1 Programming Code

```python
#from numpy import sin,pi,linspace as np
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd

def res_var():
    data = pd.read_csv('var_res.csv')
    A_x = data['Ax(in V )']
    A_y = data['Ay(in V )']
    delta = data['delta( in rad)']
    t = linspace(-pi,pi,300)

    for i in range(0,5):
        x = A_x[i]*sin(100* t)
        y = A_y[i]*sin(100* t + delta[i])
        fig = plt.figure()
        ax = plt.axes(projection='3d')
        ax.set_xlabel("x($V$)")
        ax.set_ylabel("y($V$)")
        plt.tight_layout()
        ax.grid(True)
        plt.plot(x,y)
        plt.show()

def freq_var():
    data = pd.read_csv('var_freq.csv')
    A_x = data['Ax(in V )']
    A_y = data['Ay(in V )']
    delta = data['delta( in rad)']
    t = linspace(-pi,pi,300)

    for i in range(0,3):
        x = A_x[i]*sin(100* t)
        y = A_y[i]*sin(100* t + delta[i])
        fig = plt.figure()
        ax = plt.axes(projection='3d')
        ax.set_xlabel("x($V$)")
        ax.set_ylabel("y($V$)")
        plt.tight_layout()
        ax.grid(True)
        plt.plot(x,y)
        plt.show()
```

```python
def delta_vs_freq():
    data = pd.read_csv('var_freq.csv')
    delta = data['delta( in rad)']
    freq = data['v(Hz)']

    plt.xscale('log')
    plt.tight_layout()
    plt.grid(True)
    plt.xlabel("$v$ $(Hz)$")
    plt.ylabel("$\Theta$ (rad)")
    plt.title("$\Theta$ vs $v$")
    plt.plot(freq,delta)
    plt.show()

def freq_not():
    data = pd.read_csv('var_freq.csv')
    Ax = data['Ax(in V )']
    Ay = data['Ay(in V )']
    fig, ax = plt.subplots()
    ax.plot(Ax,Ay)
    ax.set_xlabel("$A_x(V)$")
    ax.set_ylabel("$A_y(V)$")
    plt.xticks(np.arange(12, 21, 1.0))
    plt.yticks(np.arange(0, 18, 2.5))
    #ax.annotate("(17,17)", (17,17),xytext=(17,17))
    plt.title("$A_x$ vs $A_y$")
    plt.grid(True)
    plt.show()



if __name__ == "__main__":
    res_var()
    freq_var()
    delta_vs_freq()
    freq_not()
```

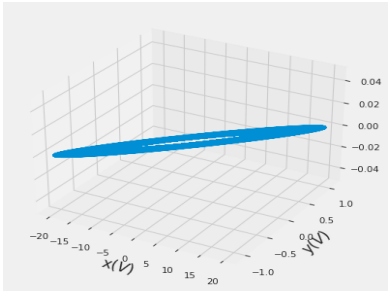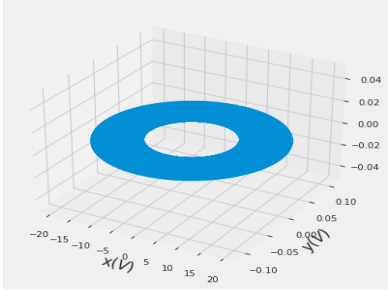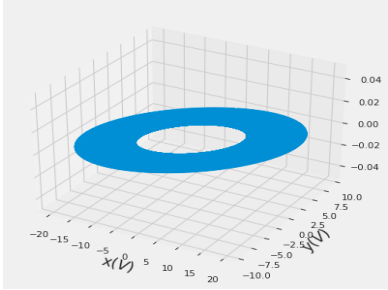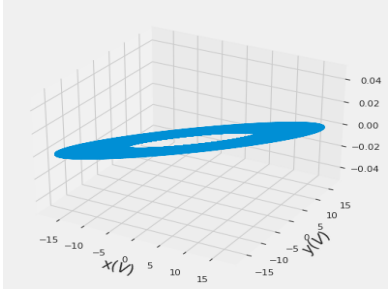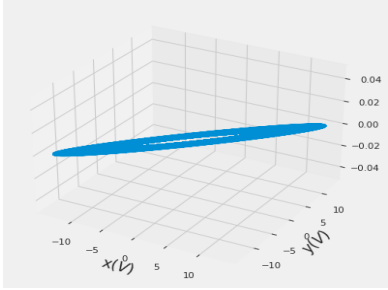| R(Ω)	A_x (V)	A_y (V)	$T_\mathrm{d}(\mathrm{ms})$	$T_\mathrm{p}(\mathrm{ms})$	$\theta(\mathrm{rad})$	Lissajous Figures
0.1	19.97	1.093	9.6875	10	6.08375	
10	19.97	0.1093	2.5	10	1.57	
1K	19.97	9.56	1.875	10	1.1775	
100K	17.005	16.865	0.625	10	0.3925	
1M	13.54	13.555	0.3125	10	0.19625	

Table 1: Table for Lissajous Figures
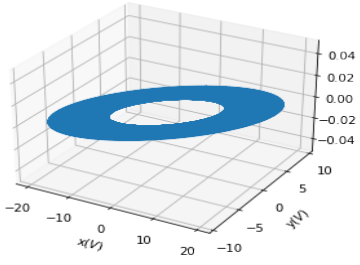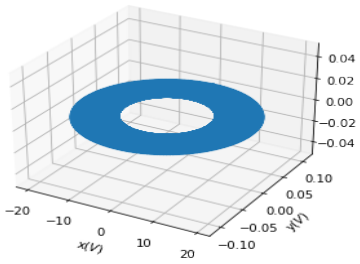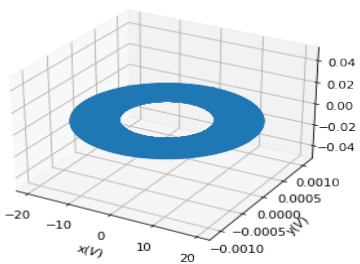
ν (Hz)	A_{x} (V)	A_{y} (V)	$T_{\mathrm{d}}(\mathrm{ms})$	$T_{\mathrm{p}}(\mathrm{ms})$	$\theta(\mathrm{rad})$	Lissajous Figures
10	19.97	9.33	15.625	100	0.98125	
1K	19.97	0.1093	0.25	1	1.57	
100K	19.97	0.0010925	0.0025	0.01	1.57	

Table 2: Frequency Variable Lissajous Figures

2 v vs θ

3 Ax vs Ay