The frequency ratio of two tones is called an interval. These intervals have special names in music. As a result, the experiment can be more easily understood by students, if the terms are known from music class, at any case (at the very least) they should know the C-major scale.
With a tensed string the string lengths behave opposite to the tone pitches (frequencies) of the notes produced. As a result, the interval of notes can be determined from the ratio of the string lengths.
In the experiment a monochord is used, which is a resonator with two tense strings, whose pitch can be changed through “bridges” placed under them. Both strings are at first tightened so that the same note is created, a bridge is placed under one string, in order to adjust the desired interval between the two strings, and the corresponding string length is measured.

Material

1	Monochord	03430.00
1	Tuning fork, 440 Hz on resonance box	03427.00
1	Striking hammer, rubber	03429.00
1	Paper, adhesive tape	

Remarks

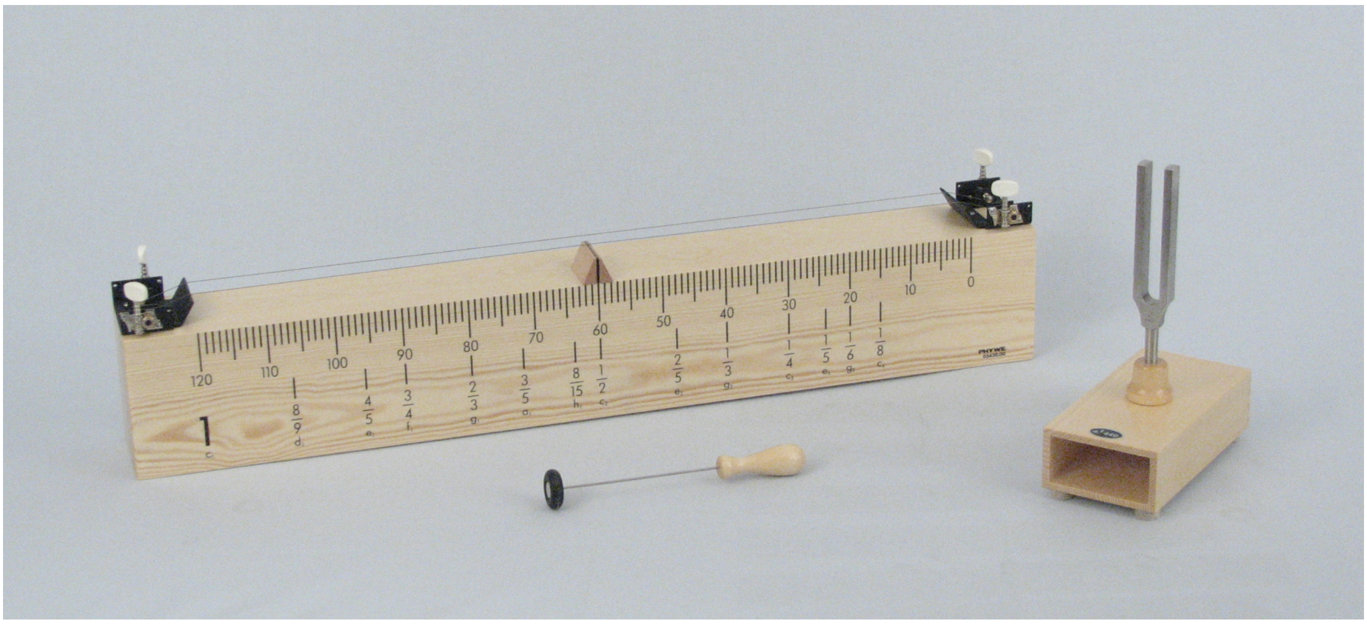
For this experiment both strings must be tuned to the same note, key note c_1. This should be performed before class, since the tuning fork with the concert pitch a_1 is used for this and functions of the monochord will be used that the students first have to become acquainted with.
The task of the experiment will be always to tune the strings to the same tone pitch or to an interval. To do so, “beats” can be used to help here: If the bridge is not positioned in the right spot under the string, but rather 1 to 2 scale sections away, then you hear the tone in a louder and softer interval (the intervals perfect fifth and perfect fourth can be heard well in this manner).
At first the lower part of the writing on the monochord should be wrapped with tape so that only the scale remains visible for measuring out the lengths of the strings. The lower part will be needed for the evaluation.

Setup

Preparing the monochord

- Place the platform on position a_1 under a string
- Strike the tuning fork, 440 Hz (a_1)
- Tune the string note and the tuning fork note to coincide with each other.
- Remove the platform and tune the second string to the sound of the first string

Fig. 1



Implementation

- Place the monochord with the labeled strings toward the students
- Strike both strings with the rubber hammer to show that they have the same note
- Place the platform under the front strings and move the bridge to create as many high notes as you like
- Divide the string, use the bridge to adjust so that the octave c_2 sounds to the other string, record the length of the string (full string) for the key tone (prime) c_1 and the octave c_2 in Table 1.
- Move the bridge and then adjust at first perfect fifth g_1 and then perfect fourth f_1, measure the lengths of the string and record in Table 1
- Additional intervals can be found depending on the musical knowledge of the students. Major third e_1 and Major sixth a_1 can also possibly be found by listening, Major second d_1 and Major seventh h_1 (B) most likely have to be demonstrated.

Measurement results

Table 1

Interval names	Note	Interval	Measured value s / mm	Nominal value s / mm
Perfect unison	c_1	1/1	120	120
Octave	c_2	1/2	60	60
Perfect fifth	g_1	2/3	80	80
Perfect fourth	f_1	3/4	90	90
Major sixth	a_1	3/5	72	72
Major third	e_1	4/5	97	96
Major second	d_1	8/9	108	107
Major seventh	h_1 (B)	8/15	63	64

Evaluation

In table 1 the intervals are indicated in the sequence in which they can be best heard and are to be tuned with the monochord. All intervals are expressed as integer ratios of frequencies. The lowest integers can be heard best and as a result the smallest measurement errors in the string length occur here.
Intervals from integer ratios with low numbers are considered to be harmonic or constant, whereas major seconds and major sevenths are dissonant, whereby this classification is based on listening habits.

If the intervals are written in the sequence of the length of their strings, then this results in the C major scale:
$c_1 – d_1 – e_1 – f_1 – g_1 – a_1 – b_1 – c_2$.
The scale created in this experiment, in which only intervals occur that have been created from integer ratios of frequencies, is called “diatonic scale”.

Remarks

1. The diatonic scale contains different sized whole and half note steps. If the octave is divided into 12 half note steps, then these intervals differ in size among each other. The scale therefore only sounds “clean” for C-major (and for A-minor, the other key without an accidental).
2. While on string instruments the tone pitch can be exactly “adjusted” when playing with the fingers, it is therefore possible to also immediately play a diatonic scale in another key. This is not possible with keyboard instruments. In order to remove this deficit and to achieve the same good sound for all keys the interval is adjusted to an octave in 12 equal intervals x.
$$x^{12} = 2 \text{ or } x = \sqrt[12]{2}$$
This results in an “evenly tempered chromatic scale”, whose principles come from the Quedlinburg organ player Andreas Werkmeister (1691). Other key types can also be used for music as a result. The most famous musical piece from this period is “The Well-Tempered Clavier” composed by J. S. Bach.

