Presidential Advisory Committee of Michigan Technological University

Proposal 17-05

(Voting Units: Academic Senators)

Interdisciplinary minor in Nanoscale Science and Engineering (Nanotechnology)

Michigan Technological University

1. Introduction

Nanotechnology is a rapidly developing field that seeks to understand, control, and exploit new physical properties that arise in systems at length scales between atoms and bulk materials. Applications of nanotechnology, which already are emerging, are highly interdisciplinary and include virtually all fields and disciplines in engineering and the natural sciences.

This proposal for a new minor is in one sense a by-product of a National Science Foundation grant for Nanotechnology Undergraduate Education (7/2003 – 12/2004) which had up to 18 faculty participants, including five PI/CoPIs, from eight departments. Offering such a minor was not part of the proposed project activities; however, it helped to clearly demonstrate the need and the tremendous interest among both students and faculty for offering a formal undergraduate educational program in nanotechnology at MTU. In a survey of students in the "Fundamentals of Nanoscale Science and Technology" elective class in spring 2004, nearly 50% of the class responded that they would be interested in taking a minor in nanotechnology if MTU offered it.

The minor in Nanoscale Science and Engineering (Nanotechnology) is deliberately designed to

(1) introduce students to the basic issues and overall scope of this field;
(2) encourage students to pursue interdisciplinary coursework outside their major;
(3) develop an understanding of the importance of flexibility in terms of careers, research, and education;
(4) be flexible to allow for participation by students in diverse majors.

2. Rationale

In order to introduce students for what some enthusiasts are calling the next "industrial revolution," a formal minor in Nanoscale Science and Engineering (Nanotechnology) is proposed to give students the necessary multidisciplinary background in physics, chemistry, biology, instrumentation, and application-specific areas. Students will choose elective courses to broaden their exposure to other disciplines, as well as to deepen their understanding in primary areas of interest. Importantly, all students will have opportunities to consider and explore real and potential societal implications of new nanotechnologies. With ever increasing interest in nanotechnology among young, bright high school students, it is anticipated that this new minor may also be valuable in recruiting excellent students to Michigan Tech.

The Nanotechnology Minor will also give MTU a important educational component as it is also continuing to develop its research programs in nanoscale science and technology areas. The nano-related

research and educational programs will help to and enhance MTU's visibility (see nano.mtu.edu) among other peer institutions developing similar programs.

The Nanotechnology Minor is a non-departmental minor that will be administered, initially, through the Department of Physics. Administrative responsibility will shift to an appropriate multidisciplinary program/unit such as a "Nanotechnology Institute"[1] upon its creation.

3. Details of Catalog Copy:

I. Title of Minor

Nanoscale Science and Engineering (Nanotechnology) Minor

II. Catalog Description

This multidisciplinary minor focuses on emerging fields of science, engineering, and technology where systems exist with one or more dimensions at the nanometer scale. A multidisciplinary exposure, including fundamental sciences, current and potential applications, modern instrumentation, and potential societal implications are emphasized. Due to the interdisciplinary nature of the minor, students are advised to consult with their major advisor and a Nanotechnology Minor advisor as early as possible to plan their schedules and a coherent program of study.

III. List of Courses

Required Courses

1. UN2600 Fundamentals of Nanoscale Science and Technology (2 credits)
2. SS 3820 Societal Implications of Nanotechnology (2 credits)
3. Independent study/Research/co-op/enterprise (3 credits- must be nano-related; program approval required)

Elective Courses

Choose at least two courses from this list of courses not in your major. Additional courses may be freely chosen from this list to bring the total number of credits from this list to at least 9, giving a total of at least 16 credits for the minor. (Remember that it is also a university requirement that you take at least two courses at the 3000-level or higher not required by your major.)

BA3780 Entrepreneurship (3)

BE 3500 Biomedical Materials (3)
BE 4700 Biosensors: Fabrication and Applications (3)

BL 1900 Molecular Biology Seminar (1) [new class in approval process]
BL 2100 Principles of Biochemistry (3)
BL 2200 Genetics (3)
BL 4010 Biochemistry I (3)
BL 4020 Biochemistry II (3)
BL 4030 Molecular Biology (3)

CH 2400 Principles of Organic Chemistry (4)

CH 3500 Physical Chemistry for
Environmental and Life Sciences (2)
CH 3520 Physical Chemistry II- Kinetics and Molecular Structure (3)
CH 4212 Instrumental Analysis (5)
CH 4310 Inorganic Chemistry I (3)
CH 4320 Inorganic Chemistry II (3)
CH 4610 Introduction to Polymer Science (3)

CM 4610 Introduction to Polymer Science (3)
CM 4710 Biochemical Processes (3)
CM 3974 Fuel Cell Fundamentals (1)

EE 4231 Physical Electronics (3)
EE 4240 Introduction to MEMS (4)
EE 4240D Introduction to MEMS (4)
EE 5470 Semiconductor Fabrication (3)
EE 5480 Advanced MEMS (4)
EE 6480 Thin Films (3)

EET 3353 Sensors, Data Acquisition and Control (3)

ENG3974 Fuel Cell Fundamentals (1)

FW 3075 Plant Biotechnology (3)
FW 4089 Bioinformatics (3)

MEEM 4405 Intro to the Finite Element Method (3)
MEEM 4640 Micromanufacturing Processes

MET 3131 Instrumentation I (3)
MET 4131 Advanced Instrumentation and Controls (3)

MY 3200 Materials Characterization I (4)
MY 3210 Materials Characterization II (4)
MY 3700 Electronic, Optical, and Magnetic Properties of Materials (4)
MY 4200 Introduction to Scanning Electron Microscopy (2)
MY 4240 Introduction to MEMS (4)
MY 4240D Introduction to MEMS (4)
MY 4710 Photonic and Micromechanical
Materials and Devices (3)
MY 5470 Semiconductor Fabrication (3)
MY 5480 Advanced MEMS (4)
MY 5550 Solid Surfaces
MY 5580 Introduction to Scanning Probe Microscopy (2)
MY 6100 Computational Materials Science and Engineering (3)
MY 6480 Thin Films (3)

PH 2400 University Physics IV: Waves and Modern Physics (3)
PH 3410 Quantum Physics I (3)
PH 3411 Quantum Physics II (3)

SS 2800 Science, Technology & Society (3)
SS 3650 Intellectual Property Law [new class in approval process]

Other appropriate electives (including those at the graduate level) may be chosen with written permission by the Nanotechnology Minor faculty advisor. Graduate-level courses may also require permission of the department or the instructor.

Students are encouraged, though not required, to take at least one course from this list related to instrumentation:

BE 3600 Biomedical Instrumentation (4)
CH 4212 Instrumental Analysis (3)
MY 3200 Materials Characterization I (4)
MY 3210 Materials Characterization II (4)
MY 4200 Introduction to Scanning Electron Microscopy (2)
MY 5580 Introduction to Scanning Probe Microscopy (2)

IV. Prerequisites

Course	Pre- or Co-requisites
UN 2600	None
BA 3780	None
BE 3500	BL 1040 and MY 2100 and (ENG 2120(C)or MEEM 2150(C))
BE 3600	EE 3010 and BL 2020
BE 4700	None
BL 1900	None
BL 2100	(BL 1040 or BL 1020) and (CH 1110 or CH 1100)
BL 2200	(BL 1020 or BL 1040) and BL2100
BL 4010	(BL 1020 or BL 1040 or BL2010) and (BL 2100 or CH 2400) and CH 2420
BL 4020	BL 4010
BL 4030	(BL 1020 or BL 1040) and BL 2100 and (BL 2200 or BL 2300(C))
CH 2400	CH 1120
CH 3500	(CH 1100 or CH 1110) and (CH 1120 or CH 1140) and (MA 2150 or MA 2160)
CH 3520	CH 1120 and (MA 3150 or MA 3160) and PH 2200(C)
CH 4212	CH 2212 and CH 3510(C) and CH 3511(C)
CH 4310	CH 3520
CH 4320	CH 4310
CH 4610	CH 1120
CM 4610	CH 1120
CM 4710	CM 3110
EE 4231	EE 3130
EE 4240	Senior standing
EE 4240D	Senior standing

EE 5480	EE 4240 or MY 4240
EE 6480	Permission of department
EET 3353	EET 1411 or EET 2220 or EET 2311 or EE 3010
ENG 3974	CH 1100 or CH 1110
FW 3075	None
FW 4089	None
MEEM 4405	MEEM 3502 and (MA 2320 or MA 2321 or MA 2330) and (MA 3520 or MA 3521 or MA 3530 or MA 3560)
MEEM 4640	MEEM 2502
MET 3131	none
MET 4131	MET 3131 and (MA 2710 or MA 2720 or MA 3710)
MY 3200	MY 2100
MY 3210	MY 3200
MY 3700	(PH 2200 or PH2260) and (MA 3150 or MA 3160) and (MA 3520 or MA 3530) or (MA 2321 and MA 3521)
MY 4200	None
MY 4240	Senior standing
MY 4240D	Senior standing
MY 4710	None
MY 5470	None
MY 5480	EE 4240 or MY 4240
MY 5550	Permission of department
MY 5580	Permission of department
MY 6100	Permission of department
MY 6480	Permission of department
PH 2400	PH 2200 or PH 2260
PH 3410	PH 2400 and MA 3530
PH 3411	PH 3410
SS 2800	None
SS 3650	UN 2002
SS 3820	Junior or Senior standing
UN 2600	None

4. New Course Descriptions

Two new courses are required for the nanotechnology minor and have been through the new-course review process, independent of the success of this Minor proposal.

Fundamentals of Nanoscale Science and Engineering (2 credits)
Course numbers: UN2600

Description: Team-taught introduction to the fundamentals of nanotechnology, emphasizing the interdisciplinary nature of this field. Modern instrumentation, key scientific foundations, and current and potential applications will be discussed. Real and potential societal implications of nanotechnology will be explored.
Semesters offered: spring.

Comments: This was a direct product of the funded NSF-NUE project. It was offered in spring 2004 as a special topics course, and was cross listed by six departments. The initial instructors were hoping for approximately 25 students to register. Over 90 students, ranging from freshmen to graduate students, registered and completed the course. A survey conducted at the end of the year showed that almost 90% of the students thought the class should be offered again and that nearly 40% of the students suggested that if be offered for more than one credit. We are planning to offer the class again in spring 2005 under special topics listings. In order to encourage in-class discussion and to keep instructional responsibilities (grading) by the primary instructors to a manageable level, we plan to cap enrollment at 25 in the future. This should not be too severe since one reason for the high initial enrollment was that this was the first time such a class had been offered at MTU.

Societal Implications of Nanotechnology (2 credits)
Course number: SS 3820
Description: Nanotechnology, considered by many to be the "next big thing" in the realm of science and engineering, involves natural phenomena where at least one dimension is at the nanoscale – 10^{-9} m. This course examines in a seminar format some of the likely implications of these developments for society. Attention will be given to the economic, social, ethical and moral, and political consequences of the unfolding development of science and engineering fields at the nanoscale.

5. Estimated Costs

The immediate initiation of this minor has no direct new costs. Participating faculty will continue to pursue external funding to purchase equipment to enhance educational experiences in the classroom and laboratories, and to provide funding for external speakers to visit campus for UN 2600 and public lectures, but such additional support is not necessary to run the program.

The offering of a new minor in nanotechnology and potentially offering other nano-related educational programs (for example, a graduate certificate is being developed for future consideration) provide exciting opportunities for MTU. With ever increasing interest in nanotechnology among young, bright high school students, it is anticipated that this new minor will be valuable in recruiting excellent students to Michigan Tech. Although no additional costs are needed to start the program immediately, small to modest support internally and externally could provide significant dividends to MTU. Examples for the near-term which do not necessarily require general fund support but could come from the overhead return to the "Nanotechnology Institute" include the following:

Enhanced publicity for nano-related educational programs (1st year).
Web support (already initiated through the NSF grant at nano.mtu.edu) $1,000.
Brochure design, printing and mailing $4,000.
Educational laboratory equipment.
Portable AFM system and STM system $30,000.
(for outreach education, recruiting, and MTU teaching laboratories)

6. Planned Implementation

This minor is planned to be offered starting fall semester 2005.

Adopted by the PAC (formerly Senate): 9 February 2005
Approved by President Mroz: 21 February 2005

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[1] The final name for the new institute may be different. The actual proposed name for this institute is "Multi-Scale Technologies Institute (MuSTI).