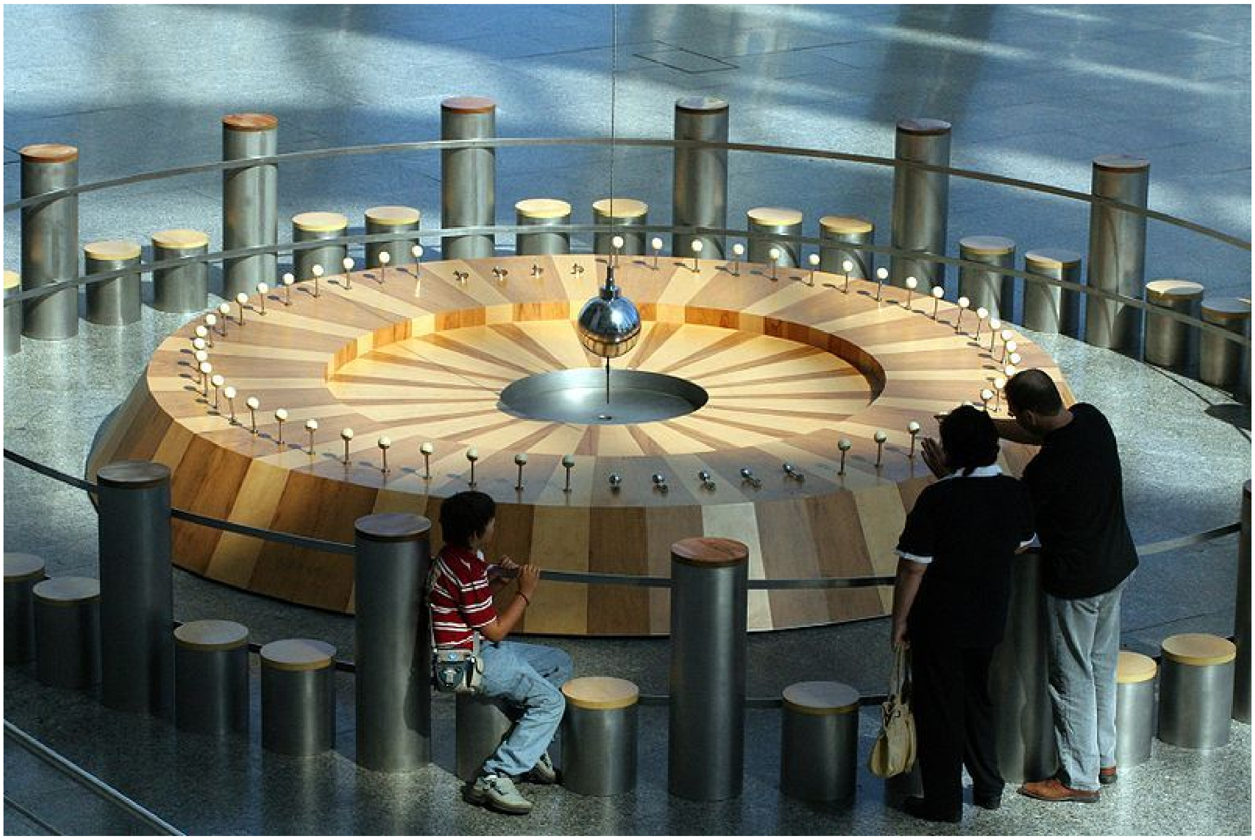
What’s Up With That?: How a Swinging Pendulum Proves the Earth Rotates



ONCE UPON A time, you were probably on an elementary school field trip at a science museum or an observatory. Just before lunch, your teacher had the class stand in a circle around an enormous weight suspended on a string, and watch it swing back and forth, back and forth.

The teacher (or maybe a tour guide) explained that if you watched the pendulum for long enough, it would seem to alter its course, swinging in a slightly different direction. And that this somehow proved the Earth was rotating beneath your feet. You probably nodded and watched the weight swing for a while. And even though you didn’t see anything really change, you thought, “Sure,” and then went to trade your friend an Oreo cookie for half of their Hi-C Ecto Cooler.

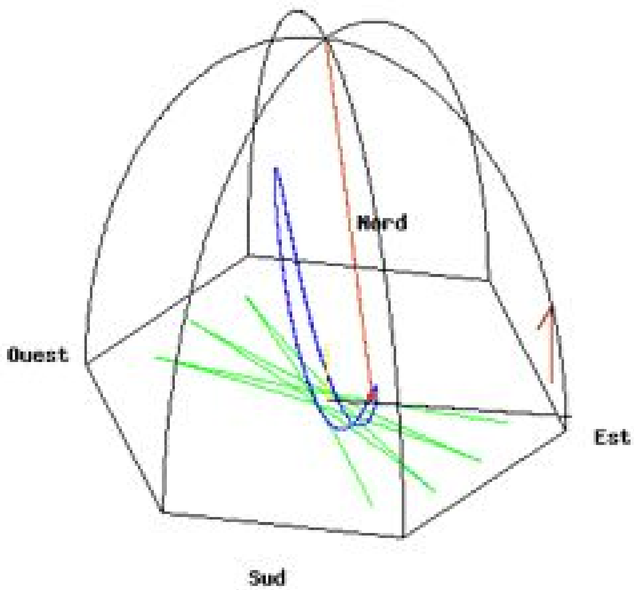
Now that you're older, you'll occasionally think back on that pendulum and wonder how it could have proved anything. After all, the demonstration was in a building on the Earth, so if the Earth was rotating, shouldn't the pendulum be rotating with it?

This famous experiment, now found in museums around the world, was first demonstrated in 1851. French physicist Leon Foucault suspended a 61-pound weight from a 200-foot-long wire at the Pantheon in Paris and set it swinging. He needed the bob to be so heavy and the wire so long to ensure that the pendulum would be able to swing for a long time, at least an hour. A pin on the bottom of the weight drew a line in a circle of wet sand set underneath the experiment.

After an hour, the line the pin drew in the sand intersected with the first line at an angle of roughly 11.25 degrees, which is exactly what Foucault had predicted. The demonstration was an international sensation and was quickly repeated to crowds across Europe and North America. By this point, everyone knew that the Earth rotated but this was the first experiment to measure the speed at which it did so. Foucault got eternal fame by having a pendulum named after him, which later became the title of a mind-bending book by Umberto Eco you probably tried to read in college before turning to the much easier candy of Dan Brown novels.

So how does this all work? To explain, we're going to have to do a little thought experiment.

Let's say that one day you and a friend decide to play a game of catch at the North Pole (your friend is an eccentric billionaire in this story). You stand on one side of the pole and toss the ball directly over the pole to your friend, who is standing opposite you. Try to think about things from the ball's perspective. At the moment it's released from your hand, its path is set. It will travel in a straight line toward the point that you threw it. But in the time it takes the ball to travel, the Earth has rotated just a tiny bit. Your friend has moved ever so slightly to the right. This movement is so minute that it's hardly going to affect your game of catch. But if you were on a planet with a very fast rotation rate, your friend would have moved much more in the time it takes the ball to travel. The ball could entirely miss your friend, going straight past her left arm.



As it goes through its swing, the pendulum acts like this ball. Once the pendulum reaches the top of its arc, its path is set. It will head to the opposite end of its swing without deviation. Essentially, it will continue swinging back and forth in the same exact plane. Imagine you've suspended the pendulum over the North Pole. You glue a pin to its bottom and send it swinging, drawing a line in the snow. But in the time it takes to go from one top of an arc to the next, the Earth underneath the experiment has rotated. And each time the pendulum swings; the Earth rotates a little more. If you kept the pendulum swinging for six hours, one-quarter of a day, the line it now traced in the snow would intersect the first line at 90 degrees. (Note: Some truly awesome and dedicated physicists did this in 2001 at the South Pole.)