

Learning Scenario Foucault's Pendulum

Language(s): English

Domain: Science>Physics>Forces and motion>Inertia, Science>Physics>Forces and motion>Circular motion, Science>Physics>Forces and motion>Foucault pendulum, Science>Physics>Forces and motion>Angular velocity, Science>Physics>Fields>Gravitational field, Science>Physics>Energy>Conservation and dissipation

Description/ main idea

Students will observe the movement of Foucault's pendulum in order to witness the Earth's rotation.

Phases & Activities

1. Introductory section and preparatory phase

Introduction to the pathway.

1.1 Guidance for preparation

Description

1. The teacher should prepare a small presentation with the proposed pictures, videos and relative material.

`diamond` **Prior** to the visit the teacher

- shows videos and images that prove Earth's rotation.
- presents pendulum images in order to explain its basic properties.
- presents the basic equations of circular motion and explains how they can be used in this experiment.
- explains the basic properties of the phenomenon and why the experiment wouldn't work at the equator.
- makes a brief presentation of Foucault's experiments.

`diamond` **After** the visit the teacher

- presents videos of pendulums around the world
- presents videos that illustrate the difference in observation between an observer on Earth

and a one over it.

2. The students' worksheets should be printed prior to the visit.

This pathway is recognized as one the 5 best pathways of the OSR repository and it is also available in [German](#), [Greek](#), [Portuguese](#), [Finnish](#), [French](#), [Hungarian](#) and [Italian](#).

2. Teaching Phase 1: Question Eliciting Activities

Activities preparing for the interaction.

2.1 1.1 Provoke curiosity

Description

How many ways can you find in order to draw the same line?

The trick in this question is that a line can be drawn either by keeping the paper still and move the pencil over it, or by keeping the pencil still and move the paper underneath it. This way the teacher gives the students a simple example of apparent movement, a concept which is essential for understanding Foucault's experiment.

After the students finish the mini quiz, the teacher informs them that by using the second way of drawing the line, one can actually prove the Earth's rotation.

Resources

Educational objects (as file):

1. [0790344001274387634.jpg](#)

2.2 1.2 Define questions from current knowledge

Description

This is a sample list of questions used to attract the students' attention and test their existing knowledge. Each question is accompanied with respective material.

- How can we tell that the Earth is [moving](#)?

Are there any direct [indications](#)?

- The [succession](#) of day and night

- The [apparent movement](#) of stars

- Can we design an experiment that can [prove](#) the Earth's rotation around its axis?

At this point the teacher introduces the idea of a swinging pendulum.

- What's a [pendulum](#) anyway?

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- How does it [work](#)?

Resources

Educational objects (as file):

1. [0436609001274387794.JPG](#)
2. [Day - Night.mp4](#)
3. [Moving Stars.mp4](#)
4. [Prove Earth rotation.pdf](#)

3. Teaching Phase 2: Active Investigation

This is a transitional phase on the borderline between the Pre-visit and Visit sections of the Educational Pathway. 'Active Investigation', and in particular the step of Planning and conducting simple investigation can take place either before or during the visit, or both, depending on whether the teacher decides to use ODS resources of an exhibit nature (exhibits, simulations, experiments, etc.) at this stage (on the web or during a physical visit to a science museum/centre). However the use of physical observation is concentrated mainly in the next Teaching Phase, under the Visit section of the Educational Pathway.

3.1 2.1 Propose preliminary explanations or hypotheses

Description

How can we use a pendulum to witness the Earth's rotation?

The teacher helps the students to combine the idea of a swinging pendulum with relevant motion. Students should realize that the pendulum's swing is independent to the surface below.

The idea of the earth spinning underneath the pendulum instead of the pendulum spinning itself, is quite difficult for students to realize. Therefore, once introduced to students, there should be some similar examples for demonstration to help them get the idea. In addition to that, certain misconceptions should first be cleared out and then the teacher may motivated the student to reach a conclusion.

Common Misconceptions:

The teacher identifies possible misconceptions. The three misconceptions mentioned below are crucial, so in case no student mentions any of the above, they should be pointed out from the teacher.

1. A pendulum can [keep oscillating](#) without stopping once it is set to motion.
2. There is a force that makes the pendulum's swing plane [rotate](#).
3. The [fixed point](#) of the pendulum rotates along with Earth, therefore the swinging plane must change respectively.

Resources

Educational objects (as file):

1. [0733213001274387908.JPG](#)
2. [Misconception 3.pdf](#)

3. [Misconception 1.pdf](#)
4. [Misconception 2.pdf](#)

3.2 2.2 Plan and conduct simple investigation

Description

At this point students have understood the idea of a pendulum swinging while the Earth rotates underneath.

- The main instrument for this experiment is the pendulum which is comprised of a thin rope, a mass attached to the end of the rope (bob) and a fixed point from where the pendulum hangs.
- Point out which [parameters](#) should be studied in order to make sure that the pendulum will swing long enough in order to demonstrate the rotation of the Earth.
- Apart from the pendulum, in order to conduct the demonstration one will also need a marked disk to be placed underneath the pendulum so the apparent change of the swinging plane may be visible. It is also advisable that students are provided with stop watches.
- The teacher may prepare a [quiz](#) for the students to answer during their visit.

Summing up:

Conditions: In order for the experiment to work:

- The string of the pendulum has to be a quite long (more than 2 meters).
- The mass of the bob should be more than 5kg.

Prediction:

After some time the swinging plane of the pendulum will appear to have changed.

The teacher:

- Informs the students that Foucault predicted that had his pendulum kept oscillating, the plane would have completed a full circle within 32 hours.
- Discusses with the students why it would take the plane longer than 24 hours to complete the [round](#).
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- Explains what changes as we move from the equator towards the [North Pole](#).

Calculations:

The teacher discusses with the students, the [equations](#) of circular motion and of a moving pendulum and how they can be used at present.

angular speed: $\omega = \frac{\phi}{t} = \frac{360^\circ}{T}$

$$\omega_x = \omega \cos \theta$$

vector analysis:

$$\omega_y = \omega \sin \theta$$

period of oscillation: $T = \sqrt{\frac{2l}{g}}$

The teacher asks the students what [quantitative assumptions](#) they believe they can make.

Resources

Educational objects (as file):

1. [0059684001274965047.gif](#)
2. [Latitudes.pdf](#)
3. [Quantitive assumptions.pdf](#)
4. [Mathematical Equations Walkthrough.pdf](#)
5. [Duration of Rotation.pdf](#)
6. [Pendulum properties.pdf](#)

4. Teaching Phase 3: Creation

Creation

4.1 3.1 Gather evidence from observation

Description

- Students observe the pendulum and witness the Earth's movement.
 - The teacher answers the students' [questions](#).
 - The teacher gives information about the [pendulum](#).
 - Students use PDAs to access the [application](#) for Foucault's pendulum:
 - they gather information about Foucault's experiment as well as his life.
 - they discuss what they have read with the teacher
 - they do the quiz at the end of the application.
 - The teacher gives the [spreadsheet](#) to the students and explains what are these [sets of measurments](#) and what they will have to do with them.
- `=>` If the physical visit to a pendulum is not possible, the teacher can use the Foucault's Pendulum interactive exhibit on OSR Camp in [Second Life](#)!

Resources

Educational objects (as file):

1. [0967586001283425691.jpg](#)
2. [Teachers Guide for the Exercise.pdf](#)
3. [Spreadsheet student.pdf](#)
4. [Calculations.xls](#)
5. [EA pendulum.pdf](#)

5. Teaching Phase 4: Discussion

This is a transitional phase on the borderline between the Visit and the Post-visit sections of the Educational Pathway. Discussion can take place either during or after the visit, or both, depending on whether the teacher considers that the use of the digital exhibits is necessary (or feasible) at this stage. Ideally, Discussion, and particularly the step of Explanation based on evidence, should take place in front of the exhibit, to reinforce the link between the physical experience of using the resource and the mental processing of the observed information by the students.

5.1 4.1 Explanation based on evidence

Description

The teacher:

- Points out again that it's them along with Earth that move and not the pendulum.
- Reminds the students that the twist of the pendulum's fixed point does not effect the oscillation plane.
 - In order to prove this suggestion the teacher may use a smaller [portable pendulum](#) with a twisting plane.
 - If such a pendulum is not available the teacher may use a respective [video](#).
- Comments on how slowly the Earth seems to twist. (At the equator the Earth's speed is 465m/sec at 50° latitude 321m/sec and at the Poles 0m/sec)

Students:

- Discuss how does the Earth's rotation [affect our lives](#).
- They discuss the [exercise](#) they are asked to do.

Resources

Educational objects (as file):

1. [0331742001283346542.gif](#)
2. [Exercise.pdf](#)
3. [small pendulum.wmv](#)
4. [DSC01114.JPG](#)
5. [How does the Earth.pdf](#)

5.2 4.2 Consider other explanations

Description

- The teacher makes a small flashback as to the [efforts](#) scientist made in the past to find out the properties of our planet's movement.
- The teacher informs the students about the [tests](#) Foucault carried out.

`=>` There is a possibility that students may come up with different explanations about the phenomenon.

1. There is a mechanism attached to the pendulum that makes it [rotate](#).
2. The [electromagnet](#) at the base of the disk (if there is one) makes the pendulum move in different directions.
3. The twist of the ceiling makes the pendulum [twist](#) as well.

Resources

Educational objects (as file):

1. [0087330001274389209.JPG](#)
2. [Explanation 12.pdf](#)
3. [Foucault Preliminary tests.pdf](#)
4. [These wrong ideas.pdf](#)

6. Teaching Phase 5: Reflection

discussion, reflection, follow-up

6.1 5.1 Communicate explanation

Description

- The teacher presents some related videos:

- [Other pendulums](#) around the world.

- The [pendulum's movement](#) as an observer who is not standing on Earth would see

- The [pendulum's movement](#) as an observer who is standing on Earth would see.

- A [full rotation](#) of the plane underneath the pendulum.

- Students are asked to fill in a [report](#).

`=>` This report will help the students get a glimpse of how scientific work is done. Moreover it will help them confront one of the main weaknesses most students have in science, which is difficulty in expression.

- Divided into groups, students are asked to make a short presentation of their report about Foucault's pendulum and present their findings.

Resources

ODS educational objects created within the community by all users:

1. [How can students put together a scientific report](#)

Educational objects (as file):

1. [0521846001275641925.jpg](#)
2. [Pendulum Animation.mp4](#)

7. Other

Other Activities

7.1 Follow-up activities and material

Description

1. The idea in which Foucault's experiment is based on is the fact that a pendulum's swing remains unaffected by the twisting of its hanging point.

Students may build a pendulum on their own in order to test this idea:

- The easiest way to build such a pendulum is by using [Lego blocks](#).
- Apart from the pendulum itself in order to perform the experiment student will also need a [twisting plane](#).

To perform the [experiment](#):

1. Place the pendulum on to the plain.
2. Set the pendulum to motion.
3. Start twisting the plain **slowly**.

2. Visit Foucault's pendulum at the [Deutsches Museum](#).

Additional Material:

1. Spreadsheet [answer key](#)
2. Exercise [answer key](#)
3. [Example](#) Report

Useful Links:

http://www.sciencenetlinks.com/lessons_printable.php?DocID=180

<http://www.sciencenetlinks.com/lessons.php?DocID=179>

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<http://www.calacademy.org/products/pendulum/index.html>

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<http://www.school-for-champions.com/science/pendulum.htm>

http://www.animations.physics.unsw.edu.au/jw/foucault_pendulum.html

Resources

Educational objects (as file):

1. [0729172001283341654.JPG](#)
2. [DSCF3584.JPG](#)
3. [Exercise answer key.pdf](#)
4. [DSC01072.JPG](#)
5. [Report Example.pdf](#)
6. [Spreadsheet teacher.pdf](#)

7.2 Sustainable contact

No content has been added for this activity.

Grade & Age

at least 12

Grade: in the science museum/centre, school-connected

Keywords/subject

Pendulum,,rotation,,vertical plane,,oscillation,,apparent movement,,period,,angular speed

Cost

Use is free of charge

Copyright

Yes