1. Experimental Objectives

1) Verify Hooke's law, and measure the stiffness coefficient of a spring.
2) Study the simple harmonic motion of a spring, measure the period, calculate the stiffness coefficient of the spring.
3) Study the properties and operation of a Hall switch sensor.

2. Experimental Procedures

1) Measure stiffness coefficient *K* of a spring using Jolly balance

   a) Adjust the three leveling screws on the bottom of the Jolly balance to make it stand straight.
   b) Mount the spring under the arm on the top of the post, then hook the initial weights (with a pointer piece in the middle). The lower initial weight connects to the weight tray through hook and 3 metal wires. At this time, the spring has been stretched at a certain length (see Figure 2).
   c) Adjust the height of the Vernier (with a fixing screw and a fine adjustment nut on the upper portion), let its reference line at the left roughly align to the pointer. Tighten the fixing screw of the Vernier. Then adjust the fine adjustment nut to make the pointer coincide with the mark line at the mirror edge. Only when the mark line of the mirror, the pointer and the image in mirror are overlapped in one horizontal plane, the viewer can read out the data through the ruler and the Vernier correctly.
   Note: the block of Hall sensor assembly (items 15 & 16 in Fig. 2) may be dismounted in this experiment by releasing the two fixing screws on the block back for convenient operation.
   d) Place a 1-g weight to the weight tray, repeat step c), read out the position of the pointer. Sequentially add 9 1-g weights, and read out each position for every weight. Then, take down the 9 weights one by one, and read out the position for each weight.
   e) Based on the position reading of each added or removed weight, use graph drawing method or successive minus method to acquire the stiffness coefficient *K* of the spring.

2) Measure period of simple harmonic motion of a spring & calculate stiffness coefficient

   a) Take down the weight tray, hook, initial weights and pointer under the spring. Hang the 20-g weight to the spring. There is a small magnet under the weight (**Note**: the polarity of the magnet should be correctly placed, otherwise it cannot trigger the Hall sensor).
   b) Connect the sensor probe (on the left side of the assembly of vernier and mirror) to the input port of the counter/timer via a coaxial cable. Preset a proper counting number (e.g. 20 times).
   c) Turn on power of the counter/timer. Preheat 5 minutes.
   d) Turn the arm and adjust the nut to change the location of the weight and spring, let the magnet and the Hall sensor face straightly to each other. Adjust the height of the Hall sensor in order to better trigger the counter/timer when the magnet vibrates. When the sensor is triggered, the LED indicator of the counter/timer is dimmed.

e) Pull down the weight at a certain distance, let the magnet surface be close to the Hall sensor. At this time, the trigger LED becomes dim. Then release the weight, and let the weight vibrate up and down. The trigger LED is blinking.
f) After reaching the preset number of vibrations, the counter/timer stops counting. View and record the timing values of the counter/timer. Calculate the period of the vibration. Use Eq. (2) to calculate the stiffness coefficient K of the spring.
g) Compare the measured stiffness coefficients by Hooke's and vibration methods.

3) Measure micro tensile force using Jolly balance & determine liquid surface tension coefficient (optional experiment)

a) Hang a thin ring under the spring.
b) Under the ring, place a lift stage and put a glass cup of pure water on the stage.
c) Raise the stage to immerse the ring into water. Then, slowly lower the stage while observing the position of the spring pointer. In this process, the liquid column between the ring and the liquid surface becomes thinner and thinner. Record the pointer position when the liquid column just breaks.
d) After the liquid column breaks, record the pointer position again.
e) The force difference before and after column breaking is just the surface tension of water, which can be derived by using the pointer position difference and the stiffness coefficient K obtained in previous experiment.

3. Example of Data Recording and Processing

Note: the following data are for reference purposes only, not the criteria for apparatus performance.

1. Measure stiffness coefficient K of a spring using Jolly balance

Add or remove 1-g weight each time while recording *m*-*y* data, as shown in Table 1. Assume the gravity acceleration is $g = 9.794$ m/s.

Table 1 *m*-*y* data

m (g)	y (add) (mm)	y (Minus) (mm)	$\bar{y}$ (mm)	m (g)	y (add) (mm)	y (Minus) (mm)	$\bar{y}$ (mm)
1.000	291.18	291.28	291.23	6.000	321.28	322.36	321.72
2.000	297.00	297.26	297.13	7.000	327.80	327.50	327.65
3.000	304.08	303.20	303.64	8.000	333.84	333.78	333.81
4.000	309.20	309.32	309.26	9.000	339.62	339.76	339.69
5.000	315.26	315.46	315.36	10.000	345.98	345.98	345.98

After processing the data using successive minus method, we got the spring extension Δy=30.44 mm after adding 5-g weights. From Eq. (1), the stiffness coefficient K=1.608 N/m.

2. Measure period of simple harmonic motion of a spring & calculate stiffness coefficient

Gently pull down the spring a little to let it vibrate by itself. The time of vibrating 50 times was measured as 39.463 s, leading to a spring vibration period of T=0.78926 s. As $P\approx 1/3$, M_0=13.81

g, and M=21.12 g, the stiffness coefficient of the spring is calculated from Eq. (2) as K=1.630 N/m. So the difference is less than 1%.