Physics 100's Lab - Vibration **Name ____**

Date _______________ **Lab partner(s)____**

A mass bouncing up and down on a hanging spring is an important example of a variable net force acting on an object. This experiment deals with the "free" vibrations of such a system, that is, the motion the mass undergoes when it is simply displaced from its "resting" position and then released. After being released, the motion is mostly controlled by the inertia of the mass and three forces: gravity (the weight of the mass); the "restoring force" exerted by the coils of the spring; and friction, which gradually slows the mass to a halt after many vibrations. The spring itself has some inertia as well, but it is fairly small, so we will ignore it for the sake of simplicity.

The force exerted by a spring is determined by two factors: the stiffness of the spring, and how far it has been stretched or compressed from its equilibrium length. The stiffness is expressed by the "spring constant", symbolized by the letter k, which tells you what type of spring you have. The higher the spring constant's numerical value, the stiffer the spring.

This experiment examines the effect of inertia. Specifically, you will investigate the effect of inertia on the dynamic behavior of the spring-mass system by observing vibrations with two different masses. Any vibrational motion has a particular *frequency* - the number of complete "round-trip" cycles per second. It is expressed in units of Hertz, abbreviated Hz. One Hz is the same as one "cycle per second". The frequency, f is the reciprocal of the *period,* T, the amount of time it takes for one complete cycle. We'll look at one aspect of the relationship between inertia and the frequency and period of vibration.

1. Put enough mass on the hanger so the total mass hanging from the spring is 300 g. (If using slotted masses, some may not fit on the hanger unless they're slid down onto it from above the hook. Of course, the hanger itself is mass too!) Alternate the position of the slot so masses are less likely to fall off. Once hanging from the spring, pull it down just a little bit, maybe just a centimeter or so, and let it go at the same instant you start the timer. Try to prevent the bouncing from veering off into side-to-side swings. Measure how long it takes to oscillate up and down 10 cycles (complete up and down "round trips.") Repeat the process nine more times. Each of these ten trials is the time for 10 cycles and should all be exactly the same for the same mass. They are slightly different due to experimental error, so discarding obvious extremes and averaging the rest produces a more reliable answer than any single measurement from a single trial.

Trial #	1	2	3	4	5	6	7	8	9	10
Time (s)										

Discard the shortest and longest times and find the average of the remaining eight trials.

2. The average you just found represents the time for 10 cycles (or 10 "bounces") to occur. Now, calculate the period and frequency of vibration for this mass-spring combination. (Consider the uncertainty and number of significant figures in your count to 10!)

3. Now try hanging a total of 1200 g from the end of the spring coil. Then, set it into vibration, again timing for 10 cycles.

Trial #	1	2	3	4	5	6	7	8	9	10
Time (s)										

Again discard the shortest and longest times and average the remaining eight trials.

4. What are the period and frequency for this mass?

5. How does the period seem to be related to the mass? Does the system vibrate more rapidly with a large inertia or with a smaller inertia?

6. Although it would damage the spring to hang much more than 1200 g from it, what would you predict theoretically the period and frequency would be if the mass were 4,800 g? Judge by looking at what happened to T and f when you quadrupled the mass from 300 to 1200g experimentally, and then assume the effect repeats itself. Give a numeric answer.

7. Place the empty hanger on the spring and locate the position of the hanger bottom against the scale on a meter stick. Record that position here.

8. Find the precise weight of slotted metal masses with a nominal mass of 500 g.

9. Add the above weight to the hanger and measure the new equilibrium position of the hanger bottom against the same scale.

10. Find the change in position, displacement, or "stretch" caused by the added weight.

11. The added weight divided by the stretch distance gives the spring constant, k that is distinct to and characteristic of this particular spring. Find k and its resulting units.

12. Use the given theoretical formula for period, $T = 2\pi \sqrt{(m / k)}$ along with the applicable mass and spring constant to verify both of your ***two earlier experimental findings for T***. The % difference between T experimental and T theoretical should be less than 10%, otherwise find the errors in your experiment and/or your theoretical calculation.