1.2: Activities

Equipment

- slinky & "wave-pulse-starter"
- heavy chain
- string
- pulley assembly
- stretchy string
- hanging weights
- tape measure
- triple-beam balance

The General Idea

There are two parts to this lab:

Part 1

The first part is a bit unusual, as it is not an experiment in the usual sense. It is more of an exploration of phenomena in search of some enlightening speculation. The idea is this: From your pre-lab work (and from lecture or the textbook), you likely have a good idea of what happens to a reflected wave when it comes from a region where the medium is either fixed or free. The results of these two cases are complete opposites of each other, but what happens if we construct an "in-between" circumstance – one where the medium is neither held firmly in place, nor allowed to move completely freely? In particular, suppose the wave strikes a "barrier" that also will carry the wave? That is, what if the wave changes medium? The medium can be displaced, so it clearly isn't held fixed. But it also resists acceleration (it has mass), so it isn't exactly free like an empty end would be.

At your disposal to explore this, you have a slinky for your primary wave. Attach one end to a new medium and stretch it (don't ***over***-stretch it - it should have some sag in it). The opposite end of this new medium should be anchored to the lab table. Then rap it suddenly from the side at the end farthest from the new medium to create a wave pulse, and observe the pulse that reflects back. Available for the new medium are two objects that couldn't be more different: a light string and a heavy chain.

Feel free to video-record your tests, if it makes it easier to make out the relevant properties of the reflected wave.

Part 2

This part is a more traditional experiment. We start with a result from the textbook and lecture. We will call it the "theory of string wave speed," and our job is to confirm or refute it. This "theory" states that the speed of a string wave v is related to the tension force F on the string and the mass density of the string μ according to:

$$v=\sqrt{\frac{F}{\mu}} \tag{1.2.1}$$

In our experiment we will have a physical setup for which we can directly measure all of these quantities, to see if the theory holds, to within the uncertainty of our measurements. Normally we would do a graphical analysis to see if this mathematical relationship holds, but for reasons we will see later, all three of these variables will change in the course of the experiment. We will therefore only look for confirmation with a single tension in the string, using the time we save to do several runs for that one tension to get a measure of uncertainty in our result.

Some Things to Think About

Part 1

Some questions to answer with your observations (and include in your lab report):

- Presumably the wave carries forward into this new medium, but this question is about reflection. Does the pulse reflect off such a "barrier" at all?
- Does the pulse reflect the same off both barriers, or is there some property of the new medium that decides what happens to the reflected wave?

- If different barriers cause different reflections, when happens when the properties get closer together – is there a sudden transition point? You will have to speculate about what happens as the properties of the chain are morphed toward the string and those of the string toward the chain, as we don't have materials available for actually testing this directly.
- Assuming this phenomenon applies to all types of waves (even though we have only studied it specifically for mechanical waves), what generic wave property appears to be responsible for the reflection properties?

Part 2

One look at the apparatus should make clear how you are going to measure the tension that is applied to the stretchy string, but you may need to put some careful thought into how you will measure the other two quantities, and how you measure their uncertainties to apply the weakest link rule.

- Measuring the speed of the wave (as usual) comes down to measuring time intervals and distances. There are hints in the Background Materials about how best to measure the times and their uncertainties.
- The "obvious" way to measure the string density is to measure its length and its mass and calculate it from there. However, written in the last paragraph of The General Idea section is an obtuse hint, where it states that all three measurements – apparently including the string density – are changing from one experiment to the next. Figure out how the two experiments can involve different densities when the same string is used, and you will be on your way to devising a way to achieve a more accurate result.

Lab Report

Craft a lab report for these activities and analysis, making sure to include every contributing group member's name on the front page. You are ***strongly encouraged*** to refer back to the Read Me as you do this, to make sure that you are not leaving out anything important. You should also feel free to get feedback from your lab TA whenever you find that your group is at an impasse.

Every member of the group must upload a separate digital copy of the report to their lab assignment in Canvas *prior to leaving the lab classroom*. These reports are not to be written outside the lab setting.
