Inverted Foucault Pendulum

Foucault's Antenna

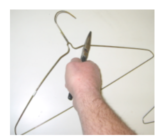
By Eric Muller

A variation of a Foucault pendulum, but upside down.

Introduction:
A variation of a Foucault pendulum can be constructed with a metal rod, weight and block of wood. A rod is made to oscillate or wiggle in a plane. As the device oscillates and is set rotating, one can see the relative effects of this rotation on the wiggling rod. This type of device is the predecessor to the Foucault Pendulum. It can be used to demonstrate how a Foucault Pendulum would move at various latitudes.

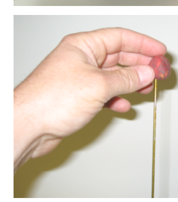
Materials:

- A straight small diameter metal, plastic or wooden rod - 70cm or longer. A straightened clothes hanger will work for this. However, a length of metal welding rod will work better.
- Block of wood (a 2 x 4 at least 4" inches long will work great, or almost any wooden block that is at least 3/4" thick and 2" by 4" or larger).
- A Mass – 10g or so… (Mass should be adjusted depending on the strength and length of the rod. Mass can be made from a small piece of wood (drilled to tightly fit the rod], lump of clay, candy, gum, etc or anything that can be attached to the end of the rod will work).
- Pliers to bend or cut the metal rod.
- A drill with an appropriate sized drill for your rod.



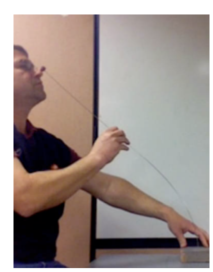
Assembly:

1. If using a metal clothes hanger, cut and straighten the metal wire.
2. Drill a hole in the center of the block of wood. The hole should be the same diameter as the metal rod. Do not drill all the way through the block, but drill deep enough to keep the inserted rod stable and upright.
3. Insert the rod into the drilled hole.
4. Place a weight on the other end of the rod.
5. This is your "wiggler" device.



Caution: The end of the rod is an eye injury hazard…be careful.

To do and notice:
Note: Movies of this activity are located on my web site at: www.exo.net/~emuller



Note: You can perform all the experiments below on a table top or lazy Susan, but you'll get more attention if you do them with your body.

Your body will represent the earth. Your axis of rotation will go from the top of your head (North Pole) to the bottom of your feet (South Pole). Your belly can represent the equator. And your chest and arm pit area can represent mid-northerly latitudes (fill in your jokes here).

A) To demonstrate how a Foucault Pendulum would work at the North or South Pole:

1. Hold or place the wiggler device on your head. You should look like you have an **Antenna** sticking out of your skull.
2. Pull back and release the rod.
3. It should swing back and forth in a plane. Once it's oscillating at a good "clip," don't add any more energy to the motion of the rod.
4. Now, keeping the base of the device tangent to your head, turn or spin your body 90˚or more.
5. Watch the orientation of the swinging rod (since it's on your head, someone has to observe the motion of the rod).

B) To demonstrate how a Foucault Pendulum works at the Equator:

1. Hold the wiggler device so that the rod sticks out from your stomach or waist (or in my case, at my equatorial bulge!).
2. Get the rod swinging up and down in a plane. Once it's oscillating at a good "clip," don't add any more energy to the motion of the rod.
3. Now, keeping the base tangent to your belly, turn or spin your body as the rod oscillates. Turn 90˚or more.
4. Watch the orientation of the swinging rod as it revolves around your body (You should also have someone else observe the rod as you turn).
5. You can repeat this demonstration, but this time; have the rod oscillate from side to side to start.

C) To demonstrate how a Foucault Pendulum works at mid-latitudes.

1. Hold the wiggler device at about chest level. Tilt the rod upwards at about a 45˚ angle (use this angle for your first trial, try other angles too).
2. Get the rod swinging up and down in a plane. Once it's oscillating at a good "clip," don't add any more energy to the motion of the rod.
3. Now, while holding the device steady at this angle, turn your body around 90˚or more.
4. Watch the orientation of the oscillating rod as it is rotated about your body (have someone else observe the rod too).
5. You can repeat this demonstration holding the device at other starting angles or by oscillating the rod from side to side.

<u>What's going on?</u>

This device works just like a Foucault Pendulum. In fact, Jean Bernard Léon Foucault came up with the idea of his famous pendulum by watching a rod wiggling in a lathe. When the rod is pulled back and released, it overshoots, rebounds and oscillates back and forth in a plane. The momentum of the rod and mass (at the tip) helps keep the rod moving in the direction even though the base (or earth) may rotate in various ways. It's all relative… The oscillating rod as well as a Foucault Pendulum ignores other motions such as the spin of the earth.

When you placed and wiggled the device on top of your head, this was analogous to a Foucault Pendulum swinging at the pole of the earth. As you turned, you may have noticed that the rod seemed to stay oscillating in the same direction.

The earth rotates under the pendulum as the pendulum stays in the same plane. Therefore a Foucault Pendulum will seem to rotate a full circle (360˚) in one day (24 hours) or 15˚ each hour.

When you placed and wiggled the device on your waist, this is analogous to a Foucault Pendulum swinging at the earth's equator. As you turned, you may not have noticed too much of change in direction of the swinging rod.

At this location, a Foucault Pendulum on the earth doesn't seem to change direction from the point of view of a person standing next to it.

When you placed, angled and wiggled your device near your chest, this was analogous to a Foucault Pendulum swinging at mid-latitude between 0˚ and 90˚ (between the equator and pole). As you turned, you may have noticed your oscillating rod trying to compensate for your turning motion.

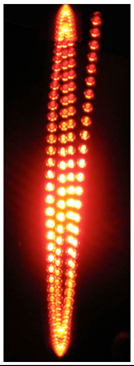
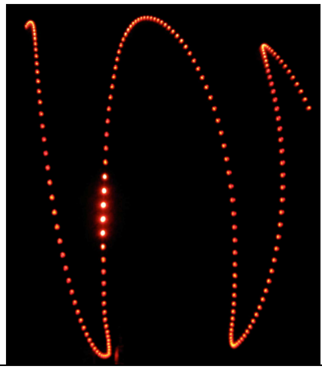
On the earth, Foucault Pendulums rotate in a circle proportional to the sine of the latitude, ϕ where the pendulum is located. The rotation rate per hour (α) is based on the formula: $\alpha = 360\text{SIN}(\phi)/24$

In San Francisco, where the Exploratorium and California Academy of Sciences are located we are at a latitude of: 37.5˚ So: $\alpha = 360\text{SIN}(37.5^\circ) / 24 = 9.1^\circ$ per hour.

<u>More Stuff:</u>

You can outfit the rod with a blinking LED and take a long-term exposure picture. This will show what the wiggling rod looks like from an observer outside of the rotating reference frame (such as looking at the earth from space as it spins).

Below are some examples:

<table>
<tr><td>Polar Pendulum
</td><td>Equatorial Pendulum
</td></tr>
<tr><td>Viewed from above as the rod is rotated about its axis…such as on top of your head. Note the similar direction of lights.</td><td>Viewed from the side as the rod is vibrated and rotated perpendicular…. at waist level. Note the up and down motion. Also, the person holding and wiggling the device does not see this pattern.</td></tr>
</table>

References:

http://www.calacademy.org/products/pendulum/page1.htm
http://en.wikipedia.org/wiki/Foucault_pendulum
http://www.abc.net.au/surf/pendulum/pendulum.htm
http://www.phys-astro.sonoma.edu/people/students/baker/SouthPoleFoucault.html