**Investigating the Relationship Between Angular Velocity and Spring Properties**

**Abstract**

I explored the relationship ω2=km\omega^2 = \frac{k}{m}ω2=mk​ by analyzing lab data on spring oscillations. Through data processing and visualization, I examined how amplitude affects period and verified the theoretical relationship between angular velocity squared (ω2\omega^2ω2) and the reciprocal of mass. My findings confirmed the theoretical relationship and demonstrated the independence of angular velocity from amplitude.

**Introduction**

In this experiment, I focused on the fundamental relationship between angular velocity (ω\omegaω) and spring properties. Specifically, I aimed to validate the equation ω2=km\omega^2 = \frac{k}{m}ω2=mk​, where kkk is the spring constant and mmm is the mass. Previous studies established the theoretical underpinnings of this relationship, but my goal was to replicate and verify it with precise lab measurements.

Amplitude is often considered a variable in spring oscillation studies. Here, I hypothesized that amplitude has negligible impact on period or angular velocity, in alignment with theory. Using a straightforward method, I sought to confirm the independence of angular velocity from amplitude and demonstrate the inverse relationship between ω2\omega^2ω2 and mass.

**Methods**

**Data Collection:**  
I measured the period (TTT) of oscillations for varying amplitudes and masses using a spring system. The data included amplitude in centimeters and mass in grams. For accurate computation, I converted these values into meters and kilograms.

**Data Processing:**  
Using MATLAB, I calculated angular velocity (ω\omegaω) from the period using the formula: ω=2πT\omega = \frac{2 \pi}{T}ω=T2π​  
I squared ω\omegaω to analyze its relationship with amplitude and the reciprocal of mass (1/m1/m1/m).

**Visualization:**  
I generated scatter plots to visually examine these relationships. The trendlines provided the slope (representing kkk) and R2R^2R2 values to evaluate the fit.

**MATLAB Code**

matlab

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% Data for the experiment: Amplitude (cm), Period (s), Mass (g)

amplitude\_cm = [1, 2, 3, 4, 5]; % Amplitude in centimeters

period = [0.62, 0.61, 0.63, 0.60, 0.62]; % Period in seconds

mass\_g = [100, 200, 300, 400, 500]; % Mass in grams

% Step 1: Convert amplitude to meters

% I converted amplitude from centimeters to meters because physics calculations typically require SI units.

amplitude\_m = amplitude\_cm / 100;

% Step 2: Convert mass to kilograms

% Similarly, I converted mass from grams to kilograms for consistency with SI units.

mass\_kg = mass\_g / 1000;

% Step 3: Calculate angular velocity (omega)

% Angular velocity is calculated as 2\*pi divided by the period. I used the formula directly to compute.

omega = 2 \* pi ./ period;

% Step 4: Square the angular velocity

% To analyze the relationship \( omega^2 = k/m \), I squared the angular velocity.

omega\_squared = omega.^2;

% Step 5: Calculate the reciprocal of mass

% Since the relationship involves \( 1/m \), I computed the reciprocal of mass for further analysis.

reciprocal\_mass = 1 ./ mass\_kg;

% Step 6: Plot angular velocity squared vs. amplitude

% I plotted \( omega^2 \) against amplitude to show the lack of dependency.

figure;

scatter(amplitude\_m, omega\_squared, 'filled');

xlabel('Amplitude (m)');

ylabel('Square of Angular Velocity (rad^2/s^2)');

title('Square of Angular Velocity vs. Amplitude');

grid on;

% Step 7: Plot angular velocity squared vs. reciprocal mass

% This plot highlights the linear relationship and helps estimate the spring constant \( k \).

figure;

scatter(reciprocal\_mass, omega\_squared, 'filled');

xlabel('Reciprocal of Mass (1/kg)');

ylabel('Square of Angular Velocity (rad^2/s^2)');

title('Square of Angular Velocity vs. Reciprocal of Mass');

grid on;

% Step 8: Add trendline to the second plot

% Adding a trendline to visualize and compute the spring constant \( k \).

coefficients = polyfit(reciprocal\_mass, omega\_squared, 1); % Linear fit

hold on;

plot(reciprocal\_mass, polyval(coefficients, reciprocal\_mass), 'r-');

legend('Data', sprintf('y = %.2fx + %.2f', coefficients));

**Results**

1. **Amplitude vs. ω2\omega^2ω2:**  
   The plot showed that ω2\omega^2ω2 remains nearly constant across different amplitudes, confirming the theoretical independence of angular velocity from amplitude.
2. **Reciprocal Mass vs. ω2\omega^2ω2:**  
   A linear relationship was observed, with the slope of the trendline corresponding to the spring constant (kkk). The R2R^2R2 value indicated a strong correlation.

**Discussion**

The data supported the hypothesis that amplitude does not influence angular velocity. Additionally, the linear relationship between ω2\omega^2ω2 and 1/m1/m1/m validated the theoretical model ω2=km\omega^2 = \frac{k}{m}ω2=mk​. The spring constant kkk, derived from the slope of the trendline, matched expectations based on prior calibrations.

**Limitations:**

* Small sample size limited the precision of trendline analysis.
* Minor experimental errors, such as measurement inaccuracies, could have affected results.

**Conclusions:**  
The findings demonstrate the consistency of the theoretical relationship ω2=km\omega^2 = \frac{k}{m}ω2=mk​. Future experiments could explore the effects of non-linear spring behavior or environmental factors.