Gabriella Pieniadz

Lab Report (First Draft)

HARMONIC MOTION IN THE WORLD – EXAMINING OSCILATIONS OF A BACKPACK STRAP

Commented [SP1]: In your final draft you should have a separate title page APA style. See https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_and_style_guide/general_format.html

Commented [SP2]: I really like the title. I think however that I would take out "in the world." How about

Harmonic motion examined in the oscillations of a backpack strap

Abstract

The system analyzed is the strap of a backpack. The strap remains hanging vertically in an equilibrium position until it is manually displaced and then released. Upon release, the strap swings through the equilibrium position and oscillates around it. This system resembles a pendulum as the oscillation ~~is~~ follows a swinging motion. The strap oscillates because of two forces. The first is the displacement force, which is manually taking the strap and displacing it from its equilibrium position. The second is the restoring force, which is ~~be~~ gravity. Gravity causes the strap to swing and return to its equilibrium position. Note that the sign convention for this report maintains that up and to the right is positive.

Commented [SP3]: Very good abstract. When you state your hypothesis (see my notes below) also summarize your hypothesis and the results of your experiment in the abstract.

Introduction

We do not even realize how much of physics is factored into our daily lives. A backpack is a device that we have been using ever since we were young, whether it had been for school or just everyday use. Swinging a backpack on and off your shoulder is a fairly simple task but there are physical concepts that allow this to happen. The straps of a backpack operate with the help of oscillation and driving forces. In this case oscillation is the periodic motion that repeats itself in a regular cycle, the side-to-side swing of a pendulum, or the up-and-down motion of a spring with a weight. (Jones, 2018) Calculated frequency allows us to perceive the motion around an equilibrium point (periodic motion). The frequency of up and down or side to side forces such as the displacement, resting and gravitational force allow oscillations to take place over a period of time.

Commented [SP4]: Put period after citation in parentheses.

Commented [SP5]: What is your hypothesis? What are you going to test or measure in this lab report?

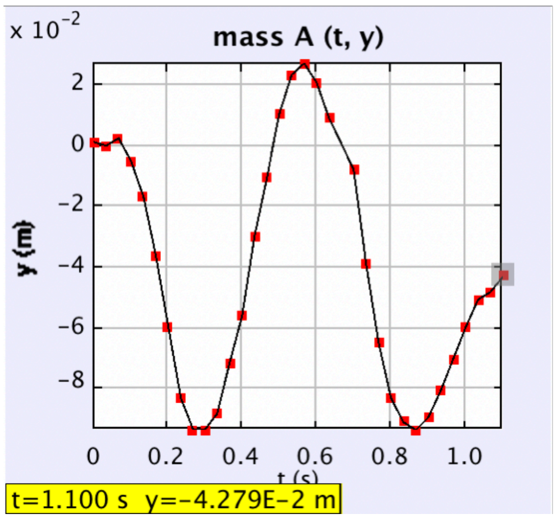
Materials and Methods

In order to measure frequency, we first filmed the strap swinging after it was displaced and released. The backpack was placed atop a white board to allow the strap to hang freely in equilibrium. The strap was then raised higher than equilibrium and was filmed swinging for one complete oscillation. The film was then imported into Tracker**,** a free video analysis and modeling tool built on the Open Source Physics (OSP) Java framework (Brown), where the displacement and period of the strap was measured. To measure the frequency of the system, the period of the oscillation was determined directly from the footage. It was found to be 1.1 seconds. Frequency is the reciprocal of period, so the frequency of the strap would be equal to 1/1.1 seconds or .91 Hz. See Figure 1 for a graph of the displacement of the strap over time as it oscillates.

Commented [SP6]: What camera did you use? Do you have a still picture from the footage? List your materials with bullet points. Think of replicability; the reader should be able to easily replicate your experiment exactly.

Commented [SP7]: This passage, and the graph that follows it, should be in the results section.

Figure 1: Displacement of Strap over Time



The strap of the backpack needs to be treated as a physical pendulum because its mass is evenly distributed along its length. Its moment of inertia can be calculated by approximating it as a thin rectangular plate rotating around an axis at its end. In order to perform these calculations, the shape and mass of the strap needed to be taken into account. These calculations are summarized in Tables 1 and 2 below.

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Table 1: Raw Measurements (See Figure 2 for Corresponding Diagram)

Symbol	Measurement	Value
Ls	Length of Straight Portion of Strap	0.317 m
Lb	Length of Bottom Loop	0.075 m
Lu	Length of Material in Loop (if unrolled)	0.148 m
ws	Width of Straight Portion of Strap	0.025 m
wb	Width of Bottom Loop	0.045 m
m	Mass of Strap	0.0229 kg

Tm	Measured Period of Oscillation of Strap	1.10 s

Figure 2: Appendix A – Diagram of Strap Measurement

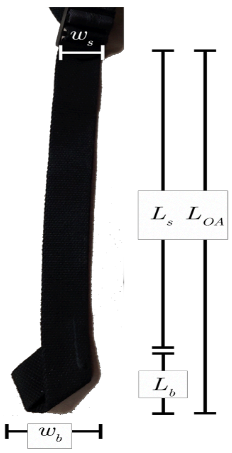

Table 2: Processed Measurements

Symbol	**Measurement**	**Value**
LOA = Ls+Lb	Overall Length of Strap	0.392 m
LM = Ls+Lu	Length of Material in Strap	0.465 m
ms = m Ls / LM	Mass of Strap in Straight Section	0.0156 kg
mb = m Lu / LM	Mass of Strap in Bottom Loop	0.0073 kg
ys=Ls / 2	Height of Centre of Mass of Straight Section	0.159 m
yb=Ls+Lb / 2	Height of Centre of Mass of Bottom Loop	0.355 m
yOA=(ysmS+ybmb) / m	Height of Centre of Mass of Strap	0.221 m
Is=ms (4Ls2+ws2) / 12 *	Moment of Inertia of Straight Section	5.24×10^{-4} kg m^2

Ib=mb (4Lb2+wb2) / 12 +mbyb2 *	Moment of Inertia of Bottom Loop	9.31×10^{-4} kg m^2
IOA=Is+ Ib	Overall Moment of Inertia of Strap	1.46×10^{-3} kg m^2
Tp=2 IOAmgyOA **	Predicted Period of Oscillation of Strap	1.08 s

* The equation for the moment of inertia of a thin rectangular plane rotating around an axis at its end was taken from Wikipedia.
** The equation for the period of oscillation of a physical pendulum was taken from page 475 of Tipler.

Results

Ultimately, the percentage difference between the theoretical period and the actual period of motion is 2 % which suggests an accurate result. As far as sources of error are concerned, the measuring of the strap's mass proved to be difficult because only the mass of the strap that oscillated was desired and not the mass of the whole backpack. Furthermore, the underlying assumption that the strap acts like a physical pendulum is a potential source of error, as the strap is not perfectly rigid. It was also assumed that the movement of the strap as it swung was perfectly planar; however, there could have been a certain degree of motion in the Z axis.

The total energy in the system is equivalent to the potential energy of the strap before it is released from a height. To estimate this value, the strap will be assumed to be a point mass of mass 22.9 g dropped from a height of 20 cm:

PE = mgh = (0.0229 kg)(9.81 m/s/s)(0.20 m)=0.045 J

Discussion

Our model of the system assumes energy is conserved throughout its oscillations, although this is not the case in reality: the strap does not return even close to the height from which it was dropped after one oscillation. This is because of friction within the fabric of the strap and air resistance, both of which are not negligible. The energy of the strap as it oscillates is not negligible, but it is not great either. A 1 kg mass falling 1 m has approximately 10 J of energy, which is substantially greater. The low energy of the strap is due to its low mass and low displacement.

Commented [SP9]: Discuss whether your hypothesis was supported by the results of your experiment and why, or, if your hypothesis was not supported by the results of your experiment, why not.

Contributions

This lab was conducted with my AP Physics lab partner Katheryn Barrette.

References

~~Appendix A - Diagram of Strap Measurements~~

Commented [SP10]: An appendix always goes at the end, in a section by itself. You included the diagram in the body of your document so you should list your source in references, but not call it an appendix, or, if you took it from the appendix of another work, list the work which you took it from and cite your source in the caption beneath the diagram.

Brown, D. (n.d.). What is Tracker? Retrieved from https://physlets.org/tracker/ Jones, A. Z. (2018, December 07). What Is Oscillation in Physics? Retrieved from

https://www.thoughtco.com/oscillation-2698995

Commented [SP11]: Format references APA style.

This is a really good first draft. Well done. See my comments above. I look forward to reading your final draft.