Unit-07 Wave Experiment

Objective：

To study the relations between wave velocity v, tension T, and density of the string μ.

Apparatus：

Function generator, mechanical driver, pulley (with support rods and hook), weight, string, ruler, electronic scales

Principle：

A. Relations between wave velocity and tension of the string

When a pulse propagates to the right on a string, an observer on the ground sees the wave propagates but the medium on the string does not propagate. Suppose that, from a different point of view, the observer is now moving with the pulse under the same velocity. He will find that the pulse is static, but the medium on the string moving to the left.

B. Measurement the velocity of wave

In figure 1, the tension τ makes the small segment Δs ($\Delta s = R \cdot 2\theta$), then the centripetal force can be further expressed as to do circular motion with radius R. Then the centripetal force will be expressed as

$$F_C = 2\tau \sin\theta \approx \tau(2\theta) = \tau \frac{\Delta s}{R} \tag{1}$$

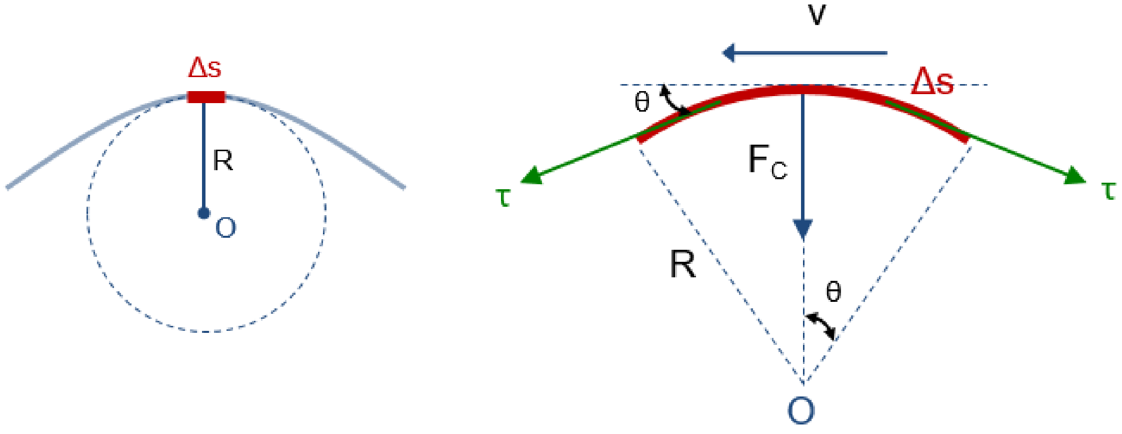

Figure 1. The force on small segment string illustration

According to Newton′s second law of motion, the centripetal force $F_C = ma$, where m is the mass of the small segment Δs, i.e. $m = \mu \cdot \Delta s$. Therefore, the centripetal force here will be written as

$$\Delta m = \mu \Delta s$$

$$a = \frac{v^2}{R}$$

v is the velocity of string

$$F_C = \Delta ma = (\mu \Delta s)\frac{v^2}{R} = 2\mu\theta v^2 \qquad (2)$$

By equation (1) and (2), the centripetal force can be expressed as

$$F_C = 2\tau\theta = 2\mu\theta v^2$$

and

$$\tau = \mu v^2$$

The velocity of string v can be expressed as

$$v = \sqrt{\frac{\tau}{\mu}}$$

<u>Remarks</u>：

1. In order to avoid the effects of the experiment results, the density of the string test to be measured after experiment.
2. The mechanical driver should be near the fixed end.
3. Chord should first pass through the top of the mechanical driver and then lock the fixed hole. One end of the string is attached to the support rod and the other end is tightly hooked.
4. Shift the shaft of the mechanical driver back to “Lock” after you finish the experiment.
5. The weight placed on the direction of cut should be staggered hook.

Procedure：

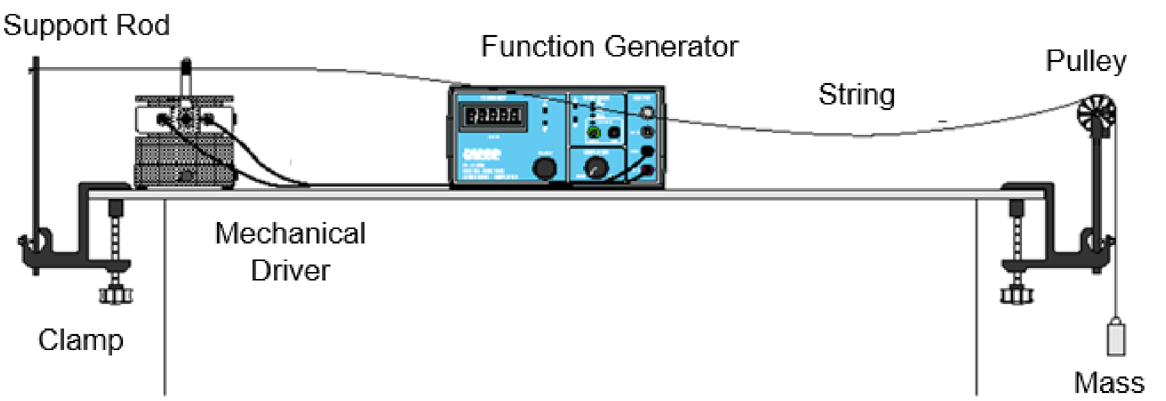

Figure 2. Experiment set-up

A. Density of the string

1. Before the experiment, measure and record the length l of the string.
2. After the experiment, measure and record the mass m_2 of the string.
3. Calculate the density of the string μ.

B. Fix the density of the string μ and vary the tension of the string τ

1. Set up the devices as Fig.2.
2. Use electronic scale to measure the mass of weights and hook m_1.
3. Calculate the tension of string $\tau = m_1 g$.
4. Adjust the oscillating frequency to obtain 3 different modes of standing waves. (Try to obtain n_1, n_2, and n_3 antinodes, and $n_1 \neq n_2 \neq n_3$)
5. Measure the wavelength λ and frequency f respectively.
6. Calculate the wave speed by using $v = f\lambda$.
7. Increase the weight and repeat above steps.
8. Plot $v^2 - \tau$ diagram.

C. Fix the tension of the string τ and vary the density of the string μ

1. Set up the devices as Fig.2.
2. Use electronic scale to measure the mass of weights and hook m_1.
3. Calculate the tension of string $\tau = m_1 g$.
4. Adjust the oscillating frequency to obtain 3 different modes of standing waves. (Try to obtain n_1, n_2, and n_3 antinodes, and $n_1 \neq n_2 \neq n_3$)
5. Measure the wavelength λ and frequency *f* respectively.
6. Calculate the wave speed by using $v = f\lambda$.
7. Replace the string and repeat above steps.
8. Plot $v^2 - \frac{1}{\mu}$ diagram.

Questions：

1. If the string vibration direction is not level. Are the results of experiment are the same? Please explain.
2. Think about why we tie the string on the support rod and then penetrate through the mechanical driver, but not just tie the string on the mechanical drive? Please explain.