A01-700S-Y32

Mechanical Wave Vibration Demonstration Kit

Purpose

I. Metal ring and soft spring

1. Use metal strips in different lengths to discuss the standing wave of transverse wave in one dimension.
2. Observe standing waves in a closed metal ring.
3. Use soft springs to observe condensation and rarefaction waves in one dimension.

II. Chladni Experiment

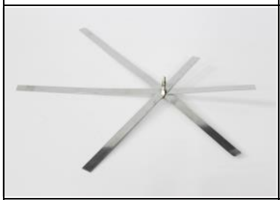
4. Observe Chladni figures in two dimensions.

III. Resonance of spring

5. Discuss the propagation speed, line tension and linear density in resonance phenomenon.

Instruments

Instrument list					
No.	Accessory	Qty	No.	Accessory	Qty
1.	Digital frequency generator amplifier	1	2.	Connecting wire	5
3.	U-shaped base	2	4.	Iron rod	4
5.	Vibration generator	1	6.	Metal sheet with slot	1
7.	Metal ring with slot	1	8.	Connector with hook	1
9.	Slot with hook	1	10.	Connector with slot	1
11.	Soft spring	1	12.	Round aluminum board	1
13.	Square aluminum board	1	14.	Sand	1
15.	Wire to be measured	1	16.	Iron rod with connector	2
17.	Hook with connector	2	18.	Spring balance with connector	1
19.	Single pulley with connector	1	20.	Double pulley with connector	1
21.	LED flash light	4	22.	Wire to be measured	1

Instrument picture				
				
1.	2.	3.	4.	5.
				
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	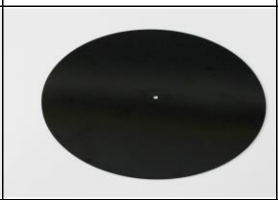	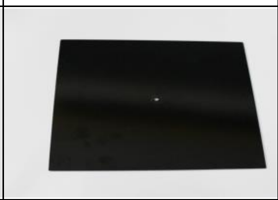		
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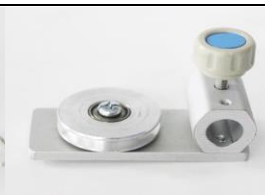
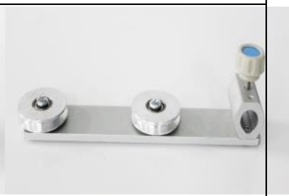
				
16.	17.	18.	19.	20.
				
21.				

Theory

Wave propagation can be divided into longitudinal and transverse waves. When a wave's particle motion is vertical to the propagation direction, it is a transverse wave; otherwise, it is a longitudinal wave. In one dimension, if a string performs a transverse wave, all waves on the string will propagate along the string. The peck of the wave is its crest and the opposite of the crest is trough. The distance between two adjacent crests or two troughs is the wavelength λ. If the oscillation frequency is f and the velocity of wave is V, we can then know

$$V = f\lambda \qquad (1)$$

If the string's velocity is V, the tension is T and the mass density per unit lengthρ, their relationship can be expressed as

$$V = \sqrt{\frac{T}{\rho}} \qquad (2)$$

From equation (1) and (2)

$$f = \frac{1}{\lambda}\sqrt{\frac{T}{\rho}} \qquad (3)$$

If we have appropriate string length or tension, waves with same strength but act at different directions will from a standing wave.

$$\lambda = \frac{2}{n}\ell \qquad (4)$$

(n is the segment number of standing wave (which is the half-wave number) and ℓ is the string length)

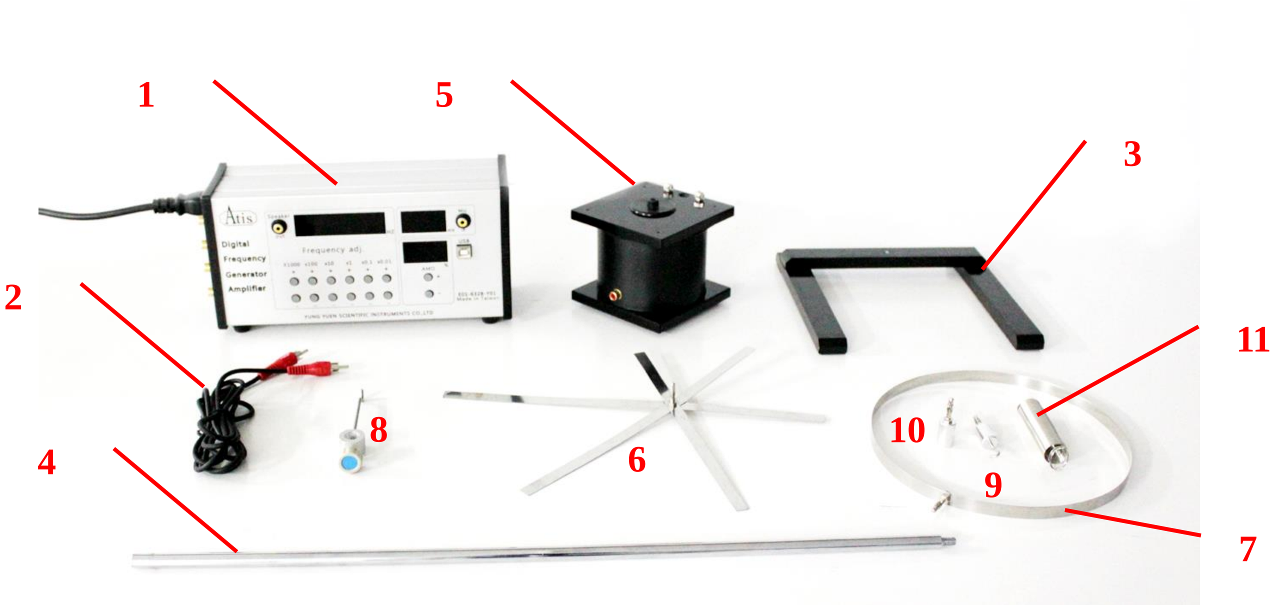
From equation (3) and (4), the formula can be expressed as

$$f = \frac{n}{2\ell}\sqrt{\frac{T}{\rho}} \qquad (5)$$

In two dimensions, students can study the theory of kymatology, wave equation and superposition principles so they can observe interesting figures in experiment II Chladni Experiment.

Ⅰ. Metal Ring and Soft Spring

Instrument setup:



(I) Experimental Setup

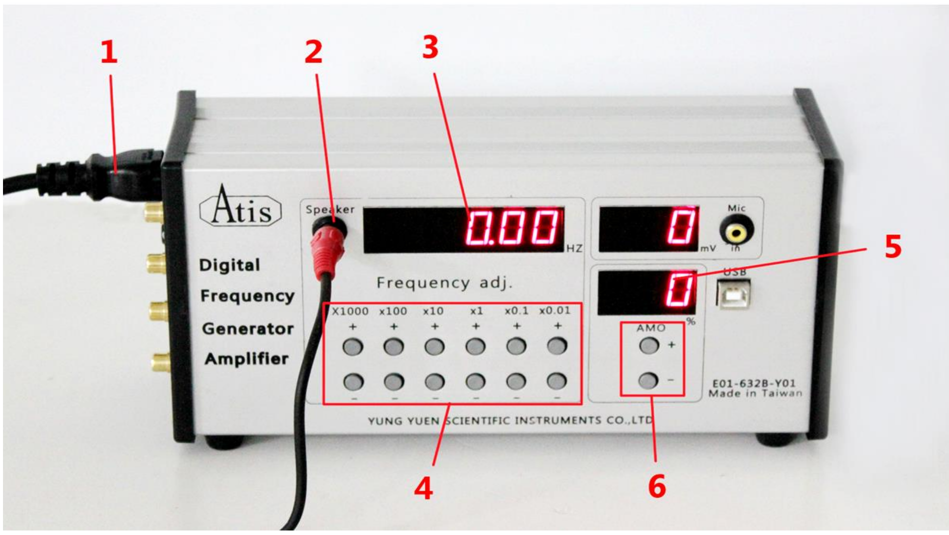


Figure 1 Digital Frequency Generator Amplifier

Digital Frequency Generator Amplifier			
No	Accessory	No	Accessory
1	Power	2	Speaker
3	Frequency display	4	Frequency adjust knob (Decimal)
5	Amplitude display	6	AMO amplitude adjustable knob

Procedure

Experiment 4-1: Standing waves of metal strips

Experimental setup is shown in **Figure 2**. Plug in the metal strip with slotting. Connect the digital frequency generator amplifier (for instruction, please refer to **Figure1**) and adjust the amplitude to 25%. Observers can adjust the amplitude based on his need. Adjust the oscillation frequency from small to large. Six metal strips with different lengths will produce different standing waves at different frequencies, as shown in **Figure 3**. Observe metal strips and explain the phenomena of standing waves and harmonic waves of metal strips. Discuss the relationship between lengths of metal strips, resonance frequencies and their figures.

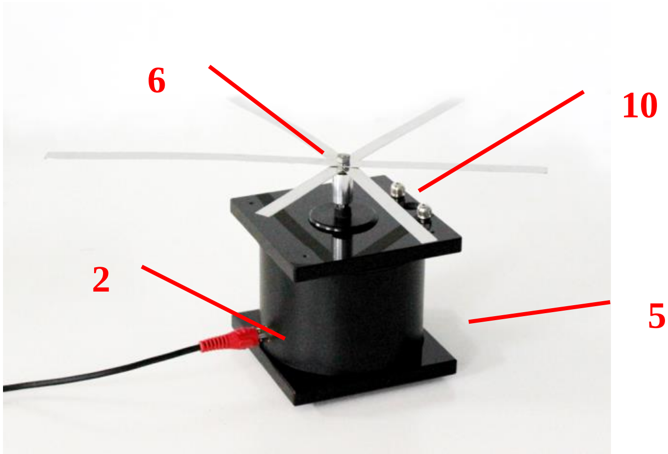


Figure 2

Experiment set up of six different metal strips

Figure 3

Standing waves of metal strips

Experiment 4-2: Standing wave of closed metal rings

Plug in the metal ring on the experiment set up as shown in **Figure 4**. Observe the resonances of metal rings under different frequencies, as shown in **Figure 5**. Compare figures of metal rings with electron matter wave: Bohr model of the atom.

Figure 4

Experimental setup of metal ring

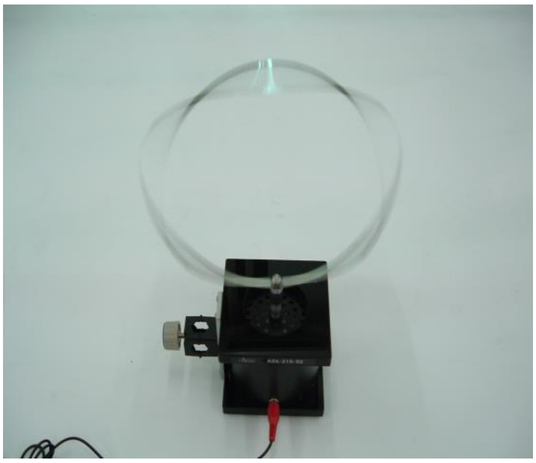


Figure 5

Standing wave of metal ring

Experiment 4-3: Standing wave of a spring

The experimental setup is shown in **Figure 6**. Observe the density of spring in the experiment. If we fix the height and change the oscillation frequency, the spring will have different resonance because of different frequencies. When the spring is at a fixed frequency but place at different height, the number of standing waves will be different. How about velocity? Will it be influenced? Please explain whether the velocity will be influenced.

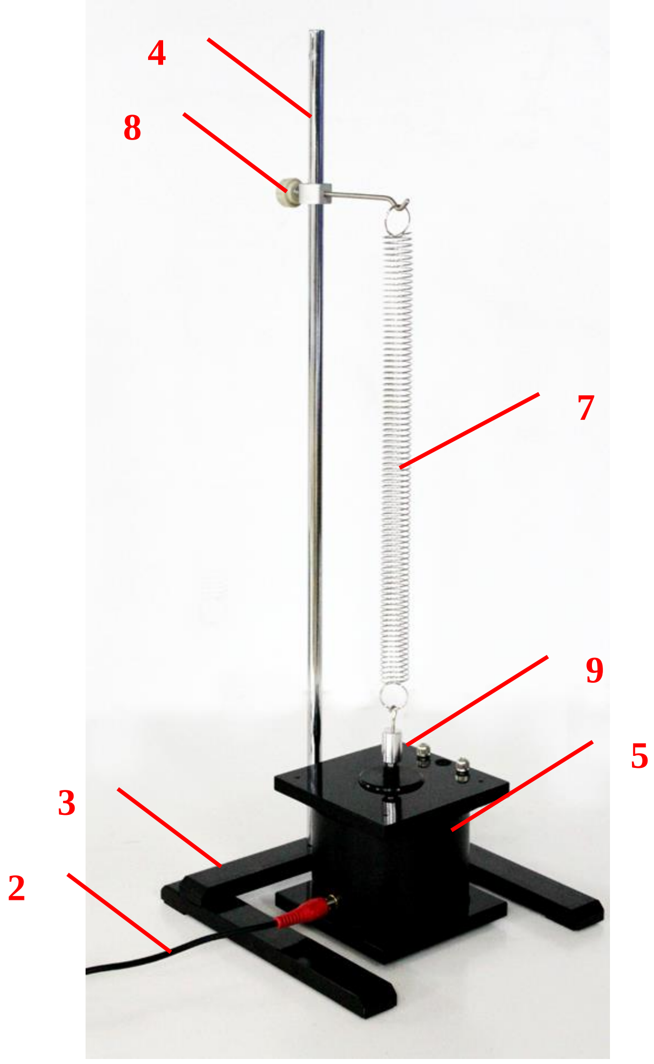
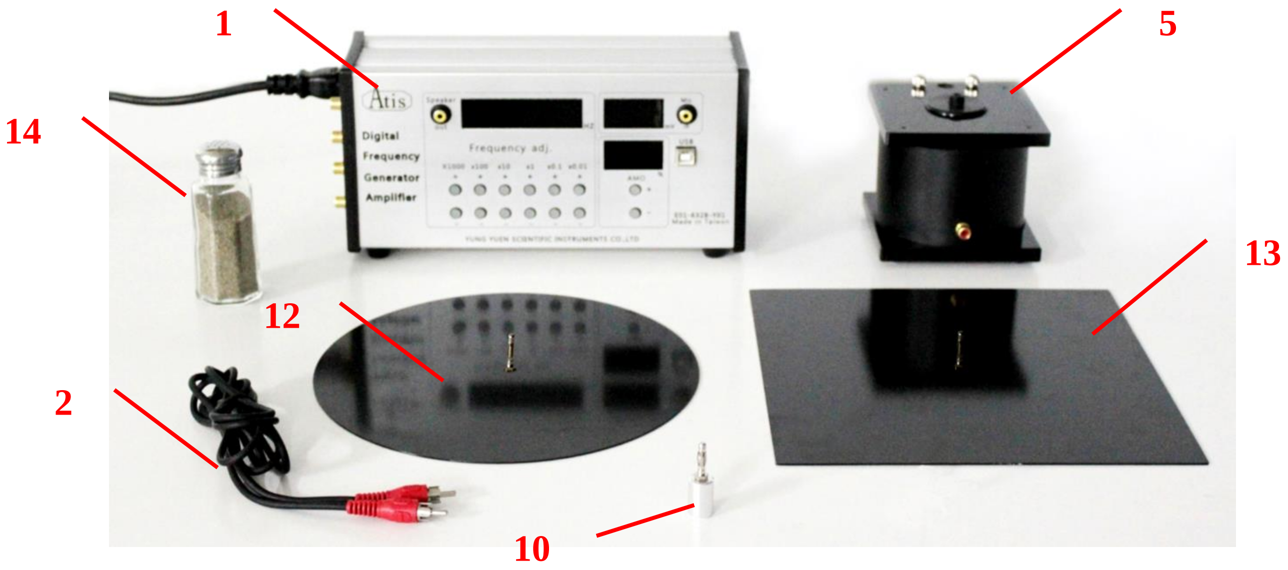


Figure 6 Experimental setup of soft spring

II. Chladni Experiment

Instruments:



(II) Instruments of Chladni Experiment

Experiment 4-4-1: Observe resonance figures on a square aluminum board

This experiment will have interesting results. When the string oscillates in one dimension, there is a standing wave with still nodes and antinodes which have great amplitudes. The oscillation in two dimensions which is also the wave propagation in two-dimensional medium will produce more complex two-dimensional standing wave figures. For example, standing wave figures of an oscillated metal boards or a drum.

The oscillation starts from the centre of square aluminum board. If the board has uniform density and its shape is symmetric, the oscillation should be adjusted to a certain frequency so the board can vibrate stably. We can then observe that some sand stay at nodes which do not oscillate. These nodes will then form nodal lines. Sand which are not at the nodal lines will continue moving until they are at nodal lines. These lines form interesting figures which are Chladni figures. When we change the oscillation frequency, the board will present different symmetrical figures.

Experimental setup is shown in **Figure 7** (the operator should read the note first before operating the experiment.) Plug in the connector into the vibration generator. Plug in the nut and place the square board on the nut. Mount the nut. Connect the digital frequency generator amplifier. Sprinkle little amount of sand on the board and then switch on the digital frequency generator amplifier. Adjust the amplitude to 20 % and then adjust the frequency. We will then have figures of resonance. If we change the frequency, we will get different figures. Experimental figures are shown in **Figure 8**.