How does a pendulum's length affect its time period?

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Introduction
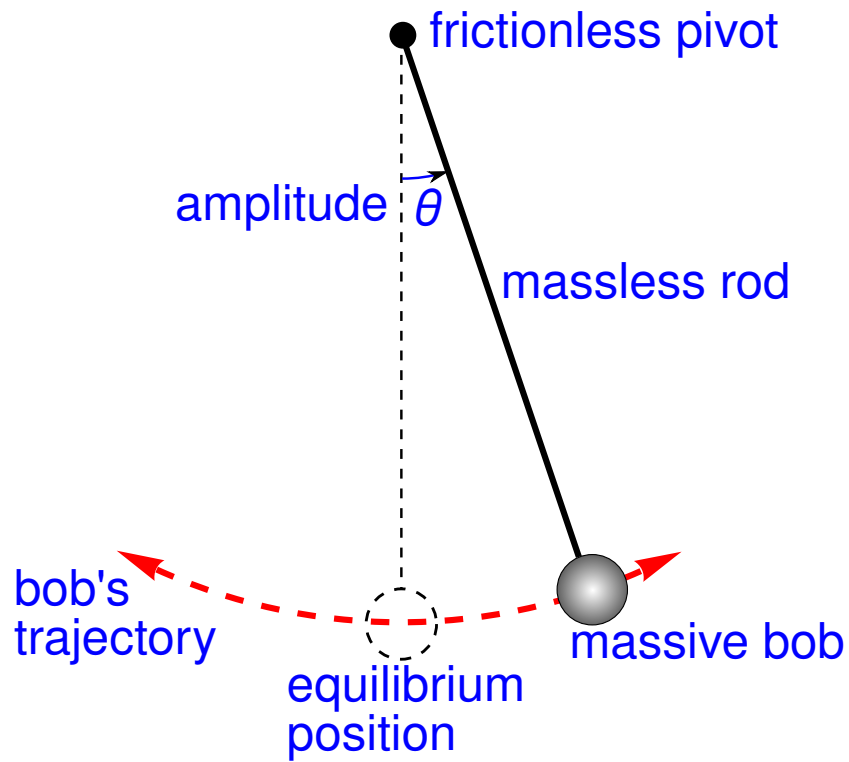

Figure 1: Simple gravity pendulum

A pendulum

Experiment design

Hypotheses

Null hypothesis: Changes in the string's length do not affect the time period.

Alternate hypothesis: Changes in the string's length do affect the time period.

Analysis

Data overview

`{r} data <- read.csv("data.csv") data summary(data)`

Treating the length as discrete groups, let us estimate the mean and standard deviation of each group.

`{r} aggregate(time_10_periods ~ length_cm, data = data, function(x) c(mean = mean(x), sd = sd(x), n = length(x)))`

This allows us to see that there is a significant Difference in Means betwen groups, of approximately 0.6 between neighbouring groups, where the standard deviation is roughly around 0.1 to 0.2.

In order to gain a general sense of the data we have obtained, let us plot the data. A box plot is used, to present the information aggregated by group above.

`{r} boxplot(time_10_periods ~ length_cm, data = data,     main = "Effect of Length on Time",     xlab = "Length (cm)",     ylab = "Time (10 periods)")`

Linear regression

`{r} model <- lm(time_10_periods ~ length_cm, data = data) summary(model)`

We shall run various diagnostic plots of this linear regression model to confirm whether it is truly a linear regression:

`{r} plot(model)`

There are insufficient sample points for the diagnostic plots to be accurate, but they seem to be acceptable for this sample size. It is however somewhat unclear what causes the enlarged residues for large theoretical quantities.

Given that a linear regression is mostly appropriate as suggested by the diagnostic tests, its p-value 4.52×10^{-12} suggests that it is extremely unlikely to obtain our result (or more extreme results) given that the null hypothesis is true, therefore suggesting with high confidence that the null hypothesis is false and that the alternate hypothesis is true. Therefore: changes in the string's length do affect the time period.

T-tests

Informal bibliography

I'm not really sure how to get BibLaTeX working with R Markdown yet, so here's just an itemized list of references without any particular bibliography format.

- Simple Gravity pendulum, by Chetvorno, public domain, https://commons.wikimedia.org/w/index.php?cur