Physics Lab 4: Oscillations

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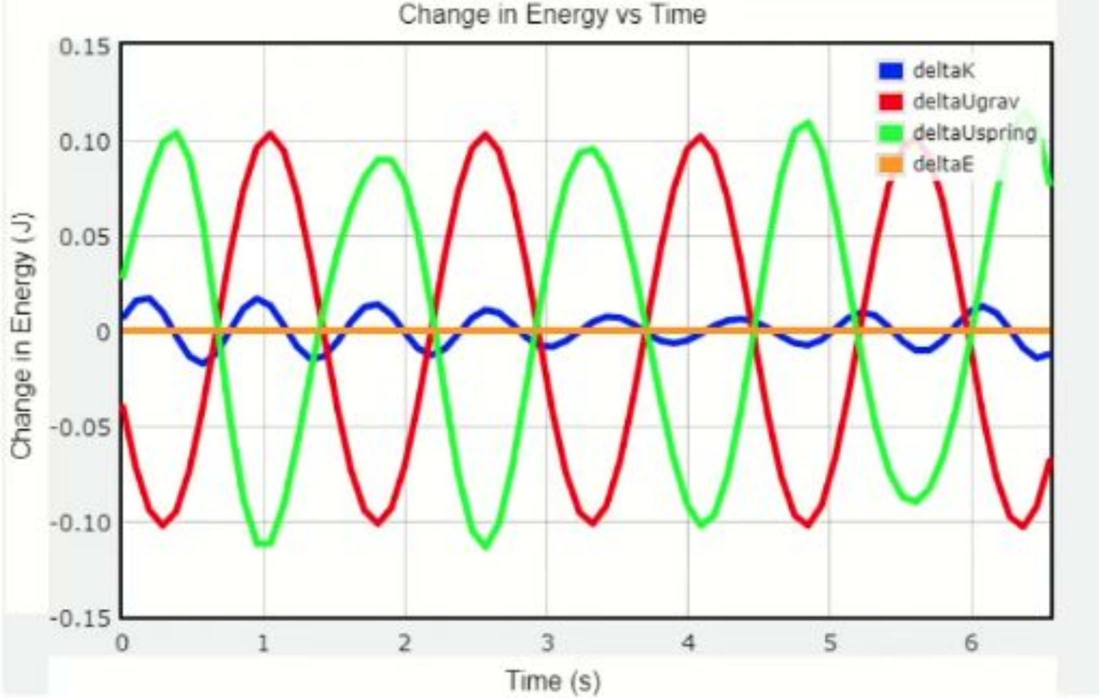
Introduction

Introduction - Purpose

Examine the motion of a spring-mass system in which the mass swings in an arc while oscillating on the spring

Use Tracker software to enable tracking and use observations as initial conditions for the computational model.

Introduction - Brief Preview



Introduction - Fundamentals

Newton's Second Law

$$\vec{v_f} = (\frac{\vec{F_{net}}}{m})\Delta t + \vec{v_i} \qquad \vec{F_{net}} = m \cdot a$$

$$\vec{p_f} = \vec{F_{net}} \cdot \Delta t + \vec{p_i}$$

These laws are used in order to calculate the position and velocity over time.

Introduction - Energy Principle

- The change in energy of a system is equal to the net transfer of energy into or out of the system
- W is the work done by force from the surrounding onto the system
- Q is the flow of energy between the system and surrounding due to temperature

$$\Delta E = W + Q$$

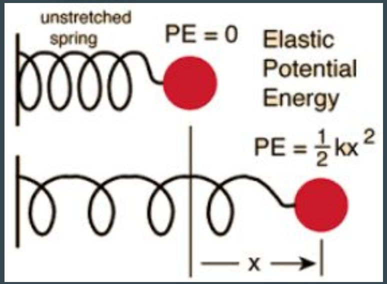
$$K \approx \frac{1}{2}mv^2 \quad \Delta E = \Delta K + \Delta U = 0$$

$$\Delta U \equiv -W_{int}$$

Different Type of Energies
Potential Energy
- this is the energy associated with pairs of interacting objects inside a system
Gravitational Potential Energy

$$\Delta U = mg\Delta y$$

Spring Potential Energy



Introduction

System: Earth Spring, Mass
Surrounding: Nothing else

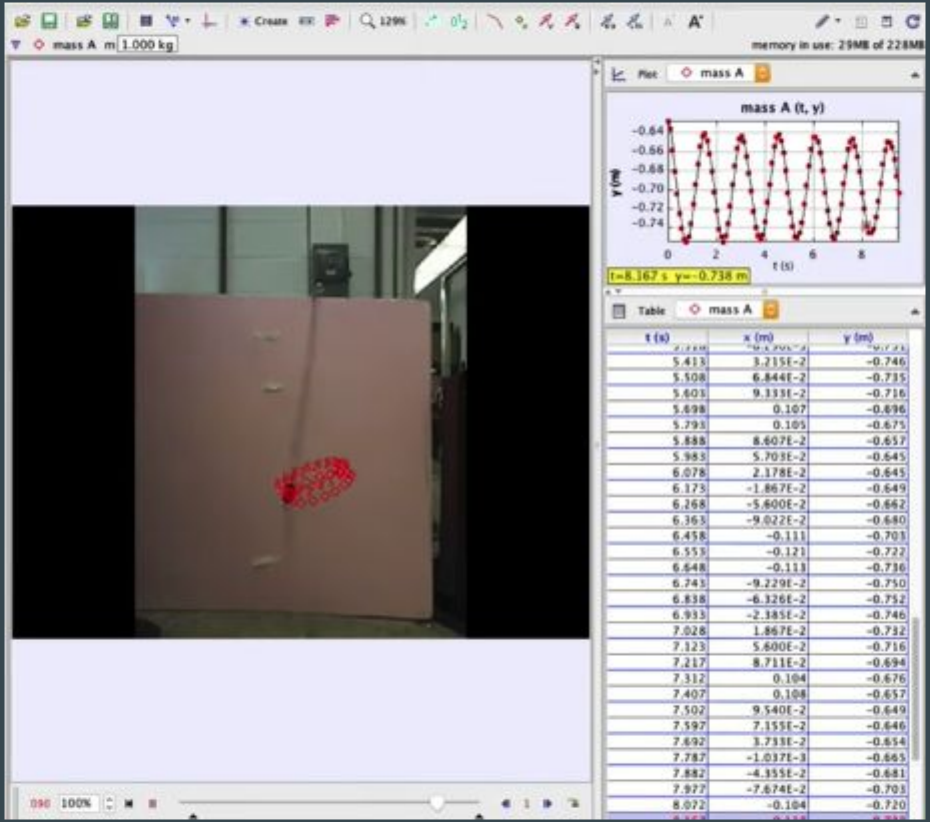
If the system include the elements that do work on the mass, the work done W and Q should be zero. Thus the change in energy for the system is equal to zero. $\Delta E = 0$

$\Delta E = \Delta K + \Delta U_g + \Delta U_s = 0$

Experiment

Details of Experiment

The video is imputed into tracker to obtain the x and y position. This data is used in GlowScript model from a CSV file.



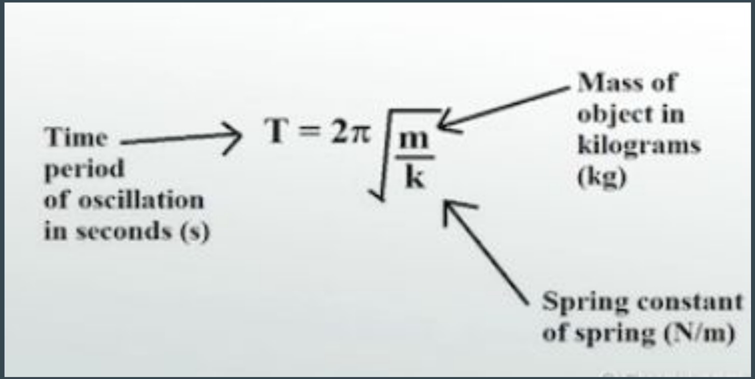
Experiment

To calculate K and L_0, I used the period of oscillation

to calculate the known spring constant, k = 0.683 N/m

L0 which is 0.123 by solving the equation

L0 = |L| - mg/k = 0.123 m



Code

Initial Conditions

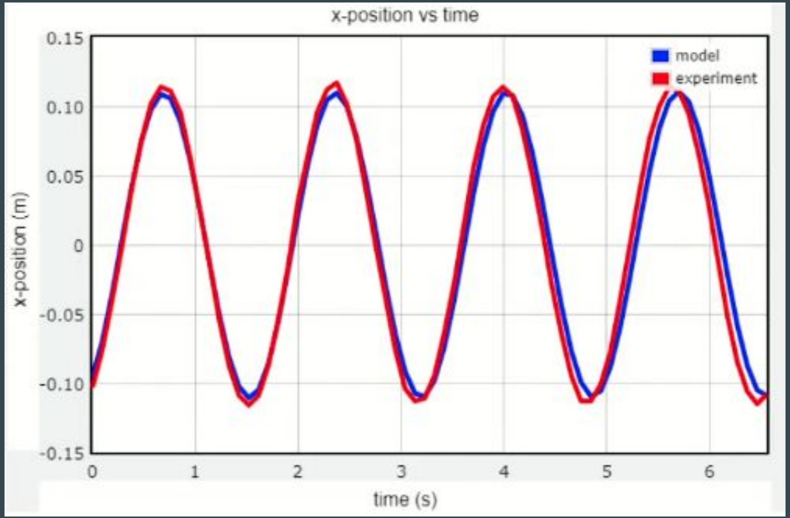
```
## =========================================
## INTERACTION CONSTANTS, SPRING, ENERGIES
## =========================================

# Constant to calculate gravitational force near Earth's surface
g = 9.8

# Spring constant -- EDIT THIS LINE to match your video analysis
k_s = 0.683

# Relaxed length of spring -- EDIT THSI LINE to match your video analysis
L0 = 0.123

# EDIT THESE NEXT THREE LINES to specify the vector L which describes both the length and orientation of the spring
L = ball.pos - spring.pos
Lhat = L/mag(L)
s = mag(L) - L0

# EDIT THESE NEXT FOUR LINES to compute the system energies
K = (1/2)*ball.m*mag(ball.vel)**2
Ug = ball.m*g*ball.pos.y
Us = (1/2)*k_s*s**2
E =  K + Ug + Us
```

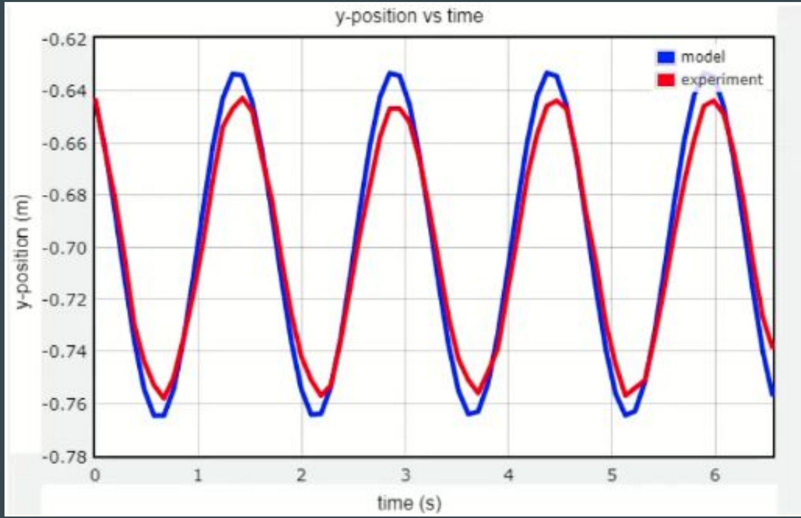
While Loop

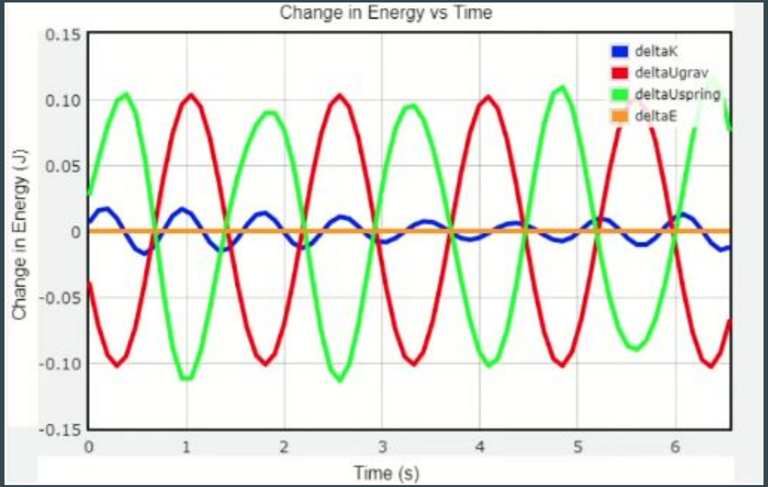
```
# Calculate gravitational force -- EDIT THIS NEXT ONE LINE
Fgrav = vector(0,-ball.m*g,0)

# Calculate spring force on mass by spring -- EDIT THIS NEXT ONE LINE
Fspring = -k_s*s*Lhat

# Calculate the net force -- EDIT THIS NEXT ONE LINE
Fnet = Fgrav + Fspring

# Apply the Momentum Principle (Newton's 2nd Law)
# Update the object's velocity -- EDIT THIS NEXT LINE
ball.vel = ball.vel + (Fnet/ball.m)*deltat
# Update the object's position -- EDIT THIS NEXT LINE
ball.pos = ball.pos + ball.vel*deltat

# Update the spring -- EDIT THE NEXT THREE LINES
L = ball.pos - spring.pos
Lhat = L/mag(L)
s = mag(L) - L0
```

```
# Calculate energy changes -- EDIT THESE NEXT EIGHT LINES
K = (1/2)*ball.m*mag(ball.vel)**2
deltaK = K - K_i
Ug = ball.m*g*ball.pos.y
deltaUg = Ug - Ug_i
Us = (1/2)*k_s*s**2
deltaUs =  Us - Us_i
E = K + Ug + Us
deltaE = E - E_i
```

Results - Graph







Potential Errors

- The y position time graph was less accurate at predicting the motion comparative to the x position time graph.
- This could be from force that are not account force such rotational kinetic energy, thermal energy, etc.
- Another error could come from incorrectly placement from human errors in tracker software.

Discussion

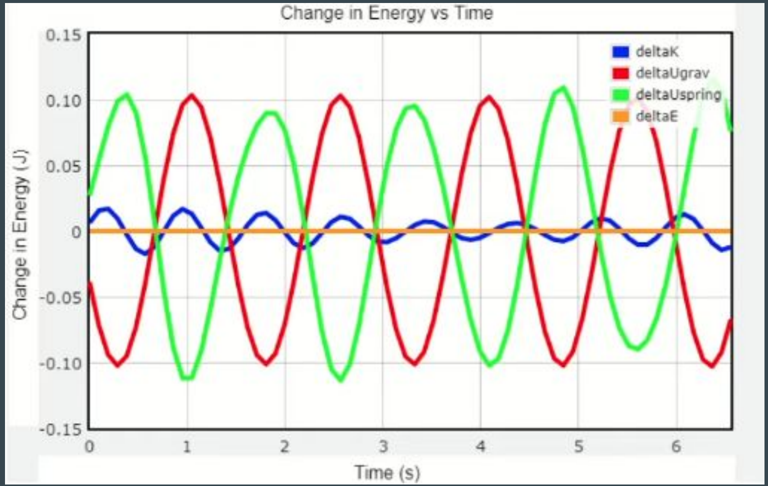
Discussion 1)

For your model system, is the energy principle satisfied?

The change in energy (orange) stay around

zero meaning there was no change in energy.

The energy was conserved.



Discussion 2)

The estimated average period of oscillation for the X is 1.63 seconds and Y is 1.52 seconds.

The difference could be explained from unaccounted forces and potential errors.