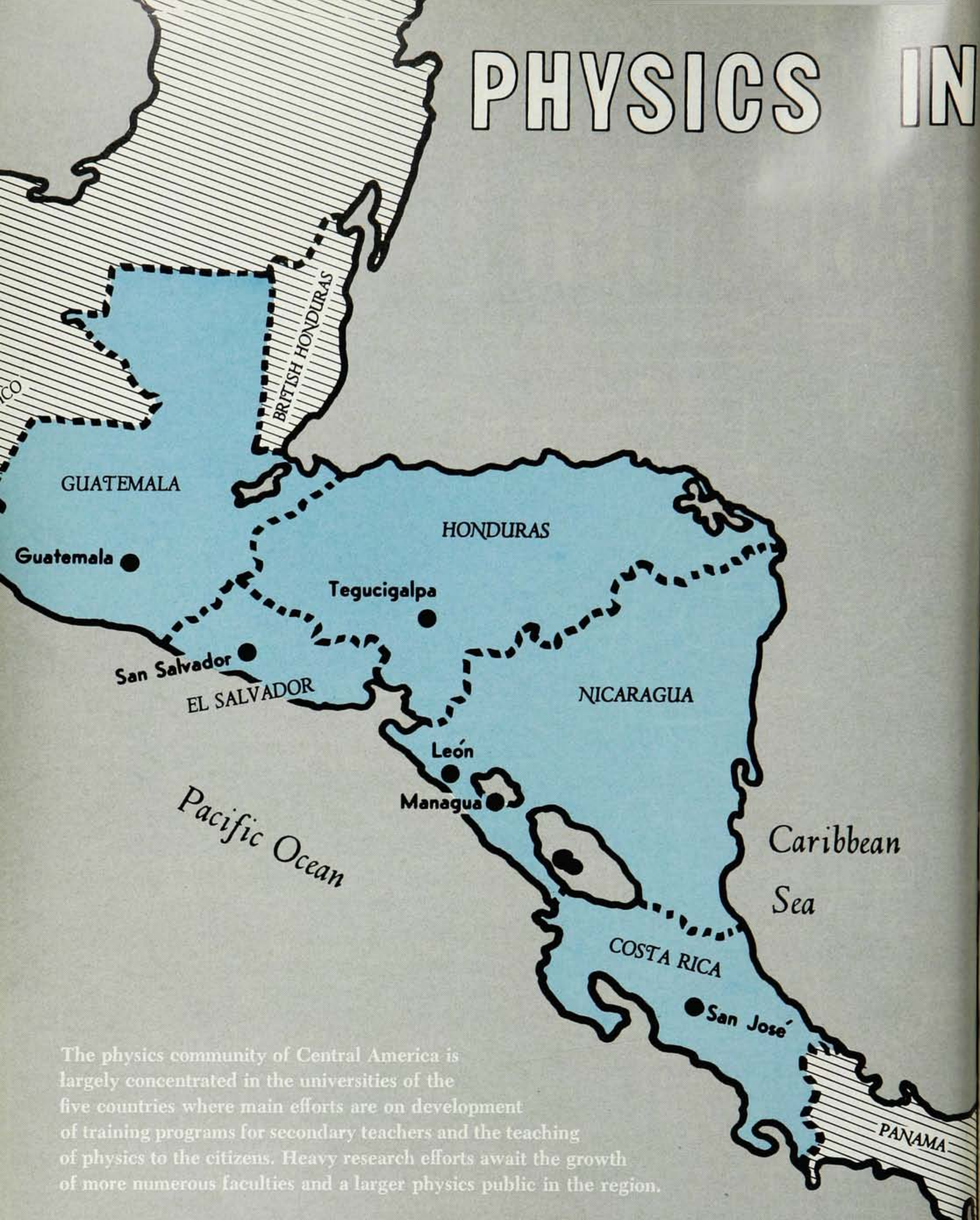
PHYSICS IN



The physics community of Central America is largely concentrated in the universities of the five countries where main efforts are on development of training programs for secondary teachers and the teaching of physics to the citizens. Heavy research efforts await the growth of more numerous faculties and a larger physics public in the region.

CENTRAL AMERICA

by John H. Wray

THE IMPACT of world scientific progress has been keenly felt throughout Central America. (For our purposes Central America includes Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica.) The people of Central America are not only cognizant of this progress, but are very interested in its effect upon their culture, national and international politics, economy and future. One needs only to assess the space devoted to reporting of significant scientific achievements by the various news media of the region, or to converse with its people, to conclude that interest in science is definitely rising.

Physics, though definitely coming up, has not made the strides so evident in other sciences. The primarily agricultural nature of economy has motivated the substantial advance of biology and agronomy, and concern for the well-being of the people has fostered modern facilities and highly skilled professionals in medicine, dentistry and microbiology. The growth of industry, and chemical industries in particular, has spurred advances in chemistry and engineering. Very adequate university curricula exist in these branches of science at the undergraduate level. In some cases, excellent graduate programs too are available, though many students still study abroad for advanced degrees. Physics, however, has come along primarily as an adjunct in these areas and now is receiving additional impetus with the growth of engineering. But physics will continue in a subordinate role for years to come—its prime use being that of a corequisite to more highly developed scientific disciplines and to engineering. At present, there is little need for a highly trained physicist in Central America, with one very important exception—university professors. This situation is in marked contrast to needs for engineers, chemists, physicians, dentists, agronomists and teachers. In the past, most people skilled in these disciplines had received their training abroad. This practice was economically sound when the demand for such skills was small. Today, however, the demand is ever increasing. The Central American Common Market is a successful venture whose goal is the economic integration of the region. It has stimulated regional economic growth and the attendant need for skilled labor and professional people.

What then is the role of physics in Central America today? To support growth in science and engineering, to assist in the assurance of a sufficient supply of skilled labor, and to impart guidance and wisdom to a changing culture, physics education at all levels is the primary task. The United States National Science Foundation in coöperation with the Agency for International Development (NSF-AID), the Pan American Union, UNESCO, the Ford Foundation, exchange programs at the university level, the Fulbright program, to name but a few, have been leaders in the coöperative development of teaching programs in the sciences, both at the secondary-school and university levels. The national universities have originated far-sighted programs in physics and have not hesitated to obtain the best possible advice at home and from abroad.

As a result of this secondary and relatively new interest in physics, the growth of physics programs at all educational levels faces some difficult hurdles. Trained teachers—university, secondary school and vocational school—are in critical shortage. Lack of a physics course combined with inadequate mathematical preparation in secondary school, ill prepares the first-year university student for a course in "university physics." Revision of the secondary school programs to upgrade courses in mathematics and to include a physics course aggravates the already critical shortage of well trained high school physics and mathematics teachers. Thus one has a vicious circle upon which to climb if one hopes eventually to rectify the situation. Within the past few years, considerable effort has been expended at the secondary-school level. Today, however, in an effort to progress more

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Table 1. Physics Curricula in Central America

University	First year	Second year	Third year	Fourth year
San Carlos de Guatemala	H&R	H&R	...	...
El Salvador	PSSC (Areas communes) H&R (Eng'ing & Phys) Sears (Chemistry)	...	...	...
Honduras	PSSC	H&R	...	...
Nicaragua	PSSC	H&R (Léon) Sears (Managua)	Constant	Leighton Dicke-Witke
Costa Rica	PSSC	H&R	H&R, Sears	Reitz-Milford Taylor-Sherwin

rapidly, stress is being shifted to the training of good high-school teachers by the universities. It is hoped that entering the circle at this point will yield the maximum "multiplication factor" in physics and mathematics education. One well trained high school teacher is exposed to many potential university students in a relatively short time as compared to the number of university education majors to which a professor is exposed in the same period.

University physics—problems

Each republic has its own national university: La Universidad de San Carlos de Guatemala in Guatemala City; La Universidad de El Salvador in San Salvador; La Universidad Nacional Autonoma de Honduras in Tegucigalpa; La Universidad Nacional Autonoma de Nicaragua with two campuses located in León and in Managua; La Universidad de Costa Rica in San José. In addition there are private Catholic universities in Guatemala, El Salvador and Nicaragua. (To exemplify the problem at the high-school level, Costa Rica presently has 91 high schools in which the normal attrition rate among physics and mathematics teachers is approximately eight times the rate at which teachers in this area are graduated from the university.)

What are the problems in physics teaching at university level and what solutions are being implemented? Lack of adequate student preparation at the high-school level is a formidable obstacle to the development of a sound university curriculum in physics. The unfortunate economic status of a very significant number of students results in their being "part time" students, and this, when coupled with traditionally heavy student loads, affects the intensity of all curricula, not only physics. Lack of modern physics laboratories and laboratory equipment is the rule rather than the exception. An unusually high percentage enrollment in beginning physics courses results in large classes taught by a relatively small staff whose members in many cases have a preparation only slightly beyond the material they teach. Though these problems are formidable, they are not insuperable.

Few first-year university students have had a formal physics course in high school. However, they have had courses in general science, chemistry and biology. The level of mathematical aptitude attained by most beginning students requires that they enroll in mathematics courses during their first year which prepare them for what is generally considered beginning university-level mathematics.

The physics problem has been handled in two ways. In some of the universities (table 1), the beginning course is a modified version of the PSSC (Physical Science Study Committee) course. Though other courses and texts exist at this level, PSSC has been translated into Spanish and texts are readily available at a reasonable price. Further, the National Science Foundation has sponsored teacher-training programs in Latin America for the PSSC course, and Central American universities have availed themselves of this opportunity to better prepare their physics staffs. It has been noted by physics professors in Central America that new or revised high-school physics texts are following the PSSC-type course. It is generally believed by these teachers that the PSSC course without modification is a bit profound for their students in some areas, an observation not peculiar to Central America. The course has therefore undergone some modifications as dictated by local conditions. One also finds *Physics for Students of Science and Engineering* by Halliday and Resnick (H&R), which is also available in Spanish, used as a beginning text in some cases. The level of this text requires close coördination of the mathematics and physics programs to insure that the student can absorb the more advanced mathematical treatment. Students taking this course are generally thoroughly screened and usually are engineering or science majors. The majority of universities in the region use PSSC as the introductory physics course and H&R as the text for the second-year course. The first-year physics laboratories are generally patterned after the PSSC laboratory for two reasons. Since most students are enrolled in PSSC physics, it is natural to adapt the corresponding laboratory and this lab may certainly be efficiently and satisfactorily utilized for the Halliday and Resnick course. Just as important is the procurement of laboratory equipment which in the case of PSSC is neither difficult nor prohibitively expensive. Much first-year laboratory equipment is made by the students and professors.

In Costa Rica, where the physics program is the most advanced, one finds a course in electricity and magnetism in the third year followed by a beginning course in quantum mechanics in the fourth year. In addition, an elective course in electronics is offered at the undergraduate level. At the graduate level courses have been offered in thermodynamics, solid-state physics, statistical mechanics and mathematical physics. These courses change from year to year, being largely dependent upon the fields of interest of visiting professors.

University physics—organization

An introductory-level physics course is obligatory for a large percentage of first-year students. Two main areas, embracing several faculties, generally require a basic physics course for all students enrolled in them. The facul-

GUATEMALA: Universidad Nacional de San Carlos at Guatemala City. The architecture here is traditional.

ties contained within these two areas vary slightly among the universities of Central America. For example, in Costa Rica the area of physical-mathematical sciences embraces the faculties of arts and sciences (physics, mathematics, chemistry, geology requiring physics) and the school of engineering (civil, chemical, electrical and mechanical), and the area of biological sciences includes the faculties of medicine, arts and sciences (biology), microbiology, agronomy, pharmacy and dentistry. On the other hand, at the University of San Carlos of Guatemala the area of physical-mathematical sciences contains the faculties of agronomy, architecture, civil and chemical engineering whereas the area of chemical and biological sciences includes medicine, dentistry, veterinary medicine, chemistry and pharmacy. The faculties requiring physics and the current number of enrollees in physics courses are shown in table 2. In addition, departments of basic or general studies exist within the universities, which may or may not require the basic physics course for their students. For example, at the University of El Salvador the areas comunes, which is the common base for all professions with the exception of law, economics and humanities, requires the basic physics course of all its students, while in Costa Rica the department of general studies does not require physics for all its students. Departments of physics or of physics and mathematics are responsible for the physics courses at all but one of the universities, the University of San Carlos of Guatemala where physics professors are in the department of basic studies. In El Salvador department members teach in areas comunes, the faculty of engineering, the faculty of humanities, the faculty of science and the faculty of chemical science. In Honduras physics department members teach in the Center for Basic Studies and the faculty of engineering. In Nicaragua there are three physics departments, teaching in the faculties of education, arts and sciences, and engineering. In Costa Rica the department is in the central university faculty of arts and sciences. These departments are organized in much the same manner as those in the United States and their method of operation is most democratic. Department meetings are held quite frequently and departmental actions are controlled by majority vote of members plus a student vote which is a percentage of the total number of physics staff members. The percentage varies from country to country running from 25% to somewhat less than a majority.

The total university enrollment and percentage enrollment in physics are given in table 2. One notes the unusually high matriculation percentage in physics. The universities have recognized the lack of a physics background in beginning students and have taken steps to provide this knowledge. One may compare the percentages with those in the United States where a 5% matriculation in physics courses is not uncommon. In table 3 the effects of this high matriculation on staff loading are presented. Abnormally high loads exist in some cases.

The large student-to-professor ratio, predominant in the first-year physics course, generally results in lectures being given to large sections of 100 or more students. In some cases demonstration experiments accompany the lecture series and problem sessions are held weekly as part of the scheduled course load. The problem of administering and scheduling the beginning physics laboratory for such a large number of students with limited facilities is a serious one. The laboratory is an integral part of the physics course and must be passed to pass the course. Considerable staff effort is required to read and grade laboratory reports for such large sections.

In Costa Rica, for example, the solution has been to schedule simultaneously two laboratory sections within a small temporary building containing two classrooms and a storeroom. The

EL SALVADOR: National University in the city of San Salvador.

sections have a maximum of 30 students. A different experiment is set up weekly in each section of the laboratory and the sections rotate weekly between experiments. This laboratory, basically PSSC, has successfully accommodated more than 500 students per semester. Laboratory sessions are held between 8:30 a.m. and 6:30 p.m. five days a week with make-up sessions on Saturday. The laboratory is under the direction of the senior member of the physics staff and is manned by instructors and graduate students. The laboratory staff also grades examinations for the first-year course. Considerable effort has been expended in the preparation and reproduction of laboratory notes and in the stocking of materials. This laboratory is an unqualified success and a tribute to those who have contributed to its operation.

In Honduras a very similar laboratory exists. Here, one is impressed by the quality and quantity of "homemade" laboratory equipment. The PSSC laboratory is slightly modified depending to a large extent on the equipment available. In Central America laboratory equipment runs from the very old to the most modern. In El Salvador a considerable amount of modern electronic laboratory equipment is used. In Guatemala the Berkeley Physics Laboratory equipment is being procured. In general, the trend in lab equipment is to provide the most up to date within the limited resources available.

The Central American university student differs little from his counterpart throughout the world. Unfortunately, his financial status often dictates the necessity of his working part time while attending the university. A fulltime student load of 24 or more contact hours per week is common. In the past, the failure rate in the beginning physics course has been high, ranging from 30% to more than 50%. This has been attributed to the usual causes—lack of student preparation, large classes, student apathy, and ill trained staff. However, the heavy student load was and is a major factor which received little consideration. Many "part-time" students had enrolled for full loads. No effective advisement system was in effect. Such a system is now being established and should materially increase efficiency.

Though often overemphasized, there is some truth in the statement that primary and secondary education in the region teaches a student to memorize rather than to reason. Students are unaccustomed to doing a sizable amount of homework. The first year at the university is therefore extremely important in the formation of a student's study and work habits and in developing his confidence in his ability to think for himself. In the physics programs, professors are well aware of the desirability of instilling these characteristics in beginning students as soon as possible, and every effort is made to do so. In Central America one finds an unusually high percentage of girl students in physics courses, often 50% or more. They are as capable as their male cohorts and have the same opportunities upon graduation. One finds many female physics teachers at both secondary-school and university level.

Improving physics faculties

The physics faculties at all universities in Central America are constantly being enlarged and improved. Emphasis is being placed on postgraduate training in physics for staff members. All Central American universities currently have faculty members in residence abroad for advanced work in physics. Table 3 shows the distribution per university. In the past, physics was taught by engineers, chemists, pharmacists, and other faculty members whose own physics training was often limited to a level a little above the course that they taught. Inbreeding was a natural result since each republic has its own university with little or no competition from other local institutions. There was practically no exchange of staff within regional institutions. Having recognized the need for more advanced training of physics staff, the universities have taken the necessary steps to provide it. International organizations have joined in this effort. NSF/AID has set up several programs for postgraduate work in physics. These programs generally consist of partial fellowships for university physics professors. The professor's home institution is required to contribute 50% of his salary during

COSTA RICA: National University near San José.

the tenure of the fellowship and he must formally agree to return to his institution as a physics staff member at the conclusion of his study abroad. These programs span all degree levels from the BS to the PhD in physics. The BS program, under the direction of R. N. Little, of the University of Texas, is designed to supplement the training of junior staff members so as to enable them to attain a BS in physics in a period of two years. Those qualified to continue thereafter at graduate level have the opportunity to do so. Initially, the Central American students at Texas are placed in a separate section where physics courses are taught in Spanish. As soon as they have sufficient command of English, they are integrated into the regular undergraduate physics sections. There are now nine professors from Central America in this program.

The Centro Latino Americano de Física (CLAF) in Rio de Janeiro has also provided fellowships for staff members. CLAF is located in the Centro Brasileiro de Pesquisas Físicas (CBPF) the Brazilian national physical research center, whose staff and laboratories are used for the graduate physics program of the University of Brazil in Rio de Janeiro. CLAF accepts students at all university levels from throughout Latin America. After an evaluation of a student's background has been made, he is sent to the University of Brazil or to the Catholic University for those undergraduate courses that he lacks to bring him up to the level of a BS in physics. The time spent in making up courses varies considerably as students range from university professors to undergraduates who have had a minimum of two years at university level. The students also actively participate in the research program of the laboratory. When ready, the student may enter either the MS or PhD programs in physics. Fellowships from CLAF include 100 percent tuition, room and board, and may include round-trip transportation for the fellow although the student's home institution is requested to defray the transportation cost. The home institution may also contribute additional monthly stipends toward support of a student's family. Presently CLAF has 30 non-Brazilian students of whom two are professors from Central America. A third Central American professor, subsequent to his MS, spent 18 months in research at CLAF after which he returned home to teach. He now is in the United States under NSF sponsorship studying for the PhD in physics. Fifty percent of his support comes from his home university.

Other fellowships for graduate work are available from the Pan American Union, the Ford Foundation, AID and programs of European countries.

Of course, sending one's staff abroad for study is no solution to the immediate problem of high staff loads. To alleviate this situation, visiting professors are being brought into Central America. These professors not only fill a temporarily vacant "slot," but contribute through seminars, curriculum revision, and research to the strengthening of physics programs in the region. In addition to the sponsoring agencies mentioned above, the International Development Bank has also contributed to the support of visiting professors. In physics, professors willing to forego a much more advanced academic climate and well equipped research facilities are not easy to find. To date, the number has been small and the predominant source has been Europe.

Physics research is virtually nonexistent in Central America. The need for research programs to hold well trained physicists in staff positions and upon which to base graduate programs is well recognized. One need only compare staff qualifications and research capability and facilities in the more advanced scientific fields mentioned earlier to assure himself that research in physics will be a reality in Central America in the near future. At present research in some areas is possible by using facilities of other faculties, such as chemistry.

Central American coöperative effort

In September of 1964 the first meeting of Central American physics professors was held in Tegucigalpa, Honduras. The Consejo Superior Universitario Centro Americano (CSUCA) in cooperation with NSF/AID, sponsored the meeting. (CSUCA is a regional university council made up of repre-


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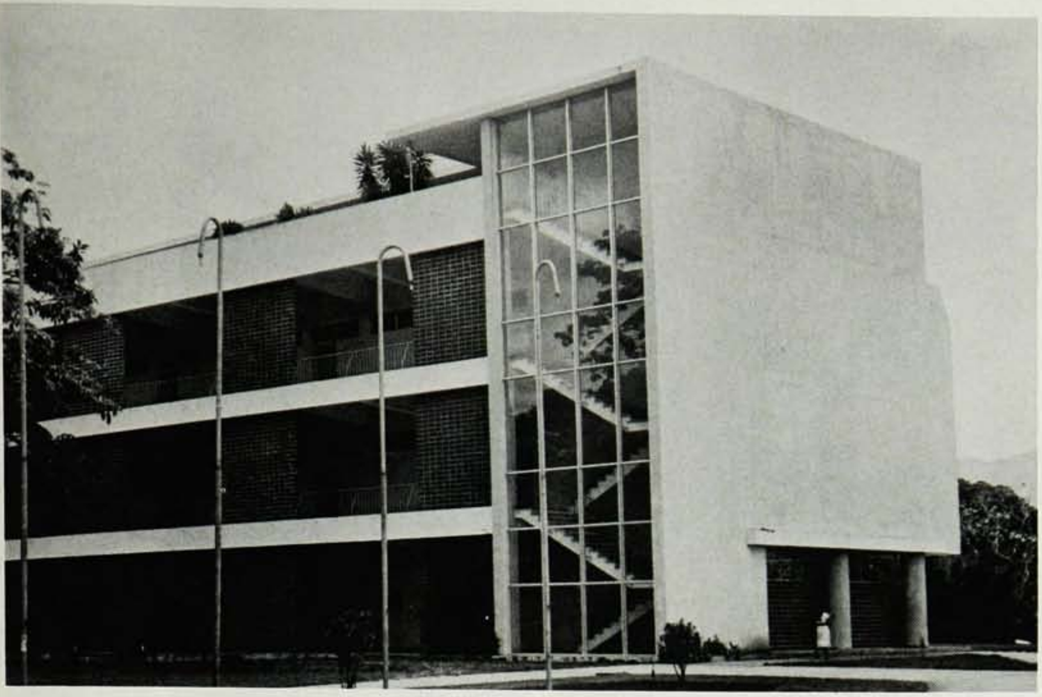

COSTA RICA: National University. The style is contemporary.

sentatives of all the national universities. The Secretary General maintains his staff and office in San José, Costa Rica, in close proximity to the NSF regional office where regional scientific advisors are based.) The rectors of the Central American universities were concerned with the physics problem and through CSUCA this regional coöperative effort was initiated. The University of Honduras was host for the meeting. At the meeting many of the common problems discussed above received attention, and solutions were proposed. Some of the solutions mentioned above resulted from the recommendations of the meeting. The idea of a Central American Physical Society was proposed, and today the society is a reality. Representatives of each national university now meet semiannually to coördinate the efforts of physics professors within the region. These meetings, under CSUCA sponsorship, provide a means of information exchange, which heretofore did not exist, among professors with the same objectives and problems. Curricula, physics laboratories, staff-exchange programs, staff training and regional physics activities are examples of areas covered at these meetings. Generally, representatives of CSUCA and NSF participate at these meetings.

Before its formal incorporation in December 1965, the Central American Physical Society (Sociedad Centroamericana de Física, SOCEF) was already concerned with the training of physics professors. During a meeting on joint educational programs in physics for Latin America held in Bogotá, Colombia in February, 1965, it was suggested that a Central American School of Physics, similar to the Latin American School of Physics held annually in Mexico, might be of invaluable assistance in the upgrading and training of regional physics staff. SOCEF acted quickly to develop this concept. After discussion at the regional physics meetings, it was decided to hold ECAF-I (Escuela Centroamericana de Física) during the summer of 1966 with SOCEF taking on the coördinating and administrative roles.

This summer institute strives to better the preparation of physics professors of the region while providing a climate for exchange of ideas between its participants. By treating experimental as well as theoretical physics it is hoped that interest in research can be stimulated. The site and director for each institute are elected by SOCEF members at the close of each institute session. SOCEF is responsible for obtaining necessary funds by local and international solicitation.

ECAF draws students primarily from the five Central American republics. Only physics professors actively engaged in teaching are eligible. To assist in training teachers in neighboring areas students may also be invited from countries such as Panama, Mexico and the Dominican Republic. It is hoped that this institute will be an annual event.

The inaugural session was held in Antigua, Guatemala, from 3 to 29 Jan. 1966. A staff planning meeting in October 1965 decided to offer a series of lectures and laboratory based on the first two volumes of the Berkeley Physics Course. The group felt that a high-level modern course in undergraduate physics was essential for professors teaching at the general-physics level. The Berkeley course was chosen over similar recently evolved courses because its presentation and focus were considered more conventional and more easily understood by participants. A course in mathematical physics, closely coördinated with the physics lectures, was also deemed essential. Students were expected to have a good knowledge of elementary calculus and their physics knowledge was to include general physics at the level of Halliday and Resnick. It was apparent quite early that there was no hope of receiving the Berkeley laboratory equipment in time for the January session. Alterna-

tively, an electronics laboratory and basic electronics lectures were substituted during the laboratory portion of the institute.

The Staff of ECAF-I consisted of Francisco Medina N. of the Institute of Physics, National University of Mexico; John H. Wray, OAS Professor of Advanced Physics, University of Costa Rica; Eduardo Suger C. of the University of San Carlos of Guatemala. Assistance was provided by R. N. Little of the University of Texas, and Wendall Spreadbury of the United States National Science Foundation.

Students received fellowships consisting of round-trip air transportation, subsistence allowance, text books and laboratory materials. Twenty-one students attended this first session distributed as follows: Costa Rica 3, Nicaragua 1, Honduras 3, El Salvador 2, Guatemala 9, Panama 2, and Mexico 1. Financing was received from CSUCA, from NSF/AID, from CLAF and from the University of San Carlos of Guatemala. A total of $10 868 was spent.

The course was very intensive. Theoretical lectures in physics and mathematics were scheduled from 8 a.m. to noon Monday through Friday. Afternoons were spent in seminars and problem sessions twice a week and in laboratory and lectures three times a week. Volumes 1 and 2 of the Berkeley Physics Course were covered almost in their entirety. Thirty-eight hours were devoted to physics and ten hours to problems and discussion. Twenty-five hours were used for the mathematics lectures, which included topics in complex numbers, vectors, vector fields, differential equations and a detailed treatment of the harmonic oscillator. Student participation in problem sessions was encouraged with a student generally presenting and arguing his solution while the professor acted as moderator. Seminars were held on elementary nuclear physics, molecular physics, the Mössbauer effect and statistical mechanics to demonstrate application of the more basic physical disciplines and to stimulate student interest in research and experimental physics.

The laboratory portion of the course used electronics kits as the skeleton around which basic concepts of electronics were taught and demonstrated.

Table 2. Physics Matriculation in Central America

University	*Phys required course for**	*No. phys students*	*Total no. students*	*% Enrolled in physics*
San Carlos de Guatemala	M, D, VM, Chem, Pharm, Ag, Arch, Chem E, CE	939	8171	11.5
El Salvador	AC, Eng, Chem	876	4679	18.7
Honduras	M, D, Pharm, Eng, N	667	2800	23.8
Nicaragua	Chem, Eng, M, Phys, Math, D, Ed	398	2500	15.9
Costa Rica	M, D, Biol, Microbiol, Chem, Pharm, Math, CE, Chem E, Ag, ME, EE, Ed	644	6150	10.5

* M-medicine, D-dentistry, VM-veterinary medicine, Chem-chemistry, Pharm-pharmacy, Ag-agronomy, Arch-architecture, ChemE-chemical engineering, CE-civil engineering, AC-areas comunes, Eng-engineering, N-nursing, Math-mathematics, Phys-physics, Ed-education, Biol-biology, Microbiol-microbiology, ME-mechanical engineering, EE-electrical engineering.

Table 3. Physics Staff in Central America Universities

University	*No. phys profs*	*No. phys prof with adv deg*	*No. abroad for BS*	*No. abroad for adv deg*	*No. students per prof*
San Carlos de Guatemala	9	0	2	0	110
El Salvador	7*	5	2	2	125
Honduras	3	1	2	0	222
Nicaragua	16	2	1	1	25
Costa Rica	11†	7	3	4	59

* Does not include 8 Instructors. † Includes Instructors.

An hour lecture on the theory of the particular kit under consideration or of a particular circuit in a kit accompanied each laboratory session. Techniques in assembly and soldering were demonstrated. The assembly of electronic instruments from kits is a major means of saving for universities with limited resources. Further, the opportunity to use their hands in such activity was new to some of the students, and all concerned felt such an experience was extremely important for professors charged with developing similar abilities in their students and with developing future experimental research programs. Students were permitted to take to their respective institutions all kits that were completed and operative at the close of the session. Kits assembled were a Heathkit vacuum-tube voltmeter, a Heathkit oscilloscope, their associated test kits, transistor radio receivers, audio amplifiers, power supplies, transmitters and relaxation oscillators. The non-Heathkits are part of the Traveling Science Teacher Program of Oklahoma State University, whose staff is to be commended for assembling and shipping the kits in such a short period. The results of this laboratory were most gratifying. It was certainly demonstrated that the required assembly skills could be taught in a short period of time. An understanding of electronic instrumentation was acquired by the students and in addition, a welcome respite from the intensive lecture series was had by all.

The reception of this first ECAF session by students and staff was extremely encouraging. It was shown that an annual course such as this is extremely valuable in improving physics faculties within the region. The contact and exchanges between students and staff were of indeterminate

COSTA RICA: National University where the author was a professor for eighteen months.

value, but all indications pointed toward continuing exchange outside scheduled meetings and institutes. The next session is scheduled for January 1967 at the University of Costa Rica. This session will be less intensive—three weeks—with a lecture course in thermodynamics or introductory atomic physics. Problem sessions in mechanics and electricity and magnetism are planned to provide continuity with material covered in ECAF-I and to augment certain topics in those areas. A laboratory consisting of demonstration experiments devised and presented by the students with subsequent critique is also planned.

Training secondary teachers

The preparation of well-qualified secondary-school teachers of physics and mathematics is of great concern to university faculties in Central America. In addition to the universities, normal schools also train teachers. The avenue taken by a student majoring in education varies from country to country. In Costa Rica, the university is the only recognized source of secondary-school teachers though the teacher shortage has forced the Ministry of Education to utilize normal-school graduates as an emergency measure. The department of physics and mathematics at the University of Costa Rica, in collaboration with the School of Education, has had a secondary-school teacher program since 1957 when the department was formed. In this role the department is responsible for the curriculum in physics and mathematics which an education major must successfully pass to receive the degree Profesorado en Física y Matemáticas. The School of Education is responsible for the education and practice-teaching portions of this curriculum. Similar programs exist in Nicaragua and El Salvador. The University of Honduras plans to initiate such a program in 1967. In Guatemala, physics forms a part of basic studies to which the majority of students are subjected.

Physics training for vocational-school teachers has also been undertaken at both university and normal school levels. Teachers charged with vocational training in electricity, machinery maintenance, carpentry and skilled trades have found a rudimentary knowledge of physics necessary and have been active in requesting and attending basic physics courses (PSSC) to upgrade their own preparation.

A good deal of work is now being done to provide workable and realistic university curricula for preparation of secondary teachers. Past curricula have been overloaded with materials now considered inessential and too advanced. The results of such curricula have been a high failure rate and an average investment by the student of from five and a half to six years in a program supposedly designed for four. The last factor is extremely important since the student can invest the same effort in another career, engineering or chemistry, for example, and demand a much higher rate of pay upon graduation. These points are reflected in the content of new curricula where student loading has been considered, essential courses are obligatory, and little "gilt on the lily" appears. It is hoped that in this manner the vicious circle can be successfully entered and that high-school graduates will be better prepared in physics—a result that can only lead to rising university standards.

Within the next three years the physics staff in Central American universities should be more than adequate to assume the teaching load through the undergraduate level. Graduate programs and research should follow within three to five years. Facilities are being either modernized or constructed to furnish an up-to-date environment for modern physics programs. Secondary-school teacher training in physics is being revised to graduate more, better trained, teachers than ever before. With the aid of international and national organizations and agencies, regional meetings between those most concerned with the problems of physics are taking place and their solutions are being implemented. Physics is definitely on the upswing in Central America. □