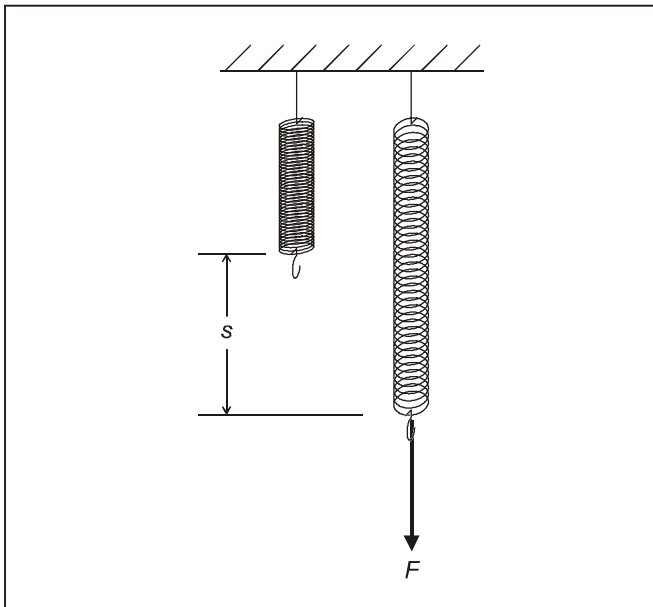


## Expansion of a helical spring

### Objects of the experiment

- Determining the change of length  $s$  of two helical springs with different turn diameters as a function of the gravitational force  $F$  exerted by the suspended weights.
- Confirming Hooke's law and determining the spring constants  $D$  of the two helical springs.



### Principles

Forces are recognized by their effects. For example, static forces can deform a body. If the force is not too strong, the deformation turns out to be proportional to the force acting on the body.

In the experiment, it is shown that the expansion  $s$  (i.e. the change of length, see Fig. 1) of a helical spring is directly proportional to the force  $F$ . Hooke's law applies:

$$F = D \cdot s \quad (I)$$

$D$ : spring constant

### Setup

The experimental setup is illustrated in Fig. 2.

- Using the short stand rod, establish a rigid connection between the stand bases MF.
- Clamp a long stand rod in each stand base MF so that the rods are aligned vertically.
- Attach the support block to the upper end of the right stand rod, and plug in the axle.
- Attach the tape measure to the upper end of the left stand rod, and unroll it.
- Clamp the tape measure with the two pointers, and fix it in addition with adhesive tape.
- Slide the upper pointer to the position 1 cm.
- Suspend the helical spring 1 ( $\varnothing 15$  mm) from the axle.
- Align the height of the support block or of the stand rod so that the upper pointer marks the upper end of the spring.

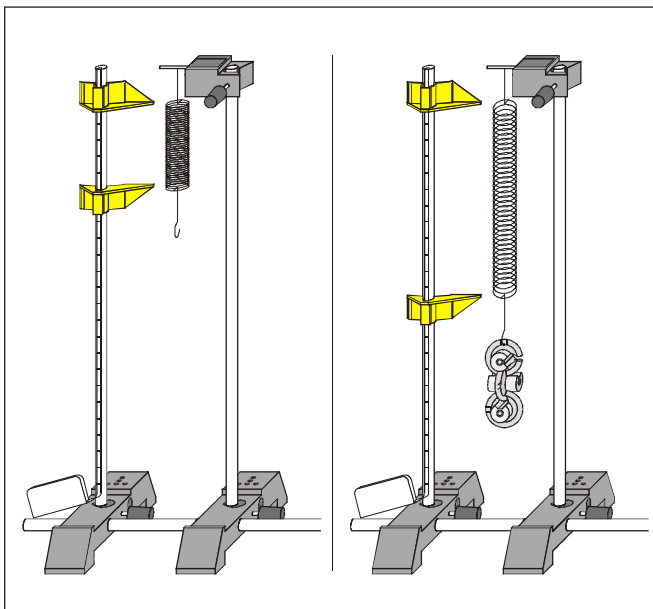


Fig. 1 Schematic illustration of the expansion of a helical spring

Fig. 2 Experimental setup for measuring the expansion of a helical spring as a function of the force acting on the spring

**Apparatus**

1 helical spring, 5 N; 0.10 N/cm	352 07
1 helical spring, 5 N; 0.25 N/cm	352 08
1 set of 6 weights, each 50 g	340 85
2 stand bases MF	301 21
1 support block	301 25
1 stand rod, 25 cm, Ø 10 mm	301 26
2 stand rods, 50 cm, Ø 10 mm	301 27
1 pair of pointers	301 29
1 tape measure 1.5 m / 1mm	311 78
1 plug-in axle	340 811

**Evaluation**

In Table 2, the values of the gravitational force  $F$  of  $n$  suspended weights and the values of the associated spring expansion  $s$  calculated from the measured values from Table 1 are listed:

$$F(n) = 0,05 \text{ kg} \cdot n \cdot g \text{ with } g = 9,81 \frac{\text{m}}{\text{s}^2}, s(n) = L(n) - L(0)$$

Fig. 3 shows the dependence of the above-mentioned quantities in a diagram. Within the accuracy of measurement, the calculated values lie on the straight lines through the origin drawn in the diagram. Thus Hooke's law is confirmed.

The slopes of the straight lines through the origin (i.e. the spring constants) are

$$D = 0,239 \frac{\text{N}}{\text{cm}} (\text{Ø} = 10 \text{ mm}) \text{ and } D = 0,107 \frac{\text{N}}{\text{cm}} (\text{Ø} = 20 \text{ mm})$$

**Carrying out the experiment**

- Mark the lower end of the unloaded spring with the lower pointer.
- Read the length of the spring taking into account the zero of the scale (upper end of the spring), and take it down.
- Suspend a weight from the spring, determine the altered spring length, and take it down.
- One after another suspend more weights, each time determining the new spring length.
- Suspend the second helical spring (Ø 20 mm), and align the upper end of the spring with the upper pointer again by shifting the support block.
- One after another suspend an additional weight, each time determining the spring length.

Table 2: changes of length and forces acting on the springs

$n$	$\frac{F}{\text{N}}$	$\frac{s}{\text{cm}}$ Ø = 15 mm	$\frac{s}{\text{cm}}$ Ø = 20 mm
1	0.49	2.1	4.6
2	0.98	4.2	9.1
3	1.47	6.1	13.8
4	1.96	8.3	18.2
5	2.45	10.3	22.9
6	2.94	12.2	—
7	3.43	14.4	—

**Measuring example**

Table 1: Spring length  $L$  as a function of the number  $n$  of weights suspended

$n$	$\frac{L}{\text{cm}}$ Ø = 15 mm	$\frac{L}{\text{cm}}$ Ø = 20 mm
0	8.8	9.7
1	10.9	14.3
2	13.0	18.8
3	14.9	23.5
4	17.1	27.9
5	19.1	32.6
6	21.0	—
7	23.2	—

**Result**

The change of length of a helical spring is proportional to the force acting on the spring (Hooke's law).

Fig. 3 Relation between the change of length  $s$  and the force  $F$  actina (circles: Ø = 15 mm. squares: Ø = 20 mm)

