A Comparison of AP and IB (HL) Physics Curricula

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Abstract

This brief document presents a comparison between AP and IB HL Physics curricula and offers an opinion that both programs represent excellent examples of intensive physics sequences. We recommend to continue offering AP Physics C and IB Physics HL, emphasize some of the stronger components of both programs and conclude that the ideal physics curriculum would combine the best elements from both programs.

1 Introduction

In this document we summarize our findings about AP and IB physics curricula. First we briefly inspect the topics covered in AP and IB curricula, then we offer a comparison between these two physics programs followed by the executive summary of college credit policies and related issues. We conclude that USC should continue offering two best advanced physics curricula: AP Physics C and IB Physics HL.

2 AP Program

AP Physics [1] developed by College Board offers three different courses: AP Physics A is a class that introduces the students to general physics concepts, this class is best described as "Physics for Poets", it is out of the scope of this brief review and is mentioned here for the sake of completeness.

AP Physics B is a class that covers many of the most important concepts in physics including Newtonian (*i.e.* classical) Mechanics, Fluid Mechanics and Thermal Physics, Electricity and Magnetism, Waves and Optics, and Atomic and Nuclear Physics. AP Physics B is the so-called "non-calculus-based" physics class which means that no AP Calculus course is required to be taken in parallel. This class is suited for future college students who plan to major in biology and other life sciences, medicine, geology and related areas. AP Physics B provides a broad outlook of the field of physics, and its role in natural sciences and the society at large. AP Physics B has been criticized by National Research Council for trying to cover too many topics in one year and is not recommended. Currently, this AP class is not offered in USC.

AP Physics C provides a very thorough and systematic coverage of two areas of physics: Mechanics and Electricity/Magnetism. This class is supposed to be taken simultaneously with AP Calculus AB or BC. Physics C emphasizes the mathematical apparatus necessary for a future physicist or an engineer. Because of demanding nature of AP Physics C, many schools (though not USC) spend the entire year studying only Newtonian Mechanics. This is justifiable because Mechanics and Electricity/Magnetism are two separate AP exams. AP Physics C is best described as the first semester of physics sequence for future physics and engineering majors. The strength of AP Physics C class is in its mathematical rigor.

All AP Physics classes are one-year long sequences, however, College Board strongly recommends that both Physics B and Physics C be taught as second-year physics courses. This makes a lot of sense because both classes are quite demanding and require some familiarity with basic ideas of physics and its role in natural sciences.

3 IB Program

IB Higher Level (HL) Physics [2] is a two-year sequence developed by IBO and currently offered in USC. IB Physics HL includes Newtonian Mechanics, Thermal Physics, Waves, Electricity and Magnetism, Atomic and Nuclear Physics. IB Physics HL covers all these subjects more thoroughly with more time allocated to each topic than in AP Physics B. IB Physics HL also requires students to learn at least two from four additional topics, not covered by AP Physics B/C. These additional topics include Biomedical Physics; the History and Development of Physics; Astrophysics; Special Relativity and General Relativity.

IB Physics HL provides a broad overview of physics, most importantly including topics from college-level Modern Physics class (usually taken by physics majors during sophomore year). The main goal of this class is to make a student well-familiar with a variety of important topics that any educated person living in 21st century should know about. Particular topics we would like to emphasize are Biomechanics, Radiation in Medicine, Medical Imaging, Introduction to the Universe, Cosmology, the Principles of Special Relativity (which are critical for modern technologies such as GPS and particle beams), General Relativity and the theory of the Big Bang.

Cosmology and General Relativity offered in the framework of IB Physics HL are among the hottest topics in today's physics – both fields are critical for understanding the recently confirmed continuous acceleration and expansion of the universe. The 2006 Nobel Prize in Physics was awarded for experimental studies of the cosmic microwave background radiation which allowed us a glimpse at the universe right after the Big Bang. These important physics topics are covered by IB Physics HL curriculum. Therefore, the strength of IB Physics HL program is in its close connection to today's most important topics in physics and technology.

4 The Comparison

AP Physics B and IB Physics HL are probably best suited for future college students who plan to major in any field of science but physics. This may be so because physics majors will have to spend (at least) four college years taking classes on a variety of above-mentioned topics studying each in thorough detail. Therefore, it might be a good idea to

start concentrating on just one or two topics (such as Mechanics and Electricity/Magnetism, *i.e.* AP Physics C) while in high school. However, there are different schools of thought concerning this issue. Studying Mechanics or any other subfield of physics in detail could be extremely boring for the students. The most important concepts could be easily obscured by tedious calculations needed to solve the problems and by the amount of effort required to overcome common difficulties with calculus.

Solid knowledge of Newtonian Mechanics and Electricity/Magnetism is important. However, Physics Panel formed by the National Research Council's Committee on Programs for Advanced Study of Mathematics and Science in American High Schools expressed a strong opinion [3] (shared by the author of this document) that the most important objectives for advanced study in high school physics should not be tied to particular topics. Instead, the panel was concerned with general dispositions, abilities and habits of mind that have to be developed when taking physics in high school. In Panel's opinion the most important goals should be sustaining the excitement, interest and motivation for further study in physics, the encouragement of scientific imagination and creativity, the development of intuition and general reasoning in the framework of theoretical principles, experimental investigation and scientific method. In our opinion, AP Physics B and IB Physics HL are best suited to achieve these goals, however, AP Physics B (which is not currently offered in USC) compresses too much difficult material in one year and lacks important connections to today's physics.

To summarize, we would recommend future physics and engineering majors to take AP Physics C while any other student should take IB Physics HL. Most likely, the latter student would not need to take any other general physics classes in college. Of course, we assume that a student actually learns the material and proves his or her knowledge by performing appropriately on the tests.

We should remark, that our recommendation is very general and is somewhat simplistic – both AP and IB Physics are often poorly implemented in high schools and nothing would help the students when this is the case. The suitability of each advanced physics program for a particular school district is the subject to local conditions, constraints and, most importantly, the adequate training of high school physics teachers. National Research Council, faculty in physics departments and teaching-of-physics professionals all across the country strongly agree that well-trained physics teachers are desperately needed for advanced physics programs. No successful advanced physics program is possible and no curriculum would offer the "silver bullet" when good teachers are not available.

Finally, when well-trained teachers are available, in our opinion the best advanced physics curriculum would be provided by a combination of strongest elements of AP Physics C and IB Physics HL, namely, the strength of the former in calculus and the breadth of the latter in topics most relevant to emerging technologies and the actively developing subfields of physics such as biophysics, condensed matter physics, astrophysics and cosmology.

Before we conclude, we would also like to address some cultural issues discussed in the next section.

5 College Credit and Beyond

Only admission officers and faculty advisors would be able to make definitive statements about each particular college's policies concerning awarding students college credits for their advanced physics classes. However, taking into account the author's experience with Pitt's policies, this is what would (on average) happen to a physics or an engineering major:

- AP Physics B or IB Physics HL classes could be used to satisfy some general education requirements (these are fairly complex and there are lots of things a college advisor could do with this).[1]
- AP Physics C class and passing grades for two AP Physics exams (Mechanics and Electricity/Magnetism) would be credited as the first semester of the two-semester introductory physics sequence.

For a student majoring in any field of science but physics, the most likely scenario is

- AP Physics B or C classes (and exams) would be credited as the first semester of two-semester physics sequence for life science ("pre-med") students. In this case AP Physics C does not "buy" a student more than AP Physics B because it covers only one or two topics.
- IB Physics HL (and at least 5 on IB exam) could allow a student to avoid taking any additional physics classes in college because IB Physics HL would be credited as the entire required general physics sequence.

Students majoring in business, art, philosophy and other fields would also do perfectly well with just IB Physics HL. This would make these students well-rounded educated individuals familiar with a broad range of important topics in science.

Finally, the issue of college credit should be evaluated also in a somewhat different light. A good way to explain why we need to look beyond "college credit" can be found in Washington Post's article published [4] on March 8, 2005. Cathy Crocker, the principal of Mount Vernon High School of Fairfax County in Virginia is promoting the IB program by saying "When you sign up your child to be in the diploma program, you are not signing up to see how many credits they are going to get in their freshman year of college. You are signing up to see how well we can develop critical thinking skills, how well we educate your child in all facets of education. If you are signing up to earn college credits, you have chosen IB for the wrong reason." The author of this document wholeheartedly supports this statement. While two advanced physics classes, AP Physics C and IB Physics HL provide excellent learning opportunities, it is active encouragement of the culture of learning (which is present across the curriculum of the IB program) that we find to be very important also.

[1] The author of this document also serves as an undergraduate advisor in Pitt's Department of Physics and Astronomy.

6 Conclusions

We conclude that both AP Physics C and IB Physics HL are demanding curricula with somewhat different goals. AP Physics C is meant for a student who will be taking at least three more physics classes in college. IB Physics HL provides a much better overview of physics and its role in natural sciences and in our society. AP Physics C is a one-year class but College Board recommends to take it as a second physics class in a two-year sequence. IB Physics HL is a two-year sequence that provides a better (than both AP Physics B and C) coverage of today's hot topics in physics and connections to emerging technologies.

Either of the two classes emphasized in this document, AP Physics C and IB Physics HL would require an active participant, a student with academic aspirations. We have plenty of these in USC, however, in our opinion, the IB program stands out as a successful example of an integrated framework which encourages the emergence of such students and the development of the culture of learning.

Finally, neither of the curricula would help even such students to succeed in college and in life in general when advanced physics classes are taught by inadequately-trained physics teachers. We are fortunate to have excellent science teachers in USC and therefore recommend to continue offering two best advanced physics curricula, AP Physics C and IB Physics HL.

References

[1] "Physics (B and C), Course Description", College Board AP, May 2006, May 2007; available at http://www.collegeboard.com

[2] "IB Diploma Programme: *Physics*", February 2001, International Baccalaureate Organization, Geneva, Switzerland; available at http://www.ibo.org

[3] "Learning and Understanding: Improving Advanced Study of Mathematics and Sciences in US High Schools: Report of the Content Panel for Physics ", Committee on Programs for Advanced Study of Mathematics and Science in American High Schools, National Research Council; National Academies Press, ISBN: 0-309-55069-6 (2002); available at http://www.nap.edu/catalog

[4] "You Can't Make Me Earn the Diploma", by Jay Mathews, Washington Post staff writer, March 8, 2005; available at http://www.washingtonpost.com