Physical Properties of the Spring

TA's signature allowing you to take the quiz or leave ______

Your Name ______

Partners' Names ______

______

Obtained reasonable experimental results?	yes ☐
Answered questions?	yes ☐
Cleaned your table?	yes ☐

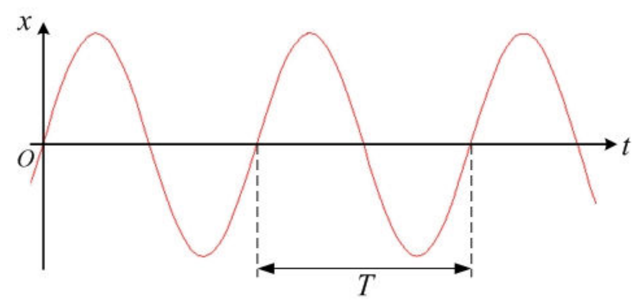
Please treat all springs gently.

Introduction

Force made by a spring is different. Most of the previous labs involve the gravitational force, which gets weaker as the distance goes farther. However, the force from spring gets stronger when the distance is increased. The magnitude of the spring force can be formulated as:

$$F = kx$$

where x is the displacement from the natural length of the spring, and k is known as the spring constant, whose unit is N/m. The larger the spring constant has, the stiffer the spring is. The general form of the equation contains the negative sign in the right hand side. It indicates the restoring force, which acts toward the equilibrium point of the spring motion.



When a mass attached to a spring is released from certain amplitude, it has a periodical (repeating) motion as shown in the figure. The period of motion can be different with the hanging mass and spring constant. The known relationship is given as follows:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where T is the period; and m is the hanging mass. In the above figure, the period is seen as the time for one unit motion called cycle. If the period becomes larger, the motion will be more slowly as far as the other condition remained same. The period is closely related to how frequently it vibrates, which is called frequency, f. The period and frequency has the reciprocal relationship:

$$T = \frac{1}{f}$$

Objectives:

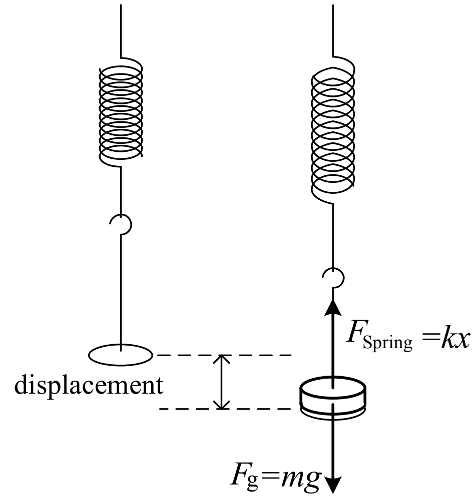
- To learn physical properties of spring, such as force and periodic motion
- To verify Hooke's law

1. **Finding spring constants** (*Use meters, kilograms, and newtons for the units.*)

Procedure:
① Record the reading at the bottom of the hanger with a meter stick without any extra mass.

② Put the designated mass on the hanger, and read the meter stick at the bottom of the hanger.

③ Calculate the displacement and the spring constant. Due to gravitational force, the above equation can be expressed as $mg=kx$. The spring constant can be solved as $k=mg/x$.



Hanging mass, m, without considering mass of the hanger	The reading at the bottom of the mass hanger, h_0	The reading at the bottom of the hanger after adding the designated mass, h	Displacement $x=h-h_0$	Gravitational force $F_g=mg$	Spring constant $k=mg/x$
0.100 kg					
0.150 kg					
0.200 kg					
0.250 kg					
0.300 kg					

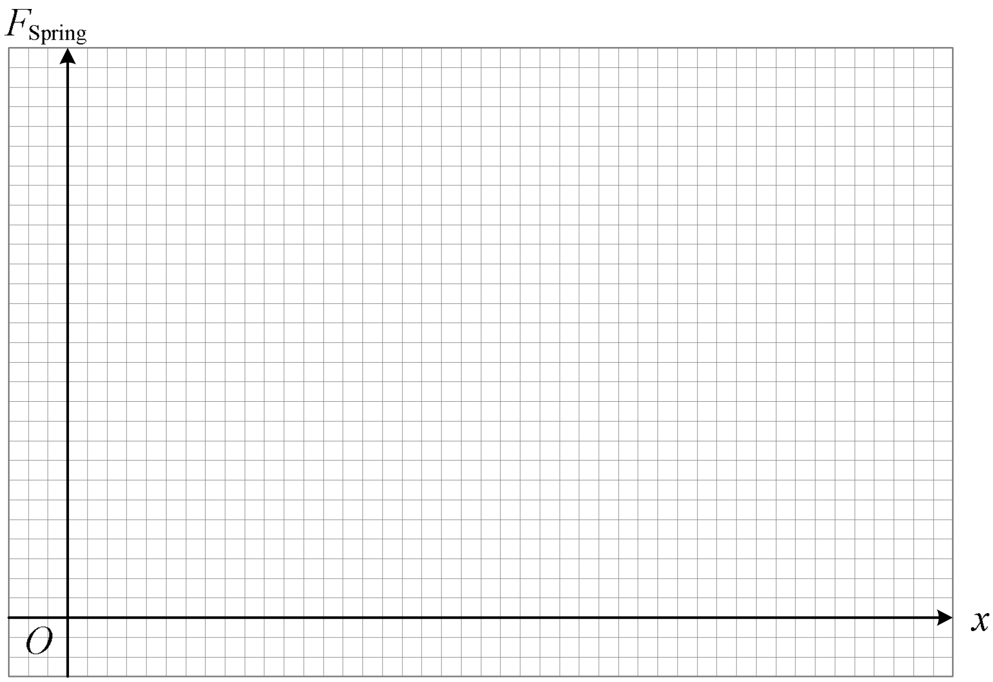
Calculate the average of the spring constant. k = ____________________ ( )←unit

Calculate the standard deviation of the measured data.

Δk = ____________________ ( )←unit

- The reference value of the spring constant is 9.60 N/m. [Some of springs have different spring constant. Conclude this from your experimental result with its standard deviation.] How well does your result agree with the reference?

④ Plot the force by the spring vs. each displacement from the above table. (Note that the magnitude of the spring force is equivalent with the gravitational force, F_g.)

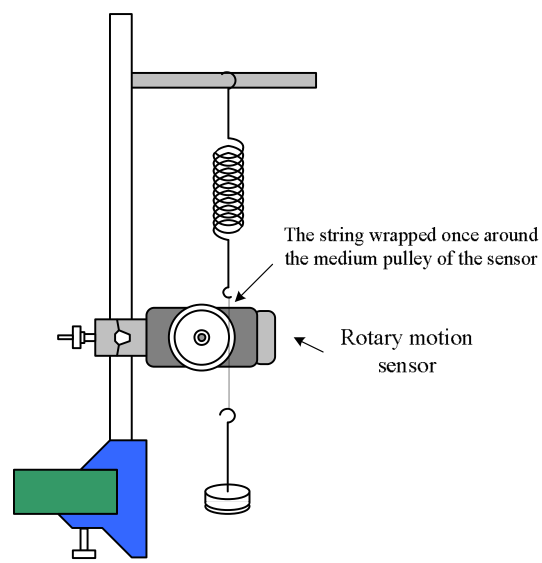


Questions:

1. If the displacement increases, how does the spring force change?

2. What is the slope of the plot above supposed to be?

2. Spring motion: position, velocity, and frequency



Procedure:

① Set up the equipment as shown.

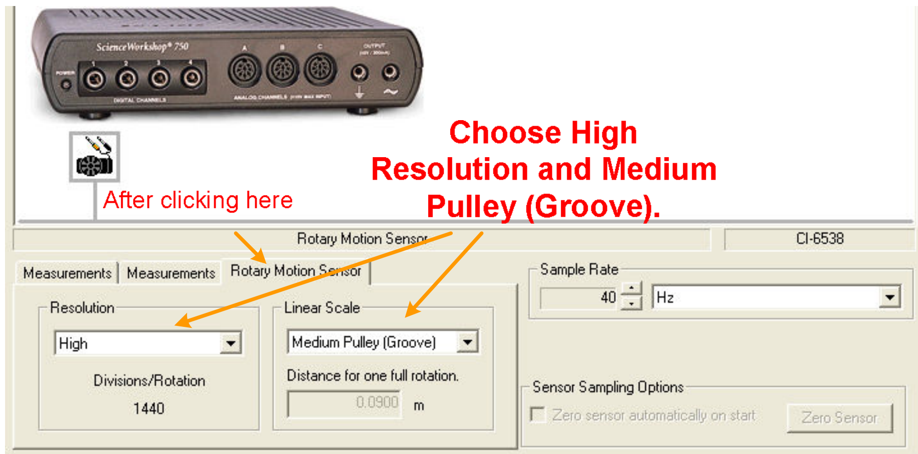
② Start up DataStudio. Click the digital channels and select the rotary motion sensor. To display two graphs, select proper visibility as follows:

③ Click "Rotary Motion Sensor" tab. Then, select High for the resolution and Medium Pulley for the linear scale as follows:

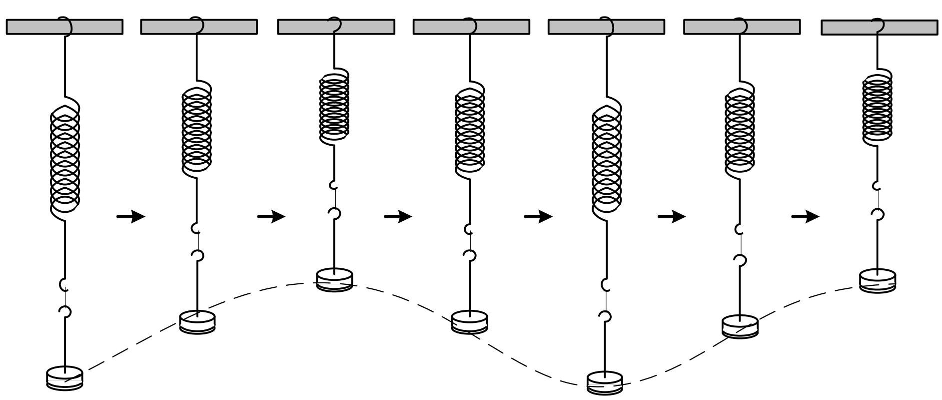
④ Put a mass (0.050 kg) on the weight hanger. (Total mass is 0.100 kg.)

⑤ Pull down the hanger by exactly 0.050 m as the displacement.

⑥ Prepare to record the motion with DataStudio and release it gently to make oscillating motion of the spring.



Question:
Take a look at three graphs ("position vs. time", "velocity vs. time" & "acceleration. vs. time"). The following figure illustrates the position of the hanging mass with respect to time evolution. By referring to the graphs, label in the figure when the velocity becomes zero or maximum with the direction up or down. Also label in the figure when the acceleration becomes zero or maximum with the direction up or down.



⑦ Repeat the same procedure, but change the displacement from 0.050 m to 0.100 m. (Use the same mass, 0.050 kg + 0.050 kg (hanger).

Question:
What are the differences from the above case? Discuss this in terms of the amplitude and timing (period). [You are supposed to have double of the previous amplitude, but the timing (period) should be the same. Discuss the reasons.]

⑧ Repeat the same procedure. Use the displacement, 0.050 m, but increase the mass 0.100 kg + 0.050 kg (hanger).

Question:
What are the differences from the above case? Discuss this in terms of the amplitude and timing (period). [You are supposed to have the same amplitude as in the first trial, but the timing (period) should be different. Discuss the reasons.]

Summary Questions

- Which parameter (displacement or mass) does it affect the period?

- When the period changes, the frequency will be changed with $f = \frac{1}{T}$. Explain this from your experimental result. If the period becomes longer, how will the frequency be changed?