AAPT Guidelines for High School Physics Programs

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AAPT Guidelines for High School Physics Programs

The American Association of Physics Teachers is actively committed to the support of high quality physics education at the high school level. The following professional guidelines have been prepared to assist high school administrators and science teachers in establishing and developing reasonable standards for physics instruction in their schools.

The guidelines were developed by a task force established on behalf of the AAPT Section Representatives. A preliminary draft was widely circulated within the physics teaching profession for evaluation and refinement. These guidelines have been officially adopted by the Council of the American Association of Physics Teachers. They are to serve as minimum standards for high school physics instruction. Periodically, these guidelines are reviewed by the Committee on Physics in High Schools, a committee whose major concern is quality physics instruction at the secondary level.

Some exemplary programs are described in "Places Where Things Are Right!" Jack Wilson and Tim Ingoldsby, *Physics Today* 39(9), September 1983.

Preamble

The quality of a high school's physics program is determined in part by the quality of preparation and the overall workload of its teachers, along with the provision for adequate budgets, facilities, and support services.

Physics teachers must do many different things, and do each of them well, in order to create an optimum setting for good physics teaching and learning. One essential component of physics education is student involvement in physics experiences and activities. Teachers and administrators must be aware that such student involvement does not just happen. It will only occur if professional development and growth opportunities are available to stimulate teachers' expertise. Teachers must seek such opportunities to expand and enhance their professionalism. Regardless of other assets the physics program cannot be strong without these elements.

While there is no complete definition of quality in describing a high school physics program, the AAPT regards certain components to be essential:

- A broad appealing course in physics which is not totally dependent on advanced mathematics should be offered for the average students.
- Laboratory activities, in which each student gets "hands-on" experience, are necessary to enhance higher understanding of physics concepts.
- Appropriate opportunities for gifted students to develop their scientific abilities should be offered in all high schools through special projects and activities.
- Support for professional growth enables teachers to remain vigorous and current in their knowledge.
- Working conditions must be such that teacher's professional needs are fulfilled.

The guidelines are described in more detail on the following pages.

Teaching Load

Guideline #1: ***Five Classes with No More Than Two Differing Science Preparations Should Be the Maximum Teaching Load.***

In small schools where several preparations are required of the teacher, the teacher of physics should have a limit of only two science preparations. Any additional preparations should be from a related area such as mathematics. A teacher of physics, to be effective, must be able to devote sufficient time to the laboratory. Time is required for preparing demonstrations, setting-up laboratory sessions, maintaining equipment, and for correcting homework, tests, and laboratory reports.

Guideline #2: ***The Maximum Student Load Should Depend on the Number of Teacher Preparations.***

The teacher with laboratory preparation and evaluation cannot do an adequate job of teaching and evaluating students if required to teach more than 125 physics students in one semester. This number should be reduced considerably if the laboratory activities are diverse in makeup. For example, if 125 is an appropriate number of students for a teacher who devotes the entire day to physics, 100 would be reasonable if this same teacher is responsible for both physics and chemistry classes. Supervision of student research projects and other science activities should be considered in assigning the overall workload.

Guideline #3: ***The Number of Students per Class Should Not Exceed the Number of Laboratory Stations.***

The optimum size of a physics class depends as much on facilities and safety as on the workload of the teacher. The typical high school physics class should have an absolute limit that is determined by the number of laboratory stations and the design of the room. The conventional limit is 24 stations. Other limiting factors for laboratory class size are the effective supervision of the students in laboratory procedures and strict monitoring of safety practices. One physics teacher with the aid of trained paraprofessional assistance could adequately supervise and instruct more students if space and equipment are available.

Guideline #4: ***The Additional Task of Maintaining the Laboratory, Equipment, and Facilities Should Be Interpreted as Equivalent to One Class Period.***

The laboratory represents the equivalent of another preparation or extracurricular assignment. Laboratory sessions require equipment set-up and take-down time, checking procedures, and grading student reports. Equipment also requires maintenance and repair. It should be pointed out that most laboratory responsibilities have to be performed at the school site and cannot be taken home to be done after school hours.

These responsibilities and requirements of the physics teacher should be considered in assigning teacher loads and extracurricular duties.

Guideline #5: ***An Effective Physics Teacher Blends Demonstrations into the Classroom Instruction.***

The use of demonstrations by the classroom teacher is an effective means to illustrate the phenomena of physics. Performing demonstrations by the teacher requires additional planning, preparation, and clean-up. This instructional technique should also be considered when teacher work loads are assigned.

Guideline #6: ***The School Should Employ Teacher Aides and Secure Student Help to Extend the Effectiveness of the Teacher.***

A teacher aide is defined as any para-professional assistant employed to work with the physics teacher and would include secretarial aides and laboratory aides.

Every effort should be made by the school to employ para-professional personnel and student help to assist the teacher in presenting classroom and laboratory experiences.

A very effective way of supporting an active laboratory and project-oriented program is through the use of student assistants. Students who would otherwise be in a study hall can contribute markedly to a science program and in turn benefit from continued exposure to one of the sciences. Duties of these assistants could include setting up and taking down equipment, keeping the storeroom, and making minor repairs on equipment.

Clerical assistance should be made available, especially to a teacher who produces teaching materials for the classroom. These materials, as well as budget and inventory, could be given to this kind of assistant for typing.

The school district should provide an opportunity for summer employment of the physics teacher to work on curriculum changes, repair laboratory equipment, construct laboratory apparatus, and prepare new physics teaching materials. These tasks require a great deal of time often not available during the academic year to the physics teacher who teaches a full class load and sponsors extracurricular activities.

Para-professional personnel could be employed during the summer to assist the physics teacher in developing and producing teaching materials.

Volunteers should not be overlooked. Retired individuals are very useful and effective if used on a regular basis. Often secretarial and scientific assistance may be obtained from school volunteer organizations for the high school level.

Curriculum

Guideline #1: ***Within a Given School, There Should Be Offered a Variety of Physics-Related Subjects That Appeal to a Wide Group of Students.***

Personally fulfilling science learning experiences and post high school goals help determine students' interest and growth in science, and certainly in physics.

Since our society is becoming more and more dependent on technology, each school has an obligation to offer at least one broadly appealing physics course which is open to most students, and which will result in a better-informed citizenry. This course would not be based upon advanced mathematics and would provide a third-year science course to complement biology and chemistry. A reduction in the math used, a greater emphasis upon laboratory experience, and a grading procedure guaranteed not to penalize students, who have chosen physics over other alternatives, would encourage a larger fraction of the student body to take a physics course.

A second physics course could be offered for the highly motivated and well-prepared student who intends to go on to college and perhaps major in a science or engineering area.

If the school so desires, a third course could be advanced placement physics or advanced physics, provided there is a strong supporting mathematics program.

Teachers, in schools where scheduling is a problem and where only one or two physics classes are offered, could individualize the instruction in such classes to meet the needs of heterogeneous grouping.

Guideline #2: ***The Teacher Should Have the Primary Responsibility for Making Curriculum Decisions.***

The teacher of physics should have a strong voice in the selection of the text used in the course. The physics teacher, the subject matter expert, should be consulted and should be given a voice in curriculum studies and decisions for the school. Texts, curriculum materials, and equipment must be kept up-to-date. All materials and equipment should be reviewed and evaluated at least every five years. In reviewing materials, teachers should carefully consider national physics curriculum programs and publications of AAPT. Each of these materials contributes unique features to the teaching and learning processes of high school physics. Many commercial text revisions and programs supply good curriculum materials.

Teaching techniques and learning styles must be reviewed periodically. Administrators should keep this is mind when setting up in-service training and when recruiting new teachers. The classroom teacher is more likely to be cognizant of new and alternative procedures through reviewing new texts, and reference and teaching materials. By being a member of professional societies and receiving such publications as *The Physics Teacher* of the American Association of Physics Teachers, *The Science Teacher* of the National Science Teachers Association, or the *Journal of Chemical Education* of the American Chemical Society, the physics teacher will be informed of the latest

curriculum developments, teaching procedures, teaching materials, texts, and equipment.

School districts and their administrators should see that professional journals are placed in their school libraries for both students and teachers to use.

AAPT has developed several workshops that attempt to respond to new curriculum changes encountered by the physics teacher and learning strategies confronted by the student learner. For information on AAPT Workshops, write the AAPT Business Office at the address on the inside front cover.

Workshops Include:

- Computer Game-Paddle-Port Laboratory Interfacing
- Computer Programming in Basic and Pascal
- Computational Methods used in Physics
- Current Research in Teaching and Learning Physics
- Lecture-Demonstration Techniques
- Developing Student Confidence in Physics
- Laboratory Skills and Techniques
- Industrial-High School Cooperative Ventures
- Leadership Skills and Workshop Management
- Instructional Media in Physics Teaching
- Materials for the Underprepared Teacher
- Laboratory Experiments Using Photovoltaic Cells
- Special Topics Tutorials

Professional Growth

Guideline #1: ***An Extensive In-Service Program Should Be Developed to Help Teachers Grow in Both Subject Knowledge and Teaching Procedures.***

All physics teachers need assistance from time to time in developing new programs and procedures. Many physics teachers have backgrounds in areas other than physics. These teachers, along with beginning teachers, need the assistance of a Master Teacher or science consultant in helping them solve problems. Physics courses such as PSSC and Project Physics require special training in initiation and effective implementation of the programs.

Modern technology, such as the use of the computer or video disc in the laboratory and classroom, introduces a new area for training and curriculum development.

Administrators should provide both consultants and time for in-service training when needed.

Physics Teaching Resource Agents (PTRA) have been trained and certified by AAPT to serve as leaders of workshops in areas that improve teaching skills and content knowledge. For names and addresses of PTRAs, write to the address on the inside front cover.

Guideline #2: ***Budget Provisions Should Be Made for Professional Travel.***

Professional growth is of supreme importance in the science areas. Release time and financial assistance should be provided to the teacher for participation in subject matter or teaching style workshops and to attend professional conferences. This is of extreme importance in schools where physics teachers are otherwise removed from interaction with professional physicists or other physics teachers.

If the teacher is to keep abreast of the rapid changes in physics and in the teaching of physics, the opportunity to attend professional meetings is important. All should have the opportunity to attend national, regional, or local meetings.

Teachers of physics must be encouraged to get together even on a limited geographical basis so that they can visit, exchange classroom ideas, and work together in implementing programs and designing new materials.

Each school's budget should include monies for the expenses incurred by the physics teacher who participates in professional activities designed to promote the science teacher's growth. No teacher should be forced to forfeit pay to attend professional meetings.

Teaching Facilities

Guideline: ***The Teaching of Physics Requires a Variety of Facilities That Are Readily Available During the Teacher's Preparation Time as Well as Class Time.***

Effective instruction in physics at the high school level requires active and significant participation in laboratory activities in addition to formal classroom work. Physics is an experimental science; therefore, a laboratory facility is an absolute necessity in teaching and learning physics. The AAPT has found that in some areas of the country, physics is not considered a laboratory course. This is comparable to trying to teach music without having students sing or play musical instruments or to a physical education program in which students have no physical exercise! The AAPT offers the following guidelines regarding teaching facilities to indicate the minimum requirements for a quality high school physics program. All classroom, laboratory, reference, and project space must be under the supervision of the classroom teacher.

Guideline on Classrooms:

The classroom and associated areas should have full audio-visual capabilities. Many audio-visual materials are now an integral part of the teaching and learning processes.

These materials should not be in an area far removed from the classroom since this practice reduces their usefulness.

The classroom must have adequate chalkboard space with a high quality surface and bulletin board space for science posters, science announcements, career information, and scholarship bulletins.

Guideline on Apparatus:

Much teaching and learning of physics is impossible without appropriate apparatus. The opportunity for active student involvement with equipment in a laboratory or experimental setting is essential. Since the cost of equipment or safety requirements may prohibit such student use, the room should have the capacity for apparatus demonstrations by the teacher. The classroom should be arranged so that all students can clearly see the demonstration. The room should be equipped with adequate demonstration space, and electricity, gas, and water should be available. Demonstrations provide a second valuable use of existing apparatus.

Guideline on Equipment Modernization:

Most physics equipment has the capacity to endure forever, often to the point that it and the course both look out of date. Old working equipment is appropriate for use in physics courses, but at the same time, students in their physics courses should encounter equipment as modern as the budget will allow. The absence of modern equipment may adversely affect students' attitudes toward the class. This is especially true in the case of modern measuring techniques which employ solid state circuits with digital readouts. Equipment should be kept in repair and unrepairable items replaced as needed.

Guideline on Laboratories:

There must be adequate laboratory space—separate or finite in an open setting. Whether it be a single area or multiple areas, it should be:

- available to the teacher during the planning/preparing period;
- available to students for special projects, makeup laboratories, etc., outside their regular physics class hours.

If extensive project work is done, a separate area where equipment may be left undisturbed is needed. If laboratory space is to be shared with other types of classes, the sharing course should be a non-laboratory subject, such as math, so that equipment may be left undisturbed between physics classes.

A more complete set of guidelines for laboratory space and conditions may be found in the December 1974 issue of *The Physics Teacher* (Gibson and Layman), "The Ideal Introductory Physics Laboratory."

Laboratory space separated from the classroom area provides an added safety factor both for students and equipment.

Recommended physical conditions in the laboratory:

- Laboratory size must be large enough so that all students can participate in real, hands-on activities.
- There must be adequate ceiling height and means for hanging apparatus.
- Tables with flat tops (no fittings are needed) are necessary for mechanics experiments which require a surface clear of obstructions.
- Sinks, water, gas, and electricity may be provided around the perimeter of the room; safe and convenient to the tables.
- Adequate lighting with light-dimming capabilities should be available.
- The ability to darken the laboratory thoroughly is required.
- Safety equipment requirements are not as stringent as for chemistry, but equipment should include a fire extinguisher and safety goggles. This may be very important if physical science is to be taught in the same laboratory. **Every laboratory should have a first-aid kit.**
- Safety-check procedures should be developed for the physics laboratory. Safety checks should include electrical apparatus, suspension systems, lasers, radioactive sources, and radiation-monitoring equipment. There should be a maximum of two years between safety checks.

Guideline on Special Space:

Apart from the classroom and laboratory, other specialized space must be considered. A darkroom, which may double as a light laboratory, is very useful. A shop or shop area is helpful for constructing and repairing equipment. This shop area should be designed to accommodate two kinds of activities: general mechanical work and electronics and electrical work. Basic tools should be available and maintained. Essential supplies should be kept in stock.

Adequate storage space must be available for equipment and materials. Adequate storage prevents unnecessary breakage and allows immediate accessibility.

Project space of some kind must be set aside for special experiences. If space is limited, part of the storage area may be used for projects.

Student assistants and aides must have their special space in which to work, but still be available to the teacher.

References play an integral part in laboratory and classroom work. General reference works may be kept in the library or media center, but some should be found in the classroom and in an area of the laboratory. Other teaching and learning aids, such as calculators, audio-visual materials with equipment, and computer terminals, may be shared with math and chemistry teachers. Conference and small group work space may also be located here.

Printed Resources

Guideline: ***A Vast Array of Physics Reference Materials Has Been Developed for Teachers and Students.***

Examples of printed materials that should be found in classrooms and libraries are:

For Teachers

- *Demonstration Handbook for Physics*, Freier & Anderson (AAPT)
- *Teaching Physics Safely*, Peterson (AAPT)
- *Resource Kit for the New Physics Teacher*, (AAPT)
- *Teaching Introductory Physics*, (AAPT)
- *Products Catalog*, (AAPT)
- *The Physics Teacher*, (monthly publication—AAPT)
- *The Science Teacher*, (monthly publication—NSTA)
- "An Evaluation of High School Physics Laboratory Manuals," Ernest Kuehl, et al., *The Physics Teacher*, **32**(4), 1984.
- "Physics Texts: An Evaluative View," Jean Brattin, et al., *The Physics Teacher* **20**(8), 1982.
- "On Selecting a New Text—A Symposium," *The Physics Teacher*, **20**(8) 1982.
- "A Curriculum Survey of High School Physics Courses," Will Pfeiffenberger and Gerald Wheeler, *The Physics Teacher*, **22**(9), 1984.

For Students

- Physics of Technology Modules, (AAPT)
  The Bicycle
  The Laser
- Issue-Oriented Modules, (AAPT)
  The Physics of Weather Modification
  Fission Reactors
- *Scientific American* (Monthly publication)
- *Discover* (Monthly publication)
- *Science 86* (Monthly publication)

Budget

Guideline #1: ***The Teacher Should Be Given an Adequate Budget.***

Each teacher should be given a budget with which to maintain physics equipment and to purchase apparatus to complement ongoing projects or classroom work. The teacher needs to know the amount of money made available so that equipment and materials may be acquired within the set limit.

Physics is a laboratory course. Without adequate laboratory experiences, learning is inhibited.

AAPT suggests a scale for minimum budget requirements. A proper starting point for a completely unequipped physics laboratory can be easily obtained by examination of science catalogs which give a list and cost of basic apparatus. Often teacher editions of physics laboratory manuals have a listing of required equipment and supplies. Many states have science consultants to assist in setting up new laboratories. The cost of the basic apparatus should be the absolute minimum for the first-year budget.

Guideline #2: ***The Minimum Budget for Equipment and Supplies Should Be Based on the Current Purchasing Power of the Dollar Plus an Additional Amount per Student for Each Student in Excess of One Section.***

AAPT recommends that the minimum per-year expenditure (1986) be $1000 and be increased by $9 per student for each student taught in the laboratory exceeding 25 students. A physics laboratory with 125 students should have a budget of $1,650. This is a minimum. A more appropriate figure would be based upon $20 per student. This expenditure is for supplies and maintaining equipment above the cost of basic equipment and apparatus.

The 1986 cost of a student text is about $30. A laboratory manual and notebook cost an additional $10. AAPT believes that the experiences in the laboratory are worth the additional expenditure.

Guideline #3: ***The Budget Priorities Must be Set by the Teacher.***

The physics teacher should go over the budget items with those responsible for budget procedures in the school. This would assure the teacher that it will be possible to get those supplies that are absolutely required for teaching the laboratory course. The teacher can better plan the laboratory experiences knowing the materials will be available.

Guideline #4: ***The Budget Priorities Should Be Modified Only with the Cooperation of the Teacher.***

Modification of the budget with the cooperation of the teacher assures that the consequences of deleting items are understood by the administration and the teacher. An expensive piece of equipment may be rendered useless if requested replacement parts or auxiliary equipment necessary for operation are deleted.

Guideline #5: ***No Budget Can Be Considered Complete Unless It Contains Petty Cash for Local Purchases.***

Many items can be purchased locally at a cheaper cost. Some items which are needed quickly, such as fuses or film, have to be purchased at a local store. Funds for local purchases should be a part of the science budget to ensure the teacher's reimbursement for these purchases.

Guideline #6: ***A Budget Must Provide for the Unanticipated Repair of Equipment.***

Funds to fix or repair equipment which breaks during the school year should be a part of the physics teacher's budget. It is bad business to allow an electronic balance to sit unused on a shelf because the budget did not cover repairs. Equipment is purchased to be used and a part of the budget should be set aside to keep it in operation.

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