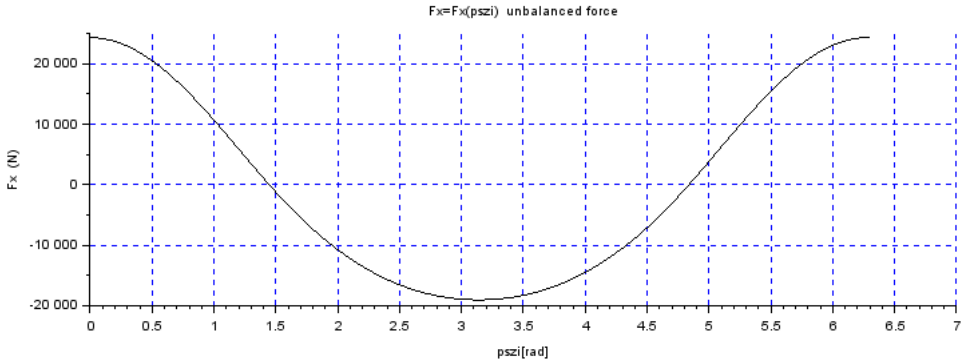


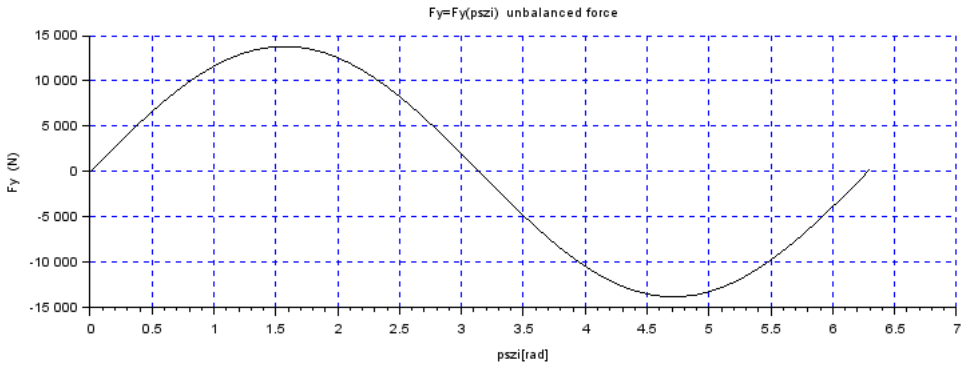

```
// week 6 – 1st exercise
// Plot the unbalanced force and unbalanced moment functions
clear;
// Variables
mA=0.7;          // reduced mass in point A (kg)
mB=0.4;          // reduced mass in point B (kg)
mr=0.5;          // mass of the connecting rod (kg)
JSrz=0.002;      // moment of inertia of the connecting rod about z axis through the Sr point (kgm^2)
r=0.05;          // crank radius (m)
l=0.15;          // connecting rod length (m)
l_s=0.06;        // length between A and Sr points (m)
n=6000;          // rotational speed (rev/perc)
// Constants:
A2=0.3431; A4=0.0101; A6=0.003;
C1=1.014; C3=0.044; C5=0.002;
// Expressions:
QA=mA*r;
QB=mB*r;
JSrz_m=mr*l_s*(l-l_s);      // moment of inertia of the mechanical model about z axis through the Sr point
(kgm^2)
lamda=r/l;                  // ratio of the crank radius and connecting rod length
Omega=2*%pi*n/60;           // angular velocity (rad/s)
//
pszi=(1:64);
Fx=(1:64);
Fy=(1:64);
// Calculation ----------------------------------------------------------------------------------------
for i=1:64
    pszi(i)=(i-1)*0.1;
    Fx(i)=(Omega^2 )*((QA + QB)*cos(pszi(i))+ QB*(A2*cos(2*pszi(i))-
    A4*cos(4*pszi(i))+A6*cos(6*pszi(i))));
    Fy(i)=Omega^2 *QA*sin(pszi(i));
    M0z(i)=(JSrz-JSrz_m)*lamda*Omega^2*(C1*sin(pszi(i))-C3*sin(3*pszi(i))+C5*sin(5*pszi(i)));
end
```

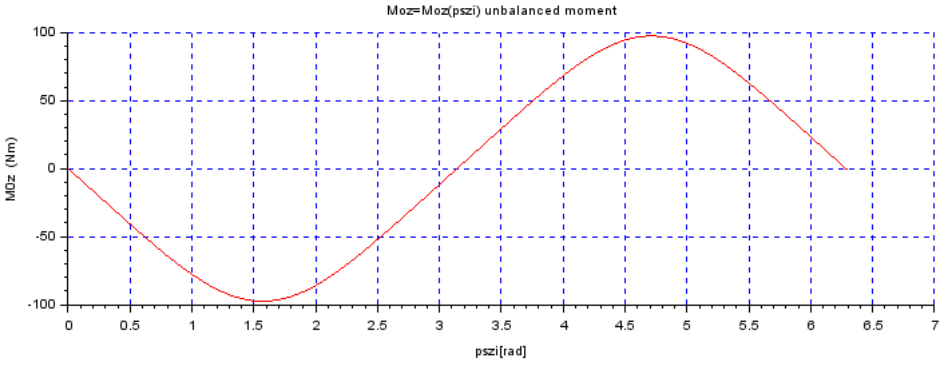
```
// Plotting results ------------------------------------------------------------------------------
subplot(3,1,1)
plot2d(pszi,Fx)
xtitle("Fx=Fx(pszi)  unbalanced force" , "pszi[rad]", "Fx  (N)" )
xgrid(2)

subplot(3,1,2)
plot2d(pszi,Fy)
xtitle("Fy=Fy(pszi)  unbalanced force" , "pszi[rad]", "Fy  (N)" )
xgrid(2)

subplot(3,1,3)
plot2d(pszi,M0z,5)
xtitle("Moz=Moz(pszi) unbalanced moment" , "pszi[rad]", "M0z  (Nm)" )
xgrid(2)
```

>>>>>> Save the script.

Execute: Execute >>>> …. file with no echo







6/2 Exercise – Complex Function Plotting

$z(t) = Ae^{(-40+150i)t}$, where: $A = (0{,}01 + 0{,}003i)$ is the amplitude of the comlplex function

$z(t) = (0{,}01 + 0{,}003i)e^{(-40+150i)t}$ complex function

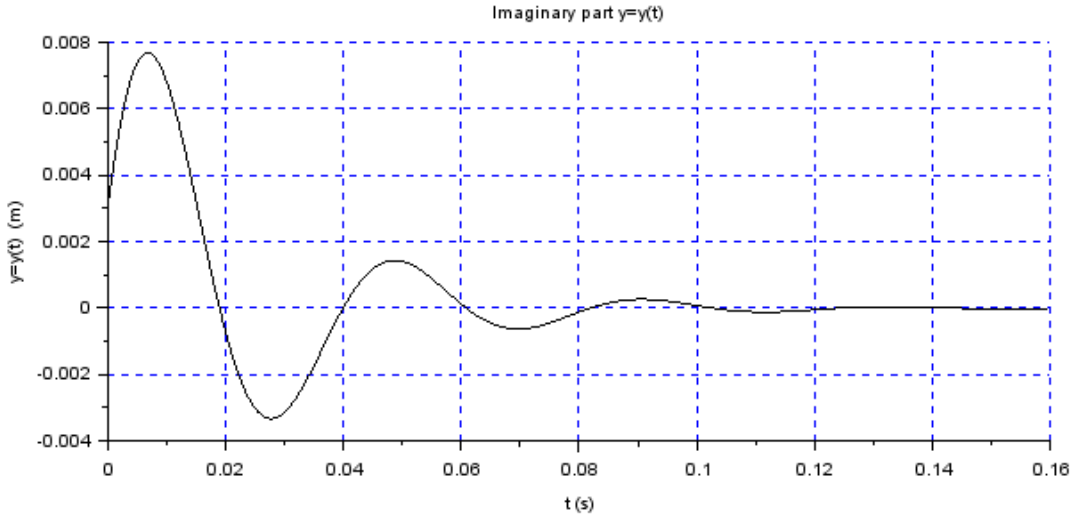
Imaginary part : $y = y(t) = Im[z(t)]$, Real part: $x = x(t) = Re[z(t)]$

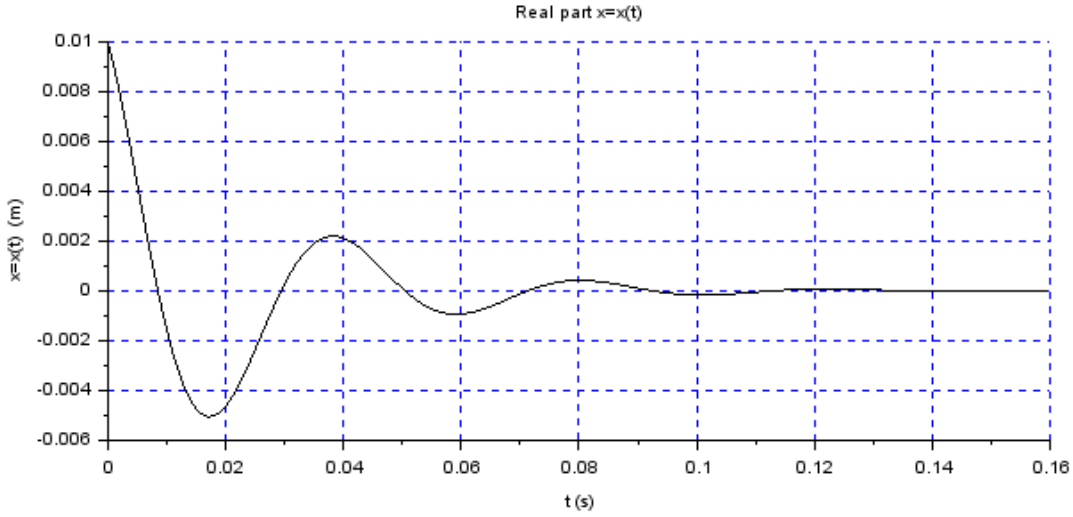
Time interval: *0 - 0,16 s*

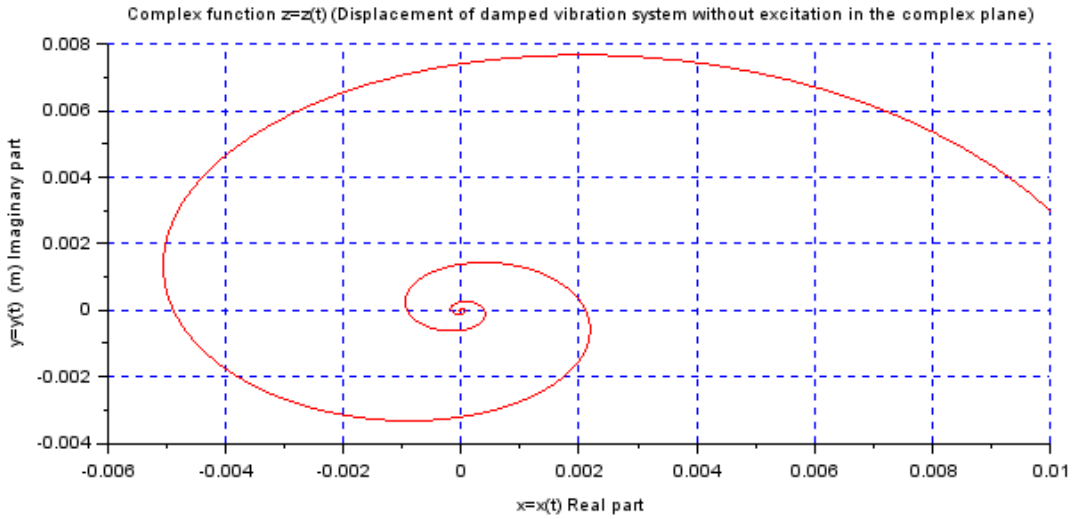
```
// week 6 – 2nd exercise
// Plot the complex function
clear;
// Variables----------------------------------------------------------------------------------------
A=(0.01+(%i)*0.003);        // complex amplitude
tmax=0.16;                  // end time (s)
dt=0.0005;                  // time increment (s)
n=int(tmax/dt);             // number of steps
t=(1:n);
z=(1:n);
y=(1:n);
x=(1:n);
t0=-dt;
// Calculation ----------------------------------------------------------------------------------
for i=1:n
    t(i)=t0+dt;
    z(i)=A*((%e)^((-40+(%i)*150)*t(i)));        // complex function
    y(i)=imag(z(i));                            // imaginary part
    x(i)=real(z(i));                            // real part
    t0=t(i);
end
// Plotting the results ----------------------------------------------------------------------------
subplot(3,1,1)
plot2d(t,y,1);              // plot imaginary part
xtitle(" Imaginary part y=y(t)"," t (s)"," y=y(t)  (m)");
xgrid(2);
subplot(3,1,2)
plot2d(t,x,1);              //plot real part
xtitle(" Real part x=x(t) "," t (s)"," x=x(t)  (m)");
xgrid(2);
subplot(3,1,3)
plot2d(x,y,5);              // plot z=z(t) complex function
xtitle(" Complex function z=z(t) (Displacement of damped vibration system without excitation in the complex
plane)"," x=x(t) Real part"," y=y(t)  (m) Imaginary part");
xgrid(2);
```

>>>>>> Save the script.

Execute: Execute >>>> …. file with no echo


Imaginary part y=y(t)
y=y(t) (m)
0.008
0.006
0.004
0.002
0
-0.002
-0.004
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
t (s)


Real part x=x(t)
x=x(t) (m)
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
t (s)


Complex function z=z(t) (Displacement of damped vibration system without excitation in the complex plane)
y=y(t) (m) Imaginary part
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.004
-0.002
0
0.002
0.004
0.006
0.008
0.01
x=x(t) Real part