

Chemical Engineering at the University of

Puerto Rico

Mayagüez Campus



Chemical Engineering facilities at the University of Puerto Rico-Mayagüez.

During the last four years, the Department of Chemical Engineering at the University of Puerto Rico-Mayagüez Campus has undergone a major transformation. We developed and implemented a strategic plan that provided specific goals and guidelines for the transformation, with the main goal of the Department being to become one of the top fifty US chemical engineering departments by the year 2002. Our mission is to

Satisfy the technological needs of Puerto Rico related to chemical engineering.

This mission will be accomplished by means of teaching, research, and services to students coming from all socioeconomic levels. These students, in turn, will become competitive professionals with a global perspective and with a clear understanding of their social responsibility.

OVERVIEW

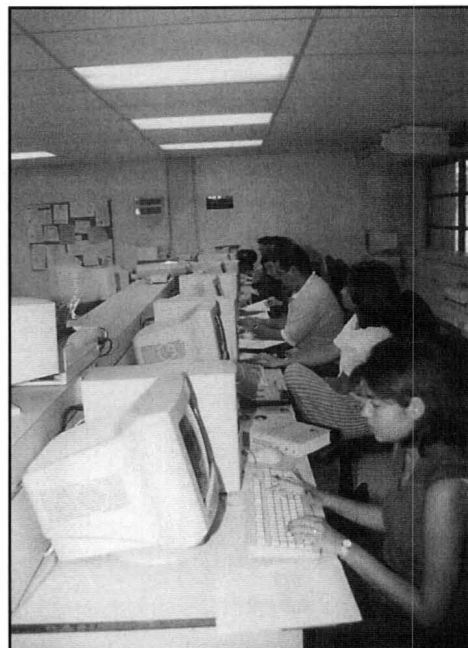
The University of Puerto Rico-Mayagüez is located on the west coast of the island of

[The] main goal of the Department [is] to become one of the top fifty US chemical engineering departments by the year 2002. . . . This mission will be accomplished by means of teaching, research, and services to students coming from all socioeconomic levels.

Puerto Rico, about ninety miles from San Juan. The location is relatively close to beautiful beaches as well as other island attractions, such as a tropical rain forest called "El Yunque," a phosphorescent bay located at the town of Guanica, the Arecibo Observatory, and national monuments such as Porta Coeli, which is located at San Germán.

The Department of Chemical Engineering at the University of Puerto Rico saw its first four students graduate in 1930 with degrees in chemical engineering with emphasis on sugar cane refining. In 1948, the University approved the Department's first Chemical Engineering Program with emphasis in other areas, and in 1978, the Department moved to its present location, which is part of the engineering complex at the University. The Department presently has a faculty consisting of 24 professors, of which 18 have PhD degrees and 6 have MS degrees.

The 36,600 ft² facility consists of administrative and faculty offices, eight modern classrooms, an amphitheater, ten research laboratories, a pharmaceutical process laboratory, a unit operations laboratory, and two computer centers. There is also an office for the Student Chapter of the American Institute of Chemical Engineers (AIChE) and for Puerto Rico's Institute of Chemical Engineering (IIQPR). As part of the services available to the students, the department has a Student Aid Center (SAC) facility, a non-profit corporation that provides services such as photocopying and supplies.



Students in the well-equipped computer center at UPR-Mayagüez.

UNDERGRADUATE AND GRADUATE PROGRAMS

Undergraduate Program • The undergraduate program has an average enrollment of 170 students per year, of which 55% are female. This includes approximately thirty to forty internal and external transfer students per year. The program is ranked among the top ten in the United States based on number of degrees awarded (see Table 1).

As part of its undergraduate program, the Department offers a Bachelors in Science Degree in Chemical Engineering (BSChE) with several elective courses as options. In the last 68 years, the chemical engineering program at the University of Puerto Rico has graduated more than 2,400 engineers, the largest source of Hispanic chemical engineers in the United States (see Figure 1).

The basic undergraduate curriculum, accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), requires 172 credits/hours for completion in five years. It includes courses in basic sciences and other branches of engineering to provide the student with a sound, fundamental, scientific, technical, and sociohumanistic education. The students are required to take courses in advanced mathematics, physics, and chemistry during the first two years. At the beginning of the third year of studies, the students start a three-year program dedicated mainly to chemical engineering courses (see Table 2, Section

TABLE 1
Degrees Awarded and Ranking
(Based on degrees Awarded) from 1990 to 1996

Year	BSChE		MSChE	
	# of Degrees Awarded	Ranking ¹ (# of schools)	# of Degrees Awarded	Ranking ¹ (# of schools)
1990	66	8 (126)	11	26 (122)
1991	68	8 (120)	7	53 (115)
1992	88	4 (113)	1	99 (108)
1993	142	1 (105)	4	67 (97)
1994	97	7 (124)	8	43 (117)
1995	132	7 (134)	5	83 (127)
1996	105	9 (141)	15	15 (133)

¹ Data obtained from the Annual Report of the American Chemical Society (ACS) Committee on Professional Training (Chemical and Engineering News).

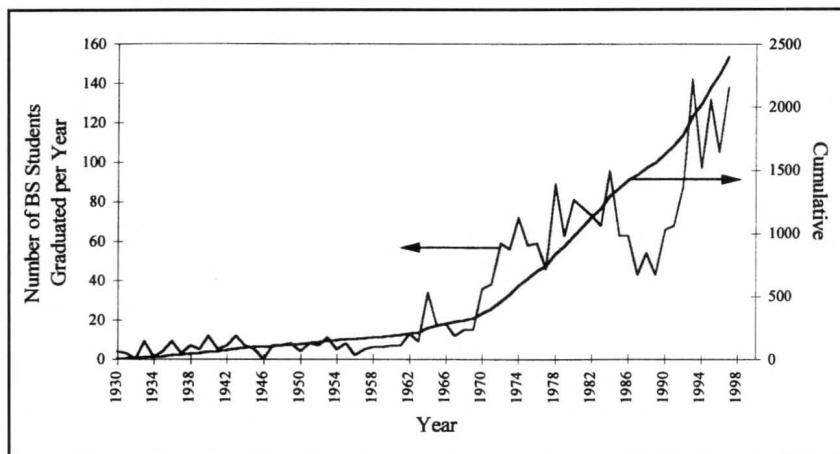
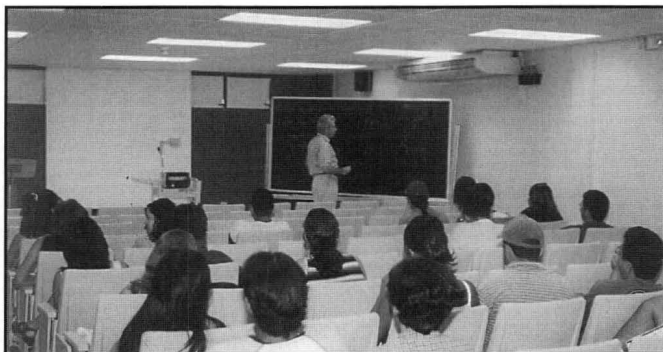


Figure 1. BSChE degrees granted from UPR-Mayagüez



The Department has eight classrooms and one amphitheater to accommodate the 450+ enrolled students.

1). Also, as part of the BSChE curriculum, the Department offers a number of specialized courses (see Table 2, Section 2). Undergraduates can also take graduate courses as electives (see the section on the graduate program).

The undergraduate research courses offer students an opportunity to obtain first-hand experience in the latest developments in areas such as electrochemistry, photocatalysis, surface catalysis, process control optimization, biochemical engineering, biomedical engineering, and supercritical fluids. Our program also offers several elective course options, in collaboration with other engineering departments, such as environmental engineering, manufacturing engineering, and (in the near future) a biotechnology option.

The manufacturing engineering option is part of the Manufacturing Engineering Partnership (MEEP) created in 1994 by three engineering schools: Pennsylvania State University, the University of Washington, and the University of Puerto Rico-Mayagüez. It is cosponsored by the Procter & Gamble Foundation and aims at providing a proper balance between science and engineering practice in such a way that the students will develop the skills employers value. The courses are supported by a learning factory and laboratory facilities for hands-on activities integrated into the courses and field trips.

The BSChE program has an excellent reputation both on the island and on the mainland. Many prestigious local and US companies, such as Amoco, Kodak, Xerox, Union Carbide, Champion, Pfizer, Abbot, Johnson & Johnson, Pharmacia-Upjohn, ARCO Chemical Co., DuPont, Procter & Gamble, and Merck Sharp & Dohme recruit on our campus (see Table 3). In addition, state government agencies such as the Environmental Quality Board, Aqueduct and Sewer Authority, Solid Waste Management Authority, and the Electric Power Authority recruit our graduates. An average of twenty students per year continue their education with graduate studies.

It should be mentioned that several foundations, such as Procter & Gamble, AMOCO, DuPont, and Sloan provide financial assistance to develop and promote research activities at the undergraduate level.

Graduate Program • The graduate program was established

**TABLE 2
Courses Offered**

Standard Courses

- Material and energy balances
- Momentum transfer operations
- Chemical engineering thermodynamics (2 semesters)
- Heat transfer operations
- Kinetics and catalysis
- Mass transfer operations
- Unit operations laboratory (2 semesters)
- Analysis and control of processes
- Process design (2 semesters)
- Mathematical analysis in chemical engineering
- Chemical Engineering electives

Specialized Courses

- Advanced process control
- Air pollution control
- Computer simulation of processes and units
- Equilibrium stage processes
- Microclimate and dispersion of air pollutants
- Industrial waste control
- Introduction to biochemical engineering
- Introduction to biomedical engineering
- Particulate systems
- Pharmaceutical process design
- Plastics technology
- Transport phenomena
- Undergraduate research
- Unit operations in food processing

**TABLE 3
Alumni Profile and Employability**

Academic Year	# of Graduated Students Working in the US ¹		# of Graduated Students Working in Puerto Rico ¹		# of Students Working Toward a Graduate Degree ¹	
	Total	% ²	Total	% ²	Total	% ²
1987-88	8	21.6	6	16.2	7	18.7
1988-89	3	6.8	14	31.8	10	22.7
1989-90	15	18.3	23	28.0	23	28.0
1990-91	16	16.8	31	32.6	27	28.4
1991-92	11	12.6	17	19.5	18	20.7
1992-93	3	2.3	37	28.2	32	24.4
1993-94	1	1.2	32	39.0	16	19.5
1994-95	6	5.0	69	58.0	17	14.3
1995-96	12	11.9	30	29.7	21	20.8
1996-97	13	9.3	30	21.4	25	17.9

¹Data obtained from the Placement Department, Univ. of Puerto Rico-Mayagüez

²Percent taken from the total amount of students graduated that academic year.

in 1972 and offers programs leading to Master in Science (MS) or Master in Engineering (ME) degrees and, in the near future, a program leading to a PhD in chemical engineering. The MS degree (Option 1) requires completion of advanced courses and research in chemical engineering and requires a thesis report plus a final oral examination. Option 2, the ME degree, differs from Option 1 in that the students develop an advanced project; it also requires a final oral examination. The courses offered for these options (see Table 4) cover most of today's top chemical engineering areas.

The Department's graduate program has generated more than three million dollars in research proposals during the last five years and has obtained funding from agencies and institutions such as the National Science Foundation (NSF), National Institutes of Health (NIH), Department of Energy, Department of Defense, and Sandia National Laboratories. As a result of the research activity, the Departments' faculty gave more than 60 presentations in technical conferences and other activities and submitted almost 40 articles for publication during the 1993-97 period. The Department's research and development areas include biochemical, biomedical, catalysis, reactors, colloids, interfaces, materials, expert systems, control, polymers, composites, thermodynamics, transport, separations, environmental ChE, and energy.

Figure 2 shows the number of students graduated from the Masters program in the years 1974 to 1997.

PHD PROGRAM

One of the key priorities of the University of Puerto Rico is the development of graduate programs and research activity. As a result of that initiative, the Chemical Engineering Department has developed a strategic plan with the PhD program as one of its primary components. The implementation of the PhD program is critical to reaching the Department's main goal of being among the top 50 US departments. The program has the following objectives:

- To educate the students in how to master and apply scientific methods as a fundamental tool in research.
- To develop the students' capacity to make original contributions to the field of chemical engineering.
- To develop in the students a high sense of social and ethical responsibility, knowing not only the technical and economical aspects of

The Department's graduate program has generated more than three million dollars in research proposals during the last five years and has obtained funding from [numerous] agencies and institutions . . .

their work, but also safety, health, and environmental protection issues.

The program will require a minimum of 58 credits/hours for completion. The new courses designed for the PhD that will be added to the graduate courses already developed are listed in Table 5.

TABLE 4
Graduate Courses Offered

- Advanced heat transfer
- Advanced process control
- Advanced reactor design
- Advanced thermodynamics
- Advanced transport phenomena
- Catalysis
- Electrochemical engineering
- Mathematical methods in chemical engineering
- Numerical methods in chemical engineering
- Chemical process optimization
- Chemical process simulation
- Plant design
- Selected topics in biochemical engineering
- Separation process analysis

TABLE 5
PhD Courses to be Added to Curriculum

- Models for flow systems in chemical reactors
- Atmospheric transport phenomena
- Special topics in heterogeneous catalysis
- Food fermentation and biotechnology
- Special problems at doctoral level
- Finite elements in transport phenomena
- Doctoral seminar
- Doctoral dissertation

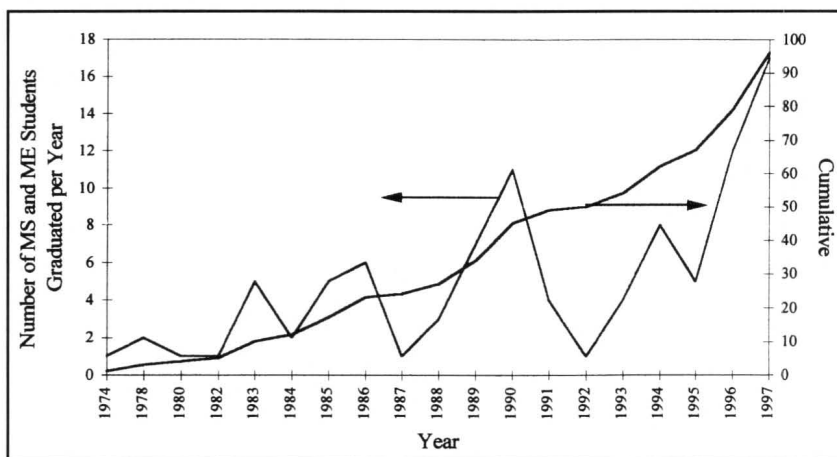
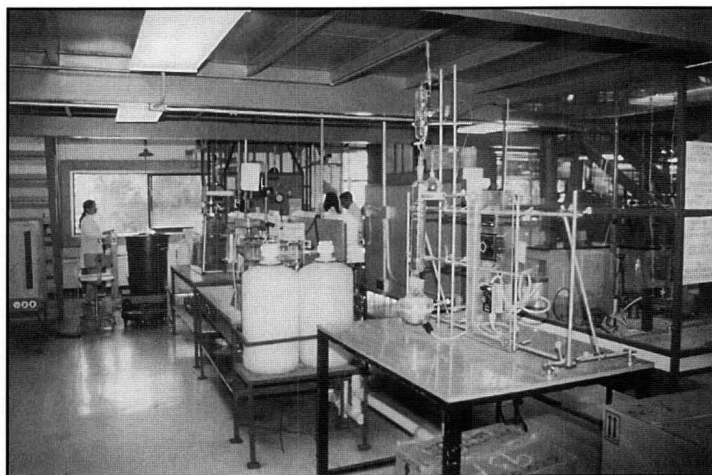


Figure 2. Master's degrees granted by UPR-Mayagüez.



The photograph at the left shows the east section of the 3,500 ft² unit operations laboratory, and the west section is shown in the photograph below.



LABORATORY FACILITIES

The Department has two facilities dedicated exclusively to unit operations, process control, reactor design, and pharmaceutical operations. The laboratory facilities reflect the requirements of the undergraduate program and are fully equipped for their effective use.

The 3,500 ft² Laboratory of Unit Operations is equipped with heat exchangers, hydraulic benches, flow-measuring devices, a cooling tower, an absorption tower, distillation columns, chemical reactors, and equipment for digital process control. The facility also has a wet chemistry laboratory equipped with analytical instrumentation such as gas chromatography, high-performance liquid chromatography, UV-Vis spectroscopy, and atomic absorption. These facilities are undergoing major changes to offer the students a state-of-the-art laboratory. Some of the changes include the addition of high-tech chemical analysis instruments, updating and validation of existing experiments, and the creation of new experiments.

As part of the addition of new experiments, the department is planning to develop and install a laboratory module dedicated exclusively to process and manufacturing control using programmable logic controllers and a virtual control room. In addition, the department is evaluating the implementation of experiments in the areas of molecular simulation, micro-chemical systems, and field applications. These developments will give the students first-hand experience in the latest technologies and opportunities available to chemical engineers.

RESEARCH FACILITIES

The Department's research facilities include ten modern laboratories, an instrumental analysis laboratory, and a computer center. The graduate students also have access to the Central Research Instrumentation Laboratory (managed by the Department of Chemistry), which provides quantitative analysis services for research projects.

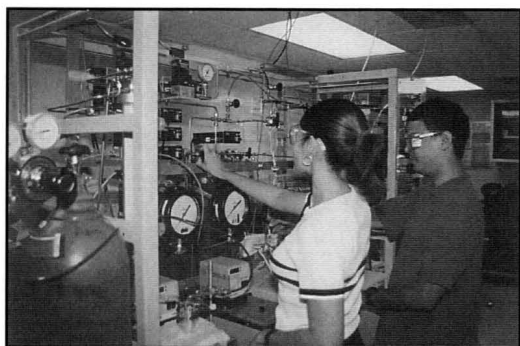
The research laboratories are equipped with a total carbon analyzer, a glucose analyzer, gas chromatographs, Fourier transform

infrared equipment, high-performance liquid chromatographs, a GC-MS, polarographs, an X-ray fluorescence analyzer, spectrometers, a dissolved oxygen analyzer, humidity analyzers, and gel permeation chromatographs. The Central Research Instrumentation Laboratory includes gas chromatography/FT-IR equipment and a nuclear magnetic resonance apparatus.

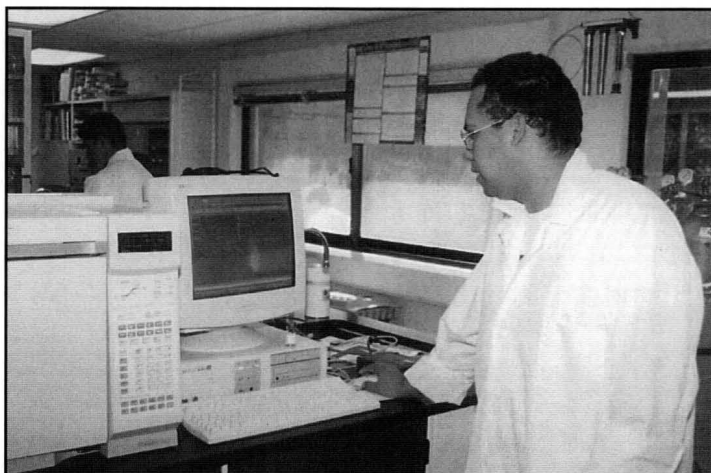
The Department is designing a 25,000 ft² facility that will host the Environmental & Biotechnology Research & Incubator Opportunities Laboratory. This five-million-dollar facility will be used by entrepreneurs and faculty involved in research and development activities. Also, the Department is finishing an area of 2,000 ft² that will be used for a research laboratory and an instrumental analysis laboratory. All these initiatives are part of the implementation of the PhD program.

CHE OUTREACH ACTIVITIES

Merck Sharp & Dohme Lecture Series • The Merck Sharp & Dohme Lecture Series was established by a grant given from the Merck Foundation in 1972. The purpose of the grant is to exchange new technical and scientific developments among those who wish to explore in depth a particular research area in chemical engineering. The grant has allowed our department to invite distinguished scientists and recognized authorities to lecture and has offered our graduate and undergraduate students an unparalleled opportunity to know first-hand these leading scientists and their projects. Most of the authors of textbooks used in our Department have been invited as lecturers in this series. It is one of the longest uninterrupted lecture series in America (25 years).



Above is Dr. Nelson Cardona's micro-calorimetry laboratory, and below is Dr. José Colucci's environmental research projects laboratory



Environmental Symposia • As part of the activities celebrated annually in the Department, the Environmental Symposia are an essential part of the strategic plan initiatives to exchange information between the Department, the industrial sector, and the community. Merck Sharp & Dohme cosponsors these seminar sessions from industry and academia on topics related to environmental issues. A poster presentation is given by undergraduate and graduate students.

Process Design Course • The Department has established a partnership with industry to assure that our students complement their academic experience with applied projects. In 1996, the Department modified the Process Design II course, incorporating business experiences into the projects as part of the initiative funded by Procter & Gamble Foundation. The business approach includes assigning real projects or problems from the industrial and governmental sector with emphasis on the development of communication and leadership skills. The final work is presented to representatives of industry and government agencies for their consideration and evaluation.

Honor Student Activity • The Department, in collaboration with the student chapters of AIChE and IIQPR, celebrates the

Honor Students Activity each year. It is dedicated to undergraduate students with a GPA higher than 3.00 (on a 4.00 scale), recognizing their hard work and dedication. The activity consists of an open house, an official ceremony, and a lunch. More than 300 guests come to the event each year.

FUTURE INITIATIVES

The Department is developing several initiatives that will support its intention to serve Puerto Rico. These initiatives include the construction of an Environmental & Biotechnology Research & Incubator Opportunities Laboratory, implementation of the PhD program, a new distance learning program, and development and implementation of a new millennium unit operations laboratory.

Also, the Department is updating the existing computer facilities with the latest software and hardware. One of the initiatives of the Department is to create a multipurpose computer facility in order to integrate the use of computers at all levels in the chemical engineering curriculum. In addition, the facility will support the development of the ME program via videoconferencing.

We have been working to improve our program in order to continue graduating the finest engineers and to solve present and future technical challenges. As the major source of Hispanic engineers in the nation, we are committed to continue these trends for the benefit of our society. We are looking forward to being one of the top fifty U.S. chemical engineering departments by the year 2002!

Additional information about the chemical engineering program can be obtained by contacting

The University of Puerto Rico - Mayagüez Campus
Department of Chemical Engineering
PO Box 9046
Mayagüez, Puerto Rico 00681-9046

Phone: (787) 832-4040, ext. 2568
FAX: (787) 265-3818

E-Mail: J_Colucci@RUMAC.UPR.CLU.EDU

ACKNOWLEDGMENTS

We thank Prof. Arturo Hernández-Maldonado, Dr. Marla Pérez-Davis, Dr. José Colucci-Ríos, and Prof. Lueny Morell for their contributions to this article.

We also acknowledge the help of Dr. Jack Allison, Dr. Nelson Cardona, Prof. Federico Padrón, Dr. Lorenzo Saliceti, the Placement Department of the University, and the University's Department of Publications. Photographs are courtesy of Mr. Carlos Díaz and the University's Department of Publications. □