# Lab Report: Length, Velocity and Acceleration

Nicholas Karlsen
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A study on different methods for determining the length, velocity and acceleration of different objects, and the errors involved in these methods.

## I. INTRODUCTION

## II. THEORY

### A. Pendulum

$$T \approx 2\pi\sqrt{\frac{L}{g}} \tag{1}$$

Where $T$ denotes the period of a pendulum, $L$ its length and $g$ the gravitational acceleration. The small angle approximation (Eqn. 1) is valid for angles $\theta \ll 1\,\text{rad}$ with an error $\approx \pm 15\,\text{s}$ per day [1].

### B. Errors

$$\sigma \approx \left(\frac{\sum x_i^2 - \frac{1}{n}(\sum x_i)^2}{n-1}\right)^{\frac{1}{2}} \tag{2}$$

$$\sigma_m \approx \left(\frac{\sum x_i^2 - \frac{1}{n}(\sum x_i)^2}{n(n-1)}\right)^{\frac{1}{2}} \tag{3}$$

Where $\sigma, \sigma_m$ denotes the standard deviation, and the standard deviation of the mean respectively of a set of $n$ values $x_i$. [2].

Any errors stated in a derived number will be calculated using the equations for combinations of errors found on page 29 in Squires [2]. Lastly, when using a linear fit on a set of linearly correlated data i used the expressions found on page 39 in Squires [2] to calculate the regression line, as well as its error.

## III. EXPERIMENTAL PROCEDURE

## IV. MEASURING THE LENGHT OF A ROD

## V. MEASURING THE PERIOD AND HEIGHT OF THE FOUCAULT'S PENDULUM

## VI. MEASURING THE VELOCITY OF THE LEGO-CAR

## VII. MEASURING THE VELOCITY OF THE RC-CAR

## VIII. RESULTS

TABLE I. Lenght of rods

| Ruler, a [cm] | Ruler, b [cm] | Laser, a [cm] | Laser, b [cm] |
|---|---|---|---|
| 119.50 | 119.60 | 120.50 | 120.60 |
| 119.50 | 119.70 | 119.60 | 119.80 |
| 119.45 | 119.60 | 119.50 | 119.70 |
| 119.40 | 119.50 | 119.40 | 119.60 |
| 119.43 | 119.55 | 119.40 | 119.60 |
| 119.40 | 119.60 | 119.68 | 119.72 |
| 119.40 | 119.50 | 119.90 | 119.70 |
| 119.45 | 119.65 | 130.60 | 130.20 |
| 119.40 | 119.60 | 119.40 | 119.50 |
| 119.43 | 119.55 | | |

TABLE II. Uncertainty in Length measurement using the meter ruler

| | $x$ | $\delta x$ |
|---|---|---|
| $l_a$ | $119.5cm$ | |
| $l_b$ | $119.6cm$ | |
| $dl_s$ | | $1.4mm$ |
| $\sqrt{n} \cdot dl_l$ | | $0.5\sqrt{5}mm$ |
| $dl_m$ | | $1.4mm$ |
| $\alpha l_a(T - 25C)$ | $-0.156cm$ | $\sim 10^{-6}$ |

| | $\sum x$ | $\sum \sigma x_i^2$ |
|---|---|---|
| $\sum l_a$ | 119.48cm | 2.27 |
| $\sum l_b$ | 119.58cm | 2.27 |

- $l_a$ : Recorded length
- $dl_s$ : Error due to aiming of the ruler
- $\sqrt{n} \cdot dl_l$ : Error due to curvature of joints
- $dl_m$ : Error due to precision of measuring lines

- $\alpha:\ 4 \cdot 10^{-5\circ} C^{-1}$, Coefficient of linear thermal expansion for glass fiber

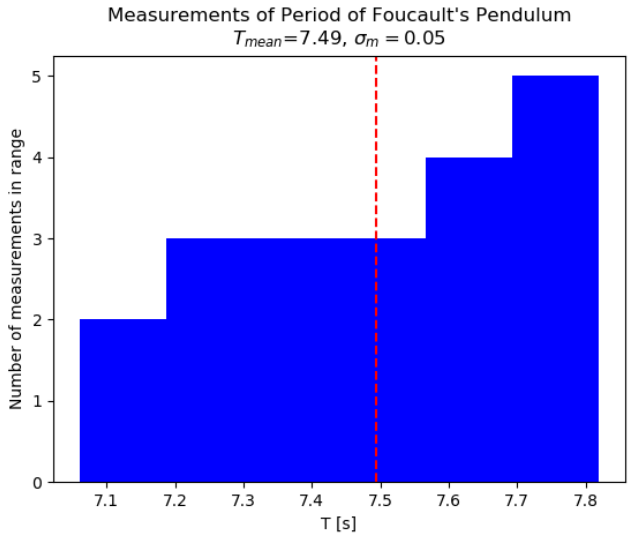


FIG. 1. Measurements of the Period of the Focault's Pendulum in the entrance hall at the Institute of Physics, UiO.

## IX. DISCUSSION

## X. CONCLUSION

[1] `https://en.wikipedia.org/wiki/Pendulum`.
[2] G. L. Squires. *Practical Physics 4th Edition*. Cambridge University Press, 2001.