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Revitalizing Undergraduate Physics Programs: Who Needs It?

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The environment in which undergraduate physics operates has changed dramatically in the last 10-15 years. Here is a partial list of those changes:

1. Physics itself is changing with many new subfields that cross disciplinary boundaries (for example, materials physics, computational physics, biophysics, chemical physics, photonics), most of which are completely absent from undergraduate physics programs.
2. The job market for physicists (and other scientifically trained workers) emphasizes the need for broader training within science and for enhanced skills in communication and the ability to work in teams.
3. Today's undergraduate student body is more diverse both ethnically and economically than that of twenty years ago. These students bring backgrounds and motivations substantially different from those of most current physics faculty when they were undergraduates.
4. Physics education research has established that there is a significant gap between what physics faculty believe they are teaching and what students actually learn. At the same time, physics education research has identified a number of teaching strategies that can help close that gap.
5. The profession as a whole faces a public perception that the most exciting scientific developments are likely to occur in fields other than physics.
6. Physics is increasingly disconnected from societal needs and federal priorities. The result is that potential students do not see the connection between physics and their daily lives and future careers.

This changing environment seems to have affected undergraduate physics in a variety of ways. The number of bachelors' degrees awarded in physics in the United States is now at a 40-year low. (These and other statistics are available from the American Institute of Physics Statistical Division at www.aip.org.) Similar drops in degrees have occurred in Europe. On the other hand, the fraction of American high school students taking physics has risen to 28%, an all time high. The number of college students taking

introductory physics in colleges and universities has tracked the number of college students.

Taken together, these changes pose a challenge to the physics community. To address these issues, the American Institute of Physics, the American Association of Physics Teachers, and the American Physical Society with support from the ExxonMobil Foundation set up the National Task Force on Undergraduate Physics in the fall of 1999. The purpose of the Task Force is

1. To provide an overview of undergraduate physics revitalization efforts and to coordinate the efforts of physics professional organizations, individual physicists and physics departments, and funding agencies.
2. To identify areas in which revitalization efforts are needed and to catalyze projects addressing those needs. Some of the projects will be national in scope; some local, some regional. Some will be centered in universities; some in professional societies. Some will require extensive external funding; some will leverage local resources. All these efforts will be strengthened if they can be coordinated and if those working on one activity can learn from the others.
3. To raise the visibility of undergraduate physics revitalization by having its members speak and write about the revitalization effort and maintain communications with the entire physics community.
4. To develop contacts with undergraduate revitalization efforts in the other scientific disciplines and to promote physics as a model for undergraduate revitalization efforts.

What do we mean by revitalization?

The revitalization of undergraduate physics focuses on providing **constructive and creative responses** to the challenges posed by the changes in the environment in which physics operates. These changes are probably irreversible, and the physics community, if it is to thrive, must respond to those changes.

There are three important principles that underlie the efforts of the Task Force:

1. Revitalization is more than curricular reform. The effort we envisage differs substantially from those large-scale curriculum projects supported by NSF in mathematics, chemistry and engineering because we focus on the entire program of an undergraduate physics department—rather than solely on curriculum and pedagogy in introductory courses. The department's program includes recruiting and mentoring students, engaging them in research, paying attention to the needs of student learning for all students, particular those in the other sciences, those who do not intend to be science majors and those who intend to be K-12 teachers.

2. The department is the critical unit for change in undergraduate education. Individual faculty members, of course, develop the ideas and carry out the activities, but the support of a large fraction of the department is crucial if the changes are to have lasting impact. Institutional support is also important, but the action takes place at the departmental level. Consequently, the Task Force has made a major effort to include departments of all sorts of undergraduate institutions ranging from two-year colleges through major research universities.

3. All reform is ultimately local. We recognize that “one size does not fit all” for serious educational innovation. The Task Force has identified a set of principles that are common to successful physics departments, but there is a wide diversity of approaches in applying those principles to the local situation.

As part of its efforts to promote undergraduate physics revitalization, the Task Force has undertaken, with the generous support of the ExxonMobil Foundation, a project called Strategic Programs for Innovations in Undergraduate Physics (SPIN-UP). SPIN-UP includes a case study site visit program to about 20 “thriving” undergraduate physics programs and a survey, carried out in conjunction with the American Institute of Physics, of all undergraduate physics programs in the United States. From the preliminary site visits, we have already discovered several common features of these thriving programs. They all include an emphasis on

- a. The undergraduate program, including both curricular and extra-curricular efforts, as a whole.
- b. Programs for recruiting and retaining physics majors and involving them in undergraduate research
- c. Strong and sustained departmental leadership that engages a significant fraction of the department’s faculty in enhancing its undergraduate program
- d. Professional development programs for physics majors
- e. A strong sense of the department’s mission and how that mission fits in with the overall mission of the home institution.
- f. Sustained efforts to improve the pedagogy of the undergraduate curriculum, particularly the introductory physics courses.

By summer 2002 the Task Force will have completed its set of site visits and will publish a case study analysis of what constitutes a thriving undergraduate physics program, how departments have set up such programs, and how they are sustained. This report will be distributed to all physics departments in the country.