Related topics

Velocity of sound; sonic bang; sound waves; frequency; wavelength.

Principle

The velocity of sound in air is determined by measurements of sound travel times.

Material

1	Cobra4 Wireless Manager	12600-00
1	Cobra4 Wireless-Link	12601-00
1	Cobra4 Sensor-Unit Timer/Counter incl.1 × 12651-01	12651-00
1	Microphone with amplifier	03543-00
1	Battery, 9V, 6 F 22 DIN 40871	07496-10
1	Support	09906-00
2	Barrel base PHYWE	02006-55
1	Measuring tape, *l* = 2 m	09936-00
2	Connecting cord, *l* = 50 cm, red	07361-01
2	Connecting cord, *l* = 50 cm, blue	07361-04
2	Support rod with hole, l = 100 mm	02036-00
1	Software Cobra4 - multi-user licence	14550-61

Additionally required

1	PC with USB-Interface, Windows XP or higher	

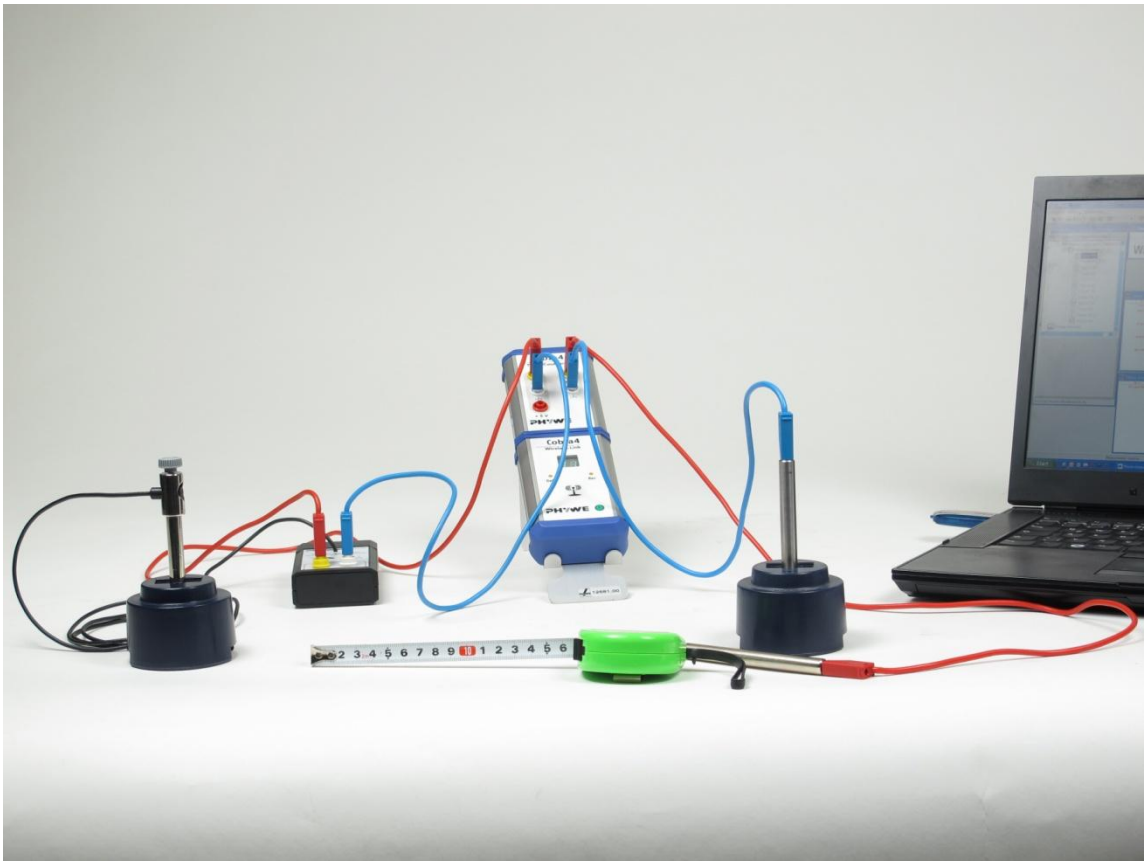

Fig. 1: Experimental setup.

Task

Determine the speed of sound in air.

Set-up and procedure

Set up the experiment in accordance with Figs. 1 and 2. The microphone amplifier is connected to the Stop and Earth jacks of Timer 1.
Connect the Cobra4 Wireless Manager to the USB interface of the computer and the Cobra4 Sensor-Unit Timer/Counter on the Cobra4 Wireless-Link. Start “measure” and load the experiment. (Experiment > Open experiment). All pre-settings that are necessary for value recording are now carried out.
Click on ● in the icon strip to start measurement. A pulse of sound is generated by striking two metal rods against each other. By doing so, an electrical contact is simultaneously closed; this starts Timer 1. After the sound has travelled the distance *s,* the pulse of sound is registered by the microphone; in this manner, Timer 1 is stopped. One obtains the sound travel time *t* or also immediately the speed of sound $v = s / t$ if the path distance has been previously entered (Fig. 3). Ensure that the sound pulse is generated at approximately the same height in which the microphone is located in order to ensure that the horizontal distance between the sound source and the microphone is in reality the distance that the sound pulse must travel. The distance *s* is the distance from the front side of the microphone capsule to the side of the clamped-in metal rod facing the microphone.
Tap the free metal rod on the side of the clamped-in rod that faces away from the microphone. Subsequently, the measured speed of can be read off and the timer is stopped. Occasionally, the timer immediately restarts after termination of the measurement because additional start pulses were sent to Timer 1 as a result of the metal rod’s rebounding after having been struck. In this case, terminate the measurement process with a noise and then perform another measurement.
Repeat the measurement several times for various microphone-sound source distances, and compare the measured values.

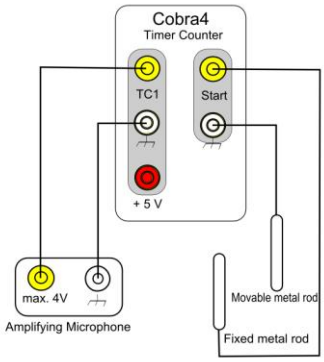

Fig.2: Circuit diagram.

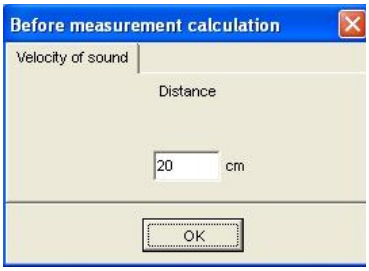

Fig.3: Path distance.

Results

A typical measurement series for the distance s = 0.3 m is given in Table 1:

v /(m/s)
338.448
338.438
338.753
337.230
337.258

Table 1: Example results.

The mean speed of sound is thus 338.0(4) m/s.
The speed of sound is constant for various microphone-sound source distances. Thus, sound propagates itself with constant velocity. In the literature one finds the following value for the speed of sound at 0° C: c_0 = 331.8 m/s, with the temperature dependence given by the following:

$$c(T) = c_0 \cdot \sqrt{\frac{T}{273}}$$

When the measurement shown here was performed, the ambient temperature was 18° C. The speed of sound for this temperature is calculated to be c = 342.6 m/s.

Remarks

If Timer 1 does not stop measuring despite clearly audible tone, it may be necessary to adapt the output voltage of the microphone amplifier to the volume of the loudspeakers.

During the measurement no background noises may occur, since they would also be registered by the microphone and could falsify the measurement. Such background noises appear as sound travel times that are too short or as excessively high apparent speeds of sound and can be thus easily recognised.

Ensure that the microphone does not detect any noise that has propagated through the table top. The speed of sound in wood or similar materials is much higher than that in air. If reproducible, excessively high speeds of sound are measured, either the metal rod which serves to produce sound should be placed on foamed material or the two barrel bases should be setup on different table tops.

Room for notes: