5/92
Newsletter

An NJAAPT Response to the Physics Proficiencies

The members of the New Jersey Section of the American Association of Physics Teachers (NJAAPT) are deeply concerned about the minimum proficiencies that have been selected for New Jersey's physics courses. While it is certainly appropriate to set some standards that must be met before a course can be designated physics, including both content and process, we have great misgivings about the particular proficiencies being imposed.

With a membership of almost 300 high school, college and university teachers committed to enhancing the quality of physics education in New Jersey, NJAAPT is one of the most active groups in the nation. It continually brings into the state the researchers who are doing carefully documented scientific studies. These studies determine the kinds of materials and techniques which most effectively develop both an understanding of basic concepts and an interest in physics itself. We are conversant not only with various innovations in content and methodology (under National Science Foundation Grants all over the nation), but also with their success or failure. The proficiencies, as written, do not reflect an awareness of much of this work.

All of the modern theories on teaching and learning, in physics as well as other disciplines, indicate that exposure is a meaningless exercise. Rather, we need to aim at some predetermined degree of mastery using a variety of techniques. Some, such as cooperative learning and guided practice, are universal. Others, such as the use of concept-based laboratory experiences and concept-driven problem solving techniques, have been developed quite specifically in and for the physics teaching community.

According to the test scores, which have touched off much of the recent concern about education, each year students arrive in our classes with weaker critical thinking skills. In addition, as we expand the base of students taking physics, the average level of preparation is necessarily lower. As a result, we need to spend even more time on fewer topics to allow students to develop an understanding that will enable them to think critically about those topics. It is not until some basic mastery has been achieved that higher thinking skills can come into play.

A common complaint among physics students is that although they have somehow learned to do all the rote problems and answer the questions they have no idea of what it all really means. They are overwhelmed, discouraged and, finally, fundamentally bored by an encyclopedic collection of topics.They may have developed some new vocabulary, but have no sense of ownership.

A beginning reader must develop some sight vocabulary and expertise at syntax, but the excitement, the delight comes when it is possible to read a story and think about its meaning. Physics is no different. If we want students to think about a concept, to be able to see its implications, they must have time to go beyond the superficial "sight vocabulary" and "read" the story for understanding. It is therefore imperative that we keep the minimum proficiencies truly minimum so that teachers can empower their students to strive for depth in a few areas rather than a "sight vocabulary" in many, to have the sense of ownership about a few science concepts that a reader does about a few favorite books. The proficiencies as they stand do not do this.

In a very fundamental way, inappropriate proficiencies deny both the professionalism and the humanity of a teacher. They can imply that the teacher is capable of choosing neither the particular content nor the emphasis that it should be given. Teachers are best able to model delight in learning when sharing with students topics that reflect their own interest and expertise. Good proficiencies must provide a range of options that make this possible.

In the present version, the proficiencies are problematic both in concept and content. In concept, they do not set an extremely narrow base of major topics and offer an optional selection amongst others. In addition to this general problem, the proficiencies, as stated, have many specific difficulties.

(Continued on next page)

While many of the process items are indisputably appropriate, some seem a bit strange. Appearing under process but never mentioned in content, are the entire areas of mechanical energy and heat energy. Maxwell's laws are never reached until the second semester of calculus-based physics courses.

The format of the content section implies that all eleven items listed are of equal importance. All of mechanics is one item, while four items (2-5), which could be grouped as simply "waves and light," are listed separately. Many parts of the item list are simultaneously too extensive and too detailed. Some, such as the direction to "apply Galileo's analysis," need an explanation of just what "analysis" is being applied. Some topics, such as longitudinal waves, have never been in the mainstream of physics courses, although they appear, often gratuitously, in every text. A few, such as diffraction, photo-electric effects, and line spectra, are sometimes touched on but carry nowhere near the importance of many subtopics of mechanics. Three items dealing with electricity and modern physics, (9, 10, 11), are extremely specific and could almost be couched as single questions to be answered in a brief essay. The eleven items need pruning and regrouping. Most importantly, in order to address effectively individual learning styles, teachers must be given the freedom to vary and refine the strategies used in both teaching and assessment.

Universally recognized proficiencies may well be important in assuring that "physics" appearing on a transcript has some concrete meaning in terms of a body of knowledge and understandings. It is vital, however, that in creating these proficiencies we not create a monster that will debilitate both our teachers and our students. NJAAPT certainly shares with the state a vital interest in encouraging every student to be not only successful at, but intrigued by the study of physics. We have chosen to teach physics because we delight in sharing it with students. Physics is not only a course in which students expand their fund of information and their depth of understanding of science. A well structured physics course is also a vehicle through which students can enhance and enjoy the power of their own minds.

We urge you to reconsider these proficiencies before imposing them. We believe that, as they stand, they are not appropriate. We would welcome an opportunity to work with you to make the empowerment they were intended to be.

* * *

PHYSICS CORE PROFICIENCIES

Overview

A. Definition of Physics

Energy and matter are the only observable things in the universe and are really the same thing. Matter is an extremely compact form of energy. The universe is a space-time continuum that is defined by matter-energy. In the belief that nature is governed by a few basic laws, the science of physics is founded upon discovering the interactive relationships of matter and energy.

Proficiencies

Proficiencies that emphasize the process of physics

Upon completion of a high school physics course, the student will be able to:

1. Use a geometric , algebraic, or physical model to explain or predict outcomes for systems considered in the content proficiencies and recognize that they are dynamic in nature.

2. Recognize and quantitatively apply the conservation principles of momentum and mechanical energy to explain and predict outcomes of one-dimensional, two-body interactions.

3. Recognize and qualitatively use the conservation of energy (mechanical, heat, electrical) and the concept of entropy to demonstrate the transformation from one form of energy to another.

4. Recognize the interrelationships, synthesis, and historical context of major breakthroughs in physics, such as the work of Copernicus, Galileo, Newton, Maxwell, and Einstein.

5. Recognize the error in measurement in light of their knowledge of the limits of precision in a given instrument and identify reasonable outcomes and predictions based on measurements with the instrument.

6. Identify the frame of reference when observing physical phenomena.

7. Realize the universality of physical laws by recognizing laws as they operate in different circumstances and/or environments (e.g., universal gravitation).

8. Realize the universality of physical laws by recognizing the basic assumptions associated with the application of laws (ideal vs. real, e.g., no friction).

9. Apply a problem- solving technique while conducting inquiries by:
   a. formulating a problem or question that can be analyzed,
   b. setting up proper experimental conditions for solving the problem,
   c. following proper and safe experimental procedure,
   d. analyzing observations,
   e. interpreting and describing this analysis, and
   f. evaluating the results against the original question.

10. Apply the tools of physics in conducting inquiries such as:
    a. Using the instruments normally found in a high school laboratory, including analog meters, to collect and organize measurements of physical variables.
    b. Describing gravitational, electrical, and magnetic effects in terms of fields.
    c. Using the International System of Units (metric system) in measurement and problem analysis.
    d. Using mathematical, simple statistical, and graphical models. Identify patterns and relationships that can be found directly from a given set of measurements.
    e. Adding and subtracting displacement, velocity, and force vectors by graphical methods.

11. Use core course concepts to make informed decisions regarding technological applications, career goals and opportunities, and safety well-being.

Proficiencies that emphasize the content of physics.

Upon completion of a high school physics course, the student will be able to:

1. Apply Galileo's analysis to describe and Newton's Laws to explain the motion of single objects (including the special cases of: linear motion, projectile motion, uniform circular motion, and universal gravitation).

2. Qualitatively identify or predict the transport of energy and the reflection, refraction, or interference of both transverse and longitudinal waves.

3. Describe the reflection and quantitatively represent the refraction of light at an interface in terms of the principles of reflection and refraction.

4. Apply knowledge of reflection and refraction of light to relate the path of light to the geometry of plane and spherical surfaces and to find the path of light through a converging lens with given foci.

5. Qualitatively apply an appropriate model (e.g., particle, wave, or photon) of electromagnetic radiation to account for reflection, refraction, interference, diffraction, photoelectric effect, line spectra.

6. Describe static and current electricity as it occurs in experimental and day-to-day settings.

7. Apply the mathematical expressions of Ohm's Law and electric power to account for experimental observations of single resistors.

8. For the simplest case in electromagnetism, qualitatively describe: (A) the effect on a charged particle moving through a magnetic field, and (b) the magnetic interaction of two current-carrying wires.

9. Recognize the fact that electromagnetic waves are generated by accelerating charge.

10. Describe the equivalence of mass and energy implicit in the relationship $E = mc^2$.

11. Describe the sources and effects of ultraviolet, gamma, alpha, beta, infrared, and cosmic radiation.