Universidad Nacional San Agustin de Arequipa

Facultad de Ingenierias de Produccion y Servicios

Escuela Profesional de Ingenieria de Sistemas

Fisica Computacional

Alumno:

Fuentes Paredes Nelson Alejandro

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```
[ ]:
```

```
[1]: %matplotlib inline
```

1 Importar Libreria

```
[2]: import math
     from matplotlib import pyplot as plt
```

2 Función RK4

```
[3]: def rk4(function, t, tfin, v, x, h, m):
         pt = [t]
         pv = [v]
         px = [x]

         while t<tfin:
             for i in range(m):
                 a  = eval(function)
                 k1 = h*a
                 x1 = x
                 v1 = v
                 t1 = t

                 t = t1+0.5*h
                 x = x1+h*0.5*v1
                 v = v1+0.5*k1

                 a  = eval(function)
                 k2 = h*a

                 t = t1+0.5*h
                 x = x1+0.5*h*(v1+0.5*k1)
                 v = v1+0.5*k2

                 a  = eval(function)
                 k3 = h*a

                 t = t1+h
                 x = x1+h*v1+h*k2*0.5
                 v = v1+k3

                 a  = eval(function)
                 k4 = h*a;
```

```
            x = x1+h*v1+h*(k1+k2+k3)/6
            v = v1+(k1+2*k2+2*k3+k4)/6
            t = t1+h
            if x>math.pi:
                x=x-2*math.pi
            if x<-math.pi:
                x=x+2*math.pi
        px.append(x)
        pv.append(v)
    return px, pv
```

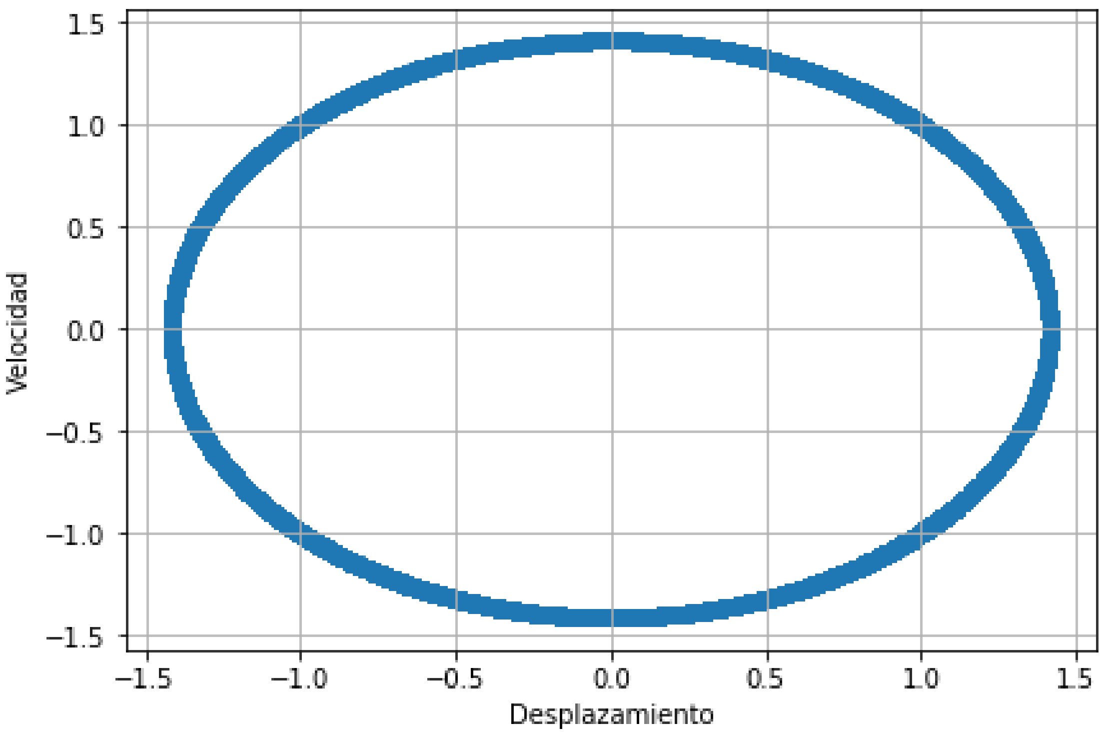
3 Ejercicios

3.1 Escriba un código para resolver el problema de un péndulo simple aplicando las secciones de Poincaré.

$\frac{d^2\theta}{dt^2} = -\frac{g}{l}\theta$

[4]:

```
m=20
g = 1
l = 1
tfin = 100000
x=1
v=-1
t=0
w = math.sqrt(g/l)
h=1/(w*m)
function='-g/l*x'
px, pv = rk4(function, t, tfin, v, x, h, m)
fig, axis = plt.subplots(constrained_layout=True)
axis.scatter(px,pv,marker='o')
#axis.set_aspect(4000)
axis.set(xlabel='Desplazamiento', ylabel='Velocidad')
axis.grid()
```

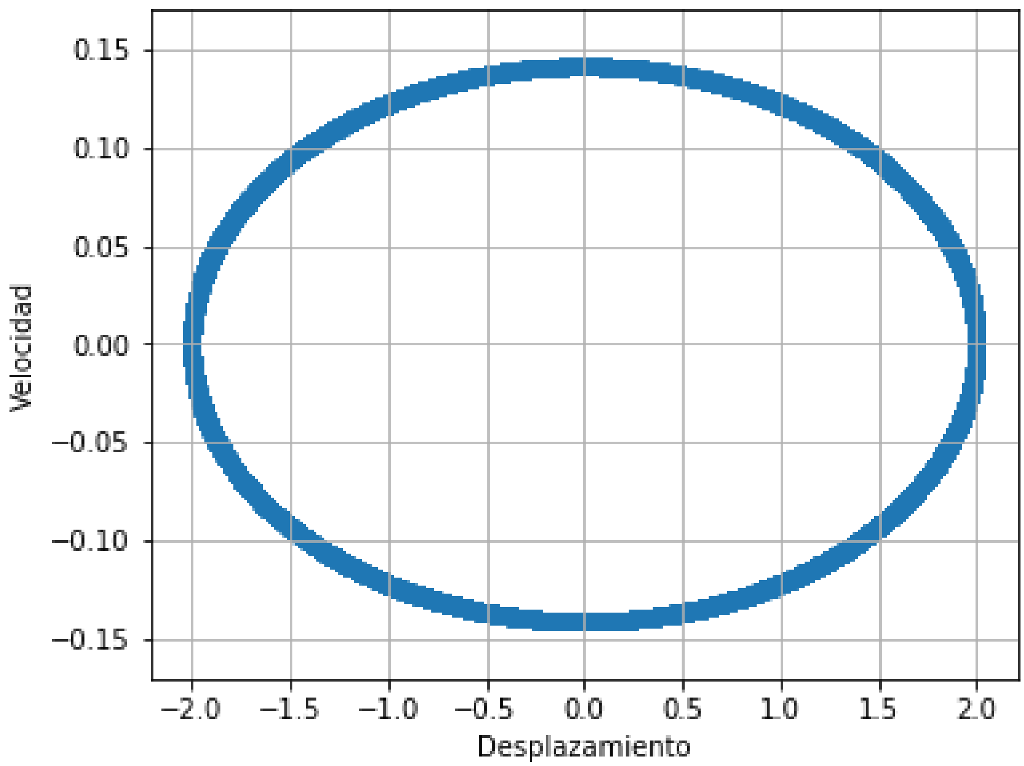


3.2 Aplique las secciones de Poincaré para resolver el sistema masa-resorte con fricción. Vea todos los casos.

$\frac{d^2x}{dt^2} + \frac{b}{m}\frac{dx}{dt} + \frac{k}{m}x = 0$

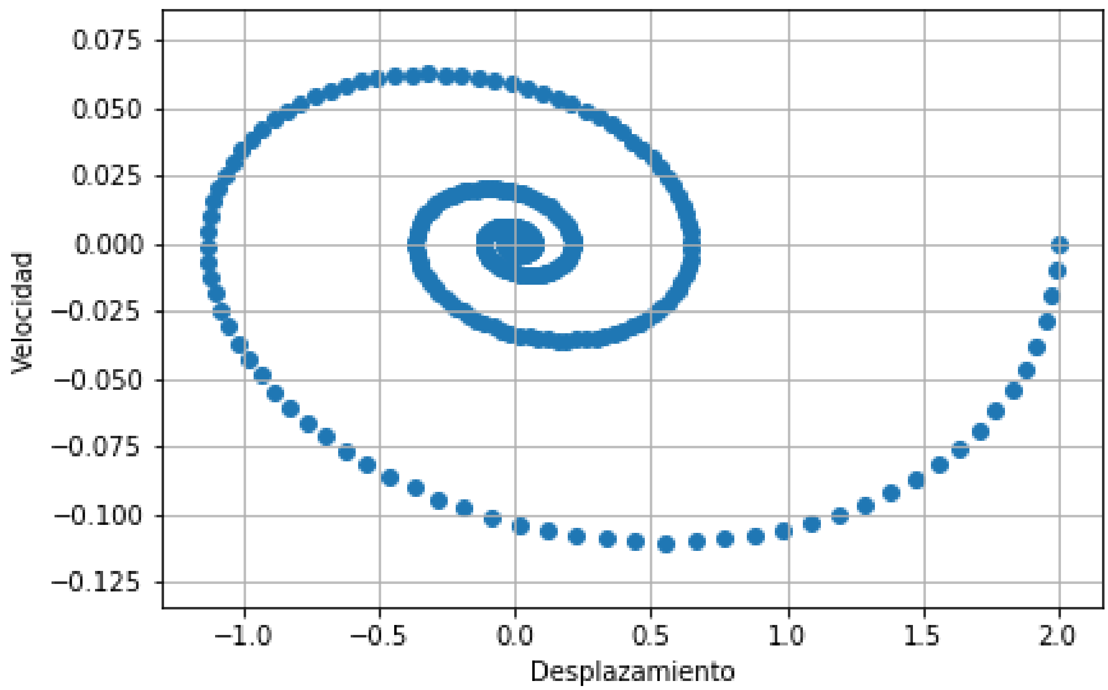
3.2.1 Armonico Simple

[5]:
```
function='-k*x/m-c*v/m'
n=20
h=2*math.pi/(2*math.pi*n)
k=0.1
m=0.2
c=0.0
t=0
tfin = 10000
v = 0
x = 2
px, pv = rk4(function, t, tfin, v, x, h, n)
fig, axis = plt.subplots(constrained_layout=True)
axis.scatter(px,pv,marker='o')
axis.set_aspect(10)
axis.set(xlabel='Desplazamiento', ylabel='Velocidad')
axis.grid()
```



3.2.2 Movimiento acelatorio en un medio

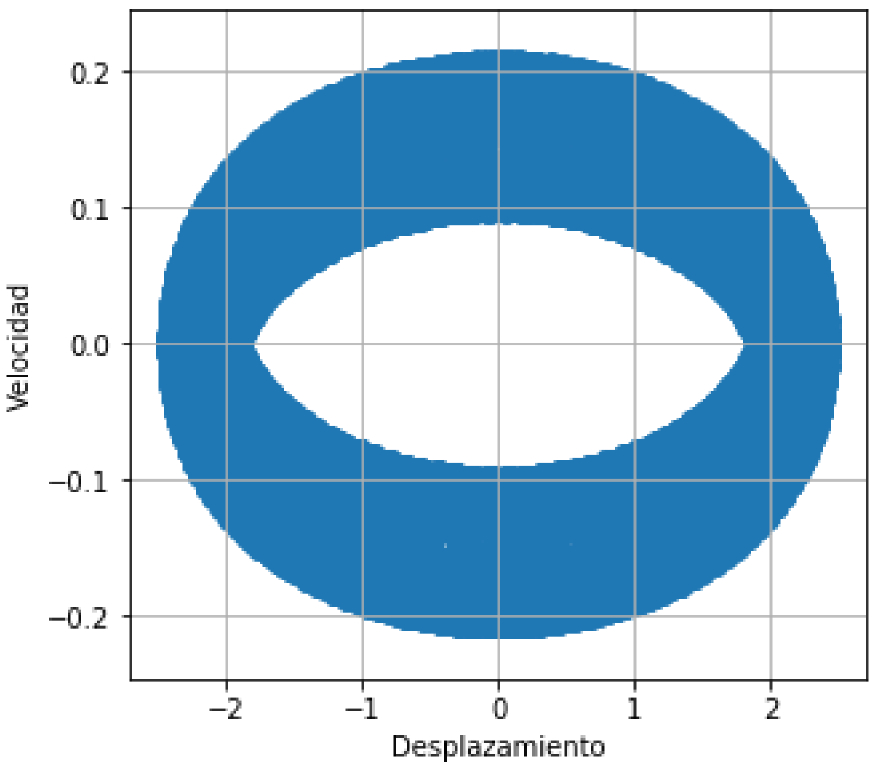
[6]:
```
function='-k*x/m-c*v/m'
n=20
h=2*math.pi/(2*math.pi*n)
k=0.1
m=0.2
c=0.5
t=0
tfin = 10000
v = 0
x = 2
px, pv = rk4(function, t, tfin, v, x, h, n)
fig, axis = plt.subplots(constrained_layout=True)
axis.scatter(px,pv)
axis.set_aspect(10)
axis.set(xlabel='Desplazamiento', ylabel='Velocidad')
axis.grid()
```



3.3 Analice mediante las secciones de Poincaré el oscilador forzado. Considere el caso especial cuando b = 0.

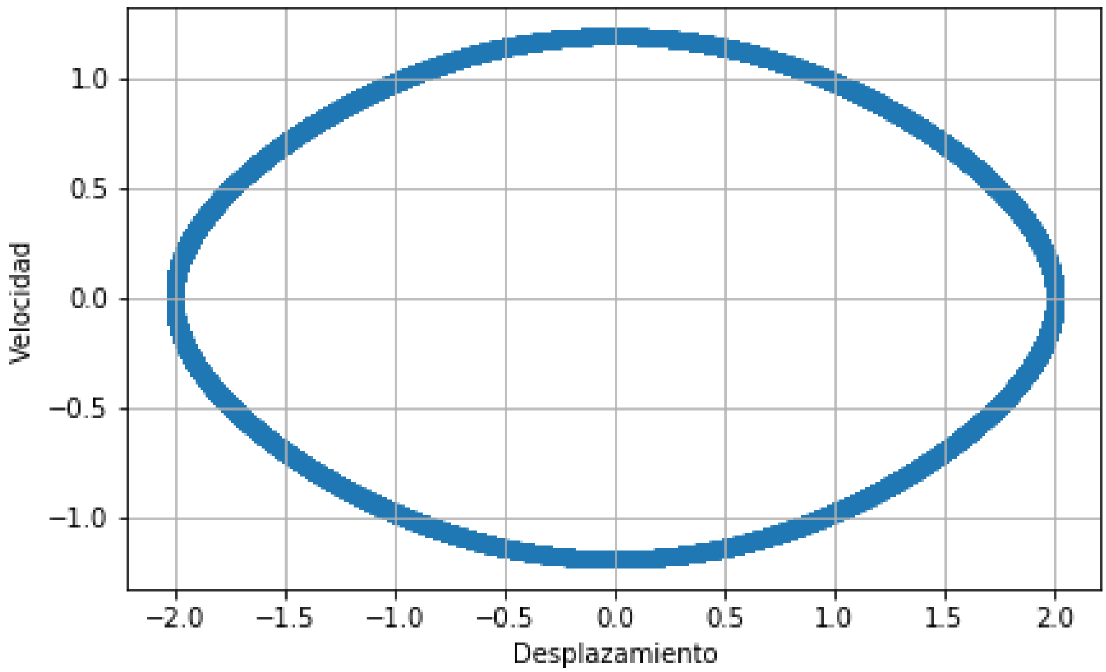
$\frac{d^2x}{dt^2} + \frac{b}{m}\frac{dx}{dt} + \frac{k}{m}x = \frac{F_0}{m}\sin wt$

[7]:
```
function='-k*x/m-b*v/m + F0/m*math.sin(w*t)'
n=20
h=2*math.pi/(2*math.pi*n)
k=0.1
m=0.2
b=0.0
F0 = 0.2
w = 0.2
t = 0
tfin = 10000
v = 0
x = 2
px, pv = rk4(function, t, tfin, v, x, h, n)
fig, axis = plt.subplots(constrained_layout=True)
axis.scatter(px,pv)
axis.set_aspect(10)
axis.set(xlabel='Desplazamiento', ylabel='Velocidad')
axis.grid()
```



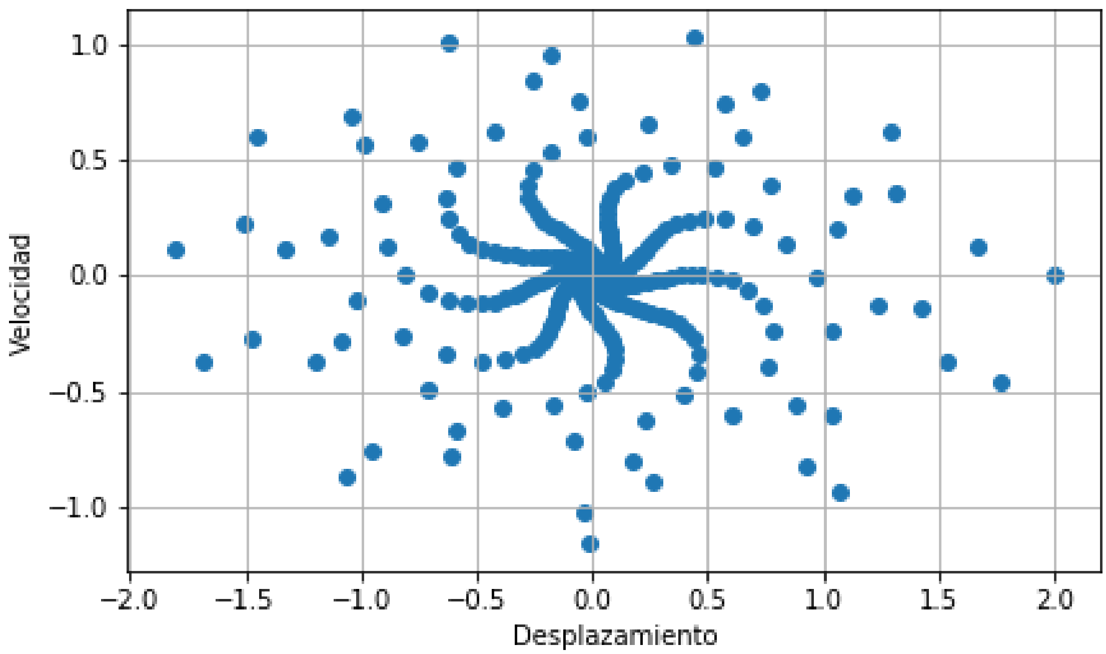
3.4 Estudie el péndulo simple cuya ecuación diferencial general es $\frac{d^2\theta}{dt^2} = -\frac{g}{l}\sin\theta$

[8]:
```
function='-g/l*math.sin(x)'
n=20
h=2*math.pi/(2*math.pi*n)
g=0.1
l=0.2
t = 0
tfin = 10000
v = 0
x = 2
px, pv = rk4(function, t, tfin, v, x, h, n)
fig, axis = plt.subplots(constrained_layout=True)
axis.scatter(px,pv)
axis.set_aspect('equal')
axis.set(xlabel='Desplazamiento', ylabel='Velocidad')
axis.grid()
```



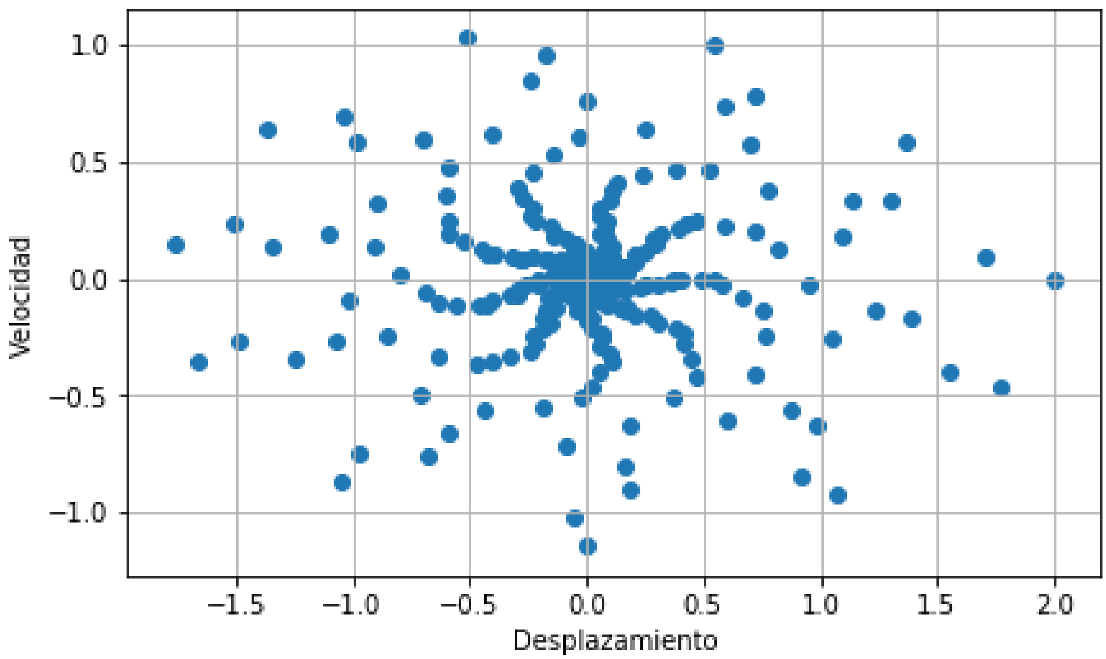
3.5 Repita el ejercicio anterior incluyendo la fricción en el péndulo simple.

[9]:
```
function='-g/l*math.sin(x) -b*v/m '
n=20
h=2*math.pi/(2*math.pi*n)
g=0.1
l=0.2
b = 0.5
t = 0
tfin = 10000
v = 0
x = 2
px, pv = rk4(function, t, tfin, v, x, h, n)
fig, axis = plt.subplots(constrained_layout=True)
axis.scatter(px,pv)
axis.set_aspect('equal')
axis.set(xlabel='Desplazamiento', ylabel='Velocidad')
axis.grid()
```



3.6 Repita el ejercicio anterior incluyendo la fuerza externa en el péndulo simple

[10]:
```
function='-g/l*math.sin(x) -b*v/m + F0/m*math.sin(w*t)'
n=20
h=2*math.pi/(2*math.pi*n)
g=0.1
l=0.2
b = 0.5
t = 0
tfin = 10000
F0 = 0.2
w = 0.2
v = 0
x = 2
px, pv = rk4(function, t, tfin, v, x, h, n)
fig, axis = plt.subplots(constrained_layout=True)
axis.scatter(px,pv)
axis.set_aspect('equal')
axis.set(xlabel='Desplazamiento', ylabel='Velocidad')
axis.grid()
```


1.0
0.5
0.0
−0.5
−1.0
Velocidad
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
Desplazamiento