

## **Request to Establish a Doctoral Program in Nanoengineering at North Carolina A&T State University**

### **Introduction**

Following a recommendation from the staff at UNC General Administration and from the Vice President for Research and Interim Vice President for Academic Planning, the Committee on Educational Planning, Policies, and Programs approved in June 2011 the request from North Carolina A&T State University to plan a doctoral program in Nanoengineering. North Carolina A&T State University now seeks approval to establish a doctoral program in Nanoengineering (CIP 14.9999) effective January 2012.

### **Program Description**

The discipline of *Nanoengineering* encompasses the knowledge and capability to control the arrangement of atoms and molecules enabling novel chemical applications with customized properties. Nanotechnology refers to structures less than 100 nanometers in size (approximately 1000 times smaller than the width of a human hair).

The proposed interdisciplinary doctoral program in Nanoengineering is being established in conjunction with the Joint School of Nanoscience and Nanoengineering (JSNN) that has been established by North Carolina Agricultural and Technical State University (NC A&T) and the University of North Carolina at Greensboro (UNCG) with designated funding from the General Assembly. This program will involve extensive collaboration among the faculty members of the NC A&T College of Engineering, the faculty members of the JSNN, and the faculty members in the basic and applied sciences of both universities. The program will be named a Ph.D. in Nanoengineering.

The proposed program is unique within the UNC system for several reasons. The JSNN involves collaboration between two major universities with complementary strengths and history. UNCG has a strong tradition in the liberal arts and has built considerable strength in the basic sciences. NC A&T State is a Historically Black University with strong programs in the engineering and basic sciences. Both institutions are classified by the Carnegie Foundation of New York as “research universities with high research activity.” The Ph.D. in Nanoengineering degree program will create a platform for interdisciplinary interactions between faculty members at JSNN with faculty members in more traditional programs at NC A&T State and UNCG. Very few Nanoengineering educational programs exist, and therefore, personnel with advanced training in Nanoengineering are in high demand.

A primary feature of the program is interdisciplinary teaching and research in the fundamentals of nanoengineering, as applied to chemical, biochemical, physical, and nanomaterials principles, and their application to emerging areas of nanoengineered materials. Through the program’s coursework, students will receive a strong background in nanoengineering theory, as well as in the experimental and computational techniques utilized in the discipline. In their first year, students will be required to take a set of four courses in the Fundamentals of Nanoengineering that will introduce them to the theoretical underpinnings of

the field. A laboratory rotation through four laboratories will also be required in the first year to provide exposure to ongoing research activities, provide experience with laboratory techniques, and aid students in the selection of a dissertation topic. In addition, a professional development seminar is required during the first year that will focus on important issues related to a career in research (e.g., grant writing, ethics, and legal issues).

In the second and third years of the program, students will take advanced elective courses in a related nanoengineering discipline to ensure they have substantial depth of understanding in their area of research and interest, and to enable them to effectively carry out advanced nanoengineering research. After admission to candidacy for the doctoral degree, the student will begin Ph.D. dissertation research during the second year. Although the student will learn through a number of traditional classroom experiences, the student's research activities and technical literature study will be the primary educational vehicles of the program. The student will learn how to apply engineering theory to real-world nanoengineering problems using research methodologies and leading-edge equipment to create innovative solutions and enable new technologies.

The Ph.D. in Nanoengineering will be a 54 credit-hour degree program beyond the Masters degree. It is planned that the Ph.D. in Nanoengineering will have a similar structure to the Ph.D. in Nanoscience at UNCG and will utilize some of the same courses where appropriate (e.g. Nanotechniques, Professional Development Seminar).

The North Carolina General Assembly appropriated funding in 2007 to establish the Joint School of Nanoscience and Nanoengineering, including funding to construct a new building for the School and funding to purchase laboratory equipment. The facility is scheduled for completion December 2011 and will be managed by the Gateway University Research Park on the South Joint Millennium Campus of NC A&T State and UNCG. The Triad business community has been very supportive of JSNN because of its potential for economic development, and JSNN has already developed relationships with companies both within and outside the Triad.

### **Educational Goals**

The educational goals of the proposed program are as follows:

- Provide theoretical and experimental foundations in Nanoengineering with emphasis on physical, chemical and biological applications and computational methods.
- Provide training in experimental design and analysis through challenging interdisciplinary research projects in Nanoengineering.
- Provide students training in reporting results and in writing grant proposals for funding.
- Provide students an education in ethical principles and in ethical problems unique to Nanoengineering
- Provide an opportunity for students to receive a PhD with an interdisciplinary emphasis in areas and in subjects that draw on faculty expertise and where otherwise there does not exist a critical mass for traditional programs due to enrollment limitations.

- Create the next generation of qualified doctorally-trained practitioners in chemical, biochemical, and physical nanomaterials principles, promoting the development of nanoscale and nanoengineered materials in engineering applications as well as in the emerging areas of nanobioelectronics, nanoengineered materials and structures, and their specific applications.

### **Program Review**

The review process is designed to identify strengths and weaknesses in proposed new degree programs. Proposals to establish new doctoral programs are reviewed both internally and externally. Major comments from the external reviewer are summarized below:

*The external reviewer stated that there exists a huge pool of students for this program from throughout the U.S. and internationally, and that the opportunities for these graduates are excellent in the worldwide economy and job marketplace. The reviewer noted that a practicum component would strengthen the program, and recommended developing an admissions process for highly-qualified B.S. applicants. The reviewer commented that there needs to be substantial hiring of new faculty for the specific subdisciplines reflected in the curriculum. Noting that the proposal stated that “no additional funding is needed for the first three years,” the reviewer asked about the longer term vision for funding.*

### **Graduate Council**

As a basis for its consideration, the Graduate Council had the proposal to establish the program, a copy of the outside reviewer’s comments, and a presentation to the Council by representatives of the program. In addition to some discussion of the issues raised previously, the following concerns/questions were expressed by Council members: the role of core and elective courses in the curriculum, why credit is being given for taking the required qualifying exam, and how the program would be supported if enrollment growth funding should not be available.

### **Response**

Representatives of the program reviewed the development of the Nanoengineering program at NCA&T State University and responded to the external reviewer and the issues raised by members of the Graduate Council.

The North Carolina A&T State University representatives agreed that a practicum component would strengthen the program, and they have already started working with some Department of Defense agencies and private companies to implement one. In addition, the Admissions Committee is examining what curriculum modifications would need to be made in order to allow B.S. graduates to directly enter the program.

NCA&T State University reported that it has recently hired three new faculty members (Dr. Lifeng Zhang – nanomaterials, Dr. Rarn Mohan – computational nanomodeling, and Dr. Shyarn Aravamudhan – nanobioelectronics) who have years of experience working in the

field of nanoengineering and who have outstanding records of attracting external research funding from both federal agencies as well as from private companies.

The NCA&T State representatives briefly reviewed the core and elective components of the curriculum, and mentioned that eight new elective courses are under development in the four broad areas of nanocomposites, nanoelectronics, nano-chemistry/biology, and nanomodeling.

The representatives noted that in doctoral engineering programs, it is common practice to award credit for taking the qualifying exam.

North Carolina A&T State University's response to the budget questions is summarized in the "Resources" section below.

### **Need for the Program**

In Spring 2005, the then Governor of North Carolina instituted the Governor's Task Force on Nanotechnology and North Carolina's Economy, which was tasked with developing "a roadmap for an aggressive and coordinated initiative to advance successful nanotechnology-based economic development and high-wage employment across North Carolina." This task force released "A Roadmap for Nanotechnology in North Carolina's 21<sup>st</sup> Century Economy." The Roadmap listed the following imperatives to enhance North Carolina's competitiveness in this area:

1. Increase our ability to innovate,
2. Increase the levels of collaboration between our companies and R&D centers,
3. Develop a well-educated and trained workforce,
4. Provide a supportive public and political policy environment, and
5. Diversify our technology cluster portfolio to include nanotechnology.

The JSNN addresses all five of these imperatives, while the proposed doctoral program addresses the imperatives of developing a well-educated and trained workforce, and of increasing the levels of collaboration between academia and industry. Governor Perdue has stated "Nanotechnology is fundamental to North Carolina's economic development strategy of growing jobs and building a new economy."

Nanotechnology is rapidly becoming a large part of the world's economy, generating an array of materials, technologies, and new products. A wide variety of industries utilize nanoengineering techniques. Students with a background in nanoengineering can find employment in the areas of electronics, materials, aerospace, chemicals, automotive, consumer goods, defense, communications, medical devices, pharmaceuticals (including drug development and delivery), information technology, environmental engineering, and energy as well as many others.

### **Resources**

The North Carolina General Assembly appropriated funds for the creation of the Joint School of Nanoscience and Nanoengineering, including \$46.3 million to build the JSNN facilities (scheduled to be completed December 2011) and \$8 million for capital equipment for JSNN

in addition to recurring funding. The current recurring budget for JSNN is \$4.9 million, and an additional \$1 million of non-recurring funds have been allocated for FY 2011-12 and FY 2012-13. The recurring JSNN budget includes seven faculty positions for the Nanoscience program, and seven faculty positions for the Nanoengineering program. If no additional State funding is provided, the Ph.D. in Nanoengineering program will be funded out of the current recurring budget.

Facilities, equipment, and faculty are the primary resources needed for this program and NCA&T State has these in place. The building is complete and equipped. While JSNN projects that the current funding level of \$5.9 million will be adequate for the next two years to support the Ph.D. in Nanoengineering and the Ph.D. in Nanoscience programs, the originally planned \$6.9 million recurring budget for JSNN is needed long-term. Recognizing that additional State funding and/or enrollment growth funding may not be available in the future, JSNN continues to pursue research funding from foundation and government sources as well as industrial partnerships. For example, in the past twelve months, nanoengineering faculty have procured more than \$3.5 million in extramural funding in support of nanomaterials/modeling research, while JSNN is currently investigating co-location models with more than 20 companies in order to enhance infrastructure and defray maintenance costs.

Based on the University funding formula, when the program reaches projected full enrollment of 37 full-time students after four years, NCA&T State would receive additional state appropriations of approximately \$1 million if fully funded by the General Assembly.

#### **Recommendation by the Graduate Council**

After consideration of the issues raised by the external reviewer and Council members, the Graduate Council voted, without dissent, to recommend approval for North Carolina A&T State University to establish a doctoral program in Nanoengineering.

#### **Recommendation**

The staff of the General Administration recommends that the Board of Governors approve the request from North Carolina A&T State University to establish a doctoral program in Nanoengineering effective January 2012 subject to the availability of funding.

#### **Approved to be Recommended for Establishment to the Committee on Educational Planning, Policies, and Programs**

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**Vice President for Research and  
Interim Vice President for Academic Planning**

**September 26, 2011**

## General Information Template for Academic Program Review

### ***Degree Area and Level:***

Ph.D. in Nanoengineering (CIP 14.9999) at North Carolina A&T State University

### ***Addressing UNC Tomorrow:***

This proposed program would address several Recommendations within the UNC Tomorrow Report including the components to enhance Our Global Readiness (Recommendation 4.1), Our Citizens and Their Future: Access to Higher Education (Recommendation 4.2), Our Communities and Their Economic Transformation (Recommendation 4.4), Our Health (Recommendation 4.5), Our Environment (Recommendation 4.6), and Our University's Outreach and Engagement (Recommendation 4.7).

### ***Role of Program in Relation to State and Regional Needs:***

According to the proposal, "The Ph.D. in Nanoengineering will provide the student with both breadth and depth in the "nano" field and enable students to take research and development positions in industrial, governmental or academic research settings as well as technical leadership roles in entrepreneurial and burden sharing organizations (e.g. SEMATECH, NC Biotech, etc.). There is a wide variety of industries that use nanoengineering skills. Students may find employment in nanoelectronics, materials, aerospace, chemicals, automotive, consumers goods such as sporting goods and textiles, defense, communications, medical devices and medical diagnostic technology, pharmaceuticals including drug development and delivery, information technology, environmental engineering and energy, just to name a few."

### ***US Labor Department Analysis:***

- *Summary* – Overall engineering employment is expected to grow by 11 percent over the 2006-16 decade, about as fast as the average for all occupations. Engineers have traditionally been concentrated in slower growing or declining manufacturing industries, in which they will continue to be needed to design, build, test, and improve manufactured products. However, increasing employment of engineers in faster growing service industries should generate most of the employment growth. Job outlook varies by engineering specialty.

Source: [http://www.occsupplydemand.org/OSD\\_UnitOfAnalysis.aspx?CLUSCODE=024A-05&ST=NC&PathNo=1](http://www.occsupplydemand.org/OSD_UnitOfAnalysis.aspx?CLUSCODE=024A-05&ST=NC&PathNo=1)

### ***Availability of Program Statewide (Enrollment and Degrees Awarded in Last 3 Years):***

- *Public universities* – Not available
- *Private universities* – Not available

***Available or not from Academic Common Market:*** Not available

### ***NCA&T Campus enrollment and degrees awarded in similar programs at the Doctoral level:***

(Based on two CIP digits – 14 CIP is the summary group for Engineering under which Nanoengineering is a program.)

Enrollment			Academic Year						
			Fall 07	Spr 08	Fall 08	Spr 09	Fall 09	Spr 10	Fall 10
NCA&T	Electrical and Electronics Engineering	PhD	32	32	38	37	39	37	37
	Mechanical Engineering	PhD	23	18	29	30	33	33	35
	Industrial Engineering	PhD	16	20	26	26	39	38	39
	Computational Science and Engineering	PhD	N/A	N/A	N/A	N/A	N/A	N/A	6

## APPENDIX H

Number of Degrees Awarded			Academic Year		
			2007-2008	2008-2009	2009-2010
NCA&T	Electrical and Electronics Engineering	PhD	7	3	8
	Mechanical Engineering	PhD	10	6	1
	Industrial Engineering	PhD	5	6	3
	Computational Science and Engineering	PhD	N/A	N/A	N/A

***Campus Average of enrollment and degrees awarded in this degree area at the Doctoral level:***

*(Based on two CIP digits – 14 CIP is the summary group for Engineering under which Nanoengineering is a program - over the last 3 Academic Years, Fall 2007-Fall 2010)*

Campus Average			
	Number of Active Programs	Enrollment per Semester	Degrees Awarded per Year
NCA&T	4	25	5
NCSU	13	64	10
UNC-CH	1	44	7
UNCC	2	52	5
Campus Average:		46	7

***NCA&T Degree Programs added in the past three years:***

- *Bachelor*
  - BS Motorsports Technology (11/05/2010)
  - BS Bioengineering (06/11/2010)
- *Master*
  - MS Bioengineering (06/11/2010)
  - MS Nanoengineering (02/11/2011)
- *Doctoral*
  - Ph.D Computational Science and Engineering (01/08/2010)

***NCA&T Degree Programs discontinued in past three years:***

- *Bachelor*
  - BS Visual Arts, Art Education (03/20/2009)
  - BS Music Education (03/20/2009)
  - BS Romance Languages and Literatures, French Secondary Education (03/20/2009)
  - BS Romance Languages and Literatures, Spanish Secondary Education (03/20/2009)
  - BS Earth and Environmental Sciences (02/11/2011)
  - BS Agricultural Economics (02/11/2011)
  - BS Family and Consumer Science Education (02/11/2011)
  - BS Technology Education (02/11/2011)
  - BS Health and Physical Education (Teaching) (02/11/2011)
  - BA Romance Languages and Literatures, French (02/11/2011)
  - BS Health and Physical Education (02/11/2011)
- *Master*
  - MS English Education (03/20/2009)
  - MS Mathematics Education (03/20/2009)
  - MS History Education (03/20/2009)
  - MS Agricultural Economics (02/11/2011)
  - MS Animal Health Science (02/11/2011)
  - MS Plant, Soil, and Environmental Sciences (02/11/2011)
  - MS Technology Education (02/11/2011)
- *Doctoral*
  - N/A