How Far is Storm?

It is possible to estimate the distance of a thunderstorm (a place where the lightning strikes) with knowledge of the speed of light and sound. Once the lightning strikes during a thunderstorm, you just need to count the seconds until you hear the thunder.

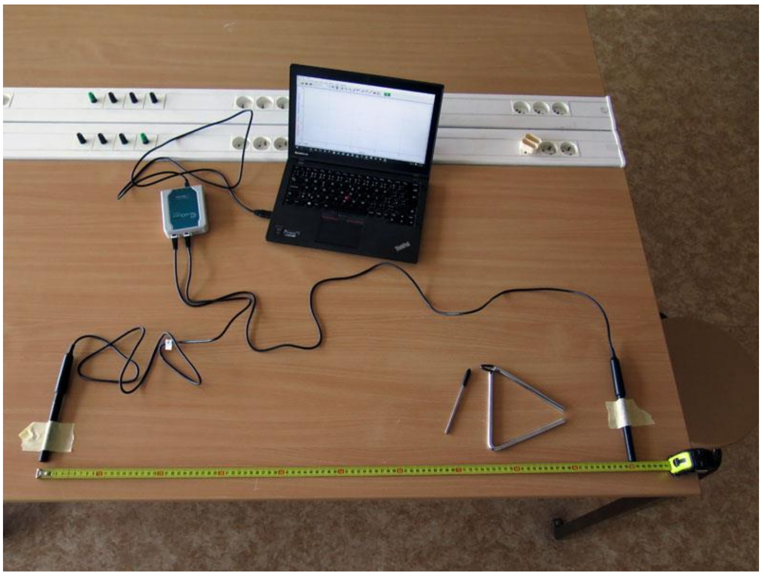
What you need

- 2 x microphone MCA-BTA
- 2 × light sensor LS-BTA
- data logger LabQuest 2 or LabQuest Mini interface
- camera with a flash
- strong and sharp sound source (e.g. a triangle)
- tape measure to measure 100 cm

Execution

Sound measurement

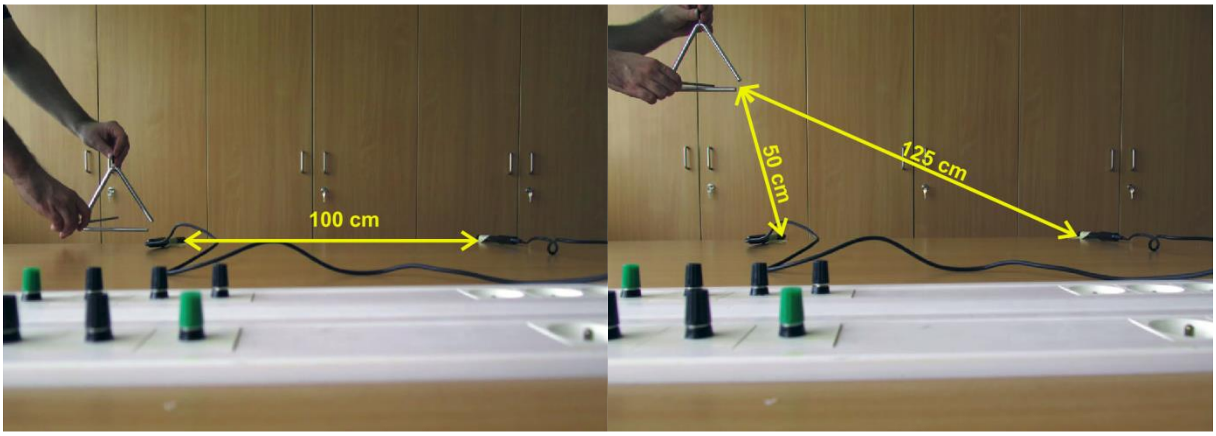
1. Attach the microphones on a table using tape with the distance between them being 100 cm (as shown in the figure).



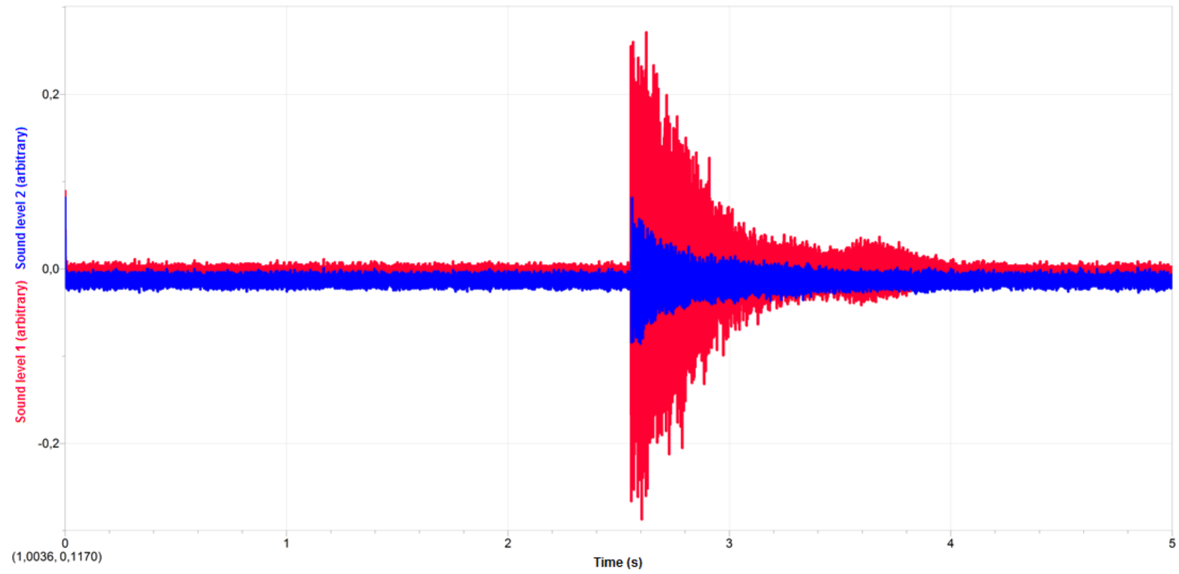
2. Connect both microphones to your computer using *LabQuest 2* or *LabQuest Mini*.
3. Launch the Logger Lite or Logger Pro computer programme.
4. Set the Duration to 5 seconds and Sampling rate to 10 000 Hz.

5. Start the measurement and strike the triangle near one of the microphones.

   Note: it is necessary that the triangle and both microphones **lie in one line** so that the path difference between the first and the second microphone is 100 cm**.** The figures below show the correct arrangement on the left and incorrect arrangement on the right. In the second case, the path difference is in fact only 75 cm.

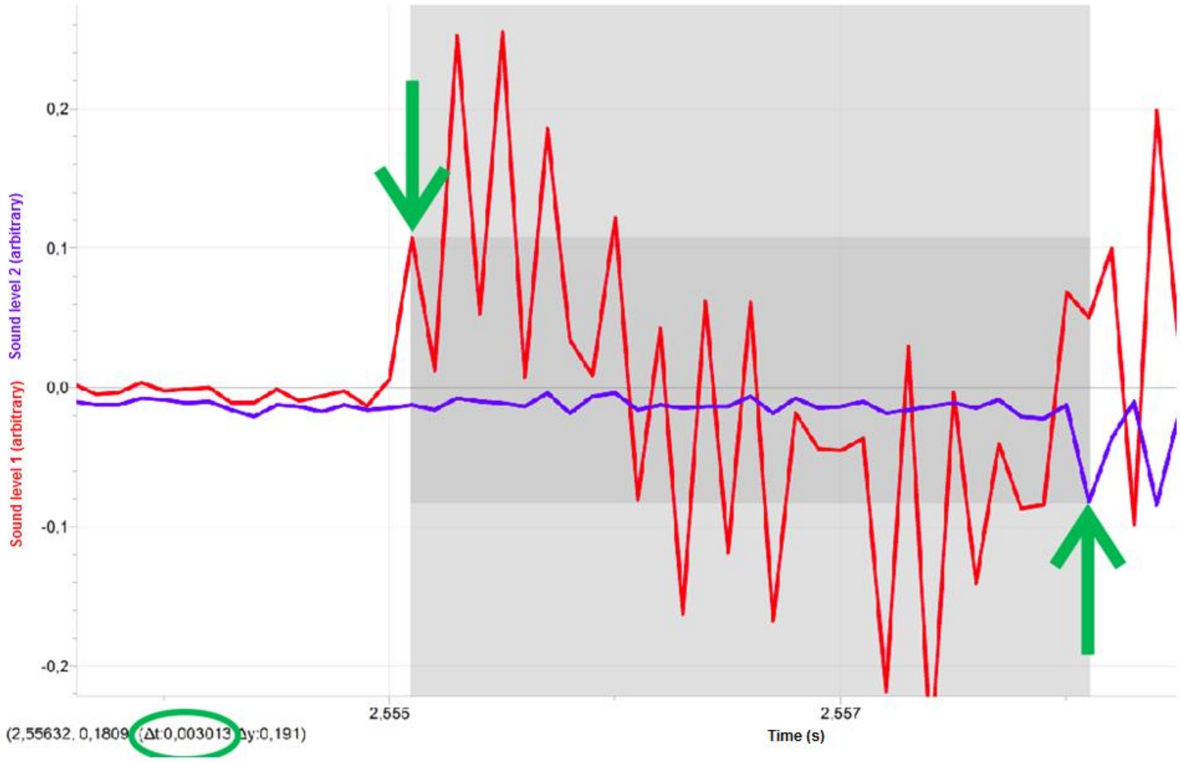


6. At first glance it would seem that the signals from the two microphones were captured at the same moment.



7. Select the relevant part of the graph and zoom in (in the menu *Analyse → Zoom Graph In*). In *Logger Pro* you can also use the icon .
8. Turn on the tool *Examine points* by clicking on the icon . Determine the time of the first peak of the red graph (first microphone) and of the blue graph (second microphone). From the time difference and the distance between the microphones calculate the speed of sound.

   Logger Pro can simplify the process - just drag the cursor to mark the graph between the peaks of the graph and at the bottom left you can read the time difference value Δ*t*.



9. In a similar way, perform the measurement of the speed of light, this time using two light sensors LS-BTA. Instead of a triangle, use a camera with a flash.
10. Now you can use the knowledge of the speed of sound and light to determine the approximate distance of the place where the lightning struck.

Notes for teachers

Determining the speed of sound

When the distance between the microphones is 100 cm, the typical delay between the microphones is about 0.003 seconds.

The sound travelled 1 m in 0.003 s. Therefore, multiplied by one thousand, the sound travels 1 km in about 3 seconds.

Higher measurement accuracy can be achieved by increasing the distance between the microphones. For this purpose, you can use one or more extension cables www.vernier.cz/EXT-BTA .

For demonstration, we used 3 of these cables (each 2 m long); the total distance between the microphones was 870 cm. The time difference was 0.0252 s, which corresponds to the speed of sound of about 345 m/s.

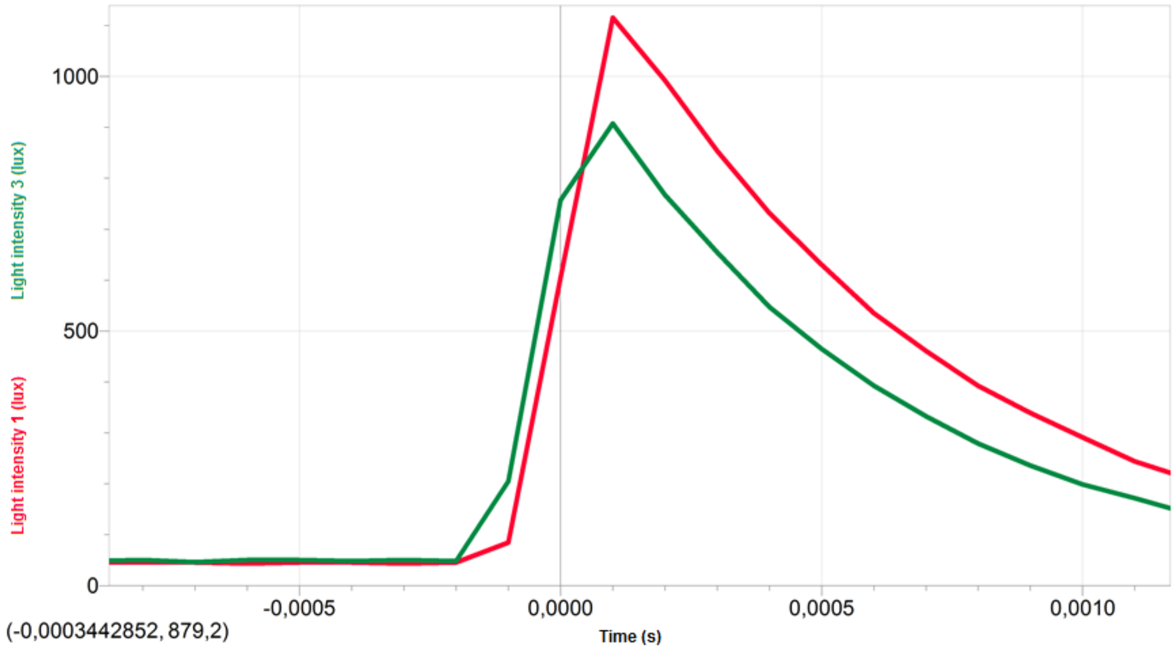
We also measured the temperature in the room (24 °C) so that we could compare the value of 345 m/s with the table value. According to Wikipedia, the speed of sound at 25 °C is about 346 m/s. This corresponds well to our measured value at 24 °C.

Pay attention to the correct location of the triangle

Proper placement of the triangle (in line with the two microphones) is necessary. If you place the triangle carelessly, you can obtain the speed of sound to be 430 m/s instead of 340 m/s.

Determining the speed of light

When measuring the speed of light, the graph after zooming in looks like the graph below.



Simplified interpretation of this graph is that both light sensors captured the light at the same time. In this simplification the light travels any distance "immediately".

For more correct interpretation is necessary to consider the sampling rate (i.e. the frequency of measurement). It was set to 10 kHz. The fact that both signals from two light sensors with the distance 1 m captured the light in the same time interval of the measurements (which is 0.0001 long), thus proves only that the light travels faster than 10,000 m/s (10 km/s). Even this, however, at normal distances compared with the sound is almost immediately.

Conclusion (guidance on determining the distance of the storm)

The sound travels approximately 3 km/s and the light with respect to the scale in which we operate travels any distance "immediately". So if a lightning strikes, we see the light almost immediately while the sound takes 3 seconds to travel each kilometre. When we count the seconds, the resulting number needs to be divided by three. Thus we get the approximate distance of the storm in kilometres.