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by

Darrell Skinner
Physics Department
University of Wisconsin-Madison
Madison, WI 53706

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(1) SUMMARY

This report results from my work in the Physics Department of the Institut Pertanian Bogor, from October 1982 through June 1983. A prominent theme here will be the planned development of a Physics Jurusan (a physics major program, a course of specialized study for undergraduates). I will also report on several of the projects which I undertook: the Kelompok Peminat Fisika (physics club), work with the department's microcomputers, and development of a "reading shelf."

Plans to expand the current Physics Department into a jurusan are part of plans to develop an IPB Faculty of Science and Mathematics. The establishment of undergraduate programs in the pure sciences would be a new phase in the growth of IPB, whose current emphasis on the applied sciences reflects its origin as an agricultural school. Indeed, the new Ph.D. programs in the applied sciences need additional support from the science departments--these small departments must expand and become more sophisticated.

I believe that there is great potential in the development of the Faculty of Science and Mathematics at IPB, and offer the following reasons: 1) Wide international contact at IPB. A large proportion of faculty members have received advanced training at long-established universities in the U.S., Europe, Japan, Canada, Australia, etc., and IPB has a commitment to seek advanced training for its educational staff. 2) IPB is a national university. Through such efforts as admitting students from all areas of Indonesia and using the Indonesian national language (rather than local dialect) in the

university community, IPB demonstrates its commitment to be a truly national university. 3) Record of educational development and reform. IPB has had tremendous influence throughout Indonesia through its innovations and reforms in admissions, curriculum, and degree programs. 4) The common first year program at IPB. Careers in pure science are not particularly attractive to many of the best Indonesian students. Unlike some other major Indonesian universities where students are admitted into a particular school or faculty, at IPB students choose specializations only at the end of the first year. Developing science departments at IPB will be able to recruit students, and based on my contact with students, I believe the new departments will be able to attract some of the best students. This is particularly important as the departments will often choose new faculty from among their own graduates. 5) The emphasis on applied science at IPB. While in some quarters this might be regarded as an impediment to the development of "pure" science, I believe this is a major advantage. It holds forth the prospect of developing science departments and research programs which are actively involved in the solution of real problems.

An inventory of the Physics Department's assets begins with the staff. Soedarsono is a dedicated teacher, has an excellent reputation with the students, and is in demand as an advisor. He has many other interests and talents, and is often sought by graduate students and other professors for technical advice. Hanedi is also a dedicated teacher, working especially with the basic physics course, Fisika

Dasar, writing teaching materials and managing the labs. His educational background should allow him to take over more of the teaching load of the support courses taught by the Physics Department for Food Technology and Agrometeorology. There are a number of administrative and laboratory assistants--without them the Physics Department could not handle its large teaching load. And there are the technicians working under Soedarsono's direction in the machine shop, an asset which would be important in the development of a Physics Jurusan.

The courses already developed are assets of the department, too. A well-developed system allows three lecturers to teach a laboratory physics course to the entire incoming class each year. It relies on the use of undergraduates as laboratory teachers, and works quite well. There are also a number of more advanced courses given to both undergraduate and graduate students from other departments. Of particular interest are the new electronics and instrumentation courses being developed by Soedarsono for graduate students. At the end of one semester, students with no previous experience have designed and built an electronic instrument, quite an achievement.

The Physics Department has a substantial collection of basic equipment. This resource, will make it much easier to begin a jurusan. There is enough hardware that one sizeable task associated with beginning a jurusan will be sorting through what has been acquired, matching it against needs of new laboratory courses, and determining what must yet be purchased or built.

The major source of pressure on the Physics Department is the steadily increasing enrollment. It would be interesting to plot the student/teacher ratio and lab space per student in the first year Fisika Dasar course over the last 25 years. University growth continues to increase the burden on the lecturers, laboratory space, and facilities. Given current scheduling methods (labs in afternoon and evening), the laboratory space for practicums is at a critical point now.

The support courses are also a source of pressure on the department, mainly on Soedarsono. His teaching load has become so large that it interferes with his desire and ability to develop new courses and with his administrative duties. If a Physics Jurusan is to be begun, he must be free to address the organizational and recruitment tasks associated with such an effort. A partial solution is for Hanedi to take over part of this teaching load. Hopefully, when Hidayat arrives, he will also take up part of the teaching load.

Another problem is the extreme difficulty of recruiting new physics lecturers to IPB. This results from the high demand for physicists by government research organizations and industry, with consequent high pay scales for physicists. This problem is discussed in more detail later in this report.

The most critical need in the Physics Department is for additional lecturers, especially if a jurusan is to be developed. I believe the development of a jurusan is itself a critical need for the department. Only by developing a jurusan will the Physics Department

be able to grow, to reach a "critical mass," so that it will not be in danger of dying out and so that it will be able to meet the teaching demands from other departments.

Further education and training is also a critical need. Because Hanedi has moved into physics from other fields, it is highly desirable that he receive further graduate training in physics. After many years of "holding down the fort," Soedarsono deserves a change of pace and a time to concentrate on some particular field of interest to him.

(2) BASIC PHYSICS COURSE, FISIKA DASAR

This section reports the results of discussions between Soedarsono, Hanedi, Eve van Rennes, and myself. A series of meetings was devoted to methods of improving and developing the first-year physics course. I believe changes should be evolutionary, rather than revolutionary. The course works amazingly well considering the limited resources available. Any changes would have to be carefully presented to the department employees and student assistants who make the course work.

The Physics Department has decided to begin trying lecture demonstrations during the 83/84 academic year. Since physics lecturers are quite busy, it is to be expected that progress will be slow. It is rather time-consuming to get even a very simple demonstration ready for use in front of a large audience. Several guidebooks to building and using physics lecture demonstrations are now available in the Physics Department. It would be most helpful if all physics lectures were given in the same lecture hall, so the demonstrations would not have to be moved around from place to place--such an arrangement as been proposed.

Another topic discussed was the use of science exhibits for students in the first-year course. There are a number of possibilities: a museum room, hall exhibits, stand-alone exhibits in the practicum labs. Problems of exhibition space and manpower are perhaps too great to permit an ambitious project now. However, Eve van Rennes frequently showed simple demonstrations to the members of Kelompok Peminat Fisika. Preparing a simple demonstration exhibit would be an interesting summer project for this group.

Currently, a copy of a standard American text (Sears & Zemansky) is loaned to each group of four students. This is an admirable effort to help students, for whom textbooks are often too expensive to purchase. But there are some growing problems associated with the current system: the books are aging and remain in limited supply while the number of students constantly grows; the text uses both the English and metric unit systems, while even in the U.S. (the only country which still uses the "English" system) the English system has been abandoned in most science courses as unnecessarily confusing; for students with a poor command of English, the language is a barrier; and finally, the text currently used is more appropriate for the original two-semester course than the current one-semester course.

For these reasons, it was decided to start translating a new physics textbook. Eve van Rennes suggested the book from among texts she brought to Indonesia. One of the co-authors is a Nobel laureate, George Gamow, a scientist well-known in the field for his love of teaching and for his efforts to present "popular science." The book is written at a fundamental level. It naturally splits into two parts, the first of which covers basic physics, and the second of which introduces a number of more advanced topics. This division makes the first half of the text a good choice for a single-semester course. One weakness of the text, which should be corrected during the translation, is its use of the English unit system in various places.

It is proposed to translate the first half of the book, together with a few selected topics from the second half. Undergraduate students from the Kelompok Peminat Fisika have volunteered to work on the translation. Soedarsono will supervise their work. Arrangements must be made to pay the students for their work. I have also volunteered to help, by selecting problems to be translated from this book and supplementary problems from other somewhat more advanced tests--work which must be done after I return to Wisconsin.

Soedarsono brought forward a plan to add recitation sections to the current arrangement of lecture and practicum. This would be very important in assisting the students and maintaining the effectiveness of the course in the face of increasing enrollments. Recitation sections would focus on solving problems, one of the most important learning methods in physics. The addition of such sections depends on the provision of additional student assistants.

The proposal is that there be approximately one new assistant per lab group (approximately 30 students). Two assistants working together would meet a group of sixty students during the week; when that group has no physics practicum. There would also be two smaller groups of thirty students with two assistants each to check the benefits of smaller class sizes. The demands on such assistants are probably greater than those on practicum assistants. It is hoped that some members of the Kelompok Peminat Fisika (selected for their proficiency or interest in physics) will want to become recitation assistants. Drawing such assistants from among students following a Physics Jurusan would be an even better arrangement, when that becomes possible.

Some discussion was devoted to the burden placed on lecturers by examination grading. With each lecturer handling two kelompoks of nearly two hundred students giving three major examinations each semester, the burden becomes quite large. Especially so because the traditional (and perhaps best) physics examination consists of problems to be worked, and grading must consider the method used by the student as well as the final answer.

I would strongly suggest that multiple choice questions be used for a substantial portion of each exam. Grading keys would lighten the grading load considerably. Because students take exams in rather cramped quarters, and because multiple choice answers are easily copied, thought must be given to reducing the opportunity for cheating. One possibility is handing out multiple versions of the test which differ only in the order of questions or in the numerical data provided with problems.

Using multiple choice questions does not mean completely abandoning solved problems. It is important to retain some of these problems for each exam. A good educational strategy is to set some exam problems which are similar, but not identical, to assigned homework problems--and to clearly explain this procedure to students at the beginning of the course. This encourages students to work to understand the homework problems, not merely memorize the solutions. One way to make grading a little less boring is to give students a choice of problems, so that all students do not work the same problem. In my experience in the U.S., students like having a choice and graders enjoy the variety; I do not know if that would be true at IPB as well.

One other topic of discussion has been the identification and separation of incoming students whose physics background is weak. Many such students are those admitted through PP-II, from outlying areas of Indonesia where the high school science teachers are less qualified. These students are at a disadvantage, which could hopefully be remedied with a little extra attention. If these less prepared students fail the course and have to repeat, they add an additional burden to the department. A separate course, beginning from a more basic level, is an alternative which would be more efficient (for lecturers) and less traumatic (for students). A separate course would also raise problems, though, such as doubts about the ability of those students compared to students who passed the regular courses.

(3) ADVANCED PHYSICS COURSES

The Physics Department teaches several courses to other departments, both to graduate and undergraduate students.

Fisika II - Food Technology, S_1.

Fisika Terapan (applied physics) - Industrial Technology, S_1.

Fisika Pertanian (agricultural physics) - Agrometeorology, S_1.

Fisika Linkungan (environmental physics) - S_2.

Modificasi Cuaca (weather modification) - S_2.

Instrumentasi (instrumentation) - Two courses, S_2.

In addition, there is a basic physics course taught each semester to students in the diploma program.

Each of the courses is currently taught by Soedarsono, resulting in far too heavy a teaching load. By mutual agreement, Hanedi will begin teaching in 83/84 one or more of the three undergraduate courses Fisika II, Fisika Pertanian, Fisika Terapan. Soedarsono will provide material needed for planning the courses. I would also recommend that Hidayat examine the Fisika Linkungan course when he joins the department, to see if he would be interested in teaching that course.

There are a number of opportunities, even demands, for more support courses from the Physics Department. The Engineering Faculty teaches courses in engineering mechanics (statics and dynamics)--there is some feeling there that these courses should be taught by the Physics Department staff. Soedarsono's S_2 courses in electronics and instrumentation are especially interesting to me. These courses would doubtless be very useful if given at the undergraduate level for students in some areas of engineering and basic science.

The new Remote Sensing program may need support in teaching basic optics and spectral physics. The LIPI-Physics Institute has begun a major material science research effort, including wood products as one of its areas of specialization. The Forestry Faculty is cooperating with them in this area, and may develop needs for support from the Physics Department.

When Hidayat joins the Physics Department, he will have his own areas of expertise in numerical analysis, computer modeling, and hydraulics--his arrival will probably result in new support courses. I also believe that the Physics Department should develop expertise in using microprocessors, and offer courses in this area.

(4) STAFF TRAINING AND SUPPORT

With only two people to handle the teaching, it now is difficult to spare either. However, as Hidayat and (hopefully) others are added, it will be possible to plan further training away from IPB.

Hanedi, especially, should receive further graduate training. His past education in food technology and agrometeorology are valuable since the Physics Department offers support courses to those disciplines. But further study specifically in physics is vital so that Hanedi can fully participate in teaching a physics S_1 curriculum.

When the Australian project begins, graduate study in Australia is one possibility. Another possibility which attracted my attention and investigation is an Indian university which has an associated "Center for Development of Physics Education." A physics graduate education combined with work and training in physics teaching would be very useful to the department here, if it could be arranged. There may be other possibilities in this area (e.g., there is a "Science Teaching Center" at the University of Maryland in the U.S.), but I know little about them.

Soedarsono deserves a "sabbatical" from his department duties. He has a number of interests (weather modification, solar energy, instrumentation, electronics, etc.). A chance to devote at least a semester to some specific area at another institution would be a well-deserved reward.

When considering training for staff members, it would be advisable not to forget about the technicians in the laboratories and machine shop. Commenting on methods used by laboratories in government institutions to keep skilled technicians, a couple of laboratory managers in Bandung mentioned education. They said that continuing opportunities for learning and training are as important as salary to some technicians.

(5) DEVELOPING A PHYSICS JURUSAN

The time is approaching for the initiation of a Physics Jurusan. There is considerable equipment, some of which will be useful and used only when a jurusan begins. Hidayat will be returning to join the Physics Department soon, bringing expertise in computers, numerical analysis, and some areas of mathematical physics. While it may be difficult to attract good permanent staff members, it should not be too difficult to find temporary lecturers to help get the program started. The Kelompok Peminat Fisika has been formed, and will help attract good students to a Physics Jurusan. And the job prospects for physics graduates appear bright in the near future.

There is already expertise at IPB in some areas of basic physics, in electronics, in computer programming. A special strength is the student shop and shop courses which have been developed in the engineering faculty. The shop is well equipped, is available (even at late night hours) to students, and excellent machine work has been produced by students there. That facility could be very helpful as a model and a source of assistance to the Physics Department in setting up similar facilities for its students.

Beginning a Physics Jurusan would mean teaching courses in disciplines new to IPB. These are the areas that pose special difficulties in setting up a curriculum. I am concerned about mathematics and mathematical physics, such as, differential equations, complex analysis, Fourier analysis; advanced physics labs, which require working with and even building specialized sophisticated

apparatus; advanced optics, image transformation, spectral analysis (to support the Remote Sensing project); "modern physics" and quantum physics, a very difficult subject to teach which is best taught by someone whose work involves quantum effects. This last area is important if IPB students are to be able to enter good graduate schools and if IPB wants to develop a biophysics specialization with these graduates.

Given the difficulty of arranging enough advanced level courses, I believe it would be wise for IPB to investigate the possibility of students finishing their education at other places. One possibility is the Physics Department at the University of Indonesia, nearby in Jakarta. Its permanent faculty is still small. They teach only their own departmental courses and a few courses for other departments in their own Faculty of Sciences and Mathematics. Lecturers from other places, particularly ITB, teach support courses needed by other faculties. Nevertheless, I was impressed with their energy as a young department. Their strength in theoretical physics and weakness in experimental physics and technology could be complementary to the situation at IPB.

Another possibility for advanced training outside IPB is the Lembaga Fisika Nasional-LIPI. They are actively seeking students to work with them on their senior theses. This Institute has for some time been assigned research activities in the area of appropriate technology. It is also starting a new materials research program, specializing in wood and ceramic materials. While it remains in

Bandung, perhaps arrangements could be made for a student working there to also take some advanced courses at ITB. Long-range plans call for the Institute to move to Serpong, nearer Jakarta.

I will note here another possibility for senior thesis work. During a visit to Gadjah Mada University, I met a physicist, Professor Seno Sastroamidjojo. He is a talented and interesting scientist, with experience and work in many areas including biology, solid state physics, and solar energy. He directs a solar energy research effort which is separate from the main Physics Department. Most interesting to me was a course which he taught emphasizing scientific enquiry, experimental methods and shop techniques, and the basic principles of physics. He has given considerable thought to basic science education, and has forceful opinions. Students from physics take his course for one year, students from biophysics for three years. He also supervises the senior theses of students from other universities. I believe that a chance to work with him would be a unique and valuable experience for the right student, one who is genuinely interested in teaching.

It is important, as IPB begins its Physics Jurusan, to seek out and use such opportunities for advanced undergraduate work and study in other established institutions. If IPB sends its best students, those who will hopefully return as IPB lecturers, the interaction will establish contacts with the physics community and will help to build the reputation of IPB's Physics Department. There already is an established community of physicists in Indonesia, and attention should be given to developing contacts with that community.

(6) LECTURE STAFF RECRUITMENT

I believe that the most serious problem facing the physics program is the difficulty of attracting new staff who have training in physics or electronics. Students who finish an S_1 degree in physics are in high demand now. The government R&D institutes BATAN and BPPT are hiring many physicists--the current starting salary is said to be about 150,000 to 200,000 Rp. per month. In addition, physics graduates from the more prestigious departments, such as ITB's Physics Department, often are attracted to the industrial sector. Even higher salaries are offered by the industrial sector to employees with technical backgrounds, especially electronics and computer programming. Furthermore, there is competition from a couple of other universities for new lecturers.

While some Physics Departments are turning out a large quantity of students, I was warned by one professor about the quality of students. With the exception, perhaps, of ITB, most Physics Departments are still trying to build up their own departments. They would of course try to keep their best graduates for themselves. There is a feeling that today the best Indonesian students are not often attracted to the basic sciences.

The Physics Department could also try to recruit some new people from the electroteknik (electronics engineering) field, particularly with training in instrumentation, digital electronics, and hardware microprocessor applications. Again, these students are highly sought by business and industry, so that competing wage scales are high.

One suggestion was offered by a physicist at the Lembaga Fisika Nasional. He felt that electrical engineering students from the private universities Trisakti in Jakarta and from Satyawacana in Salatiga near Yogyakarta are close to the level of ITB graduates. But this is not generally known, he said, and they have more trouble finding jobs. He suggested recruiting from these universities.

Given current conditions, IPB should be cautious about those accepted as new lecturers. Taking a long-term view, the future of the Physics Department depends on finding staff who can succeed in advanced graduate study, particularly outside the country. The Department cannot afford to staff itself with mediocre or lazy graduates who do not have the potential to become good teachers and scientists.

While the pay scales work against IPB's advantage, IPB does have some benefits to offer. One is the academic atmosphere, which appeals to many scientists. Another is the opportunity for further education. IPB values graduate education for its staff, has international contacts, and has a good record of arranging such education for those who want it. And the advantages of living in Bogor should not be overlooked--to many people, Bogor is the "right distance" from Jakarta, and has a more comfortable climate as well.

Still, the matter of supplemental income must be addressed. The opportunities in Bogor are not encouraging. If funds could be secured to support textbook authors and translators, their activity could benefit themselves as well as the department. I believe that a great

need exists for new teaching materials in physics: more introductory tests in Bahasa Indonesia at various levels of difficulty; materials to ease the transition to using English text which generally occur as the student progresses; laboratory materials for advanced courses; lecture demonstrations; even software for computer-based education adapted to Bahasa Indonesia. If support could be secured for such efforts, the additional income and the interesting nature of the work would greatly improve IPB's chances of attracting good physics graduates from outside. Young staff members' efforts would be concentrated within the Department. The Department would have more time to devote to improvement and innovation in the educational process itself.

(7) CURRICULUM FOR A PHYSICS JURUSAN

This section reports the curriculum development work which I did during my first semester at IPB. Since IPB has the goal of establishing a Physics Jurusan, I hope that this work will have some utility. Nevertheless, I should at the outset emphasize that this effort is only an initial one. It is truly impossible to set out a curriculum until the lecturers are assembled and their talents and areas of specialization are known. Similarly, the curriculum will depend on the local "character" which the department will develop and on the areas of specialized training which will be offered to students.

Since the eventual shape of a Physics Jurusan is yet unknown, the detailed results of this curriculum development effort are relegated to Appendix B. This section of the report will present the general constraints and goals which influenced this work, and note potential problem areas which the exercise uncovered.

While working on this project, I examined the curricula of Physics Jurusans at ITB, Gajah Mada, and UI. The University of Wisconsin Physics Department provided me with similar information on their undergraduate program, along with lists of the textbooks chosen for these courses by the individual lecturers over the last few years. Also influential was my undergraduate education at Florida State (which, by coincidence, was patterned after the University of Wisconsin program). The physics curriculum reform efforts of the last couple of decades (described elsewhere in Appendices D, E, and F) also had an influence.

Enumerated below are ten specific constraints on this work or goals which I adopted, along with brief discussions.

(1) The curriculum should prepare students for entry into physics graduate school. Since I am most familiar with U.S. graduate schools, and since the largest proportion of IPB faculty receiving advanced training outside Indonesia have so far studied in the U.S., I took preparation for entry into U.S. graduate schools as my goal in this exercise. A mastery of the basic physics and math courses is the single most important element, in my opinion--a good understanding of a few basic principles is more important than a broad knowledge of the many fields of physics.

If a student did well in the core courses listed for the third through sixth semesters, I believe he would be ready to enter most graduate schools in the U.S. (although he would probably need an extra year there to study advanced undergraduate courses, a common practice for American graduate students who enter from smaller colleges or without a physics major). The advanced undergraduate courses listed for the seventh and eighth semesters would give a student preparation similar to that of most good entering graduate students in the U.S. The practical courses in machine shop techniques, electronics, and computer programming are also very important--as undergraduates, many American students will have had practical experience as lab assistants to university researchers.

(2) Students should learn specific technical skills, to prepare them for careers in industry. Hopefully, some of the best students will choose to work in universities and government research organizations, but students should have specific skills to fall back on if these jobs are not available. (For years, computer programming skills have guaranteed jobs for physicists in America when too few jobs in physics proper have been available.) This is another reason for the strong emphasis given to the practical courses covering the tools of physicists: instrumentation, machine shop, electronics, computers.

(3) A modern approach toward teaching physics should be used where appropriate. Appendix D is devoted to the "Sputnik revolution" in American secondary school physics education. The effects of these projects and experiments are slowly but surely showing up in university curricula, both in the U.S. and around the world. From this "modern" point of view, the fifth semester course on the physics of oscillations and waves is central to the curriculum I have prepared. The subject has not traditionally been treated in a single course, but it is excellent preparation for many areas of applied physics as well as modern quantum physics. The suggested text, from the University of California at Berkeley, is in my opinion an excellent example of the new approach to physics education.

(4) A small core of courses should receive the primary emphasis. Most challenging new ideas in math and physics should be introduced in at most two or three courses per semester. A student can assimilate just so much new material and work just so many hours on problem assignments. The curriculum should be filled out with courses of a different nature, such as laboratory work or survey-type courses. But these courses used to fill out the schedule must not divert the students' primary focus away from the core courses.

(5) The common first year program at IPB complicates planning a program. The single semester physics course taught during the first year does not provide a sufficient basis for the more specialized courses of a major program, as I am familiar with them in the U.S. (I would estimate that the IPB one-semester course is equivalent to 20% - 30% of the University of Wisconsin two-semester physics sequences for science and engineering students.) On the other hand, it is not practical to teach the traditional one year intensive physics course before starting the more specialized courses.

Thus, the elements of the usual one-year course (mechanics, thermal physics, optics, electricity and magnetism) are covered in an untraditional order in this curriculum. The third semester would begin with a course in electricity and magnetism, so that in the following semester an electronics course could be taught to students on a sufficient theoretical basis. A survey course in

thermal physics is scheduled for the third semester as well, with an intensive mechanics course set for the fourth semester.

(6) Could the students finish the jurusan program at another university? In view of the difficulty of IPB beginning an entire jurusan program, I tried to synchronize the curriculum with that of another university to examine that possibility. I only attempted this exercise using the ITB Physics Department curriculum. Due to the head start which their more rigorous first year physics course gives to ITB students, I felt that IPB students would have to finish the fifth or possibly the sixth semester of an IPB curriculum before they could transfer to ITB. Arriving at ITB for their final two or three semesters, they would have a roughly equivalent education.

(7) Some assumptions were made about the areas of specialization in which IPB students might be trained. The primary "practical" focus is on instrumentation, especially electronic instrumentation. Such experience and expertise would be useful to workers in physics as well as other areas of science and technology. Such a focus also naturally follows from one of Soedarsono's special interests. The curriculum is slightly shaped by the possibility of a specialization in remote sensing. The assumption that the department will eventually develop a specialization in biophysics is reflected in the preparation for studying quantum physics in graduate school.

(8) Students' preparation for the KKN program should receive support in the formal academic curriculum. The KKN program offers a wonderful opportunity for students to both perform social service and receive practical experience in applying science and technology to real problems. To the benefit of students as well as lecturers, some courses in the curriculum could be directed toward preparing students for this work. The curriculum contains one shop class and one discussion course devoted to these purposes.

(9) Training and practice in the English language should have a place in the curriculum. Every scientist should have some familiarity with English, since it has become the international language of science. In Indonesian physics departments an encounter with English textbooks will be almost inevitable for students, since Indonesian language texts are available for the basic physics courses only. At issue is whether formal coursework should assist students across the language barrier. While reading English textbooks is the first barrier students must pass, they could also benefit by developing other language skills, such as translating between English and Indonesian, English composition and conversation.

The curriculum detailed in Appendix B specifies one course centered around a literature search, at the beginning of the last year and associated with the senior project. A useful assignment in this course would be translating a major article or review paper from English to Indonesian, useful for the student as well

as for the library which could thereby build its collection of Indonesian language material. A sequence of four courses is intended to provide some practice and assistance with English, both technical and non-technical English.

(10) The curriculum should provide some background to science and technology: history, social impact, ethics. The fact that this point is last on the list probably reflects real priorities, i.e., education in specific scientific and technical areas takes precedence over more general concerns. Nevertheless these general concerns should not be completely neglected. Students who enter science are joining a human endeavor with a long history. Science is related to technology in a complicated way, and inseparably linked to our ideas of progress. Modern science and technology are transforming human society.

Many graduates of such a prestigious school as IPB will eventually find themselves in places of responsibility, where they will take part in decisions about investments in science research and technological development, and about applications of the fruits of this work. An introduction to the difficult issues which surround such decisions should have some place in the education of a scientist. The curriculum detailed in the appendix suggests that the same four-course sequence in which English is practiced could give attention to some of these non-technical topics as well.

While this curriculum planning exercise can provide little detailed information for a future Physics Jurusan, it does survey the types of courses that might be offered and indicate where problems may be encountered. Appendix B groups courses together in clusters: physics core, math core, shop, electronics and computers, advanced physics, nontechnical support, supplementary physics. In some of these areas, IPB has at hand the resources needed to develop needed courses. In other areas, there will be more difficulties.

In the area of electronics and computers, the Physics Department already has considerable resources in equipment as well as personnel. With Soedarsono's hardware expertise and Hidayat's software education, it should be possible to develop needed courses. The outlook is similar for the development of shop courses. The IPB shop, under Soedarsono's direction, could probably be tapped for resources. And on the Darmaga campus, the engineering faculty has developed an excellent shop program. In both of these areas, though, there will be problems related to the cost of materials and new equipment.

The physics core courses could probably be developed and taught by most any lecturer with an undergraduate degree in physics. Of course, it would be preferable that the lecturer have a graduate degree. But for these fundamental, important courses, good teaching and a good text are probable more important than advanced training for lecturers. One exception to the above statement is the the "modern physics course"--it should definitely be taught by a lecturer holding an advanced degree.

It appears that developing the core math courses may be difficult. The applied math courses in this area could be taught by lecturers from either the Math or Physics Departments, but the lecturers should be knowledgable about both disciplines. Because of the burdens resting on physics lecturers as they develop a new jurusan, it might be best if the math department could take responsibility for such courses. But the math and statistics department has a strong emphasis on statistics, and I believe the department currently does not have lecturers ready to teach these applied math courses.

The advanced physics courses present even more problems. As conceived here, they would be advanced undergraduate theoretical courses intended to prepare students to pass graduate school examinations. These would best be taught by physicists who hold advanced degrees and are familiar with the graduate schools which the students will enter.

On the whole, the resulting curriculum plan is an ambitious one. It aims to produce students fully qualified to enter graduate school. At the same time, it aims to train students in specific technical skills which would make them attractive to modern industries. The two goals are not mutually incompatible, if the technical skills taught are the "working tools" of experimental physicists. Nevertheless, the result is a full and demanding course of studies.

This planning exercise assumed that the Physics Department itself would offer all or almost all the courses. Developing a complete complement of courses (theory & math courses, lab equipment, access to computers or microcomputers, a shop equipped for student work) over a

couple of years is a formidable goal. Other units could perhaps assist: the Mathematics Department with the mathematical physics courses, the Engineering Faculty with shop courses. Perhaps other science departments and the English teaching program could cooperate in development of the "non-technical" courses.

A less ambitious plan could fill out a course of study with technically oriented courses already taught in other departments (e.g., Agrometeorology, Engineering). Still, the core physics and math courses and at least a few applied courses (shop, electronics, computing) must be developed if students are to receive a physics education.

The type of curriculum plan developed here is rather conventional. Some features of "modern" curriculum development projects are included, but in general the curriculum is quite similar to the "traditional" U.S. physics programs I am personally familiar with. It does not strongly reflect the special goals and character of IPB--at most this plan can provide a starting point for the IPB Physics Department.

(8) SURVEY OF PHYSICS TEXTS AVAILABLE IN INDONESIA

One of my particular interests has been the availability of texts in Indonesia. My observations of the current situation must be qualified by several facts. One is my limited ability to evaluate texts in the Indonesian language--I read "at a snail's pace" and have been able to read only small portions of the texts examined. My impressions of the situation at the major Physics Departments were formed in visits to ITB, Gadjah Mada, and UI. But these visits were only for one or two days. Although I collected considerable written material, I did not observe any classes and had limited opportunities to speak with students there.

The available texts for secondary school use may be located with a trip to almost any large bookstore. There are texts for various kinds of high schools in the Indonesian secondary school system. There are a couple of sets for the science-oriented schools from which most IPB students come, one of which is the Ministry of Education's designated choice. IPB students will have had physics during each year of high school. The series of texts for these courses typically provide, for each year, a textbook and a problem book. The text contains explanations but no problems, while the problem book contains solved problems.

For the university level general physics course, there are also several texts in Indonesian. Perhaps the most complete is a translation of the English-language text by Sears & Zemansky, a "classic" text in American colleges. It is available in a three-volume set, and

in a newer two-volume set. However, this translation is based on an edition some 25 years old. Sears & Zemansky is still used in American colleges, but in a much revised form. The publishers of this translation announced several years ago that a new translation was being prepared from a more recent edition, but nothing has appeared on the market yet. Another often-encountered text is by Bueche, a more elementary text. It is available only in English, although apparently there are some privately circulated translations of portions of the text.

There are also indigenously produced texts for a first-year course. Most notable is the ITB series, which is published as separate volumes devoted to each subject of basic physics (mechanics, electricity and magnetism, etc.). The first volumes in the series have only explanatory text, while the later volumes also include a selection of unsolved problems. Other Indonesian texts generally take the form of a collection of solved problems, sometimes also incorporating a summary of physical principles and basic equations. Laboratory manuals are produced at most physics departments, including the IPB Physics Department.

The situation for the specialized courses in Physics Jurusans is rather different. These courses are almost exclusively based on English texts. There are few Indonesian texts available for these specialized courses, except in electronics. Although texts are listed for most courses in the larger Physics Departments, it is my impression that these lists contain more information about the texts used by lecturers than by students--three or four titles may be listed for one course, and the titles may specify rather old editions.

I found a reasonably good selection of imported English advanced topic titles in bookstores in Bandung and Yogyakarta. But they were not stocked in the quantities that a class would need, and in any case, these imported books are generally too expensive for most students to consider buying. One Bandung bookstore, however, had made a special effort to import the "International " and "Asian" editions. These books are reproductions of the large international publishers' science and mathematics texts, printed under special agreements in such countries as Singapore, Hong Kong, India, the Philippines, and Japan. They are much cheaper than the standard texts printed in the U.S., England, and Australia. The Indian editions, though of rather low quality, are definitely affordable for students, sometimes as low as 2000 Rp. (about two U.S. dollars).

The problem of language deserves some attention here. It seems obvious that the first year general physics text should be in the Indonesian language. Entering IPB students do not have enough English to effectively use an English text, and a general physics couse is difficult enough without introducing a language problem. It seems equally obvious that graduates of a Physics Jurusan should be able to handle English texts. That is an important professional ability. The problem area is early in the jurusan curriculum. There is a need for materials which help the student make the transition from Indonesian to English. These could take many forms, such as: partial translations from English; Indonesian definitions of new vocabulary and technical terms; and commentaries or summaries in Indonesian.

How do Indonesian texts treat problems? At both high school and university levels, I found few texts which integrated explanation and examples together with problems to be worked by students. A number of texts were essentially collections of examples, each problem immediately followed by the worked-out solution. I feel this is not a good teaching technique (although it is generally popular with students).

The ITB basic texts stand out from the other Indonesian texts which I had a chance to examine. In terms of material and order of presentation, it has the modern "flavor" of recent English textbooks--the influence of the PSSC secondary textbooks and the innovative Berkeley University texts is visible. But some of the ITB volumes do not incorporate problems for solution by the student.

I was also impressed by one of the high school series; the texts were comprehensive, and almost advanced enough to serve as the basis of a university general physics course. However, only solved problems were included in the companion volumes.

(9) COMMENTS ON THE USE OF PHYSICS TEXTS

One must bear in mind the limited resources of the students for whom textbooks are intended. IPB students suggested to me that 10,000-15,000 Rp. per semester is about the most that students would be able and willing to spend on books. Another consideration is that the photocopy revolution has made it to Indonesia, in a big way. There are cheap efficient photocopy services all over Bogor. This makes it easy for students to copy what they want, but may reduce revenue substantially for textbook publishers and writers.

Another point to bear in mind is that educational materials developed at one large university are not often used by other large universities. The explanation sometimes offered is that the different institutions have different needs. This is true, of course, but perhaps at least equally important is the competitive and independent attitudes of the major universities. This situation can be viewed as a healthy cultivation of various approaches, or as a wasteful use of limited expertise. In any case, it is pretty much a fact of life. One result is that much of the Indonesian language material used by the IPB Physics Department should be developed within the department itself. However, translations of foreign texts (as opposed to original work) are more acceptable at other institutions. Thus, translations and reprints by the IPB Physics Department would probably gain the most acceptance at other institutions in Indonesia, especially the smaller universities.

Foreign observers of Indonesian university education often direct criticism at the use of dated texts and notes as the basis for courses, and at heavy reliance on lectures and oral transmission the ("chalk and talk") method. Based on my own observations of some of the largest Physics Jurusans in Indonesia (through short visits and examination of the listings of course offerings and textbooks used), I would tend to agree. This state of affairs may be a response to the expense of textbooks in Indonesia, however.

There is a real opportunity at IPB, if a Faculty of Science and Mathematics and a Physics Jurusan is begun, to advance science education in Indonesia. The reform-minded attitudes toward education at IPB is evident in the existing small Science Departments through such efforts as development of curriculum review procedures, textbook development, and the fraction of lecturers who receive post graduate training outside Indonesia where they are exposed to various types of educational systems. If a Physics Jurusan is formed at IPB, I believe it would be very important that, from the start, new physics courses be based on textbooks, and that special efforts be made to make the textbooks available to lecturers and students alike.

If guest lecturers are used (whether from Indonesia or from outside), a textbook-based course would be more easily taken over by new IPB lecturers as they are added--the work done in selecting appropriate sections from the text, developing problem assignments and exams, etc., would remain within the department. This would also allow IPB physics staff members to more easily substitute for each other when they leave IPB temporarily to enter graduate programs.

(10) RECOMMENDATIONS FOR THE PHYSICS DEPARTMENT

First, for the first year general physics course, I would like to note two important steps which the department is attempting. The department would like to add recitation sections to the course structure, so that problem-solving can be given more attention. The department has also begun the translation of a textbook. Problem-solving is a part of the current course--lecture time is devoted to encouraging students to try problems, and a problem set is assigned for the period before each exam. And students do work on the problems, especially as the exam approaches (as I shared an office with Soedarsono, I can personally testify to the number of students who came seeking help). However, one lecturer can give very little individual attention to students in a class of two hundred; setting up recitation sections would improve the course greatly. While the department already publishes material for the course--each semester, a lab manual and book of example problems are produced under Hanedi's direction--the development of an integrated text would be a step forward.

There is no text in Indonesian which is well suited to a one-semester course like that taught at IPB. I believe one of the main goals should be delivering such a text at a price affordable to IPB students. It is better to print cheap, inexpensive books with a short lifetime than quality books, to be used over and over again at IPB. Only in this way would it be possible to periodically issue new editions which incorporate corrections and improvements.

Considerable attention should be given to the selection of problems. A large number of problems, especially simple ones, should be assembled. But perhaps some difficult problems should also be included for use with the best students who are not challenged by the simpler ones. The use of "thought questions" and even simple home experiments would be an added plus. By giving attention to this area, a step forward can be made in the quality of available physics texts. Of course, problems need not be included in a text, because they can be assigned by the lecturer during the course. But the inclusion of a good selection of problems would make the text much more useful at other universities, especially at smaller Indonesian universities where physics courses may be given by non-physicists.

The text selected for translation at IPB contains a large number of simple problems. If other types of exercises are to be included, they must be collected from other sources. Examples of more solved problems would be very helpful, I feel. The text could also be improved by the addition of chapter summaries.

A useful strategy in teaching the course would be to treat only a portion of the material at a mathematical, problem-solving level. Physics is only one of a large number of courses which first year IPB students must take--problem-solving is a time-consuming process, and it is not realistic to greatly increase the load on students. Since problem-solving is in itself a useful skill to learn, I believe it is better for students to practice on a smaller amount of material, perhaps only 50 percent or less of all the material covered in the

course. Other material can be taught at a different level, emphasizing physical principles and developing the students' intuition. Such a division should be clearly explained to the students, so they know how to focus their efforts, and should be reflected in the types of questions set on examinations.

If additional student assistants become available for the course, it would be possible to add recitation sections and increase emphasis on problems. In this case, I would recommend problem set assignments every two weeks, synchronized with the lectures. Around eight to ten problems would be about right, if most are very easy and two or three are at the same level of difficulty as exam problems. Some kind of deadline is needed at the end of the two-week period. If assistants cannot correct or grade the problems, they should check to see that students have at least attempted the assignment. Immediately after the deadline, detailed solutions should be made available to students which they can compare against their own efforts. The solutions could be posted on a bulletin board, printed by the department, or made available for student-arranged photocopying.

As an incentive for students to work and understand homework problems, it is good practice to base some examination problems on the more difficult homework problems. This practice must be clearly explained to the students ahead of time, if it is to be effective. Such an examination problem should be enough like the corresponding homework problem to reward students who worked the problem, but different enough so that students who merely copied or memorized the homework solution are not benefited.

A few students will be bored by the elementary level of the course which is appropriate for most of the students. Since some of these are students that the Physics Jurusan would like to recruit, it is important to present them with a greater challenge to retain their interest. I would suggest designation of some optional, much more difficult, problems--rewarded not with grades but with more personal contact with the lecturer. This is the approach often taken with honors students in U.S. university courses. References to readings outside the textbook on modern applications might also be helpful, and encourage these students to use materials available in libraries.

Turning now to the proposed Physics Jurusan, I would like to argue for textbook-based courses. Textbooks are not available for all courses, but I believe they should be used whenever possible. When a student graduates from a Physics Jurusan, his own class notes and his course textbooks form an important part of his "professional toolbox." Class notes are useful, but textbooks have certain advantages over notes--the text was written by an expert, while the notes were taken by a learning student. The text should contain a good index, references to more advanced sources, and a selection of exercises. Use of a textbook provides a certain continuity to a course, which may not always be taught by the same lecturer. The textbook is like an extra teacher brought into the class. Finally, the use of some standard texts for third and fourth year courses will be beneficial, even essential, if IPB graduates are later to go abroad for advanced graduate education.

The challenge is to find good textbooks that the students can afford. I believe the best place to look is among the "Asian editions" of standard texts. These texts are not widely available in Indonesia, but they are sometimes imported by bookstores. The Physics Department should determine what books are published in low-price editions in such places as Singapore, Hong Kong, and especially India. It might be advantageous in the long run if arrangements could be made with a private bookstore to import needed texts and make them available for student purchase.

(11) ASSISTING STUDENT ACCESS TO TEXTBOOKS

One way to increase access for the first-year students is to place texts in the IPB central library. If the department would place a request for library acquisition through formal channels, it would, I have been told, probably receive a favorable response for books printed in Indonesia. The department could request multiple copies of the better texts and problem collections, both high school level and introductory college level.

The department currently owns a number of copies of the text by Sears & Zemansky, and loans them each semester. This was an admirable example of making texts available for students, although it has over the years become less effective (the number of students has greatly increased and their ability to handle English has fallen).

Perhaps the best thing the department could do for the first year students is to see that the text being prepared is available at a low enough price. If students tend to resell their texts to new students, this will further reduce the effective costs to the students. The department might help facilitate this, but students are quite capable of handling this themselves, I imagine.

Students in the jurusan, on the other hand, should be encouraged to keep their textbooks. I am concerned that, even if arrangements are made to provide inexpensive Asian editions, the costs may still be too great for many students. Where could funds be found to assist such students? The only ongoing source that comes to my mind would be an alumni fund, maintained by contributions from students that have

graduated from the Physics Jurusan. Graduates might be willing to support such a fund, expecially if they themselves benefited from it during their student years. Based on his experience in the Agrometeorology Jurusan, Soedarsono suggested linking this contribution with distribution of a student and alumni newsletter. The strong spirit that can develop within a small department could make this project a success.

But until there are some graduates from the jurusan, funds would have to be secured from another source. The following table, representing an sample "model" of such a fund, should give some idea of how much start-up money is involved and when the fund would become self-sufficient. Rather arbitrarily, the model assumes fifteen entering students the first year of the jurusan, rising to thirty incoming students and plateauing there. It assumes that each student receives assistance for three years, then graduates and begins paying back to the fund the next year at the same annual rate, 20 (dollars or thousands of rupiahs, as you wish). In this model, the fund becomes self-sufficient after six years.

Physics Jurusan Alumni Fund

Year of Jurusan	Number of Entering Students	Payments From Funds 20*/Student Year	Contributions To Funds 20*/Graduate/Year	Shortfall
1	15	300	-	300*
2	20	700	-	700
3	25	1200	-	1200
4	30	1500	300*	1200
5	30	1700	700	1000
6	30	1800	1200	600
7	30	1800	2400	-0-
Total Startup Costs				5000*

*Figures represent 1000s of rupiahs (or, approximately $1 US).

(12) KELOMPOK PEMINAT FISIKA/"PHYSICS CLUB"

During the second half of my stay in Indonesia, during the second semester of the academic year, I helped organize a group of first year students interested in science. This direct contact with students was one of the most enjoyable aspects of my work. This sort of student organization has great potential, both for a new physics jurusan and for other jurusans to be established in the new Faculty of Science and Mathematics.

While the common first year of courses at IPB presents some difficulties in planning science department curricula, at the same time it offers a very important potential benefit to science departments. Students do not commit themselves to a particular field of study until the end of this first year. This provides more time for students to learn about their own interests and aptitudes, and for new departments to promote themselves and recruit good students.

A major contribution of an organization like the "physics club" could be identifying students with special talent in physics and encouraging them to consider the field.

It is my impression that the basic sciences are not attractive as career choices to most students. When IPB does begin jurusans in the new Faculty of Science and Mathematics, it will be important that they attract talented students, for they will probably recruit new faculty members from among their own graduates. Based on my one semester experience with the Kelompok Peminat Fisika ("physics interest group"), I believe such groups could help attract very talented students into the sciences.

A "physics club" is a common feature of physics departments in U.S. universities. It is an extra-curricular organization for undergraduates majoring in physics. The physics department provides a faculty advisor and facilities, such as a meeting room, and assist the students in organizing projects, field trips, etc. There is a journal in the U.S. in which undergraduates publish papers resulting from special projects and senior theses. The "physics club" provides a way for students to pursue interests outside the formal curriculum and informally meet with faculty members. Through the organization, students are encouraged to consider entering physics graduate school.

There are such student groups in various established IPB jurusans. And, as I later discovered, efforts had been made (by those planning the new Faculty of Science and Mathematics) to organize a similar group for students with an interest in physics. Not knowing of this effort, and wanting to better understand how the first year students view physics, I undertook the organization of a group along the lines of the "physics clubs" I am familiar with in the U.S. Soedarsono agreed to be the responsible faculty advisor.

From among the first year students who were enrolled in physics during the first semester, on the basis of their physics exam and laboratory grades, I chose about thirty students. These students were invited to an initial meeting at which plans for the organization were presented. Those interested later brought friends who also wanted to join. And students also wanted to join from the above-mentioned group already in existence. After a month or so, the number of students

attending meetings had settled down to about twenty-five. This group met each week through the rest of the semester.

Meeting activities were simple, namely, watching movies and carrying out experiments. Eve Van Rennes generally organized these mind-provoking experiments and demonstrations, using common materials and encouraging students to experiment for themselves. The movies, covering various areas of science and technology, were brought from foreign embassies in Jakarta which have such media material on hand.

Various students also volunteered for activities outside the normal meetings. Several students interested in computers began using the physics department TRS-80 microcomputer and learning the BASIC language. Other students arranged the books made available to the group. One student, under Soedarsono's supervision, began translating an introductory physics textbook from English into Indonesia. (These three activities are more fully described in other sections of this report).

Such a student group would be particularly valuable if a physics jurusan were begun. Until that time, it may have some value as a means of recruiting student assistants for the introductory physics course, of popularizing and promoting science, of identifying particularly talented students and providing them early personal contact with lecturers.

(13) PHYSICS DEPARTMENT MICROCOMPUTERS

Some of my activities involved the Physics Department microcomputers and the potential uses of microprocessors in the department. As most of my own computer experience has been with large scientific computers, perhaps I gained more than I contributed. I helped a few talented first-year students use microcomputers and gathered a small collection of books on interfacing microcomputers to measuring and control circuits.

There is a special place that microprocessor-based electronics could have in the physics department, and I believe that IPB can begin encouraging students to learn about microcomputer technology now, informally, before a formal educational program is in place.

The microprocessor chip will surely rank as one of the major inventions of the twentieth century. Perhaps most familiarly, such chips are the core around which microcomputers are built. Microcomputers are miniaturized versions of larger computers, and have similar but smaller capabilities. They follow directly from the first huge room-sized computers, in a sequence of smaller and smaller computers. But in this report, I want to emphasize another usage of microprocessor chips.

In many applications the microprocessor may be viewed, not as a computer or part of a computer, but rather as a very flexible piece of electronic circuitry. This in fact was the type of application for which the very first microprocessor chip was developed. Microprocessors are now appearing in consumer products (e.g., home

appliances, automobile ignition systems and instrument panels), because their use makes a product more flexible or less expensive. Most new scientific instrumentation similarly uses microprocessors.

An example may help to explain. Soedarsono showed me a small data recorder that he had built. It used electronic circuitry and a tiny printer scavenged from a printing calculator to measure and record a piece of meteorological data. The cost of this device was a small fraction of the chart recorder traditionally used for such purposes. This is a very clever adaptation for scientific purposes of cheap available hardware--and this is precisely the way in which university research, as I am familiar with it in the U.S., is able to "do more with less."

Continuing with the example, suppose that the goal is to simultaneously measure several things, such as temperature, humidity, sunlight intensity. It is not necessary to use a microprocessor, because this could be accomplished with additional electronic circuitry. But using the microprocessor may be the cheaper and easier way, and would certainly provide a more flexible instrument. The microprocessor merely replaces a portion of the complicated logic circuitry.

After collecting this meteorological data from several sites, a researcher might want to do a statistical analysis, plot out some of the information, or try to model various physical processes. A microcomputer would probably be capable of performing this work. In both cases then--in collecting the data and in processing it--microprocessors might be used, perhaps even identical microprocessors. But

in one case the microprocessor replaces complicated electronic circuitry, in the other it is used as a computer.

Another way to contrast the two uses of microprocessors is through costs of the hardware. The most popular microprocessor chips now cost about five to ten dollars each. For one hundred to three hundred dollars, they are available with support circuitry on small printed circuit boards. These "single board processors" combine a microprocessor with memory and circuitry through which measurement and control devices are connected. They are intended for industrial and scientific applications (and are popular with hobbyists and students). On the other hand, a fully equipped programmable microcomputer would be about ten times more expensive due to the accessories: keyboard, television screen, disk drives, printer, and so forth.

When a microprocessor is used to build an instrument or in other so-called "dedicated" applications, both hardware and software support (both electronic circuitry and computer programming) must be developed. A fully equipped microcomputer is often used to develop the software, preferably one built around the same microprocessor chip to be used in the application.

The preceding discussion of the hardware applications of microprocessors is not meant to overlook the other applications of microcomputers in physics. Modeling, data analysis, solution of equations, and other methods developed on large scientific computers are very important, and often may be carried out on microcomputers. But the "dedicated" applications are also important. When taught to

students, they offer some educational advantages. Students learn both software and hardware techniques. And, microprocessors are cheap and students can experiment with them, while microcomputer systems are relatively expensive.

The microcomputer field is one of the few which is easily learned as a hobby. Up until the past few years, in fact, it was dominated by hobbyists rather than professionals. By comparison, it would be impossible for someone to study, say, recombinant DNA methods for a year or so, and then proceed to try a few genetic engineering experiments--this field is highly technical and would require years of study and training before a person could accomplish anything useful. But microcomputing is just that accessible.

If a physics jurusan is begun, microcomputers and microprocessors-based electronics would certainly have a place in the educational program. But because microcomputing is so accessible, it seems possible that it can be introduced to some students before any jurusan is established. It is only necessary that interested students have access to some equipment and instructional materials, that the hobby be encouraged, and they receive a little guidance. There are several IPB faculty members who have become experts themselves through their own interest in a similar way.

The physics department owns two TRS-80 Model I systems. Soedarsono expressed a desire to see more use made of this equipment, and made it available to interested undergraduates. Several students from the Kelompok Peminat Fisika ("physics club") were interested and began to

learn the BASIC programming language. Some introductory material in both English and Bahasa Indonesia was provided, and the students themselves located more. They experimented with the computer and learned by themselves, though I tried to be available to answer their questions.

These TRS-80 computers had a history of frequently breaking down. This model is notorious for its sensitivity to glitches and spikes in the power line voltage, so that the frequent thunderstorm and lightning activity around Bogor could be one source of the problems. With supplies and assistance from the physics department, I built a simple power supply which should protect electronic equipment from this hazard.

With the departments investment in TRS-80 computers, Soedarsono suggested that any attention to microprocessor electronics be focused on the Z80 chip, the microprocessor chip used in the TRS-80 computers. This chip is a good choice: it is used in many industrial applications; it is a powerful chip; it supports the commonly used CP/M operating system; it will be the basis for the new inexpensive MSX microcomputers from Japan; though it is one of the earlier chips it is in no way obsolete; a powerful new version (the Z800) will soon be available.

With the goal of supporting some future work in microprocessors-based electronics, I collected information about assembly language programming together with a couple of programs (an assembler and a debugger) for the TRS-80. Students who have mastered

BASIC may be able to experiment with assembly language programming using these materials--although better introductory material or an experienced teacher would probably be more helpful.

By mail and during trips to Bandung and Singapore, I selected for the physics department a small collection of books. These books cover programming the Z80 chip and interfacing it to other electronic circuitry. Most are written for people already knowledgeable about electronics.

(14) PHYSICS DEPARTMENT READING SHELF

Toward the end of my work at IPB, the books resulting from my activities were assembled to form a small collection. Space for this collection was provided in the physics department office. Student volunteers from the Kelompok Peminat Fisika arranged the collection into an orderly form.

The books originated from several sources. Those mentioned in the previous section on microcomputers were provided by Soedarsono and the physics department. The University of Wisconsin/IPB project also contributed a couple of books on computing, as well as several reference books for physics lecture demonstrations. There is a small collection of material on appropriate technology, mostly donated by various organizations working in the field. As I visited physics department at other Indonesian universities, I was sometimes given laboratory manuals and texts which found a place in this collection. Also included were some Indonesian language physics texts and Asian editions of standard U.S. physics texts which I bought in Indonesia, along with a few texts I brought from the U.S.

Students in the Kelompok Peminat Fisika took responsibility for keeping the collection in order, and were given special access to the books. This was intended as a special privilege to those taking part in the group activities. It would be a better privilege if the collection had material more appropriate to their interests. There was no shortage of suggestions from the students for such material: science magazines in Bahasa Indonesia; information to help them

prepare for their KKN service which some students were quite interested in; general information about science and technology. If this little collection is augmented with material more interesting to students, it should also be made available to the student assistants who teach the physics department practicums.

A good portion of the collection contains texts and reference books which should be useful to lecturers as they plan courses. If a physics jurusan is to be started, a wider selection should be sought. This could serve as the nucleus of a future physics department library.

(15) FUTURE DIRECTIONS FOR THE PHYSICS DEPARTMENT

"It is hard to predict, especially the future"
Danish physicist Niels Bohr

What is the future of the IPB Physics Department? Should an S_1 program be initiated? What place does a "pure science" department have in an agricultural university? In what activities could an enlarged physics department participate?

Administrative decisions will largely determine the answers to these questions. Such decisions will be based on a broad perspective, encompassing long term goals and needs of IPB, perceived national development requirements, various institutional and political factors. I cannot view that broad perspective myself--I have had a rather narrow involvement with the physics department, so perhaps more enthusiasm than knowledge enters into this final section.

I will argue for the expansion of the physics department and the establishment of a S_1 program. This concluding section presents advantages which might result from this development. It also describes potential problems which, I believe, call for administrative attention.

This presentation breaks into three parts. The first part summarizes relevant points from previous sections. The second part relates the IPB Tridarma to some possible activities of the physics department. In the third part, a couple of long term possibilities are suggested.

15.1 Review of Prior Discussions

Several negative aspects of the status quo have already been discussed. The physics department has not kept pace with the rapid growth of IPB, neither in personnel nor in laboratory space--the first year physics course has been cut to a single semester, but still grows increasingly burdensome. Of the three faculty members, only the chairman Soedarsono has an education in physics. The department seems too dependent on a single person, on Soedarsono.

But some aspects favor the establishment of a jurusan. A fair amount of equipment has been assembled. There is an experienced group of lab assistants, office and shop workers. The two lecturers I have met, Hanedi and Soedarsono, seem dedicated to teaching. I was particularly impressed with the electronics courses developed by Soedarsono.

IPB's institutional character has positive aspects, as well. IPB has a strong record of educational reform and development. The common first year provides a period during which science departments may recruit students and attract some of the best. IPB's roots in the practical and applied disciplines should benefit experimental science programs. IPB has a record of securing graduate education for its faculty members.

There are some obstacles in the path to a larger department and a jurusan. The primary difficulty, I believe, is attracting and keeping new lecturers trained in physics or electronics. There is now a strong demand for such people in Indonesia. If IPB is to be competitive, new

lecturers must be afforded opportunities to earn an income closer to that offered elsewhere. Perhaps even more significantly, there must be opportunities to take part in interesting work--a physics jurusan is important in this regard. Young, new lecturers will need guidance from senior lecturers to effectively work within the institutional setting of a large university. New laboratory space will also be needed. There will be continuing problems related to the costs of giving good laboratory courses, supervising student work, providing materials, buying and building apparatus.

15.2 Mission of the Physics Department at IPB

The trifold primary missions of IPB are expressed in the Tridarma: education, research, and public service. This provides one context in which plans must be examined. IPB has grown so rapidly that its main focus has necessarily been its educational tasks. But in recent years, IPB has been increasingly working to establish stronger research and public service roles as well.

This section portrays the potential of a physics department within the context of the Tridarma missions. It is neither an inventory of its current activities nor a catalog of future possibilities. Rather, in each mission area I will describe one avenue through which the department could contribute. These three enterprises would involve other departments and structures within IPB. I truly believe these activities could address important needs and deliver significant benefits. But I also believe there are significant institutional barriers, which will be described.

In the ensuing discussion, the department will be cast in a service role--serving those within and without IPB. This touches on a major dispute concerning science activity in the third world. One side of the argument stresses that third world scientists should work on projects which are locally relevant and potentially beneficial to their countrymen. In this view, fundamental research is an extravagance that developing countries cannot afford. Scientists who pursue such topics there are depicted as selfish and morally insensitive to local human needs.

The countervailing view argues that such attitudes treat third world scientists as second class members of the world scientific community. Practical justification is not demanded for many disciplines (such areas of physics as cosmology, astrophysics, high energy particle physics)--as a human activity and achievement, science stands on its own, as do the arts and athletics. In this view, it is highly discriminatory to deny world class scientists in the third world a moral justification for fully participating in internationally significant work which could use their talents and bring honor to their countries and races. If there is a resolution to this dispute, I myself certainly do not know about it--both sides present potent arguments.

Science can certainly be done in a developing country--though it is certainly difficult. In physics, the Indian subcontinent offers the prime example. Throughout this century, it has maintained a tradition of excellence in many areas of physics and has produced its

share of Nobel prize winning physicists. But the present reality must be considered. Many areas of scientific investigation now depend on such expensive apparatus that only the wealthiest countries can afford to sponsor the research. Without proper equipment, a physicist can only be a theorist. In most fields of physics, a researcher is either a theorist or an experimentalist (or, lately, a "computerist"). Both theory and experiment are important, but the great majority of physicists are experimentalists.

I do not believe that a theory-oriented department would build on IPB's strengths. Nor would such a department greatly benefit IPB's existing activities. The great English physicist P.A.M. Dirac said that a physicist should do something useful when he is young, then when he is old he can sit and ponder the mysteries of the universe. That seems a useful motto for a physics department as well.

In the near future, it seems to me, the department would do well to develop the skills and tools of experimental physicists--skills and tools which can be immediately useful in other contexts at IPB. I can imagine the department, several decades hence, participating in research of international significance (into such a matter, for example, as the workings of the human brain and "natural intelligence"--a formidable subject now attracting attention from many kinds of scientists, including physicists and biophysicists).

15.2.1 Research--Instrumentation

I believe that problems with instrumentation and apparatus will continually be a tremendous obstacle to research in the Bogor area, at

IPB and at other research institutions there. A formal study could clarify the situation--my own information is mainly anecdotal, from young IPB scientists and from friends in the foreign technical assistance community. The technical support structure is still weak in Indonesia, and particularly so in Bogor where the primary emphases have been biological and agricultural. Even the weather in Bogor poses special problems. The uniformly high humidity can quickly corrode electronic gear. Frequent lightning storms are doubtless one source of damaging surges in the power mains.

The equipment situation often appears to go through "boom-and bust" cycles. An international cooperative project delivers apparatus to a Bogor institution--sophisticated apparatus, sometimes newer and better than the foreign counterparts themselves have used. Even during the project period, maintenance and repair pose problems--one Bogor project just purchased at least two of everything (effective but expensive); others bring in trained technicians from outside. When the cooperative period ends, equipment problems become more acute. Many projects seem to give insufficient attention to training Indonesian technicians, stocking spare parts, and otherwise preparing for equipment problems. Indonesian counterparts sometimes complicate the situation with a predilection for the most modern and sophisticated apparatus, a choice which can exacerbate maintenance problems. Scientific equipment in the Bogor area comes from manufacturers around the world, and this variety further muddles matters. A significant exception to this general discussion is the equipment from the Japanese companies which send repair personnel to Jakarta (permanently or on a rotating basis).

Throughout this report, an underlying assumption has been that instrumentation will be a major component in any development plans for the Physics Department. Activities here would build on the department's strengths. Other Indonesian physics departments offer specializations in instrumentation, and it seems likely to be one of the first specializations available to physics S_1 students at IPB. The curriculum exercise presented earlier incorporated a strong electronics sequence. I have suggested adding some lecturers with training in electronics/electrical engineering. A diploma program for technicians was mentioned, which could help prepare the way for a physics jurusan.

I believe that the physics department can most effectively work toward IPB's research goals by addressing the associated equipment problems of researchers. Such activity is nothing new, for Soedarsono has long assisted other departments in this way. But he has many other duties, and the department is small. Finding a manager for this activity, someone with business or technical training, would be a beneficial step--perhaps the single most effective step that could be immediately taken. At the least, documentation (technical manuals, repair manuals, parts lists) could be assembled for all new equipment coming into IPB.

There is clearly an opportunity for any group which can assist with equipment problems at the various research centers in Bogor. The IPB physics department is one of the few technically oriented groups in Bogor. Again, a manager seems essential for this type of enterprise. It might be possible to arrange for technical and managerial

training from the LIPI centers for electronics and instrumentation, from institutions outside IPB, or from commercial suppliers of scientific equipment.

Something is involved here that to my mind is even more important than repair and maintenance--effective improvisation. It is nice for a researcher to have just the right tool or piece of equipment. But when it is unavailable or too expensive or broken, clever improvisation can make the difference between failure and success. Movies generally show panels and switches for everything the scientists might want to know or do. That may be what scientific research is like in Hollywood (or in large well-financed government, industrial and pharmaceutical labs), but that is not what it is like in most university labs. In my research group, equipment was often scrounged from industrial and government surplus, thrown together in a makeshift way from older junk, or designed and built "in house" with lots of cheap undergraduate and graduate labor.

Soedarsono himself has shown the ability to cleverly improvise equipment--from common things such as childrens' toys or household appliances. This facility is visible in the work of graduate students from his electronics courses as well. These are not just clever tricks, but rather, I feel this activity is at the heart of university-style research. It should receive the encouragement of IPB--too-strict fiscal controls and the rigidity of large institutions can inhibit such effective but unconventional work.

A broad policy issue is raised by the concept of a service center for instrumentation (whether within the university shop or organized as a separate entity). I think it is fair to say that centralized

service units in Indonesian universities often do not work out well. I was able to make short visits to half a dozen service centers (such as repair shops and computer centers) in institutions other than IPB. Some did not seem very active. A couple did a brisk business, but mainly with customers outside their own institution. Only one impressed me, during my short period there, with the service it delivered to its university. It may be no accident that this center was the only one which charged university users for its services (with tacit permission from higher authorities).

As I understand the situation, Indonesian law forbids a service unit from recharging its work within its own institution, the feeling quite logically being that service units are established and funded to provide service and should do so. But other institutions and nongovernmental organizations are charged for work done. These funds are important for units that must keep technicians. There is a clear incentive to maximize the work taken from outside a service unit's own institution--this institution must develop countervailing incentives.

If the structural arrangements are a problem for service units at IPB (it is certainly my impression that this is the case), then finding a solution is a job for administrators. An internal accounting system would provide some way to gauge the demand for some service, distribute access to the service, and measure actual usage. This information then could be used in a budget cycle to determine appropriate support for the service unit and to allocate rights to draw on the services. Such dependable and automatic decision making

is extremely important to maintain a sense of fairness and stability. A scientific institution must recognize the high cost of scientific equipment parts and supplies. Surely there are administrative arrangements which could better accomplish these ends at IPB without violating Indonesian law.

15.2.2 Instruction--Science Teaching Methods

With the establishment of a Faculty of Science and Mathematics, IPB would break new ground. The proposed new Faculty could well exercise nation-wide influence through IPB's leadership role to outlying universities. Among the reasons to be hopeful for the future of the science departments is IPB's practical orientation, its involvement in solving national development problems. If science lecturers help solve real problems now, this activity will lay a strong foundation for the future. Then when sufficient resources and national commitment to basic science research appear, realistic programs may be built on this foundation.

But initially, the science departments will be relatively isolated from international activities in their own fields. For some time, there would be no graduate programs and no associated research activities. In fact, a strong rationale for the new faculty is the support it would give to other applied, agriculture-oriented graduate and research programs. Many graduates of the S_1 science programs will not go on to become science researchers, but rather will become teachers or industrial researchers or government officials.

How then can these science departments find their own identities? What route would carry the Physics Department toward the eventual goal, a full department involved in some modern research? How can it avoid being permanently detoured off as a "technical physics" or "physics of technology" program?

I believe one good tactic would have the lecturers investigate science teaching and the issues involved therein. The result would not just be better curriculum planning or better lecturers who use better teaching methods--though such benefits should accrue. More importantly, a lecturer should gain a deeper understanding of his own discipline.

There is now little opportunity for IPB lecturers in the proposed faculty to learn about undergraduate education in their own fields. IPB will likely build up the science departments in a "bootstrap" fashion, transferring lecturers from other departments and then seeking graduate training for them in their new fields. In the Physics Department, most lecturers would teach courses which they did not study as undergraduates. IPB lecturers sent to the U.S. for graduate study have not generally received much experience with undergraduate education--most native U.S. graduate students in basic science departments, on the other hand, work as teaching assistants or graders for a while. There is no faculty or department of education at IPB to bring up these concerns within the institution.

The inner dynamic of the basic sciences, even of their more applied subfields, is somewhat different from that of the applied

sciences. Perhaps the greatest discovery of science is the significance of seemingly trivial details, the importance of pursuing the merely curious. The potential usefulness of research is not totally ignored. But this consideration is not at the heart of research in the basic sciences as it is in the more applied sciences. IPB basic science departments must capture the spirit of their own disciplines. They must be able to teach some of their own students how science works, not merely results of previous scientific investigation.

This concern launched the "science teaching revolution" of the sixties in the U.S. The initial project concerned high school physics, but soon other sciences and university level courses were touched. (See appendices D, E, and F to this report). Science teaching centers were established at several major U.S. institutions (among them, M.I.T., University of California at Berkeley, Harvard, University of Maryland) to study different methods and develop teaching materials. Their work remains influential, although most of these centers no longer exist.

Over the past two decades, similar work has been carried out in many nations. UNESCO provided numerous forums in which the various issues and approaches have been aired. Already mentioned in this report, as a possible graduate school for Hanedi, is the Centre for Development of Physics Education at the University of Rajasthan in Jaipur, India.

There has been so much work done worldwide on teaching the basic sciences. It would be a shame if IPB did not review this work as its new science curricula are prepared. After all, their S_1 educational programs will be the primary duty of the science departments.

In the curriculum development exercise for the Physics Department, I proposed the adoption of several modern features. Some of the new undergraduate course material is very different in style from older material, and is partly based on different educational theories. Using this type of material would require considerable preparation by IPB physics lecturers. It is not easy to develop courses using new, unaccustomed approaches.

An investigation of science teaching should also consider teaching materials and tools. This report has mentioned demonstrations and given considerable attention to textbooks. I firmly believe that many courses in the S_1 physics curriculum should be based on "standard" texts, if the goal is to educate students who can later enter graduate school.

Basing most undergraduate courses on textbooks could be considered innovative in the general context of Indonesian higher education. By this, I mean not just selecting titles, but making the books locally available at prices the students can afford. The language barrier raised by English texts would seriously distract from the physics itself. Indonesian translations of some texts used early in the S_1 curriculum would help. Especially helpful would be materials specifically designed to ease the transition and develop bilingual

abilities: Indonesian notes to accompany English texts; scientific vocabulary lists; Indonesian summaries; parallel translations of critical passages.

Demonstrations have long had an important place in physics lectures, having evolved in the great English and German universities. They can make lectures vivid and memorable, and provide a connection between abstract knowledge and physical reality. Demonstrations still provide a fertile field for innovation. Today, many films have been produced for similar purposes.

Modern "hi tech" tools could become important, expanding the powers of lecturers and helping them meet the demands of a rapidly growing university. The next wave of change in science education may be driven by new technology. The U.S. National Science Foundation has offered to support several Educational Technology Centers. The first was recently begun at the University of California at Irvine, led by a physicist who has long used computers in undergraduate physics education.

Videocassette technology has arrived in Indonesia, equipment and repair service is readily available. Classes and lecturers alike could benefit from demonstrations, problem solutions, and lectures on videotape. Computers are also increasingly being used in physics education. Small cheap microcomputers are entering educational laboratories. Computer programs are being written to provide demonstrations. Much effort has been invested in developing and testing Computer Assisted Instruction (CAI) physics courses.

15.2.3 Public Service--Through KKN Work

There is a strong idealistic appeal to the KKN concept: sending university students to directly work on rural development while living in the villages. How do IPB students feel about this work? To illustrate the extremes, I remember meeting one student in the market who was earnestly practicing the Sundanese language in preparation, another who was quite happy to have escaped the duty on a medical excuse. One suspects that students' feelings vary as much as do the students themselves. But it would be hard to find any other group containing a larger proportion of energetic and idealistic people. Many of the students I knew, mostly talented first year students, were already thinking about what they might do. The potential of the KKN program derives from the sheer number of students, from their youthful idealism and energy, from the direct human contact the program affords.

What kind of contribution could physics students make, on what kind of projects could they work? Most likely, their best KKN contribution would apply their practical skills to technological problems. It seems that preparation for so important an experience as this deserves a place in the curriculum, if it can be integrated into the student's formal study. This report's curriculum exercise included two courses which could be oriented toward this end: a general topics course on technology and development, and a shop course. Technology is not the same as physics, not even applied physics--but there is a strong interrelationship. IPB should not graduate physics students lacking basic practical understanding, for they may later be called on to teach or assist in matters concerning technology.

This connection between physics and spreading basic technology has a precedent in Indonesia. The LIPI National Institute for Physics was assigned to evaluate and work with "appropriate technology." Since more than technological assessment was involved, the Institute developed a team approach which included social scientists, field workers and technicians. The students sent out to do their KKN work may not be trained scientists of any sort--but they do have personal contact with the people among who they live. Techniques and knowledge travel inside people. Direct human contact is crucial to "technology transfer" and is at least as important, if not more so, than expertise.

"Appropriate technology" and "intermediate technology" have become controversial cliches. This development strategy originated in concern over high demand for new jobs in developing countries, the limited available investment capital, the growth of dual economies, and swelling cities. This approach promoted direct aid to the rural grass roots (or rice roots) level. To met the need for jobs, it encouraged investment in tools whose expense and sophistication lay at an intermediate level between the traditional and the most modern.

The goals are important ones: improving rural life, creating jobs, forestalling migration to urban areas. At its best, this approach could quicken the dissemination of useful knowledge and improved techniques and better tools, speeding a process that has gone on throughout human history. At its worst, it can mean distributing to villagers a lot of simple little gadgets rather than planting a technological seed which could grow and flourish.

During a visit to the ITB Appropriate Technology Center, proponents of this strategy outlined to me their conception of the role of a local appropriate technology effort. It occupies the central position between villagers on one side and international research organizations on the other. These international organizations collect information about successful tools and methods from around the world. They may try to develop new techniques or improve traditional tools using modern research methods. Of course, what works well in one region and culture may fail in another, and a success in the lab may crop a miserable failure in the field. A local program should use the extensive literature which is available, select promising projects, carry the information into the village world in demonstrable form, assess the work's value, and complete the information cycle by publishing the results to benefit the international community.

As outlined above, the work of a local appropriate technology program actually resembles modern Research and Development (R&D) work: first, researching a problem in the literature; then experimenting and trying to improve; finally, evaluating and publishing the results. A student who carries on his KKN work in this spirit would get a small-scale introduction to the principles (and frustrations) of R&D work. Surely he would become acquainted with Murphy's Law ("if anything can go wrong, it will"), that principle known universally among scientists and engineers. He would learn the importance of "trial and error" by examining what has been done before and building on that experience and knowledge.

15.3 Long-Term Possibilities

Some advances so increase man's capabilities and so broaden the range of future possibilities that the "rules of the game" themselves are changed. Biotechnology and computer technology are two that contain the seeds for such revolutionary changes. No one knows whether in time they will fulfill this potential or not--but both are progressing at a pace unexpected only a decade or two ago.

The structure of DNA was a spectacular scientific discovery, resulting from decades of basic research. Immediately there appeared the possibility of exerting some control over genetic processes--but how was information encoded in DNA, and what tools could possibly be used to make changes? Now, there is increasing understanding of the genetic code. Natural tools have been discovered and used to manipulate genetic information. Though the most glamorous, this "gene-splicing" is by no means the only component of the new biotechnology--tissue culture techniques and exhaustive research into some single-celled organisms have also been important.

This revolution has mainly been a scientific one, carried out in university research laboratories. Only very recently can a "technology" be described. But the organizations suddenly entering into this field--corporations, national governments, the United Nations through UNIDO--attest to the mounting interest. Apparently the first applications will be in medicine and pharmacy. Large scale industrial applications and some relatively simple agricultural uses are also in the making.

Biotechnology raises puzzling new issues, including questions about the ownership of naturally occurring genetic information and of "engineered" organisms. The search has begun for useful genetic information. Particularly relevant to Indonesia is the fact that a large proportion of all species are found in the tropical rain forests, fragile ecosystems which are under stress and dwindling around the world. Will that genetic information become a major resource? Will these ecosystems survive long enough for this to be determined? Which countries would be able to exploit and profit from such a resource?

Genetic engineering is barely beginning. The work in view involves relatively simple shifting around of already extant DNA sequences which regulate single functions. Most immediate applications will involve one-celled organisms. A tremendous amount of basic scientific research would have to be completed before new DNA sequences, even new organisms, could be designed.

Computer technology is also rapidly advancing, and holds the potential for revolutionary changes. The last three decades have seen the appearance of ever faster, cheaper and tinier computers (on the average, twice the power for half the price every two years). But the actual concept of a computer is well over a century old. This first plan (an "analytic engine" to its designer) used mechanical gears and levers, which proved so difficult and expensive that it was never completed. The computer was a concept which had to wait on technology. And it is technology--first electric relays, then vacuum

tubes, transistors, now integrated circuits--which has governed progress in computer hardware.

There is no doubt that the computer is a useful tool. Increasingly its more important role is that of an "information processor" rather than of a "computing machine". Japan has challenged other major industrial countries with its Fifth Generation Computer Project. The goal is a computer which would understand ordinary human communication, which would be intelligent (or at least seem intelligent). Humanity has amassed an overwhelming amount of information--revolutionary consequences would result from an intelligent tool which could help people learn, sift and analyze this information.

The Japanese and other projects rely on progress in both computer hardware and software. It is the software side that has destroyed or delayed so many projects. Computer programming has proven a remarkably difficult task. Programming is not exactly science (although mathematical analyses help) or engineering (although "software engineering" systematizes useful methods). It sometimes resembles a skilled craft, sometimes a creative art.

Attempts are being made to emulate certain human abilities, such as: speech and handwriting recognition; computer vision; languages translation; "expert systems" which combine the knowledge of several experts about a specific problem. Such artificial intelligence work points up how complex is natural intelligence and how poorly we understand it. No one knows how well such efforts will work out. The result could be a steadily if rapidly improving technology. Or they could combine synergistically, creating a sum greater than the value of its parts, with genuinely revolutionary consequences.

Computer technology and biotechnology--each rests on an extremely broad base of science and technology. Why do I bring these up in this report, when IPB rests on a weak technological base and has barely begun its basic science programs? Why discuss biotechnology, when so much critical but fundamental agricultural work needs to be done? Why even consider computer information systems and computer aided instruction, when IPB's libraries are in a rudimentary state and a basic textbook system has yet to be developed? And what relationship does all this have to the Physics Department?

This is a recurring theme in development, finding the best path toward modernization. It may mean carefully and slowly retracing part of the path previously traveled by the industrial countries. It may mean taking a shortcut which has only recently been available. I believe the two technologies listed here will provide dramatic examples of such shortcuts. Both are relatively new, and basic research and development will continue for decades. It does not seem to me impossible for Indonesia to build expert scientific groups before the action has settled down in these areas. But it would surely take several generations of Indonesian teachers and students, as well as progress in building the underlying technical base.

Since Bogor is the center of agricultural and biological research in Indonesia, it would logically be the site of biotechnology activities. It is natural to expect IPB to be centrally involved, especially if it succeeds in developing the Faculty of Science and Mathematics. This technology would require broad technical and basic scientific support. Such work is clearly a long-term goal.

Like any university, IPB's very existence revolves around information--gathering, storing, teaching, analyzing information. Computers may be useful as computational tools in much research. But as information tools, according to some predictions, they will become indispensable to anyone who would maintain access to the expanding worldwide pool of scientific and technical knowledge. If such predictions come true, IPB cannot afford to be left out. Even if such predictions are overdramatic, computers are powerful tools with growing importance in many university activities.

What connections do these promising technologies have with physics? What role could the Physics Department play in the assimilation of these technologies at IPB? After all, the discipline of physics does not include computer hardware or software, or molecular biology or genetics. Yet there are important interrelationships. Twentieth century physics produced the instruments on which much modern genetic and biomolecular research depends--a number of pioneer researchers in these fields received a physics education. Physics has made more demands on computers and has been more closely associated with computers than any other field of science. As the IPB physics department is developed, these connections could be utilized in support of goals larger than those of a single department.

In view of the other activities in and around Bogor, it seems natural that the physics department will eventually develop a biophysics specialization. The term biophysics describes a very broad interdisciplinary field, though, and does not imply much about the

type of physics department that would be developed. A more specific focus would be the instrumentation important in modern biomolecular and biochemical research: x-ray and neutron diffraction; electron microscope; conventional florescence and spectroscopy; nuclear magnetic resonance spectroscopy.

Such a goal calls for a physics department oriented toward instrumentation and experimental work. Yet it must be a modern department, comfortable with quantum physics, atomic and molecular physics. Innovative educational methods, which move such topics earlier into the undergraduate physics curriculum or teach it to nonphysicists, will be important. The department would need instrumentation experts at both theoretical and technical levels, physicists and technicians.

Since the first computer was finished, there has been a close and mutually profitable relationship between physics and the computer field. Professional physicists use computers to numerically solve mathematical models; to record and process experimental data; and lately, to carry out large derivations in symbolic algebra and calculus. Perhaps because so many physicists are comfortable with computers, they have been leaders in using computers educationally, from large CAI projects to small microcomputers used in undergraduate labs. And today the chances are high that a physics graduate student will use computers in some way or another during the course of his research.

Computers are designed and programmed by many kinds of specialists. So specialized are the tasks involved, so rapidly is the technology advancing, that there is no such thing as a general computer expert, or even a software or hardware expert. As IPB develops its ability to use computers, I believe it could use as much specialized expertise as it can develop. In this report, I discussed one particular area--interfacing microprocessors--which is closely related to electronics and would seem the logical first step for the department. Physics lecturers sent to graduate school in the future will bring back other kinds of experience with computers as well.

APPENDIX A -- GLOSSARY OF INDONESIAN LANGUAGE TERMS

The following brief glossary, for the benefit of English speaking readers, defines IPB educational terminology, acronyms, and Indonesian language words used in this report.

Batan, Badan Tenaga Atom Nasional, National Atomic Energy Agency. A major government employer of physics graduates.

BPPT, Badan Penelitian Pengembangan dan Teknologi, Agency for Assessment and Application of Technology. This agency implements large projects which apply modern technology to assist national development.

Diploma Program, A one- to two-year course of studies in a specific area, particularly vocational and technical training. Indonesian universities are being encouraged by the Ministry of Education to offer such programs.

Fisika Dasar, Basic physics. Title of the one semester laboratory physics course which all IPB undergraduates take during their first year.

Jurusan, Field of study, academic department. This term is apparently used to refer to the field of study in which an undergraduate specializes, the specialized course of study, and the department which offers the course. In American terminology, jurusan means a major (field) and a department which offers a major. As there is no consistent terminology in the English speaking world, I have used the Indonesian term in the body of the report. Most of the courses taken by a student after choosing and entering a jurusan are offered by that department. IPB undergraduates enter a jurusan when they successfully complete the common first year program.

Kelompok, group. In the IPB common first year program, each student is assigned to a kelompok of approximately 150-200 students. Each kelompok follows a single schedule and its members receive lectures together through the year. A few kelompoks are formed from students who did not pass the common first year program and are given a second chance.

KKN, Kuliah Kerja Nyata, National Study Service Scheme, or practical university work/study. This rural educational and development program was pioneered by IPB, and has been accepted as a national model. During the vacation following his junior year, each IPB undergraduate student lives with a small group of students in a rural area and works on some educational, agricultural or rural development project.

Kelompok Peminat Fisika, Physics "interest group". This title was adopted for the "physics club" formed from interested freshmen students during my stay at IPB.

Lapan, Lembaga Penerbangan dan Antariksa Nasional, National Aeronautics and Space Institute. A major government employer of physics graduates.

Lembaga Fisika Nasional, National Institute for Physics. One of the LIPI research institutes. It had the assignment of investigating "appropriate technologies" or "intermediate technologies". More recently, it has been assigned a part in a materials science research program.

LIPI, Lembaga Ilmu Pengetahuan Alam, Indonesian Institute of Sciences. This is an umbrella organization for a number of research and instrumentation, electronics and national standards. Most LIPI institutes are now based in Bandung, but are scheduled to move closer to Jakarta near an industrial park, to be more related to problems in industrial development.

Luar Biasa, extraordinary. Using a "luar biasa" lecturer, a guest lecturer, is a common practice in Indonesian universities, both public and private. Such a lecturer is a staff member at another university, but is brought in weekly to give lectures at a university which lacks or has a shortage of expertise in a particular field.

PP I, Indicates the traditional examination system through which undergraduates gain admission to national universities. This system tends to favor students from the inner islands (Java, Bali), who have easy access to the best universities, or wealthier students who can afford special preparation and several attempts.

PP II, Indicates a new admissions procedure initiated by IPB. 80% of students entering IPB are now selected by this method. IPB takes recommendations from high schools throughout Indonesia, then tracks the progress of students admitted from each high school and uses this information in evaluating later recommendations from that high school. The student population selected in this way is more representative of the many geographic and ethnic groups throughout the Indonesian archipelago.

S_1, S_2, and S_3, Degrees granted by IPB, corresponding to the BSc, Master of Science, and PhD degrees in the American educational system.

APPENDIX B

DETAILED RESULTS OF CURRICULUM EXERCISE

This appendix is a more detailed presentation of the results of the curriculum planning exercise described in section (7) of this report. Course titles for Semesters III through VIII of an eight semester program are listed below. Semesters I and II, being set by the IPB common first year program, are omitted. During these first two semesters, students take two semesters of math and a one semester lab course in physics. Course numbers are designated for later reference in this appendix.

Semester III

Dept.	#	Hours	Title
Math/Phys	200	3	Integral Calculus
Phys	220	4 L	Physics II, E&M and Optics
Phys	230	3	Thermal Physics
Phys	260	3 C	FORTRAN & Statistics
Engr/Phys	290	3 S	Shop I
????/Phys	280	3	History of Science & Technology/English

Semester IV

Dept.	#	Hours	Title
Math/Phys	201	3	Mathematical Physics I
Phys	210	4	Intermediate Mechanics
Phys	250	3 L	Physics of Light
Phys	321	3 L	Electronics I
Engr/Phys	291	3 S	Shop II
????/Phys	281	3	Scientific English

Semester V

Dept.	#	Hours	Title
Math/Phys	302	3	Mathematical Physics II
Phys	310	4	Oscillations & Waves
Phys	360	3 C	Numerical Methods for Physics
Phys	322	3 L	Electronics II, Digital
Engr/Phys	390	3 S	Shop III, Group Project
????/Phys	380	3	Readings for KKN/English

Semester VI

Dept.	#	Hours	Title
Math/Phys	303	3	Mathematical Physics III
Phys	420	3	Electricity & Magnetism
Phys	350	5 L	Modern Physics
Phys	323	3 L	Electronics III, Analog
Engr/Phys	391	3 S	Shop IV, KKN Preparation
????/Phys	381	3	Physics & the Environment/English

Semester VII

Dept.	#	Hours	Title
Phys	410	3	Mechanics I
Phys	430	3	Thermodynamics/ Statistical Physics
Phys	470	3 L	Instrumentation
????	---	3	Open/Elective
Phys	499	3	Senior Project
????/Phys	480	3	Literature Search/ Translation

Semester VIII

Dept.	#	Hours	Title
Phys	411	3	Mechanics II
Phys	450	3	Quantum Mechanics
????	---	6	Open/Electives
Phys	499	6	Senior Project

Legend L -- Laboratory work
C -- Computer assignments
S -- Shop course
Phys - Physics Department
Engr -- Faculty of Engineering
???? -- Other departments which might/could develop courses for or in cooperation with the Physics Department

The remainder of this appendix will concentrate on the content of the courses listed above. These courses are presented in related groups.

Some discussion accompanies each group and additional information is presented for many of the course titles. However, this scheme is not complete--in some cases, I have only written down a course title which might appropriately fill out a semester schedule.

On returning to the University of Wisconsin, I have collected some information about textbooks. This information accompanies the course discussions. In a few cases, I recommend texts. In others, I provide a list of typical texts used in U.S. universities.

It will be evident that I have given more attention to the mathematical and theoretical aspects of the curriculum than to the laboratory work which should accompany many of the courses. This reflects my own background and knowledge, not the intended priorities of the plan--more attention to the experimental side is needed.

Core Math Courses

200 - Integral Calculus
201 - Mathematical Physics I
302 - Mathematical Physics II
303 - Mathematical Physics III

As I understand the IPB common first year program, its two semesters of mathematics cover differential calculus and barely introduce integral calculus. A number of other mathematical topics are covered. But I do not know whether or to what extent partial differentiation, matrix algebra (linear algebra) and complex functions are covered. These latter two topics should be taught in either the third and fourth semester. The courses numbered 201 (differential equations) and 321 (electronics) use the complex representation, while 210 (mechanics) might use matrix algebra.

If a specialization in remote sensing is developed, more attention might be given to the standard transform techniques (Fourier transforms). Or a special course might cover these as well as image transformation techniques.

200 - Integral Calculus One and two dimensional integration. Applications should include center of mass and moment of inertia calculations for two-dimensional bodies. If not covered earlier, some matrix algebra might be squeezed into this course as well.

201 - Mathematical Physics I. Ordinary differential equations. This course should cover standard solution methods including series expansions, Fourier transforms and especially Laplace

transforms (used in electronics), and line dimensional eigenvalue problems. If not covered earlier, the complex representation used in Fourier and Laplace transform methods may need extra emphasis. Should be synchronized with needs of 321 (electronics. A standard text often used is Boyce and Deprima (Wiley). Other texts more directly oriented toward physics or engineering may be as appropriate.

302 - Mathematical Physics II. Partial differential equations. This course should cover the classic equations of physics (wave equation, diffusion equation, Laplace's equation), introduce potential theory and Sturm-Louisville eigenvalue problems.

303 - Mathematical Physics III. Vector calculus and complex analysis. Should cover more rigorously concepts which have already been introduced in physics courses: divergence, curl, laplacian, Gauss's theorem. Vector calculus is particularly needed for 420 (Electricity and Magnetism) which is given concurrently. Coverage of complex analysis should introduce harmonic functions, poles, residue theory.

Core Physics Courses

220 - Physics II, E&M and Optics
210 - Intermediate Mechanics
310 - Oscillations and Waves
350 - Modern Physics
420 - Electricity and Magnetism

Designation of courses as core courses is a very subjective task. But it is important to emphasize the most basic, most important courses. The rest of the curriculum must not so burden the students that they neglect these core courses.

In conformity with some recent major U.S. university curriculum development projects (UC-Berkeley and MIT), a course on vibrations and waves is included and emphasized as one of the most important courses. This emphasis comes at the cost of de-emphasizing some topics which form the core of more traditional courses (such as thermodynamics).

The unusual sequence (Electricity and Magnetism 220 before Mechanics 210) is discussed in the main body of this report, in connection with the single semester physics course of the common first year program.

220 - Physics II, Electricity and Magnetism and Optics. This course should cover its material at the level of a traditional introductory university course. This material is

usually presented as the second semester of a two semester course. It should cover fundamental theorems of E&M (Gauss's law, Ampere's Law, etc.), introduce circuit theory (resistors, capacitors, inductors, Kirchoff's Rules) and geometric optics.

210 - Intermediate Mechanics. The level at which this course can be taught depends on the preparation students receive during secondary school and the first year at IPB. A good understanding of basic mechanics would allow the course to concentrate on more advanced topics, such as Lagrangian mechanics, relativity or rigid body motion. I doubt, though, that students would be ready for the text by Symon (a standard text for intermediate mechanics). They would probably need more detailed coverage of basic mechanics and more problem-solving experience. Two texts that might be useful are "Newtonian Mechanics" by French (Norton) and "Newtonian Dynamics" by Baierlein (McGraw-Hill).

310 - Oscillations and Waves. Such a course is excellent preparation for both modern quantum physics and many areas of applied physics. I would recommend the text "Waves" (Berkeley Physics Course - Volume 3) by Crawford (McGraw-Hill). I greatly admire the Berkeley text for its fascinating teaching methods. It requires less mathematics but covers more areas of physics than the MIT text. Other similar texts are: "Vibrations and Waves" (M.I.T. Introductory Physics Series) by French (Norton & Co.); "Physics of Vibrations and Waves" by Pain (Wiley); "Physics of Waves" by Elmore and Heald (McGraw-Hill). Another text that might provide useful supplementary material is "Introductory Eigenphysics" by Croxton (Arrowsmith Ltd., Wiley).

350 - Modern Physics. This course is traditionally a survey-type course. An appropriate text which touches on nuclear, atomic, solid state and laser physics is "Modern Physics, 3rd ed." by Sproull and Phillips (Wiley). Other texts, with the same title, include those by Krane (Wiley) and by Tiptree (Worth). Demonstrations or lab exercises or even a separate lab course for modern physics would be highly desirable if the equipment can be assembled at IPB. More information can be found in two books with the title "Experiments in Modern Physics", one by Melissano (Academic Press) and the other by Mark and Olson (McGraw-Hill).

420 - Electricity and Magnetism. This course would cover magnetostatics, electrostatics, and some wave propagation theory. This type of course sometimes is taught as a two semester course, with the second semester covering such topics as radiation and antenna theory. Some typical texts are:

"Foundations of Electromagnetic Theory, 3rd ed." by Reitz, Milford & Christy (Addison-Wesley); "The Electromagnetic Field" by Shadowitz (McGraw-Hill); "Introduction to Electromagnetic Fields" by Paul & Nasan (McGraw-Hill); "Electric and Magnetic Fields, an Introduction" by Oatley (Cambridge U. Press); "Electromagnetic Fields" by Wangsness (Wiley).

Auxiliary Physics Courses

230 - Thermal Physics
250 - Radiation Physics
- Electives

These courses might be offered to provide a specialization or to fill open places early in the curriculum. But particularly during the sixth semester, they should be relatively light courses, perhaps of a survey nature, to provide a manageable course load for students.

There are three open slots in this schedule for electives or courses associated with a specialization - such courses could well be provided by other departments. Other physic topics that might be considered in place of the ones listed below include: optics, materials science, statistical physics, introduction to solid state, astronomy and astrophysics.

230 - Thermal Physics. The core curriculum does not cover calorimetry, heat engines, and the introduction to thermodynamics traditionally given in the introductory university physics course. If the common first year physics course does not cover this area sufficiently well, then this subject seems to merit more coverage. In the spirit of a survey course covering thermal properties of matter, low temperature effects (superconductivity and superfluidity) and high temperature effects (ionized gases and plasmas) might be mentioned.

250 - Physics of Light. I have in mind a course dealing with properties of light, spectroscopy, interference effects, optical instruments. Such a course may be related to the remote sensing program at IPB.

Advanced Physics Courses

410 - Mechanics I
411 - Mechanics II
430 - Thermodynamics.Statistical Physics
450 - Quantum Mechanics

These advanced theoretical courses for the senior year are intended to prepare students for graduate work. These are the most

dispensable part of this plan, in my opinion. In many U.S. universities, at least, a graduate student may initially take extra time to take such undergraduate courses.

410-411 Classical Mechanics. An undergraduate education should cover mechanics at the level of "Mechanics 3rd ed." by Symon (Addison-Wesley). Often undergraduate programs cover the initial portions of "Classical Mechanics 2nd ed." by Goldstein (Addison-Wesley), the standard graduate school textbook.

430 - Thermodynamics/Statistical Physics. These texts cover a spectrum of approaches to such courses: "Thermal Physics" by Desloge (Holt, Rinehart & Winston); "Thermal Physics" by Morse (Benjamin); "Statistics and Thermal Physics" by Reif (McGraw-Hill); "Statistical Physics" by Mandl (Wiley); "Thermal Physics" by Kittel (Wiley); "Thermal Physics 2nd ed." by Kittel & Kroemer (Freeman). The first text by Desloge, despite the title, is a mathematical treatment of thermodynamics, an undergraduate version of the standard graduate school text "Thermodynamics" by Callen (Wiley). The other texts combine thermodynamics with statistical physics, particularly quantum aspects - those texts listed last place the most emphasis on statistical physics.

Electronics Courses

321 - Electronics I
322 - Electronics II, Digital
323 - Electronics III, Analog
470 - Instrumentation

The electronics sequence listed here is quite tentative - I myself have little experience with such lab courses. The possibility of a specialization in instrumentation partially motivates the inclusion of the course 470.

A few texts for one and two semester courses are: "Introduction to Modern Electronics" by Sprott (Wiley); "The Art of Electronics" by Horowitz & Hill (Cambridge University Press); "Electronic Circuits and Devices, 2nd ed." by Smith (Wiley).

321 - Electronics I. Passive circuits, filters, introduction to solid state components, power supplies.

322 - Electronics II, Digital Logic gates, TTL packages, A/D and D/A converters, perhaps an introduction to microprocessors.

323 - Electronics III, Analog. Op amps, feedback, FETs.

Computer Courses

260 - FORTRAN & Statistics
360 - Numerical Methods for Physics

260 - FORTRAN & Statistics. The goal of this course would be to teach some computer language (FORTRAN or BASIC or whatever is most easily used on the computers available) along with a few simple statistical methods used to analyze physical data. The programs given to the students to use or developed by the students should be available for use by the students in subsequent lab courses.

360 - Numerical Methods for Physics. I would expect appropriate texts (numerical methods for undergraduate physics students) to be appearing soon, but am not yet acquainted with any. Some general undergraduate texts are: "Computer Methods for Mathematical Calculation" by Forsythe, Malcolm and Moler (Prentice-Hall); "Numerical Methods that Work" by Acton (Harper & Row). A very interesting resource book is "Using Computers in Physics" by Merrill (Houghton-Mifflin) - in many areas of physics, it presents BASIC and FORTRAN programs along with some exercises.

Shop Courses

290 - Shop I
291 - Shop II
390 - Shop III, Group Project
391 - Shop IV, KKN Preparation

One or two semesters should be sufficient to introduce the basics: machining, welding, brazing, soldering. If the equipment and instruction is available, experience with more advanced techniques would be useful: vacuum techniques, photographic darkroom practice, glass-blowing. The third and fourth semesters of shop are intended to assure continued practice and access to the shop facilities. With appropriate supervision, a small group of students could build a device or instrument that could be useful in the physics department educational program. Another useful experience for students would be shop work developing technical projects in preparation for the KKN service. The senior project may involve further shop work.

Nontechnical Courses

280 - History of Science & Technology/English
281 - Scientific English
380 - Readings for KKN/English
381 - Physics & the Environment/English
480 - Literature Search/Translation

This group of courses is intended to provide at least one course per semester which is a rest from the science and math courses. The students could surely benefit from some help with English when they first begin using English texts, help which these courses could provide. The main purpose, though, is through reading and discussion to provide the students with a wider perspective on science and technology: history, ethics, relationship to society, place in national development, how scientists and science work, difference and interplay between science and technology. The specific topics assigned in course titles are only rough suggestions.

APPENDIX C

TEXTBOOK USE IN THE TRADITIONAL U. S. GENERAL PHYSICS COURSE

Drawing on my experience in U.S. universities, I would like to summarize how textbooks are arranged and used there to support problem solving by students. In particular, I will focus on the one-year introductory physics courses offered for science and engineering students. I have been a teaching assistant at the University of Wisconsin during four semesters, and have worked with three different lecturers (who both lecture and are responsible for planning and managing the course). In addition, the physics course I took as an undergraduate at Florida State University was very similar to the Wisconsin courses, having been developed by graduates from Wisconsin.

This one-year course is very similar to the course offered at most U.S. universities, and is based on lectures, demonstrations, laboratory work, problem assignments, and discussion sections. A number of different textbooks are available (each of the three lecturers I worked with chose different texts), varying in difficulty, level of mathematical sophistication, and intended audience. Each university generally develops its own experiments and demonstrations, depending on what equipment it builds or acquires. But nonetheless, the resulting course is fairly standard throughout most major U.S. universities.

This appendix is addressed to Indonesian physicists who may make use of the U.S. texts developed for such courses. Most American physics graduate students spend at least one year as teaching assistants in these introductory courses. Many will also serve as graders or lab instructors for more advanced undergraduate courses. However, most graduate students from outside the U.S. sponsored by their own countries escape this duty. They may not be able to teach in English when they first arrive, there is more pressure on them to complete their graduate work, and U.S. universities use the assistantships as financial assistance and may be reluctant or legally restricted in granting assistantships to foreigners. Unfortunately, this means that while graduate students from abroad may learn advanced topics and research methods, they do not gain any more experience in teaching, and are not exposed to undergraduate teaching methods in use at their graduate institution.

The discussion in this appendix concerns only the relatively standard lecture course that is given at many large U.S. universities to beginning science and engineering students. Some universities have developed innovative approaches using self-paced or computer-based instructional materials. Some universities have developed completely new curricula--the next appendix will touch on these.

A fairly standard format has been adopted by most texts used in large physics courses. A very large number of problems are collected in the text. There are typically thirty or forty chapters in a text used for a one year course, and problems are presented at the end of each chapter. Sometimes the problem list also indicates which subsection of the chapter contains the information needed for each problem's solution. The problems cover a wide range of difficulty, beginning with the simplest "plug-in" problems which require that students only find and use the appropriate equation from the text. The problems may be arranged in order of difficulty. At the least, the most difficult problems are indicated by an asterisk or some other special notation. Customary practice is to give, in the back of the book, the answers for about half of the problems. Only the final answer is given, not the method of solution. There are no answers given for half of the questions, although hints may be given for the most difficult problems.

Using the textbook problems in an effective way involves: (a) selection and assignment; (b) assistance to the students; (c) grading and evaluation of student efforts; and (d) feedback to the students.

(a) In my experience, problem selection is finished before the semester begins. In the first week of classes, students receive a syllabus which lists reading and problem assignments for each week along with the exam and lab schedules. The problem assignments are different each time the course is offered. It is the lecturer's responsibility to select problems which are coordinated with the selected portions of the text and with his lectures. Most, but not all, lecture topics have associated problems. Working problems is often a difficult and time-consuming task for students--it is important to choose a good sequence of problems, so that students do not become discouraged. The simplest "plug-in" problems require only that the student find and use the appropriate equation. Increasingly difficult problems require the student to perform some transformations on the equation before using it, and to use more than one equation simultaneously. The most difficult problems call for the student to find derivations, to analyze and solve a problem in several stages, or to use various "tricks" and special methods. The "answers in the back of the book" also give considerable reassurance to hesitant students. But since examination (and real-life) problems do not come with the answers, a mixture of problems with and without answers are usually assigned.

(b) Assistance to students who are working on solving problems is provided in various ways. Examples of problem-solving in the textbook are quite important. Collections of solved problems may be helpful to some students. The lecturer may also work problems in his lectures. Teaching assistants hold office hours when students can bring questions for personal help. These assistants sometimes hold their office hours in a special room on a regular schedule. And sometimes

student volunteers offer similar assistance in libraries or other places where students work in the evening. Student assistants concentrate on problem-solving when they meet students in "discussion sections."

(c) Grading of problems depends on the teaching assistants. If there are enough assistants, the problem solutions can be collected and checked for completion, and perhaps one or two problems can be corrected and graded. In one case in my experience where there were too few assistants to handle problem solutions, the students were asked to write their solutions into notebooks which were collected at the end of the term, lightly checked and returned--this was a surprisingly successful procedure.

(d) Feedback to students is very important, both for psychological support and to help them develop good work habits and find the best ways to solve problems. The ideal method would be individual correction of all their work, but that is not possible in a large class. After working on problems, students are often interested enough to check their own work. Student assistants may work out difficult problems on the blackboard, or the lecturer may give the solutions during a special meeting. Traditionally, written solutions are posted at the appropriate time behind glass in a special bulletin board or solutions may be printed and distributed to students each week.

APPENDIX D

PSSC AND THE REVOLUTION IN AMERICAN HIGH SCHOOL PHYSICS TEACHING

There was a revolution in American science education, beginning around 1960. In the past two decades, high school physics teaching has been transformed by this revolution. For various reasons, most university physics programs have not been so quickly and drastically transformed. Nevertheless, slowly and surely, curriculum revisions and improvements are appearing in university physics programs. This promises to be a continuing trend in U.S. universities.

Indonesian educators planning new science programs cannot afford to overlook this trend. It is easier to introduce the "new" science and "new" educational methods, where appropriate, when a curriculum is initially developed, than to later introduce them as reforms of a curriculum based on more traditional approaches.

This appendix will concentrate on the PSSC (Physical Science Study Committee) physics course produced around 1960: its history, motivation and major goals. This new high school physics course was the first of the major efforts to remake high school science in the U.S., and was one of the most far-reaching. This project had tremendous influence on subsequent projects in high school biology and chemistry, on science education throughout the world, and increasingly on higher education as well. After this look at the PSSC project, the next appendix will give some attention to university-level curriculum development projects and trends.

The PSSC was organized in 1956 with support from the U.S. National Science Foundation. This activity was originally stimulated by Dr. Jerrold Zacharias (professor of physics at MIT), and preceded by efforts of the American Institute of Physics, the American Association of Physics Teachers, and the National Science Teachers Association. During the summer of 1957, in Boston, a large group of high school teachers, film makers, equipment designers, and university professors of education and physics began the development of a new course. As it was developed, it was tested in many high schools under hundreds of teachers. In 1960, after the expense of five million dollars, the first commercial version of the course appeared.

On October 4, 1957 the first satellite "Sputnik" was launched into orbit by the Soviet Union. During the ensuing furor in the U.S., the state of science and math education in the nations' schools received tremendous attention--so much so that the phrase "the Sputnik revolution in American science and math education" is often used to describe the changes made. As is clear from the dates given above, hurt American pride was not the original impetus for the PSSC project. Rather, it was the tremendous growth and increased importance of the scientific community during and after World War II, and a high school

physics course which had not received a major overhaul since 1915, before the birth of modern quantum physics.

There is no doubt that the national concern aroused by the Soviet achievement opened pocketbooks and doors for the new curriculum effort. The PSSC project received grants from the National Science Foundation, the Department of Education, the Ford Foundation, the Alfred P. Sloan Foundation and the Rockefeller Foundation. In the U.S., decisions about secondary school textbooks and curricula are made by the local school districts, with some guidance from the state education departments. Despite the lack of official guidance from the national level, over half of all American high school students studying physics were studying this new course only five years after its introduction.

The following points indicate some of the major goals of the PSSC project. They were gathered from the three historical references listed at the end of this appendix (1,2,3).

**The science taught in schools should resemble science itself. Physics is not just a collection of facts and formulae, and learning physics does not mean rote learning and memorization. With knowledge doubling each decade, no course could keep up with the facts anyway. The PSSC course concentrated on methods and procedures, and intended that the methods and procedures of science teachers should resemble those of modern scientists.

**Physics involves observations and measurements, but the heart of modern physics is the development of models. These models are subject to further experimental checks, which can give rise to better models. A goal of the PSSC course was encouraging students to create models, to see and use models as physicists do. This leads to viewing physics as a dynamic activity--since models are created in the realm of human thought, they are even more subject to change than physical measurements and observations.

**The PSSC course attempted to present physics as a unified story. Their judgment was that even the best existing texts, by trying to cover too many topics, partook of a patchwork nature and did not clearly present the major themes of physics. The PSSC course presented fewer topics and dropped much of the material traditionally presented in such courses. But the new course repeatedly touched on its major themes, and went more deeply into what are currently considered the most fundamental principles of physics.

**As a means of motivating students and maintaining their interest, traditional texts had illustrated physical principles with many applications to modern technology. The PSSC believed that this practice obscured the difference between science and technology and led students to a false understanding of the nature of science. By

contrast, the PSSC course was centered on the principles of science. For student motivation, the educators relied on their students' curiosity and the fascination of solving puzzles and problems. The course encouraged students to discover and learn for themselves, by placing them in carefully arranged situations in which the students had almost enough information to solve problems on their own. The intention was to present science as a series of questions, rather than a series of answers.

**PSSC planners intended that lab experiments truly be experiments. That is, students were to discover things in their labs, not merely accumulate data or get the answer already provided in the book (or force results to yield the "right" answer). The labs were closely tied to development of ideas in the text.

**The PSSC labs were to be based on very simple equipment. This simple apparatus has the advantage of not obscuring and complicating the physical events. In fact, the original plans called for students to build their own equipment for each experiment, using inexpensive commonly available materials. In view of the extra load this would place on teachers (shopping for material and supervising construction), the committee settled on a compromise, on commercial kits that could be quickly assembled by students. Still, the bulk of the equipment could be built by students at home or by teachers if so desired.

**The new course incorporated a strong historical perspective. It described individual physicists, recounted important experiments, and explained the development of major new models. The goal was to present physics as a human activity, set within society and carried on as a part of the development of humanity.

The following quotation, from a history of the early curriculum reforms, further emphasizes that view of the nature of modern science which underlay the PSSC work: (4)

> Many people look upon the scientist essentially as one who describes nature by careful observations, and upon the scientific process as the accumulation of his descriptions which, based on direct observation, represent "irrevocable fact."
>
> This conception is in part correct. As a matter of fact, almost all science begins with observation. In many of the sciences, several hundred years were devoted to the accumulation of a large volume of observed descriptions of nature and some scientists are still confined largely to this type of work. To the scientist, however, his discipline "grows up" when it allows him to ascertain relationships between some of the observations made and thereby go beyond the information obtained through the senses. The usual

result of this process is an abstract mental picture which tends to see nature in an orderly, though man-made, pattern. This, of course, is the stuff of which scientific theories are made. In essence, the scientist constantly seeks to alter his questions from "what is the situation?" to "can I find similarities which might give a hint as to why this situation exists?" When he can begin to provide answers to the latter question, he considers himself to have been most successful.

Many of the most important aspects of science have nothing to do with microscopes, test tubes, telescopes, atom smashers, or acids. Such things are often important since they are useful tools in collecting the information about nature without which the scientist cannot operate. The scientist makes his major "discoveries," however, when he leaves his laboratory, contemplates his measurements, and says to himself, "what does this mean?" The important ideas contributed by such men as Darwin, Einstein, Rutherford, Fermi, and the vast majority of well-known scientists resulted from this sort of mental effort.

Science, then, as it matures, tends to proceed from the practical to the theoretical. It moves from preoccupation with concrete objects to the development of abstractions which relate objects and events, one to another. Unfortunately, in much of traditional science teaching little or no distinction has been made between the results of measuring and observing things (scientific facts) and the principles of science which are in reality only mental pictures (the abstractions mentioned above) but which have the greater power in opening new doors of understanding. Traditional teaching has lead to serious misconceptions in terms of both science content and the nature of science itself.

As an example, when the average high school graduate is asked to give his conception of an atom, he is likely to respond with a very precise and careful description of an object composed of a nucleus made up of protons and neutrons with other particles called electrons traveling around it in discrete orbits. On the other hand, when the chemist is asked the same question, his answer is likely to be punctuated with statements like "I think," "Perhaps," "Maybe," or "Our present thought is." In this situation the high school student is talking about atoms as if they had actually been observed and measured, while the chemist realizes that the atomic theory is the chemist's way of organizing a large number of indirect observations into a meaningful pattern.

Our high school student is likely to be shocked if he discovers that atoms are described quite differently ten years later. In fact, he is likely to lose confidence in scientists and in his teachers when he discovers that he has been given the "wrong information" in his high school course. The chemist, on the other hand, realizing that all descriptions of atoms take him beyond the level of concrete information, will not be surprised by such changes; he will expect them. This difference of outlook arises from the fact that the high school student was probably taught atomic theory as atomic fact.

Hence, as science progresses it tends to become more abstract and the more scientific information depends upon the scientist's interpretations, the more it is subject to change. Even more confusing for the layman is the fact that the interpretations made by scientists sometimes call for abstractions which give "a picture" represented by a series of mathematical equations impossible to visualize. In such cases the "model" obviously does not correspond to what one observes directly, but the scientist, lacking a better explanation, is willing to use it since it provides some of the order which he is seeking.

In short, then, modern science consists of a rapidly increasing volume of information with an accompanying set of organizing principles (the theories of science), neither of which remains constant. Neither all the facts nor all the concepts of science which were "true" ten years ago can be accepted today.

The following report from a Swedish secondary school teacher illustrates how the PSSC course can work. In 1962, the Scandinavian countries began adapting the PSSC course to their own educational systems and languages, and began using these materials on an experimental basis. A teacher who participated in this experiment, after two and a half years of experience, offered his personal impressions: (5)

What made the PSSC course so attractive to me from the outset was its consistency. It is divided into three large blocks: optics, mechanics and electromagnetism (including atomic physics). In each block the course concentrates on the most important laws and principles and devotes a lot of space to the fundamental laws of physics. The haphazardness of other textbooks is replaced by a clear, logical line of reasoning. Moreover, the PSSC textbook is so comprehensive that students are able to read it without too much aid from the teacher. It was mainly these apparent advantages that made me participate in this educational experiment.

Since then I have discovered other advantages with the course that I consider more essential. There are two aspects

in particular which I would like to point out. The one is the epistemological clarity with which new laws are presented and the other is the essential requirement that the students really must understand physics.

The epistemological aspect is the most interesting one. I can understand that the PSSC course tends to repel many who want an answer to the question: "What is the Truth?". At first, many students are irritated at never being told what the definitive truth is. They are victims of the common misconception, that the laws of physics discovered by scientists are true, and that when these laws are changed, then some physicist must have made a mistake previously. The PSSC course presents a different way of looking at it. It shows that reality can be described by means of a model of some kind. This model represents a first approximation and does not need to be especially accurate. It is shown that the first model has certain inherent deficiencies, and another model is presented which is more accurate in some respects, but which also has certain defects. In this manner, by successive approximations the physical reality can be approached more and more closely.

Students do not seem to have any great difficulty in understanding this way of looking at it. This can perhaps best be illustrated by relating a discussion we had in a physics class. We had established that movements and velocity could be added in a certain way (as vectors) and we were going to investigate if the same law was valid for forces. A simple experiment was made therefore with forces of different directions and magnitudes but with the same point of action. We established that the law (the parallelogram of forces) was valid. I asked if there were any objections. Yes, the students were critical on several points. In our experiment we had only investigated gravitational forces and tensions in pieces of string. The law was not necessarily valid for electric or magnetic forces. Furthermore, the system we had investigated had been at rest. If it had been in motion the law might not apply. Moreover our measurements may not be sufficiently accurate and therefore small deviations from the law may exist undetected by us. Well, what should we do? Should we start a long series of experiments with different kinds of forces and with systems both at rest and in motion? No, because we still could not be certain that we had tried all possible cases. But can we then use this law without being absolutely certain of its validity at all time? Yes, because it is not possible to get any further. This is what we do. We use the law until it becomes evident that it is no longer valid.

The discussion above can also be used to illustrate the other aspect of the PSSC course which I would especially like to point out. It is the requirement that the students really must understand what they are doing. This requirement may seem trivial, but every physics teacher knows the great difficulties this involves. The danger of mechanical application of formulae learnt by heart is always present and threatens to make physics teaching rather meaningless. It is only too easy for the students to learn formulae and to insert in them the values taken directly from the problems. Of course it is of some value that they are at least able to do this. It does not show however that they know any physics, but perhaps that they know some mathematics.

I know how difficult it is for many physics teachers to find problems that really test the students' knowledge of physics. A great advantage of the PSSC textbook is that it contains an abundance of such problems. Some of these can be very irritating even for the teacher because their solution sometimes requires some really careful thought. A single example will be sufficient here to illustrate this: "Can you suggest reasons why no interference is seen when light reflects from the two surfaces of a windowpane?" In this way the PSSC course makes great demands on the teacher but it is also very instructive. I did not believe it possible to accumulate such a vast number of problems of this type.

It should be noted that not all reactions to the new curriculum were so positive. On the contrary, it raised a storm of controversy. Some of the PSSC's goals were questioned and questionable (e.g., the intentional lack of attention to technology, the restricted coverage of topics). Another question was how well the new course attained some of its goals. While PSSC students were not as well prepared for traditional examinations, it was difficult or impossible to test the new abilities supposedly developed by the course. Being a pioneering project, it was bound to be followed by others which built on experience and corrected its weaknesses, or combined aspects of the new and old. But no subsequent school course development could afford to ignore the PSSC course.

With its "modern" goals and "new" educational philosophy, the PSSC project was tremendously influential. The project produced a new textbook, a lab book, and three teacher manuals (for labs, text and problems). The project involved far more than just textbooks, though. Dozens of new films were produced and integrated into the course. Over fifty books covering different areas and applications of physics were commissioned--the Science Study Series. These books were aimed at the general public and beginning university students as well as high school students, and were published in inexpensive paperback

form. The new course was presented to high school teachers at dozens of universities across the country, where summer courses and in-service institutes were organized.

The PSSC course set a number of precedents in American education. For the first time, scientists worked closely with professional educators to produce a course. For the first time, expert scientists admitted that not all important topics of a field should be covered in a science course.

The influence of the PSSC course was international in scope. UNESCO in particular provided many forums through which new science teaching methods could be exchanged, and the PSSC approach stimulated similar projects in many other countries. The PSSC course itself was first adapted by other industrialized countries, but some aspects were equally attractive and relevant to the developing countries as well. The fundamental thesis of the PSSC course--that science taught should resemble science itself--is of crucial importance if developing countries are to become producers of science rather than just consumers of science performed elsewhere. (On the other hand, it should be noted, the neglect of technology by the PSSC course could be questioned in any country and particularly in developing countries.) Also attractive was the work done by the PSSC in developing labs based on the simplest equipment--the PSSC asserted that not only was such equipment easiest on a budget, but it was also the best way to teach.

By 1960, similar curriculum revision projects for biology and chemistry had been initiated in the U.S. The Biological Sciences Curriculum Study (BSCS), set up three groups which produced three separate courses. These different versions were organized around three points of view: the molecular level, the ecological point of view, and the cellular level. (These courses were respectively named BSCS Blue, Green and Yellow.) Two different chemistry courses were developed as well: the Chemical Bond Approach (CBA) Course, and the Chemical Education Materials (CHEM) Study Course. The second course is more experimentally based than the first.

In concluding this section on secondary school science education, note should be taken of some other curriculum projects. In England, a major curriculum program in physics, biology and chemistry was initiated by the Nuffield Foundation. The Nuffield Physics Project was part of this program, and shared many of the concerns of the PSSC. In the U.S., a second physics course named Project Physics was created at Harvard. The aim of this course was to attract more American students into physics classes--the PSSC course was developed for college-bound students, and most other students did not study physics before graduating from high school.

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2) "New Trend in Physics Teaching, Vol. I", ed. W. Knecht; UNESCO; 1968.

3) "International Education in Physics--Proceedings of the International Conference on Physics Education, Paris, 1960, ed. S.C. Brown and N. Clarke; jointly published by MIT Technology Press and John Wiley & Sons.

4) "Current Trends in Science Education", ibid., pp. 2-5

5) "New Trends in Physics Teaching, Vol. I" ibid., pp. 247-248. Article originally published in the Swedish paper Skolvarlden (The school world) No. 36, December 17, 1965.

APPENDIX E

CURRICULUM REFORMS AND TRENDS IN U.S. UNIVERSITY PHYSICS CURRICULA

The preceding section described the origins and motivations of the PSSC course, which was so influential in changing physics education in American high schools. There has been no single project with the same impact at the university level. Nevertheless, through its innovative approach and through the expectations of students who studied it, the PSSC project did stimulate changes in college courses.

It might be argued that such major curriculum reforms are not to be expected at universities, where courses are taught by practicing physicists who, through their research activities, stay abreast of current attitudes. But there are problems associated with traditional forms of undergraduate education. In the following passage from the introduction to his introductory text, California Institute of Technology professor Richard Feynman discusses one (1):

> The special problem we tried to get at with these [new] lectures was to maintain the interest of the very enthusiastic and rather smart students coming out of the high schools into Cal Tech. They have heard a lot about how interesting and exciting physics is--the theory of relativity, quantum mechanics, and other modern ideas. By the end of two years of our previous course, many would be very discouraged because there were very few grand, new, modern ideas presented to them. They were made to study inclined planes, electrostatics, and so forth, and after two years it was quite stultifying. The problem was whether or not we could make a course which would save the more advanced and excited student by maintaining his enthusiasm.

This problem was not and is not confined to the extremely bright students at Cal Tech. It became more serious as more students entered universities with prior experience in the PSSC and other similar courses. Since a rigorous treatment of quantum theory and relativity is more difficult mathematically, it did not seem easy to include such subjects earlier. It was generally believed that physics students should receive a thorough grounding in "classical" physics (pre-1900 physics) before they were ready to go on and study the more difficult concepts of modern physics.

However, this belief came under increasing challenge from educators. Were the new concepts intrinsically more difficult than the older concepts? Or, did the initial education from the classical point of view make more difficult the student's transition to a more modern point of view? In any case, a perceptible shift occurred in higher education toward the earlier introduction of "modern" (twentieth century) ideas and the replacement of some portions of a classical physics education by more recently developed disciplines.

In the early sixties, there were a spate of conferences and curriculum revision projects. Three major projects should be mentioned: 1) The Feynman Lectures on Physics (Addison-Wesley); 2) the MIT Introductory Physics Series (Norton); 3) the Berkeley Physics Course (McGraw-Hill). All three efforts produced texts to be used in an introductory two year course for science and engineering students.

There was no stampede by colleges and universities to use these texts. Curriculum changes generally occurred (and are still occurring) in an evolutionary rather than revolutionary way. It is only necessary to compare the most recent editions of the "standard" introductory texts (such as Halliday & Resnick and Sears & Zemansky) with the earliest editions to see such changes. Many newer texts are even more affected by the spirit of the reform projects.

The Feynman Lectures resulted from the activities of Cal Tech's Physics Course Revision Committee. Over two years, physics's pre-eminent theorist prepared and delivered lectures to beginning students. Other professors transformed the lectures into book form. Three volumes cover mechanics, electromagnetism, and introduce quantum mechanics, and separate volumes contain student exercises. Brilliant though they are, the lectures are probably not appropriate texts for most physics students. They are aimed at the most intelligent and highly motivated students. The new approaches used were experimental in nature. But they presented fascinating material with a fresh approach, and they remain stimulating and enlightening even for graduate students and professional physicists. Especially intriguing is the amount of information concerning various "tricks of the trade"--information rarely written down.

The MIT Introductory Physics Series was a product of the Science Teaching Center/Education Research Center at MIT. Texts were produced on the subjects of Newtonian mechanics, relativity, and vibrations and waves, along with films and laboratory materials. MIT professor A. P. French was heavily involved in preparing these books. The influence of the PSSC project is clearly evident in the result.

The Berkeley Physics Course resulted from the creation of a new introductory physics course and laboratory course at the University of California--Berkeley. The five textbooks deal with mechanics, electricity and magnetism, waves and oscillations, quantum physics,

and statistical physics. Again, the work of the PSSC project is clearly evident here. The project was conceived and overseen by Charles Kittel. However, the five texts were, rather traditionally, written separately by different authors who had the freedom to develop their areas as they thought best.

Certain trends in university physics curriculum development can be seen in these projects, trends which were given further impetus by them. Changes are still occurring in these directions. Special relativity may now be introduced earlier and be given more emphasis, either in mechanics courses or electricity & magnetism courses or both. A commonly introduced course covers vibrations and waves in classical systems--this course prepares students for quantum mechanics, and unifies concepts from many branches of physics. The "modern physics" course may be taught earlier, or may contain less material of a survey nature while more rigorously introducing the Schroedinger equation. More "modern physics" experiments are done in the student lab. There is a tendency to de-emphasize classical thermodynamics in favor of statistical physics based on quantum principles--the latter approach actually seems easier for students and is more relevant to areas of current interest (e.g., laser physics and solid state physics).

During the sixties, especially, there were reforms directed at other areas of teaching: laboratory reforms, self-paced instruction, "programmed" learning, etc. This type of activity seems to have slowed in more recent times. Individual institutions and teachers initiate reforms, but no major theme has attracted the attention of the physics community at large.

Many of the newer projects revolve around computers--as instructional aides, or as tools of physicists (in view of the importance of computers in all areas of physics, both theoretical and experimental). This may provide the next national theme for curriculum reforms. Work has been accomplished in many areas: Computer Assisted Instruction (CAI) using large mainframe computers; exhibiting computer solutions of equations during lecture courses; teaching numerical methods to undergraduates; teaching digital and microprocessor techniques in the electronic lab courses; using microcomputers as lab tools for taking and analyzing data.

APPENDIX F

CONFERENCE REPORTS ON UNDERGRADUATE PHYSICS CURRICULA

After returning from IPB to the University of Wisconsin, I located summaries of several conferences on university physics education. I did not use this material during the curriculum development work at IPB. In view of its importance, excerpts from two reports will be reprinted here.

The first of these reports (1) resulted from intense concern about American science teaching during the early sixties. It reports recommendations from the final of three conferences, involving hundreds of physicists representing over a hundred American universities and colleges. Although over twenty years old now, these recommendations are still useful.

The conference proposed two types of physics curricula: Curriculum R (for Research) and Curriculum S (for Synthesis). The first was intended for students who would go on to graduate school or directly enter government or industrial service. The second was a more interdisciplinary study, whose graduates might still enter physics graduate school (but who would need an extra year of course work).

Curriculum R was largely defined to meet the requirements of graduate schools. It is worth reprinting those here. Though twenty years old, graduate school requirements have not greatly changed. In fact, some of the texts mentioned are still commonly used, though in newer editions. The referenced paper also contains a very long and detailed listing of individual topics which is not reproduced here.

> Because many, or even most, of the students in Curriculum R will be preparing for immediate entrance to graduate school, the present principal objectives of the curriculum may be best defined in terms of the demands that graduate departments now make on their entering students. There was a consensus among the conferees that the well prepared student should be ready to take the following four courses in appropriate sequence, starting with at least two of them immediately upon entering graduate school:

(1) Classical Mechanics, through Hamilton's equations, canonical transformations, Hamilton-Jacobi theory, and Lagrangian and Hamiltonian formulations for fields. (Level of Goldstein or Landau and Lifshitz.)

(2) Electrodynamics, through wave equations, vacuum electrodynamics, Lienard-Wiechert potentials, and radiation from an accelerated charge. (Level of Panofsky and Phillips or Jackson.)

(3) Quantum Mechanics, through matrix formulations, scattering perturbation theory, and the Dirac equation. (Level of Morse and Feshbach or Sommerfeld.)

(4) Mathematical Physics, including topics such as field equations, variational methods, Green's functions, approximation methods, diffusion and boundary value problems. (Level of Morse and Feshbach or Sommerfeld.)

Also, every beginning graduate student should be ready to enter a graduate laboratory course, where it exists, or to begin graduate level experimental research. Such experimental work cannot be characterized in as clear a fashion as are the four courses listed above. The conference felt strongly that preparation for it will prove of value to the future theorist as well as to the future experimentalist.

The conference also issued recommendations concerning the student load. A note about the relative value of semester hours in the typical U.S. university and IPB is in order. In the U.S., a typical student load is 15 semester hours initially, and 12-13 semester hours in his final year. The corresponding figures for an exceptionally talented student might be 18 semester hours dropping to 15 in his final year. A load of more than 18 semester hours is unusual, and may require high level administrative approval.

Indonesian university curricula typically prescribe a student load of 18-20 semester hours. For non-lab courses in the U.S., one semester hour normally indicates one hour of lecture. This is not strictly the case in Indonesia. On the other hand, the semester hours credited for lab courses in the U.S. undervalue the time actually spent by students in organized lab work--one or two semester hours may indicate three, five, or more hours of actual laboratory work.

Here are the recommendations of the conference concerning an appropriate student load for Curriculum R:

There is no unique answer to the question of how much time must be spent by an able student in acquiring the necessary background and preparation for graduate work. Departments represented at the conference vary greatly in their

requirements, but a considerable portion of the conferees believed that their departments succeed in bringing their majors to a satisfactory level if they require a minimum of 36-40 semester hours in physics and 18-20 semester hours in mathematics, starting with the calculus. This time allows about 12 of the 15 topics of Appendix A to be covered in adequate depth. But, on the other hand, many conferees stated that they needed more than 40 semester hours in physics to accomplish this.

A large number of the departments include in the 36-40 semester hours a minimum of six semester hours of laboratory (two in the introductory course and four in intermediate physics courses). Many require an additional four semester hours in a senior laboratory. Some have found it advantageous to conduct an open-ended senior laboratory in which as much as half of the student's time is spent in the library, preparing for and interpreting the laboratory work. Such a laboratory can play a unique role in introducing the student to experimental research and in helping him to recognize the part that it plays in the development of physics.

The conference also considered the physics portion of the Curriculum S, which it proposed:

A majority of the conferees recommended that the requirement in physics be set at about 26 semester hours, in mathematics at about 15 semester hours (starting with calculus), and in the other sciences at 18 semester hours. The physics requirement is assumed to include at least 18 semester hours beyond a one-year introductory course and the requirement in other sciences at least 8 semester hours of bona fide junior and and senior work. Physics laboratory work is no less important than in Curriculum R.

The second report considered in this appendix is that of the Southeast Asian Regional Conference on University Physics Education. (2) It met during 1977 in Malaysia, and was attended by nearly one hundred participants from Australia, Bangladesh, Hong Kong, India, Indonesia, Malaysia, Pakistan, Philipines, Singapore, Sri Lanka, and Thailand.

Some general discussion and five of the nineteen specific recommendations are reproduced here from the conference report:

The principal recurring theme which came through during the workshop sessions of the Regional Conference on Undergraduate Physics Education (RCUPE) was that of self-reliance. This basic idea was seen in both cultural and economic terms and each was applied to the problems of physics education in

Asia today. Cultural self-reliance was interpreted in terms of teaching methods and physics curricula, both at undergraduate and at postgraduate levels. The Conference recognized that the current curricula and teaching methods are far from being satisfactory, and that physics education will not, of course, be easy, since it will require a reorientation of both the physics teachers and students, and also the writing of textbooks and other materials appropriate to the region.

The move towards regional self-reliance was forced upon the universities of the region by the circumstances in which many of them find themselves. The complement to regional self-reliance was cooperation, and to this end the Conference recommended the founding of a number of regional centers for the pooling of resources and the dissemination of information.

A third aspect of self-reliance was the feeling that, while recognizing the importance of innovation in teaching, the Conference also considered it necessary that modern methods should be introduced only after proper attention has been given to problems of training and resources. There was also a considerable body of opinion in support of spending more time and resources in improving traditional teaching methods, such as in lecture demonstrations and in helping lecturers improve their style and presentation.

(1) There is a growing realization that most of our students are not likely to pursue research in physics but become teachers, administrators, etc. Many universities, therefore, are restructuring their programs to provide two or more alternatives. Similarly, more and more universities are providing combinations of physics with other subjects. The Conference, therefore, recommended the wider adoption of more flexible course structures to cater to the needs of students' future careers.

(2) The importance of broadening the education of physics students by exposure to nonscience and interdisciplinary subjects was discussed. It was felt that it is equally important to increase nonscience students' awareness of physics, especially as many of these later go on to become decision makers.

(3) The Conference felt that the current physics curriculum needs improvement. Some courses are too rigid, stereotyped, and crowded, and do not promote the creative and problem-solving abilities of the students. There was a need, therefore, for evolving new, more appropriate curricula.

. . .

(8) Careful innovation, reflecting local needs, was required but traditional experiments may not be entirely disregarded. It was felt that a simple undergraduate experiment to show physical principles was as valuable as a highly accurate experiment using sophisticated apparatus. Open-ended experiments should be introduced and experimental work should, where possible, be in phase with lectures. Emphasis should also be placed on the teaching of experimental techniques.

(9) There should be greater stress on project/report work for senior students. The subject chosen should, where appropriate, be related to the needs of the country concerned.

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