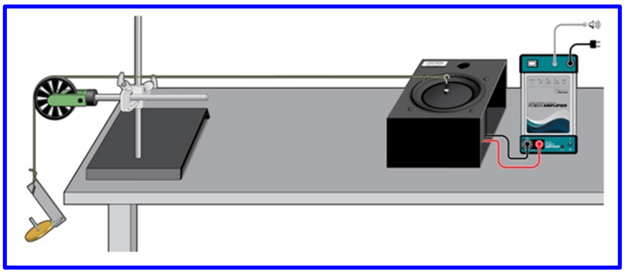
Experiment 01:
Standing Waves



Experiment progression:

This report is prepared by:

Full name		Remarks	Group
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Standing Waves

Objectives

- Study of stationary waves along a stretched string.
- Investigation of the formation and characteristics of standing waves.
- Analysis of the relationship between tension, wavelength, and frequency.
- Observation of nodes and antinodes in stationary wave patterns.
- Exploration of the effects of varying tension and length on wave behavior.

I. INTRODUCTION

A wave forms when coupled systems capable of vibrating execute similar vibrations in succession. It can appear, for example, as a transverse wave on a string or as a longitudinal wave along a coil spring.

The propagation speed of a vibrational state (phase velocity $\boldsymbol{v}$) is related to the oscillation frequency $\boldsymbol{f}$ and the wavelength $\boldsymbol{\lambda}$ by the following relationship:

$$\boldsymbol{v} = \boldsymbol{\lambda f} \qquad (\mathbf{1})$$

If the string (or coil spring) is fixed at both ends and is made to vibrate, there will be reflection at these two ends. This leads to the superposition of the emitted wave and the reflected wave. A **stationary wave** is defined as the addition of two waves of identical frequency propagating in different directions within a medium. The result of this addition produces a standing wave (a wave that does not move either to the left or to the right) (**Figure 1**). The medium then vibrates in a stationary manner, which is where the term "standing wave" comes from. The distance between two nodes of vibration or two antinodes of a standing wave corresponds to half the wavelength

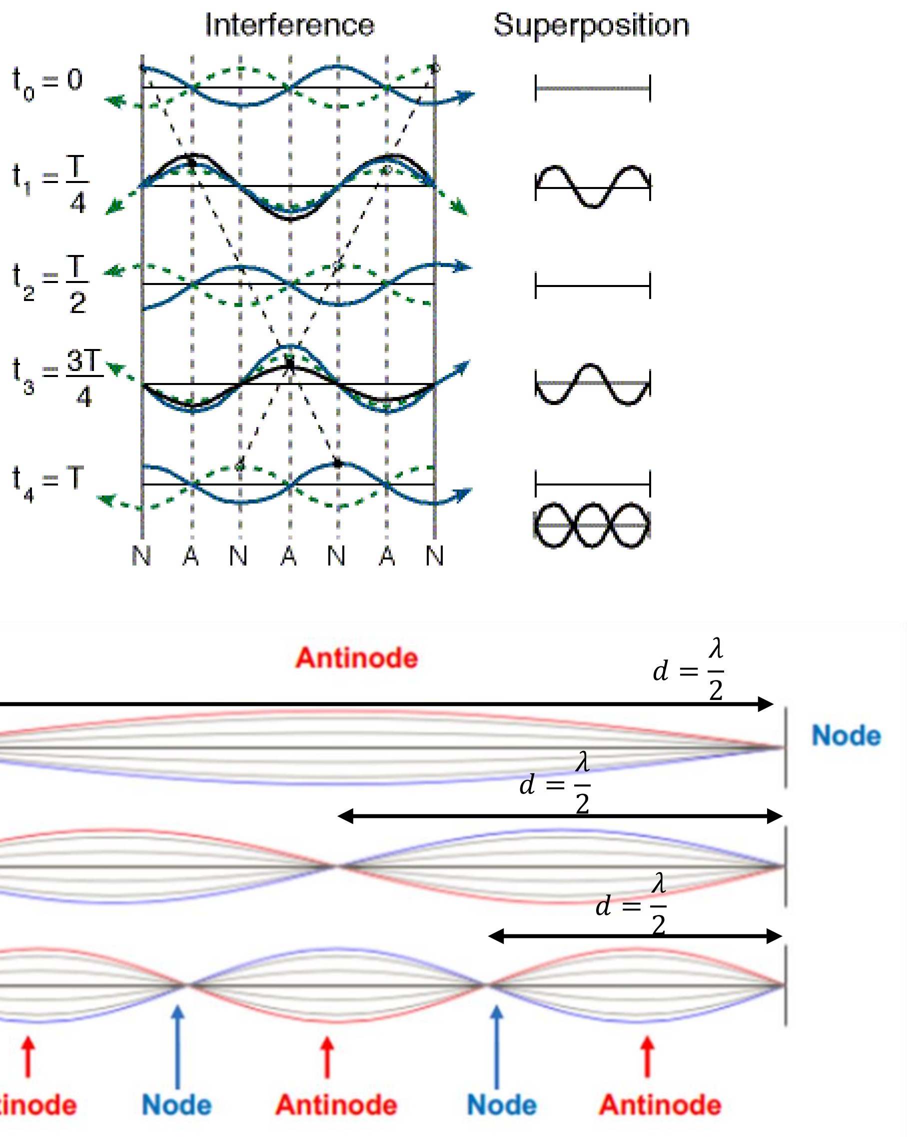

Figure 1 : Creating standing wave from two waves moving in opposite directions.

II. VIBRATING STRING

1. Theoretical Part

For a string fixed at both ends with tension **T** and linear mass density **μ**, the propagation speed of the standing wave is given by:

$$v = \sqrt{T/u} \quad (2)$$

For a stationary wave with **n** antinodes, the length of the string is:

$$L = n\frac{\lambda_n}{2} \quad (3)$$

The frequency of the string's natural vibration modes is:

$$f_n = n\frac{v}{2L} \tag{4}$$

It follows from (1), (3), and (2):

$$L = \frac{n}{2f}\sqrt{\frac{mg}{u}} \tag{5}$$

$$x = \frac{\lambda}{2} = \frac{L}{n} = \frac{1}{2f}\sqrt{mg/u} \tag{6}$$

The wave corresponding to n = 1 is called the fundamental vibration or the first harmonic.

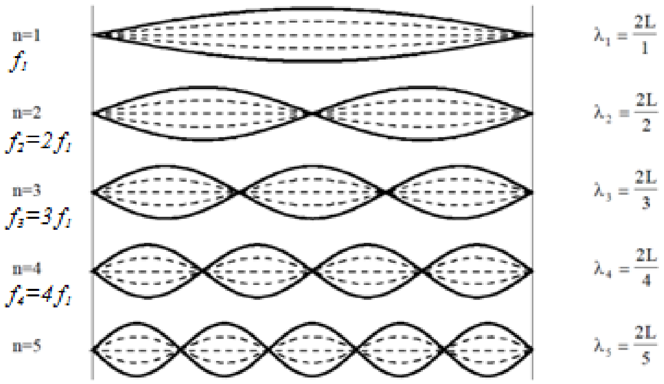

Figure 2. Standing wave on a vibrating string.

2. Required Work

a. Influence of mass on the wavelength.

- From equation (6), determine the function $T(x^2)$. What does the ratio T/x^2represent?

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b. Influence of Frequency on Wavelength

Provide the equation $f_n(n)$. What does the ratio f_n/n represent?

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3. Manipulation

A- Influence of Tension T

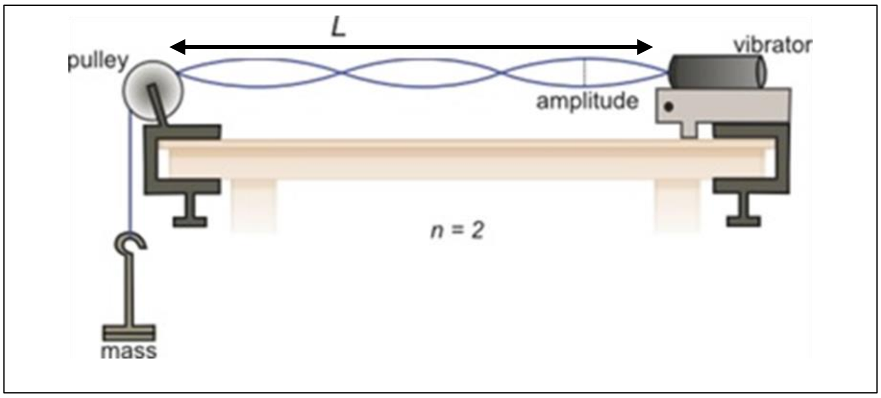
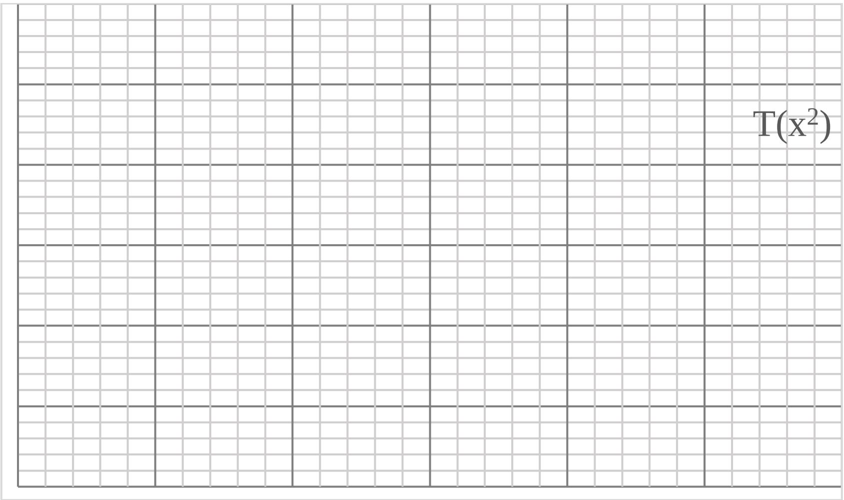


Figure 3. Setup of the vibrating string.

1- According to Figure 3, for a string of length **L=1.17m** and a mass of **m=1.75g**, calculate the linear mass density $\boldsymbol{u} =$ …….
2- For a length $\boldsymbol{L = 0.8m}$ and a vibration frequency f = 50 Hz, find the masses m_1, m_2, m_3 and m_4 attached to the string to achieve three, four, five, and six stable antinodes along the string, respectively. Complete the table below.

n antinodes	3	4	5	6
$x = \lambda/2$ (m)				
Mass (g)				
T (N)				
x^2				

Plot $T(x^2)$and deduce the vibration frequency of the string: f=…



B. Influence of Vibration Frequency **f**

For a tension in the string **T= 1 N** and a length of the string L=0.8 m, find the vibration frequencies f_1, f_2, f_3 and f_4 that allow for one, two, three, and four stable antinodes along the string, respectively. Complete the table below.

Number of Antinodes **n**	1	2	3	4
f (Hz)				

Plot $f(n)$ and deduce the phase velocity $\boldsymbol{v}$