# Experiment 7: Standing Waves on a Wire

Brandon Tsang
PHYS 122L-002

January 29, 2020

## Goals

*The following are quoted directly from PHYS 122L Lab Manual (Department of Physics and Astronomy, 2020).*

- To produce and observe standing waves on a wire.
- To demonstrate that the fundamental frequencies are proportional to the square root of the tension of the wire when the length is fixed.
- To observe the harmonic frequencies of a wire of fixed length and fixed tension.
- To demonstrate that the fundamental frequencies of standing waves on a wire depend inversely on the length when the tension is fixed.
- To analyze data graphically.

## Part A: Investigation of the dependence of $f_1$ on $T$ with $L$ constant

### Experiment Summary

### Results

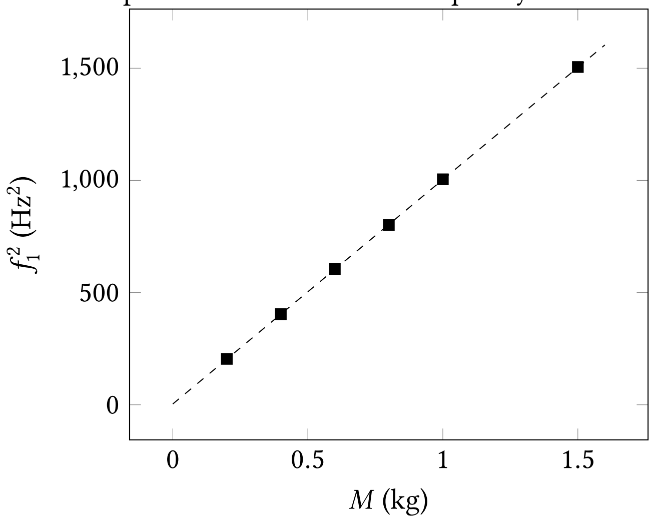
The length $L$ of the wire: $1.0\,\mathrm{m}$

Table 1: Data for fundamental frequencies for different masses

| $M$ (kg) | $f_1$ (Hz) | $\Delta f_1$ (Hz) | $f_1^2$ (Hz$^2$) | $\Delta f_1^2$ (Hz$^2$) | $\log(M)$ | $\log(f_1)$ |
|---|---|---|---|---|---|---|
| 0.2 | 14.3 | 0.1 | 204 | 2.9 | -0.699 | 1.16 |
| 0.4 | 20.1 | 0.1 | 404 | 4.0 | -0.398 | 1.30 |
| 0.6 | 24.6 | 0.1 | 605 | 4.9 | -0.222 | 1.39 |
| 0.8 | 28.3 | 0.1 | 801 | 5.7 | -0.0969 | 1.45 |
| 1.0 | 31.7 | 0.1 | 1010 | 6.3 | 0.000 | 1.50 |
| 1.2 | 34.7 | 0.1 | 1200 | 6.9 | 0.0792 | 1.54 |
| 1.5 | 38.8 | 0.1 | 1510 | 7.8 | 0.176 | 1.59 |

Below is the plot of $f_1^2$ vs. $M$. The error bars are too small to be shown.

Figure 1: Relationship between fundamental frequency and mass of weight

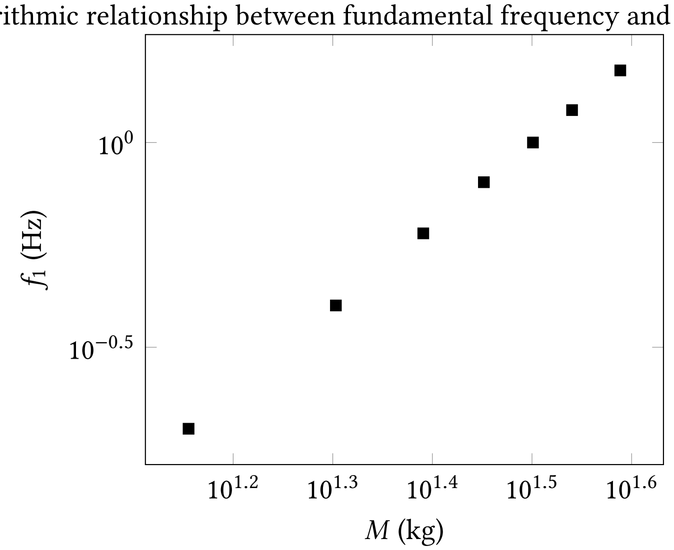



Slope of the above graph: $1000\,\mathrm{Hz}^2\,\mathrm{kg}^{-1}$
The slope $m$ should be equal to $\frac{g}{4L^2\mu}$. Solving for $\mu$:

$$\begin{aligned}
m &= \frac{g}{4L^2\mu} \\
4L^2\mu &= \frac{g}{m} \\
\mu &= \frac{g}{4L^2 m} \\
&= \frac{9.8\,\mathrm{m\,s^{-2}}}{4(1.0\,\mathrm{m})^2(1000\,\mathrm{Hz}^2\,\mathrm{kg}^{-1})} \\
&= 0.002\,45\,\mathrm{kg\,m^{-1}}
\end{aligned}$$

Logarithmic plot of $f_1$ vs $M$:

Figure 2: Logarithmic relationship between fundamental frequency and mass of weight



$M = 1$ intercept: 31.6 Hz

This intercept (call it $b$) should be equal to $\frac{1}{2L}\sqrt{\frac{g}{\mu}}$. Solving for $\mu$:

$$
\begin{aligned}
b &= \frac{1}{2L}\sqrt{\frac{g}{\mu}} \\
2Lb &= \sqrt{\frac{g}{\mu}} \\
4L^2b^2 &= \frac{g}{\mu} \\
\mu &= \frac{g}{4L^2b^2} \\
&= \frac{9.8\,\mathrm{m\,s^{-2}}}{4(1.0\,\mathrm{m})^2(31.6\,\mathrm{Hz})^2} \\
&= 0.002\,45\,\mathrm{kg\,m^{-1}}
\end{aligned}
$$

## Parth B: Investigation of harmonic frequencies

### Results

The following results are using a 0.5 kg weight:

| $n$ | $f_n$ | $\Delta f_n$ | $\frac{f_n}{f_1}$ |
|---|---|---|---|
| 1 | 22.7 | 0.1 | 1.00 |
| 2 | 44.4 | 0.1 | 1.96 |
| 3 | 67.7 | 0.1 | 2.98 |
| 4 | 90.8 | 0.1 | 4.00 |
| 5 | 113 | 1 | 4.98 |
| 6 | 136 | 1 | 5.99 |
| 7 | 160 | 1 | 7.05 |

## Part C: Investigation of the dependence of $f_1$ on $L$ with $T$ fixed

### Results

Table 2: Using a 500 g mass, the fundamental frequencies at different distances

| $L$ (m) | $\Delta L$ (m) | $L^{-1}$ ($\mathrm{m^{-1}}$) | $\Delta L^{-1}$ ($\mathrm{m^{-1}}$) | $f_1$ (Hz) | $\Delta f_1$ (Hz) | $\log(L)$ | $\log(f_1)$ |
|---|---|---|---|---|---|---|---|
| 0.2 | 0.1 | 5.00 | 2.50 | 113 | 1 | -0.70 | 2.05 |
| 0.3 | 0.1 | 3.33 | 1.11 | 74.6 | 0.1 | -0.52 | 1.87 |
| 0.4 | 0.1 | 2.50 | 0.625 | 57.5 | 0.1 | -0.40 | 1.76 |
| 0.5 | 0.1 | 2.00 | 0.400 | 44.8 | 0.1 | -0.30 | 1.65 |
| 0.6 | 0.1 | 1.67 | 0.278 | 38.9 | 0.1 | -0.22 | 1.59 |
| 0.7 | 0.1 | 1.43 | 0.204 | 32.2 | 0.1 | -0.15 | 1.51 |
| 0.8 | 0.1 | 1.25 | 0.156 | 28.2 | 0.1 | -0.10 | 1.45 |
| 0.9 | 0.1 | 1.11 | 0.123 | 25.1 | 0.1 | -0.05 | 1.40 |
| 1.0 | 0.1 | 1.00 | 0.100 | 22.7 | 0.1 | 0.00 | 1.36 |