Spring Combinations

Introduction

Show what happens when springs are combined in parallel and series. The results might surprise you.

Science Concepts

- Hooke's law
- Spring constant

Materials (for each demonstration)

Hooked weight, 100-g
Spring scales, 250 g/2.5 N, 3 (identical)
Pencil

Safety Precautions

Handle the hanging spring scales carefully to prevent the mass from slipping off and falling to the floor. Please follow normal laboratory safety guidelines.

Procedure

1. Hang the 100-g weight from the end of one of the spring scales.
2. Record the measurement on the spring scale *(100 g/1 N)*.
3. Remove the weight.
4. Link three spring scales together as shown in Figure 1.
5. Hang the 100-g weight from the end of the bottom spring scale.
6. Note the length of the overall spring system.
7. Record the measurement of each spring scale. Why does the bottom scale not measure 100 g?
8. Remove the weight and unlink the spring scales.
9. Hang the three spring scales from a pencil as shown in Figure 2.
10. Hang the 100-g weight on the three hooks from the three spring scales.
11. Note the length of the overall spring system.
12. Record the measurement of each spring scale.

Figure 1.

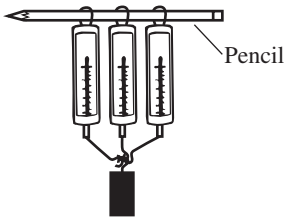

Figure 2.

Tips

- Use identical spring scales so that the length of the spring scales and hooks are nearly the same.
- Larger-scaled spring scales and masses may be used. However, the spring scales should all have the same measurement scale, and the mass should not exceed the limit on the spring scales.
- When the springs are combined in series, the mass of the spring scale body affects the total mass of the system, so the overall stretch of the combined springs will be longer than expected. Using stronger spring scales and a heavier mass will reduce the effect of the additional mass from the spring scale bodies.

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Discussion

Hooke's law shows that the force produced by a spring is proportional to how far it is stretched ($F = -kx$; the negative sign indicates it is a restoring force). The proportionality constant (k) for a spring is known as the spring constant and is dependent on the type of material used to make the spring, the number of coils in the spring, the tightness of the spring, etc.

When springs are combined in parallel (Figure 2), the forces produced by the springs add together. Therefore, it can be stated that the spring constants add together when springs are used in parallel. For example, if the spring constant for a spring is 10 Newtons per meter (N/m), then when two identical springs are used in parallel, the spring constant for the two-spring system is 20 N/m.

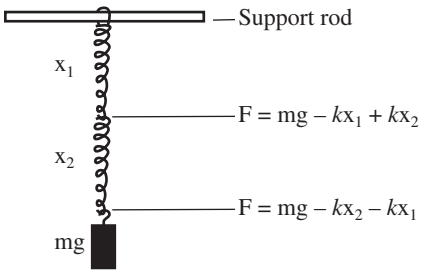

Figure 3.

When springs are combined in series, the springs still obey Hooke's law. However, now there are two forces pulling on the attached (top) spring—the force of gravity, and the restoring force produced by the attached stretched spring (Figure 3). Since there are two forces acting on the upper and lower springs, the overall spring system will stretch further than expected. The result is that the spring constants of springs in series add as reciprocals (Equation 1).

$$1/k_{eff} = 1/k_1 + 1/k_2 \qquad \textit{Equation 1}$$

$$k_{eff} = k_1k_2/(k_1 + k_2) \qquad \textit{Equation 2}$$

Using the same springs as the first example, when two 10-N/m spring scales are combined in series, the resultant spring constant for the two-spring system is 5 N/m. The resultant spring constant is half the value of the original, single spring constant. Therefore, for the same force, the two-spring system will stretch twice as far relative to the one-spring system.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Process: Grades K–12
- Systems, order, and organization
- Evidence, models, and exploration
- Constancy, change, and measurement

Content Standards: Grades 5–8
- Content Standard A: Science as Inquiry
- Content Standard B: Physical Science, understanding of motions and forces, transfer of energy.

Content Standards: Grades 9–12
- Content Standard A: Science as Inquiry
- Content Standard B: Physical Science, motions and forces, conservation of energy and increase in disorder.

Materials for *Spring Combinations* is available from Flinn Scientific, Inc.

Catalog No.	Description
AP4836	Spring Scale, Pull-Type, 250 g/2.5 N
OB1091	Metric Weight, 100 g

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.