SOCIETY OF PHYSICS STUDENTS
An organization of the American Institute of Physics

SPS Chapter Research Award Proposal

Project Proposal Title	Development of scientific knowledge through a Foucault Pendulum
Name of School	Universidad Autónoma de Ciudad Juárez (UACJ)
SPS Chapter Number	3291
Total Amount Requested	$1,980.00

Abstract

Physics students from the Universidad Autonoma de Ciudad Juárez present a proposal to design and build an interactive Foucault Pendulum based on a real time traking-system. Motivations behind the proposal are: Earth's rotation properties in a science museum, development teaching tools of Classical Mechanics and valuable scientific skills.

Proposal Statement

Overview of Proposed Project

Research question

What effects related to cognitive activity and scientific curiosity will produce a Foucault Pendulum in both physics students and community people throught the use and inside physics curriculum and museums?

Motivation

Regularly in elementary schools science teachers tell children that earth rotates on its own axis. However students's scientific interpretation and conceptual undertanding is fundamental to develop important knowlegde. Students need a demostration process through the visualization of this phenomena. We believe that design and the implementation of physical demostrations, suggest a Foucault Pendulum could help in the cognitive process during academic life.

A Foucault Pendulum could be a good alternative to: i). Help UACJ's physics students during the process of conceptual understanding, and ii) encourange community to enjoy and achieve scientific knowledge.

Brief description

This research project is based on the design, construction and implementation of a Foucault Pendulum. Design elements built will achieve technology-hardware process. This technology will incorporate not only trayectory tracing sensors, but also the necessary software for graphing the corresponding data on an integrated screen.

Research goals of the project

1. Develop a functional prototype for several academic activities in the Universidad Autonóma de Ciudad Juárez.
2. Make investigation related with the electronic components and materials for the construction of the Foucault Pendulum.
3. Implement a high technology Foucault Pendulum at "La Rodadora Science Museum" .
4. Raise the scientific divulgation, interest and curiosity in the Juárez City Community.

SPS connection

To strengthen the objetives of the SPS this project will also consist in the creation of a web page with free access for anyone who wants to interact and adquire the data provided by the Foucault Pendulum at any time.

Background for Proposed Project

Currently in science museums and universities it's common to find a Foucault Pendulum as an exhibition piece. This type of pendulum was introduced firstly in 1851 by Michael Foucault given the experimental proof Earth´s rotation, hence these devices has a utility in

the physics laboratories to the undergrad students because it can useful to demonstrate this fact and the physical principles that government the Foucault Pendulum behavior.

Using the Hamiltonian method to find the equations of motion a spherical pendulum of mass *m* and length *b.*

The generalized coordinates are θ y Φ. The kinetic energy is:

$$K = \frac{1}{2}mb^2\dot{\theta} + \frac{1}{2}mb^2Sin(\theta)\dot{\Phi}^2$$

The only force acting on the pendulum (other than at the point of support) is gravity, and we define the potential zero to be at the pendulum's point of attachment

$$U = -mbgCos(\theta)$$

The generalized momenta are then

$$p_\theta = \frac{dL}{d\dot{\theta}} = mb^2\dot{\theta}$$

$$p_\Phi = \frac{dL}{d\dot{\Phi}} = mb^2Sin(\theta)\dot{\Phi}$$

We can solve the equations for $\dot{\theta}$and $\dot{\Phi}$ in terms of p_θ and p_Φ.

We can define the Hamiltonian like the mechanical total energy

$$H = K + U$$

$$H = \frac{{p_\theta}^2}{2mb^2} + \frac{{p_\Phi}^2}{2mb^2Sin(\theta)^2} - mbgCos(\theta)$$

The equations of motion are

$$\dot{\theta} = \frac{dH}{dp_\theta} = \frac{p_\theta}{mb^2}$$

$$\dot{\Phi} = \frac{dH}{dp_\Phi} = \frac{p_\Phi}{mb^2Sin(\theta)^2}$$

$$\dot{p_\theta} = -\frac{dH}{d\theta} = \frac{{p_\Phi}^2}{mb^2Sin(\theta)^3} - mgbSin(\theta)$$

$$\dot{p_{\Phi}} = \frac{dH}{d\Phi} = 0$$

In the case that we consider a Foucault pendulum we can found a relation between the angular velocity Ω of rotation of the plane oscillations pendulum with the angular velocity ω earth's rotation

$$\Omega = \omega Sin(\lambda)$$

In agree with the before expression we can determine the period's plane oscillation pendulum as

$$T = \frac{2\pi}{\omega Sin(\lambda)}$$

Expected Results

Once this project is executed, the following results are expected: It is expected that a interactive Foucault Pendulum with a tracking system in real time, in orter to show the rotation of the Earth at the "La Rodadora Science Museum", in Cd. Juaréz, Mexico, in the border area with Texas (Scientific divulgation purposes for all the people en our city). This is a result that we believe is very important to promote scientific culture in our city, so that society values and promotes the development of physics and its applications. This type of projects contribute to the development of physics because it motivates future physicists. The expected pendulum will be interactive, well instrumented and very beautiful that will allow visualizing on a screen its trajectory and its explanation in a visual way.

From the academic point of view, this project will be a very useful didactic tool for the Classical Mechanics course, specifically to help to understand the topics of Mechanical of Lagrange and Mechanical of Hamilton, this is because any student of physical can validate their theoretical knowledge with our experimental proposal, which will allow us to validate the theoretical solutions with the experimental observations. Additionally, we will elaborate a list of academic activities that allow to challenge or improve the knowledge of Classical Mechanics of physics students, in order to achieve a more proficient knowledge of Classical Mechanics.

The electronics (tracking system in real time) that we will develop to obtain the precise position of the trajectories of our Pendulum (3D), can be incorporated into other experiments of classical mechanics, the previous due to the small and high degree of precision that we expect.

Finally, as a result of the execution of this project we hope that our scientific skills and those of the rest of our classmates will improve, that we gain experience in order to be able to face the study of more challenging problems in physics.

Description of Proposed Research - Methods, Design, and Procedures

- Review of the State of the Art abaut Foucault Pendulum
- Meetings will be conducted with fellow students on how to determine the the specific design of the pendulum.
- Meetings will be conducted with fellow students on how to determine the the specific design of the real time traking-system.
- Made theoretical calculus for experimental design.
- Buy all materials necessary.
- Build a prototype of the interactive Foucault pendulum. The above with the help of our infrastructure (workshops and laboratories).
- Characterization and optimization of the Foucault pendulum, including physical parts and real time traking-system.
- Meeting with advisors for feedback, and Write and submit interim report (May 1)
- Build final Foucault Pendulum, for a science museum in Mexico. Present and announce this project in our city.
- Verify if results match with expected findings, if not, solve technical problems.
- Diffusion of the project.
- Write and submit the final report (Dec 1).

Plan for Carrying Out Proposed Project

- Personnel. Four SPS members will be involved in the research of activities: Fernando, Julio, Gabriel and Raúl are the ones who assume the responsibility of the project, designing and executing the activities of the project. Additionally, in January-2019 two more students of physics and two students of Electronic Engineering will be integrated that support with electronics and instrumentation. All the team will be under the supervision of Dr. Abdiel Ramírez-Reyes and Dr. Sergio Flores-García. Finally, there is the support of the personnel in charge of laboratories and workshops of the UACJ.
- Expertise. Fernando, Julio, Gabriel and Raúl has necessary background completion of courses like General Physics, Classical Mechanics and Instrumentation which are helpful to achieve success in the proposed project.

- Research space. The work of this research will be carried out in the Physics Laboratories of the UACJ and in their respective workshops. The final stage of this project will be held at the "La Rodadora Science Museum", in Cd. Juaréz, Mexico, in the border area with Texas.

Project Timeline

ACTIVITY	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019	Sep 2019	Oct 2019	Nov 2019	Dec 2019
-Review of the State of the Art													
-Search for additional Resources													
-Design tracking system and Foucault Pendulum													
-Buy sensors, electronics and materials													
-Build a first prototype of the Foucault pendulum													
- Build a tracking system in real time													
-Write and submit interim report (May 1)													
-Build APP in order to see and understand the Earth´s rotation													
-Make adjustments and calibration of the device as necessary													
-Build final Foucault Pendulum, for a science museum in Mexico													
-Describe the Foucault Pendulum in terms of Classic Mechanics													
-Optimization and diffusion of the project													
-Write and submit the final report (Dec 1)													

Budget Justification

The financing of the project is necessary for the acquisition of materials for the construction of the Foucault Pendulum, for example we require Laton, Iron, steel cable, motion tracking sensors, electronic components, etc.

At our university, we have well-equipped laboratories and workshops. Additionally, we have academic support from various professors from our faculty. In addition, we are currently looking for more support so that our project can be in the museum of our city, but first we must count with your financial support.

We are sure that investing in our project will bring many benefits to our society, particularly to Ciudad Juárez, on the border with Texas. This project will allow us to have educational teaching tools for Lagrange and Hamilton Mechanics. Finally, we can develop skills that are necessary in a 21st century scientist. We appreciate your support.

Bibliography

[1] Goldstein, H. (2011). Classical mechanics. Pearson Education India.

[2] Marion, J. B. (2013). Classical dynamics of particles and systems. Academic Press.

[3] Staudt, K. (2009). Violence and activism at the border: Gender, fear, and everyday life in Ciudad Juárez. University of Texas Press.

[4] Zhu, R., & Zhou, Z. (2004). A real-time articulated human motion tracking using tri-axis inertial/magnetic sensors package. IEEE Transactions on Neural systems and rehabilitation engineering, 12(2), 295-302.