How to find spring constant with mass and period

Objectives: 1. To verify Hooke's law for a linear spring, and 2. To check the formula for the period, T, an oscillating mass spring system equipment: A linear spring, slot weights, a stopwatch, a spring bar, a metre stick or a 30.0 cm ruler, a mass scale, a C-clamp and rod attachment, an inclined clamp, a normal weight hanger and a few sheets of Cartesian graphene paper Theory: Hooke's law simply states that for a linear spring the spring force is Proportional to the length change. (Here, the term spring force means the force that the spring exerts on the object attached to it. The object is often referred to as mass. Mathematical, Fs = - kx, where k is the spring constant. The reason for the (-) character is that Fs and x always have opposite characters. When a spring is pulled to the right, Fig. (a), the external force applied is Fappl., right, but the spring force, Fs , acts to the left. On the other hand, when the spring is pressed to the left, fig. (c), Fs trades to the right. When mass M is suspended from a spring, as shown below, it expands the spring of the initial length y1 and the spring reaches an equilibrium length of yo + y1. When the mass is pushed up a distance A and then released, it oscillates above and below this equilibrium level. Distance A, i.e. the maximum deviation from equilibrium, is called the amplitude of vibrations. This formula is the result of the solution of a second-order linear differential equation with constant coefficients. The differential equation is very easy to set up as follows. At each vibration alging moment, it is the spring force Fs = -ky, the mass M accelerates at a rate a = d2y /dt2. According to Newton's 2nd Law, Fs = Ma. This can be written as: - ky = Ma, or - ky = Md2y /dt2, or d2y /dt2 + (k /M) y = 0. This can be written like: d2y /dt2 + 2 y = 0, where s2 = k /M of those s = (k /M)(1/2). Method: The value of k, the spring constant, can be measured in two ways. One method is to use Hooke's law. The other method is to measure the period T of the vibrations of a mass spring system. The values of k obtained by the two methods can then be compared and used as a check of the validity of the theories involved. I. The Hooke's Law Method: The mass spring system acts similarly to a spring scale. It has a vertical ruler that measures the elongation of the source. 1. Measure the mass of the hanger without spring. 2. Attach the spring and the hanger to the support. Zero the system by pushing the ruler against the needle. The ruler slides slightly as soon as its collar or slider (on the back of the ruler) with two pressed. By zeroing the system with its small weight hanger weight hanger You don't have to consider its mass for this part of the experiment. 3. Place a 100g mass M1 on the hanger and measure the length change of the spring. It is better to use two 50g slotted masses instead of a single 100g mass. Make sure the slots are exactly parallel and opposite each other so that the weights hang perfectly vertically. If the slots are not opposite, the weights hang tilted, which tilts the needle and causes incorrect reading of the balance. Note the measurements of M and Y and the calculated value of F in a table similar to the one shown below. 4. Repeat the above step for two or three additional ground values up to about 250g. Re-use smaller slot weights configured with the slots to avoid tilting. 5. Plot F compared to y and find the slope of the chart. The spring constant k is equal to the slope. II. The oscillation period method: 1. Place the first recommended mass on the weight bar. 2. Add the mass of the weight bar to this mass and record it in the appropriate room in a table similar to the one shown below. 3. Pull the mass with its weight hanger up to about 2 to 3 cm below its equilibrium level and release it freely. Start counting vibrations when the mass reaches either the highest or lowest point. Start counting from zero while starting a stopwatch. The greater the number of vibrations, the more accurate the measurement of the period. Count about 25 to 50 vibrations and stop the clock. Record the total time in the table and calculate period T and T2. Repeat this process for all recommended masses. 4. Plot T2 against M and find the slope of the chart. The spring constant k is indicated by k = (2)2/slope, an equation that can be obtained from the value of n = 2 x/D. Calculate the spring constant. 5. Calculate a percentage difference for the k-values determined using the two methods. Note that the oscillating mass is not only the mass of the slotted weights in any case. The mass of the weight bar must be taken into account in each calculation. M(kg) Total time(s) T(s) T2(s2) Data: Specified: M1 = 100. g M2 = 150. g M3 = 200. g M4 = 250. g Measured: Mass of the weight hanger = calculations: Perform the calculations and calculate k in method II with k = (2)2/slope. Comparison of results: Calculate a percentage difference with conclusion: To explain by the students. Discussion: To be explained by the students. Questions: 1) Is the solution for the differential equation d2y/dt2 + 2 y = 0 of the form: y = A cos (t) + B sin (t) ? ja, was was the role of s in the equation? What unit should it have if t is in seconds? 2) If a second order is linear d.e. in the form: d2y/dt2 + (k /M) y = 0, what should be the value of s? 3) If the angular frequency and in rad/s, how are f in (cycles/s) and T in (s) related to it? Power probes are versatile tools in the physics lab, but their internal functionality can introduce artifacts when they measure rapidly changing forces. Vernier's Dual-Range Force Sensor (Fig. 1) uses strain measurement to measure force based on the bendofof of a beam. Strain gags along the length of the beam change the resistance when the beam bends (Fig. 2). The elasticity of the beam leads to vibrations that persist after being stimulated by an impulsive force. How quickly the force probe returns freely to zero is therefore related to the stiffness of the beam and the total mass attached to it. By varying the added mass and measuring the resulting frequency of the internal free vibrations of the probe, the effective mass and spring constant of the moving parts of the probe can be found. Weighing the probe parts and performing a hooke law experiment allow static verification of these parameters. Studying the behavior of the force sensor helps students learn more about subdued harmonic movements, mathematical modeling, and the limits of measuring devices.1. Some poppers require that the toy be dropped to trigger the pop (e.B. the Dropper Popper available from), while others automatically pop (e.B. Large Marbleized Popper available from). We used the latter type in this study. Google Scholar2. David R. Lapp, Exploring 'extreme' Physics with an expensive plastic toy popper, Phys. Educ. Educ. 43, 492-493 (Sept. 2008). Google ScholarCrossref3. Michael Vollmer and Klaus-Peter Möllmann, Bouncing poppers, Phys. Teach. 53, 489 (Nov. 2015). High-speed videos from Poppers are included. , Google ScholarScitation4. When a delta function pulse is applied to an ideal spring mass system that is originally in equilibrium, the mass receives an initial velocity, briefly comes to rest after a quarter period, and then continues to oscillate. The preservation of momentum (during the impulse) and the momentum-impulse relationship (later) show that the initial impulse corresponds to the integral under the F-versus-t curve during the first quarter point, even if the time scales differ. In a representative experiment, the popper gained 0.046 kg/s momentum, while the integral force integral in terms of time N s for the first quarter cycle of the graph was a fairly close match despite the damping and the momentum that occurred over a finite period of time. Google Scholar5. In order to determine the time at which the popper left the surface, a laser beam at the impending gap between the popper and the platform. An analog light sensor dropped this beam, and timing information was referenced to the force data. The relative timing of the departure of the popper and the graphtip depends on the platform mass. We used a 37.9g platform. Repeating the experiment with a 500 g platform delays reaching the climax by up to several milliseconds after the popper has left the surface. Google Scholar6. Similar restrictions exist with the Vernier force plate and sound level meters. The latter usually allows the user to choose slow or fast response to detect instant compared to time-averaged decibel values. Such a setting is not provided for at the Vernier force sensors, but the temporal smoothing could be carried out via software filtering. Google Scholar7. A quartz piezoelectric sensor is more suitable for force measurements of high-speed shocks. A typical sensor of this type has an upper frequency limit of 36 kHz and a nominal stiffness of over 109 N/m. See . Google Scholar8. The observed vibrations have a uniform damping ratio of less than 0.1. With such light attenuation, the frequency of the attenuated harmonic motion is essentially identical to the frequency of simple harmonic movements. Google Scholar9. The reaction time of the force sensor is determined by Vernier as 2 ms. John Gastineau, private communications (Sept. 2015). Google Scholar10. A careful examination of Fig. 6 shows a small increase in the frequency when the amplitude decreases. Pure DHM would not produce this effect. Its origin is probably a deviation from Hooke's law (too minor to be obvious in Fig. 9). The discussion about nonlinear oscillators goes beyond the scope of class activity. Google Scholar11. The effective mass of a uniform coil spring corresponds to one third of its mass. A good discussion can be found in A. P. French, Vibrations and Waves (Norton, New York, 1971), p. 60. Google Scholar