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educational materials

CIRCUS PHYSICS ACTIVITY GUIDE
Pendulum Motion

Swinging back and forth, the solo trapeze is a giant pendulum just like the one in a grandfather clock. The time it takes to swing forward, then back to where it started is called the *period*.
Surprisingly, this time has very little to do with the height of the swing, or *amplitude*. It depends mainly on the length of the pendulum, the longer the pendulum, the longer the *period*. In this unit students will learn how to find how to find a pendulum's period from its length, and vice-versa.

How to Incorporate the Video Into Instruction

This video can be used to motivate the study of pendulum motion, or to introduce the concept of simple harmonic motion. It can also serve as an extra illustration to reinforce previous lessons on these topics. If you watch the video in class, ask students to pause it at different points in the routine where velocity is greatest or smallest. Given stopwatches, have students time the swings and compare.

Questions to Ask Students Before Watching the Video

1. How is the trapeze like a grandfather clock?
2. What influences how long it takes to go back and forth?
3. What would happen if Regita were lighter or heavier?

Watch the Video: Pendulum Motion

Questions to Kick-Start Class Discussion After the Video

1. What happens as the trapeze-artist changes position from sitting on the trapeze, to hanging below it, to hanging on the rope?
The period of the swing increases as the length of the pendulum increases, so hanging from below results in the slowest swing.
2. How is this similar to a grandfather clock?
Both the trapeze and a grandfather clock are examples of pendulum motion.
3. What are some other types of pendulum you have seen or can think of?
Playground swings, hypnotist's watch in cartoons, the lower leg in walking, etc.
4. What do we mean by period of the swing?
One full cycle, back and forth.
5. What are some other types of systems that have this kind of regular repeating motion?

Anything with reciprocal motion, like a jackhammer, jigsaw, old-style oilderrick, etc.

Connections to Everyday Life
Most students will be familiar with swings on the playground. Rope swings are also likely to be a familiar example. Periodic motion, swaying tree branches, sound, light… etc.

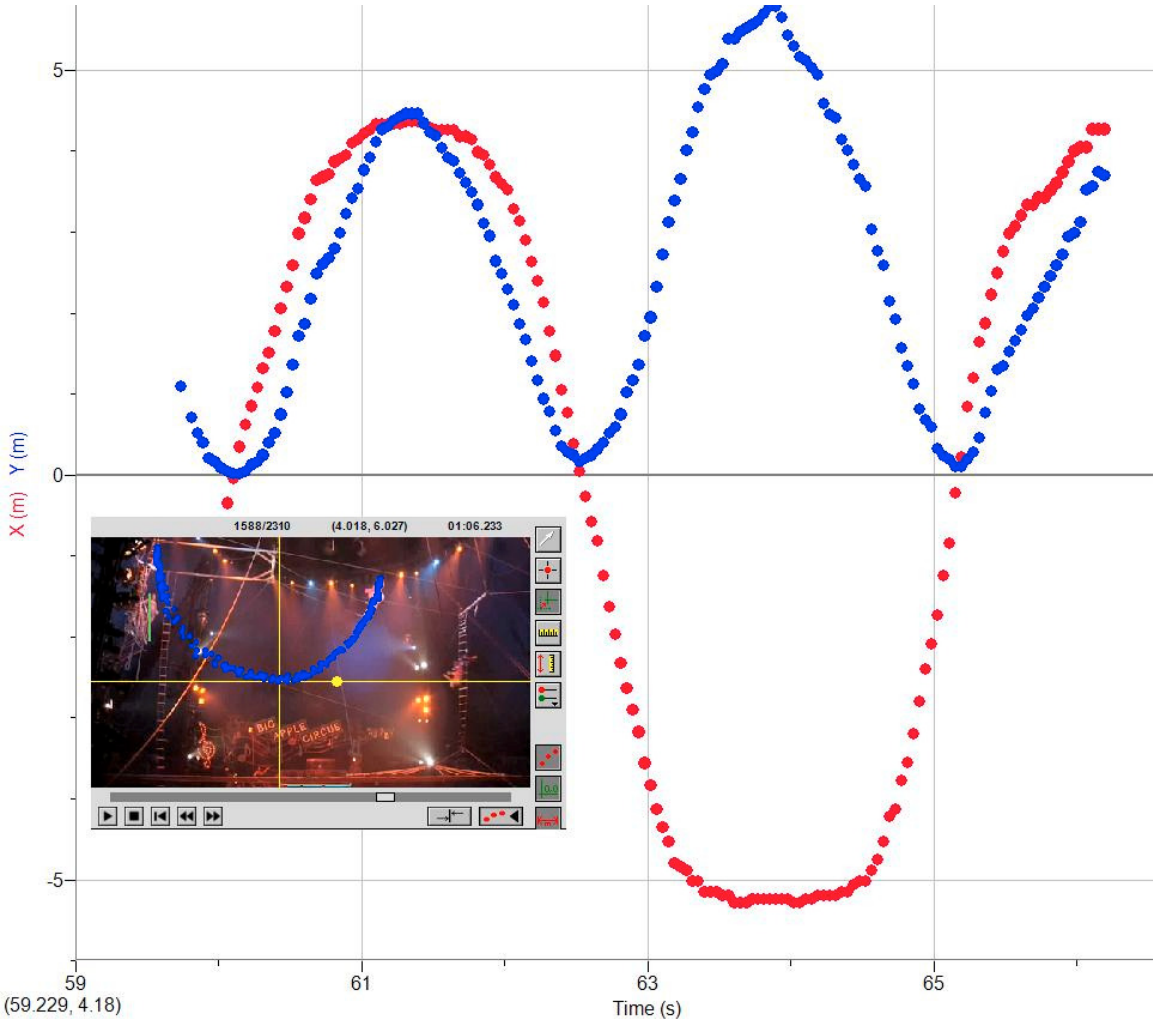
Suggested Classroom Activities

Activity 1: Pendulum Lab
Hang pendulums of various lengths and weights from the ceiling of your classroom. You can use stretch-resistant string and fishing swivels to reduce the effects of friction and string deformation during the swing. Ceiling hook magnets can also help. Have groups of students visit each station, recording the length, weight, and period of swings of different amplitudes. Have them graph the measured relationship between length and period and compare to the theoretical values given by the period equation.

Activity 2: Spring and Weight
With a spring, spray paint, butcher paper, and a *well-ventilated* space, you can show the relationship between a spring's oscillation and a sine wave. A gate spring or other soft spring will work. Hang a weighty object from the spring from the ceiling of your classroom. Bob it up and down until you get a feel for its period. Then, you or a trusted student should attempt to match this frequency by squatting and standing in sync with the spring bob. Once you have the rhythm, have students stretch a length of butcher paper between them and have them walk by you. Hold the spray paint a steadily as you can, relative to your bobbing body, and spray the paper as they walk by. Done correctly, this will produce a sine wave on the butcher paper. Students can then mark amplitude, wavelength, frequency, and then derive velocity = wavelength times frequency.

Activity 3: Pendulum Motion Video Analysis
To do this activity you will need to watch the "Video Analysis: Pendulum Motion" video. Use VideoPoint or similar software for graphing and analysis. This is an extremely fun activity for students because there are lots of different trapeze artists to choose from, all hanging from different lengths. It would be best to do this lab as a follow up after students have derived the formula for a pendulum. Students could use this to verify the formula.

In the figure below you can see a screen shot of the "pendulum".



Notice the two curves, the red shows the x position and the blue shows the y position. For each time the pendulum swings back and forth in the x, it goes through two cycles in the y (up-down-up brings it to the right side, up-down-up again brings it back to the left). Use the red curve to find the period by looking at where it crosses the time axis. On this curve, a rough calculation shows a 5.09 second period for a calculate length from the pendulum formula of 6.4 meters. Or the length of the pendulum is about three times the length of a person. Have students do similar calculations on other performers.