Mechanics

Acoustics

Wavelength and velocity of sound

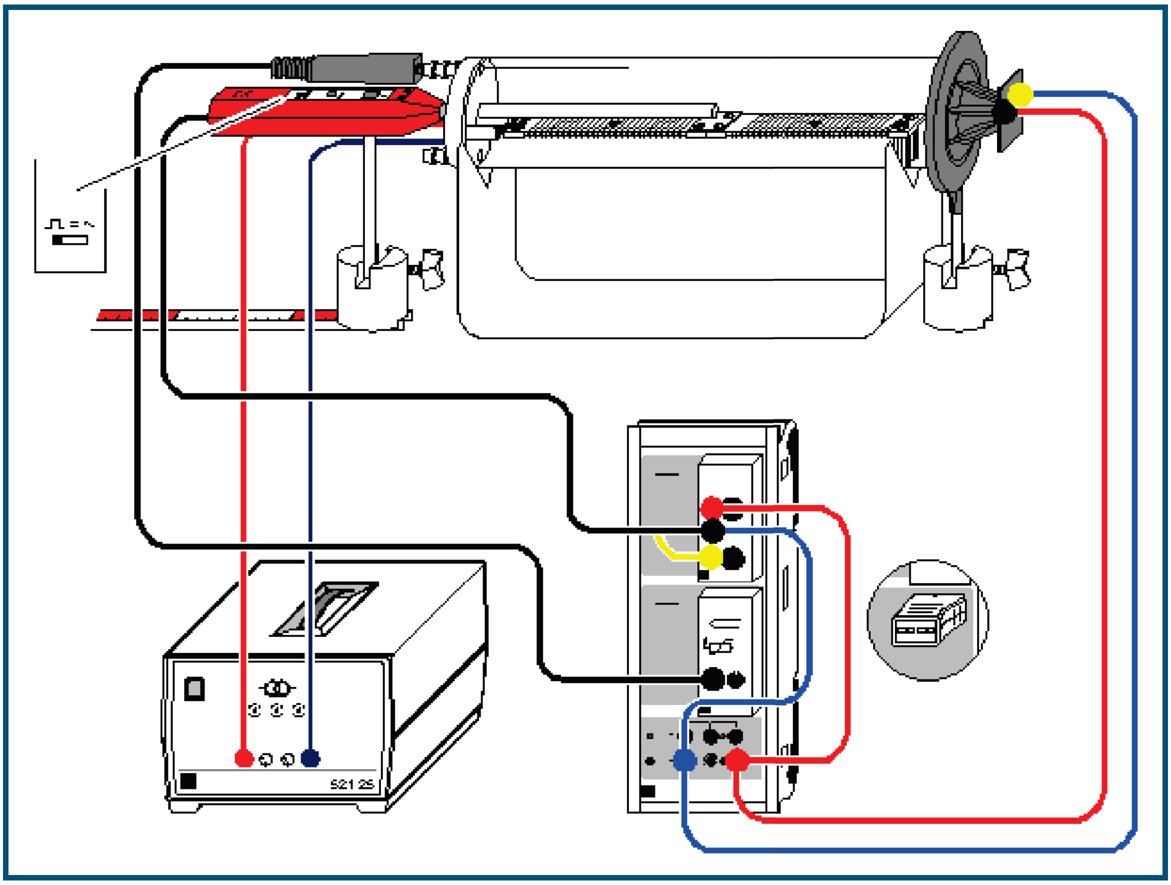
Determining the velocity of sound in air as a function of the temperature

Description from CASSY Lab 2

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

CASSY Lab 2 (2012-09-27)

Velocity of sound in air



Experiment description

This experiment determines the speed of propagation of a sound pulse in air, and thus, since the group and phase velocities coincide, the velocity of sound. The sound pulse is generated by "shaking" the membrane of a loudspeaker with a steep voltage edge; this motion causes the pressure variation in the air. The sound pulse is registered by a microphone at a specified distance from the loudspeaker.

To determine the velocity of sound c, we measure the time t between generation of the pulse at the loudspeaker and registration at the microphone. As the exact point of origin of the sound pulse in the loudspeaker cannot be determined directly, two measurements are conducted, once with the microphone located at point s_1, and one at s_2. The velocity of sound is determined from the path difference $\Delta s = s_1 - s_2$ and the corresponding difference in the transit time $\Delta t = t_1 - t_2$ as $c = \Delta s/\Delta t$.

The apparatus for sound and velocity lets you heat the air with a heater; at the same time, this apparatus blocks out ambient effects such as temperature differences and air convection which can interfere with measuring. In this system the pressure p remains constant (actual ambient barometric pressure). As the temperature T rises, the density ρ decreases and the velocity of sound c increases.

Equipment list

1	Sensor-CASSY	524 010 or 524 013
1	CASSY Lab 2	524 220
1	Timer box	524 034
1	Temperature box	524 045
1	Temperature sensor NiCr-Ni	666 193
	or	
1	NiCr-Ni adapter S	524 0673
1	Temperature sensor NiCr-Ni, type K	529 676
1	Apparatus for sound velocity	413 60
1	Stand for tubes and coils	516 249

1	Tweeter	587 07
1	Multi-purpose microphone	586 26
1	Transformer 12 V/3.5 A, e.g.	521 25
1	Scaled metal rail, 0.5 m	460 97
2	Saddle bases	300 11
1	Pair of cables, 25 cm, red and blue	501 44
2	Pairs of cables, 100 cm, red and blue	501 46
1	PC with Windows XP/Vista/7	

Experiment setup (see drawing)

- Attach the heater of the apparatus for sound and velocity in the plastic tube on the plug pins of the cover.
- Place the plastic tube on the stand for tubes and coils and push the tweeter against it so that it seals the plastic tube as tightly as possible.
- Insert the multipurpose microphone approx. 1 cm deep into the middle hole of the cover and align it so that it moves parallel to the plastic tube when displaced. Set the function switch of the multipurpose microphone to the "Trigger" mode. Do not forget to switch the microphone on.
- Lay the scaled metal rail immediately under the saddle base.
- Plug in the timer box at input A and the temperature box at input B on Sensor-CASSY and set up the circuit as shown in the drawing; set the maximum output voltage at the voltage source S.

Safety notes

The plastic tube of the apparatus for sound and velocity can be destroyed by excessive temperatures.

- Do not heat it above 80 °C.
- Do not exceed the maximum permissible voltage of 25 V (approx. 5 A) for the heating filament.

Carrying out the experiment

a) Measuring at room temperature

- Load settings
- Store multiple single measurements with .
- Slide the multipurpose microphone all the way into the plastic tube and read off the change in distance Δs from the scaled metal rail.
- Store multiple single measurements with .
- Determine the velocity of sound using c = Δs/Δt (determine the mean values of the transit times in the diagram using Draw Mean).

b) Measuring as a function of temperature

- Load settings
- Pull out the universal microphone.
- At room temperature, determine the transit time Δt_{A1} again and, using the velocity of sound c already determined, calculate the distance $s=c\cdot\Delta t_{A1}$ between the microphone and the speaker and write this value in the table (click on the first row in the s-column).
- Connect the heating filament to the voltage supply (12 V / approx. 3.5 A) via the sockets in the cover of the apparatus.
- Save the current transit times with (e.g. every 5 °C).

Evaluation

Once you determine the velocity of sound at room temperature in a) and thus the distance s between the microphone and the speaker in b), the software calculates the correct sound velocity c for each transit time Δt_{A1} simultaneously. The sound velocities are plotted in the **Temperature** display as a function of the temperature while the measurement is running. By fitting a straight line you can easily confirm the literature value of

$c = (331.3 + 0.6 \cdot \vartheta/°C)$ m/s.