



## **PSSC and me**

*by Jim Nelson*

It seemed like an easy task for a senior physics major at Lebanon Valley College. Dr. Rhodes, my professor, had each of us in his class select an experiment that had a significant historical impact on human understanding of physics. We were instructed to develop a presentation about the experiment, to present it first to our classmates, and then to students in other physics classes. Since it seemed simple and straight forward, I chose Young's two-point interference experiment. At the time, I thought I did a nice job drawing rays of light and then constructing similar triangles to show that the wavelength of light waves ( $\lambda$ ) can be calculated from other quantities that can be measured (i.e.,  $x$ ,  $L$ , and  $d$ ) using  $\Delta x = \frac{\lambda L}{d}$ .<sup>1,2</sup> In retrospect, I did not have a clue about what was really going on. Today we might say I could do the problem, yet I was unaware that I did not have a conceptual understanding of the situation.

And so it remained for a couple or years. After graduation from Lebanon Valley, I started graduate studies at Temple University, but lack of financial support after the first year led me to look for a job. It was late spring in 1961 and to my amazement; I was offered a position teaching science at Harriton High School, in Rosemont, PA. For the first two years I used a traditional physics textbook. Harold Ferguson was the science department chair and he was a pilot teacher for the new CHEM Study chemistry curriculum. He suggested that we visit Charles Smith who was teaching PSSC physics at Radnor High School in a district adjacent to ours. The meeting date was established and on that day Charlie Smith introduced me to the PSSC curriculum. I did not know it then, but this meeting had a significant impact on my teaching career. The next year I was using the PSSC textbook, first edition, as my class textbook.

I loved the textbook. It spoke to me like other textbooks did not. The textbook told a coherent story rather than the being an encyclopedic approach that was the custom. The curriculum reinforced for me the aspects of physics that I loved. Physics is interesting, logical, and challenging.

As I look back over my 45-year career as a physics teacher, I realize that the greatest impact that the PSSC program had on me was the philosophy of the PSSC laboratory component. The laboratory approach was to present many questions, but with no blanks to fill-in, encourage students to develop their own ideas and methods, consider the experimental design, and to coordinate the laboratory activities with the textbook. The

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<sup>1</sup>  $\Delta x$  is the distance between maximums or  $x/n$ ,  $L$  is the distance from sources to screen, and  $d$  is the distance between sources.

<sup>2</sup> I like this form of the two-slit interference equation. It helps student remember that the two "L"s (Greek & English) are in the numerator and the "d" is in the denominator. Like the PSSC philosophy, I realize that remembering equations is not the ultimate goal, but it is nice to be able to find a trick that help one recall the more fundamental relationships in physics.



laboratory activities stressed the nature of physics, the importance of measurement, and the analysis of laboratory data. In addition, the laboratory activities were very creative, used simple and available equipment, and I continued to use many of the laboratory activities for my entire career. I came to realize that the leading edge of understanding for me as well as for many of my students is rooted in experience. For students learning physics this experience very often happens in the laboratory. The “Preface for Students” in the *PSSC Laboratory Guide* states, “This Guide is designed to help you with your laboratory work. It provides a general introduction to the problems at hand, gives you technical hints, but leaves the thinking to you. ...Throughout this Guide you will find many questions. Finding the answer to these questions may sometimes require a little thought about what you have done before, or it may require a short calculation. Sometimes more experimentation will be called for. It is up to you to decide what to do in each case.”<sup>3</sup>

The book was divided into units and the second was “Optics and Waves.” Later I learned that Charlie Smith along with Walter Michels from nearby Bryn Mawr College had contributed a great deal to the development of this section of the PSSC curriculum. This became my all time favorite topic to teach and laboratory activity II-12 was titled “Waves from Two Point Sources.” To this day, I remember the first time I set up a ripple tank and looked at the resulting dynamic two-point interference pattern. The memory of my senior project came flooding back to me. Suddenly a light bulb went off in my head. I began to develop a conceptual understanding of Young’s experiment, and it was so much clearer to me. I have also learned that Young himself had developed a ripple tank demonstration to illustrate the experiment that now bears his name. In addition to this specific epiphany, this experience reversed my thinking about the role of the laboratory activity in teaching introductory physics. This is summarized by the mantra “The Laboratory Activity is the leading edge of the learning experience.” The “Preface for Teachers” in the *PSSC Laboratory Guide* states, “Most of the experiments in this Guide are so presented as to pave the way for reading the text. Thus, students can investigate physical phenomena rather than just verifying known conclusions. When a student performs experiments, the results of which are not known to him in advance, he gains a feeling of personal participation in the discoveries of science; both science and the role of scientist become more meaningful to him.”<sup>4</sup>

The first PSSC Unit, titled “The Universe”, was an introduction to physics as a human enterprise. The symbol of the American Institute of Physics shows a pendulum, a cylindrical mass, and a ruler. These are devices for measuring the basic physical quantities of time, mass, and space and the measurement of these were stressed in Unit I of the PSSC curriculum. I remember working with my students on laboratory activities measuring the distance to the smoke stack at Villanova University, using oleic acid to approximate the size of a molecule, and using a vibrating timer to measure short time intervals for the first time. Because the vibrating timer is a transparent, yet powerful way to connect graphs to real motion, the vibrating timer is still used by many teachers as a

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<sup>3</sup> Physical Science Study Committee, *Physics Laboratory Guide*, (Boston, D. C. Heath and Company, 1960), v

<sup>4</sup> *ibid.*



way of gathering data and analyzing motion. Real-time computer displays available today should not replace this but rather extend this experience for students.

Of all the equipment inspired by the PSSC project, I was most taken by the slinky and ripple tank activities in Unit II. In all, there are six activities using a ripple tank, which illustrate the basic properties of waves. After the Young's two-point interference simulation in the ripple tank, laboratory activity II-13 asks the student to do an elegant reproduction of Young's experiment using equipment that the students make themselves. The slinky and ripple tank photographs used in this unit on waves are shown in almost every introductory physics textbook available today. Although we can now supplement the teaching of one- and two-dimensional waves with computer animation, the Slinky and ripple tank are still important tools in the arsenal of the introductory physics teacher. The use of the semicircular disk for studying refraction of light by clear liquid is a gem. It shows how simple equipment can lead to quite sophisticated data analysis.

In fact the entire waves and optics section of PSSC was masterfully constructed to tell a story from the properties of light as developed during the laboratory activities to the models that explain these properties. This unit clearly illustrates how newly discovered properties lead to modification of the models used to represent light, and how the models lead to uncovering new properties of light. In essence, when using the PSSC curriculum, a student becomes a "junior physicist" discovering the wonder and rhythm of nature.

Other PSSC laboratory activities helped me and my students develop an understanding of the nature of physics, and have become a staple in contemporary introductory physics teaching. The laboratory for *PSSC Unit III, Mechanics*, originated unique and today ubiquitous activities including the introduction of the dynamics cart that is so common today, and expanded the use of the vibrating timer. The idea to use rubber bands to apply and vary the force to accelerate a dynamics cart was at once simple but very real to the student. A complete analysis of uniform circular force and motion was introduced using very common materials. Conservation of momentum was introduced by spring explosion between dynamics carts, and a delightful collision in two dimensions was provided that produced exceptionally good results for the students if they were careful and skillful with the apparatus. The idea of the kinesthetic learner was embedded in the PSSC laboratory activities long before this was an educational "buzz word."

*PSSC Unit IV, Electricity and Atomic Structure*, included laboratory activities on determination of Coulomb's Law, measuring the number of electrons in a coulomb, tangent galvanometer to investigate magnetic fields, and the measurement of the mass of an electron.

To say the least, I loved the PSSC program. I feel it made a grand contribution to teaching, had some of the most respected university and high school teachers involved in its development, changed the nature and role of laboratory activities for high school physics, and fanned the flames of curriculum development in chemistry and biology in the 60's.