Experiment 11: SCILAB and Mechanical Oscillator

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Abstract

The purpose of this experiment is to learn scilab and its usefulness in manipulating large data sets and analyzing a physical system such as a mechanical oscillator. The results for the lab were in the graphs that were plotted using the data acquired from the oscillator. The position, velocity, and acceleration graphs were sinusoidal with time. The kinetic, potential, and total energies were plotted with position and shown that the potential and kinetic energies are symmetric and parabolic as expected, with the total energy conserved and slowly decreasing.

1 Introduction

The purpose of this lab is to work with SCILAB to analyze the motion of a mechanical oscillator. SCILAB is a free open source software analogous to MATLAB, used to do numerical calculations. SCILAB uses matrices or vectors to store data, which then can be manipulated using operations. It can also be used to manipulate large sets of data and create plots. The motion of a mechanical oscillator has quantities that will be plotted such as the kinetic, potential, and total energies from measured quantities such as displacement, velocity, and acceleration. The data for the oscillator will be collected using a labpro unit and loggerpro software. Scilab will be used to manipulate this large data set and use the quantities mentioned to plot the necessary figures.

1.1 Equations

$$M_{eff} = m + \frac{1}{3}m_s \tag{1}$$

The total effective mass is the mass of the weight plus a third of the mass of the spring two springs.

$$T = 2\pi\sqrt{\frac{M_{eff}}{k}} \tag{2}$$

The period can be calculated using this equation where M_{eff} is the total effective mass of the system, and k is the spring constant.

$$U_s = \frac{1}{2}kx^2 \tag{3}$$

The potential energy is calculated using the spring constant and the displacement acquired from the labpro unit connected to the physical oscillator.

$$K = \frac{1}{2}M_{eff}v^2 \tag{4}$$

the kinetic energy is calculated using the effective mass and the velocity acquired from the labpro unit.

2 Experimental Procedure and Design

The first part of the lab was a training exercise in how to use SCILAB and some basic commands. Commands such as assigning numbers to variables, creating vectors with a certain size in certain steps. Creating plots in 2D and 3D and using trigonometric functions as well. A mass of a horizontal spring system was analyzed using scilab. The code below is split into two parts, 2.2 for some basic training in using scilab and 2.3 is the code used to analyze the mechanical oscillator. The mass was measured using a scale to measure the weight and the two springs. It was determined to be $0.49047 \pm 0.016kg$ from equation 1. The spring constant k, was determined using the period acquired from the sinusoidal graph produced and using equation 2, to get a value of 2.24 $\pm 0.112 N/m$.

2.1 Code

2.2 Basic training with scilab

```
t=(1:0.01:1000) %Creates vector t, from 1 to 1000 in steps of 0.01
si = sin(t)  % sin(t) is assigned to si
co = cos(t)  % cos(t) is assigned to co
plot(t,si);xtitle ( "t vs sin(t)" , "t" , "sin(t)" ); %plot of t vs si; with labels
plot3d3(t,si,co); %3D plot of t vs si and co
decay=exp(.02.*-t); %exponential decay term assigned to decay
plot(t,decay.*si) %plotting t vs decaying sine function in amplitude
w=exp(-.02.*t); %decaying frequency term
plot(t,sin(w.*t)); %plot t vs decaying sine in frequency
plot(t,decay.*sin(w.*t))  %decaying sine with amplitude and frequency
plot(t,sin(0.1.*t)+sin(0.5.*t))  %Beat pattern is produced with sine oscillation
```

2.3 Mechanical Oscillator

```
name=mgetl('scilabdata.txt'); %Assigning text file to name
num=evstr(name); %converting name to numbers
plot(num(:,1),num(:,3)) %time vs position plot
plot(num(:,1),num(:,4)) %time vs velocity plot
plot(num(:,1),num(:,5)) %time vs accel plot
plot(num(:,3),num(:,4)) %dist vs vel plot
plot3d3(num(:,1),num(:,3),num(:,4)) %t,dist,vel plot in 3D
x_half_cycle = num(22:52,3) % Slicing half cycle from position curve
half_cycle_vel = num(22:52,4) % Slicing half cycle from velocity curve
M = .49047 % Total effective mass
k=2.24 %Spring constant k
PE=0.5.*k.*X_p^2 %Potential energy function
KE=0.5.*M.*half_cycle_vel^2; %Kinetic energy function
plot(x_half_cycle,KE) %plotting half cycle of position with KE
plot(x_half_cycle,PE) %plotting half cycle of position with PE
plot(x_half_cycle,KE+PE) %plotting half cycle of position with KE+PE
```

3 Results

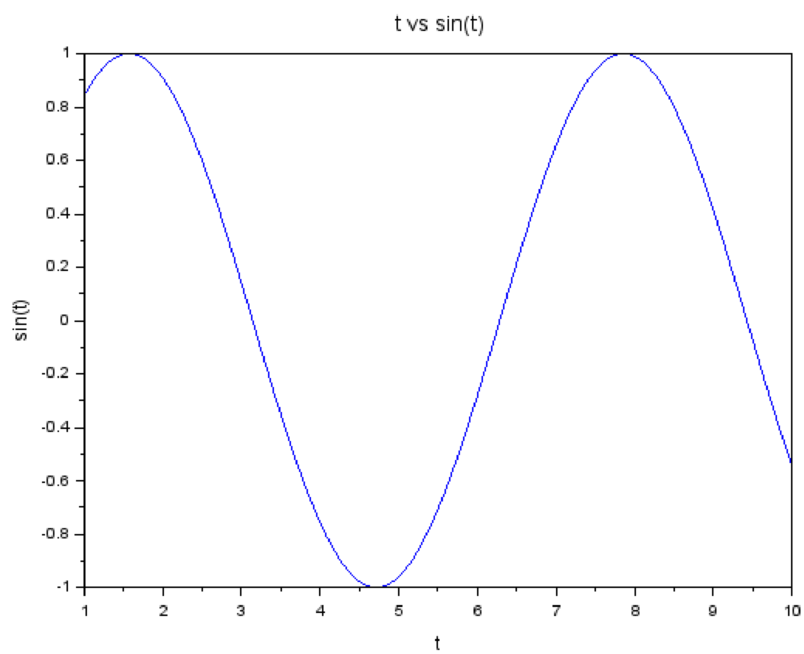

Figure 1: Sine wave as a function of time t.

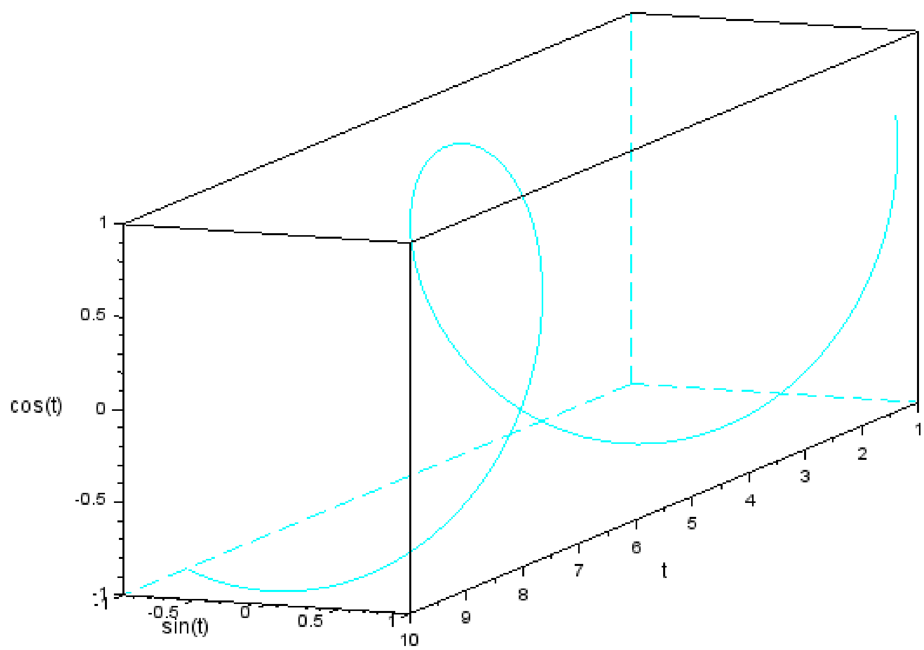

Figure 2: 3D plot of sin(t) and cos(t) as a function of time t.

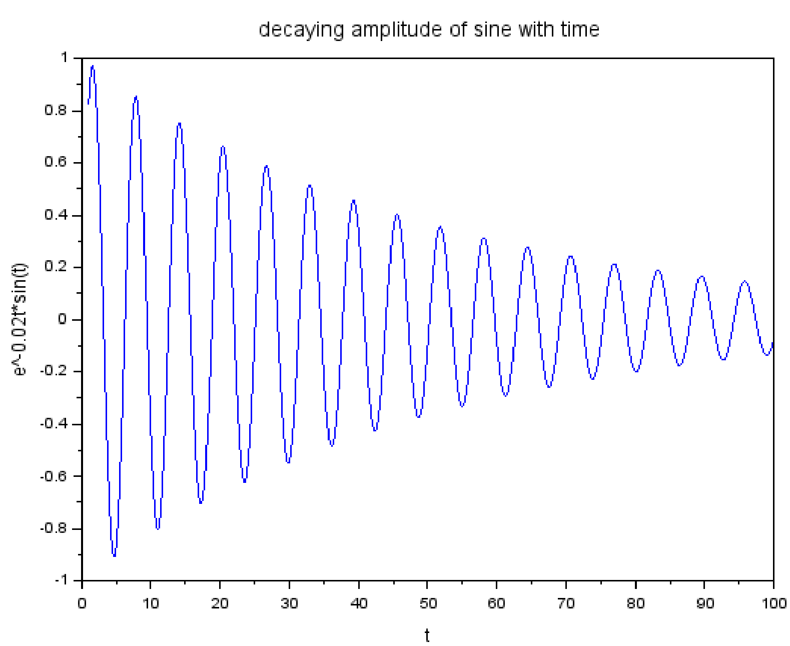

Figure 3: Sine wave decaying in amplitude with time

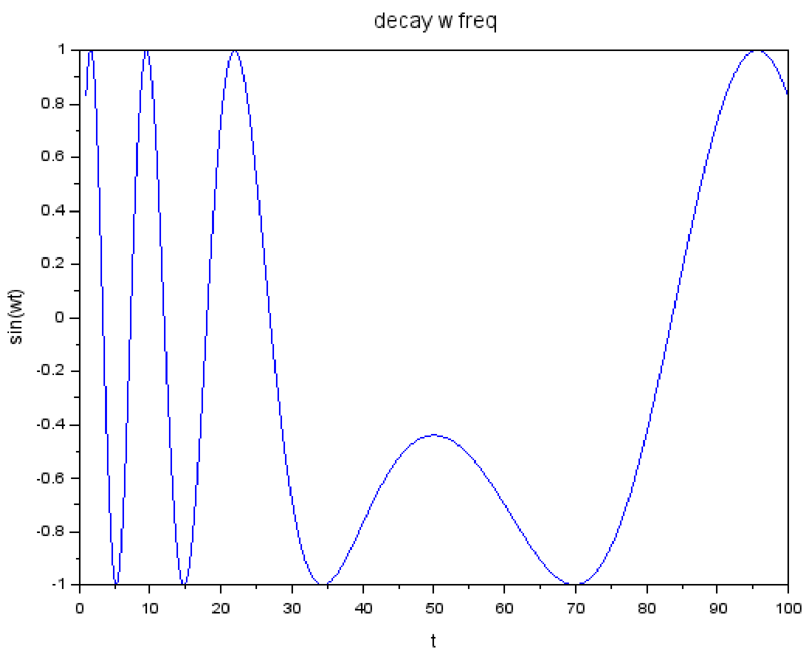

Figure 4: Sine wave decaying in frequency with time

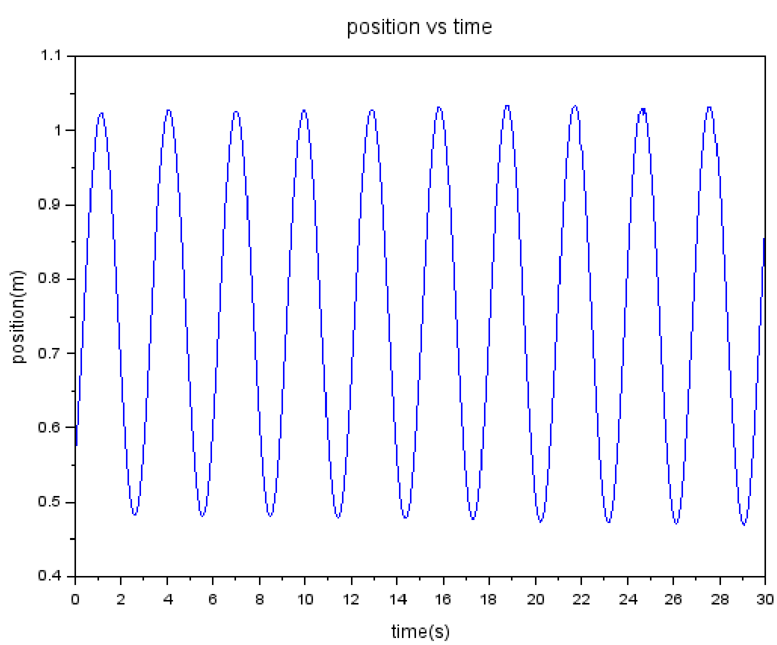

Figure 5: position vs time of the mechanical oscillator

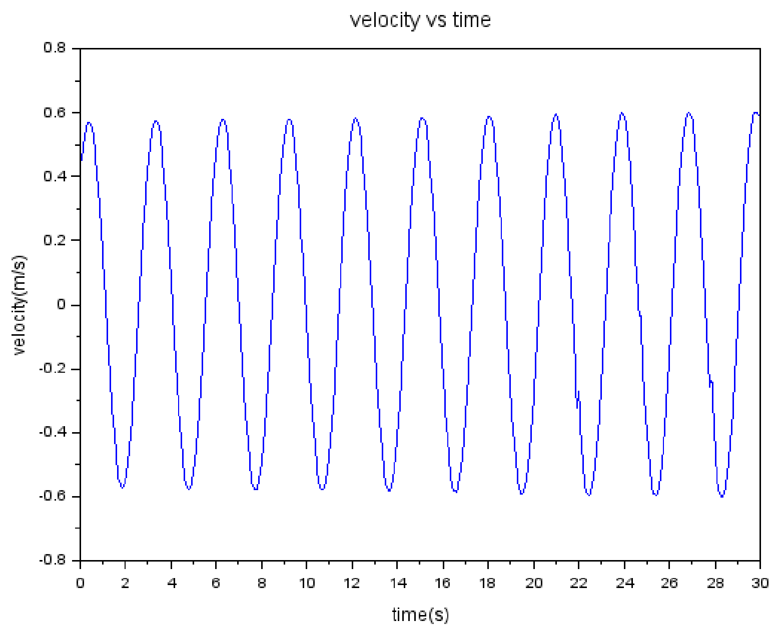

Figure 6: velocity vs time of the mechanical oscillator

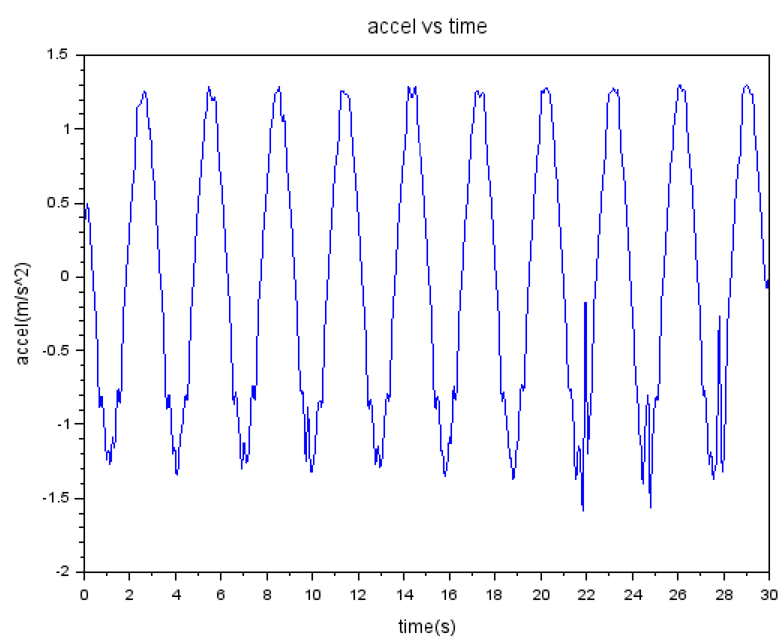

Figure 7: Acceleration vs time of the mechanical oscillator

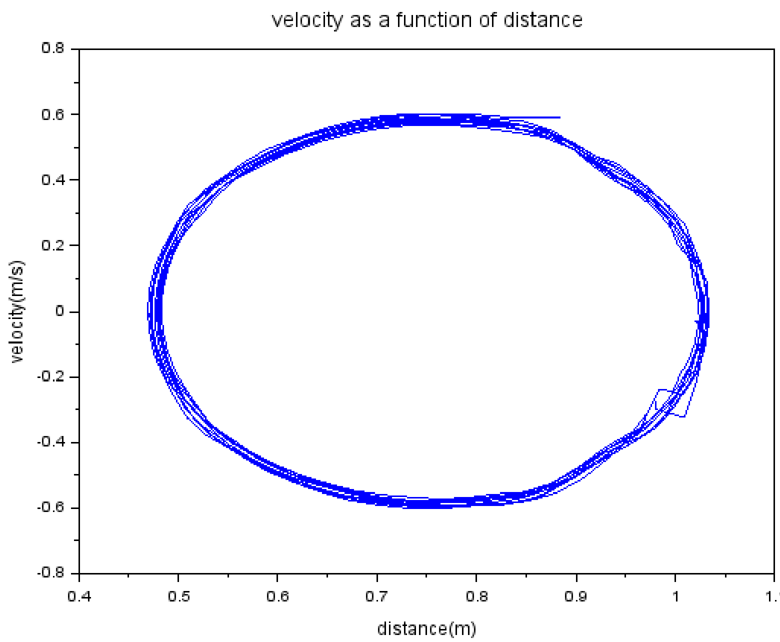

Figure 8: velocity vs position of the mechanical oscillator

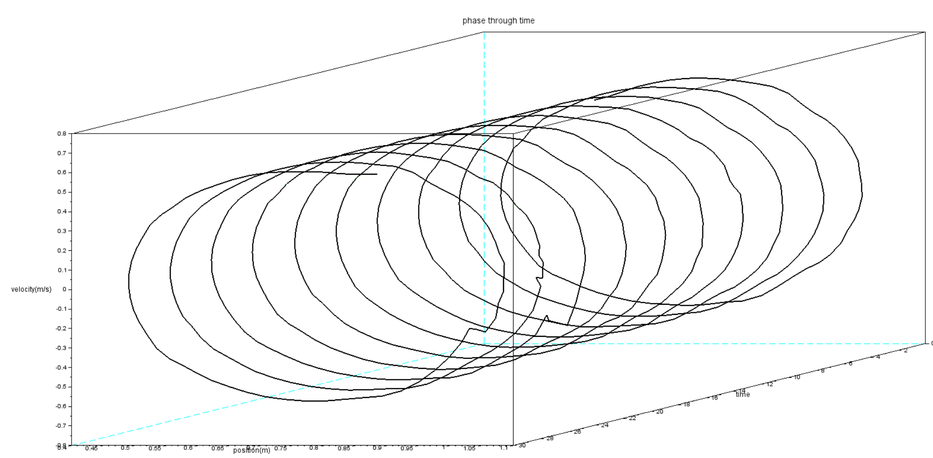

Figure 9: velocity vs position of the mechanical oscillator through time

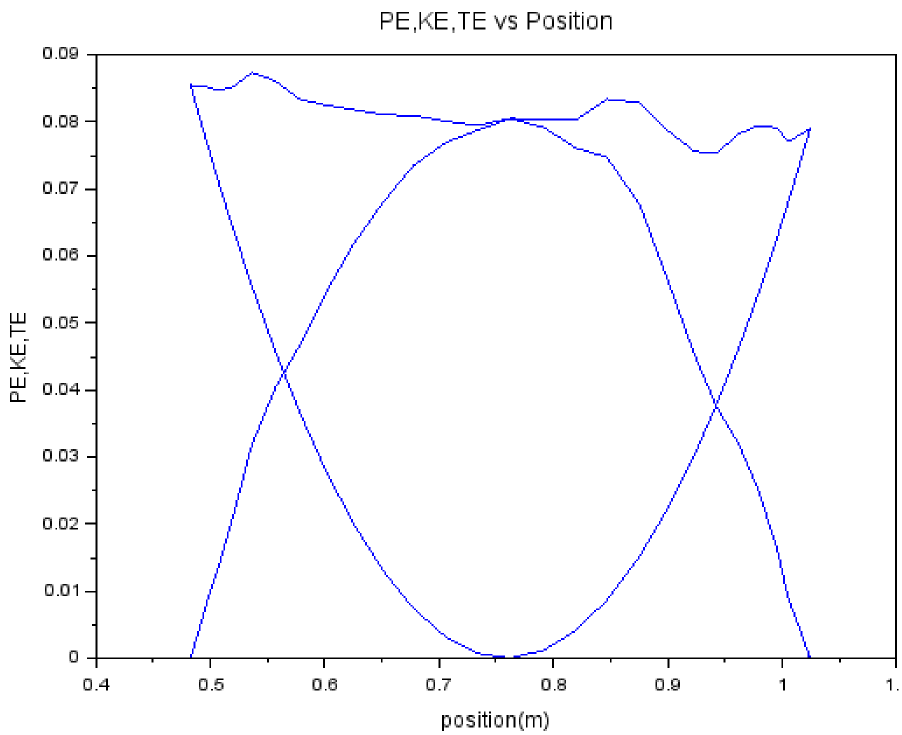

Figure 10: Potential, Kinetic, and Total energy vs position. As it can be seen from the graph that the total energy is the sum of the potential and kinetic energies. The potential and kinetic energies are parabolic and symmetric.

4 Discussion

The mechanical oscillator used two springs connected to a mass in a horizontal oscillator system. This system is connected to the labpro unit which measures the position, velocity, and acceleration through time as the system oscillates. The plots of position, velocity, and acceleration with time can be seen in figures 5, 6, and 7, respectively. These are sinusoidal waves in each case, which makes sense physically for the oscillator. The plot of position and velocity created the phase space figure seen in 8 and 9. This plot shows that there's an ellipse relationship between the position and velocity. As the mass moves horizontally from one end to the other, the velocity reaches minimum and maximum values, and eventually this ellipse will get smaller as time goes on. The plot of the potential, kinetic, and total energies with position can be seen in figure 10 for a half-cycle, and shows that the kinetic and potential energies are parabolic and symmetric, as the kinetic energy increases the potential energy decreases, while the total energy is always the sum of the two. There's also a slope to the total energy line, which is decreasing from left to right. This means he energy is decreasing while the mass moves from one side to the other. During this half-cycle, the slope also means that the direction that the mass is moving is that of decreasing total energy, in this case from left to right. The total energy of the system is also conserved with there being energy loss through friction.

5 Conclusion

The experiment overall fulfilled its purpose of learning scilab and using it to analyze a physical system such as the mechanical oscillator. The results for the oscillator were as expected from theory.

References

[1] Physics 321A, Laboratory Manual. University of Victoria, 2022.