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Variation of Mass Value for Spring Damper System in Suspension Using Python Simulation in Google Colab

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ABSTRACT

An analysis has been carried out for the Spring Damper System using the Python programming language on Google Colab. The first stage that is carried out before the simulation is to determine the differential equation based on Newton's II law equation. The Python programming language was chosen because only needs to run in a browser, users can monitor the training process (or even coding) via a smartphone browser if the smartphone is connected to the same Google Drive. The simulation is carried out by varying the mass value from 5kg - 50kg with a mass increase range of 5kg. This is done to determine the effect of mass on changes in position and velocity/speed. Based on the simulation results, the greater the mass value given will affect the amplitude value, the position graph will increase while the velocity graph will decrease, and the time needed for both amplitudes to stabilize will increase.

Keywords : Spring Damper System, Python Programming, Google Colab

I. INTRODUCTION

There have been many attempts to combine the fields of systems engineering and intelligent control with the latest research on information science, particularly on robust stabilization of uncertain dynamics [1] [2] [3]. The spring damping system in the suspension is an important factor in the performance characteristics of the vehicle [4]. Installation of springs and dampers is an important factor to ensure proper tire contact with the ground [5]- [9], maintain ride height [10] - [14], minimize spring forces [15] - [19], smooth ride [10][20] and driver comfort [21] – [24].

Many researchers are conducting research to improve the performance of suspension systems. Ookubanjo et al [25] presented the mathematical model for the coupled mass spring-damper system (CMSDS) was based on a set of nonlinear second-order ordinary differential equations and to simulate the dynamic accurately Lagrangian and Euler Lagrange equations. The simulation is done using matlab and simulink. Yang et all [26] presented on a two-dimensional Mass

Spring of thin film transistor (TFT) internal dynamics to determine the internal stress/strain distribution and its induction effect.

Currently computer modeling is an important part of engineering education to develop and apply the knowledge. Computers can be used to gain a better understanding of how various components interact in complex systems [27][28]. Knowledge of computer programming is the most important thing for scientists. The Python Programming Language is used and developed in many science applications [29]. The Python programming language offers a user-friendly work environment [30][31], offers quite good documentation [32] [33], and can be used even by new scientists. Researchers who use python to optimize mass spring damper, namely Madhan et al [4] propose the python programming language to optimize the orientation of the damper springs in the suspension using a genetic algorithm by maintaining optimal rider frequency and static rider height.

Python's ever-evolving libraries make it a good choice for Data analytics [29] and numerical methods. As the application of these methods, we will present variation of Mass Value for Spring Damper System in Suspension Using Python Simulation in Google Colab to determine the effect of mass on changes in position and velocity/speed.

II. METHODS AND MATERIAL

a) Determine the equation of Mass Spring Damper System

The design of a spring damper system with a python simulation that will be made can be shown in Figure 1. the design is made using a spring, damper, and mass.

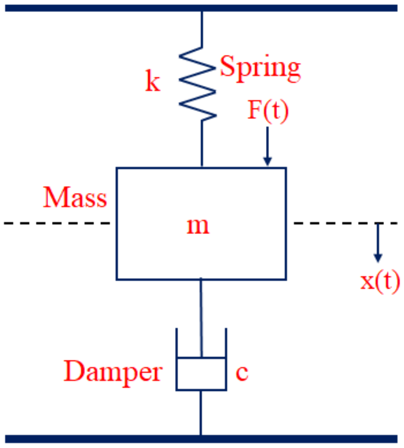


Figure 1. Design Spring Damper System

The dynamic equation of the system can be known by using Newton's II law, namely:

$$\sum F = m\,a$$

The system can be described by the following equation:

$$F(t) - c\frac{dx}{dt} - kx(t) = m\frac{d^2x}{dt} \dots\dots (1)$$

Description of the parameters in the Figure above as follows:

t = Time
F(t) = external force applied to the system
c = damping constant
k = stiffness of the spring
m = mass
x(t) = position of the object (m)
$\frac{dx}{dt}$ = first derivative of the position, which equals the velocity/speed of the object (m)
$\frac{d^2x}{dt}$ = second derivative of the position, which equals the acceleration the object (m)

$$F(t) - c\frac{dx}{dt} - kx(t) = m\frac{d^2x}{dt}$$

$$m\frac{d^2x}{dt} = F - c\frac{dx}{dt} - kx$$

$$\frac{d^2x}{dt} = \frac{1}{m}\left(F - c\frac{dx}{dt} - kx\right) \quad \dots\dots(2)$$

If,

$x = x_1$

$\frac{dx}{dt} = x_2$

So, then equation 2 becomes:

$$\frac{d^2x}{dt} = \frac{1}{m}(F - cx_2 - kx_1) \quad \dots\dots(3)$$

Where,

x_1 = Position

x_2 = Velocity / Speed

Equation (3) is used for simulation in Python programming, to determine the effect of mass on changes in position and velocity/speed.

b) Python Simulation

The simulation is carried out using the Python programming language on Google Colab. Google Colab is a cloud computing platform like Jupyter Notebook and Google Research. One of the advantages is being able to easily run deep learning programs via HP. Because in essence Google Colab only needs to run in a browser, users can monitor the training process (or even coding) via a smartphone browser if the smartphone is connected to the same Google Drive. The following is the display when opening Google Colab.

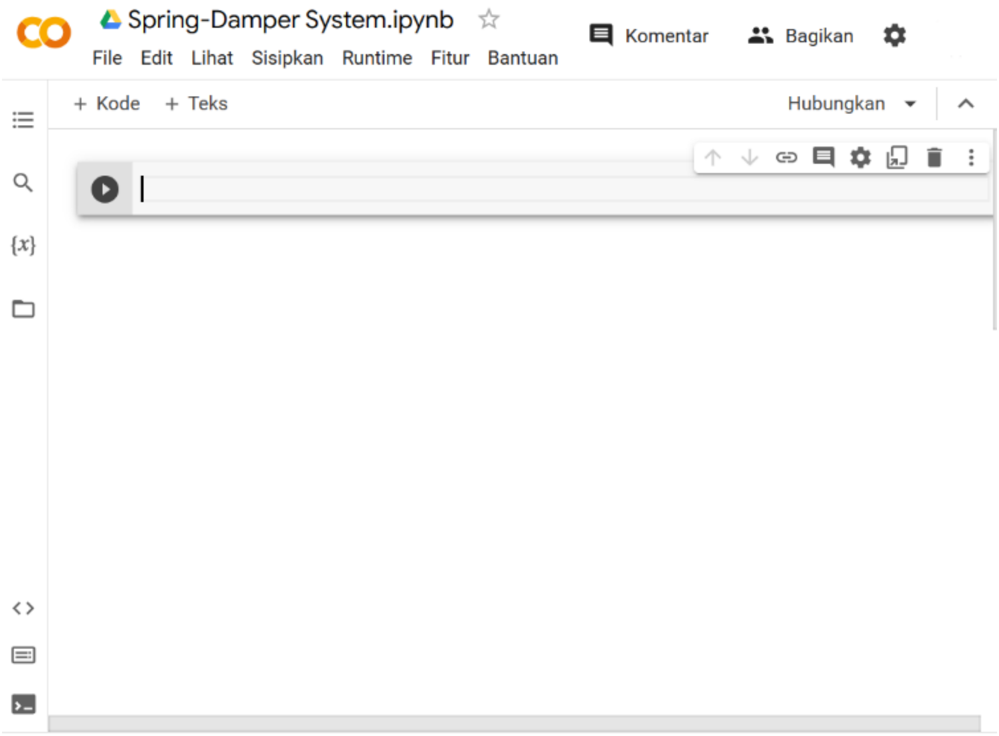


Figure 2. Google Colab

The first step to make the Spring Damper System program is to import the Python library, as shown in the program below:

```
import numpy as np
from scipy.integrate import odeint
import matplotlib.pyplot as plt
```

The simulation is carried out by varying the mass value from 5 kg - 50 kg with an increase of 5kg for 240 seconds. The initial time used is 0 seconds – 240 seconds. The variable values used in this simulation are:

damping constant (c) = 4,
stiffness of the spring (k) = 2 N/m, and
force (F) = 5 N,
as shown in the program below:

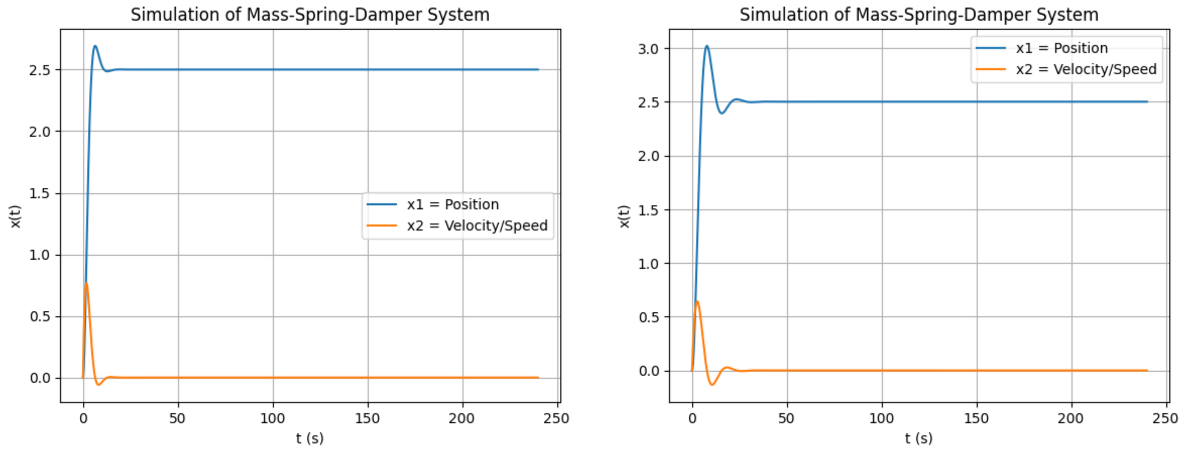
```
t_start = 0
t_stop = 240
increment = 0.01
x_initial =[0,0]
t = np.arange(t_start,t_stop,increment)

def mydiff(x,t):
  c = 4 #Damping Constant
  k = 1 #Stiffness of the Spring
  F = 5
  m = 25 #Mass
```

Equation (3) is used for simulation in Python programming. This is done to determine the effect of mass on changes in position and velocity/speed. The program that has been created is as follows:

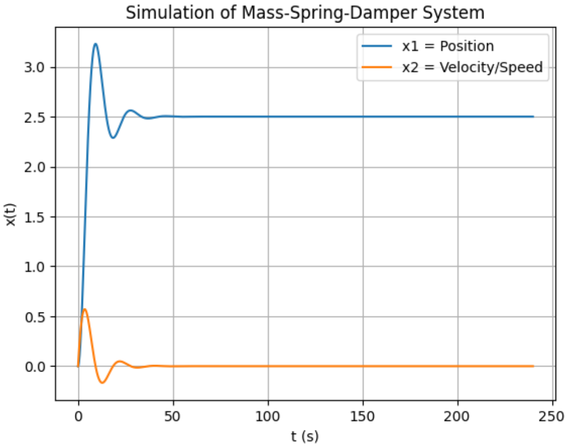
```
  dx1dt = x[1]
  dx2dt = (F-c*x[1]-k*x[0])/m
  dxdt = [dx1dt, dx2dt]
  return dxdt

x = odeint(mydiff, x_initial,t)
x1 = x[:,0]
x2 = x[:,1]

plt.plot(t,x1)
plt.plot(t,x2)
plt.title("Simulation of Mass-Spring-Damper System")
plt.xlabel("t (s)")
plt.ylabel("x (t)")
plt.legend(["x1 = Position","x2 = Velocity/Speed"])
plt.grid()
plt.show()
```

III.RESULTS AND DISCUSSION

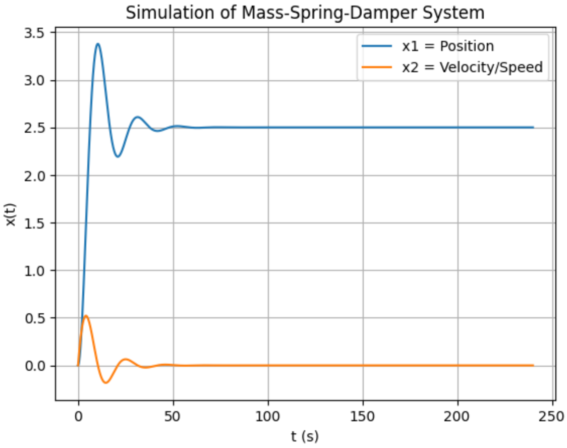
The research has been done variation of Mass Value for Spring Damper System in Suspension Using Python Simulation in Google Colab to determine the effect of mass on changes in position and velocity/speed, by inputting the value of damping constant (c) = 4, stiffness of the spring (k) = 2 N/m, force (F) = 5 N, and varying the mass value from 5kg-50kg with a range of 5kg changes, the position and velocity graphs are obtained as shown in Figure (3)



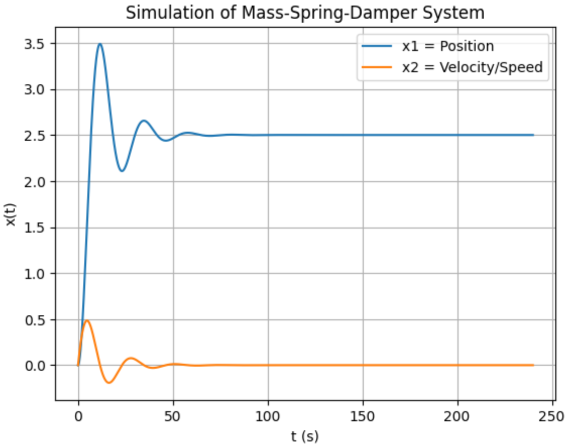
(a) (b)


Simulation of Mass-Spring-Damper System
x1 = Position
x2 = Velocity/Speed
x(t)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0
50
100
150
200
250
t (s)

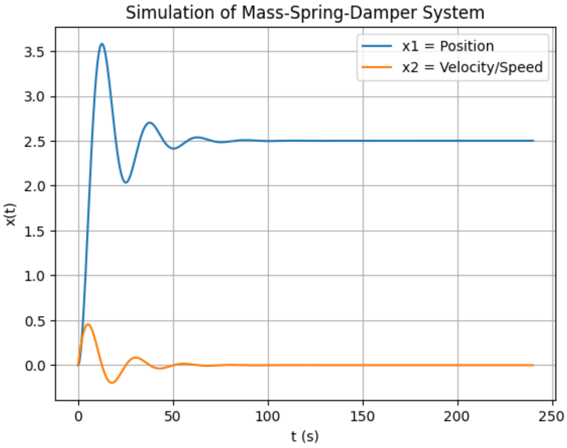
(c)


Simulation of Mass-Spring-Damper System
x1 = Position
x2 = Velocity/Speed
x(t)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
50
100
150
200
250
t (s)

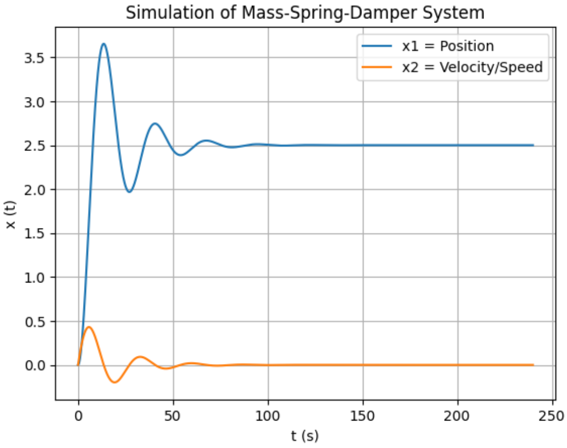
(d)


Simulation of Mass-Spring-Damper System
x1 = Position
x2 = Velocity/Speed
x(t)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
50
100
150
200
250
t (s)

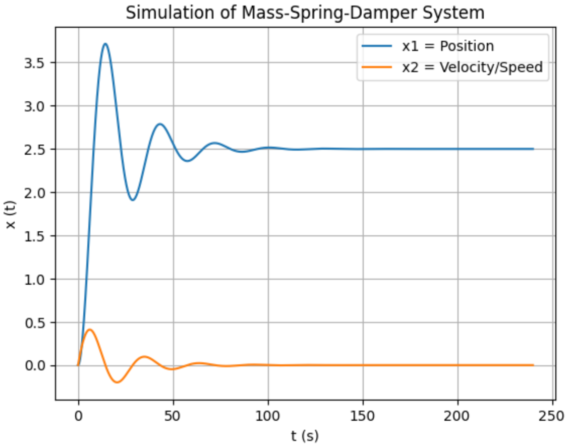
(e)


Simulation of Mass-Spring-Damper System
x1 = Position
x2 = Velocity/Speed
x(t)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
50
100
150
200
250
t (s)

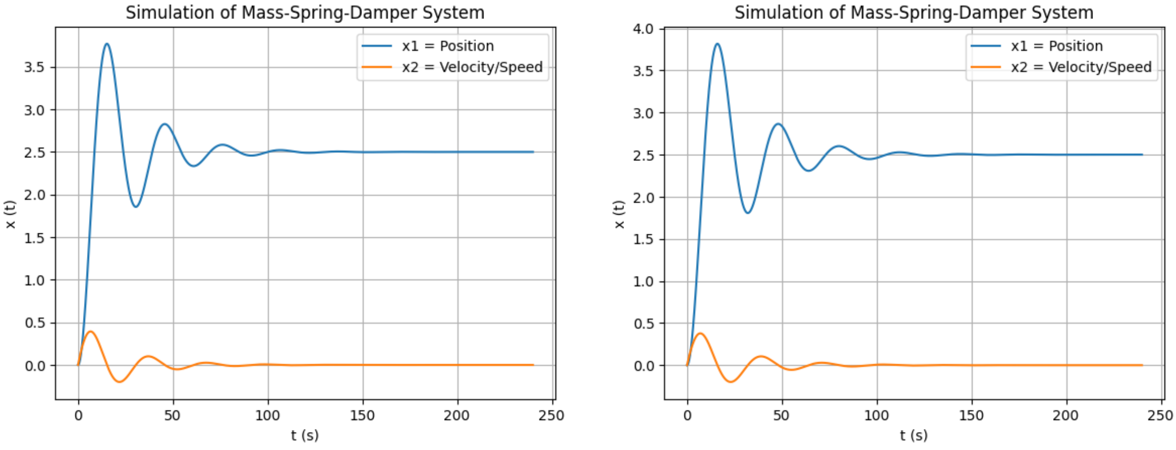
(f)


Simulation of Mass-Spring-Damper System
x1 = Position
x2 = Velocity/Speed
x (t)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
50
100
150
200
250
t (s)

(g)


Simulation of Mass-Spring-Damper System
x1 = Position
x2 = Velocity/Speed
x (t)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
50
100
150
200
250
t (s)

(h)



(i) (j)

Figure 3. Mass variation results: (a) 5kg, (b) 10kg, (c)15kg, (d) 20kg, (d) 25kg, (f) 30kg, (g) 35kg, (h) 40kg, (i) 45kg, and (j) 50kg

Based on the results of the graph shown in Figure (3), there are differences in the amplitude for each output signal when given different mass variations. The graph represented in blue represents the output signal in the form of position, while the graph represented in orange represents the output signal in the form of speed.

Figure 4(a) is a graph of position and velocity/speed when given the values damping constant (c) = 4, stiffness of the spring (k) = 2 N/m, force (F) = 5 N, and mass = 5kg, while Figure 4(b) is a graph when the mass variation is changed to 10kg, Figure 4(c)is when the mass is changed to 15kg, Figure 4(d)when the mass is changed to 20kg, Figure 4(e) when the mass is changed to 25kg, Picture 4(f) when the mass is changed to 30kg, Picture 4(g) when the mass is changed to 35kg, Picture 4(h) when the mass is changed to 40kg, Figure 4(i) when the mass is changed to 45kg, and Figure 4(j) when the mass is changed to 50kg.

Based on the graph in Figure 4 it can be seen that the greater the mass value given will affect the amplitude value, besides that the time needed for the amplitude to stabilize will also be longer when the mass is greater. On the graph of the position of each mass variation, it increases with increasing mass given, besides that the amplitude will decrease and become stable with increasing time when the mass variation increases. In the velocity graph, each mass variation decreases as the mass is given, besides that the amplitude will decrease and become stable with increasing time when the mass variation increases.

IV. CONCLUSION

Optimization of the performance characteristics of the spring damper system has been carried out by varying the mass value. The greater the mass value given, the position graph will increase while the velocity graph will decrease, and the time needed for both amplitudes to stabilize will increase.

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