Twenty Seven Years with PSSC

by McLaurin Smith-Williams [i]

Introduction

PSSC physics has been in use at Christian Brothers High School (CBHS) in Memphis, Tennessee since 1963. When the school moved to its present location in 1965, the physics laboratory was specifically designed for the PSSC laboratory exercises.

Fourth Edition PSSC at CBHS

When I came to the school in1978 after having taught for nine years in a public school in a small town in North Mississippi, PSSC had already been in use for a number of years. Class size was large. I had ninety physics students in three classes, one of them with thirty eight students.

We started using the fourth edition of PSSC which began with optics and wave behavior. The classroom had eighteen lab desks each seating two students and having a variable voltage AC and DC power supply which was invaluable for powering virtually any lab requiring DC power and eliminating the need for dry cell batteries. The small lamps used in many of the optics experiments had been purchased by a predecessor of mine for use with 1.5 V #6 dry cells of which we had several boxes With the desk power supplies, I saw little need for them (most were dead in any case) but quickly found out that no matter how much one cautioned students not to turn the power supply knob past a certain point or to keep the voltage range switch in the low (0-6 V) position the bulbs were being burned out at a rate that quickly exhausted my supply. Since the power supplies could produce a maximum voltage of 14 V on the high range, the purchase of 18 V bulbs from a local electronic supply house solved the problem. To this day I've yet to have one burn out. This would be first of many variations made to adapt the equipment on hand to the labs or the labs to the equipment.

PSSC used ripple tanks for studying wave properties . These were shallow glass bottomed trays about two feet on a side that would be filled with water to a depth of about 1 cm. A 150 W clear bulb in a cardboard housing clamped to a rod in the desk would be placed above the tank which was on a stand on top of the lab desk. The shadows cast by the waves on the desk top were used to investigate the refraction, reflection, diffraction and interference of waves. The lamps had a rather disturbing habit of getting hot enough to cause the cardboard housing to smoke and/or catch fire. With a request to the Brothers who lived on the campus to start saving 64 oz. juice cans from their kitchen and a few evenings in my home shop with a chassis punch and some black heat resistant paint we had new metal housings for the lamps that clipped on the bulbs.

To freeze the action and allow measurement of wavelength, students would rotate a slotted strobe wheel in front of one of their eyes. A predecessor of mine had built a variable speed rotating disk with a fluorescent orange stripe for training students to use the strobe disk. They would practice freezing the rotation and could see the rather interesting effects when the strobe frequency was an integer multiple of the rotational frequency.

Lab days with fifty-nine-minute periods, very large classes, and lots of water-filled ripple tanks were a crash introduction to classroom management and spill control. Although having taught for nine years, this was like basic training.

When we finished optics, which pretty much took one semester, we started mechanics. Lumber two-by-fours would be clamped on the ends of the desks which were about one and one-half meters in length to act as cart stops. Carts which ran on roller skate wheels would be pulled by stretching a rubber band over the end of a meter stick with a student trying to keep the stretch constant as he pulled the cart across the desk. Four students would be assigned to each lab station and even though one would be designated as "cart catcher" invariably the cart would collide with the bumper which would not have been clamped securely so that the cart and its contents (we used paper wrapped bricks to add mass) would go flying. As a result we would alternate the desks on which the experiment was run so that no two were in the line of fire, so to speak, with each other. To record its position each cart had a paper tape attached, running through a device with a disk of carbon paper and a small DC electric motor. As the motor rotated, a small chain attached to a wheel would beat against the paper tape leaving a mark. The position vs. time data that resulted was not all that good. It was difficult to keep the force constant and the tape timers could be troublesome to operate.

The rubber band towed roller skate wheeled carts have been replaced with Pasco cart tracks, smart pulleys (a pulley/photo gate connected to a computer interface for determining the cart velocity) and a falling mass to pull the cart (one has to be very careful in how this is presented, especially at this early stage in the course). Mechanics would pretty much exhaust the school year.

After several years of feedback from students in college, I decided to alter the sequence of presentation. Students were telling me that they could have handled optics in their college course had they not had it in high school although they also reported that they were extremely well prepared in it and that we needed to be covering electricity and magnetism. As a result, I started going to mechanics first and then electricity and magnetism. The fifth edition of the text adopted a similar sequence. We are now up to the seventh edition of the text.

Some Changes but the Lab Remains Central

Today, our class periods are 51 minutes in length with overall physics enrollment about the same, ninety or so seniors. The classes, however, are now spread over five periods meaning that the size is about eighteen per class. We start the course with the "Analysis of an Experiment" lab in the appendix of the laboratory guide. This consists of a set of data that is a function of two variables. By holding one constant and graphing the data as a function of the other in various ways the equation of the data is determined. This lab is an excellent tool for teaching graphing skills and an early warning radar as to what the ability level is for the current crop of students. On all labs, I insist on complete control of the data. All work is done in class and I take up the work at the end of the period. If more time is needed it is passed out the next day to be worked on again. This allows me to go around the room providing aid where needed. The process also prevents students simply copying one another's work. When completed the labs are fairly closely inspected for the "usual mistakes" such as incorrectly labeled axes or improperly calculated slopes or a number of others. There are about a dozen or so common mistakes I see year after year. Labs with mistakes are returned to the student as rejected and he is required to make corrections. Correct labs are retained. Students cannot simply copy the ones that are correct because I have those.

As an incentive, their grade in the course is held as incomplete until the lab is accepted. It is not unusual for a lab to be rejected several times before final acceptance and I encourage them to see me for assistance if it is rejected more than once. I also assure them that this process is normal and that in the course of the school year rejection of a lab and its eventual acceptance are just part of normal class procedure. The techniques used in this first lab are used throughout the rest of the course and I generally block out the first week of school for it.

To start chapter two of the text on motion along a straight line, I use a linear air track to generate a graph of position vs. time for a cart moving at constant velocity. I perform the experiment on the lecture desk, calling out the data to the students who record it and later graph it. I ask them to try and figure out the significance of the slope and the intercept of the graph and the relationship to the apparatus (the intercept being the location of the first of two photo gates that the cart passes through). After taking up these graphs, we elevate one end of the air track a fixed amount and repeat the experiment. After graphing the data, students immediately see that unlike the first graph, this is non-linear. After some explanation of instantaneous velocity and limits, we show how to draw a tangent to the curve (which most couldn't do) and ask them to find the tangent at a specified time and its slope. After taking that graph, up we reconfigure the set up using the same track elevation to measure the transit time of a small flag on the cart through a single photo gate placed at the same points along the track as previously. These data are used to produce a graph of velocity vs. time. After they find its intercept and slope, we discuss the significance (initial velocity of the cart and the cart's acceleration). The students are asked to find the area under the graph to the same time as used previously for finding the instantaneous velocity. I then pass out the previous position vs. time graph, and they compare the results they got with their tangent to the position vs. time graph to the velocity as read directly from the velocity vs. time graph. They also add the initial cart position to the area under the velocity graph and compare the result with the cart location at the given time as read from the position vs. time graph. This final cross check between the two graphs becomes the last lab of the series and is taken up. It is only then, after two weeks of working with lab data and graphs, that we open the text and start going over the problem sets.

The problem sets are the backbone of the present course. They are rigorous, accurate, with a solid physics base. It is in that process of going over them that I introduce most new material. One of the things I am particularly fond of is the use of pictures which are an integral part of the text and problems unlike in most texts where they are peripheral. One of the early problems asks for the position of a car in a photograph and this is used to introduce the students to the use of scale factors and measurements from pictures. This technique is used throughout the course with both photographs and videos.

Our laboratory classroom now has a computer stored in every other desk with a network connection that allows data to be sent to a color printer in the lab. A number of problems in the text lend themselves to demonstrations and these are done as we go over each problem. Using computer interfaces and equipment we have modified some of the old PSSC labs and replaced others with new ones. We still try to open each chapter with one or more labs and/or demonstrations. In the course of a typical school year, we cover mechanics (chapters 1-8) and electricity and magnetism (chapters 10-12, 23 and 25) working and discussing almost all the problems of those chapters.

We make liberal use of the “Mechanical Universe and Beyond” videos as well as the “Cinema Classics” which I have on laser disk. We even use some of the old film loops such as the Tacoma narrows bridge collapse with an ancient but still working film loop projector.

An Extension to the Course

Occasionally a junior takes the course and will request an additional year. As a result, we set up a Physics II course in which we cover all remaining chapters of the text. So far six students have completed that course and I recently received a rather glowing letter from one, now in graduate school working on his doctorate in chemistry, telling me how much he enjoyed the course and how useful it had been to him even in graduate school.

All of our optics equipment, including ripple tanks and strobe wheels that had been unused since changing the sequence of the course, are used for that program.

We had a great deal of fun with the new chapter on stellar distances, temperatures, and masses. I put my now outdated Polaroid camera to good use doing the photographic parallax lab in the lab manual. Some other old equipment in the lab that had been acquired over the years is put to use including an old microwave optics kit with reflex klystron (a vacuum tube microwave oscillator). In addition to the lab in the lab guide on absorption of light we did gamma ray absorption in lead sheets. Some rather ancient scalers and Geiger tubes were acquired many years ago as surplus from a nearby college, and I still use them with the regular physics classes for a demonstration lab on the radioactive half life of Ba-137.

Hard but Well Liked

With the exception of the honors level class which has a usual enrollment of 15 to 20, the majority of students taking the course would be described as average to slightly above average ability. Although algebra II and trigonometry are prerequisites, most of the students have poor mathematics skills. As a result I take nothing for granted and teach the necessary mathematics as an integral part the course. The course is well liked by students taking it even though it has a reputation for being “hard”; many report that it is their favorite course.

[i] *Physics Instructor, Christian Brothers High School, Memphis, Tennessee, 38120*