Pendulum Kit

In this kit you will have the following experiments:

1. Wild Wild Pendulum Resonance!

   Designed by: Stefan Kildal-Brandt, Lucas Kramarczuk, and Zach Van Fossan
2. Punctual Pendulums

   Designed by: Avery Truong and Arnauld Dedry

These kits are designed to explore the properties of pendulums. Wild Wild Pendulum Resonance! Looks at pendulums of different length and how fast the oscillate for different lengths of pendulum. Punctual Pendulums looks at what happens if you have a pendulum with different masses on them.

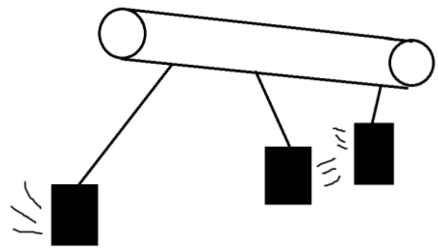
This kit contains some of the materials needed, but we highly encourage you to explore how you can use the stuff around your house. Be creative, be curious, and have fun!

Kit Contents

- String
- Various Wooden Masses to act as pendulum bobs

Wild Wild Pendulum Resonance!

In this experiment you will shake pendulums to create an oscillations. You will then analyze this oscillation to answer questions about the physical property of resonance.



Materials:

- One rod or wooden spoon
- String and 3 Equal Masses
- A Ruler

To set up the experimental equipment, measure out three strings with lengths 10 cm, 20 cm, and 30 cm. Attach a mass to one end of each string and attach the other end to the rod so that all three masses are hanging from the rod like pendulums of different lengths, like the figure above.

Instructions: To start this experiment stand and hold your rod still. Try shaking the rod side to side at different tempos to see if you can find a tempo where each of pendulums has bigger swings than the others. The tempo where the pendulum has its largest swings is considered that pendulum's resonant frequency.

- When one has large swings, how much do the others swing
- Which pendulum requires the fastest tempo to make large swings?
- What happens to the position of the other pendulums when one is in resonance? Are they all moving at the same directions at the same time?
- Try shaking the rod up and down? Do you the observe the same behavior of the pendula? You might want to try shaking faster or slower for up-and-down than side-to-side.
- Instead of shaking you can walk or run at different tempos while keeping the rod as still as you can!

Parents/Teachers

This experiment is designed to explore the concept of resonance. Resonance is when the frequency of the force driving the oscillation is completely in sync with the natural frequency of the oscillator and therefore is able to deliver power into the system without any coming back into the driver. Key words from this definition are...

- Oscillation: A repetitive variation in amplitude around an equilibrium point
- Driving Force: An oscillating force that incites oscillations in systems. An example of this is someone pushing another person on a swing set.
- Natural Frequency: A property of an oscillating system which determines at what frequency the system will oscillate when there is no force driving it.

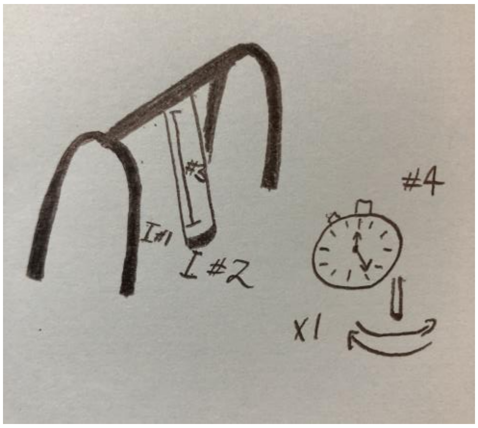
The reason the pendulums in this experiment resonate at specific shaking tempos is because these tempos are closest to their natural frequency. The natural frequency of a simple pendulum on Earth such as the ones that are used in this experiment is determined solely by the length of its string.

The reason why the other pendulums have low amplitudes is because the frequency of a driving force is not close to the natural frequency, there will not be resonance and the amplitude of the resulting oscillation will be very small. Some pendulums lead/lag the others depending on whether the driving frequency is greater/less than their natural frequency. Pendulums with natural frequencies lower than the driving frequency will lag behind while pendulums with greater natural frequencies will lead.

This experiment is important because display a basic view of resonance. The concept of resonance is extremely valuable for an engineer because it is necessary to consider when designing any buildings or bridges.

Punctual Pendulums

Have you ever wondered how fast you're moving when you're on the swings? Or who might be the fastest swinger? Is it the lightest person or the heaviest usually? This activity will answer those questions for you – the answer might surprise you!



Materials:

- Swing set
- Stopwatch
- Measuring Tape
- Two volunteers to go on the swing

Instructions: Go out to a swingset with a couple people of different masses, a child and adult works well. Take a few measurements:

1. How high the swing is hanging, How high the swing is hanging when it's pulled back and someone is sitting in it about to swing, and how long are the chains or ropes on the swingset are,
2. Then measure how long it takes each person to go back and forth once on the swing.

That's what will give us the most important part. We call that the period. What do you notice about the period (time it takes to go back and forth once) when you change who is swinging when they start from the same place? Does this always work for every starting place?

Parents/Teachers

The main message of this experiment is to determine that the motion of a pendulum is independent of the mass. They will find this out when they see that no matter who is on the swing, as long as they start from the same position, their time for one swing (the official terminology is one *period*) will be the same in all instances. The easiest way to figure this out is by keeping the swing height constant and just changing who is riding the swings.

If the students want to take it a step farther, they can try and think about all the different forces that are acting on the person swinging (maybe consider things like gravity, what else?). We can draw out these forces in what's called a free body diagram. The force that drives the swing is due to gravity which is proportional to the mass of the person. The amount of acceleration a person experiences is also proportional to their mass. Since these terms are equal to each other then

Something fun that the students might be able to do is figure out what height they need to be at to attain a certain period (i.e. how high should they start if they want one full swing to take one second? Half a second?).