College of Saint Benedict and Saint John's University
DigitalCommons@CSB/SJU

Physics Faculty Publications Physics

12-1980

An Experiment in Discovery

Daniel J. Steck
College of Saint Benedict/Saint John's University, dsteck@csbsju.edu

Follow this and additional works at: https://digitalcommons.csbsju.edu/physics_pubs

Part of the Physics Commons, and the Science and Mathematics Education Commons

Recommended Citation

Steck DJ. 1980. An Experiment in Discovery. *Physics Teacher* 18(9): 672-673.

This Article is brought to you for free and open access by DigitalCommons@CSB/SJU. It has been accepted for inclusion in Physics Faculty Publications by an authorized administrator of DigitalCommons@CSB/SJU. For more information, please contact digitalcommons@csbsju.edu.

The Physics Teacher

An experiment in discovery

D. J. Steck

Citation: Phys. Teach. **18**, 672 (1980); doi: 10.1119/1.2340660
View online: http://dx.doi.org/10.1119/1.2340660
View Table of Contents: http://tpt.aapt.org/resource/1/PHTEAH/v18/i9
Published by the American Association of Physics Teachers

Related Articles

The process of transforming an advanced lab course: Goals, curriculum, and assessments
Am. J. Phys. 81, 63 (2013)

The Pulley: A Parable of Effort and Reward
Phys. Teach. 50, 488 (2012)

BIG Physics
Phys. Teach. 50, 376 (2012)

Online with Integers
Phys. Teach. 49, 510 (2011)

Physics Myth Busting: A Lab-Centered Course for Non-Science Students
Phys. Teach. 49, 448 (2011)

Additional information on Phys. Teach.

Journal Homepage: http://tpt.aapt.org/
Journal Information: http://tpt.aapt.org/about/about_the_journal
Top downloads: http://tpt.aapt.org/most_downloaded
Information for Authors: http://www.aapt.org/publications/tptauthors.cfm

ADVERTISEMENT

Downloaded 28 Aug 2013 to 152.65.133.142. Redistribution subject to AAPT license or copyright; see http://tpt.aapt.org/authors/copyright_permission

An experiment in discovery

D. J. Steck
Department of Physics, St. John's University, Collegeville, Minnesota 56321

During a recent revision of our introductory curriculum, we noticed that our old courses adequately treated theoretical topics, but failed to develop the equally important experimental aspects of physics. We needed to find a way to introduce students to the concepts of discovery through experimentation. This need was particularly urgent in our general physics course where liberal arts students would have their only exposure to the philosophy and methodology of experimentation. Thus, we devised the following scheme to gradually develop experimental skills. During the first few lab periods we guided students through the experiments step-by-step, taking pains to show them how the "methods" were properly applied. Subsequently, we weaned them from this strict guidance until, at semester's end, they conducted an investigation on their own. That final experiment is the subject of this paper.

Rare are those experiments that are simple enough to be successfully completed by the average student working independently. Rarer yet are such experiments in rotational mechanics, the topic being covered at semester's end. There are two extremes that a "do-it-yourself" investigation must avoid if it is to be successful. It must not be transparent, lest the student view it as an exercise in confirming some physical principle. Neither should the experimental system be obscure, for then students would require detailed instructions in order to complete their work within a reasonable time. In either extreme, the sense of experimental discovery is destroyed.

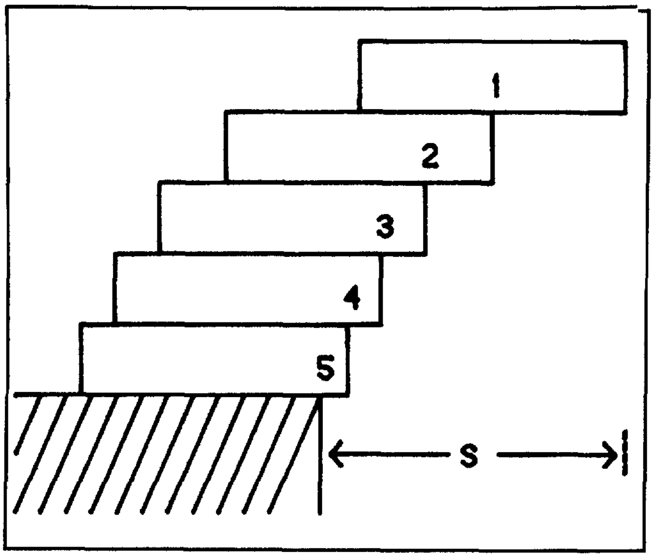

Fig. 1. The five-step staircase having the maximum total span (S) is shown. Note that the step number for each step is located at the center of mass of the compound object consisting of that step and all steps above it.

One experiment that challenges the student's skill and imagination without inducing a coma, is based on the maximum-span staircase, sometimes called the "Leaning Tower of Lire"[1] (Fig. 1). To ease students' concerns about the "test-like" atmosphere in the lab, they are introduced to the staircase problem through a light-hearted scenario. In this scenario, each student is challenged to build a staircase of specified dimensions. He may use only the minimum amount of materials and has no glue, nails, etc. He is reassured that a solution can be easily found using his experimental skills of modelling, observing, and data analysis.

Although torque, center-of-mass, and rotational equilibrium are covered in lectures, the written instructions contain no theoretical analysis of the staircase. Thus, the student must either develop his own theoretical guide or rely upon his experimental skills. The following suggestions are provided in advance to help students find a solution within the one hour time period: (1) the maximum extension of any step is achieved when that step is just in-balance, (2) model and analyze the problem numbering the steps from the top (Fig. 1), (3) find a relationship between the step's number and its extension using graphical or curve-fitting techniques, (4) construct a theoretical table of staircase span versus number of steps for staircases having as many as ten steps, (5) apply the results of the model system to solve the specific problem assigned. After reading these suggestions, students came to an open lab where wooden steps, meter sticks, and an instructor were available. Before leaving, students had to make measurements and use graphical or curve fitting analysis so that they could convince the lab instructor of the validity of their specific solution.

Several features make this a successful "do-it-yourself" experiment. First, the visual effect of a well-placed demonstration staircase, with its top step extending well beyond the point of support of the bottom step, will pique the curiosity of most students. Second, simple ap-

Downloaded 28 Aug 2013 to 152.65.133.142. Redistribution subject to AAPT license or copyright; see http://tpt.aapt.org/authors/copyright_permission

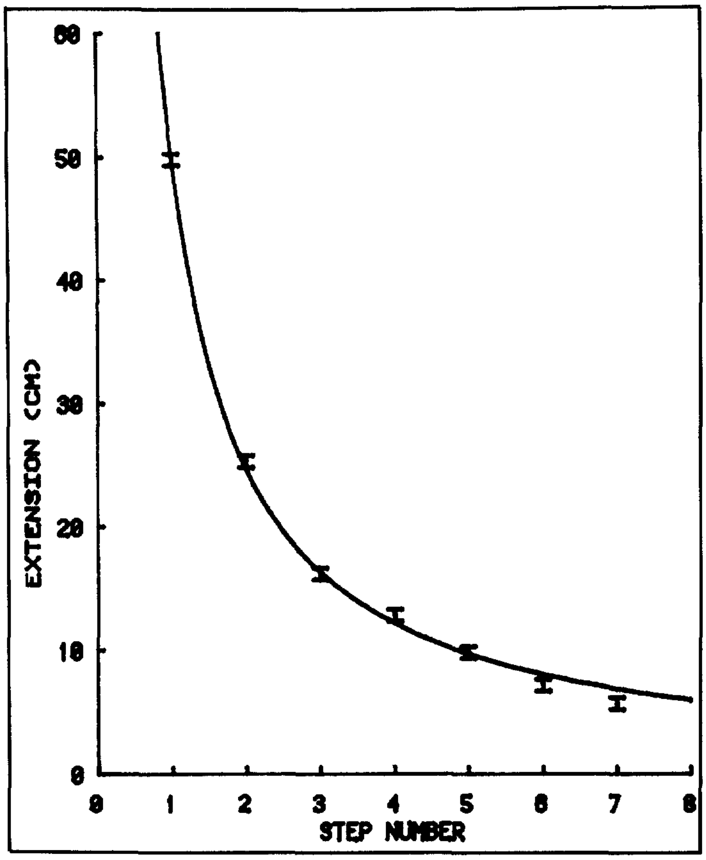

Fig. 2. Typical data for the staircase problem obtained with standard meter sticks. The distance that a step extends beyond its point of support is plotted versus the position of the step in the staircase as numbered from the top. The solid line represents a least squares fit (with 70% confidence level) using an inverse relationship [Eq. (1)].

paratus will yield good results (Fig. 2). Although we presently use wooden steps (25 x 25 x 1.5 cm), metal rules would be better since they are easily aligned and have a built-in scale. Finally, data can be taken and analyzed in a short time. The average student who has read the introductory material and planned his investigation, can finish within one hour.

Since most students who found the correct relationship empirically used it to solve their individual problems, there was little motivation to pass the "answer" to others. We deferred giving any student a theoretical explanation until all students had finished. At that time, those still interested were given the following solution: An object is in rotational equilibrium when supported at its center-of-mass. The center-of-mass positions of the first, second, ... nth composite object consisting of the top one, two, ... n steps of length "L" is $L/2, L/4, \ldots L/2n$. Thus, the maximum total span (S) of an n step staircase is the sum of these center-of-mass positions.

$$S = L/2 \left(\sum_{i=1}^{n} 1/i\right) \quad (1)$$

Student reaction to this experiment was mixed. It was rated slightly above average in the end-of-the semester written evaluations. Some students were quite enthusiastic. Several individuals, skeptical that trickery was not involved in the demonstration stack, couldn't wait to build one themselves, analyze the data, and find a theoretical explanation. Interviews with students and lab assistants disclosed that any negative feelings were generated by the "test-like" nature of the experiment (i.e., lack of detailed instructions). The popularity of this experiment could easily be increased by adapting it to nontesting uses, adding a theoretical analysis, and giving stricter guidance.

From our viewpoint, this mixed reception is less important than the students' realization that they could actually discover some worthwhile relationships using methods learned in their physics course. Thus, I rate this experiment a success and recommend it to you as either a lab test or an exercise in rotational mechanics.

References

1. P. B. Johnson, Am. J. Phys. 23, 240 (1955).

Answer to question on p. 650.

The topic of the course is "light" phenomena, and the subtopic is formation of images by a plane mirror.

Downloaded 28 Aug 2013 to 152.65.133.142. Redistribution subject to AAPT license or copyright; see http://tpt.aapt.org/authors/copyright_permission