Program Description

The MSE graduate program was designed as an interdisciplinary venture that would attract highly qualified graduate students, considered as backbone of any research in academia. Although there are several UPRM departments involved in MSE research, there is no appealing accretion program available on this area. Without easy access to graduate students, it is virtually impossible for the faculty to justify the need to setup laboratories where they can conduct research. Therefore, the proposed program offers specialization in the different fields of materials science such as materials selection, nanostructured materials, magnetic materials, electronic materials, bio-materials, materials characterization, materials recycling, etc. Many of the courses offered in each of the concentrations are to be available to graduate students in other UPRM graduate programs.

The Materials Science and Engineering (MSE) program confers two degrees, depending on the plan of study selected by the participating student: a) Master of Science; and b) Master of Engineering. There are three plans of study available:

- Plan I (Master of Science): 37 credit-hour program including research thesis
- Plan II (Master of Engineering): 37 credit-hour program including a project
- Plan III (Master of Engineering): 37 credit-hour program with courses only.

Curricular Structure

The following tables provide examples of course line-up for the expected two-year endeavor according to the Plan selected.

Plan I

<table>
<thead>
<tr>
<th>First Semester</th>
<th>10crd</th>
</tr>
</thead>
<tbody>
<tr>
<td>INGE 6001 Fundamentals of Advanced Materials (Core)</td>
<td>4crd</td>
</tr>
<tr>
<td>INGE 6002 Structure and Properties of Materials (Core)</td>
<td>3crd</td>
</tr>
<tr>
<td>INGE 6008 Diffractometry and Complementary Techniques</td>
<td>3crd</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Second Semester</th>
<th>9crd</th>
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<tbody>
<tr>
<td>INGE 6004 Kinetics and Phase Transformation</td>
<td>3crd</td>
</tr>
<tr>
<td>INGE 6005 Thermodynamics and Phase Equilibria</td>
<td>3crd</td>
</tr>
<tr>
<td>INGE 6003 Fundamentals of Materials Chemistry</td>
<td>3crd</td>
</tr>
<tr>
<td>Plan II and Plan III</td>
<td></td>
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<tr>
<td>----------------------</td>
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<tr>
<td><strong>Third Semester</strong></td>
<td><strong>Fourth Semester</strong></td>
</tr>
<tr>
<td>INGE 6012 Nanostructured Materials</td>
<td>10crd</td>
</tr>
<tr>
<td>INME 6016 Mechanical Metallurgy</td>
<td></td>
</tr>
<tr>
<td>INCI 6064 Advanced Concrete Technology</td>
<td></td>
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<tr>
<td>INGE 6017 Graduate Seminar</td>
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</tbody>
</table>

**Overview**

It is understood that with these titles, traditional and modern areas of materials science and engineering are covered (metals, ceramics, polymers, semiconductors, composites, magnetic
materials, and their mechanical as well as physical and chemical behavior). These areas are of interdisciplinary character, that is, the topics are relevant to mechanical, chemical, industrial, electrical and civil engineering, as well as physics, chemistry and computer science. The program targets materials synthesis and processing, device modeling, device fabrication and applied and computational materials and mechanics.

It is expected that the program will have considerable impact on the growth and development of Puerto Rican industry in design, fabrication, characterization of materials and product evaluation and in achieving so, it will be serving its community in vital areas, consistent with UPRM’s mission. All efforts to set up the program are, therefore, a genuine investment in the future of this university and Puerto Rico.

Industrial environments are teamwork-oriented, where graduates from various conventional engineering disciplines need to interact and work with each other. Therefore, many professionals prefer an interdisciplinary graduate program such as the one proposed. As mentioned, MSE shares many aspects of its discipline with civil, mechanical, electrical, industrial and chemical engineering, and with chemistry, mathematics and computer science, and physics among other basic sciences. Their respective departments or programs sometimes do not offer the environment where students can pursue special interests of interdisciplinary nature. The strong emphasis on research in this program is the key factor in the student success rate in industry or in a research institution.

Puerto Rican industry and the government realize that a research base is required to gain competitiveness in the global market. In particular, MSE expertise is critical in the world market today, as the demand for new materials such as, semi-conductors, smart construction materials to high technology composite materials for aircrafts grows at an exponential rate. The mechanical behavior of materials makes the backbone of structural mechanics, machine design and biomechanics among others areas. Mechanical, structural, aerospace, materials, and chemical engineering, depend on the mechanics of materials to design, analyze and fabricate increasingly complex products.

Accordingly, this MSE graduate program is to benefit the industry and government of Puerto Rico by offering the following:

- Advanced technical skills and research experience in material selection, testing and design, materials engineering, device fabrication, smart materials and mechanic of materials.
- A flexible graduate program where professionals from industry can customize their graduate studies, which can be completed within an attractive time-frame for the employers.
- An interdisciplinary program where faculty and students of various science and engineering departments can participate, conduct research and learn from each other.
- Attract well-prepared MSE faculty, making UPRM even more effective in academic research and community service in a high demand, high profile and well-funded field.

All these goals can be achieved with the proposed graduate program, placing PR students on equal footing with the rest of the professionals in the country. The master’s degree will also prepare and encourage students to pursue doctoral degrees.
Number of graduate assistantships

For the first year of the program one should expect at least 10 students enrolled (all Plans). As the program starts with an introductory line-up of courses (three new ones per semester), five graduate students are expected to enroll in the first semester while five more would move from other related programs. These latter groups is formed by students who are already working on MSE research who perceive the academic formation offered by the program more aligned with their career goals. Of the first cohort of 10, it is believed that 6 to 8 could be enrolled in Plan 1. These are the ones that would require sponsorship, i.e. graduate assistantship upon the first and ensuing years of the program. To support their research endeavor leading to a thesis, they will have to be supported either with external funding or institutional moneys.

Plan for graduate assistantships

It is estimated that of the aforementioned 8 yearly assistantships (to initiate the program), four would be supported by existing and upcoming federal grants. Therefore, there is the need for four more assistantships provided by the institution. Naturally, if more federal and local grants are obtained, the program will expand; yet, the need of institutional support may not diminished. In effect, more often in the last years, federal grants (as those awarded by NSF, for instance) require that stipends and assistantships budgeted in the funded proposals be restricted to US citizens, US nationals and –not always- permanent residents. In Puerto Rico and the mainland, a strong component of graduate programs is the participation of foreign nationals. At UPRM, those international students are frequently from Latin American nations. The impossibility of defraying their participation with federal monies is obliging that, in order to support research, those foreign nationals be awarded institutional assistantships. For this reason, it is not foreseen that such institutional investment should lessen in the upcoming years of the program.

Courses

The following list of courses will be offered for the master's program

Core Graduate Level Courses

INGE 6001 Fundamentals of Advanced Materials
INGE 6002 Structure and Properties of Materials
INGE 6004 Kinetics and Phase Transformation
INGE 6005 Thermodynamics and Phase Equilibria
INGE 6008 Diffractometry and Complementary Techniques
INGE 6011 Computational Materials Science
INGE 6007 Polymer Science & Engineering
INGE 6003 Fundamentals of Materials Chemistry
INGE 6012 Nanostructured Materials.
INGE 6010 Materials Microprocessing and Engineering
INGE 6006 Diffusion Phenomena in Materials
INGE 6009 Solidification Processes
INGE 6995 Selected Topics

Other Advanced Undergraduate Elective Courses (existing courses)

INGE 5066 Recycling of Materials
INGE 5065 Materials Selection
QUIM 5125 Chemical Thermodynamics
QUIM 5165 Polymer Chemistry
INME 5008 Corrosion
INME 5018 Materials Failure Analysis
INME 5025 Metals Fatigue

Other Graduate Level Elective Courses (existing courses)

INEL 6055 (FISI 5011) Introductory Solid State Devices
INEL 6075 Solid State Device Fabrication and Technology
INME 6015 Dislocation Theory
INME 6016 Mechanical Metallurgy
INME 6030 Mechanics of Composite Materials
INME 6009 Advanced Manufacturing Processes
INME 6019 Fracture Mechanics
INME 6037 Finite Element Analysis I
INCI 6023 Analysis of Structures of Composite Materials
INCI 6064 Advanced Concrete Technology
INCI 6057 Theory of Elasticity
INCI 6018 Finite Element Analysis II
**Faculty**

The following is a list of the members of the MSE Committee along with their academic preparation:

<table>
<thead>
<tr>
<th>Name</th>
<th>Academic Background</th>
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</table>
| Prof. Bárbara Calcagno        | B.S., Chemical Engineering, Universidad Simón Bolívar, Venezuela, 1977  
                             | M.S., Chemical and Biochemical Engineering, University of Pennsylvania, 1981  
                             | Ph.D., Materials Science, University of Wisconsin-Madison, 2010 |
| Prof. Yang Li                 | B.S., Physics, University of Science and Technology, Beijing, China, 1984  
                             | M.S., Materials Physics, University of Science and Technology, Beijing, China, 1989  
                             | Ph.D., Materials Physics, University of Science and Technology, Beijing, China, 1993 |
| Prof. Carlos Marín            | B.S., Physics of Materials, Universidad Autónoma de Madrid, Spain, 1992  
                             | M.S., Physics of Materials, Universidad Autónoma de Madrid, Spain, 1994  
                             | Ph.D., Physics of Materials, Universidad Autónoma de Madrid, Spain, 1997  
                             | Ph.D., Mechanical Engineering, Rensselaer Polytechnic Institute, 2002 |
| Prof. Agnes Padovani          | B.S., Chemical Engineering, University of Puerto Rico - Mayagüez, 1997  
                             | Ph.D., Chemical Engineering, Georgia Institute of Technology, 2002 |
| Prof. Oscar Perales           | B.S., University of Engineering, Lima, Perú, Metallurgical Engineering, 1986  
                             | Dr. Eng., Tohoku University, Sendai, Japan, Materials Processing, 1998 |
| Prof. Jeannette Santos        | B.S., University of Puerto Rico - Mayagüez, Chemical Engineering, 1980  
                             | M.S., University of Wisconsin - Madison, Chemical Engineering, 1982  
                             | Louisiana State University - Baton Rouge, Chemical Engineering, Ph.D. 1995 |
| Prof. Oscar Marcelo Suárez    | B.S., Universidad Nacional de Córdoba, Argentina, Aeronautical & Mechanical Engineering, 1984  
                             | M.S., University of Wisconsin-Madison, Metallurgical Engineering, 1993  
                             | Ph.D., University of Wisconsin-Madison, Metallurgical Engineering, 2000 |
| (coordinator)                 |                                                                                       |
| Prof. Oswald Uwakweh          | B.S., University of Ibadan, Nigeria, Mechanical Engineering, 1981  
                             | M.S., University of Nancy, France, Materials Science and Engineering, 1985  
                             | Ph.D., University of Nancy, France, Materials Science and Engineering, 1990 |
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