Advanced Higher Physics: Assignment Support

Astronomy & Physics Education Group

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Measuring speed of sound using Lissajous' figures

Introduction

Lissajous' figures are named after Jules Lissajous who demonstrated them in Paris in 1855. He was not the first to demonstrate them though: Nathaniel Bowditch in the United States did this first, and in the States they are known as Bowditch curves.

In these figures, two signals are plotted against each other, with the resulting shape depending on the relative phase difference between the two signals. Figure 1 shows some example Lissajous figures. Each figure shows the figure for different values of phase difference, ϕ.

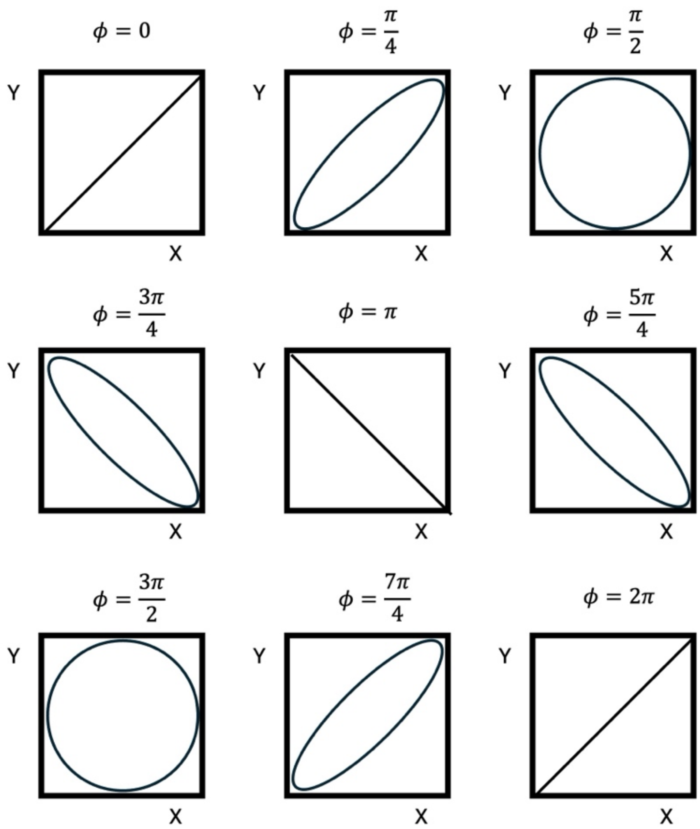

Figure 1: Example Lissajous figures

As shown, when the two signals are an integer multiple of π radians out of step the resulting Lissajous figure is a straight line at $45°$ to the horizontal. This experiment takes advantage of this to determine the wavelength and hence speed of a particular signal.

The experimental set up used here is shown in Figure 2.

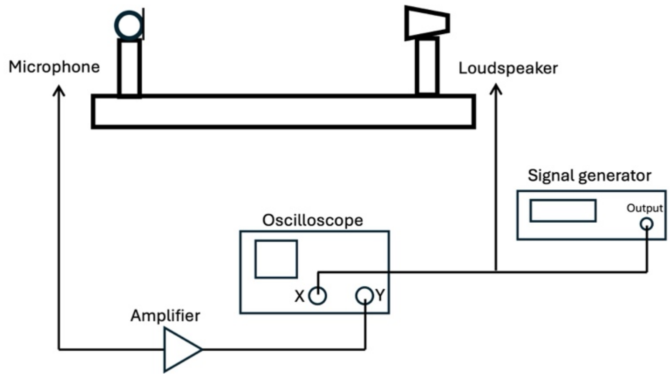

Figure 2: Experimental set up

The signal generator sends a suitable audio frequency signal to a loudspeaker and, at the same time, to the X-input of the Oscilloscope. The sound that then reaches the microphone creates a small signal which is amplified by the high gain amplifier and fed to the Y-input of the Oscilloscope. If the X-input gain and the Y-input gain are adjusted to give each input the same amplitude, then the shapes shown in Figure 1 will be produced.

If the microphone is placed such that the cycle of images goes from $\phi = 0$ to $\phi = 2\pi$, then the distance moved by the microphone will equal one wavelength, λ, of the sound. And since the corresponding frequency, f, is displayed on the signal generator, it is possible to determine the speed of the signal, v, using

$$v = f\lambda \quad [1]$$

Notes on equipment

Equipment list

The equipment provided for this Experiment are:

- The hollow plastic tube
- Loudspeaker and microphone
- Signal generator and oscilloscope
- Metre rule

- Dry wipe marker

Equipment guidance

Oscilloscope:

The display on the oscilloscope should be adjusted to make sure that the signal is as clear as possible. By monitoring the amplitude – the height – of the signal on the screen it is possible to determine when the microphone is at a point of maximum, or minimum, amplitude. Make sure it is set to plot X against Y, not one of these against time, which is the "normal" display setting.

Signal generator:

This can generate a wide range of signals – it is recommended to choose an initial frequency that will create a wavelength that will fit in the tube. By using the accepted value for the speed of sound in air of $\sim 340 \text{ ms}^{-1}$ it is possible to determine a suitable value for f.

Hollow tube:

It is best to use as much of the length of the tube as possible, so starting by positioning the microphone at a node around three-quarters of the way along the tube is recommended. It should then be possible to determine the position of several nodes before reaching the other end of the tube.

Locations of where the straight-line figures appear can be marked on the tube using dry wipe markers.

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