

Double-layered Resonance Apparatus

Narika Cat. No. C15-8256-W0



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Safety Precautions

- Teachers or trainers must instruct students on the operating procedure and the safe ways of conducting experiments with this product prior to experiments.
- Always carry out students' experiments under the supervision of teachers/trainers.
- Do not use this product on an uneven surface.
- Do not use this product for unintended purposes.
- Do not disassemble, repair, or remodel this product. This product might not work properly, and the warranty will be void.

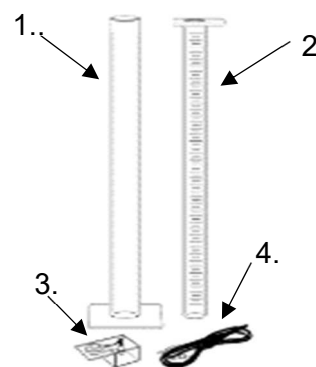
Introduction

This air column resonance apparatus consists of two compact vertical plastic resonance tubes and a mini speaker. This apparatus is compact due to the double-layered structure of the resonance tubes.

The outer tube works as a cylindrical water tank and the inner tube with a scale works as a movable resonance air column. Each of the two tubes has only half the length (48 cm & 49 cm, respectively) of other similar devices (~100 cm). The length of the air column is adjustable by raising or lowering the inner tube, which is easier than changing the length of the water column with a movable water reservoir as is typically required in conventional air column resonance apparatus.

Contents

1. 1 Plastic cylindrical water tank (Outer tube): 10 x 10 x 49 cm
2. 1 Plastic resonance tube (Inner tube) with printed scales: 6 x 7 x 48 cm
Measurable Scale Range: 3 cm–46 cm, 1mm division
3. 1 Mini speaker unit: 8Ω, 400Hz–8kHz
4. 1 Monaural jack cable



How to use

Preparation

Additional items needed for the experiment:

You will need any sound source, such as tuning forks or any app or website, that can produce a single frequency sound, including a smartphone app (e.g., Function Generator). Also, a low-frequency sound oscillator with a mini monaural plug will work (e.g., A05-7631-W0, Portable low-frequency sound oscillator CR-T, available from Narika Corporation).



A05-7631-W0 Low-frequency sound oscillator



Smartphone app or frequency generator app

Set up:

1. Mount mini speaker unit on resonance tube (inner tube):

Attach the mini speaker unit to the flange of the resonance tube (inner tube) using the included knurled screw (see Fig.1 and 2). When using a tuning fork as a sound source, the speaker is not necessary.

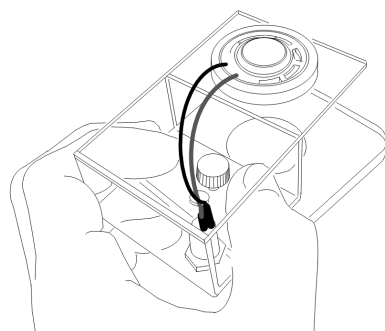


Fig.1

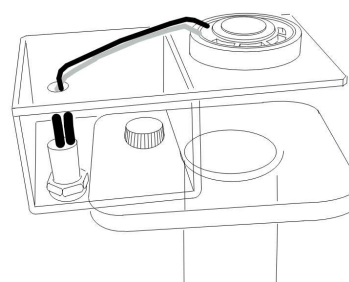
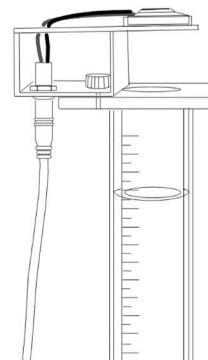


Fig.2

2. Pour an appropriate amount of water into the plastic cylindrical water tank (outer tube):

Prepare around 300ml of water in a beaker. Then, pour the water into the outer tube. Make sure the amount of water is always less than 330 ml to prevent overflow when the inner tube is inserted into the outer tube. Note that the water surface does not line up with the minimum scale value on the inner tube.



Experiment: Measuring the speed of sound based on resonance in a pipe closed at one end

Objectives

- Determine the wavelength of a standing wave in an air column created by the variable height difference between inner and outer tubes.
- Calculate the speed of sound in air using the principle of resonance.
- Learn how the speed of sound is affected by temperature.

Theoretical background: Formula for speed of sound in air

The speed of sound in air at 0° C is theoretically 331 m/s and increases by 0.6 m/s for each additional degree Celsius. Therefore, the corrected speed of sound as a function of temperature is expressed as the formula shown below. Compare the theoretical values with the one(s) that can be obtained as mentioned later.

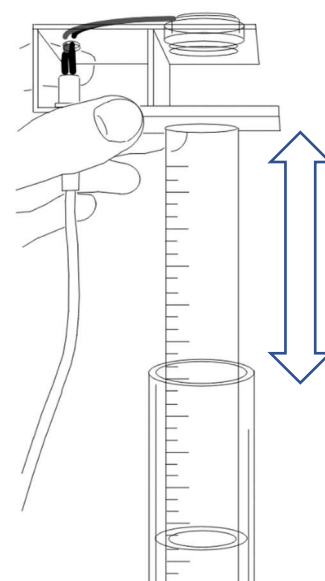
$$v(T) = 331 \text{ m/s} + 0.6 T$$

Basic operation

Length (height) of the air column is changeable by raising and lowering the resonance tube (inner tube). Measure the length of the air column as the distance between the water surface and the open end of the inner tube by reading the printed scales.

Determining wavelength and calculating speed of sound

- 1) If using the mini speaker, connect the mini speaker unit with an appropriate sound source emitting a sound of known frequency.
- 2) Measure the room temperature and record the sound frequency f of the sound source.
- 3) Fully insert the inner tube into the outer one, and then raise it carefully and slowly to gain the length of the air column until the sound is loudest. This can also be determined using a sensor to locate the point of greatest sound level. This point occurs when the node of the standing wave created in the inner tube lines up with the water surface.
- 4) Stop raising the inner tube and record the length of the air column at that moment measured by reading the printed scales ($L_1 = \lambda/4$). Then, raise and lower the inner tube, once or twice by a small amount, to detect if you may hear any louder sound. If this is the case, amend the recorded value for L_1 .
- 5) Restart and keep raising the inner tube carefully and slowly until the sound you would hear is maximized again at the next resonance point. Stop raising the inner tube and record the length of the air column at that moment to be measured by reading the printed scale (L_2). Again, raise and lower the resonance tube to ensure the correct measurement of this length. Repeat step 5 as far as the length of the inner tube permits to measure L_3 if possible.
- 6) Calculate $\Delta L = L_2 - L_1 = \lambda/2$. The difference represents the distance between the two nodes.
- 7) Calculate $\Delta L = L_3 - L_2 = \lambda/2$ for any measurements of L_3 .
- 8) Calculate $v = \lambda f$.



Speed of sound by resonance

Frequency f (Hz)	First node L_1 (m)	Second node L_2 (m)	$L_2 - L_1$ (m)	$\lambda = 2(L_2 - L_1)$ (m)	$v = \lambda f$ (in air) (m/s)

Storage

1. Remove the mini speaker from the inner tube. Keep the mini speaker dry when stored.
2. Drain the water in the outer tube. Let the inner and outer tubes air dry.

Do not use abrasive cleaners. Apparatus is not dishwasher safe. Make sure to avoid external shock applied on the tubes.

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