NaRiKa

Plastic Spring

for Transversal and Longitudinal Wave's Experimentation

CAT. No. C15-4103-W0

- ☐ **Thank you for purchasing Plastic Spring.**
- ☐ **Be sure to read this manual before using it.**

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OBJECTIVE

Measurement of the phase of reflected waves and the velocity of transversal and longitudinal waves and experiments on standing waves.

CONTENTS OF PACKAGE & CAUTION

Material: Plastics

Size: ca ϕ 17mm x 500mm (Wire: ϕ 1.5mm)

<CAUTION>
To prevent entanglement, the spring is placed gently in the box fixed in a pipe shape. If you hold both ends and stretch the spring slowly, it will easily become soft. So please conduct the experiment after doing so.

DEMONSTRATION

1. Transversal Waves

(1) Phase of Reflected Waves

Two pupils hold a spring and stretch it until it is approximately 3 m (Fig. 1). One end of the spring is pulled up (or down) approximately 10 cm high and quickly released, or hit briskly, to send a clear-cut pulse wave (a crest or a trough). The reflected wave is observed at the other (fixed) end of the spring (reversal of the phase).

[Pull up end B swiftly approximately 10cm high and quickly release to send a pulse wave.]

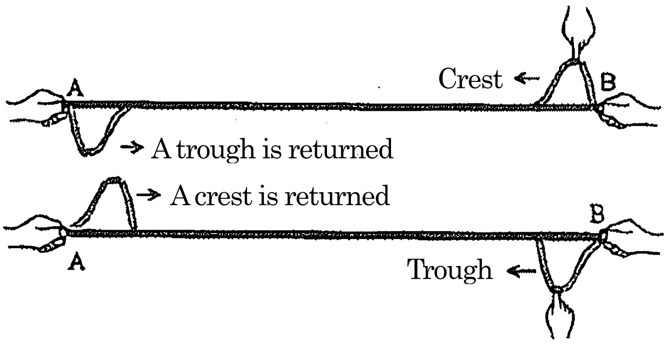

Fig.1 Phase of Reflected wave

(2) Measurement of Wave Velocity

① Stretch and hold the spring 2.0 m long. Attach Newton spring balance to one end of the spring and measure tension S. Also measure tension S after stretching the spring to 3.0, 4.0 and 5.0 m, respectively.

② Remove the scale. While keeping the spring 2 m long, send a pulse wave from one end to the other. Start the stopwatch when starting the wave. Measure time t for the pulse to return to the original position three times (three round trips). Repeat the measurement for three or four cycles and calculate the average. Using the average, calculate wave velocity $\nu=\frac{2l\times 3}{t}$.

③ Place a paper tray on an electronic balance and measure the mass m of the plastic spring. Divide the mass by length l=2.0(m) to obtain the mass per unit length (line density $\rho=\frac{m}{l}$). Calculate wave velocity $\nu=\sqrt{\frac{S}{\rho}}$. Compare the value with the value obtained in Experiment (2).

④ Perform the same experiments for spring lengths increased to 3.0, 4.0 and 5.0 m, respectively. Have the pupils understand that wave velocity ν increases as the spring length increases because the line density ρ decreases and tension S increases. Have them also understand that the relation $\nu=\sqrt{\frac{S}{\rho}}$ holds good because the wave velocity v determined in Experiment (2) is equal to calculated value (3) regardless of spring length.

(3)Relation between Wavelength and Frequency of Standing Waves

① Stretch the spring to 3.0 m long and have one pupil hold one end of the spring steadily. Have the other pupil hold the free end of the spring and swing it up and down with appropriate amplitude to generate a steady wave. The pupils change roles and repeat the same experiments.

Have the pupils understand that, once the standing wave is created, the spring can be easily swung up and down by hand with small amplitude and the spring will continue to vibrate steadily. Have them understand that the swinging of the hand and the vibration of the spring resonate so that the energy supplied by the hand is very small.

Have the pupils also understand that resistance is felt when attempting to change the swinging motion of the hand to increase the number of antinodes and that their hand must pass energy to the spring to increase the vibration of the spring.

② Create a stable standing wave with one antinode. Use the stopwatch and measure time 10 T(T: period) to swing the spring 10 times to find frequency f. Have the pupils confirm that the relation λ(=2l) holds good, where $\nu=f\lambda$ and ν= the velocity determined in the above experiments.

(Caution for measurement) When counting vibrations, the pupils tend to count from 1 after starting the stopwatch, resulting in counting only 9 instead of 10 vibrations. Have them start counting from zero followed by 1, 2, 3 and up to 10.

③ Repeat the same experiments by increasing the number of antinodes to 2 and 3.

④ Repeat the same experiments with the number of antinodes 1, 2 and 3 by increasing the spring length to 4.0 m.

⑤ The pupils will understand from the above experiments that the following general equations defining the relation between wavelength and frequency for n antinodes hold good: General equations: $\lambda=2l/n$,

$$f=\frac{v}{\lambda}=\frac{n}{2l}\sqrt{\frac{S}{\rho}}$$

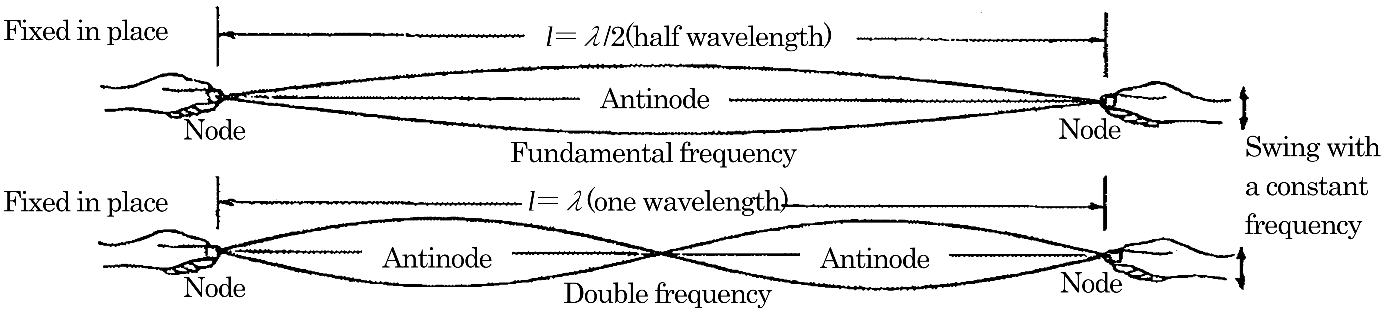

Fig.2 Standing Wave

2. Experiments of Longitudinal Waves

(1) Observation of Longitudinal Waves (Compressional Waves) and Phase of Reflected Waves at Fixed End

Fix the plastic spring at both ends after stretching to 3.0 m. Compress the spring until it is proximately 5 to 10 cm long at one end and release. A compressed pulse wave is reflected at the other end as a compressed pulse wave. Pull the spring partly at one end and release. A rarefied pulse wave is reflected at the other end as a rarefied pulse wave. Have the pupils observe the propagation at the fixed end. The phase of the reflected wave of the longitudinal wave is shifted by π (or $\lambda/2$ by the wavelength) at the fixed end. Compressed pulses are reflected as compressed and rarefied pulses are reflected as rarefied. Avoid the misunderstanding that a compressed pulse wave reflects as a rarefied pulse wave.

(2) Measurement of Velocity of Longitudinal Waves

① Hold the spring at l = 2.0 m. Compress the spring until it is approximately 5 to 10 cm long at one end and release to send a compressed pulse wave. Start the stopwatch at this time and measure time t for the wave to return to the starting point after three round trips.

Calculate the velocity of the wave ($v=\frac{2l\times3}{t}$).

② Measure the velocity of the longitudinal waves for spring lengths l = 3.0, 4.0 and 5.0 m.

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