Playground Physics

Swing Set Physics Teacher's Guide

The students will explore the concept of pendulums by using pendulums they are already familiar with: swings.

Before the playground

Go over the terms and concepts the students will be using, the importance of units, and have your students fill out the pre-playground worksheet on swing set physics. Have the students work individually or in small groups to make their hypotheses. If adults unfamiliar with the activity will be helping on the playground, familiarize them with the activity prior to leaving for the playground. When you choose a playground look for swings of different lengths.

The Theory: (to be explained only after the experiments)

The length of the chain is the important factor in this experiment. Regardless of how much mass is placed on the swing, or how fast the swing is moving, the period will be the same or nearly the same (allowing for experimental error and a non-ideal pendulum). For a simple (ideal) pendulum, the period is equal to the square root of (length over the acceleration due to gravity of 9.8 meters per second squared at the surface of the Earth) times 2 Pi or

$$T = 2\ Pi\ (\ l\ /\ g)^{1/2}$$

Of course the swing is not an ideal simple pendulum. The chain is not massless, and the mass at the end is not concentrated into a single point. This will be a source of error, but in classroom testing this activity the results worked out surprising well. Your students can help eliminate error by keeping their legs close to their body while they swing rather than extending them (which lengthens the pendulum and makes it depart even further from a simple pendulum.)

On the playground

You will need bathroom scales, and tape measures with metric units and stop watches for this experiment (possibly a step ladder as well). The tape measures must be long enough to measure the length of the chain from the pivot point to the seat of the swing.

Ask the students what variables are in determining the period of the swing and what experiments they would like to do to test their hypotheses. If you will be using the experiment report formwith your students, give the students a chance to read it after they have suggested their own experiments but before they begin the experiments.

The students and if necessary any available adults will be the "masses" for this section of playground physics. If possible, try to have one adult for each group of 3 to 4 children. (I recommend that as many of the adults as possible be parents.) If there are insufficient adults, then you may have to be the "large mass" for the entire class or an older student can be the large mass and a younger child can be the small mass. I do not recommend that children from the same grade be separated into different groups by weight unless absolutely necessary. The large and small masses should determine their masses (in kilograms) on the bathroom scale. An adult should measure (with the help of the students) the length of the swings since they chain may be quite long. You may wish to consider bringing a step ladder to the playground to make the measurements easier.

The experiment:

The basic experiment is to time 5 oscillations for a given mass on the swing. Try at least eight variations: the large mass on a swing with a short chain, the large mass on swing with a long chain, the small mass on a swing with a short chain, and the small mass on swing with a long chain all at a slow speed (or from a lower starting position) and repeat for a faster speed (or higher starting position). The order doesn't matter, but you may wish to follow the order in the chart on the experiment report to help reduce confusion for the students when they record their data. Repeating the experiments at least 3 times and /or using at least 3 stop watches will allow the measurements to be averaged and reduce some of the random error. After the measurements have been made for 5 oscillations, have the students divide by 5 to produce the length of a single period. (This can be done in the follow-up class.) Ask the students why they measured 5 periods instead of one.

Before you leave the playground or the next class, ask the students about how their hypotheses held up. Would they change any of their answers to the questions in the before the playground section? Did they learn anything new? If the experiments didn't work well, discuss what should have happened, and have the students come up with reasons why it didn't. Discuss the student responses, and add your own suggestions if necessary.

For older students (who understand square roots), you may wish to have them do some calculations in addition to the experiment report using the equation:

$$\textbf{Period} = 2 \times \text{Pi} \times (\text{length} / \text{acceleration due to gravity})^{1/2}$$

or

$$\textbf{Period} = 2 \times 3.14 \times (\text{length} / \text{acceleration due to gravity})^{1/2}$$

(If the concept of Pi has not been introduced to the students, you may wish to just use the numerical value rounded off to the appropriate number of decimal places.)

For instance, using the length of the chain, have them calculate period of the oscillation for all or a few of their experiments. The students can then compare the calculated periods with the experimental results to determine the experimental error. Traditionally the experimental error is given as a percent error. To prevent confusion from negative numbers (particularly if absolute values have not been introduced to the students) use

Percent Error= ((calculated period - measured period)/(calculated period)) x 100%

if the calculated period > the measured period and

Percent Error= ((measured period - calculated period)/(calculated period)) x 100%

if the calculated period < the measured period

Back to Introduction or **Experiment Report**

Playground Physics

Swing Set Physics

Key Words:

equilibrium position

hypothesis

length

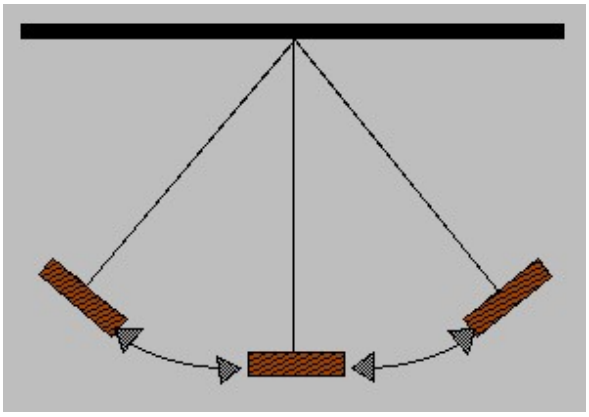
pendulum

period

mass

weight

When you play on a swing you are really working with **pendulums**. A pendulum consists of a string , rod , cable , or chain connected to a fixed point with an object attached at the end .



How much time it takes a pendulum to swing back and forth once is called the **period** of the pendulum. The position in the center is the **equilibrium position.** The equilibrium position is also the position of the pendulum when it is not in motion.

Before the playground

We will experiment with swings as pendulums on the playground. Before we do, you will need to think about what experiments you would like to do with the swings.

First: Make your own hypotheses about what controls how the swing moves.

Remember, a hypothesis is an educated guess based on your previous experience. Before you make you own hypothesis about each of the following cases, think about what you have done on see-saws in the past. It is perfectly OK to make an incorrect hypothesis...scientists do that all the time. The **only** thing you could do wrong if you make an incorrect hypothesis is if you change your observations to match your hypothesis instead of changing your hypothesis to match your observations. That is cheating and **not** real science.

1) What determines how long it takes a swing to go back, forward, and back again? Is your weight important? Is the length of the string important? Is gravity important?

2) When you swing higher does your speed on the swing change?

3) When you swing higher does the period of the swing change?

4) If you want to swing as fast as you can which swing would you pick: a swing with a short chain, a swing with a long chain, a swing with a heavy seat, or a swing with a light seat?

5) How does a swing really work? What allows it to move back and forth?

On the playground

Now comes the fun part! We will experiment with the swing and test our hypotheses.

What experiments should we perform?

How did each of your hypotheses work? A yo-yo can be a pendulum, too. Can you think of any experiments you might like to try with a yo-yo? In what way or ways could your experiments be different experiments you could do on a swing?

Physics on the Playground

Swing Set Physics Experiment Report

Who are your experiment partners?

What is the purpose of this experiment?

Choose a "large mass" and and one "small mass". The large mass can be an adult. Now using a bathroom scale, measure mass of the large mass and of the small mass.

mass of large mass:

mass of small mass:

Have an adult measure the length of the pendulum for you. If no measurement is available just use long for the longest and short for the shortest swing (from the bar).

length 1:

length 2:

For the table below, time 5 back and forth movements (oscillations) of the swing with stop watch. Divide that time by 5 to get the period of one oscillation.

large or small mass?	length	fast or slow? (high or low?)	Time of 5 periods	Time of one period
large	1			
	2			
small	1			
	2			

Why are we timing 5 periods instead of just one?

What properties of your pendulum affect the period? Mass, length,speed, none of these, or all of these?

How did each of your hypotheses work? A yo-yo can be a pendulum, too. Can you think of any experiments you might like to try with a yo-yo? In what way or ways could your experiments be different experiments you could do on a swing?

Now that your experiment is over, will you change any of your answers to the questions below?

1) What determines how long it takes a swing to go back, forward, and back again? Is your weight important? Is the length of the string important? Is gravity important?

2) When you swing higher does your speed on the swing change?

3) When you swing higher does the period of the swing change?

4) If you want to swing as fast as possible which swing would you pick: a swing with a short chain, a swing with a long chain, a swing with a heavy seat, or a swing with a light seat?

5) How does a swing really work? What allows it to move back and forth?

Finally, write a brief paragraph about what you learned in this experiment.
