Mechanics

Acoustics

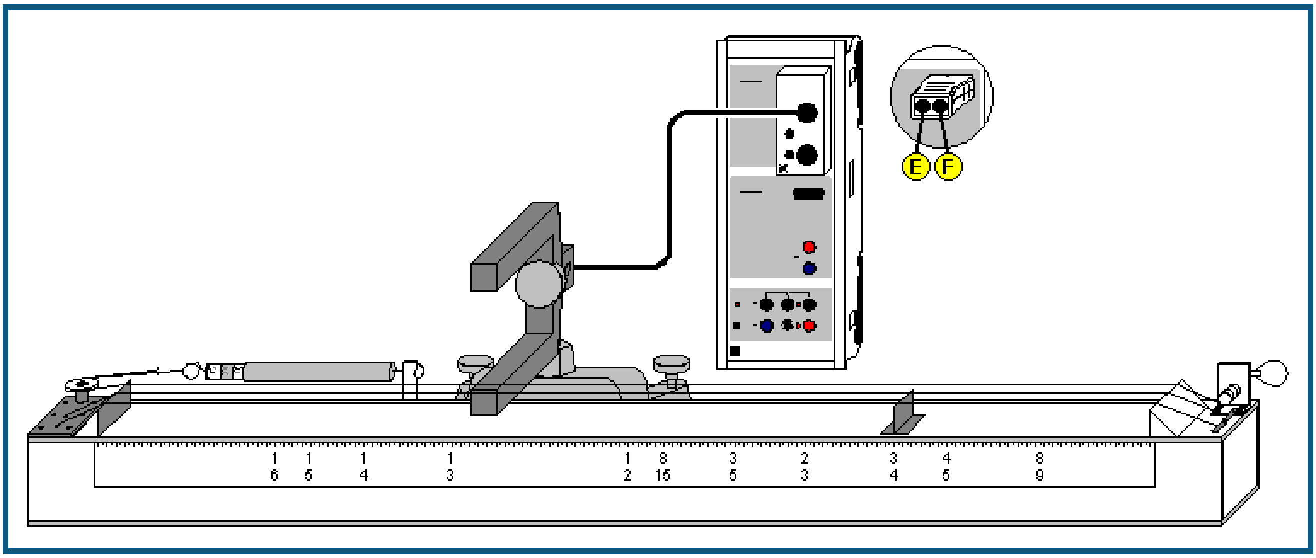
Oscillations of a string

Determining the oscillation frequency of a string as a function of the string length and tension

Description from CASSY Lab 2

For loading examples and settings, please use the CASSY Lab 2 help.

String vibrations



can also be carried out with Pocket-CASSY

Experiment description

When a string is stretched, the string length L is equal to half the wavelength of the fundamental mode: L = λ/2. Therefore the frequency f of the fundamental tone of the string is

$f = c/(2L)$,

where c is the phase velocity of the string. It depends on the tensile force F, the cross-sectional area A, and the density ρ. This dependence is described by the following relation:

$c^2 = F/(A\rho)$

In this experiment, the vibrational frequency f and thus the pitch of the string is measured as a function of the string length L and the tensile force F. For this the CASSY is used as a high-resolution stopwatch for measuring the period of vibration T. The relations $f^2 \propto F$ and $f \propto 1/L$ are confirmed.

Equipment list

1	Sensor-CASSY	524 010 or 524 013
1	CASSY Lab 2	524 220
1	Timer box or Timer S	524 034 or 524 074
1	Forked light barrier, infrared	337 46
1	Multicore cable, 6-pole, 1.5 m	501 16
1	Monochord	414 01
1	Precision dynamometer, 100 N	314 201
1	Stand base, V-shape, 20 cm	300 02
1	Stand rod, 10 cm	300 40
1	Stand rod, 25 cm	300 41
1	Leybold multiclamp	301 01
1	PC with Windows XP/Vista/7/8	

Experiment setup (see drawing)

The period of vibration T is measured by means of a forked light barrier, which is positioned between the wooden resonance box of the monochord and the string. The light barrier is connected to the input A of the Sensor-CASSY via the timer box by means of the multicore cable.

Experiment notes

The period of vibration T is determined unambiguously if the passages of the string through its position of rest are determined. For this the string has to be positioned so that the red LED on the side of the forked light barrier does not shine when the string is in its position of rest. The forked light barrier has two small apertures for the infrared beam. The best results are obtained if the string is positioned immediately over the smaller one of the two apertures (if necessary, turn the light barrier correspondingly).

The string is made vibrate by plucking it parallel to the surface of the resonance box.

The tensile force F is measured manually with the precision dynamometer. For this the hook is replaced with the precision dynamometer. The tension of the string on the monochord can be varied by means of a tuning key. In the first experiment, the best results are obtained if a string tension of 100 N is adjusted at first and then the measurement is carried out starting from high tension to lower tensions.

In the measurement with varying string length L, the string length is varied by displacing the bridge. When plucking the string, do not touch the part which does not vibrate with the other hand. For an optimal measurement of the period of vibration T, always position the forked light barrier in the middle of the vibrating part of the string.

Carrying out the experiment

a) Variation of the tensile force

- Load settings
- Adjust the desired string tension F by turning the tuning key.
- Write the force F displayed on the dynamometer in the prepared column of the table.
- Position the forked light barrier under the string at rest and check whether the red LED is out; if necessary, position the forked light barrier anew.
- Make the string vibrate by plucking it (while the string vibrates, the LED shines), and immediately transfer the displayed measured value into the table with .

b) Variation of the string length

- Load settings
- Adjust the desired string length by positioning the bridge.
- Read the string length, and write it in the prepared column.
- Check whether the red LED is out; if necessary, position the forked light barrier anew.
- Make the string vibrate by plucking it (while the string vibrates, the LED shines), and immediately transfer the displayed measured value into the table with .

Evaluation

a) Variation of the tensile force

The T(F) and the f(F) diagram already appear while the measurement is running. In the prepared display **Evaluation**, the square of the frequency f is plotted against the tensile force F. The relation $f^2 \propto F$ can be confirmed by fitting a line through the origin (right mouse button). That means, the pitch, and thus the frequency, of a vibrating string increases with increasing string tension. Correspondingly, the pitch of a string can be lowered by decreasing the string tension.

b) Variation of the string length

The T(L) and the f(L) diagram already appear while the measurement is running. In the prepared display **Evaluation**, the square of the frequency f is plotted against 1/L. The relation $f \propto 1/L$ can be confirmed by fitting a line through the origin (right mouse button). That means, the pitch, and thus the frequency, of a vibrating string increases with decreasing length.