PHYS207: Simple Harmonic Motion

Andrei Tumbar
Robert-Jason Pearsall
Cyrus Uedoi

Abstract

The purpose of this lab was to utilize two different methods of determining the spring constant of a provided spring. The first method, 'Static', consists of recording how different hanging masses affected the length of the spring. The second method, 'Dynamic', involved recording how hanging differing values of masses on the spring affected the spring-mass system's simple harmonic oscillations.

1 Static Measurements

Because a spring is defined with the following force equation: $F_s(x) = -kx$. The slope of the Mass vs Displacement graph will yield the k of the spring.

$$1.19\frac{\cancel{kg}}{m}\cdot\frac{9.81N}{\cancel{kg}} = \boxed{11.674\frac{N}{m}}$$

Figure 1 shows the graph generated by ploting mass vs displacement. As expected a straight line is generated indicating that the $F_s(x) = kx$ is a good model for this spring.

Mass (g)	Length (cm)	Δx (cm)
50	21.6	4.6
100	27.7	10.7
250	45.5	28.5
150	33.5	16.5
175	36.4	19.4
200	39.4	22.4
300	51.4	34.4

Table 1: Data collected for static experiment.

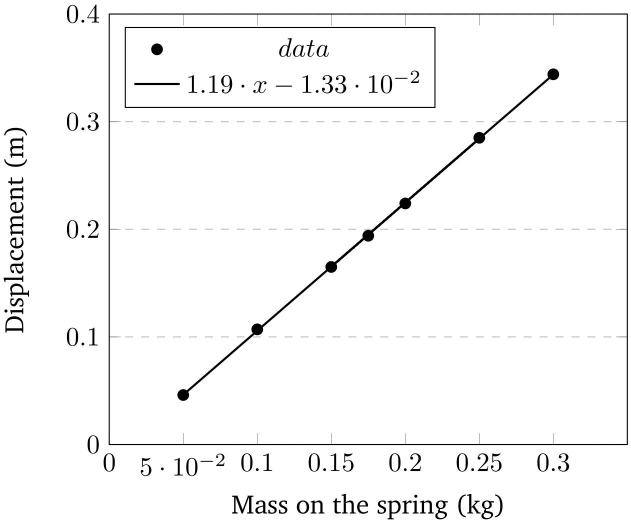

Figure 1: Mass vs Displacement

2 Dynamic Measurements

To derive the period of a spring as it oscillates we need to start at the definition of a spring.

$$F_s(x) = -kx \tag{1}$$
$$m\frac{d^2x}{dt^2} = -kx \tag{2}$$
$$\frac{d^2x}{dt^2} = \frac{-kx}{m} \tag{3}$$

If an object is experiencing a force in the form below, we know that it must be in harmonic oscillation. With a frequency of ω.

$$\frac{d^2x}{dt^2} = -\omega^2 x$$

Because are differential equation is of the same form we can say:

Mass (g)	T^2 (s^2)	Error (%)
550	2.98	± 9.85
250	1.45	± 14.93
300	1.74	± 2.28
100	0.74	± 13.90
150	0.98	± 0.000
200	1.24	± 10.78
50	0.48	± 21.57
275	1.63	± 2.35

Table 2: Data collected for dynamic experiment.

$$\omega = \sqrt{\frac{k}{m}} \tag{4}$$
$$T = \frac{2\pi}{\omega} \tag{5}$$
$$T = 2\pi\sqrt{\frac{m}{k}} \tag{6}$$

To linearize this function, we graph T^2 instead of T on the y-axis. Figure 2 is a graph of the following function:

$$T^2(m) = \frac{4\pi^2}{k}(\frac{m}{1000})$$

Mass is divided by 1000 to convert it to kilograms. The slope of the regression in figure 2 will be equivalent to $\frac{4\pi^2}{k}$.

$$5.012 \cdot 10^{-3} = \frac{4\pi^2}{1000k} \tag{7}$$
$$k = \frac{4\pi^2}{5.012} = 7.876\frac{N}{m} \tag{8}$$

Conclusion