PHYSICS
EXPERIMENTS
(SOUND)

'In the matter of physics, the first lessons should contain nothing but what is experimental and interesting to see. A pretty experiment is in itself often more valuable than twenty formulae extracted from our minds.' - Albert Einstein

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LEAVING CERTIFICATE PHYSICS

LISTED EXPERIMENTS

CONTENTS

SOUND

Experiment at Higher Level only*

NOTE

For examination purposes any valid method will be acceptable for describing a particular experiment unless the syllabus specifies a particular method in a given case.
Students will be expected to give details of equipment used, assembly of equipment, data collection, data manipulation including graphs where relevant. Students will also be expected to know the conclusion or result of an experiment and appropriate precautions.

SAFETY

1. The Leaving Certificate Physics syllabus states on page three:

    'Standard laboratory safety precautions must be observed, and due care must be taken when carrying out all experiments.
    The hazards associated with electricity, EHT, lasers etc. should be identified where possible, and appropriate precautions taken. The careful use of sources of ionising radiation is essential. It is important that teachers follow guidelines issued by the Department of Education and Science.'

2. The guidelines referred to here consist of two books, which were published by the Department of Education in 1997. The books are

    'Safety in School Science'

    and

   'Safety in the School Laboratory (Disposal of chemicals)'

    When these books were published they were distributed to all schools. They have been revised and are available on the 'physical sciences initiative' web site at www.psi-net.org in the 'safety docs' link of the physics section.

3. Teachers should note that the provisions of the Safety, Health and Welfare at Work Act, 1989 apply to schools. Inspectors appointed under that act may visit schools to investigate compliance.

MEASUREMENT OF THE SPEED OF SOUND IN AIR

Apparatus

1000 ml graduated cylinder, resonance tube, set of tuning forks in the frequency range 256 Hz to 512 Hz, vernier callipers, metre stick, stand (longest upright type), clamp and wooden block.

| Fig.1 | Fig. 2 |
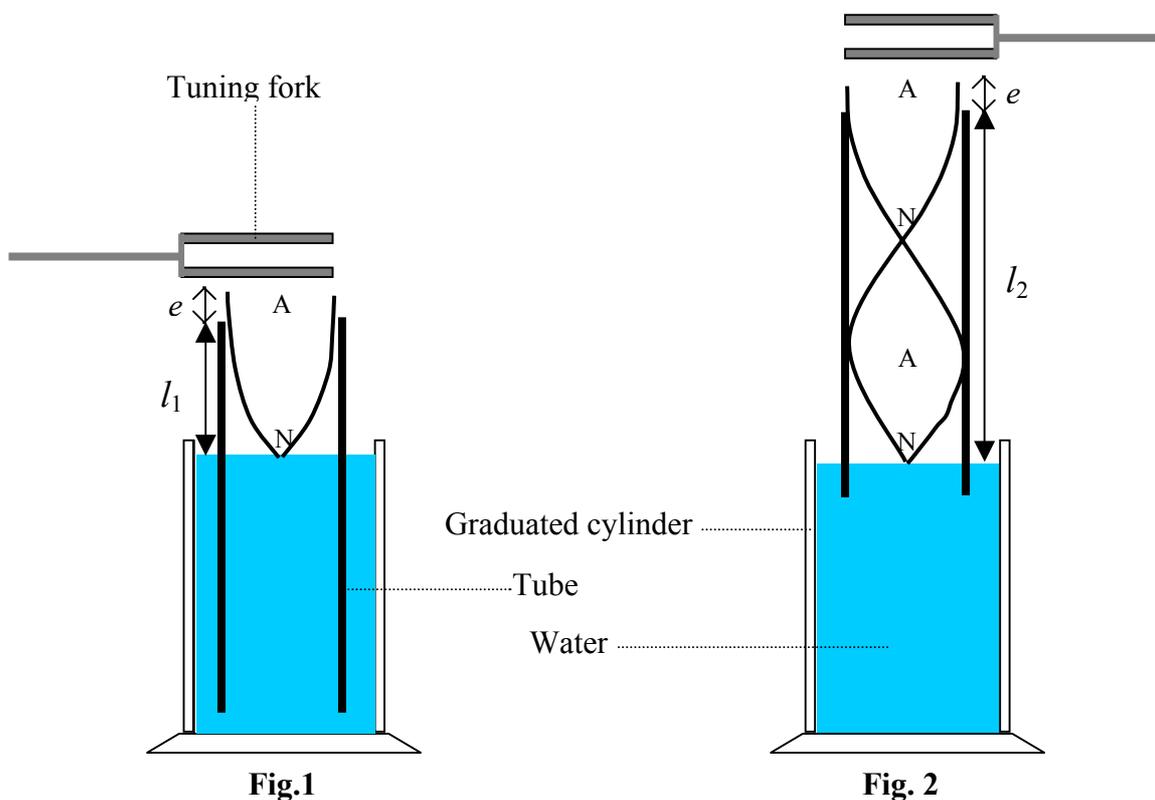
Procedure

1. Clamp the tube so that the water in the graduated cylinder closes its lower end. The tube should be free to slide vertically through the clamp jaws. Take an approximate value of 300 m s^{-1} for the speed of sound to obtain a rough estimate of the quarter wavelength resonance position.
2. Strike the highest frequency (512 Hz) tuning fork on the wooden block, and hold it in a horizontal position just above the mouth of the tube (Fig. 1).
3. Slide the tube slowly up/down until the note heard from the tube is at its loudest; resonance is now occurring.
4. Tighten the clamp in this position and measure the length of the air column (from the water level to the top of the tube) l_1 with a metre stick.
5. Clamp the tube (or its extension) so that the air column is 2 or 3 cm less than $3l_1$ (Fig. 2).
6. Obtain a second weaker resonance with the same tuning fork by again sliding the tube until the note heard is at its loudest, at the three-quarters wavelength resonance position.
7. Clamp the tube in this position and measure with a metre stick, the air column length l_2 at this resonance.

8. Repeat this procedure to obtain the corresponding values of l_1 and l_2 for all the tuning forks in order of decreasing frequency.
9. Record the measurements in a table.
10. Calculate the wavelength using $\lambda = 2(l_2 - l_1)$ in each case.
11. Calculate the speed of sound from $c = f\lambda$, for each of the tuning forks.
12. Find the average value for the speed of sound.

Results

f/Hz	l_1/m	l_2/m	λ /m	c/m s^{-1}

The average value of the speed of sound in air =

Notes

The experiment can be done using just one tube. Proceed to obtain resonance as before. Measure the length l_1. The antinode forms above the top of the tube and so an end correction factor has to be added to the length. From theory, it is found that the correction factor $e = 0.3d$, where d is the average internal diameter of the tube (measured using a vernier callipers).
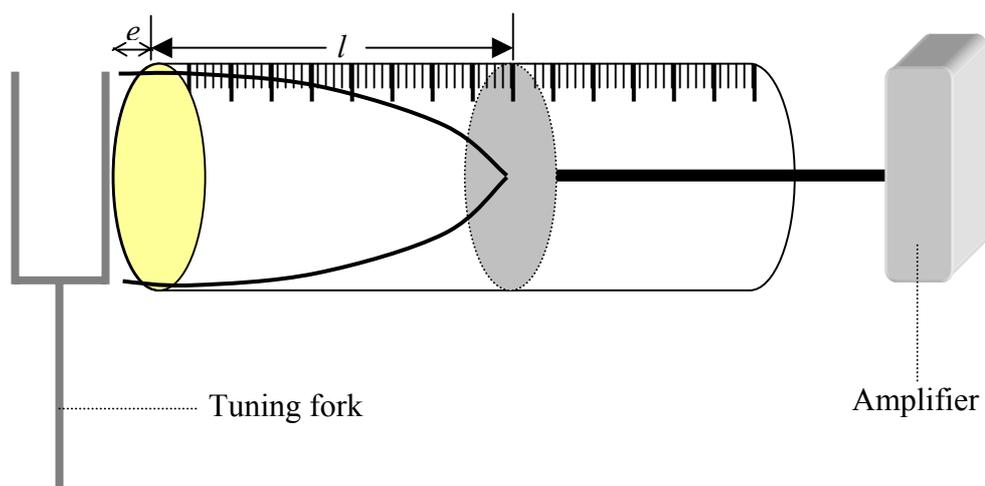
Hence $\lambda = 4(l_1 + 0.3d)$
$\quad c = f\lambda$
$\quad c = 4f(l_1 + 0.3d)$.

Calculate a value of c for each tuning fork and find an average value for the speed of sound.

If a resonance tube is not available, use 50 cm lengths of 40 mm and 30 mm plastic pipes.

A specially designed apparatus called a resonometer can also be used to obtain the data.

Tuning fork   Amplifier

Beginning with the highest frequency tuning fork and a very short column of air, adjust the piston until the sound from the vibrating air column is loudest; this is the first resonance point. Measure the length *l* of the air column at resonance. Proceed to use the set of tuning forks to complete the data table as in the previous method (it is difficult to distinguish resonance for frequencies below 340 Hz).

$\lambda = 4(l + e)$ where *e* is the end correction factor
$\lambda = 4(l + 0.3d)$ where d is the internal diameter of the tube
$c = f\lambda$
$c = 4f(l + 0.3d)$.

It is also possible to cause resonance in the air column using a signal generator and a loudspeaker; the 8 Ω, 5 cm diameter model of loudspeaker is ideal. Clamp the loudspeaker in a horizontal position just above the mouth of the tube. Connect the loudspeaker to the low impedance output of the signal generator. Gradually increase the signal generator frequency from zero until the air column resonates. Calculate the speed of sound using the same procedures as before. Repeat the experiment for different lengths of the air column.

INVESTIGATION OF THE VARIATION OF FUNDAMENTAL FREQUENCY OF A STRETCHED STRING WITH LENGTH

Apparatus

Signal generator, U-magnet, sonometer with a newton balance or tensionometer (0 to 50 N) and tension key.

Safety note: Wear safety goggles in case the sonometer wire snaps.
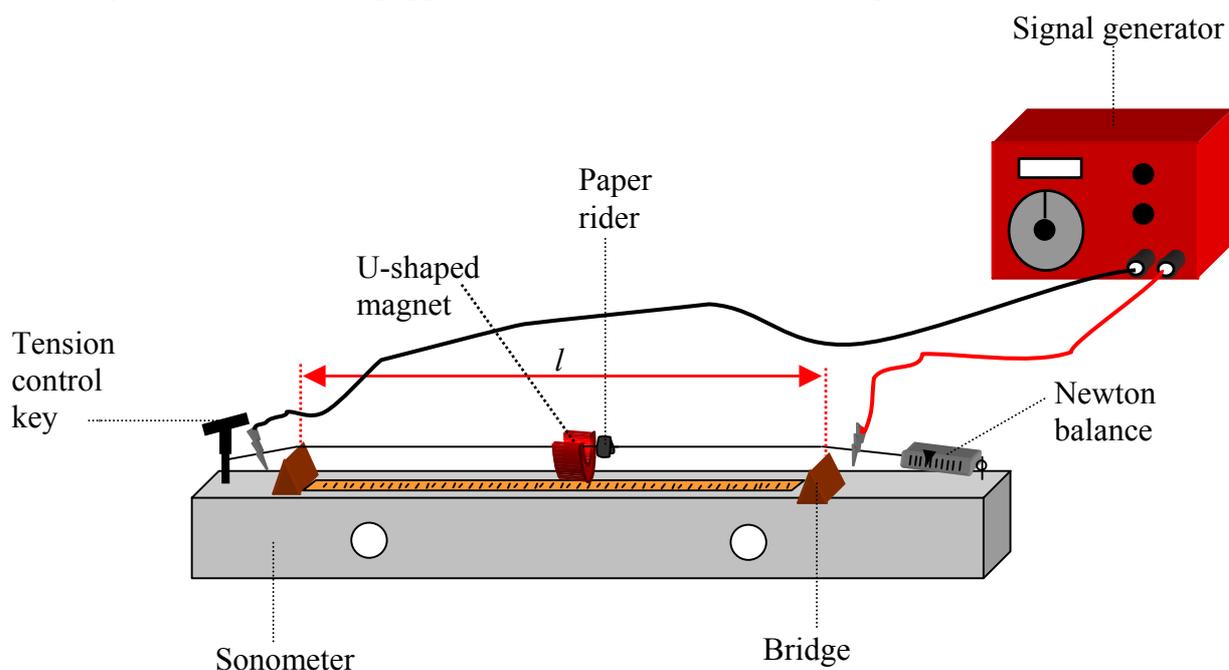
Procedure

1. Place the sonometer wire between the poles of the U-magnet, positioned midway between the bridges.
2. Fix the tension at a constant value (e.g. 20 N), using the tension control key.
3. Place the bridges as far apart as possible and measure the length of the wire l between the bridges with a metre stick.
4. Slowly increase the applied a.c. frequency from 0 Hz, until the wire vibrates.
5. Note the value of this frequency when the vibration is at its maximum.
6. Reduce the length of the wire, by sliding one bridge towards the other one. Reposition the magnet midway between the bridge supports and measure the fundamental frequency for that length.
7. Repeat this procedure for different lengths of wire and measure the corresponding fundamental frequencies.
8. Record the measurements in a table.
9. Plot a graph of frequency f against inverse of length $\dfrac{1}{l}$.

Results

f/Hz	l/m	$\dfrac{1}{l}$/m^{-1}

Conclusion

A straight line through the origin will verify that frequency f is inversely proportional to the length l.

Notes

If the frequency cannot be read with reasonable accuracy from the signal generator, use a multimeter with a suitable frequency scale. Connect it across the signal generator.

Use the amplitude control on the signal generator to adjust the current flowing through the wire, to prevent overheating.

Keep the paper rider as light as possible. Use a small piece of cellotape to hold the paper in the form of a loop. This allows the rider to sit loosely on the wire without falling off. The movement of the paper is then easier to see and hence the position of resonance is easier to identify.

A short length of drinking straw can also be used as a very light rider. Slit the straw length-wise first; cut off a 0.5 cm piece and slip it onto the string. This rider can be moved along the string to detect the positions of nodes and antinodes when the string is vibrating at resonance.

A set of tuning forks may be used as an alternative to the signal generator and magnet.

Use the low impedance output of the signal generator.

A guitar string may be used instead of the sonometer wire.

INVESTIGATION OF THE VARIATION OF THE FUNDAMENTAL FREQUENCY OF A STRETCHED STRING WITH TENSION*

Apparatus

Signal generator, U-magnet, sonometer with a newton balance or tensionometer (0 to 50 N) and tension key.

Safety note: Wear safety goggles in case the sonometer wire snaps.
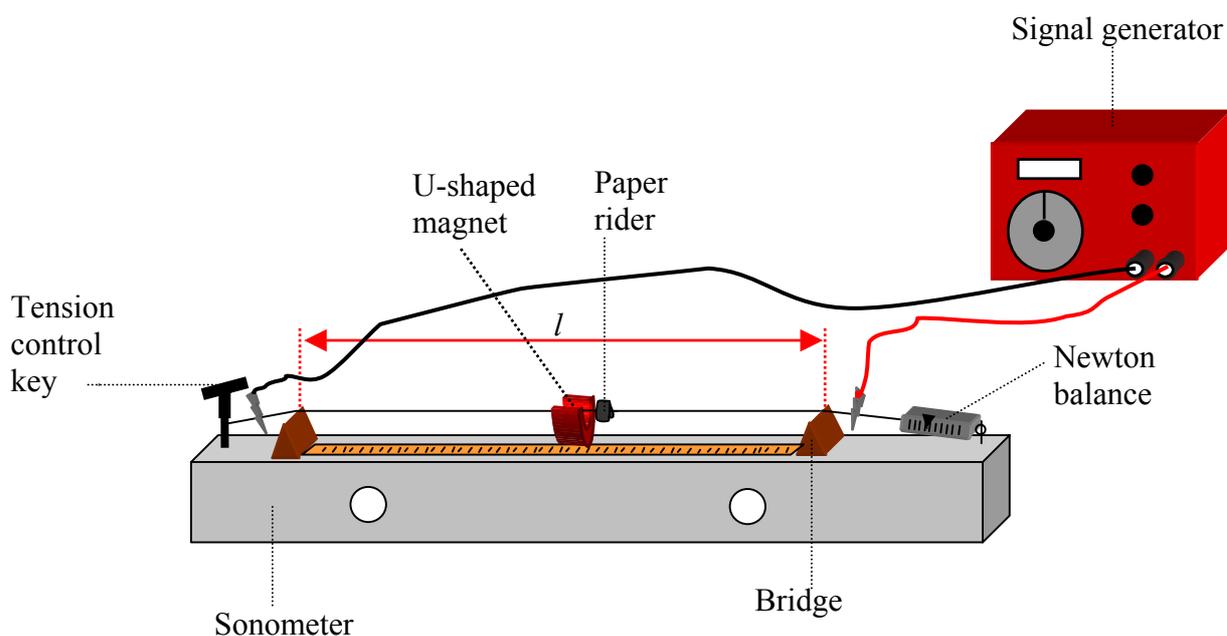
Procedure

1. Place the sonometer wire between the poles of the U-magnet, positioned midway between the bridges.
2. Select a wire length l (e.g. 30 cm), by suitable placement of the bridges. Keep this length fixed throughout the experiment.
3. Set the tension at a low value (e.g. 4 N), so that the stationary waves set up at resonance have large amplitude and are easily visible.
4. Increase the frequency slowly from zero until resonance occurs.
5. Increase the value of the tension (in steps of 4 N, for example) and again increase the applied a.c. frequency until resonance occurs.
6. Record the frequency and tension values in a table.
7. Repeat the procedure to obtain at least six readings.
8. Plot a graph of frequency f against the square root of tension $\sqrt{T}$. Draw a straight line of best fit through the plotted points.

Results

f/Hz	T/N	$\sqrt{T}$ /N$^{1/2}$

Conclusion

A straight line through the origin will verify a proportionality between the frequency f and the square root of the tension $\sqrt{T}$.

Notes

Ensure that the breaking strain of the wire is greater than 50 N.

Use the low impedance output of the signal generator.

If the frequency cannot be read with reasonable accuracy from the signal generator, use a multimeter with a suitable frequency scale. Connect it across the signal generator.

Use the amplitude control on the signal generator to adjust the current flowing through the wire, to prevent overheating.

Keep the paper rider as light as possible. Use a small piece of cellotape to hold the paper in the form of a loop. This allows the rider to sit loosely on the wire without falling off. The movement of the paper is then easier to see and hence the position of resonance is easier to identify.

A short length of drinking straw can also be used as a very light rider. Slit the straw length-wise first; cut off a 0.5 cm piece and slip it onto the string. This rider can be moved along the string to detect the positions of nodes and antinodes when the string is vibrating at resonance.

Students may find the data easier to handle if the tension values 4 N, 9 N, 16 N, etc., are chosen.

A guitar string may be used instead of the sonometer wire.

A set of tuning forks may be used as an alternative to the signal generator and magnet.