Assignment 3

Meta

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Date: Jan 22, 2022

Objective

Provide the code for the damped oscillator.

Implementation

Julia

The Julia implementation for the damped oscillator is below. The `DampedOscillatorClass.jl` file creates the damped oscillator `struct` and provides methods/functions for operating on that structure. The `assignment_3_sciprt.jl` creates oscillators with various dampening factors, and plots thier positions against time.

- `DampedOscillatorClass.jl`

```
module DampedOscillatorClass

using Plots

export DampedOscillator, releaseSpring, initializeOscillator,
plotSpring

struct DampedOscillator
    springConstant::Float64
    dampeningConstant::Float64
    deltaT::Float64
    positions::Vector{Float64}
    velocities::Vector{Float64}
    accelerations::Vector{Float64}
    times::Vector{Float64}
end


"""
_updateAcceleration(osc)
Appends a new entry into osc.accelerations for the current time step.
This function shoud not be directly called. Instead use releaseSpring.
"""
function _updateAcceleration(osc:: DampedOscillator)
    acc = -1 * osc.positions[end] * osc.springConstant -
osc.dampeningConstant * osc.velocities[end]
    push!(osc.accelerations, acc)
```

```
end


"""
_updateVelocity
Appends a new entry into osc.velocities for the current time step.
This function shoud not be directly called. Instead use releaseSpring.
"""
function _updateVelocity(osc:: DampedOscillator)
    vel = osc.velocities[end] + osc.accelerations[end]*osc.deltaT
    push!(osc.velocities, vel)
end


"""
_updatePosition
Appends a new entry into osc.positions for the current time step.
This function shoud not be directly called. Instead use releaseSpring.
"""
function _updatePosition(osc:: DampedOscillator)
    pos = osc.positions[end] + osc.velocities[end]*osc.deltaT
    push!(osc.positions, pos)
end


"""
initializeOscillator(initialPosition,initialVelocity,springConstant,da
mpeningConstant)

Initializes a DampedOscillator structure with the appropriate values
and types given the above inputs.
"""
function initializeOscillator(
    initialPosition::Float64,
    initialVelocity::Float64,
    springConstant::Float64,
    dampeningConstant::Float64,
    deltaT::Float64,
)
    positions=[initialPosition]
    velocities=[initialVelocity]
    times=[0.]
    accelerations=[]

    osc = DampedOscillator(
        springConstant,
        dampeningConstant,
        deltaT,
        positions,
        velocities,
        accelerations,
        times
    )
```

```
    _updateAcceleration(osc)
    return osc
end


"""
releaseSpring(osc, stopTime)

Calcualte the acceleration, velocity, and position of the oscillator
at each time step until stopTime is reached
"""
function releaseSpring(osc::DampedOscillator, stopTime::Float64)
    if (stopTime<osc.deltaT)
        ErrorException("Time must be larger than $(osc.deltaT)")
    end

    currentTime = osc.times[end]
    while (currentTime <= stopTime + osc.deltaT)
        currentTime += osc.deltaT
        push!(osc.times, currentTime)
        _updateAcceleration(osc)
        _updateVelocity(osc)
        _updatePosition(osc)
    end
end


"""
plotSpring(osc, which)

Plots a time series of either the position, velocity, or acceleration
for the input oscillator.
"""
function plotSpring(osc::DampedOscillator, which::String = "position")
    if which=="position"
        y = osc.positions
        yLabel = "Position (m)"
    elseif which == "velocity"
        y = osc.velocities
        yLabel = "Velocity (m/s)"
    else
        y = osc.accelerations
        yLabel = "Acceleration (m/s^2)"
    end

    plot(osc.times, y, lab="Dampening Factor:
$(osc.dampeningConstant)")
    plot!(
        title = "$(yLabel) versus Time (s) for a Dampening
Oscillator",
        xlabel = "Time (s)",
        ylabel = yLabel
    )
    dampeningConstantName = replace(string(osc.dampeningConstant),
```

```
"."=>"_")

savefig("./assignment3/julia_plots/$(yLabel)_with_dampening_$(dampenin
gConstantName).png")
end

end # MODULE
```

- assignment_3_script.jl

```
include("DampedOscillatorClass.jl")

using .DampedOscillatorClass

initialPosition = 10.0 # meters
initialVelocity = 0.0 # meters
springConstant = 3.0 # Newtons / Meter
deltaT = 0.1 # second
runTime = 25. # seconds

dampeningConstants = 0.1:0.1:1.0 # Include 1.0

for dampeningConstant in dampeningConstants
    osc = initializeOscillator(
        initialPosition,
        initialVelocity,
        springConstant,
        dampeningConstant,
        deltaT
    )

    releaseSpring(osc, runTime)

    plotSpring(osc, "position")
end
```

Python

```
""" Damped Oscillator

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"""
from pathlib import Path
import matplotlib.pyplot as plt

class DampedOscillator(object):
    def __init__(self,
        initial_position: float,
```
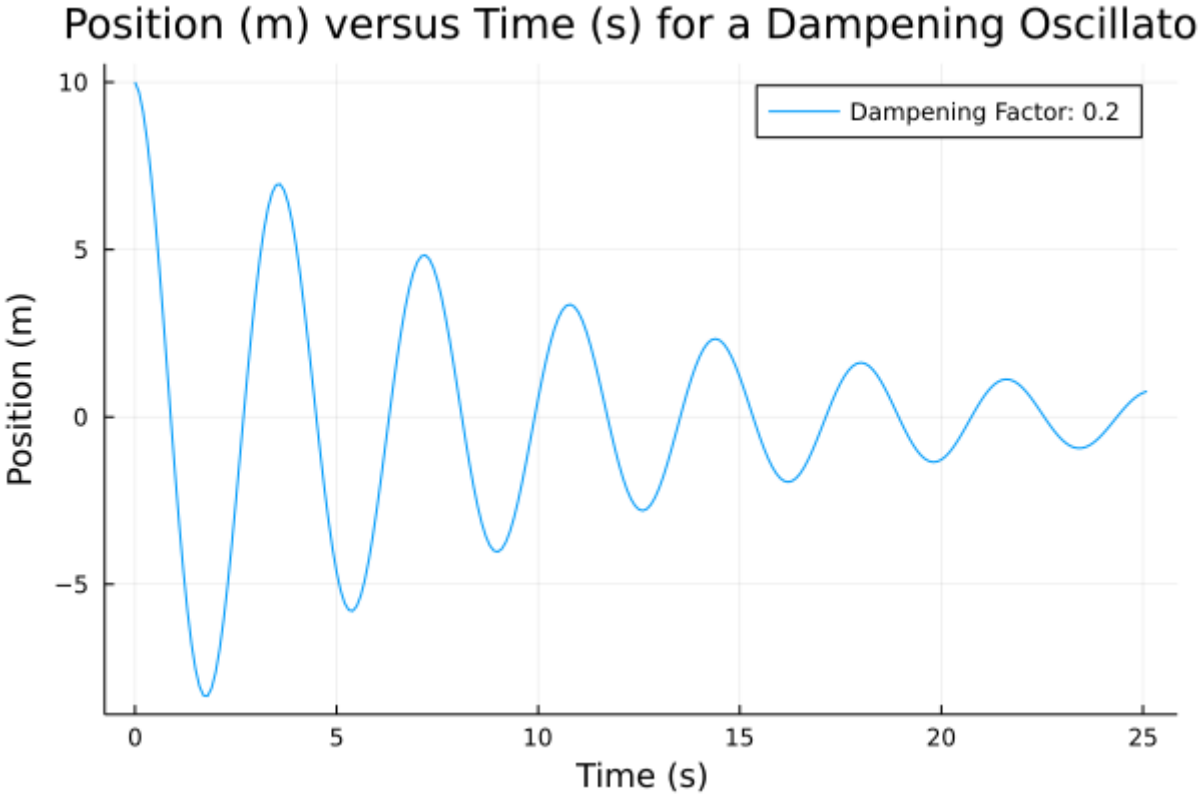

```
            initial_speed: float,
            spring_constant: float,
            delta_t: float,
            dampening: float,
        ):
            self.spring_constant: float = spring_constant
            self.delta_t: float = delta_t
            self.dampening: float = dampening
            self.positions: list = [initial_position]
            self.speeds: list = [initial_speed]
            self.accelerations: list = []
            self.times: list = [0]

            self._update_acceleration()

        def release_spring(self, time: float):
            if time < self.delta_t:
                raise ValueError(f"Time should be larger than
{self.delta_t}!")
            current_time = 0
            while current_time < time + (self.delta_t):
                current_time += self.delta_t
                self.times.append(current_time)
                self._update_acceleration()
                self._update_velocity()
                self._update_position()

        def _update_acceleration(self):
            acc: float = (-1 * self.positions[-1] * self.spring_constant
                - self.dampening * self.speeds[-1])
            self.accelerations.append(acc)

        def _update_velocity(self):
            vel: float = self.speeds[-1] +
self.accelerations[-1]*self.delta_t
            self.speeds.append(vel)

        def _update_position(self):
            pos: float = self.positions[-1] + self.speeds[-1]*self.delta_t
            self.positions.append(pos)

        def plot_spring(self, save_path: Path = None):
            fig, axs = plt.subplots(3, 1, figsize=(12, 8), sharex=True)
            axs[0].plot(self.times, self.positions)
            axs[0].set_title("Position")

            axs[1].plot(self.times, self.speeds)
            axs[1].set_title("Velocity")

            axs[2].plot(self.times, self.accelerations)
            axs[2].set_title("Acceleration")

            fig.suptitle(f'Oscillator With Dampening: Dampening Factor:
{self.dampening}')
```

```
            if save_path is not None:
                plt.savefig(save_path)
            plt.show()

    if __name__ == "__main__":
        sprint_constant: float = 2
        initial_position: float = 10
        initial_velocity: float = -2
        delta_t = 0.1
        total_time: float = 100.0

        for dampening in range(1, 15, 1):

            dampening = dampening / 10

            save_path =
Path(f"./juliapsych420/assignment3/oscillator_damped_{dampening}.png")

            spring = DampedOscillator(
                initial_position,
                initial_velocity,
                sprint_constant,
                delta_t,
                dampening
            )
            spring.release_spring(total_time)
            spring.plot_spring(save_path)
```

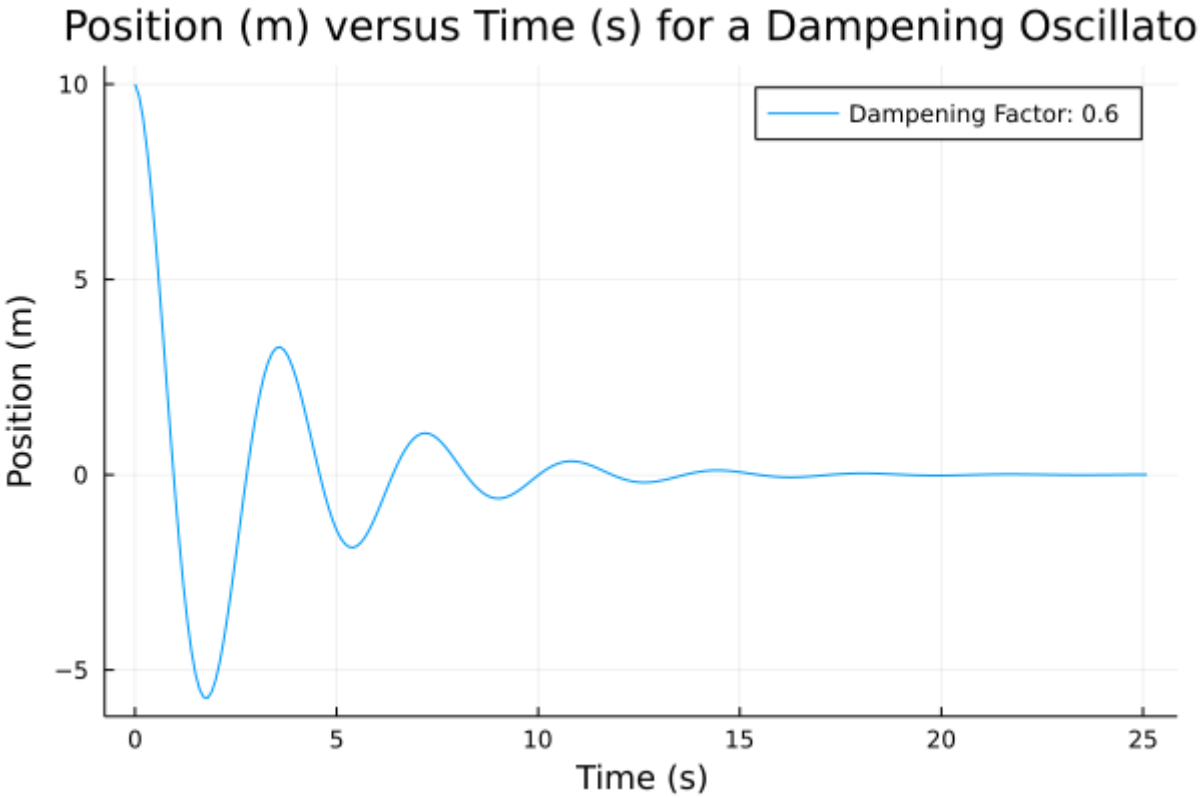
Results

Julia Graphs

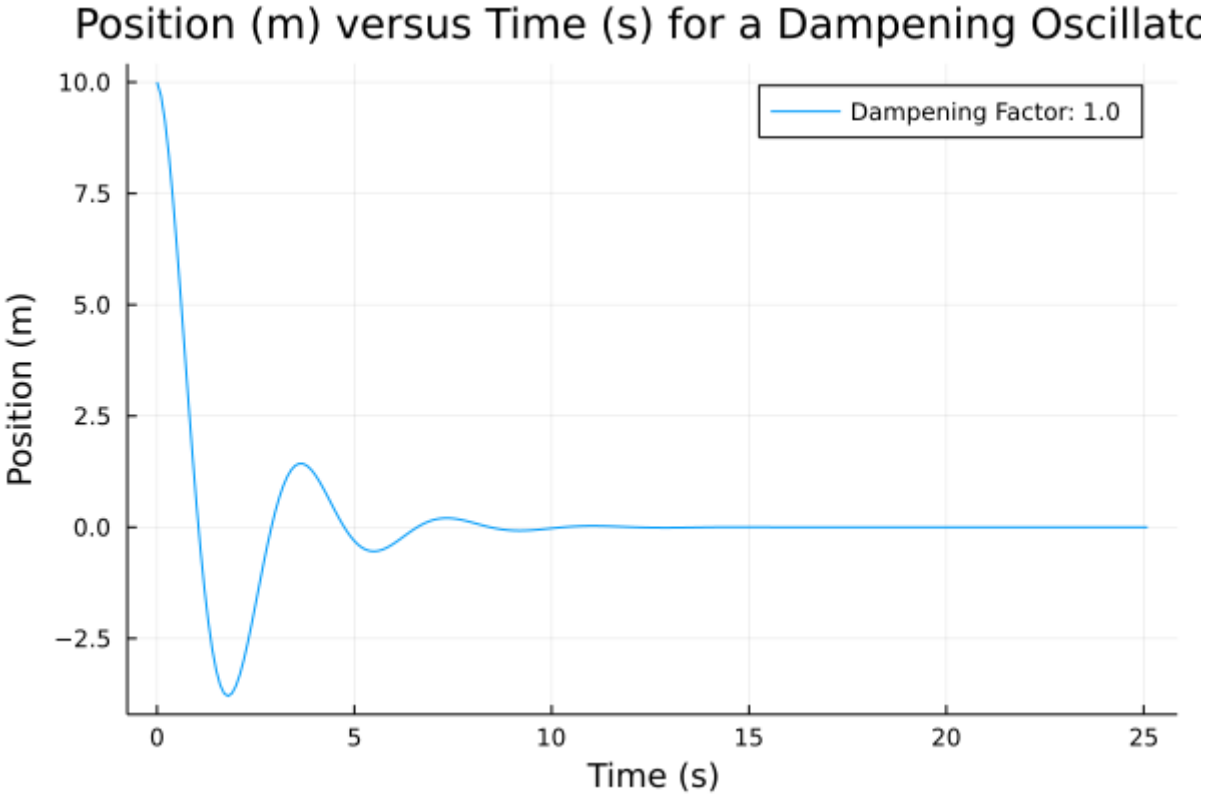
- Dampening 0.2



- Dampening 0.6

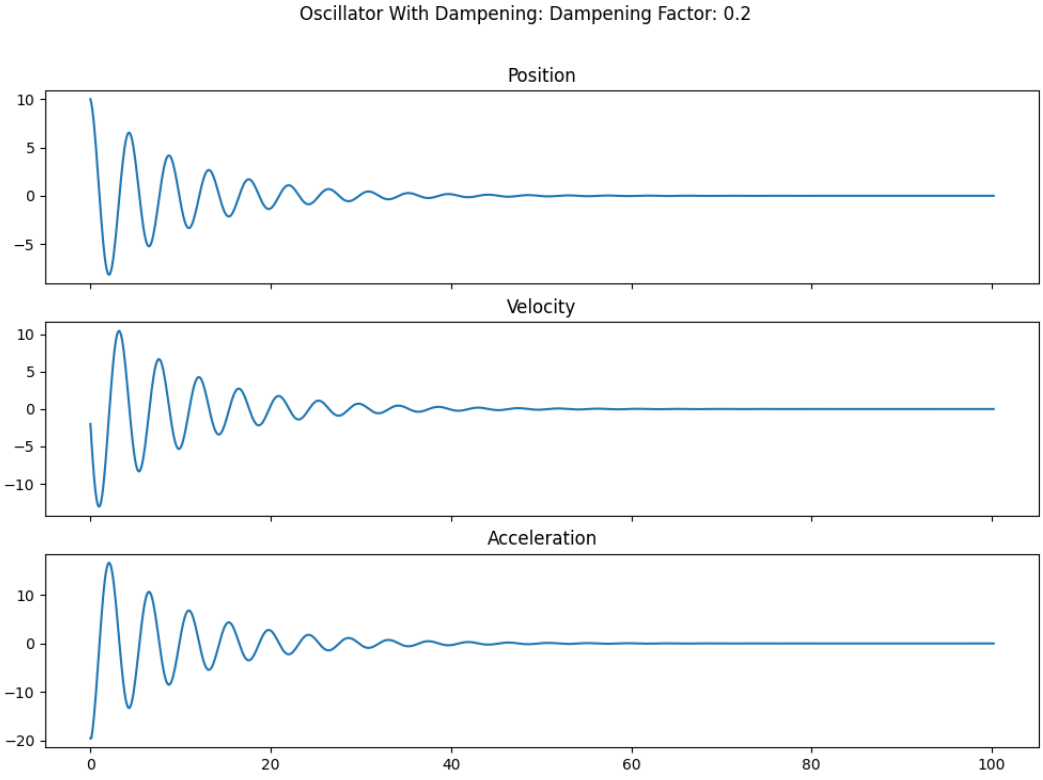


- Dampening 1.0

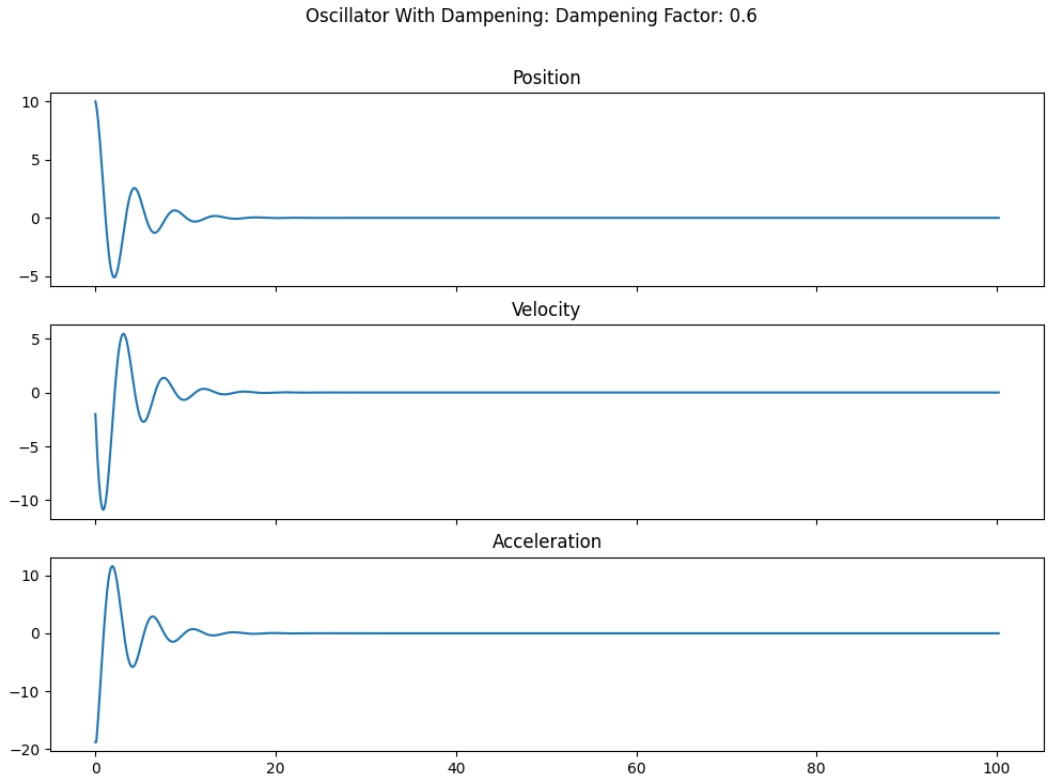


Python Graphs

- Dampening 0.2



- Dampening 0.6



- Dampening 1.0