| | |
|---|---|
| **Lesson Title** | Period of a Pendulum |
| **Length of Lesson** | 2 class periods (100 min) |
| **Created By** | Charles Vaughan |
| **Subject** | General Science |
| **Grade Level** | 8 |
| **State Standards** | 1a, 1c, 1d |
| **DOK Level** | DOK 3 - Hypothesize, Investigate, Compare, Draw Conclusions |
| **DOK Application** | Identify research questions and design investigations for a scientific problem. |
| **National Standards** | 5-8: A: Science as Inquiry |
| **Graduate Research Element** | Time period is a useful quantity for orbital bodies, such as comets. The period is the amount of time it takes for an object to complete one cycle of motion (e.g., a revolution around the sun). |

**Student Learning Goal:**

MS 8th Grade:

Inquiry (1a): Design, conduct, and analyze conclusions from an investigation that includes using experimental controls.

Inquiry (1c): Summarize data to show the cause and effect relationship between qualitative and quantitative observations (using standard, metric, and non-standard units of measurement).

Inquiry (1d): Analyze evidence that is used to form explanations and draw conclusions.

National Standards for Grades 5-8:

A: Science as Inquiry: Design and conduct a scientific investigation:

- Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.

**Materials Needed (supplies, hand-outs, resources):**

String (up to 2m in length for every table), weights or pendulum bobs of various masses (about 5-7 are needed), scale/balance for measuring masses, stopwatches, protractors,

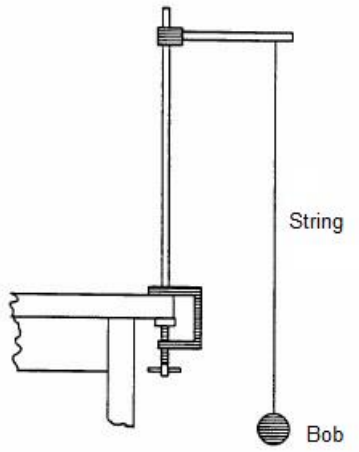
paperclips, meter sticks, long rods (~1m in length), clamps to vertically affix the rods onto the tables, data table handout (file name: INSPIRE_Vaughan_08_01_12_DataSheet.doc), graph paper (for more advanced classes).

**Lesson Performance Task/Assessment:**
Time period is the amount of time it takes for an object to complete one full cycle of motion. A swinging pendulum, without any external interference or changes, will have a constant period. Students will explore what properties of the pendulum will cause the period to vary. Specifically, they will vary the bob mass, string length, and inclination angle to determine what causes a change in the period.

**Lesson Relevance to Performance Task and Students:**
This experiment is a high-transfer activity that allows students to test variables and determine qualitatively how one property of a system affects another (more advanced classes can develop quantitative relationships as well). This experiment serves as a sound example of how the scientific method is applied toward solving a research-based problem.

**Anticipatory Set/Capture Interest:**
"If you've ever seen a grandfather clock, you know that it has a swinging pendulum. The purpose of this pendulum is to keep accurate time within the clock. If the pendulum swings too quickly, the clock runs fast. Likewise, if it swings slowly, the clock will run slow. The real question is, what factors affect how fast or slow the pendulum moves? If the pendulum is made lighter or heavier, will that change how quickly it moves? Or if the length is changed, will that affect the time? What will happen if I swing the pendulum at a wider or narrower angle?"

**Guided Practice:**
For this lesson, the students will be testing three variables to see how they affect pendulum period: mass, length, and inclination angle. Whenever a student tests one variable, it is critical that the other two are held as controls (constant) during the procedure.




- Mount the rods onto the tables, allowing about 2m of distance from the top of the rod to the floor. Cut ~1m or longer of string and tie one end to a clamp/extension at the top of the rod. Tie a large paperclip to the other end of the string. Bend the paperclip so that weights/bobs can be easily added and removed without having to cut and tie string (this will really save class time).
- As an example, pull the pendulum bob back about 10-20 degrees, and show the students how to measure this angle. Then, while holding the stopwatch in the other hand, release the bob and simultaneously start the watch at the exact moment of release. Begin counting the number of times the pendulum swings. Note that one full cycle of motion occurs when the pendulum returns to its starting point.
- Once the pendulum has swung through 10 cycles, stop the watch. Record the time in seconds, and divide this number by 10. This value is the time period of the pendulum, in seconds. The purpose of allowing the pendulum to swing through multiple cycles is to improve the accuracy of the period, and 10 is a very easy number for division.
- Record the period on the worksheet, along with whichever variable is being tested (mass, length, or angle). Then, alter this variable while keeping the other two constant. Repeat the procedure of allowing the pendulum to swing 10 times, record the time, then divide by 10 to obtain the period.

**Independent Practice:**

It is recommended that the students work in groups of 2 or 3 for this activity.

- The students should choose one variable to test while keeping the other two constant. It is often easiest to start by varying mass. Have the students record the values for the other two controls.

- As demonstrated in the guided practice, the students should measure the period for every variable being tested. For example, if five bobs of different masses are available, they should have five different entries in the worksheet table.
- Once they have filled in the table, the students should describe whether or not the period changed appreciably. Note that any variation in the third significant figure does not indicate an appreciable change in period (e.g. 2.33s and 2.39s are essentially the same period).
- For varying length, students should simply tie/untie a very long piece string from the top of the rod attachment. Cutting and retying the string will take too much class time. It is recommended that students vary the length greatly, ranging from ~15cm to 150cm.
- For varying the angle, do not allow students to pull the pendulum back further than about 40 degrees. Extremely wide swings will cause air friction to become a noticeable factor.

**Remediation and/or Enrichment:**
Remediation – IEP

Enrichment - For advanced classes, have students plot period (y-axis) versus mass, length, or angle (x-axes) to show the dependence of period on these three variables.

**Check(s) for Understanding:**
The instructor needs to walk around the room, checking to see that they are performing calculations and pendulum swings accurately. **SPOILER ALERT:** The bob mass and inclination angle should not cause any appreciable change in the period of the pendulum. The pendulum length, however, will cause a change. Do NOT tell your students this! They are meant to discover this relationship on their own.

**Closure:**
For a clock-maker, what is the only important factor in keeping time with a pendulum? If this experiment were done on the moon, where gravity is weaker, do you think the period would change there? If we consider air resistance or friction, how would that affect the period of the pendulum?

Periodic motion is a common feature in nature, particularly within the cosmos. Planets, moons, and comets all have predictable periodic motion that is dependent on their distance from the central (larger) body.

**Possible Alternate Subject Integrations:**
Physical Science

**Teacher Notes:**
Some of these materials were borrowed from a partner university for the lesson.