Foucault's Pendulum: Answer Key

What's a pendulum anyway?

- What is the definition of a pendulum? (A pendulum is loosely defined as something hanging from a fixed point which, when pulled back and released, is free to swing down by gravity and then out and up because of its inertia, or tendency to stay in motion.)
- What are the parts of a pendulum? (A pendulum consists of a fixed point, string or wire, and a bob or weight.)
- What effect does inertia have on a pendulum? (It keeps the pendulum moving once it is in motion.)

Why is a pendulum scientifically important?

- Why can pendulums be used for time keeping? (The consistent swing of the pendulum keeps accurate time.)
- Why is measuring the acceleration of gravity or "g" important? (It helps to determine the shape of the earth and the distribution of materials within it.)
- How do you think a pendulum can be used to show that the earth spins? (If it is accepted that a pendulum swings in a straight plane, and we know there is no force available to make the pendulum rotate, then it must be the earth that spins underneath it.)

Wrong ideas: what people used to believe about the earth

- What were some of the early ideas about the earth that were later proven wrong? (Earth is flat, earth does not move.)
- Who were some of the first scientists to believe the earth rotates? (Aristarchus in the 6^{th} century B.C., Copernicus in 1543, Newton in 1700s.)

Early experiments to prove the rotation of the earth

- What were some early experiments that try to prove the rotation of the earth? (Dropping a stone down a mineshaft and shooting a projectile in a north/south direction.)
- Why were these experiments inconclusive? (The depth of the mineshaft was too small compared to the radius of the earth.)

Foucault's three pendulum experiments

- Describe Foucault's three experiments. In each experiment, what were the length of the wire and the weight of the bob? (1^{st} Experiment: Wire – 6.5 ft., Bob – 11 lbs.; 2^{nd} Experiment: Wire – 36 ft., Bob – information not included; 3^{rd} Experiment: Wire – 220 ft., Bob – 61 lbs.)
- Why did the longer wire result in longer and slower oscillations? (With the longer wire, it takes longer for the pendulum to complete one swing back and forth.)
- What did Foucault use to show how the plane of oscillation moved? (A pin moving through sand showed the path of the pendulum over a 24-hour period.)
- Explain how this proved that the earth rotates. (It demonstrated that the plane of oscillation evolved 270 degrees in 24 hours.)

How the Foucault pendulum works (California Academy of Sciences pendulum)

- Why would a pendulum normally stop after a few hours? (It would stop due to air resistance.)
- What keeps the pendulum moving? (Wire is surrounded by an iron collar with an electromagnet. The magnet attracts the wire and is turned on and off automatically.)

Why does the pendulum demonstrate the rotation of the earth?

- Describe how each of the following affects the movement of the pendulum:
  - Inertia (Makes the pendulum swing straight out.)
  - Gravity (Pulls the pendulum straight back.)
  - Air Resistance (Makes the pendulum swing in shorter arcs, but still straight arcs.)
- Why does the pendulum demonstrate the rotation of the earth? (There is no force acting on the pendulum to make its plane of oscillation rotate or go around its own axis.)

What are the different kinds of motion around the earth's axis?

- Describe the motion of a pendulum and the building around the earth's axis under the following conditions:
  - Perpendicular axis at the North Pole (The floor of a building would "twist" under the pendulum, but the pendulum would stay in its original plane.)
  - Parallel axis at the Equator (The building floor would "travel" eastward on the earth's axis and the pendulum, being tied to the building would travel with the building. There is no visible effect since there is no twisting motion.)
- What happens if the pendulum was at latitudes between the North Pole and the Equator? (Some amount of twisting and traveling takes place. Since the pendulum does not share the twisting motion, it lags behind the twisting part of the floor's rotation and loses part of a full circle in 24 hours. When you move toward the equator, the time it takes for the earth to make one complete turn under the pendulum increases, until at the equator itself there is no rotation at all. This is why the degrees of "twist" at the North Pole is 360 degrees and it will gradually diminish to 0 degrees at the Equator.)

How the rotation of the earth affects our lives

- Describe how the earth's rotation affects the following:
  - Plane flights (The earth's rotation creates deviation to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.)
  - Weather (The earth's rotation creates cyclones, hurricanes, and typhoons in the Northern Hemisphere. It also results in a wider distribution of rain over the earth.)

How to figure the period of a simple pendulum

- Discuss the equation to calculate the period swing of a pendulum. What does each part of the equation represent?
  - What is the period of swing? (One back and forth motion of a pendulum.)
  - Define what is meant by the acceleration of gravity. (The force that gravity exerts on an object.)

How to figure the number of degrees of rotation of earth beneath a pendulum in 24 hours

- Discuss the equation to calculate the number of degrees the earth rotates beneath a pendulum in 24 hours. What does each part of the equation (n = 360 degrees x sin of latitude) represent? (360 degrees is the circumference of a circle; sin of latitude is the angular distance of a place from the equator.)