

A Proposal for  
the Nanoscience and Microsystems (NSMS)  
M.S. and Ph.D. Degree Program  
at the  
University of New Mexico  
Albuquerque, 87131



Required Signatures of Departments:

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Statement for:

3. Does this new degree affect any existing program? Yes  No . If yes, attach statement.

The impact on existing programs primarily comes from the fact that all participating faculty are in existing programs at UNM. However, the emphasis in recruitment will be for new students whose specific goals can be met with our new degree program, and therefore these would be students who otherwise would not come to UNM. Thus, there will be very little to no impact in terms of new student demographics on the participating or other departments at UNM.

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A program to be administered jointly  
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## **Chapter 1**

### **Purpose of the Program (Sec 9.1.1, 5 NMAC 5.2)**

#### **1.1 Objective**

The purpose of this proposal is to establish a M.S. and Ph.D. degree program in Nanoscience and Microsystems (NSMS) at the University of New Mexico (UNM). This interdisciplinary graduate degree program will educate and train students in the exciting new field of nanoscience and its applications to microsystems technology (MST), and foster opportunities not only for the acquisition of new knowledge, but also the production and application of new knowledge.

What is nanoscience? The word nano is from the Greek “nanos” (or Latin “nanus”) that means “dwarf,” and is defined as the  $10^{-9}$  power or one billionth, in terms of a meter or a nanometer on the scale of atomic diameters. Nanoscience therefore is the study of materials and systems at the nano-scale. Nanoscience lies at the confluence of the traditional disciplines of solid-state physics, chemistry, biology, materials science and engineering. These disciplines have been the source of all previous material technologies that were developed based on our understanding and control of the material world. However new properties and functions arise at the nanoscale where forces that were insignificant at macroscopic scales become dominant. A significant portion of this degree program entails acquiring new knowledge about nanoscience and the application of nanoscience to MST. MST, based on nanostructured materials, constitutes a portfolio of techniques and processes at the nano level having its foundation in the design and creation of miniature systems such as sensors and actuators. It encompasses the full range of inorganic, organic and biological nanoscience materials. While the theoretical basis and basic sciences are grounded in fields in the arts and sciences, designing systems and the application of knowledge is typically the domain of engineering. Hence, the program is truly interdisciplinary, to be jointly administered by the School of Engineering (SOE) and the College of Arts and Sciences (A&S).

This program will provide educational opportunities for students interested in interdisciplinary materials science at the nano-level. Particular efforts will be made to ensure this program is a cross-disciplinary effort between the College of Arts and Sciences (A&S) and the School of Engineering (SOE), and it also will likely involve collaborations in the near future with the School of Medicine (SOM) and the Anderson Schools of Management (ASM). Furthermore, the program will build upon our current collaborative efforts with local and regional industry leaders as well as researchers at Los Alamos (LANL) and Sandia National Laboratories (SNL) who are engaged in state-of-the-art nano research. The proposed program will be implemented by an impressive group of faculty from both A&S and SOE, and selected other individuals, who will educate master’s and doctoral students in this cutting edge NSMS research area. Some of these courses will also be available for undergraduate students.

#### **1.2 Program is Consistent with Role and Scope of UNM**

The UNM strategic plan, approved by the faculty and by the Board of Regents on December 11, 2001, includes the objective to “evaluate and restructure UNM’s support for graduate education and raise the effectiveness and stature of our programs.” The proposed NSMS program meets the

criteria of this objective. In the next decade, universities in the U.S. and abroad will begin to offer specific training programs in nanoscience. Those universities that provide specific training in nanoscience will attract the top students and faculty interested in this growing field. UNM must offer this graduate degree program to compete favorably for high quality students and faculty, and for federal funds, with other universities who will provide this training.

The proposed degree program is consistent with UNM's mission of providing graduate education and training in technical and scientific areas that are critical to the economy of the State of New Mexico, specifically, and to the U.S. economy in general. In addition, because this program is unique, it will promote UNM's value of "excellence." Our proposed program has great potential to become a national model for nanotechnology programs because it brings together a cutting edge combination of NSMS courses, laboratories, pioneering NSMS research programs and a statewide network of nanomaterials characterization facilities. This program will promote the acquisition of new knowledge and the production and application of new knowledge in classrooms and laboratories, and produce highly trained and skilled graduates well qualified to move into academic, industrial or federal NSMS-oriented research positions.

Several *interdisciplinary* programs are emerging at UNM that include departments in the School of Engineering, and physical and biological sciences in the College of Arts and Sciences. Some cohere as degree-granting entities (i.e., Optical Science and Engineering, Water Resources, and Biomedical Sciences Graduate Program), others as extramurally funded graduate training programs (i.e., IGERT, AGEP, GK-12), and others conjoin with a developing research program (i.e., EPSCoR, CMEM and CHTM). Such programs are vital for UNM (a) to achieve the goals of these colleges to recruit not only the best research faculty but also excellent graduate students, and to prepare them for nanoscience teaching and research positions. Their training will prepare them for positions in academia and in laboratories across the nation and worldwide, where they will discover and create breakthroughs in biomedical, engineering and basic scientific fields. The benefits in terms of research priorities are that such programs (b) will make UNM more competitive for research and training grant funding from NSF, DOE, NIH and other sources, and (c) enhance UNM's research and training partnerships with other institutions, federal and state programs, and private industry. In summary, the proposed graduate degree program supports UNM's teaching and research vision. The Deans of the College of Arts & Sciences and the School of Engineering are fully committed to helping this program to succeed.

### **1.3 The Proposed Program is an Institutional Priority**

The College of Arts and Sciences and the School of Engineering place a high priority on establishing the proposed M.S. and Ph.D. program in nanoscience and microsystems. This is demonstrated by the extent to which research and graduate education in nanotechnology is already taking place in the classrooms across campus and at several UNM affiliated centers, including the Center for High Technology Materials (CHTM) and the Center for Micro-Engineered Materials (CMEM). Furthermore, the Interim Provost has made it one of his priorities to create new interdisciplinary degree programs, and he specifically highlighted the NSMS program as an example in his memo to the faculty dated April 11, 2005.

## Chapter 2

### Justification for the Program (Sec 9.1.2, 5 NMAC 5.2)

#### 2.1 Need

Nanotechnology has been referred to as the Industrial Revolution of the 21<sup>st</sup> century. The U.S. government recognizes the extensive possibilities offered by nanotechnology and has invested heavily in the National Nanotechnology Initiative (NNI), with over \$710 million in FY2003. It is estimated that large industry currently supports about half of the R&D in nanotechnology in the U.S.—with about \$2 billion per year. The other half comes from small companies and venture capitalists, as well as federal agencies, and state and local governments. At the national level, federal government experts recognize the importance of nanoscience and are rapidly increasing its funding allocations for nano research. As a consequence, the demand for researchers and employees with comprehensive nanoscience training is increasing rapidly. Yet, there are few educational programs nationwide that can meet this demand by being focused on nanoscience.

No doctoral or master's programs in nanoscience or nanomaterials exist in Southwestern U.S. Presently, those interested in nanoscience and nanomaterials research, including UNM's undergraduate and graduate students and faculty researchers, create their own nano training programs in a piecemeal manner, by taking appropriate courses in the sciences and engineering, coupled with on-the-job training. The proposed NSMS program will provide an effective template for students interested in nanoscience and microsystems. The local national laboratories (LANL and SNL), and the Center for Integrated Nanotechnologies (CINT) are enthusiastic about hiring graduates from the proposed program. Support letters have been solicited and are expected from local industry and federal and national laboratories (see Appendix G) that point to their need for graduate students trained in these areas.

Nanoscience graduate degree programs exist in the United Kingdom (Sussex and Cambridge) and the Netherlands and elsewhere, but there is only one program that is even similar to ours that now exists in the nation. There are several *materials science* programs, such as at the New Mexico Institute of Mining and Technology, University of Texas at Austin, and University of Wisconsin at Madison, but these programs focus on materials *in general* and not on materials and processes at the *nano level*. A few programs partly resemble what we propose, notably at the Center for Nanotechnology at the University of Washington, California NanoSystems Institute at the University of California, Los Angeles. But these programs do not offer distinct Nanoscience Graduate degrees. The University of Washington has a Ph.D. program in Nanoscience that is a traditional degree program plus a *concentration in nanoscience*: students take additional courses beyond what is required for a degree in a traditional field with a *concentration in nanoscience*.

However, these programs do not offer a nanoscience degree, and hence they are less attractive to students interested in an interdisciplinary degree-awarding curriculum, and in receiving their degree in nanoscience. The NSMS program at UNM will be among the first programs in the nation with this specific nano focus. It will resemble closely the program of the State University of New York at Albany, which was established in 2004 as part of a nanoscience college with funding from the New York State Governor's Office. Like SUNY, our students will receive master's and doctoral degrees in NSMS through a multidisciplinary educational program.

Because of the rapidly-growing interest in nanostructured materials and the identification of nanoscience as a major research thrust area, the stage is set for UNM to develop one of the model NSMS programs in the nation. The justifications for establishing such a program are listed below and are explained in detail in subsequent paragraphs.

## **2.2 Justifications for establishing a graduate program in Nanoscience and Microsystems**

The demand for the scientific and technological development of nanoscience is growing and concomitantly the demand for professionals with expertise in NSMS. UNM and the State of New Mexico will benefit by responding to demands for the development of the NSMS program.

- A. The NSMS program will promote UNM's stature as a leader in creating and disseminating new knowledge, and in the application of new knowledge.
- B. The NSMS program will fulfill the need for cross-disciplinary training of students, and enhance UNM student recruitment with a degree program that is in increasing demand.
- C. The NSMS program will establish more effective collaborations between UNM and the prominent local national laboratories, SNL and LANL.
- D. The NSMS program as a new field of research and application will create increased opportunities for employment for UNM students, and economic growth in the state.
- E. The NSMS program will enable UNM to maintain its competitive edge in the National Nanotechnology Initiative, including being more competitive in recruiting high quality graduate students and faculty.

### ***A. Promote UNM's stature in creating and applying new knowledge.***

UNM is fortunate to have an active research and teaching base with faculty from both Arts and Sciences and in Engineering collaborating in teaching interdisciplinary courses and conducting research. While the fundamental basis is grounded in the natural sciences, designing systems and the application of knowledge is typically the domain of engineering. The NSMS program will strengthen and expand these collaborative efforts and provide unique opportunities for creating new knowledge and developing new applications of NSMS findings, and for developing curriculum offerings that stimulate creating new knowledge and insights for new applications. As described below, the development of the NSMS program at UNM will also help to establish New Mexico as a key participant in nanotechnology.

### ***B. Meet needs for cross-disciplinary training and create a unique degree program.***

The NSMS program will enable UNM to compete successfully to attract talented graduate students interested in a degree in nanoscience, one of the fastest growing interdisciplinary science and engineering fields. Many UNM students are interested in materials science but do not fit neatly into one discipline because their interests cross disciplinary boundaries. Enrollment in current and recent courses illustrates the level of interest of UNM students today.

Advanced Materials Science (ME 471/571): S'05 - 23 students

Engineering Materials Science (ME/ChNE 370): F'05 - 35 students

Introductory Biochemistry (Bioch 423): S'05 - 97 students; F'05 - 140 students

Nanomaterials Science (ECE 595, ChNE 575): F'05 - 10 students

Quantum Information Theory (Phys 552A): F'05 - 29 students

Societal/Ethical Implications of Nanoscience - F'05 (first time offered): F'05 - 8 students

Because UNM does not have a materials science department, students with backgrounds or an interest in materials science or ceramics are reluctant to undertake graduate study at UNM since

they will have to take extra courses for a degree in one of the established UNM departments. The NSMS program will attract students who do not easily fit into one of the currently existing departments. For example, we could attract students with backgrounds in the biological sciences who want to do research in nanoscience, but cannot now find a suitable department at UNM to accommodate a nanoscience curriculum. At present, there is no mechanism to assimilate the entire nanoscience related courses into one organized curriculum. Current UNM graduate students who are interested in nanoscience must take nano courses where they can find them, usually in Chemistry, Physics and Astronomy, and in various engineering departments. Creating a program in nanoscience and microsystems will enable students to pursue their cross-disciplinary interests because the program itself is interdisciplinary, through a collaborative effort between the College of Arts and Sciences and the School of Engineering.

***C. Establish effective collaborations with local national and federal laboratories.***

SNL and LANL are developing a collaborative nanoscience user facility, the Center for Integrated Nanotechnologies (CINT), as one of five nanoscience centers being established in the U.S. with DOE funding. The presence of a major center like CINT in close proximity to UNM provides many opportunities for UNM students to conduct research during short-term internships and for faculty interested in nanoscience and nanomaterials research. However, CINT does not have an educational program to complement this research to prepare nanotechnology scientists. The NSMS program will enhance the ongoing extensive research collaborations between UNM and national laboratory researchers. Several national laboratory scientists from LANL and Sandia already have appointments at UNM, and the NSMS program promises to allow us to expand the involvement of national laboratory scientists in UNM's academic programs. A CINT scientist is among those who will help to develop one of the new courses. These kinds of collaborative efforts with these scientists are important because they bring with them essential experience in microsystems. This makes UNM's NSMS program truly unique in the nation.

***D. Train Students for Jobs and Create Economic Growth.***

Recruiters from national laboratories and local industry have indicated their interest in having an NSMS graduate degree program at UNM, and their desire to hire graduates from this program. SNL and LANL indicated that they are currently somewhat limited in their ability to hire UNM graduates, because these graduates are not receiving sufficient training in nanotechnology. The NSMS program will provide a recruitment pool for the national laboratories, and local and regional high tech companies that are engaged in nanotechnology research.

The development of the NSMS program will help to establish New Mexico as a key participant in the nanotechnology field. As the demand for nanotechnology professionals increases, and the NSMS program is able to meet this demand, New Mexico will benefit from increased revenue. For example, there are locally-based high tech companies that will benefit materially from a program in nanoscience at UNM, as well as receiving help with start-ups. Many of these companies already employ UNM graduates and former postdoctoral fellows, and they have indicated their interest in the proposed NSMS program and hiring its students. A list of these companies is included in Appendix B. It is likely that a novel educational program will encourage new companies to locate in New Mexico because of the availability of highly trained graduates, potential research collaborations with faculty, available technology and facilities and a supportive research environment offering help with start-ups.

### ***E. Maintain UNM's leadership within the National Nanotechnology Initiative.***

This initiative emphasizes long-term fundamental research that aims to discover and understand phenomena at the nano level, specifically the synthesis and processing of new nanostructured materials and tools and techniques that are required to prepare, process, and characterize nanomaterials. It supports the formation of new interdisciplinary centers and networks of excellence including shared user facilities. NNI supports research infrastructure developments, and addresses research and educational activities that concern the societal implications of advances in nanoscience and nanotechnology.

Establishing the NSMS program will help strengthen UNM's position as a national player in this emerging field, and will enable UNM to benefit from the NNI resources. Critical steps to accomplish this include (1) attracting highly skilled new faculty interested in establishing leading edge nanomaterials research programs, and (2) attracting top graduate students interested in pursuing a degree in nanoscience and nanomaterials science.

### **2.3 Duplication**

As indicated above, there are no formal nanoscience instructional programs in New Mexico or the Southwest. The only comparable program in the U.S. to what we propose is at SUNY-Albany, as described above. The closest institution to UNM with a nanoscience curriculum is the California Nanosystems Institute, a center that supports research collaboration between UCLA and UCSB. Like UNM, this center offers courses in nanoscience but not yet graduate degrees in nanoscience. They are creating a graduate program in nanosystems and will likely establish a degree-granting program in the near future. The Center for Nanotechnology at the University of Washington, in collaboration with the Pacific Northwest National Lab (PNNL), offers a Ph.D. in nanoscience. However, as noted above, this requires students to take the full set of courses in a traditional field *plus* the nanoscience courses for a doctorate in the traditional field with a *concentration* in nanoscience. There are several non-degree granting, outreach programs for undergraduates and high school teachers in nanoscience at Cornell University, Arizona State University, Harvard University, University of North Carolina, Northeastern University, Northwestern University, Rensselaer University, Rice University and University of Wisconsin at Madison. These programs will provide UNM with an additional focus for student recruitment.

The proposed NSMS program builds on the excellent research in nanoscience and nanomaterials being conducted at CHTM, CMEM/CCMC and other programs that involve investigators from both the College of Arts and Sciences and the School of Engineering. The only *materials* program in New Mexico is at New Mexico Institute of Mining and Technology. There is no duplication since our NSMS degree is focused on *nanoscience*, and the New Mexico Tech program focuses on the broader array of materials sciences, from polymers and ceramics to metals. We plan to share some of the NSMS courses with both NMSU and NMT just as we currently share our research facilities with each of these institutions through the EPSCoR distributed research facilities. The opportunity for students to pursue their graduate research in conjunction with SNL and LANL researchers is an additional potential benefit of the NSMS program as is the possibility for employment at these or similar laboratories nationwide.

### **Chapter 3**

## **Clientele, Recruitment Strategies and Projected Enrollment (Sec 9.1.3, 5 NMAC 5.2)**

NSMS students in this program are likely to come from a broad range of disciplines, such as engineering, materials science, ceramics, chemistry, physics, biology, biochemistry, earth and planetary sciences, or mathematics. We expect that a significant number of students will come initially from the three New Mexico based government laboratories, SNL, LANL and the Kirtland Air Force Phillips Laboratory, through national laboratory-sponsored mentorship and retraining programs for their employees. It is important to also note that “Microsystems” is one of the six key technology clusters identified by the New Mexico *Next Generation Economy Initiative* (<http://www.nextgenclusters.net/pages/617113/index.htm>). Thus, the program is strategically oriented to serve the needs of current and future industrial and government sectors of New Mexico. The academic qualifications for admission into the NSMS program are listed in Section 8 below.

The NSMS program will be consistent with state goals for equitable representation of various student groups. It is expected that the students in this program will reflect the present ethnic, gender and age make-up of the technical workforce in New Mexico. Biology, chemistry and chemical engineering programs have traditionally attracted a higher percentage of women than physics or other engineering disciplines. Thus, we expect that the proposed program will help to narrow the existing gender gap in the graduate programs at the UNM School of Engineering. Similarly, biology often attracts larger numbers of underrepresented students, and thus serves as a gateway program for introducing these students to other scientific and engineering disciplines.

In view of the strong industrial and governmental laboratory support for the program, we hope to attract and prepare a continuous pool of applicants from and for these laboratories and businesses. Aggressive recruitment strategies will be implemented to attract other potential students. Such strategies will include:

- Maintaining a frequently updated web page that informs the browsing individual of the organization, opportunities, accomplishments, and excitement of the program.
- Faculty presentations about the program at various technical meetings that are devoted to science and engineering education.
- Faculty visits to other institutions with potential sources of students.
- Mass mailings and e-mailings of flyers and other publicity materials about the program.
- Contact with our alumni and other potential benefactors through e-mail and open houses.

With input from industry (via NexGen), from representatives of AFRL, Sandia and Los Alamos National Laboratories and comments from students currently enrolled in our Ph.D. programs (Physics and EECE, for example), we project the enrollment indicated in Table 3.1, beginning with 8 in the first year, and culminating with 33 full-time students in the fifth year. The proposed

credit hours, as listed in Table 3.2, are for a student enrolled as an M.S. or Ph.D. candidate who will take two years of course work. Students will be enrolled in 18-24 credit hours per year.

**Table 3.1. Projected Enrollment**

Year	New Graduate Students	Returning Students	Total Number of Students In program
1	8	0	8
2	9	8	17
3	10	17	27
4	11	19	30
5	12	21	33

**Table 3.2. Projected Student Credit hours**

Year	Project Total Number of Students	Credit Hours/ Student/Year	Total Credit Hours/Year
1	8	18-24	144-192
2	17	18-24	306-432
3	27	18-24	486-648
4	30	18-24	540-720
5	33	18-24	594-792

## Chapter 4

### Institutional Readiness for the Program (Sec 9.1.4, 5 NMAC 5.2)

UNM is ready and strongly committed to establish the proposed NSMS degree program. We have received approval and encouragement to develop this program and to commit various kinds of resources to implement it from the highest levels of the UNM administration. The NSMS program will build on the nanomaterials and microsystems research already in place at UNM. Much of the current research occurs through the Category III research centers, CHTM and CMEM, as well as individual and collaborative research projects and grants that cut across the various departments in the School of Engineering, the College of Arts and Sciences, and the School of Medicine. While we provide excellent research training for students at UNM, we lack a formal curriculum that will provide the kind of credentials desired by many of our graduate students and their prospective employers in the federal laboratories and private industry.

In response to this demand, our preparations for the UNM NSMS program include the following:

- We have an abundance of resources that are already available for this program.
- We have identified needs that must still be met, and made progress in satisfying some of those needs, in part by helping to obtain new resources to train students and for research.
- We have carefully reflected upon what is needed to ensure a smoothly functioning administrative structure amid a complex array of departments and program prerequisites.
- We developed a set of procedures for graduate students to meet their degree program requirements without the kind of disruptions that can accompany multidisciplinary training programs.

#### 4.1 Available Resources at UNM for a NSMS Graduate Degree Program

The NSMS program will build on the nanomaterials and microsystems research already in place at UNM. We have identified an abundance of resources that are already available: UNM's growing reputation in the scientific community as being among the top nanoscience research institutions, UNM's nanoscience research centers, a large number of faculty with nanoscience interests and expertise, having assigned space accommodations, and numerous relevant courses for the curriculum.

##### ***A. UNM's Stature as a Nanoscience Research and Training Institution.***

UNM has achieved significant stature as one of the country's leading materials science research universities even without a materials science department or degree-granting program. UNM was ranked as being among the top five of all U.S. universities conducting materials science research in *ESI Essential Science Indicators* ([http://www.in-cites.com/research/2001/august\\_27\\_2001-2.html](http://www.in-cites.com/research/2001/august_27_2001-2.html)) based on the number of publications in materials science and the impact of these publications on the scientific community. This high ranking was achieved largely through the dissemination of information through publication and presentation of the excellent research being conducted by individuals and research teams across UNM.

##### ***B. UNM's Previous Investments in Developing Research Centers.***

Over the past twenty years, UNM has invested heavily in building up strategic centers of excellence, such as CHTM (the Center for High Technology materials) and CMEM (the Center

for Micro-Engineered Materials) and NNIN (the National Nanotechnology Infrastructure Network) as well helping departments acquire and maintain sophisticated characterization tools that are vital for nanomaterials research. These centers and the participating departments have helped attract and retain the faculty who are on campus today and who will largely be involved in teaching the curriculum planned for the proposed NSMS degree.

***C. UNM's Faculty Prepared to Teach and Mentor Students.***

The NSMS degree program has adequate faculty, with four new hires during 2005 filling vacancies from retirements with faculty who have nanoscience expertise, to teach the courses and mentor master's and doctoral students who will enter the program as degree candidates. Appendix C contains a list of more than 60 faculty members from 10 UNM departments in three colleges (thus far) with relevant expertise and active research agendas. These individuals have expressed interest in being included in participating in this program as student mentors and course instructors.

***D. Adequate Space is Committed.***

The Deans of the College of Arts and Sciences and the School of Engineering agree that the program office should be separate from department offices, but on the main campus to ensure easy access by students. The Vice President for Research and Economic Development has committed his office to providing space though it has not yet been identified where it will be. This space will serve as the Program Office for the Director and Administrative Assistant, and a conference room to convene meetings and seminars.

***E. Numerous Courses Already Available for the Curriculum.***

Chapter 8 below contains a detailed description of the initial set of 18 courses, plus 37 electives for the NSMS curriculum. Of these 55 courses, 9 are either recently developed or entirely new courses developed as part of the entry-level core, and several of the existing courses have evolved to include instruction in NSMS, and keeping in mind plans for the NSMS graduate degree program. The administrative structure includes a Curriculum Planning Subcommittee (see below) responsible for encouraging the development of new interdisciplinary courses and revisions in the syllabi of existing courses to include more nanoscience content or application. In addition, as described in Chapter 8 below, the NSMS courses will be assigned separate NSMS codes with cross-listing in relevant departments, and credit for courses and faculty mentoring will be allocated to both the participating department and the NSMS program.

**4.2. Key Enablers for NSMS Program are in Place**

Critical to the successful launching of the UNM NSMS program were the ability to hire new faculty (some to replace retired faculty, others as new faculty lines), the funding for graduate student fellowships--to attract the best and the brightest, and supportive access to federal funding for research and additional student training funding. Two major steps were taken during 2004-2005 that are critical to establishing and growing this program.

***A. New Mexico EPSCoR.***

The first major achievement occurred when the New Mexico NSF EPSCoR program selected nanomaterials as an area for infrastructure development on a statewide basis. A team of

researchers from UNM with assistance from institutional collaborators statewide spearheaded this effort. The EPSCoR (*Experimental Program to Stimulate Competitive Research*) is a NSF program that operates on the state level with the objective to develop the infrastructure to enable New Mexico research institutions to compete more favorably for external research grants. The New Mexico EPSCOR grant recently awarded is providing startup funds for new faculty in the nanoscience area. Through participation of the departments, new faculty will join this program as they are hired to replace retiring faculty. This currently involves two lines in A&S (one in chemistry and one in physics) and two in Engineering that are targeted for faculty with nanoscience backgrounds.. Hence, the program will increase the number of participating nanoscience faculty without requiring additional UNM resources. In addition, the recently funded NSF NNIN program will help us maintain advanced characterization and synthesis facilities for nanoscience research.

***B. UNM's Nanoscience IGERT Graduate Student Training Program.***

The other achievement is the recent award for our Nanoscience IGERT program, which is described in Appendix D. This program will provide fellowships for students and a new teaching laboratory. In summary, the faculties that are needed are already here, the facilities are in place and there are students anxious for the program to begin. Once the NSMS degree program is established, UNM will be in an excellent position to benefit from national funding agencies such as NSF and DOE and others that support nanoscience and nanomaterials research and education. The lack of a formal degree program has been a hindrance since these funding agencies increasingly demand visible integration of research and education.

**4.3. NSMS Graduate Degree Program Administrative Structure.**

See Appendix E for the chart illustrating the administrative structure of the NSMS program.

***A. Executive Committee.***

The UNM Interim Provost as well as the Deans of the School of Engineering and the College of Arts and Sciences strongly support the proposed NSMS program. They have played an active role during development of the proposal and are enthusiastic spokespersons on behalf of the proposed NSMS program. Four individuals will comprise the Executive Committee: the Vice President for Research and Economic Development, the Dean of the College of Arts and Sciences, the Dean of the School of Engineering, and the Dean of the Office of Graduate Studies. The Provost will launch the establishment of this Committee during Spring 2006.

The Executive Committee is responsible for establishing policy and procedures for the NSMS Graduate Degree Program, approving revisions of the curriculum and other procedures for awarding degrees, and serving as arbiter of faculty or student complaints. The Committee chair will rotate among the Committee members, with the first term being assumed by the Dean of the School of Engineering. The Chair's term normally will be two years. The Chair is responsible for calling meetings of the Executive Committee at least twice/year and more frequently as needed. The Director reports to the Chair who is also responsible for carrying out a yearly performance evaluation of the Director and the program, in consultation with faculty in the program, the Faculty Governing Committee and its evaluation process (page 23 below), and the Executive Committee.

- ***The External Advisory Board*** will assist the Executive Committee by providing broader oversight and recommendations regarding how the program could be improved, so as to reflect the needs of the constituencies that are represented on this Board. This Board will include members from other units at UNM, specifically the School of Medicine, the College of Pharmacy, the Anderson Schools of Business, and the Science and Technology Corporation. It will also have representatives from regional research laboratories, such as a microsystems researcher from Sandia National Laboratories, a nanomaterials researcher from Los Alamos National Laboratory and the Chair of the UNM/Rutgers/ Penn State Ceramic and Composite Materials Center (CCMC) Industrial Advisory Board. Other national laboratory or industrial representatives can be added at the discretion of the Board members and approval of the NSMS Executive Committee. The Board will meet regularly once a year.

### ***B. Director and Staff.***

The Executive Committee will appoint the Director of the NSMS degree program, with the following qualifications: tenure track appointment in one of the participating departments and active research agenda in nanoscience. This individual will serve as Director with .5 FTE release time from established teaching responsibilities, and will report to the Executive Committee. The Director will hire a full-time administrative assistant who will serve as the Program Coordinator and Graduate Advisor. This individual will maintain student records from applications to graduations, and through post graduation career follow-ups; monitor and report on students' progress toward degree status; answer inquiries from prospective and current students, faculty and the public; coordinate outreach activities; respond to faculty requests; assist the Faculty Governing Committee with scheduling meetings and follow-up, and various other official tasks for the Director. The Director will meet with chairs of participating departments and the IGERT program to select members for the Faculty Governing Committee and subcommittees. A final slate of members will be submitted to the Executive Committee for approval.

### ***C. Faculty Governing Committee.***

The Nanoscience Faculty Governing Committee will be comprised of faculty representing the participating departments (those with NSMS courses in the curriculum) and each will be selected by their respective department. The term of office will be three years. Organizationally, this Committee will have an official Chair and Vice Chair, elected by the members and approved by the Executive Committee. They will advise and report to the Director and assist with several administrative functions, including developing proposals for changes in policy or practice that are then brought to the Executive Committee, planning additional curriculum and symposium offerings as needed, assisting with recruitment, oversee the Admissions Subcommittee process of reviewing applications and accepting students into the program, planning course offerings each semester to ensure that students' needs for courses are met and prevent scheduling conflicts, and assisting the Director with managing difficulties that can be encountered with student-faculty relations or student issues. In addition, revisions in the program requirements and relevant courses will be proposed through a subcommittee of the Faculty Governing Committee and will be first reviewed by the Faculty Governing Committee and the Director of the NSMS, and then submitted for final review and approval from the Executive Committee.

Under the rubric of the Faculty Governing Committee, the following subcommittees will be established, with each composed of representatives from participating departments and one individual on each committee from the NSF IGERT Program:

- ***The Admissions Subcommittee*** of the Faculty Governing Committee will review applications and admit students who qualify for one of the three degree plans.
- ***The Curriculum Planning Subcommittee*** is responsible for planning course offerings each semester to ensure that students' needs for courses are met and prevent scheduling conflicts, and will encourage development of new courses to be added to the curriculum.
- ***The Graduate Subcommittee*** is empowered to make the final decision on pass/fail of the Master's oral examination that is recommended by a student's Committees on Studies. Students will be allowed at most two attempts to pass the Oral Exam. The Graduate Subcommittee will be the first body to review requests and appeals by graduate students who fail to pass examinations, or to resolve other conflicts on academic matters.
- ***Task Forces.*** The Faculty Governing Committee and the Director are also authorized to create time-limited Task Forces to study and provide advisement concerning any specific issues that arise with regard to administering the program, curriculum, faculty participation, processes and procedures, and other matters.

## Chapter 5

### Projected Costs and Benefits of the Program (Sec 9.1.5, 5 NMAC 5.2)

The creation of a graduate Ph. D. level degree program, such as this, would ordinarily call for a substantial investment of funds. However, as mentioned above and described in detail below, most of the investments have already been made by UNM over the past twenty years in terms of faculty hires, curriculum development, student training options, strategic centers of excellence, facilities and regional collaborations with national laboratories and industry partners.

In addition, we expect the NSMS program will benefit from significant funding commitments from the NSF, plus support from industry, national labs and other UNM benefactors, so that the degree program can be established at the level that is necessary for this very important program. UNM will commit additional resources for hiring new faculty, which would be done in any case, since these are replacements for retiring faculty. New resources will, however, be required to house the new program, for administrative support, to create a teaching lab, for access to periodicals and release time for key faculty involved in teaching the curriculum. But, given the significance of the NSMS degree program, it is clear that the academic and research benefits to UNM and the colleges involved far outweigh the costs. Most of the required funding and costs of the Nanoscience and Microsystems (NSMS) M.S. and Ph.D. degree programs are *already covered* from existing resources that are available to participating departments from the college offices and from other sources. As the following details show, the NSMS program fits well into the existing framework of science and engineering courses as well as the budget resources that already exist on campus. The “New Program Fiscal Data” sheets, attached, also provide details.

#### 5.1 Substantial Investments - Many Have Already Been Made

- **Faculty Appointments.** The NSMS program will require a substantial number of faculty to help us attain a critical mass in the area of nanoscience and microsystems. However, the majority of the faculty we need are already at UNM (see list of participating faculty). In addition, it is expected that the relevant departments in science and engineering will be filling vacancies as they occur with faculty with expertise in nanoscience. For instance, during this past year alone (2004-05), two lines in A&S (one in chemistry and one in physics) and two in Engineering were targeted for faculty with nanoscience backgrounds. The salary lines for these positions already exist since these are replacements for retiring faculty. The needed investment in the form of start-up funds is coming in part from the EPSCoR program, which is providing over \$500K, and the rest will come from internal UNM resources.
- **Shared Financial Burden.** The School of Engineering and College of Arts and Sciences will share the financial responsibility for the NSMS program. The Director will be a tenured faculty member in one of the departments and additional costs required will be for an Administrative Assistant and space to house the NSMS Program Office.
- **Costs of Administration.** The NSMS graduate degree program has been developed and will be funded as a collaborative partnership of the Deans of the College of Arts and Sciences and the School of Engineering, who will continue to provide oversight as members of the Executive Committee.

- ***Specialized Courses.*** Initially, the NSMS program will consist of a carefully selected collection of existing and new courses, with a set of four new core courses and a nanoscience ethics course. These are described below in Chapter 8. We will also develop some specialty courses that would focus on critical aspects of nanoscience and nanomaterials which would also be offered as electives in the participating departments. Some of these nano courses have already been developed during the last two years as special topics and will now become regular courses. Our goal is to offer an integrated course of study, but without having to develop the entire curriculum from scratch. Our Curriculum Planning Subcommittee can review nanoscience courses offered at other New Mexico universities, and arrange with the host institutions to offer them through web-based or distance learning media.
- ***Additional Fees for Courses.*** A flat fee per credit hour will be charged for all courses offered through the NSMS program since they will require high tech, extensive and high cost laboratory and computational equipment. The fee structure will be comparable to fees charged for engineering, physics and chemistry courses.
- ***Graduate Teaching Assistantships.*** It is anticipated that no additional graduate teaching assistantships will be required to support the NSMS program. Funding for fellowships will be coordinated with the NSF IGERT program, and alternative sources of funding will be pursued such as the U.S. Department of Education Graduate Assistance in Areas of National Need (GAANN). NSMS students interested in teaching will be supported through existing state-funded GA monies in Chemistry, Earth & Planetary Sciences, Mathematics, and Physics & Astronomy. Currently, given the decline in foreign students and the short supply of domestic students, we are experiencing a challenge to fill these positions with qualified candidates. Thus, the funds are already budgeted, the need is there, and this program will help us with filling a continuing and growing shortage in the workforce.
- ***Faculty and Teaching Load.*** Initially, the NSMS program will not require additional teaching faculty because faculty already here or being hired have nanoscience expertise, and these and other faculty are already teaching the proposed core courses. Some faculty will need release time from their other course assignments to develop additional courses needed to provide hands-on experience in the synthesis and processing of nanomaterials for NSMS students. As the chart below indicates, a total of eight months of faculty release time is budgeted for new course development, four by the Nanoscience IGERT plus an additional four months to be covered by UNM administrative offices.
- ***Research Facilities.*** UNM already has excellent hands-on nanomaterials characterization facilities, which will become an integral part of the NSMS laboratory courses. In addition, as the EPSCoR Nanoscience initiative with the distributed network of nanomaterials characterization facilities comes on line, NSMS students will have at their fingertips world-class materials characterization instrumentation. Furthermore, the Nanoscience IGERT has funds budgeted for developing a new teaching laboratory.
- ***Library Resources.*** Because nanoscience is among the most attractive new research areas in the sciences and engineering, there are a large number of journals and other resources that

have sprung to life in the last few years. The needs for our program are much more selective. Although it is estimated that the total figure for library resources needed for this program is about \$40,000, a good number of these journals are already available through our science and technology library. However, we are fully cognizant of the current crisis of the University Library System, given planned major budget cuts and current journal price increases for both hard copies and on-line subscriptions. Therefore, the NSMS program Faculty Governing Committee under the leadership of the Program Director will take the following measures to alleviate the situation as much as possible:

1. Commit the NSMS program to find creative ways to obtain research resources or funding for those resources, some of which are identified below.
  2. Establish a library resources review process to identify journal subscriptions that are relevant, and to prioritize which are most vs. least critical, and whether there are other sources (individual, departmental, center, LANL, SNL) for obtaining access to these media.
  3. Strongly encourage faculty to post pre- and post-publication prints of publications in a community collection (UNM Dspace at Dspace.unm.edu) archive for use by and distribution to those who need access to these resources.
  4. Take measures to ensure that all major and large nanotechnology grants include a budget line to fund research information resources that are needed for the NSMS program students and faculty, and the University Library System agrees to use those funds to purchase and make those resources accessible to those who need them.
  5. With assistance from the External Advisory Board, investigate and pursue options for sharing information resources that are available to and at LANL and SNL, both through the Fair Use process and through formal collaborative agreements.
- **Laboratory Equipment.** The NSMS program will require some special equipment and faculty effort to develop some of the laboratory courses that are needed to provide the NSMS students with state-of-the-art hands-on experiences in nanotechnology. In addition to the equipment that is being made available through the EPSCoR grant, and the research teaching laboratories and new office and meeting area covered through the IGERT grant, the program will look to industry and the national laboratories to help offset some of these expenses.
  - **Student Support Services and CIRT Requirements.** There should be no additional needs for CIRT support, or academic advising, other than what students ordinarily receive as UNM students or from faculty mentors.

## 5.2 Expected Benefits of Establishing the NSMS Degree Programs

- **UNM Established as a Leader in Creating, Disseminating and Using New Knowledge**
- **Graduate Student Recruitment.** The proposed NSMS program capitalizes on the national reputation of the University as one of the leading edge research institutions in nanomaterials science in the nation. It will attract many high quality graduate students who wish to pursue a course of study in nanoscience and microsystems, especially those who wish to improve their knowledge and skills for current positions as investigators in the national and federal

laboratories and industry. We find that many highly qualified graduate students have elected to go to elsewhere since UNM lacks a formal graduate degree program in nanoscience.

- ***Appeal of an NSMS Degree vs. as an Area of Concentration.*** The NSMS program will recruit students from various disciplines who want to have their graduate degree specifically in NSMS. These students will have a department home in the NSMS Graduate Program, not distributed among the various traditional departments, and they will receive their NSMS graduate degree from the NSMS Graduate Program. Since the participating faculty will have tenure in one of the UNM departments, it is expected that the graduate students will also participate in seminars, etc. in their advisor's home department. The NSMS degree will provide career opportunities that are not as readily available with a traditional physical or engineering science degree program, but it can also enhance career opportunities for students in traditional fields who take NSMS courses. Participating departments across the UNM campus can establish a concentration in NSMS and their students can take courses as electives for their traditional degree programs.
- ***NSMS Program will Enrich Undergraduate Education.*** The NSMS program would not directly affect undergraduate students in science and engineering, but would provide some courses that they could take as electives. The Nanoscience/microsystems career path option, however, could be a recruitment vehicle since it would also provide high quality graduate elective courses for science and engineering undergraduates.
- ***Attracting High-Quality Faculty.*** The proposed NSMS program would attract outstanding nanoscience and microsystems research faculty to UNM. This will strengthen not only UNM departments but also the NSMS program. New faculty will enhance the excellence of nanoscience and microsystems research at UNM, especially at the departmental level.
- ***Greatly Enhanced Capacity to Obtain Research Funding.*** Nanoscience and nanomaterials are important research arenas with increasing opportunities for receiving priority funding from federal agencies. Because of the state-of-the-art research being conducted at the New Mexico national laboratories in nanostructured materials and the collaborative programs already in place between UNM and national lab researchers, UNM occupies a very favorable position to become one of the leading universities conducting nano research and offering a comprehensive nano oriented course of study. The NSMS program provides an opportunity for the integration of research and education, which is an important criterion for research funding as it provides for broader impact.
- ***Enhancing the New Mexico Economy.*** The establishment and growth of the UNM NSMS would provide a trained pool of talented nano researchers for currently existing New Mexico high tech businesses and the national labs. If adequately publicized, it could attract and provide a strong inducement for other high tech companies, new or old, especially those based on nanotechnologies, to locate (relocate) in New Mexico.

### 5.3 Summary of Costs and Benefits

In summary, as described above and as shown in the table below, the proposed NSMS program fits well into the existing framework of science and engineering courses and resources that already exist on campus. See Appendix A for the budget spreadsheet and justification with information on headcount, estimated revenues, as well as operational expenses.

**Table 5.1. Resource Allocation/Reallocation Table.**

Resources		What is needed	Who pays/ paid for it	Recurrent vs. Nonrecurrent
1.0 Faculty Salaries	Faculty Release Time - Course Development	8 months of faculty time	4 months IGERT; 4 months A&S and SOE	nonrecurrent
	4 Faculty - retiree replacements	salaries	Home Department	recurrent
		start-up costs	EPSCoR, VPR/ED, Home Department, Home College	nonrecurrent
2.0 Part-time Faculty		See 1.0 above		
3.0 Student Fellowships		Funding for 5-10/ year	IGERT	recurrent
4. Staff	Admin Assistant (II upper levels or III at midlevel)	1.0 FTE - \$30K Y1 + 3% increase/year	½ A&S, ½ SOE	recurrent
5.0 Salary Benefits (Ad.Ass't)		\$7,500 Y1 + 3% increase/yr	½ A&S, ½ SOE	recurrent
6.0 Office Supplies		\$1,000/year	Provost, A&S, SOE	recurrent
7.0 Office Equipment		\$6K Y1, then \$2K/year	Provost, A&S, SOE	recurrent
8.0 Travel		\$1,500/year ?		
9.0 Library Resources		\$15K Y1, then \$10K/year	A&S, SOE	recurrent
10.0 Other:	Director	.25FTE position + benefits	A&S, SOE	recurrent
	Teaching Laboratory	Specialized lab setup	IGERT	nonrecurrent
	Office Space	Office, Conference Room	VPR/ED for IGERT	recurrent
	Student recruitment materials, mailing, travel	\$10,000	IGERT	recurrent
	Web page development and maintenance	\$10,000	IGERT	recurrent

The program also fits well with New Mexico's legacy of assuming a role in cutting-edge science and technology education and research development, and student and industry demands for a training program that has degree credentials. With the level of support that has been generated (EPSCoR, IGERT, and from industry, the national labs and other sources) and the fact that UNM's participating departments in the College of Arts and Sciences and School of Engineering will already be investing heavily in the coming years with new and replacement hires targeted at nanoscience education and research, the NSMS program can be established without incurring undue expense or disruption of established programs.

Furthermore, we expect to be able to recruit students who otherwise would not be coming to UNM, and through the NSMS Graduate Program to expand the number and diversity of the population of graduate students. In establishing the NSMS program, UNM is responding to industry and federal laboratory workforce needs, and to the expressed interests of graduate students in obtaining expertise through research training in cutting-edge technology.

## Chapter 6

### Quality of the NSMS Graduate Degree Program (Sec 9.1.6, 5 NAMC 5.2)

The program quality will be comparable to the high standards that must be met by all M.S. and Ph.D. programs in the School of Engineering and the College of Arts and Sciences at UNM. See additional details in Chapter 8. The Faculty Governing Committee will establish an evaluation process with quality criteria and goals and ways in which these can be assessed. Areas of emphasis that will receive special attention to maintain the highest quality program that we can provide include the following:

- **Students.** Admission standards and requirements for completing the M.S. as well as entry into the Ph.D. program and graduation will meet or exceed the requirements of the participating departments in the School of Engineering and in the College of Arts and Sciences. Details are provided below in Chapter 8 about the requirements that students must meet to gain acceptance into the program, and to obtain the M.S. degree, as well as qualifying for and completing the Ph.D. degree.
- **Faculty.** Since the study of nanoscience, nanomaterials and microsystems is currently at the forefront of materials and scientific research, understanding the current state of nano research and its applications to develop cutting edge MST must be an integral part of the NSMS program. Therefore, the faculty will largely consist of professors from SOE and A&S, and a select few in the SOM whose biomedical research involves nanotechnology. Many of them have been recognized by their professional organizations and peers worldwide with such distinctions as election to The National Academy of Engineering (NAE); and as fellows of high-respected professional societies such as the American Physiological Society; the Institute of Electrical and Electronics Engineers; the American Association for the Advancement of Science; the National Science Foundation Presidential Award for Excellence in Science, Mathematics, Engineering and Technology Mentoring; the Optical Society of America; and others.
- **Research Facilities and Equipment.** To ensure a high quality educational experience, Chemistry, Physics, Earth and Planetary Sciences plus Chemical & Nuclear Engineering, Electrical & Computer Engineering and Mechanical Engineering, Mathematics and other science and engineering departments will play critical roles in supporting the NSMS program. They provide the extensive research facilities for synthesis, materials characterization and the determination of structure/ property relationships necessary to support a dynamic academic program in nanoscience and microsystems. The NSMS program is designed so that graduate students will receive extensive hands-on training in the laboratory. Great efforts have been made and will continue to be made to assure that there is a constant and productive interplay between lectures, laboratories and graduate thesis and dissertation research projects, which are required of each Ph.D. participant. In addition, participating faculty and departments will continually seek funding to upgrade the NSMS facilities, equipment and materials resources with grant proposals to federal, state and private funding sources.

- ***NSMS Course Curriculum.*** The NSMS curriculum has been carefully developed to ensure that it is of the highest quality as an academic program. The curriculum is currently comprised of a total of 55 courses, 46 of which are courses that are already taught on campus that have evolved to include significant content about nanoscience; and 9 new courses, a few of which are still being developed. All students must complete the four core courses plus an ethics course (3 credit hours each for a total of 15 credit hours), and then they will select courses for their programs of study from three concentrations-- Nano-Bio Interfaces, Complex Functional Materials, Information Nanotechnology --and a large selection of cross-listed electives. The courses that are still under development will require some faculty release time, and funds have been budgeted for 8 months of faculty release time for course development for the NSMS program. To ensure continued high quality in course offerings, proposals for new courses in any of the categories will be encouraged to enhance the curriculum in terms of new developments in NSMS. These proposals will first be reviewed and approved by the NSMS Curriculum Planning Subcommittee, then the Faculty Governing Committee and ultimately by the Executive Committee.
- ***Student and Faculty Group Identity.*** As a new program, it will be important to cultivate a sense of group identity among students and faculty that will enhance the educational experience of students and generate career development opportunities for all. To encourage this level of interaction outside the classroom or laboratory among the NSMS students and of students with as many participating NSMS faculty as possible, various additional activities will be planned and conducted on an annual basis through the Director's Office. These will include speakers' events followed by receptions, and symposia with research presentations by NSMS faculty and graduate students. The NSMS Annual Symposium will provide an opportunity for faculty and graduate students to highlight research and academic work on campus to external constituencies, especially the regional federal laboratories and industry liaison. Students will prepare posters to showcase their research and will be given opportunities to visit with guest speakers. Other events will include planned group trips to attend professional conferences, local and regional cultural and recreational events and activities, and a potluck picnic.

## Chapter 7

### Assessments of Operations and Impact (Sec 9.1.7, 4 NAMC 5.2)

The assessment of the proposed NSMS program will conform to the guidelines governing the assessment of other graduate programs at the University of New Mexico. The NSMS Program Director in consultation with the Executive Committee will establish the goals for the program and the process for assessing whether the goals are achieved. The Director and Faculty Governing Committee will arrange for external reviews by panels of distinguished members in the nanoscience academic and research communities, and self-assessments in consultation with the various interested departments to evaluate whether the objectives for the program are being met--in terms of creating and disseminating new knowledge; educating students to prepare them for positions in academia, industry and national laboratories; and the extent to which this program is a model for other institutions to follow. Whenever possible, these reviews will be part of the graduate reviews that are scheduled periodically. The External Advisory Board will also be consulted to identify the highest quality criteria and goals they believe are necessary for the NSMS program to prepare scientists for professional careers. The assessments will be performed by the Program Administrator under the supervision of the Director, and the outcomes reports will be submitted to the Faculty Governing Committee and the NSMS Executive Committee. The assessment will include the following:

- Development of New Knowledge, and Maintaining Leadership Role for UNM: Number of research grants awarded to faculty, fellowships awarded to students, publications by faculty (highlighting those coauthored with students), applications and proposals awarded for patents and trademarks, conferences attended by faculty and students, and presentations given by students and faculty.
- Application and admission records: how many students applied, their qualifications, which students (high/mid/low quality) were accepted, and which of those enrolled.
- Enrollment and grade records: Tracking enrollment and grades of students in the NSMS program, and their career development activities.
- Mapping the number of students that receive graduate degrees and secure academic, industrial or federal positions in New Mexico, elsewhere in the nation, and abroad.
- Conducting and assessing student evaluations of each course, lecture and laboratory period as well as each instructor at the end of each semester, with the anonymous results provided to each instructor and to the NSMS program Director.
- Assessing how well the NSMS program prepares its graduates for positions in the field. The External Advisory Board may also be asked to conduct on-site assessments and report the results to the Executive Committee, with recommendations for improvement.
- Development and implementation of a formal one-on-one exit interview procedure to solicit comments, criticism, and recommendations from each program graduate before they leave campus.
- Creation of and results of a tracking program to monitor the post-graduation careers of the NSMS program graduates and to conduct periodic surveys to determine the impact that participation in the program has had on their careers, as well as on the careers of faculty participants.

## Chapter 8

### Admission Criteria and Requirements for M.S. and Ph.D. Degrees.

To serve the broad diversity of backgrounds, interests, and career goals of students, two plans are offered leading to the M.S. degree and one for the Ph.D. degree in NSMS. The M.S. Plan I requires the student to participate in a research project and requires a written thesis while the M.S. Plan II requires an oral examination for completion, and is generally intended for students working full time in industry or the national labs; only plan I can be a step toward entry to the Ph.D. degree program, but all students must pass the qualifying examination to become candidates for the Ph.D. The Ph.D. degree requires that students qualify for admission and successfully complete the required coursework and a comprehensive examination, and write and defend a research-based dissertation. The Admissions Subcommittee of the Faculty Governing Committee will initially admit each student into one of these plans, depending upon the student's interests and desires, and qualifications. Some NSMS Program applicants will choose the M.S. as a terminal degree because this is sufficient to satisfy their purpose in completing the M.S. degree.

#### 8.1 Master's Degree (M.S.) Requirements

##### *A. M.S. Admission Pre-requisites.*

The general admission requirements described in the Graduate Program in this Catalog apply to the NSMS program. An applicant must hold a bachelor's degree from an accredited institution, have a scholastic average of B (3.0 on a 4.0 scale) or better, and have completed the GRE with acceptable scores. Applicants who plan to apply to the NSMS program must have a bachelor's degree in a natural science or engineering field in which they attained a sophisticated level of mathematical ability (differential equations at minimum). Those who meet all requirements except mathematics, but are otherwise well prepared, can meet the mathematics requirement by completing Math 316 during the first semester with a B or better, or by taking and passing with a B or better an equivalency test that certifies their level of preparation in mathematics.

##### *B. M.S. Application Process.*

To apply, domestic applicants must complete and submit the on-line application form with a \$40 nonrefundable application fee, two official transcripts (unopened) to the Office of Graduate Studies (OGS) by the NSMS Program annual deadline of January 31. OGS will forward these materials to the NSMS Program Office for the Admissions Subcommittee review and selection. In addition, applicants must submit the following directly to the NSMS Program Office:

- a. letter of intent from the applicant about why this program is of interest
- b. three sealed letters of recommendation (sent directly to the NSMS Office)
- c. GRE entrance examination scores
- d. any other materials that are relevant to this application, such as experiential credit

International applicants must submit the additional materials identified in the Catalog to the UNM International Admissions Office, including their undergraduate education documents, demonstrated proficiency in English, and document attesting to adequate financial resources and health insurance.

### ***C. M.S. Admission and Advising Roles.***

All applications will be reviewed to determine whether all required materials were submitted, and they will be notified about the status of their application. The *Admissions Subcommittee* of the Faculty Governing Committee will review applications and make admission decisions. Applicants who are selected will be sent a notice of acceptance and program information to guide them in making decisions as they complete their studies and degree programs. This includes whether they qualify for fellowships and how they can apply, and information about the details of becoming a student--obtaining an ID card and procedures for enrolling in classes.

**Selecting a Faculty Advisor/Mentor.** Students will also receive a description of how to select a faculty mentor who will help them establish a *Committee on Studies*. To facilitate this process, faculty will present their areas of research at the beginning of each fall semester, and indicate how many students they can support within their research groups. Students will indicate their choice of research areas, and based on openings available and student interest, assignment of students to research groups will be made. The Admissions Subcommittee will facilitate this process.

**Committee on Studies.** The student and faculty mentor will invite three faculty members to serve on the student's *Committee on Studies*. The committee members will help the student to plan a *Program of Studies*--a list of courses that meets the student's interests and needs, which will be counted toward the degree. This plan must be approved by the student's advisor and the NSMS Program Director prior to being submitted to the OGS. The Committee will also supervise the student's progress and conduct the required thesis or other exams. If the student subsequently qualifies for entering the doctoral program, this committee can continue in the role of *Doctoral Studies and Dissertation Committee* to assist the student in completing the Ph.D.

### ***D. M.S. General Degree Completion Requirements.***

The maximum time-to-degree for Master's students is 7 years, during which time the student must be enrolled full-time for at least three consecutive semesters. It is expected that the average time for a M.S. degree will be 18 months. To be a full-time student, 9 credit hours must be taken per semester, or 6 credit hours if the student has an assistantship. In order to complete the M.S., students must maintain a minimum cumulative grade point average of 3.0 in graduate-level courses taken in graduate status and a GPA of at least 3.0 for courses listed in the Program of Studies. Students cannot graduate with Incompletes pending nor while on probation.

### ***E. Two M.S. Plans - Degree Completion Requirements.***

UNM requires 24 credit hours (8 courses) for the M.S. plus 6 hours for the Plan I thesis option. These are minimum requirements, since the actual number of thesis credits will in most cases be larger. The NSMS M.S. degree program for both Plan I and Plan II will include 4 core courses, and an ethics course, and 4 courses in one Concentration within NSMS.

### **M.S. Plan I. Thesis Based**

The minimum requirements for the thesis-based M.S. include 6 hours of thesis credit (599) and 24 hours of course work that must include 18 hours of mandatory courses, as approved by the Committee on Studies, and at least 3 hours from the electives such as those listed below. Plan I

automatically meets the requirement of at least 12 hours of course work at the 500 level or higher, exclusive of thesis credit, as stipulated by the UNM Catalog for this plan.

In this option, students must consult with a faculty member and pick a topic of research on which to do a Master's thesis. The student's Thesis Committee must approve the topic before the student begins work. Copies of the completed M.S. thesis must be provided to each member and, if approved, the student will make an oral defense in a pre-advertised and open presentation to the Thesis Committee and other interested members of the university.

### **M.S. Plan II. Standard Course Based Degree Program**

The minimum requirements for the standard course-based M.S. include 33 hours of course work for credit, with at least 24 hours drawn from the list of NSMS required and elective courses and 3 hours of research seminar/problems course. At most, 6 hours of 400 level SOE or A&S courses, excluding those that are cross-listed, are allowed. Also, at least 12 hours of course work should be at a 500 level or higher, as stipulated by the Catalog for this Plan. All students in the Plan II M.S. degree program must pass an Oral Exam, administered by the student's *Committee on Studies*, to test the student on material from his/her NSMS courses. The NSMS Graduate Subcommittee will make the final decision about pass/fail recommendations from the student's *Committee*. Students are allowed at most two attempts to pass the Oral Exam.

## **8.2. Ph.D. Degree Requirements**

### ***A. Ph.D. Application and Admission Process.***

For prospective doctoral students, the process of applying and being selected is the same as for applicants to the master's program, with the Admissions Subcommittee assuming responsibility for reviewing applications and selecting candidates. Newly admitted doctoral student must also go through the process of selecting an advisor/mentor and then request of the Graduate Subcommittee that their Qualifying Exam be scheduled sometime during or immediately after their second semester.

### ***B. Ph.D. Candidacy Requirements.***

*Advancement to Candidacy* requires satisfactory completion of the core courses and passing the qualifying and comprehensive examinations, as described below. Students who complete the four core courses with grades of A and no more than one B and the required ethics course with a grade of B or better plus a 3.25 GPA overall are eligible to take the Doctoral Qualifying examination, which is described below. After completing the qualifying examination, the student will propose and defend their research plan (the comprehensive examination conducted by the Committee on Studies).

### ***C. Ph.D. General Degree Completion Requirements.***

The Ph.D. requires that students complete 48 credit hours of courses plus 18 credit hours of dissertation research credit (699). UNM requires 24 credit hours (8 courses) for the M.S. and an additional 24 credits for the Ph.D. Students will have the option to apply and to be considered for candidacy for the Ph.D. degree program directly from their B.S. degree, and then they would take 48 credit hours past their B.S. degree plus 18 dissertation research (699) credit hours. These are minimum requirements. The actual number of thesis or dissertation credits will in most cases

be larger. In addition to the basic requirements of 4 core courses and an ethics course, and 4 courses in a concentration area for the master's degree, the Ph.D. candidate will take a second concentration (4 courses) and 4 elective courses as suggested by the student's Committee on Studies. The second concentration can be in one of the participating departments, for example, biology, chemistry, earth and planetary science, mathematics or statistics, physics and astronomy, or in engineering (ChNE, CS, ECE or ME). Students who already have a master's degree in one of these disciplines will automatically acquire a second concentration. Ph.D. candidates have a maximum of five years from the semester in which they pass the doctoral comprehensive examination to complete all of the degree requirements.

#### ***D. Ph.D. Qualifying Examination.***

All Ph.D. candidates must take a qualifying exam, and can take it only twice. Students in the NSMS degree program must petition the Graduate Subcommittee to take the exam during or soon after their second semester on campus to be admitted to the NSMS Ph.D. degree program. Permission is normally given only if the student meets the qualifications for admission to the Ph.D. program, which include satisfactory grade point requirements in the core courses.

The Ph.D. qualifying examination consists of an oral examination in which the student will prepare a research proposal and present it to a qualifying exam committee. The student will prepare the proposal on their own, with no help from any other person. All library and internet resources will be available. The topic for the proposal will be based on an archival journal publication that will be provided to the student two weeks before the examination.

#### *NSMS Program Qualifying Examination Procedure*

The Ph.D. qualifying exam will consist of two steps. In the first step, the student demonstrates mastery of the core nanoscience and microsystems subjects. For the second step, the student demonstrates the potential to conceive, formulate and conduct independent and original research. The first step must be completed before the second step can be attempted. The student will be allowed two attempts for each step.

1. Mastery of the core nanoscience and microsystems subjects will be demonstrated by the cumulative grades in the core NSMS classes. Students will be required to commence their graduate program by taking these core classes. The students will demonstrate their mastery of the subject with a minimum grade of A- in three out of the four required graduate core NSMS classes. One individual final grade could remain below A- but should be at least a B.
  - NSMS 510. Chemistry and Physics of Nanostructures*
  - NSMS 512. Characterization Methods for Nanostructures*
  - NSMS 518. Synthesis of Nanostructures*
  - NSMS 519. MEMS Transducer Devices and Technology*

Students who fail to receive the requisite A- or above grade will be administered an equivalency exam (offered in the semester immediately following the course) for each of the core courses involved. If there is more than one grade that requires an equivalency exam, the student will be given the choice to select the course in which s/he prefers to take the exam. This equivalency exam will be structured like a final exam and be prepared by a sub-committee that includes the core course instructor of record, a former/alternate instructor of

the course, and the member of the graduate committee responsible for the qualifying procedure. The committee sets the bar on pass/fail before the exam is administered. The committee will also inform the student about the expected level of difficulty and hand out a practice exam. Passing marks of this equivalency exam will be determined by the sub-committee of three faculty members preparing the exam. In each core area, passing will be based on the course grade or exam, constituting in effect the two chances to demonstrate proficiency in each area.

2. The Ph.D. qualifying exam will consist of an independent, critical analysis of a research article by the student and the preparation of a research proposal. The student prepares a 30 minute presentation on the critique and the research proposal, with all of the work being done by the student, with no help from any other person. All internet and library resources will be available to the student. The student will have 15 days to work on this exam from the date that the research paper is given to the student by the qualifying exam committee. Prior to the exam, the students will receive an orientation on the format of the presentation, the types of questions the student should prepare for and the grading scheme. The objective of this exam is to explore the students' readiness to do research. The general preparation of the student in the core subjects is also tested during the questioning of the students' paper critique. All students taking the exam in a given semester get the same research paper as a starting point. Generally, the exam will be conducted during the winter or summer breaks so as to cause minimum interference with other classes that the student may be taking. Students will have two opportunities to pass the oral qualifier.

#### ***E. Formation and Roles of the Ph.D. Committee on Studies.***

After the Ph.D. qualifying examination is passed, each student in consultation with their advisor will form their own *Committee on Studies*. The initial role of the committee is to advise the student on courses the student should take. The committee is required to meet annually with the student to monitor progress towards completion of the Ph.D. and to provide career and professional mentoring to the student. As the student progresses in completing the program, the role of the committee evolves, too. The committee will administer the comprehensive examination, and then--in serving as the Dissertation Committee--the committee will review and approve the dissertation and conduct the student's Dissertation Defense.

#### ***F. Ph.D. Comprehensive Examination.***

The comprehensive examination involves a defense of the student's dissertation research *proposal*. Students carefully select their dissertation topic in consultation with the dissertation advisor and the committee, to ensure that the topic is appropriate in scope, originality and significance. The Committee on Studies administers the comprehensive examination, with the objective to determine whether the student is able to complete a doctoral program and dissertation. During the semester that the comprehensive examination is passed, the student must prepare and submit an *Application for Candidacy*, which is signed by the committee members and the Director of the NSMS program. If the student fails the examination, the Committee on Studies can recommend that a second opportunity to pass be scheduled within the following year. Students can attempt to pass the examination only twice.

### ***G. Ph.D. Dissertation Approval and Defense.***

A completed dissertation or thesis must be submitted to each of the members of the student's *Dissertation Committee* after the completion of research. Upon their approval, the student must defend his/her dissertation work in a pre-advertised and open presentation to the members of the *Dissertation Committee* and other interested members of the university.

## **8.3. Other Details and Problem Resolutions**

### ***A. Notice of Intent to Graduate.***

Students who expect to graduate must submit their intent to the NSMS Program Office and the Office of Graduate Studies early in the semester of graduation: October 1 for fall, March 1 for spring, and July 1 for summer.

### ***B. Catalog Details About Meeting Degree Requirements.***

The Catalog provides significant details about requirements that master's and doctoral candidates must meet to complete their degree, which apply equally for students in the NSMS Graduate Degree Program. These include what is necessary if a student wishes to defer entry into the program, or have a leave of absence, or to have credits transferred, or issues regarding academic standing or petitions to modify academic requirements.

### ***C. Requests for Changes in Advisor or Committee Member, and Appeals of Decisions.***

In the event that issues arise between a student and a committee member (Committee on Studies, Thesis Committee, Dissertation Committee) at any time, students are encouraged to speak with their advisor/mentor to determine whether a change is needed and they will consult with the Director of the NSMS Program before implementing a change in committee membership. All such communications will be maintained in strict confidentiality. If a student experiences conflict with their faculty mentor/advisor, they are expected to speak with the Director of the NSMS Program, who will determine whether the Graduation Committee should be asked to intervene and seek a solution. The NSMS Executive Committee will be informed about all such requests and incidents.

All decisions by the Admissions Committee, by the Committee on Studies concerning the Qualifying Examination and the Comprehensive Examination, and by the Dissertation Committee regarding approval of the dissertation and passing the defense, can be appealed to the Director and the Graduate Subcommittee, who will follow the *Graduate Student Academic Grievance Procedures* described in the Catalog. The Executive Committee of the NSMS will be advised about the situation and, if necessary, can choose to assist with mediating a dispute.

## **8.4 NSMS Graduate Degree Program Curriculum**

The NSMS curriculum is comprised of four NSMS core courses plus an ethics course, three concentrations and many cross-listed electives. Many of the necessary courses for the NSMS curriculum are already taught on campus, and some of these have been revised in response to the need to teach nanoscience and microsystems. Some courses are still under development, and as

with other science fields, the curriculum will evolve in response to new findings. The IGERT program has budgeted four months of faculty time for course development in the first year's budget, and this NSMS proposal budget has added an additional four months that expected to be necessary to develop the additional courses. The proposed Catalog Materials are in Appendix F attached.

#### ***A. NSMS Program Core courses.***

The NSMS core courses offer a fundamental introduction to the concepts of nanoscience and microsystems. They are designed to address each of the four cornerstones of nanoscience/microsystems education, namely materials, characterization, synthesis and systems. The suggested prerequisites for the core courses are modern physics, general chemistry and differential equations. The Societal Implications and Ethics course description is included in this section. The set of courses proposed here will cover students' needs in terms of the core required curriculum.

- **NSMS 510/410. Chemistry & Physics at the Nanoscale. (3)** Duncan, Brozik, Evans, Keller (Also offered as Chem 471\*, Physics 410\*.) Students will study chemical and physical concepts necessary to understand nanoscale materials: Quantum properties, charge confinement, and nanoscale thermodynamics, surface and interfacial forces, nanomachines and nanostructures, self-organization, and scaling. Emphasis on problem-solving skills development. {fall}
- **NSMS 512. Characterization Methods for Nanostructures. (3)** Brearley, Datye, Fulghum (Also offered as ChNE 512.) Nanostructure characterization methods. Examine principles underlying techniques and limitations, and how to interpret data from each method: electron beam, scanning probe, x-ray, neutron scattering, optical and near field optical. Lab demonstrations and projects provide experience.
- **NSMS 518. Synthesis of Nanostructures. (3)** Brinker, Brueck (Also offered as ChNE 518, ECE 518.) Underlying physical and chemical principles (optics, organic and inorganic chemistry, colloid chemistry, surface and materials science) for nanostructure formation using 'top-down' lithography (patterned optical exposure of photosensitive materials) and 'bottom-up' self-assembly. Labs will synthesize samples. Prerequisite: NSMS 510. {spring}
- **NSMS 519. MEMS Transducer Devices and Technology. (3).** Chen, Christodoulou, CINT Scientists. (Also offered as ECE 519.) Bridging nanostructures and microsystems, about integrating nanostructures into systems and functional devices. Covers silicon based MEMS, biological systems, other applications, modeling and reliability.
- **NSMS 550. Social and Ethical Implications of Nanotechnology. (3)** Mills, Fledderman (Also offered as ChNE 550, ECE 550.) In this course, students will examine issues arising from this emerging technology, including those of privacy, health and safety, the environment, public perception and human enhancement.

#### ***B. NSMS Program Concentrations.***

**Concentration: Nano-Bio Interfaces.** This set of courses exposes students to concepts of biological and chemical reactions, biosensor platform fundamentals and applications through nanofluidics and biomimetics. Suggested prerequisites are undergraduate-level transport phenomena, organic chemistry, electromagnetism, and quantum chemistry.

- **NSMS 522L. Fundamentals of Nanofluidics. (3)** Petsev, Lopez, Han  
(Also offered as ChNE 522L.) This course exposes students to comprehensive yet essential elements in understanding nanofluidics for the purpose of effective separation of biomolecules: dynamics of complex fluids, colloidal chemistry, biochemistry, biomimetic surface functionalization, electroosmosis/electrophoresis, electrodynamics, optics, and spectroscopy.
- **NSMS 530. Surface and Interfacial Phenomena. (3)** Van Swol  
(Also offered as ChNE 530.) Introduces various intermolecular interactions in solutions and in colloidal systems; colloidal systems; surfaces; interparticle interactions; polymer-coated surfaces; polymers in solution, viscosity in thin liquid films; surfactant self-assembly; and surfactants in surfaces.
- **NSMS 538. Biosensors: Fundamentals and Applications. (3)** Lopez, Whitten, Atanassov  
(Also offered as ChNE 438/538.) Introduction to biosensors as analytical devices and biosensor technology as an emerging field of industrial development. Survey of biochemical fundamentals and immobilization of the biological components, methods for biosensors fabrication, microfluidic devices and sensor arrays. {spring upon demand}
- **NSMS 545L. Intensive Introductory Biochemistry I. (4)** Anderson  
(Also offered as Biomed 511L.) An introduction into the physical and chemical properties of proteins and enzymes; enzymatic catalysis; structure, synthesis and processing of nucleic acids and proteins; structure and control of genetic material. {fall}

**Concentration: Complex Functional Materials.** The courses in this Concentration will expose students to specific interface science, materials synthesis and processing. At least one additional course still needs to be developed for this curriculum. Suggested prerequisites for this set of courses are undergraduate-level transport phenomena, organic chemistry, electromagnetism, and quantum chemistry.

- **NSMS 530. Surface and Interfacial Phenomena. (3)** Van Swol  
(Also offered as ChNE 530.) Introduces various intermolecular interactions in solutions and in colloidal systems; colloidal systems; surfaces; interparticle interactions; polymer-coated surfaces; polymers in solution, viscosity in thin liquid films; surfactant self-assembly; and surfactants in surfaces.
- **NSMS 533. Vapor and Aerosol Phase Materials Processing. (3)** Ward  
(Also offered as ChNE 533.) Materials synthesis and processing by physical vapor deposition, chemical vapor deposition, and aerosol routes are explored. Underlying physicochemical

fundamentals are discussed, and examples from the recent literature are used to exemplify the methods. {Offered upon demand}

- **NSMS 569. Advanced Materials Science. (3)** Al-Haik, Khraishi, Shen  
(Also offered as ME 471/571.) This course covers advanced treatments of the science of engineering materials and mechanical behavior of materials. Examples are crystal structures, defects, micro mechanisms of deformation, thermodynamic and kinetic processes, and structure-processing-property relations of engineering materials.
- **NSMS 575. Polymer Science and Engineering. (3)** Curro  
(Also offered as ChNE \*475.) Introduces wide range of contemporary polymer science topics, emphasizing physical chemistry, polymer physics and engineering properties of polymer systems. Exposure to unique behavior of polymers in engineering applications and preparation for further studies in polymers.

**Concentration: Information Nanotechnology.** This set of courses exposes students to materials growth processes, quantum devices and nanofabrication techniques. Suggested prerequisites are undergraduate-level semiconductor devices, quantum mechanics, electricity and magnetism.

- **NSMS 532. Nanoscale Electronic and Photonic Devices. (3)** Huffaker  
(Also offered as ECE 532.) Introduces devices, device physics, characteristics and possible applications specific to the nanoscale. Topics include single electron transistor, carbon nanotube electronics, quantum dot devices, spin-polarized electronic and photonic devices.
- **NSMS 571. Quantum Computation. (3)** Caves, Deutsch, Geremia, Landahl, Moore  
(Also offered as CS 571, Phys 571.) This course explores the concepts and mathematical techniques underlying quantum computation. Topics include quantum entanglement, quantum cryptography, teleportation, models for quantum computation, quantum algorithms, quantum error correction, and fault-tolerant quantum computation.
- **NSMS 572. Semiconductor Physics. (3)** Sigmon  
(Also offered as ECE 572.) Crystal properties, symmetry and imperfections. Energy bands, electron dynamics, effective mass tensor, concept and properties of holes. Equilibrium distributions, density of states, Fermi energy and transport properties including Boltzmann's equation. Continuity equation, diffusion and drift of carriers.
- **NSMS 573. Physics and Computation. (3)** Moore  
(Also offered as CS 573/473, Phys \*473.) A survey of complex systems at the interface between physics and computer science, including phase transition, power laws, social networks, NP-completeness, and Monte Carlo methods.
- **NSMS 574L. Microelectronics Processing. (3)** Fledderman, Hersee  
(Also offered as ECE 574L/474L.) Materials science of semiconductors, microelectronics technologies, device/circuit fabrication, parasitics and packaging. Lab project features small group design/fabrication/testing of MOS circuits.

- **NSMS 595. Special Topics. (1-3 to a maximum of 9)**
- **NSMS 599. Master's Thesis. (1-6)**
- **NSMS 650. Research. (1-12 to a maximum of 24)**
- **NSMS 699. Dissertation Research. (3-12)**

### ***C. General Electives.***

Many courses offered at UNM will be accepted for NSMS elective credit with the intent to supplement the nano-based coursework. We have also listed numerous elective courses here, some of which were developed as new courses specifically for this degree program, with very specific relevance to the nanoscience program. This is not an exclusive list. Many other courses will be added as they are developed and identified. Currently, the list of electives includes:

- Bchm 546L Intensive Introductory Biochemistry II—Anderson (*Existing Course*)
- ChNE 499/515 Topics: Nanoscale Quantum Structure Growth—Han (*New Topic Course*)
- EPS 538 Analytical Electron Microscopy - Brearley (*Existing Course*)
- EPS 558, Biol 558 Geomicrobiology - Crossey, Dahm (*Existing Course*)
- MGT 594 Topics: Innovation in Technology - Salazar (*Existing Course*)
- Math 466\* Mathematical Methods in Science and Engineering (*Existing Course*, Fall)
- Math 579 Selected Topics: Mathematical Methods for Science & Technology (*Existing Course*)
- Math 471\* Introduction to Scientific Computing (*Existing Course*, Fall)
- Math 504 Introductory Numerical Analysis: Numerical Linear Algebra (*Existing Course*, Spring)
- Math 505 Intro. Numerical Analysis: Approximation & Differential Equations (*Existing Course*, Fall)
- Math 512 Introduction to Ordinary Differential Equations (*Existing Course*, Fall)
- Math 513 Introduction to Partial Differential Equations (*Existing Course*, Spring)
- Math 514 Applied Matrix Theory (*Existing Course*, Fall)
- Math 557 Selected Topics in Numerical Analysis (*Existing Course*)
- Math 576 Numerical Linear Algebra (*Existing Course*, offered Fall 03, Fall 05)
- Math 577 Numerical Ordinary Differential Equations (*Existing Course*, Spring 01, Spring 05)
- Math 578 Numerical Partial Differential Equations (*Existing Course*)
- Math 579 Selected Topics in Applied Mathematics (on demand, usually each semester)
- ME 561 Special Topics: Nanomechanics of Materials - Al-Haik, Shen (*Existing Course*).
- Phys 430 Introduction to Solid State Physics (*Existing Course*)
- Phys 529 Condensed Matter I (Phys 529) (*Existing Course*)
- Phys 531 Atomic and Molecular Structure (Phys 531) (*Existing Course*)
- Phys 552 Problems: A Quantum Information Theory (*Existing Course*) - Caves, Deutsch, Geremia, Landahl, Moore.
- Phys 566 Quantum Optics (*Existing Course*) - Caves, Deutsch, Geremia, Landahl, Moore.
- Phys 581 Advanced Topics: Density Functional Theory (*Existing Course*) - Atlas
- Stat 527 Advanced Data Analysis I (*Existing Course*, Fall)
- Stat 528 Advanced Data Analysis II (*Existing Course*, Spring)
- Stat 540 Regression Analysis (*Existing Course*, offered every Fall)

- Stat 545 Analysis of Variance and Experimental Design (*Existing Course*, Spring)
- Stat 553 Statistical Inference with Applications (*Existing Course*, Spring)
- Stat 561 Probability (*Existing Course*, offered every Fall)
- Stat 565 Stochastic Processes with Applications (*Existing Course*, Fall every 2 years)
- Stat 570 Industrial Statistics (*Existing Course*, Fall)
- Stat 576 Multivariate Analysis (*Existing Course*, Spring every 2 years)
- Stat 581 Introduction to Time Series Analysis (*Existing Course*)
- Stat 586 Nonparametric Curve Estimation & Image Reconstruction (*Existing Course*, Fall every 2 years)