In [1]:
```
%matplotlib notebook
import numpy as np
import sympy as sp
from matplotlib import pyplot as plt
from matplotlib.animation import FuncAnimation
from IPython import display
from mpl_toolkits.mplot3d import Axes3D
from IPython.display import HTML
```

Simulacion de tres cuerpos

In [2]:
```
x,y,z,r,x1,x2,x3,y1,y2,y3,z1,z2,z3=sp.symbols('x,y,z,r,x1,x2,x3,y1,y2,y3,z1,z2,z3')
vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,t,m_1,m_2,m_3=sp.symbols('vx1,vx2,vx3,vy1,vy2,v
```

In [3]:
```
k=39.478
p1=sp.Matrix([x1,y1,z1])
p2=sp.Matrix([x2,y2,z2])
p3=sp.Matrix([x3,y3,z3])
v1=sp.Matrix([vx1,vy1,vz1])
v2=sp.Matrix([vx2,vy2,vz2])
v3=sp.Matrix([vx3,vy3,vz3])
```

In [3]:
```
F1
```

In [8]:
```
F2
```

Out[8]:

$$\left[\begin{matrix}\frac{3.9478x_1-3.9478x_2}{\left(|x_1-x_2|^2+|y_1-y_2|^2+|z_1-z_2|^2\right)^{\frac{3}{2}}}-\frac{3.9478x_2-3.9478x_3}{\left(|x_2-x_3|^2+|y_2-y_3|^2+|z_2-z_3|^2\right)^{\frac{3}{2}}}\\ \frac{3.9478y_1-3.9478y_2}{\left(|x_1-x_2|^2+|y_1-y_2|^2+|z_1-z_2|^2\right)^{\frac{3}{2}}}-\frac{3.9478y_2-3.9478y_3}{\left(|x_2-x_3|^2+|y_2-y_3|^2+|z_2-z_3|^2\right)^{\frac{3}{2}}}\\ \frac{3.9478z_1-3.9478z_2}{\left(|x_1-x_2|^2+|y_1-y_2|^2+|z_1-z_2|^2\right)^{\frac{3}{2}}}-\frac{3.9478z_2-3.9478z_3}{\left(|x_2-x_3|^2+|y_2-y_3|^2+|z_2-z_3|^2\right)^{\frac{3}{2}}}\end{matrix}\right]$$

In [9]:
```
F3
```

Out[9]:

$$\left[\begin{matrix}\frac{3.9478x_1-3.9478x_3}{\left(|x_1-x_3|^2+|y_1-y_3|^2+|z_1-z_3|^2\right)^{\frac{3}{2}}}-\frac{-3.9478x_2+3.9478x_3}{\left(|x_2-x_3|^2+|y_2-y_3|^2+|z_2-z_3|^2\right)^{\frac{3}{2}}}\\ \frac{3.9478y_1-3.9478y_3}{\left(|x_1-x_3|^2+|y_1-y_3|^2+|z_1-z_3|^2\right)^{\frac{3}{2}}}-\frac{-3.9478y_2+3.9478y_3}{\left(|x_2-x_3|^2+|y_2-y_3|^2+|z_2-z_3|^2\right)^{\frac{3}{2}}}\\ \frac{3.9478z_1-3.9478z_3}{\left(|x_1-x_3|^2+|y_1-y_3|^2+|z_1-z_3|^2\right)^{\frac{3}{2}}}-\frac{-3.9478z_2+3.9478z_3}{\left(|x_2-x_3|^2+|y_2-y_3|^2+|z_2-z_3|^2\right)^{\frac{3}{2}}}\end{matrix}\right]$$

Runge Kutta 4to orden

```
In [4]: def d2ydt2(y,f1,f2,f3,g1,g2,g3,h1,h2,h3):
            return np.array([y[9],
                             y[10],
                             y[11],
                             y[12],
                             y[13],
                             y[14],
                             y[15],
                             y[16],
                             y[17],
                             f1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             g1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             h1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             f2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             g2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             h2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             f3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             g3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             h3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                             1])

        def RK42(c1,c2,c3,dt,tf,F1,F2,F3,R,CV,M):
            #Vectorizcion de funciones
            f1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            f2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            f3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            g1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            g2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            g3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            h1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            h2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            h3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
            ts=np.arange(0,tf,dt)
            TT=0#tiempo en completar orbita
            n=len(ts)
            ####################################Posiciones
            ys1=ts*0
            xs1=ts*0
            zs1=ts*0
            #
            ys2=ts*0
            xs2=ts*0
            zs2=ts*0
            #
            ys3=ts*0
            xs3=ts*0
            zs3=ts*0

            #####################################Velocidades
            vys1=ts*0
            vxs1=ts*0
            vzs1=ts*0
            #
            vys2=ts*0
            vxs2=ts*0
            vzs2=ts*0
```

```python
    #
    vys3=ts*0
    vxs3=ts*0
    vzs3=ts*0
    ###########################3##aceleraciones
    ays1=ts*0
    axs1=ts*0
    azs1=ts*0
    #
    ays2=ts*0
    axs2=ts*0
    azs2=ts*0
    #
    ays3=ts*0
    axs3=ts*0
    azs3=ts*0
    #############Condiciones iniciales
    xs1[0]=c1[0]
    ys1[0]=c1[1]
    zs1[0]=c1[2]
    vxs1[0]=c1[3]
    vys1[0]=c1[4]
    vzs1[0]=c1[5]
    #############
    xs2[0]=c2[0]
    ys2[0]=c2[1]
    zs2[0]=c2[2]
    vxs2[0]=c2[3]
    vys2[0]=c2[4]
    vzs2[0]=c2[5]
    ###########
    xs3[0]=c3[0]
    ys3[0]=c3[1]
    zs3[0]=c3[2]
    vxs3[0]=c3[3]
    vys3[0]=c3[4]
    vzs3[0]=c3[5]

    for i in range(0,n-1):
        #Runge Kutta
        z0=np.array([xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i]
        k1=d2ydt2(z0,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k2=d2ydt2(z0+(dt*k1)/2,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k3=d2ydt2(z0+(dt*k2)/2,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k4=d2ydt2(z0+dt*k3,f1,f2,f3,g1,g2,g3,h1,h2,h3)

        #Vectores M1
        xs1[i+1]=xs1[i]+(dt/6)*(k1[0]+2*k2[0]+2*k3[0]+k4[0])
        ys1[i+1]=ys1[i]+(dt/6)*(k1[3]+2*k2[3]+2*k3[3]+k4[3])
        zs1[i+1]=zs1[i]+(dt/6)*(k1[6]+2*k2[6]+2*k3[6]+k4[6])
        vxs1[i+1]=vxs1[i]+(dt/6)*(k1[9]+2*k2[9]+2*k3[9]+k4[9])
        vys1[i+1]=vys1[i]+(dt/6)*(k1[12]+2*k2[12]+2*k3[12]+k4[12])
        vzs1[i+1]=vzs1[i]+(dt/6)*(k1[15]+2*k2[15]+2*k3[15]+k4[15])

        axs1[i]=f1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays1[i]=f2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
```

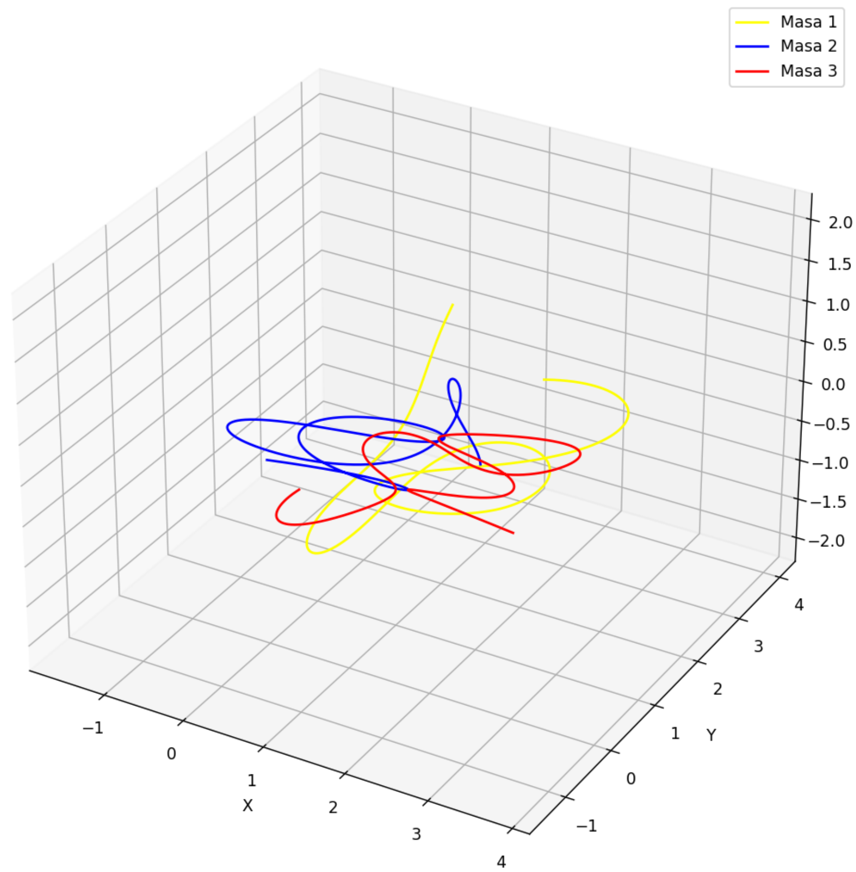
```
        azs1[i]=f3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v

        ################Vectores M2
        xs2[i+1]=xs2[i]+(dt/6)*(k1[1]+2*k2[1]+2*k3[1]+k4[1])
        ys2[i+1]=ys2[i]+(dt/6)*(k1[4]+2*k2[4]+2*k3[4]+k4[4])
        zs2[i+1]=zs2[i]+(dt/6)*(k1[7]+2*k2[7]+2*k3[7]+k4[7])
        vxs2[i+1]=vxs2[i]+(dt/6)*(k1[10]+2*k2[10]+2*k3[10]+k4[10])
        vys2[i+1]=vys2[i]+(dt/6)*(k1[13]+2*k2[13]+2*k3[13]+k4[13])
        vzs2[i+1]=vzs2[i]+(dt/6)*(k1[16]+2*k2[16]+2*k3[16]+k4[16])

        axs2[i]=g1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays2[i]=g2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs2[i]=g3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v

        ###Vectores M3############################################

        xs3[i+1]=xs3[i]+(dt/6)*(k1[2]+2*k2[2]+2*k3[2]+k4[2])
        ys3[i+1]=ys3[i]+(dt/6)*(k1[5]+2*k2[5]+2*k3[5]+k4[5])
        zs3[i+1]=zs3[i]+(dt/6)*(k1[8]+2*k2[8]+2*k3[8]+k4[8])
        vxs3[i+1]=vxs3[i]+(dt/6)*(k1[11]+2*k2[11]+2*k3[11]+k4[11])
        vys3[i+1]=vys3[i]+(dt/6)*(k1[14]+2*k2[14]+2*k3[14]+k4[14])
        vzs3[i+1]=vzs3[i]+(dt/6)*(k1[17]+2*k2[17]+2*k3[17]+k4[17])

        axs3[i]=h1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays3[i]=h2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs3[i]=h3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
       #######Graficas####################################

   ########################vectores relativos####################################
    if R==True:
        fig = plt.figure(figsize=(10,10))
        ax = fig.add_subplot(111, projection='3d')
        #fig2=plt.add(figsize=(10,10))
        #ax.scatter(0,0,0,color='yellow',s=30)
        ax.plot(xs1,ys1,zs1,color='yellow',label='Masa 1')
        ax.plot(xs2,ys2,zs2,color='blue',label='Masa 2')
        ax.plot(xs3,ys3,zs3,color='red',label='Masa 3')
        plt.xlabel('X')
        plt.ylabel('Y')
        #plt.axis('equal')

        #plt.plot(vxs,vys,color='blue',label='Velocidad x vs velocidad y')
        #plt.plot(axs,ays,color='red',label='Aceleracion x vs aceleracion y')
        if CV==True:
            ll=50
            ax.quiver(xs[1:-1:ll],ys[1:-1:ll],axs[1:-1:ll],ays[1:-1:ll],color='red'
            ax.quiver(xs[1:-1:ll],ys[1:-1:ll],vxs[1:-1:ll],vys[1:-1:ll],color='blue
        plt.axis('equal')
        plt.grid('on')
        plt.legend()
        plt.show()
    ####################Campos vectoriaels########################################

    if M==True:
    ##############################Magnitudes#################################
        fig3=plt.figure(figsize=(7,7))
```

```
        plt.plot(ts,np.sqrt(xs**2+ys**2),color='yellow',label='r vs tiempo')
        plt.plot(ts,np.sqrt(axs**2+ays**2),color='blue',label='aceleracion neta vs 
        plt.plot(ts,np.sqrt(vxs**2+vys**2),color='red',label='Velocidad neta vs tie
        #plt.plot(ts,vxs,color='red',label='Velocidad')
        #plt.plot(ts,axs,color='blue',label='aceleracion')
        plt.ylabel('Unidades Atronomicas UA')
        plt.xlabel('tiempo(años)')
        #plt.axis('equal')
        plt.grid('on')
        plt.legend()
        plt.show()
    return xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,v
```

Caso Arbitrario

In [203…

```
m1=1.5/10# Sol
m2= 2.5/10#333030 #Tierra
m3=3.2/10#3.69432e-8#Luna


F1=(-k*m2*(p1-p2)/(p1-p2).norm()**(3)-k*m3*(p1-p3)/(p1-p3).norm()**(3))*(m1/m1)
F2=(-k*m1*(p2-p1)/(p2-p1).norm()**(3)-k*m3*(p2-p3)/(p2-p3).norm()**(3))*(m2/m2)
F3=(-k*m1*(p3-p1)/(p3-p1).norm()**(3)-k*m2*(p3-p2)/(p3-p2).norm()**(3))*(m3/m3)


MM1=np.array([0,4,0,0,0,0])
MM2=np.array([0,0,0,0,0,0])
MM3=np.array([3,0,0,0,0,0])
xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2,vzs3,ax
```



Velocidad Centro de masa

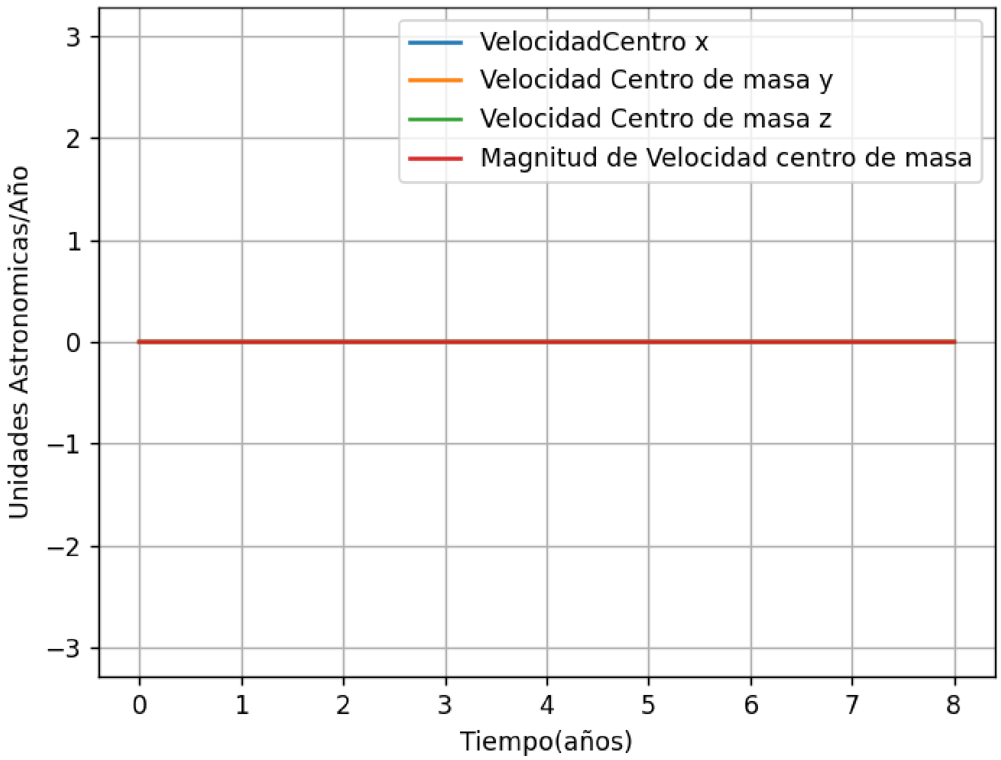
In [204…

```
VX=vx1*m_1+vx2*m_2+vx3*m_3#xs1*m1+xs2*m2+xs3*m3
VY=vy1*m_1+vy2*m_2+vy3*m_3#ys1*m1+ys2*m2+ys3*m3
VZ=vz1*m_1+vz2*m_2+vz3*m_3#zs1*m1+zs2*m2+zs3*m3
M=m_1+m_2+m_3
VM=sp.Matrix([VX,VY,VZ])*(1/M)

vx11=sp.lambdify([vx1,vx2,vx3,m_1,m_2,m_3],VM[0])
vy11=sp.lambdify([vy1,vy2,vy3,m_1,m_2,m_3],VM[1])
vz11=sp.lambdify([vz1,vz2,vz3,m_1,m_2,m_3],VM[2])
```

In [205…

```
fig2=plt.figure()
vxx=vx11(vxs1,vxs2,vxs3,m1,m2,m3)
vyy=vy11(vys1,vys2,vys3,m1,m2,m3)
vzz=vz11(vzs1,vzs2,vzs3,m1,m2,m3)
plt.plot(ts,vxx,label='VelocidadCentro x')
plt.plot(ts,vyy,label='Velocidad Centro de masa y')
```

```
plt.plot(ts,vzz,label='Velocidad Centro de masa z')
plt.plot(ts,np.sqrt(vxx**2+vyy**2+vzz**2),label='Magnitud de Velocidad centro de ma
#plt.ylim([-0.5,0.5])
plt.legend()
plt.ylabel('Unidades Astronomicas/Año')
plt.xlabel('Tiempo(años)')
plt.grid('on')
plt.axis('equal')
```



Out[205]:
```
(-0.39999950000000006,
 8.3999895,
 -5.1164942487929194e-14,
 8.559431211857843e-14)
```

In [43]:
```
np.sqrt(vxx**2+vyy**2+vzz**2)[-100000]-np.sqrt(vxx**2+vyy**2+vzz**2)[0]
```

Out[43]:
```
7.388945199675211e-14
```

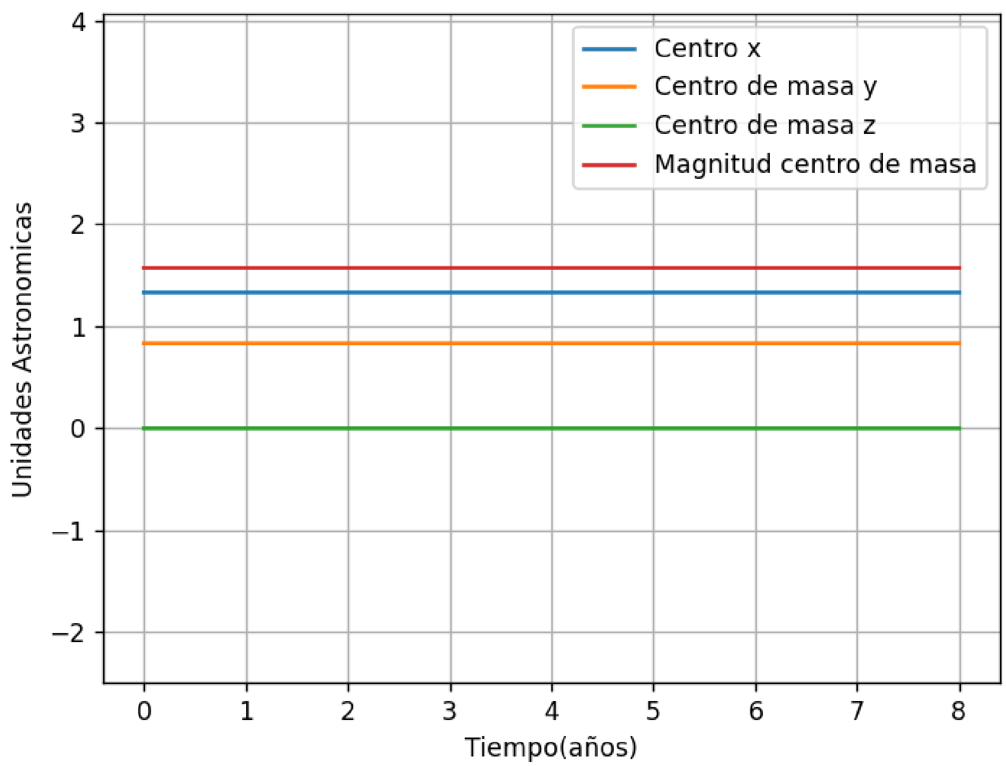
Centro de Masa

In [4]:
```
CX=x1*m_1+x2*m_2+x3*m_3#xs1*m1+xs2*m2+xs3*m3
CY=y1*m_1+y2*m_2+y3*m_3#ys1*m1+ys2*m2+ys3*m3
CZ=z1*m_1+z2*m_2+z3*m_3#zs1*m1+zs2*m2+zs3*m3
M=m_1+m_2+m_3
CM=sp.Matrix([CX,CY,CZ])*(1/M)

cx1=sp.lambdify([x1,x2,x3,m_1,m_2,m_3],CM[0])
```

```
cy1=sp.lambdify([y1,y2,y3,m_1,m_2,m_3],CM[1])
cz1=sp.lambdify([z1,z2,z3,m_1,m_2,m_3],CM[2])
```

In [207…:

```
fig2=plt.figure()
cxx=cx1(xs1,xs2,xs3,m1,m2,m3)
cyy=cy1(ys1,ys2,ys3,m1,m2,m3)
czz=cz1(zs1,zs2,zs3,m1,m2,m3)
plt.plot(ts,cxx,label='Centro x')
plt.plot(ts,cyy,label='Centro de masa y')
plt.plot(ts,czz,label='Centro de masa z')
plt.plot(ts,np.sqrt(cxx**2+cyy**2+czz**2),label='Magnitud centro de masa')
plt.legend()
plt.ylabel('Unidades Astronomicas')
plt.xlabel('Tiempo(años)')
plt.grid('on')
plt.axis('equal')
```



Out[207]:

```
(-0.39999950000000006, 8.3999895, -0.07861650943381412, 1.6509466981100964)
```

Puntos de Lagrange

In [5]:

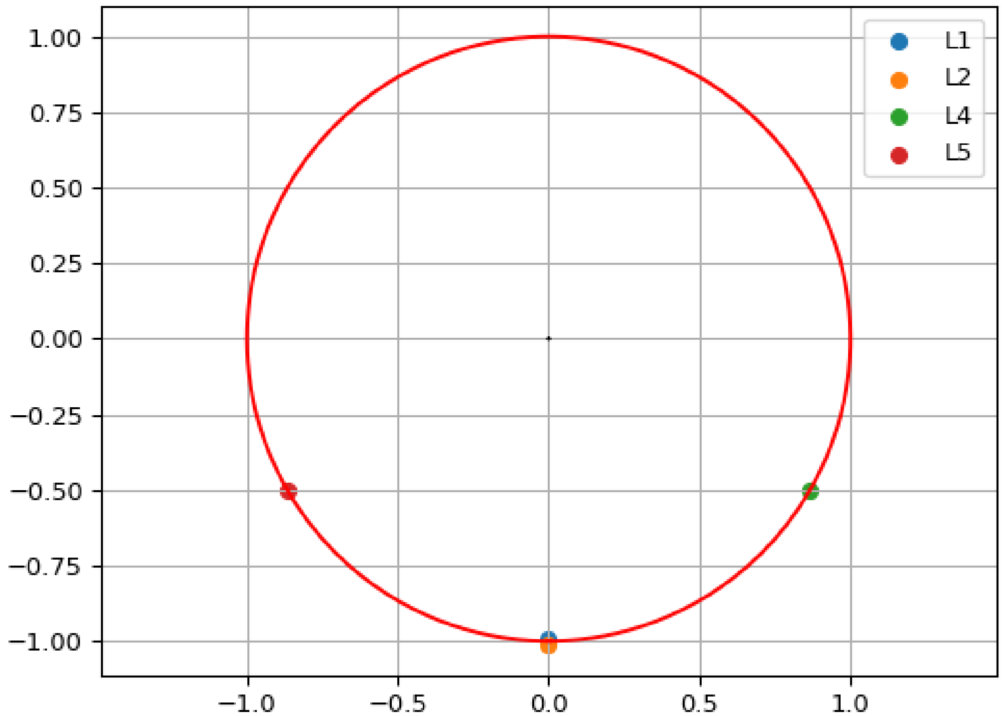
```
r1=(p1-CM).subs(z1,0).subs(z2,0).subs(z3,0)
r2=(p2-CM).subs(z1,0).subs(z2,0).subs(z3,0)
a=r1+r2


L1=a.norm()*(1-((m_2/(3*m_1))**(1/3)))*(a.subs(z2,0)/a.subs(z2,0).norm())
```

```
L1x1=sp.lambdify([x1,x2,x3,y1,y2,y3,m_1,m_2,m_3],L1[0])
L1y1=sp.lambdify([x1,x2,x3,y1,y2,y3,m_1,m_2,m_3],L1[1])


L2=r2.norm()*(1+(m_2/(3*m_1))**(1/3))*(a.subs(z2,0)/a.subs(z2,0).norm())
L2x1=sp.lambdify([x1,x2,x3,y1,y2,y3,m_1,m_2,m_3],L2[0])
L2y1=sp.lambdify([x1,x2,x3,y1,y2,y3,m_1,m_2,m_3],L2[1])


#L4x=(r2.norm()/2)*((m1-m2)/(m1+m2))
#L4y=(sp.sqrt(3)/2)*r2.norm()
#L4x=sp.lambdify([x1,x2,x3,y1,y2,y3],L4x)
#L4y=sp.lambdify([x1,x2,x3,y1,y2,y3],L4y)

#L4x=sp.Matrix([(x1-2*CX+x2)*((m1-m2)/(m1+m2)),,0])
o=sp.pi/3
oo=(a.subs(z2,0)/a.subs(z2,0).norm())
spp=oo[1]*sp.cos(o)+oo[0]*sp.sin(o)
cpp=oo[0]*sp.cos(o)-oo[1]*sp.sin(o)

L4=sp.Matrix([a.norm()*((m_1-m_2)/(m_1+m_2))*cpp,a.norm()*spp,0])
L4=(r2.norm()/2)*sp.sqrt(((m_1-m_2)/(m_1+m_2))**2+3)*sp.Matrix([cpp,spp,0])
L4x1=sp.lambdify([x1,x2,x3,y1,y2,y3,m_1,m_2,m_3],L4[0])
L4y1=sp.lambdify([x1,x2,x3,y1,y2,y3,m_1,m_2,m_3],L4[1])



###L5
o=-sp.pi/3
oo=(a.subs(z2,0)/a.subs(z2,0).norm())
spp=oo[1]*sp.cos(o)+oo[0]*sp.sin(o)
cpp=oo[0]*sp.cos(o)-oo[1]*sp.sin(o)
L5=(a.norm()/2)*sp.sqrt(((m_1-m_2)/(m_1+m_2))**2+3)*sp.Matrix([cpp,spp,0])
L5x1=sp.lambdify([x1,x2,x3,y1,y2,y3,m_1,m_2,m_3],L5[0])
L5y1=sp.lambdify([x1,x2,x3,y1,y2,y3,m_1,m_2,m_3],L5[1])



#L4y=r2.norm()/2*((m1-m2)/(m1+m2))

#L1x=
```

In [100…

```
fig6=plt.figure()
b=0
plt.axis('equal')
plt.grid('on')
plt.scatter(L1x[b],L1y[b],label='L1')
plt.scatter(L2x[b],L2y[b],label='L2')
plt.scatter(L4x[b],L4y[b],label='L4')
plt.scatter(L5x[b],L5y[b],label='L5')
#plt.plot(cx+L4x,cy+L4y,color='blue')
#plt.plot(ts,LL)
LL=np.sqrt(L4x**2+L4y**2)
plt.plot(xs2,ys2,color='red')
plt.plot(xs1,ys1,color='black')
plt.legend()
```

```
#plt.plot(L4x,L4y)
#plt.plot(L5x,L5y)

#plt.scatter(L1x-xs2,L1y-ys2)
```



Out[100]: <matplotlib.legend.Legend at 0x2431f9634c0>

conservacion de la energía

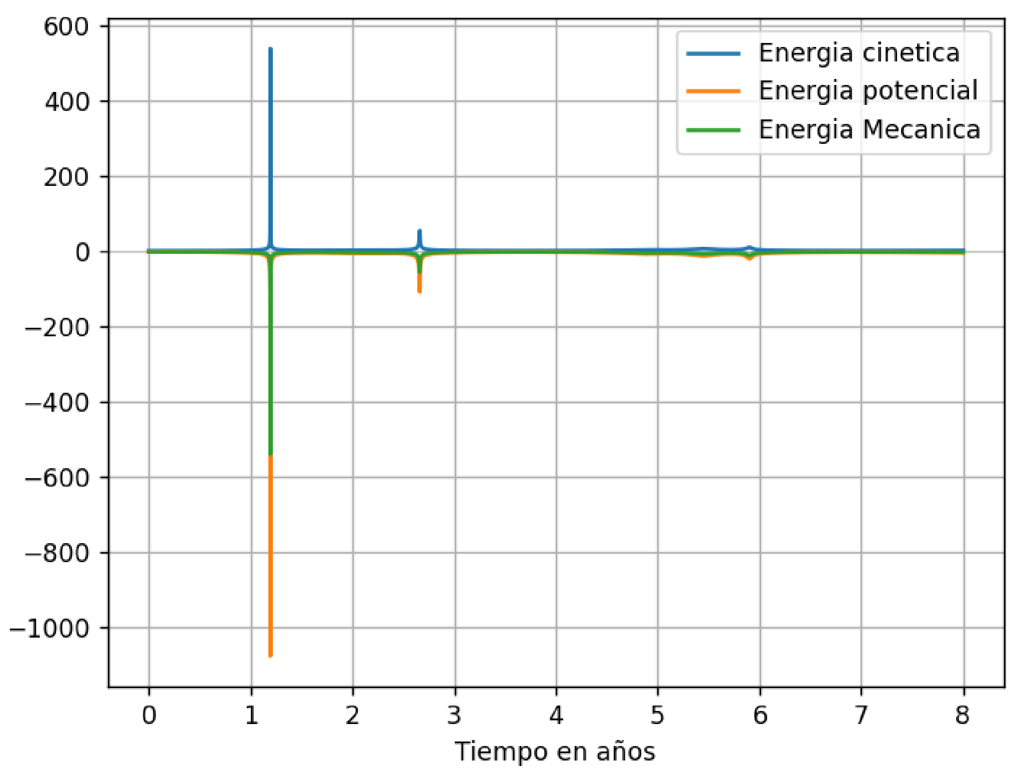
$$T_1 = \frac{1}{2} m_1(\dot{x}_1^2 + \dot{y}_1^2 + \dot{z}_1^2)$$

$$U_1 = \frac{km_1}{r_1}$$

In [208…

```
fig6=plt.figure()
T1=(1/2)*m1*(vxs1**2+vys1**2+vzs1**2)
T2=(1/2)*m2*(vxs2**2+vys2**2+vzs2**2)
T3=(1/2)*m3*(vxs3**2+vys3**2+vzs3**2)
T=T1+T2+T3
U1=-k*m1*(m2/((p1-p2).norm())+(m3/((p1-p3).norm())))
U2=-k*m2*(m1/((p2-p1).norm())+m3/((p2-p3).norm()))
U3=-k*m3*(m2/((p3-p2).norm())+m1/((p3-p1).norm()))
#U1=-k*m1/np.sqrt(xs1**2+ys1**2+zs1**2)
#U2=-k*m2/np.sqrt(xs2**2+ys2**2+zs2**2)
#U3=-k*m3/np.sqrt(xs3**2+ys3**2+zs3**2)
```

```python
U=U1+U2+U3
UUU=U3+U1+U2
UU=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3],UUU)
U=UU(xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3)
plt.plot(ts,T,label='Energia cinetica')
plt.plot(ts,U,label='Energia potencial')
plt.xlabel('Tiempo en años')
plt.plot(ts,T+U,label='Energia Mecanica')

#plt.axis('equal')
#plt.ylim(-1,1)
plt.grid('on')
plt.legend()
###
#r1=sp.sqrt((x-x1)**2+(y-y1)**2+(z-z1)**2)
#r2=sp.sqrt((x-x2)**2+(y-y2)**2+(z-z2)**2)
#r3=sp.sqrt((x3-x)**2+(y3-y)**2+(z3-z)**2)
#L1=p1.cross(m1*v1).norm()
#L2=p2.cross(m2*v2).norm()
#L3=p3.cross(m3*v3).norm()
#U11=-k/r1
#U22=-k/r2
#U33=-k/r3
#UU1=sp.lambdify([x,y,z,x1,y1,z1,vx1,vy1,vz1],U11+L1/(2*m1*r1**2))
#UU2=sp.lambdify([x,y,z,x2,y2,z2,vx2,vy2,vz2],U22+L2/(2*m2*r2**2))
#UU3=sp.lambdify([x,y,z,x3,y3,z3,vx3,vy3,vz3],U33+L3/(2*m3*r3**2))
```

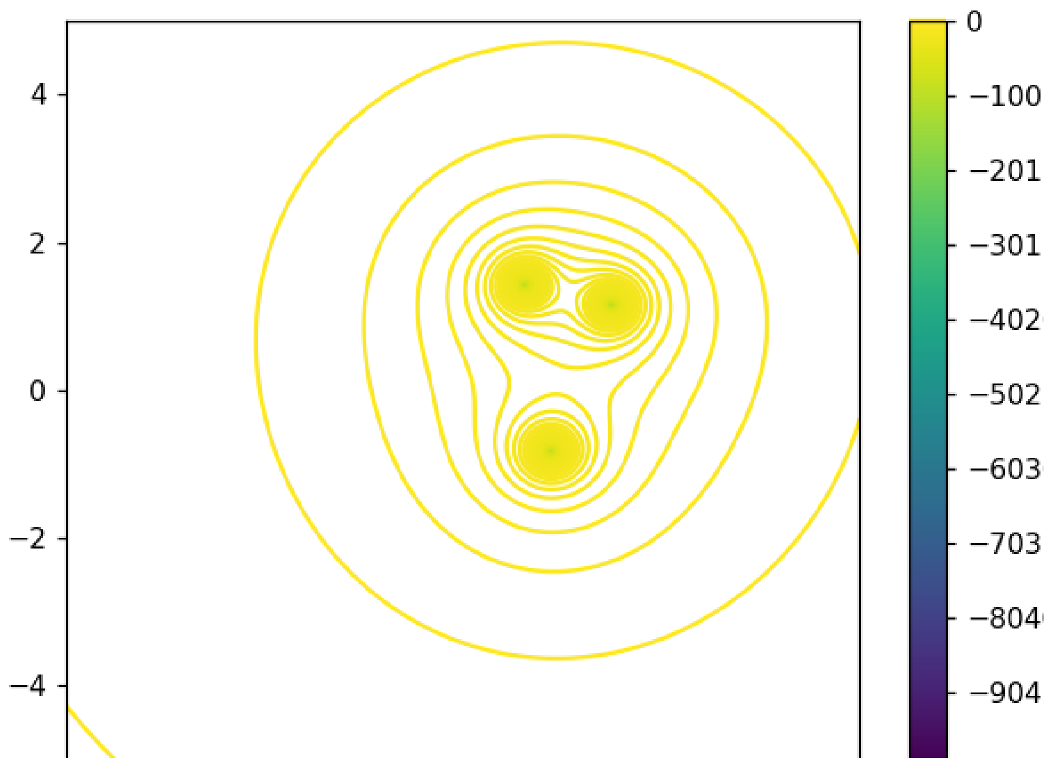


Out[208]: <matplotlib.legend.Legend at 0x1b2e2b97370>

$$U = \frac{km_i}{r_i}$$

In [628…

```
fig32=plt.figure()
xxs=np.linspace(-5,5,1000)
X,Y=np.meshgrid(xxs,xxs)
tss=-1
Z=UU2(X,Y,0,xs2[tss],ys2[tss],zs2[tss],vxs1[tss],vys1[tss],vzs1[tss])+UU3(X,Y,0,xs3

cm=plt.contour(X,Y,Z,levels=700)
plt.colorbar(cm)
```



Out[628]: <matplotlib.colorbar.Colorbar at 0x11324f98e20>

Sistema Sol,jupyter,asteroide

In [21]:

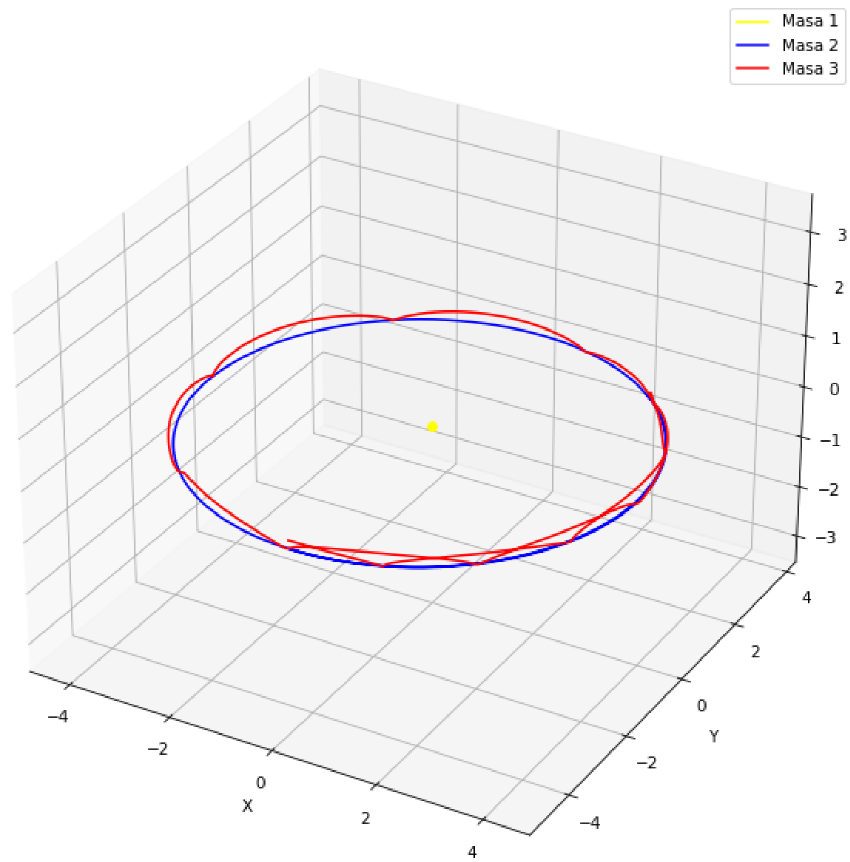
```
k1=k
m1=1# Sol
m2= 0.000954588 #jupyter
m3=0.000000000000000000000008#
F1=(-k*m2*(p1-p2)/(p1-p2).norm()**(3)-k*m3*(p1-p3)/(p1-p3).norm()**(3))*(m1/m1)*(k1
F2=(-k*m1*(p2-p1)/(p2-p1).norm()**(3)-k*m3*(p2-p3)/(p2-p3).norm()**(3))*(m2/m2)*(k1
F3=(-k*m1*(p3-p1)/(p3-p1).norm()**(3)-k*m2*(p3-p2)/(p3-p2).norm()**(3))*(m3/m3)*(k1
```

In [22]:

```
MM1=np.array([0,0,0,0,0,0])
MM2=np.array([0,-4.6433,0,2.75312,0,0])
```

```
MM3=np.array([0,-4.7,0.2,2.9,0,0])
dt=0.00002
tf=12
```

In [24]:
```
xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2,vzs3,ax
```



SOL, tierra, satelite

In [20]:
```
ss=1
k1=k*ss
m1=1 # Sol
m2=3.00273e-6 #tierra
m3=3.165105302e-27 #James webb telescope
F1=(-k*m2*(p1-p2)/(p1-p2).norm()**(3)-k*m3*(p1-p3)/(p1-p3).norm()**(3))*(m1/m1)*(k1
F2=(-k*m1*(p2-p1)/(p2-p1).norm()**(3)-k*m3*(p2-p3)/(p2-p3).norm()**(3))*(m2/m2)*(k1
F3=(-k*m1*(p3-p1)/(p3-p1).norm()**(3)-k*m2*(p3-p2)/(p3-p2).norm()**(3))*(m3/m3)*(k1
```

In [21]:
```
MM1=np.array([0,0,0,0,0,0])*ss
```

```
MM2=np.array([0,-1,0,6.282,0,0])*ss
MM3=np.array([0,-1.3,0,6.3,0,0])*ss
dt=0.0001
tf=1
```

In [22]:

```
xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2,vzs3,ax
cx=cx1(xs1,xs2,xs3,m1,m2,m3)
cy=cy1(ys1,ys2,ys3,m1,m2,m3)
cz=cz1(zs1,zs2,zs3,m1,m2,m3)

L1x=L1x1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
L1y=L1y1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)

L2y=L2y1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
L2x=L2x1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)

L4x=L4x1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
L4y=L4y1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)

L5x=L5x1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
L5y=L5y1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
```

Punto de lagrange L2

In [25]:

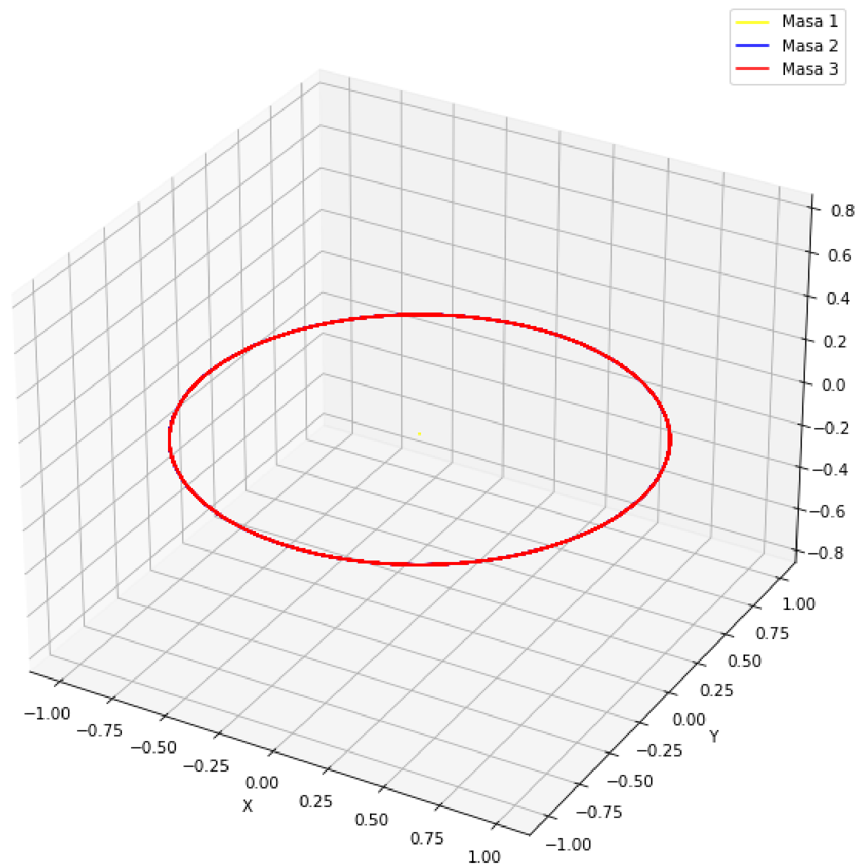
```
MM2=np.array([0,-1,0,6.282,0,0])
MM3=np.array([cx[0]+L2x[0],cy[0]+L2y[0],0,6.282,0,0])
dt=0.0001
tf=1
```

In [26]:

```
xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2,vzs3,ax
cx=cx1(xs1,xs2,xs3,m1,m2,m3)
cy=cy1(ys1,ys2,ys3,m1,m2,m3)
cz=cz1(zs1,zs2,zs3,m1,m2,m3)

L1x=L1x1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
L1y=L1y1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)

L2y=L2y1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
L2x=L2x1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)

L4x=L4x1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
L4y=L4y1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)

L5x=L5x1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
L5y=L5y1(xs1,xs2,xs3,ys1,ys2,ys3,m1,m2,m3)
```

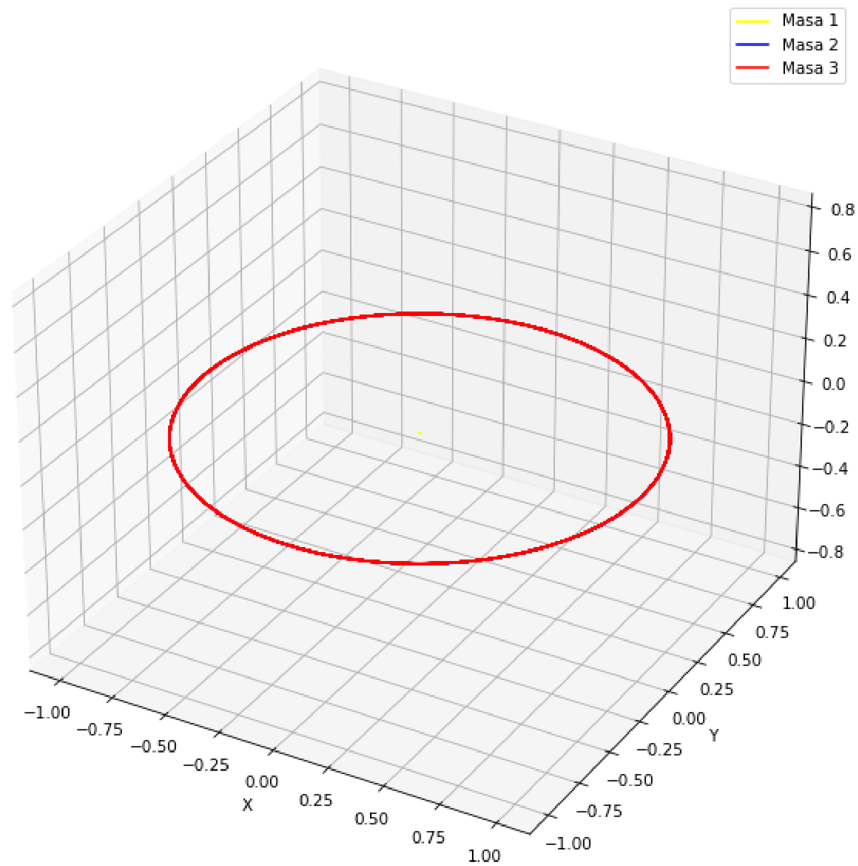
Punto de estabilidad L4

In [55]:
```
MM2=np.array([0,-1,0,6.282,0,0])*ss
MM3=np.array([cx[0]+L4x[0],cy[0]+L4y[0],0,3.141,5.44,0])*ss
dt=0.0001
tf=1
xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2,vzs3,ax
```



Punto de estabilidad L5

In [57]:
```
MM2=np.array([0,-1,0,6.282,0,0])*ss
MM3=np.array([cx[0]+L5x[0],cy[0]+L5y[0],0,3.141,-5.44,0])*ss
dt=0.0001
tf=1
xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2,vzs3,ax
```



In [ ]:
```
fig25=plt.figure()
plt.plot(ts,np.sqrt(L2x**2+L2y**2),label='Magnitud de L2')
plt.axis('equal')
plt.grid('on')
plt.legend()
plt.title('Magnitud de L2(Au) vs tiempo(AÑOS)')
plt.xlabel('tiempo (años)')
```

James Webb

In [353…
```
MM2=np.array([0,-1,0,6.282,0,0])
MM3=np.array([cx[0]+L2x[0],cy[0]+L2y[0],0.005,6.282+0.064,0,0])
dt=0.00001
tf=1
```

In [389…
```
MM2=np.array([0,-1,0,6.281,0,0])
MM3=np.array([cx[0]+L2x[0],cy[0]+L2y[0],0.003,6.281+0.047,0,0])
```

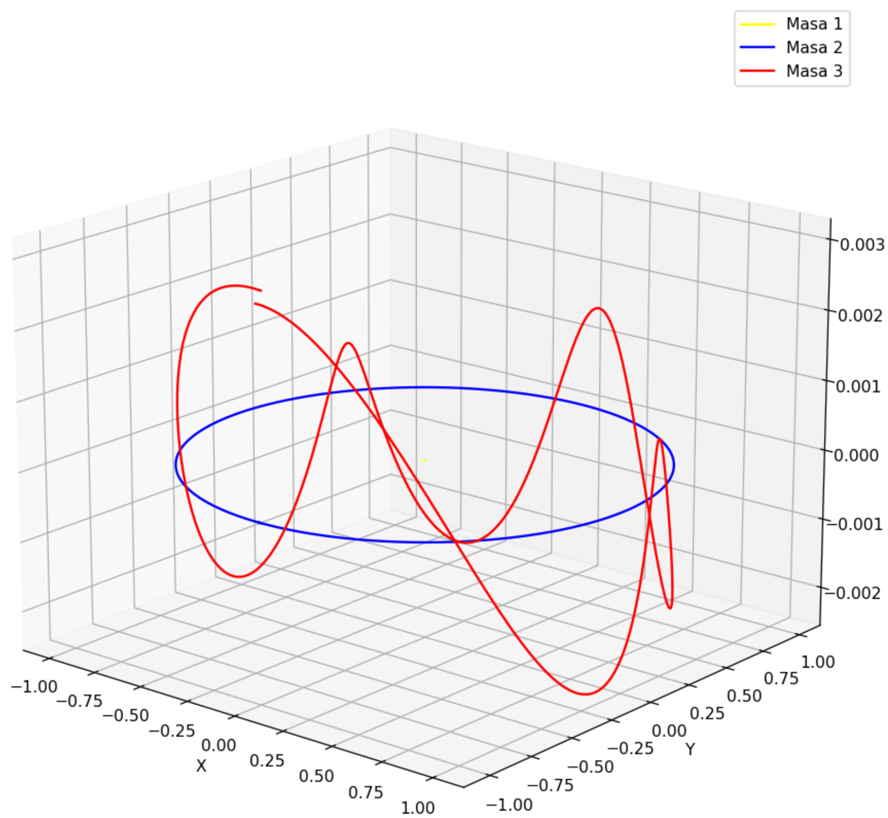
```
dt=0.00001
tf=1
```

In [387…

```
MM2=np.array([0,-1,0,6.281,0,0])
MM3=np.array([cx[0]+L2x[0],cy[0]+L2y[0],0.003,6.281+0.047,0,0])
dt=0.00001
tf=1
```

In [390…

```
xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2,vzs3,ax
```



Metodo de Disparo

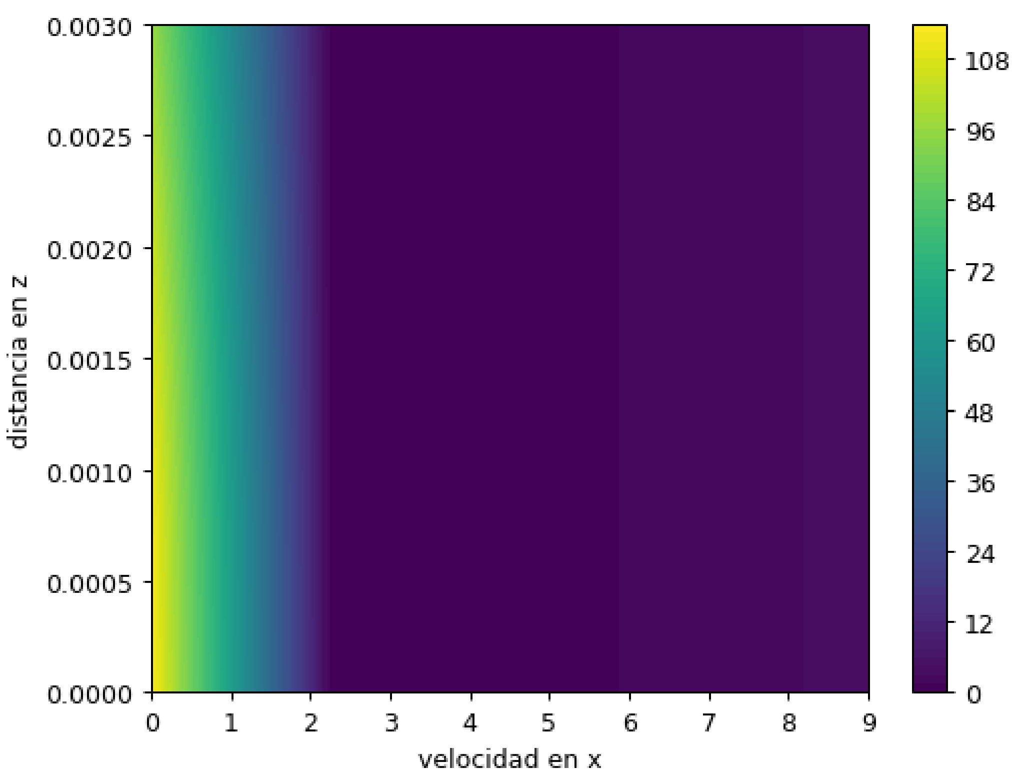
In [173…

```
nn=5
cc1=np.linspace(0,9,nn)
cc2=np.linspace(0,0.003,nn)
CC1,CC2=np.meshgrid(cc1,cc2)
E=CC1*0
tol=1/100
```

```
dt=0.0005
tf=1/2
for j in range(nn):
    for i in range(nn):
        MM3=np.array([cx[0]+L2x[0],cy[0]+L2y[0],CC2[j,i],CC1[j,i],0,0])
        xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2
        E[j,i]=np.sqrt(abs(xs3[0]-xs3[-1])**2+abs(ys3[0]-ys3[-1])**2+abs(zs3[0]-zs3
        #if (abs(xs3[0]-xs3[-1])<tol and abs(ys3[0]-ys3[-1])<tol and abs(zs3[0]-zs3
         #   CC1=i
          #  CC2=j
          #  i=nn
           # j=nn
           # break
```

In [179…

```
fig55=plt.figure()
cm=plt.contourf(CC1,CC2,E,levels=100)
plt.xlabel('velocidad en x')
plt.ylabel('distancia en z')
plt.colorbar(cm)
```



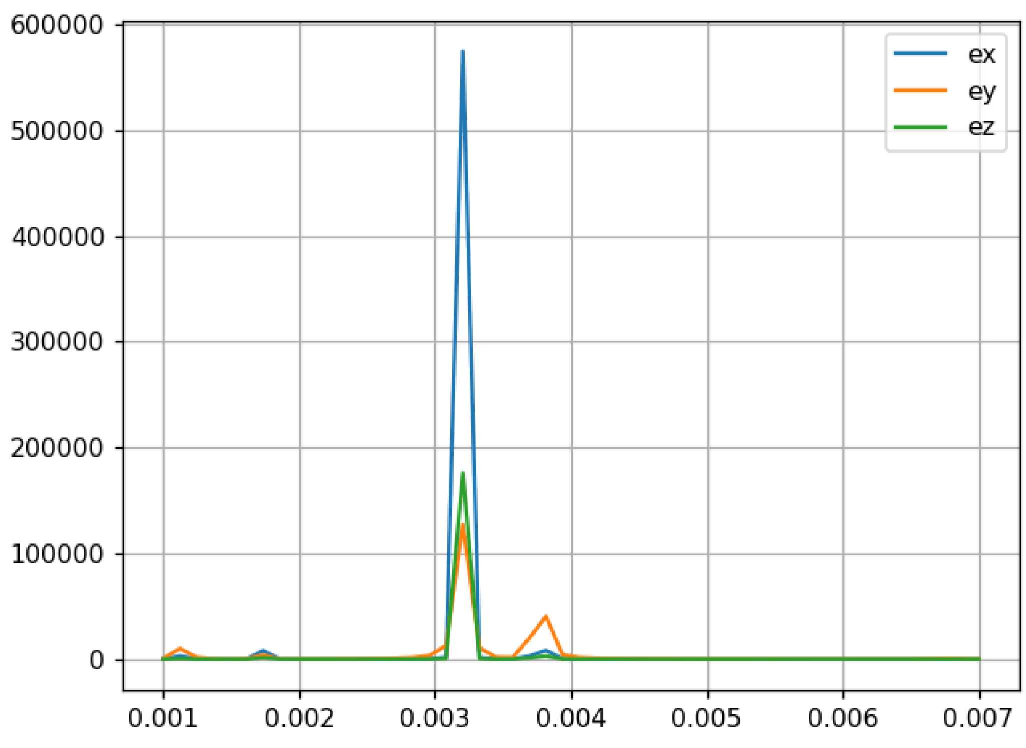
Out[179]: <matplotlib.colorbar.Colorbar at 0x200260a3160>

In [239…

```
nn=50
cc1=np.linspace(0,2,nn)
cc2=np.linspace(0.001,0.007,nn)
tol=1/100
dt=0.0001
tf=1/2
```

```
ex=cc1*0
ey=cc1*0
ez=cc1*0
for i in range(nn):
    MM3=np.array([cx[0]+L2x[0],cy[0]+L2y[0],cc2[i],0,0,0])
    xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,vzs2,vzs
    ex[i]=abs(xs3[0]-xs3[-1])
    ey[i]=abs(ys3[0]-ys3[-1])
    ez[i]=abs(zs3[0]-zs3[-1])
    if abs(xs3[0]-xs3[-1])<tol and abs(ys3[0]-ys3[-1])<tol and abs(zs3[0]-zs3[-1])<
        CC1=cc1(i)
        i=nn
        break
```

In [243…
```
fig32=plt.figure()
plt.plot(cc2,ex,label='ex')
plt.plot(cc2,ey,label='ey')
plt.plot(cc2,ez,label='ez')
#plt.plot(cc1,np.sqrt(ex**2+ey**2+ez**2),label='mag')
plt.grid('on')
plt.legend()
```



Out[243]: `<matplotlib.legend.Legend at 0x1ffe5246f40>`

In [244…
```
min(np.sqrt(ex**2+ey**2+ez**2))
```

Out[244]: 27.859738860128726

Animacion 2d

In [211…
```
fig3 = plt.figure(figsize=(10,10))
fx = fig3.add_subplot(111)
fx.set_facecolor('black')
plt.axis('off')

nn=len(xs1)
xx=np.concatenate((xs1,xs2,xs3))
yy=np.concatenate((ys1,ys2,ys3))
plt.grid('on')
plt.axis('equal')
ii=1/3
plt.xlim([min(xx)-ii, max(xx)+ii])
plt.ylim([min(yy)-ii, max(yy)+ii])



#resorte,=plt.plot([],[],color='black', label='trayectoria')
#plt.scatter(0,0,color='red')
#Q=plt.quiver(xs,ys,axs,ays)
#pp,=plt.plot([],[],'bo',label='Astro')
#plt.axis('equal')
plt.legend()

n=200

def animate(i):
    fx.clear()
    #plt.axis('off')
    plt.axis('equal')
    plt.xlim([min(xx)-ii, max(xx)+ii])
    plt.ylim([min(yy)-ii, max(yy)+ii])

    ss=60
    fx.scatter(xs1[i-1],ys1[i-1],color='yellow',label='Masa1',s=ss)
    fx.plot(xs1[:i],ys1[:i],color='yellow')
    fx.quiver(xs1[i-1],ys1[i-1],axs1[i-1],ays1[i-1],color='yellow')


    fx.scatter(xs2[i-1],ys2[i-1],color='blue',label='Masa2',s=ss)
    fx.plot(xs2[:i],ys2[:i],color='blue',lw=1)
    fx.quiver(xs2[i-1],ys2[i-1],axs2[i-1],ays2[i-1],color='blue')

    fx.scatter(xs3[i-1],ys3[i-1],color='red',label='Masa 3',s=ss)
    fx.plot(xs3[:i],ys3[:i],color='red',lw=1)
    fx.quiver(xs3[i-1],ys3[i-1],axs3[i-1],ays3[i-1],color='red')

    ##Puntos de Lagrange
    Ls=40
    #fx.scatter((cx+L1x)[i-1],(cy+L1y)[i-1],color='white',label='L1',s=Ls)
    #fx.scatter((cx+L2x)[i-1],(cy+L2y)[i-1],color='white',label='L2',s=Ls)
    #fx.scatter(L4x[i-1],L4y[i-1],color='white',label='L4',s=Ls)
    #fx.scatter((L5x)[i-1],(L5y)[i-1],color='white',label='L5',s=Ls)
```

```
    plt.legend()
    return fig3


fr=np.linspace(0,len(ts),n,dtype=int)
anim=FuncAnimation(fig3,animate,frames=fr,interval=20)
video=anim.to_html5_video()
html=display.HTML(video)
display.display(html)
plt.close()
```

```
No artists with labels found to put in legend.  Note that artists whose label star
t with an underscore are ignored when legend() is called with no argument.
c:\users\arif\appdata\local\programs\python\python39\lib\site-packages\matplotlib
\quiver.py:658: RuntimeWarning: divide by zero encountered in double_scalars
  length = a * (widthu_per_lenu / (self.scale * self.width))
c:\users\arif\appdata\local\programs\python\python39\lib\site-packages\matplotlib
\quiver.py:658: RuntimeWarning: invalid value encountered in multiply
  length = a * (widthu_per_lenu / (self.scale * self.width))
```

```
C:\Users\Arif\AppData\Local\Temp\ipykernel_5724\2275789233.py:63: MatplotlibDeprec
ationWarning: The close_event function was deprecated in Matplotlib 3.6 and will b
e removed two minor releases later. Use callbacks.process('close_event', CloseEven
t(...)) instead.
  plt.close()
```

Animacion 3D

In [380…

```
fig10 = plt.figure(figsize=(10,10))
bx = fig10.add_subplot(111, projection='3d')

#bx.set_facecolor('black')
plt.axis('equal')
plt.axis('on')
nn=len(xs1)
pch=10
xx=np.concatenate((xs1,xs2,xs3))
yy=np.concatenate((ys1,ys2,ys3))
zz=np.concatenate((zs1,zs2,zs3))
bx.set_xlim3d([min(xx)-min(xx)/pch, max(xx)+max(xx)/pch])
bx.set_ylim3d([min(yy)-min(yy)/pch, max(yy)+max(yy)/pch])
bx.set_zlim3d([min(zz)-min(zz)/pch, max(zz)+max(zz)/pch])
bx.view_init(elev=20, azim=45)

n=100

#orbita=ax.plot([],[],[],color='black', label='trayectoria')

#astro,=ax.plot3D([],[],[],'ro',label='Astro')
#astro, = ax.plot([xs],[ys],[ys],'ro',label='Astro')
#orbita, = ax.plot([], [], [], lw=2,color='black', label='trayectoria')

def animate(i):
    bx.clear()
    pch=10
    #plt.axis('equal')
    bx.set_xlim3d([min(xx)-1/3, max(xx)+1/3])
    bx.set_ylim3d([min(yy)-1/3, max(yy)+1/3])
    #bx.set_zlim3d([min(zz)-1/3, max(zz)+1/3])
    #bx.view_init(elev=20, azim=i/(len(ts)/7.5))
    bx.view_init(elev=15, azim=i/(len(ts)/n))
    plt.xlabel('x')
    plt.ylabel('y')
    #plt.axis('equal')
    #plt.axis('off')
    mim=500
    ll=1/5
    norm=True
    ###Trayectoria masa1
    bx.scatter(xs1[i-1],ys1[i-1],zs1[i-1],color='yellow',s=mim*m1/10,label='mas1')
    bx.plot(xs1[:i],ys1[:i],zs1[:i],color='yellow',lw=1)
```

```python
    #bx.quiver(xs1[i-1],ys1[i-1],zs1[i-1],axs1[i-1],ays1[i-1],azs1[i-1],color='yell
    ###Trayectoria masa2
    bx.scatter(xs2[i-1],ys2[i-1],zs2[i-1],color='blue',s=mim*m2*10000,label='masa2'
    bx.plot(xs2[:i],ys2[:i],zs2[:i],color='blue',lw=1)
    #bx.quiver(xs2[i-1],ys2[i-1],zs2[i-1],axs2[i-1],ays2[i-1],azs2[i-1],color='blue
    ###Trayectoria masa3
    bx.scatter(xs3[i-1],ys3[i-1],zs3[i-1],color='red',s=mim*m3*10000,label='masa3')
    bx.plot(xs3[:i],ys3[:i],zs3[:i],color='red',lw=1)
    #bx.quiver(xs3[i-1],ys3[i-1],zs3[i-1],axs3[i-1],ays3[i-1],azs3[i-1],color='red'
    ###############Puntos de Lagrange
    Ls=20
   # bx.scatter((cx+L1x)[i-1],(cy+L1y)[i-1],0,color='green',label='L1',s=Ls)
    #bx.scatter((cx+L2x)[i-1],(cy+L2y)[i-1],0,color='green',label='L2',s=Ls)
    #bx.scatter(L4x[i-1],L4y[i],0,color='green',label='L4',s=Ls)
    #bx.scatter((L5x)[i],(L5y)[i],0,color='green',label='L5',s=Ls)
    plt.legend()


    return fig10#orbita, #(astro,)


#np.linspace(0,len(ts),n,dtype=int)
#fr=np.arange(0,len(ts),n)
fr=np.linspace(0,len(ts),n,dtype=int)
anim=FuncAnimation(fig10,animate,frames=fr,interval=24)
video=anim.to_html5_video()

html=display.HTML(video)
display.display(html)
plt.close()
```

```
C:\Users\Arif\AppData\Local\Temp\ipykernel_7244\817327584.py:73: MatplotlibDeprecationWarning: The close_event function was deprecated in Matplotlib 3.6 and will be removed two minor releases later. Use callbacks.process('close_event', CloseEvent(...)) instead.
  plt.close()
```

Runge Kutta Fehlberg

In [31]:

```
def d2ydt2(y,f1,f2,f3,g1,g2,g3,h1,h2,h3):
    return np.array([y[9],
                     y[10],
                     y[11],
                     y[12],
                     y[13],
                     y[14],
                     y[15],
                     y[16],
                     y[17],
                     f1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     f2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     f3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     1])

def RKF(c1,c2,c3,dt,tf,F1,F2,F3,R,CV,M):
    #Vectorizcion de funciones
    flag=1
    f1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    f2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    f3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    g1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    g2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    g3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    h1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    h2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    h3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    ts=np.arange(0,tf,dt)
    TT=0#tiempo en completar orbita
    n=len(ts)
    ####################################Posiciones
    ys1=ts*0
    xs1=ts*0
    zs1=ts*0
    #
    ys2=ts*0
    xs2=ts*0
```

```
zs2=ts*0
#
ys3=ts*0
xs3=ts*0
zs3=ts*0

#####################################Velocidades
vys1=ts*0
vxs1=ts*0
vzs1=ts*0
#
vys2=ts*0
vxs2=ts*0
vzs2=ts*0
#
vys3=ts*0
vxs3=ts*0
vzs3=ts*0
###########################3##aceleraciones
ays1=ts*0
axs1=ts*0
azs1=ts*0
#
ays2=ts*0
axs2=ts*0
azs2=ts*0
#
ays3=ts*0
axs3=ts*0
azs3=ts*0
#############Condiciones iniciales
xs1[0]=c1[0]
ys1[0]=c1[1]
zs1[0]=c1[2]
vxs1[0]=c1[3]
vys1[0]=c1[4]
vzs1[0]=c1[5]
#############
xs2[0]=c2[0]
ys2[0]=c2[1]
zs2[0]=c2[2]
vxs2[0]=c2[3]
vys2[0]=c2[4]
vzs2[0]=c2[5]
###########
xs3[0]=c3[0]
ys3[0]=c3[1]
zs3[0]=c3[2]
vxs3[0]=c3[3]
vys3[0]=c3[4]
vzs3[0]=c3[5]

for i in range(0,n-1):
    #Runge Kutta
    z0=np.array([xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i]
    k1=d2ydt2(z0,f1,f2,f3,g1,g2,g3,h1,h2,h3)
```

```
        k2=d2ydt2(z0+dt*((k1)/4),f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k3=d2ydt2(z0+dt*((3*k2)/32+(9/32)*k2),f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k4=d2ydt2(z0+dt*((1932/2197)*k1-(7200/2197)*k2+(7296/2196)*k3),f1,f2,f3,g1,
        k5=d2ydt2(z0+dt*((439/216)*k1-8*k2+(3680/513)*k3-(845/4104)*k4),f1,f2,f3,g1
        k4=d2ydt2(z0+dt*(-(8/27)*k1+2*k2-(3544/2565)*k3+(1859/4104)*k4-(11/40)*k5),

        #Vectores M1
        xs1[i+1]=xs1[i]+(dt/6)*(k1[0]+2*k2[0]+2*k3[0]+k4[0])
        ys1[i+1]=ys1[i]+(dt/6)*(k1[3]+2*k2[3]+2*k3[3]+k4[3])
        zs1[i+1]=zs1[i]+(dt/6)*(k1[6]+2*k2[6]+2*k3[6]+k4[6])
        vxs1[i+1]=vxs1[i]+(dt/6)*(k1[9]+2*k2[9]+2*k3[9]+k4[9])
        vys1[i+1]=vys1[i]+(dt/6)*(k1[12]+2*k2[12]+2*k3[12]+k4[12])
        vzs1[i+1]=vzs1[i]+(dt/6)*(k1[15]+2*k2[15]+2*k3[15]+k4[15])

        axs1[i]=f1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays1[i]=f2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs1[i]=f3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v

        ################Vectores M2
        xs2[i+1]=xs2[i]+(dt/6)*(k1[1]+2*k2[1]+2*k3[1]+k4[1])
        ys2[i+1]=ys2[i]+(dt/6)*(k1[4]+2*k2[4]+2*k3[4]+k4[4])
        zs2[i+1]=zs2[i]+(dt/6)*(k1[7]+2*k2[7]+2*k3[7]+k4[7])
        vxs2[i+1]=vxs2[i]+(dt/6)*(k1[10]+2*k2[10]+2*k3[10]+k4[10])
        vys2[i+1]=vys2[i]+(dt/6)*(k1[13]+2*k2[13]+2*k3[13]+k4[13])
        vzs2[i+1]=vzs2[i]+(dt/6)*(k1[16]+2*k2[16]+2*k3[16]+k4[16])

        axs2[i]=g1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays2[i]=g2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs2[i]=g3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v

        ###Vectores M3############################################
        xs3[i+1]=xs3[i]+(dt/6)*(k1[2]+2*k2[2]+2*k3[2]+k4[2])
        ys3[i+1]=ys3[i]+(dt/6)*(k1[5]+2*k2[5]+2*k3[5]+k4[5])
        zs3[i+1]=zs3[i]+(dt/6)*(k1[8]+2*k2[8]+2*k3[8]+k4[8])
        vxs3[i+1]=vxs3[i]+(dt/6)*(k1[11]+2*k2[11]+2*k3[11]+k4[11])
        vys3[i+1]=vys3[i]+(dt/6)*(k1[14]+2*k2[14]+2*k3[14]+k4[14])
        vzs3[i+1]=vzs3[i]+(dt/6)*(k1[17]+2*k2[17]+2*k3[17]+k4[17])

        axs3[i]=h1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays3[i]=h2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs3[i]=h3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
       #######Graficas#################################

     ########################vectores relativos##################################
    if R==True:
        fig = plt.figure(figsize=(10,10))
        ax = fig.add_subplot(111, projection='3d')
        #fig2=plt.add(figsize=(10,10))
        ax.plot(xs1,ys1,zs1,color='yellow',label='Masa 1')
        ax.plot(xs2,ys2,zs2,color='blue',label='Masa 2')
        ax.plot(xs3,ys3,zs3,color='red',label='Masa 3')
        plt.xlabel('X')
        plt.ylabel('Y')
        #plt.axis('equal')

        #plt.plot(vxs,vys,color='blue',label='Velocidad x vs velocidad y')
```

```
        #plt.plot(axs,ays,color='red',label='Aceleracion x vs aceleracion y')
        if CV==True:
            ll=50
            ax.quiver(xs[1:-1:ll],ys[1:-1:ll],axs[1:-1:ll],ays[1:-1:ll],color='red'
            ax.quiver(xs[1:-1:ll],ys[1:-1:ll],vxs[1:-1:ll],vys[1:-1:ll],color='blue
        #plt.axis('equal')
        plt.grid('on')
        plt.legend()
        plt.show()
    ###################Campos vectoriaels########################################

    if M==True:
    ##############################Magnitudes##################################
        fig3=plt.figure(figsize=(7,7))
        plt.plot(ts,np.sqrt(xs**2+ys**2),color='yellow',label='r vs tiempo')
        plt.plot(ts,np.sqrt(axs**2+ays**2),color='blue',label='aceleracion neta vs
        plt.plot(ts,np.sqrt(vxs**2+vys**2),color='red',label='Velocidad neta vs tie
        #plt.plot(ts,vxs,color='red',label='Velocidad')
        #plt.plot(ts,axs,color='blue',label='aceleracion')
        plt.ylabel('Unidades Atronomicas UA')
        plt.xlabel('tiempo(años)')
        #plt.axis('equal')
        plt.grid('on')
        plt.legend()
        plt.show()
    return xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,v
```

RK 5to orden

In [39]:

```
def d2ydt2(y,f1,f2,f3,g1,g2,g3,h1,h2,h3):
    return np.array([y[9],
                     y[10],
                     y[11],
                     y[12],
                     y[13],
                     y[14],
                     y[15],
                     y[16],
                     y[17],
                     f1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     f2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     f3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     1])

def RK5(c1,c2,c3,dt,tf,F1,F2,F3,R,CV,M):
    #Vectorizcion de funciones
    f1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    f2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
```

```
f3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
g1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
g2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
g3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
h1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
h2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
h3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
ts=np.arange(0,tf,dt)
TT=0#tiempo en completar orbita
n=len(ts)
####################################Posiciones
ys1=ts*0
xs1=ts*0
zs1=ts*0
#
ys2=ts*0
xs2=ts*0
zs2=ts*0
#
ys3=ts*0
xs3=ts*0
zs3=ts*0

#####################################Velocidades
vys1=ts*0
vxs1=ts*0
vzs1=ts*0
#
vys2=ts*0
vxs2=ts*0
vzs2=ts*0
#
vys3=ts*0
vxs3=ts*0
vzs3=ts*0
##########################3##aceleraciones
ays1=ts*0
axs1=ts*0
azs1=ts*0
#
ays2=ts*0
axs2=ts*0
azs2=ts*0
#
ays3=ts*0
axs3=ts*0
azs3=ts*0
#############Condiciones iniciales
xs1[0]=c1[0]
ys1[0]=c1[1]
zs1[0]=c1[2]
vxs1[0]=c1[3]
vys1[0]=c1[4]
vzs1[0]=c1[5]
#############
xs2[0]=c2[0]
```

```
    ys2[0]=c2[1]
    zs2[0]=c2[2]
    vxs2[0]=c2[3]
    vys2[0]=c2[4]
    vzs2[0]=c2[5]
    ###########
    xs3[0]=c3[0]
    ys3[0]=c3[1]
    zs3[0]=c3[2]
    vxs3[0]=c3[3]
    vys3[0]=c3[4]
    vzs3[0]=c3[5]

    for i in range(0,n-1):
        #Runge Kutta
        z0=np.array([xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i]
        k1=d2ydt2(z0,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k2=d2ydt2(z0+(dt*k1)/2,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k3=d2ydt2(z0+dt*(3*k1+k2)/16,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k4=d2ydt2(z0+dt*k3/2,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k5=d2ydt2(z0+dt*(-3*k2+6*k3+9*k4)/16,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k6=d2ydt2(z0+dt*(k1+4*k2+6*k3-12*k4+8*k5)/7,f1,f2,f3,g1,g2,g3,h1,h2,h3)

        k1=7*(k1+k6)
        k3=16*k3
        k2=16*k5
        k4=12*k4



        #Vectores M1
        xs1[i+1]=xs1[i]+(dt/90)*(k1[0]+2*k2[0]+2*k3[0]+k4[0])
        ys1[i+1]=ys1[i]+(dt/90)*(k1[3]+2*k2[3]+2*k3[3]+k4[3])
        zs1[i+1]=zs1[i]+(dt/90)*(k1[6]+2*k2[6]+2*k3[6]+k4[6])
        vxs1[i+1]=vxs1[i]+(dt/90)*(k1[9]+2*k2[9]+2*k3[9]+k4[9])
        vys1[i+1]=vys1[i]+(dt/90)*(k1[12]+2*k2[12]+2*k3[12]+k4[12])
        vzs1[i+1]=vzs1[i]+(dt/90)*(k1[15]+2*k2[15]+2*k3[15]+k4[15])

        axs1[i]=f1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays1[i]=f2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs1[i]=f3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v

        ################Vectores M2
        xs2[i+1]=xs2[i]+(dt/90)*(k1[1]+2*k2[1]+2*k3[1]+k4[1])
        ys2[i+1]=ys2[i]+(dt/90)*(k1[4]+2*k2[4]+2*k3[4]+k4[4])
        zs2[i+1]=zs2[i]+(dt/90)*(k1[7]+2*k2[7]+2*k3[7]+k4[7])
        vxs2[i+1]=vxs2[i]+(dt/90)*(k1[10]+2*k2[10]+2*k3[10]+k4[10])
        vys2[i+1]=vys2[i]+(dt/90)*(k1[13]+2*k2[13]+2*k3[13]+k4[13])
        vzs2[i+1]=vzs2[i]+(dt/90)*(k1[16]+2*k2[16]+2*k3[16]+k4[16])

        axs2[i]=g1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays2[i]=g2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs2[i]=g3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v

        ###Vectores M3############################################

        xs3[i+1]=xs3[i]+(dt/90)*(k1[2]+2*k2[2]+2*k3[2]+k4[2])
```

```
        ys3[i+1]=ys3[i]+(dt/90)*(k1[5]+2*k2[5]+2*k3[5]+k4[5])
        zs3[i+1]=zs3[i]+(dt/90)*(k1[8]+2*k2[8]+2*k3[8]+k4[8])
        vxs3[i+1]=vxs3[i]+(dt/90)*(k1[11]+2*k2[11]+2*k3[11]+k4[11])
        vys3[i+1]=vys3[i]+(dt/90)*(k1[14]+2*k2[14]+2*k3[14]+k4[14])
        vzs3[i+1]=vzs3[i]+(dt/90)*(k1[17]+2*k2[17]+2*k3[17]+k4[17])

        axs3[i]=h1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays3[i]=h2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs3[i]=h3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
       ########Graficas####################################

     ########################vectores relativos####################################
    if R==True:
        fig = plt.figure(figsize=(10,10))
        ax = fig.add_subplot(111, projection='3d')
        #ax.set_zlim3d(-0.2,0.2)
        #fig2=plt.add(figsize=(10,10))
        #ax.scatter(0,0,0,color='yellow',s=30)
        ax.plot(xs1,ys1,zs1,color='yellow',label='Masa 1')
        ax.plot(xs2,ys2,zs2,color='blue',label='Masa 2')
        ax.plot(xs3,ys3,zs3,color='red',label='Masa 3')
        plt.xlabel('X')
        plt.ylabel('Y')
        #plt.axis('equal')

        #plt.plot(vxs,vys,color='blue',label='Velocidad x vs velocidad y')
        #plt.plot(axs,ays,color='red',label='Aceleracion x vs aceleracion y')
        if CV==True:
            ll=50
            ax.quiver(xs[1:-1:ll],ys[1:-1:ll],axs[1:-1:ll],ays[1:-1:ll],color='red'
            ax.quiver(xs[1:-1:ll],ys[1:-1:ll],vxs[1:-1:ll],vys[1:-1:ll],color='blue
        #plt.axis('equal')
        plt.grid('on')
        plt.legend()
        plt.show()
    ####################Campos vectoriaels########################################

    if M==True:
    ##############################Magnitudes##################################
        fig3=plt.figure(figsize=(7,7))
        plt.plot(ts,np.sqrt(xs**2+ys**2),color='yellow',label='r vs tiempo')
        plt.plot(ts,np.sqrt(axs**2+ays**2),color='blue',label='aceleracion neta vs
        plt.plot(ts,np.sqrt(vxs**2+vys**2),color='red',label='Velocidad neta vs tie
        #plt.plot(ts,vxs,color='red',label='Velocidad')
        #plt.plot(ts,axs,color='blue',label='aceleracion')
        plt.ylabel('Unidades Atronomicas UA')
        plt.xlabel('tiempo(años)')
        #plt.axis('equal')
        plt.grid('on')
        plt.legend()
        plt.show()
    return xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,v
```

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In [18]:

```
def d2ydt2(y,f1,f2,f3,g1,g2,g3,h1,h2,h3):
    return np.array([y[9],
                     y[10],
                     y[11],
                     y[12],
                     y[13],
                     y[14],
                     y[15],
                     y[16],
                     y[17],
                     f1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h1(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     f2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h2(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     f3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     g3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     h3(y[0],y[1],y[2],y[3],y[4],y[5],y[6],y[7],y[8],y[9],y[10],y[1
                     1])

def RK38(c1,c2,c3,dt,tf,F1,F2,F3,R,CV,M):
    #Vectorizcion de funciones
    f1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    f2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    f3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    g1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    g2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    g3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    h1=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    h2=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    h3=sp.lambdify([x1,x2,x3,y1,y2,y3,z1,z2,z3,vx1,vx2,vx3,vy1,vy2,vy3,vz1,vz2,vz3,
    ts=np.arange(0,tf,dt)
    TT=0#tiempo en completar orbita
    n=len(ts)
    ####################################Posiciones
    ys1=ts*0
    xs1=ts*0
    zs1=ts*0
    #
    ys2=ts*0
    xs2=ts*0
    zs2=ts*0
    #
    ys3=ts*0
    xs3=ts*0
    zs3=ts*0

    #####################################Velocidades
    vys1=ts*0
    vxs1=ts*0
    vzs1=ts*0
    #
    vys2=ts*0
    vxs2=ts*0
```

```python
    vzs2=ts*0
    #
    vys3=ts*0
    vxs3=ts*0
    vzs3=ts*0
    ###########################3##aceleraciones
    ays1=ts*0
    axs1=ts*0
    azs1=ts*0
    #
    ays2=ts*0
    axs2=ts*0
    azs2=ts*0
    #
    ays3=ts*0
    axs3=ts*0
    azs3=ts*0
    #############Condiciones iniciales
    xs1[0]=c1[0]
    ys1[0]=c1[1]
    zs1[0]=c1[2]
    vxs1[0]=c1[3]
    vys1[0]=c1[4]
    vzs1[0]=c1[5]
    #############
    xs2[0]=c2[0]
    ys2[0]=c2[1]
    zs2[0]=c2[2]
    vxs2[0]=c2[3]
    vys2[0]=c2[4]
    vzs2[0]=c2[5]
    ###########
    xs3[0]=c3[0]
    ys3[0]=c3[1]
    zs3[0]=c3[2]
    vxs3[0]=c3[3]
    vys3[0]=c3[4]
    vzs3[0]=c3[5]

    for i in range(0,n-1):
        #Runge Kutta
        z0=np.array([xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i]
        k1=d2ydt2(z0,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k2=d2ydt2(z0+(dt*k1)/3,f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k3=d2ydt2(z0+dt*(-(k1/3)+k2),f1,f2,f3,g1,g2,g3,h1,h2,h3)
        k4=d2ydt2(z0+dt*(k1-k2+k3),f1,f2,f3,g1,g2,g3,h1,h2,h3)

        k2=(3/2)*k2
        k3=(3/2)*k3
        #Vectores M1
        xs1[i+1]=xs1[i]+(dt/8)*(k1[0]+2*k2[0]+2*k3[0]+k4[0])
        ys1[i+1]=ys1[i]+(dt/8)*(k1[3]+2*k2[3]+2*k3[3]+k4[3])
        zs1[i+1]=zs1[i]+(dt/8)*(k1[6]+2*k2[6]+2*k3[6]+k4[6])
        vxs1[i+1]=vxs1[i]+(dt/8)*(k1[9]+2*k2[9]+2*k3[9]+k4[9])
        vys1[i+1]=vys1[i]+(dt/8)*(k1[12]+2*k2[12]+2*k3[12]+k4[12])
        vzs1[i+1]=vzs1[i]+(dt/8)*(k1[15]+2*k2[15]+2*k3[15]+k4[15])
```

```python
        axs1[i]=f1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays1[i]=f2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs1[i]=f3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v

        #################Vectores M2
        xs2[i+1]=xs2[i]+(dt/8)*(k1[1]+2*k2[1]+2*k3[1]+k4[1])
        ys2[i+1]=ys2[i]+(dt/8)*(k1[4]+2*k2[4]+2*k3[4]+k4[4])
        zs2[i+1]=zs2[i]+(dt/8)*(k1[7]+2*k2[7]+2*k3[7]+k4[7])
        vxs2[i+1]=vxs2[i]+(dt/8)*(k1[10]+2*k2[10]+2*k3[10]+k4[10])
        vys2[i+1]=vys2[i]+(dt/8)*(k1[13]+2*k2[13]+2*k3[13]+k4[13])
        vzs2[i+1]=vzs2[i]+(dt/8)*(k1[16]+2*k2[16]+2*k3[16]+k4[16])

        axs2[i]=g1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays2[i]=g2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs2[i]=g3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v

        ###Vectores M3#############################################

        xs3[i+1]=xs3[i]+(dt/8)*(k1[2]+2*k2[2]+2*k3[2]+k4[2])
        ys3[i+1]=ys3[i]+(dt/8)*(k1[5]+2*k2[5]+2*k3[5]+k4[5])
        zs3[i+1]=zs3[i]+(dt/8)*(k1[8]+2*k2[8]+2*k3[8]+k4[8])
        vxs3[i+1]=vxs3[i]+(dt/8)*(k1[11]+2*k2[11]+2*k3[11]+k4[11])
        vys3[i+1]=vys3[i]+(dt/8)*(k1[14]+2*k2[14]+2*k3[14]+k4[14])
        vzs3[i+1]=vzs3[i]+(dt/8)*(k1[17]+2*k2[17]+2*k3[17]+k4[17])

        axs3[i]=h1(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        ays3[i]=h2(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
        azs3[i]=h3(xs1[i],xs2[i],xs3[i],ys1[i],ys2[i],ys3[i],zs1[i],zs2[i],zs3[i],v
       ########Graficas####################################

     ########################vectores relativos####################################
    if R==True:
        fig = plt.figure(figsize=(10,10))
        ax = fig.add_subplot(111, projection='3d')
        bx.set_zlim3d(-1, 1)
        #fig2=plt.add(figsize=(10,10))
        ax.scatter(0,0,0,color='yellow',s=30)
        ax.plot(xs1,ys1,zs1,color='yellow',label='Masa 1')
        ax.plot(xs2,ys2,zs2,color='blue',label='Masa 2')
        ax.plot(xs3,ys3,zs3,color='red',label='Masa 3')

        plt.xlabel('X')
        plt.ylabel('Y')
        plt.axis('equal')

        #plt.plot(vxs,vys,color='blue',label='Velocidad x vs velocidad y')
        #plt.plot(axs,ays,color='red',label='Aceleracion x vs aceleracion y')
        if CV==True:
            ll=50
            ax.quiver(xs[1:-1:ll],ys[1:-1:ll],axs[1:-1:ll],ays[1:-1:ll],color='red'
            ax.quiver(xs[1:-1:ll],ys[1:-1:ll],vxs[1:-1:ll],vys[1:-1:ll],color='blue
        plt.axis('equal')
        plt.grid('on')
        plt.legend()
        plt.show()
```

```
    ###################Campos vectoriaels#########################################

    if M==True:
    ##############################Magnitudes##################################
        fig3=plt.figure(figsize=(7,7))
        plt.plot(ts,np.sqrt(xs**2+ys**2),color='yellow',label='r vs tiempo')
        plt.plot(ts,np.sqrt(axs**2+ays**2),color='blue',label='aceleracion neta vs
        plt.plot(ts,np.sqrt(vxs**2+vys**2),color='red',label='Velocidad neta vs tie
        #plt.plot(ts,vxs,color='red',label='Velocidad')
        #plt.plot(ts,axs,color='blue',label='aceleracion')
        plt.ylabel('Unidades Atronomicas UA')
        plt.xlabel('tiempo(años)')
        #plt.axis('equal')
        plt.grid('on')
        plt.legend()
        plt.show()
    return xs1,xs2,xs3,ys1,ys2,ys3,zs1,zs2,zs3,vxs1,vxs2,vxs3,vys1,vys2,vys3,vzs1,v
```

In [ ]: