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ICGE 2

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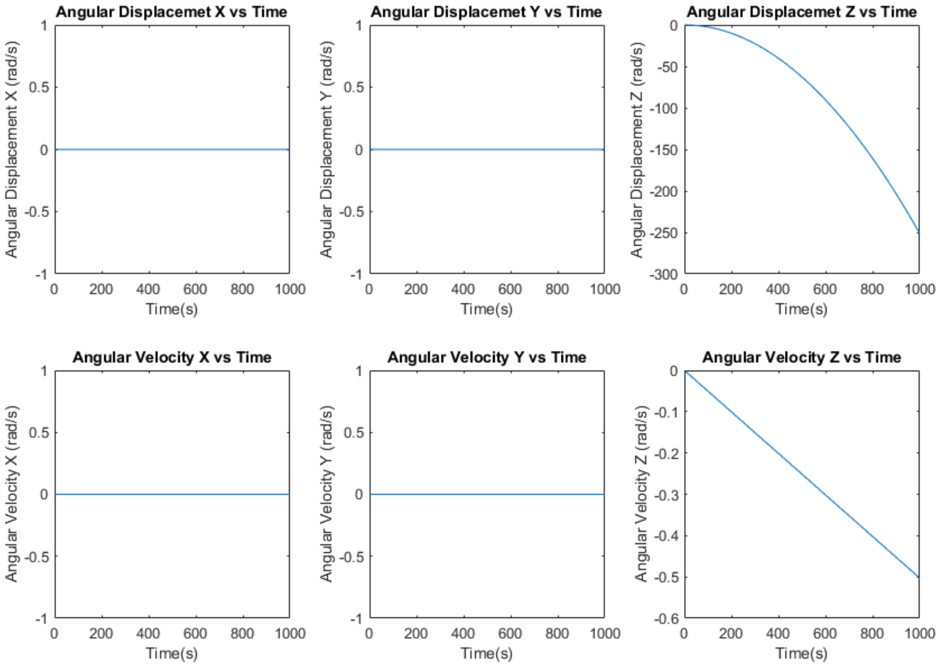
```
clear ; close all; clc;
ICGE2() ;
function ICGE2()

    L = 4 ; % Cylinder length in meters
    RR = 0.25 ; % Rocket radius in meters
    hn = 1 ; % nose height in meters
    Mb = 600 ; % Mass of body in kg
    Mn = 50 ; % Mass of nose in kg
    rW = 0.2 ; % radius of wheel in meters
    tW = 0.04 ; % thickness of wheel in meters
    mW = 10 ; % mass of wheel in kg

    % inertia matrix of the rocket body
    Ib=[ (1/12)*Mb*(3*RR^2+L^2) , 0 , 0 ; ...
        0 , (1/12)*Mb*(3*RR^2+L^2) , 0 ; ...
        0 , 0 , 0.5*Mb*RR^2 ] ;

    % inertia matrix of the rocket nose
    In = [ ((1/10)*Mn*hn^2)+((3/20)*Mn*RR^2) , 0 , 0 ; ...
        0 , ((1/10)*Mn*hn^2)+((3/20)*Mn*RR^2) , 0 ; ...
        0 , 0 , (3/10)*Mn*RR^2 ] ;

    % inertia matrix of the wheel
    Iw=[ (1/12)*mW*(3*rW^2+tW^2) , 0 , 0 ; ...
        0 , (1/12)*mW*(3*rW^2+tW^2) , 0 ; ...
        0 , 0 , 0.5*mW*rW^2 ] ;

    % Centers of mass from bottom of rocket in meters
    CoM_rocket = [ 0 ; 0 ; (2*600+4.25*50)/650 ] ;
    CoM_cone = [ 0 ; 0 ; 4.25 ] ;
    CoM_body = [ 0 ; 0 ; 2 ] ;

    % distance of center of mass of piece from system center of mass
    rwc = [ 0 ; 0 ; 0 ] ;
    rbc = CoM_rocket - CoM_body ;
    rnc = CoM_rocket - CoM_cone ;

    % inertia matrix about rockets center of mass
    Jb = Ib - Mb*crossmatrix(rbc)*crossmatrix(rbc) ;
    Jn = In - Mn*crossmatrix(rnc)*crossmatrix(rnc) ;
    Ir = Jb + Jn ;

    % Set up
    opts = odeset( 'AbsTol' , 10^-8 , 'RelTol' , 10^-8 ) ;
    tspan = [ 0 1000 ] ; % Time span to integrate over
    dwrel = [ 0 ; 0 ; 0.05 ] ; % angular acceleration
```

3

```
    Td = [ 0 ; 0 ; 0 ] ;
    state = [ 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 0 ] ;
    RocketAndWheelPlots( tspan , state , opts , dwrel , Td , Iw ,
Ir , '3 (no torque)' ) ;
```

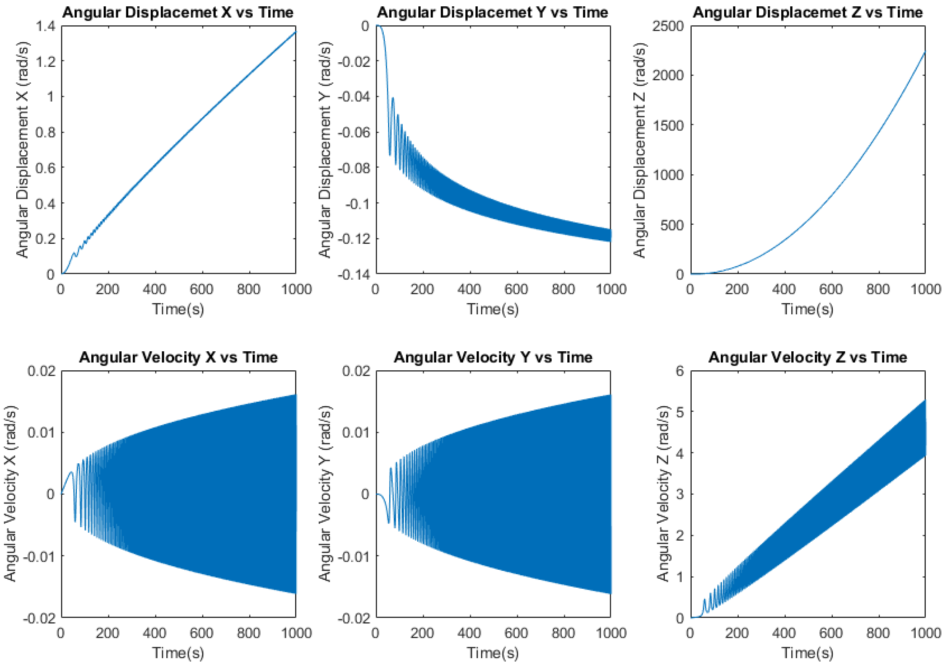


4

```
    Td = [ 0.1 ; 0 ; 0 ] ;
```

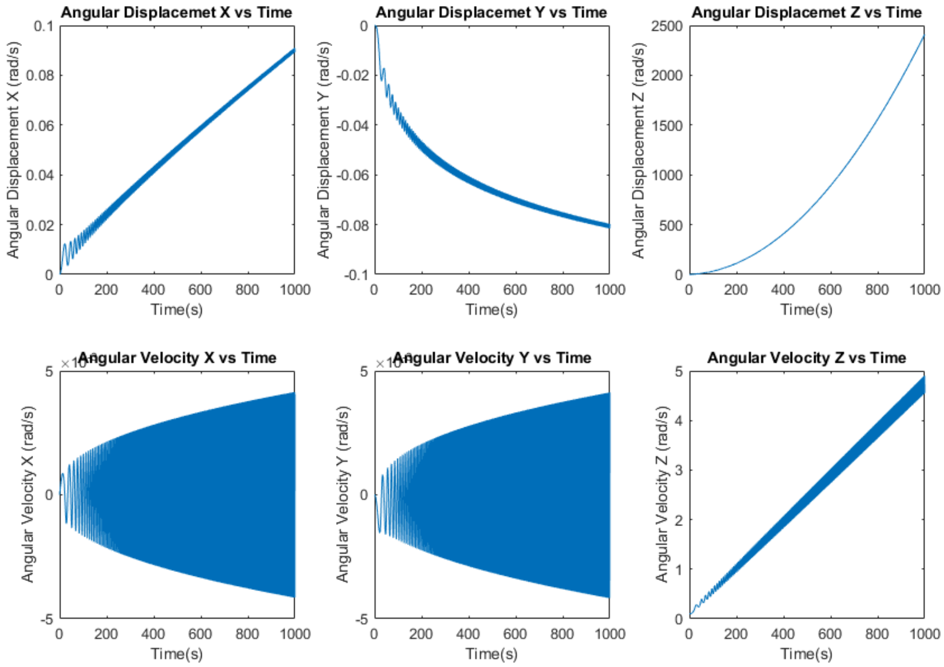
a

```
    statea = [ 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 0 ] ;
    RocketAndWheelPlots( tspan , state , opts , dwrel , Td , Iw ,
Ir , '4a' ) ;
```



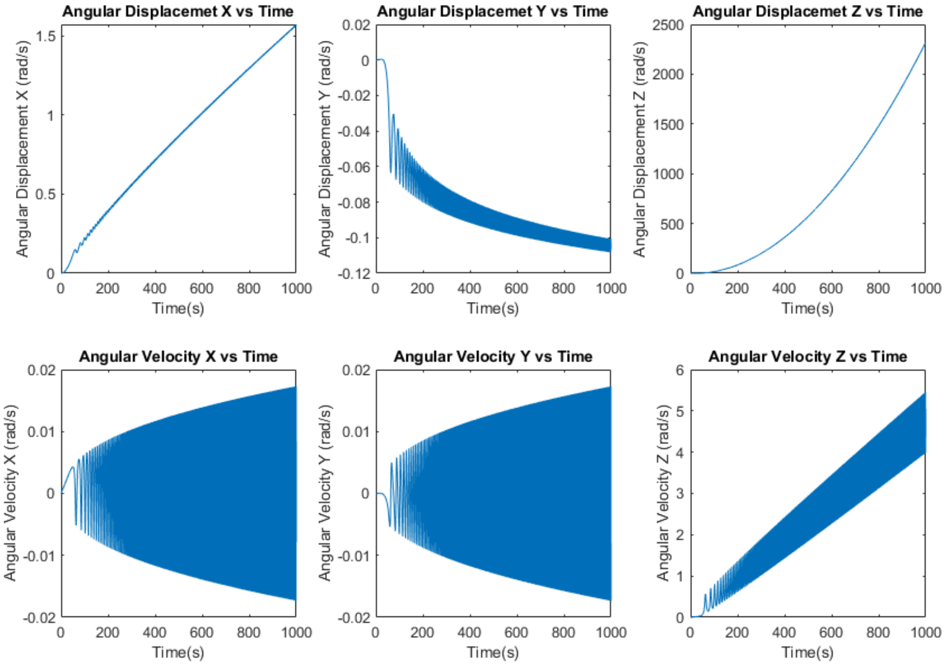
b

```
   stateb = [ 0 ; 0 ; 0 ; 0 ; 0 ; 0.1 ; 0 ; 0 ; 0 ] ;
   RocketAndWheelPlots( tspan , stateb , opts , dwrel , Td , Iw ,
Ir , '4b' ) ;
```



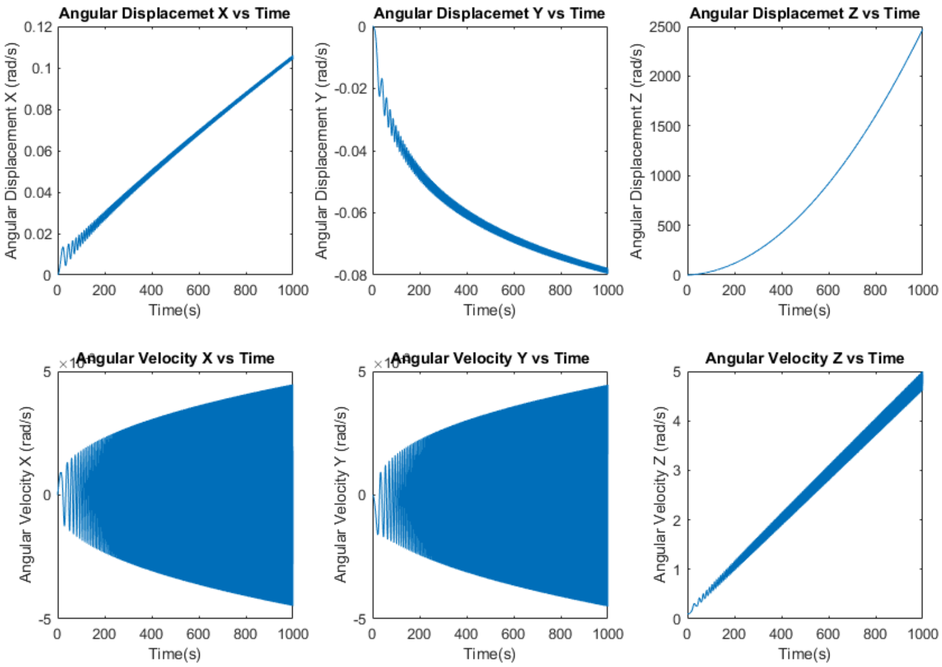
c

```
   statec = [ 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 0 ; 100 ] ;
   RocketAndWheelPlots( tspan , statec , opts , dwrel , Td , Iw ,
Ir , '4c' ) ;
```



d

```
   stated = [ 0 ; 0 ; 0 ; 0 ; 0 ; 0.1 ; 0 ; 0 ; 100 ] ;
   RocketAndWheelPlots( tspan , stated , opts , dwrel , Td , Iw ,
Ir , '4d' ) ;
```



Functions

```
   function [ across ] = crossmatrix( a )
       across = [ 0 -a(3) a(2) ; ...
                  a(3) 0 -a(1) ; ...
                 -a(2) a(3) 0 ] ;
   end

   function RocketAndWheelPlots( tspan , state , opts , dwrel , Td ,
Iw , Ir , name )

       [t,state]=ode45( @RocketAndWheel , tspan , state , opts ,
dwrel , Td , Iw , Ir ) ;

       figure( 'Name' , name , 'NumberTitle' , 'off' , 'Position' ,
[ 100 50 1000 650 ] ) ;

       subplot(2,3,1)
       plot( t , state(:,1) )
       title( 'Angular Displacemet X vs Time' )
       xlabel( 'Time(s)' )
       ylabel( 'Angular Displacement X (rad/s)' )

       subplot(2,3,2)
       plot( t , state(:,2) )
       title( 'Angular Displacemet Y vs Time' )
       xlabel( 'Time(s)' )
       ylabel( 'Angular Displacement Y (rad/s)' )
```

```
        subplot(2,3,3)
        plot( t , state(:,3) )
        title( 'Angular Displacemet Z vs Time' )
        xlabel( 'Time(s)' )
        ylabel( 'Angular Displacement Z (rad/s)' )

        subplot(2,3,4)
        plot(t,state(:,4))
        title( 'Angular Velocity X vs Time' )
        xlabel( 'Time(s)' )
        ylabel( 'Angular Velocity X (rad/s)' )

        subplot(2,3,5)
        plot(t,state(:,5))
        title( 'Angular Velocity Y vs Time' )
        xlabel( 'Time(s)' )
        ylabel( 'Angular Velocity Y (rad/s)' )

        subplot(2,3,6)
        plot(t,state(:,6))
        title( 'Angular Velocity Z vs Time' )
        xlabel( 'Time(s)' )
        ylabel( 'Angular Velocity Z (rad/s)' )

    end

    function [ dstate ] = RocketAndWheel( t , state , dwrel , Td ,
 Iw , Ir )

        thetar = state(1:3) ;
        wr = state(4:6) ;
        wrel = state(7:9) ;
        dstate = zeros( 9 , 1 ) ;

        dwr = -inv( Ir+Iw ) * ( Iw*dwrel + crossmatrix(wr+wrel)*Iw*(wr
+wrel) + crossmatrix(wr)*Ir*wr - Td ) ;
        dstate(1:3) = wr ;
        dstate(4:6) = dwr ;
        dstate(7:9) = dwrel ;
    end

end
```

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