Driven Harmonic Oscillator

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I. Introduction

This experiment on the driven harmonic oscillator introduces you to precise and accurate measurements. Data will be taken to higher precision and the analysis will be more in-depth than in your previous introductory physics lab experiments. You should become intimately familiar with all the components of the apparatus. This *real life* system is not an *ideal* harmonic oscillator and you will look for deviations from ideal behavior and quantify them. Be sure to make final curve fits on the graphs for the Lab Reports and discuss the results in detail.

With the exception of this experiment, the descriptions of most of the experiments are not given as *cookbook* recipes to be followed item-by-item. You are expected to continually ask, "why is that happening," or "what if I do this." All the while you should periodically examine the results. It is essential that you not only record the raw data in your notebook, but also ***plot the data as it is taken***. This will help you to spot errors quickly and make strategic decisions.

II. Apparatus

chassis with 2 horizontal coil springs and sliding mass, strain gauge transducer,
frequency meter, storage oscilloscope and interfaced computer,
motor speed control box; microswitch with screw adjustment and reference pulse voltage

III. Procedure

A. Free Oscillations

The strain gauge output will be recorded on the scope and used to determine the position of the sliding mass. Pull the mass several cm to one side and store the oscillations on the scope. Select a time sweep to observe the decay of the amplitude peak (A) to about 20-30% of the initial A. Store the scope trace in a file on the computer.

Curve fit ***several*** cycles to determine the free frequency f_{free} and uncertainty.

Find the damping constant g and uncertainty by "eyeballing" the envelope decay to $A_o \exp(-gt/2)$.

What is the value of Q ?

Plot the log of A to see if the damping is a constant over time.

Repeat for a larger A.

B. Off-Resonance Regions

Here you will examine the two off-resonance regions defined by $|f_o - f| >> g/2$. Use the reference voltage pulse from the microswitch and voltage source to trigger the scope. Input the position signal into channel-1. Adjust the motor control to the lowest speed where the amplitude *A* on the scope is still measurable. Measure *A* on the scope and measure *f* with a frequency meter. Make sure to measure the amplitude as determined from the vertical centers of the noisy traces, not the highest and lowest values of the noise.

Record data of *A* versus *f*, beginning at low *f* and increase *f* until *A* becomes large.

Continue to record data until *A* becomes too small to measure. For both sections, curve fit to *A* versus *f* to $A = a/f^2$.

Transform the x-axis to f^2 and the y-axis to $1/A$.

How linear is the $A^{-1}(f^2)$ dependence in the off-resonance regions?

Plot both data sets on one graph.

Discuss where the two linear curves intersect.

C. Near-Resonance Region

Finely adjust the motor frequency near f_{free} to achieve the maximum amplitude (A_m) of the sliding mass. Quantify this resonance region by measuring *A* on the scope while changing *f* on both sides of A_m to obtain data down to about $A_m/5$ on both sides of the resonance.

Plot *A* versus *f* ***as you take the data***.

Curve fit $A(f)$ to the expected resonance formula to obtain f_o and g and their uncertainties.

Compare the frequency, damping, and Q to that measured in the previous sections.

Visually, compare the ***sign*** of the phase angle on either side of the resonance?