NANO SCIENCE AND ENGINEERING

Ph.D. Program

HANDBOOK

2015-2016

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(Note: This handbook is for informational purposes - it provides more detailed explanations than are available in the SDSM&T Catalog, as well as specific NANO policies established by the NANO Ph.D. Advisory Council. This handbook should be used in conjunction with the SDSM&T Catalog.

TABLE OF CONTENTS

General information concerning the Graduate School and the Nano Science and Engineering (NANO SE) Ph.D. program is contained in the South Dakota School of Mines and Technology Catalog. Detailed listings of graduate courses, as well as additional information concerning program and university graduate degree requirements, are contained in the catalog. All graduate students should familiarize themselves with pertinent information contained in this catalog.

The following guide relates to specific requirements of the NANO SE Ph.D. program and is intended to supplement catalog information. It should be studied carefully by all Ph.D. students in the Nano Science and Engineering Program. A discussion of the various forms that must be filed is included herein. The procedure for completing a degree program including pertinent forms can be found in Appendix A.

I. ADMISSION

The Nano Science and Engineering Ph.D. program requires GRE (Graduate Record Examination) scores of all applicants; applicants must take the Verbal, Quantitative, and Analytical parts. The GRE subject test in the individual's undergraduate degree major is encouraged, but not required. Any exception to the GRE requirement should be approved by the NANO AC. In addition to the general admission requirements, the Graduate School requires applicants from foreign countries to achieve a satisfactory TOEFL (Test of English as a Foreign Language) score. TWE test is strongly recommended for a student who wants to be considered for a teaching assistantship or other financial aid. All students whose first language is not English may be tested upon arrival and may be required to take one or more remedial English courses. All graduate students are expected to have or to develop a proficiency in both written and oral English. Any student, who is found weak in communications, as evidenced by written reports and/or seminar presentations, may be required to take additional English or speech course work.

A student whose bachelor's degree is in any science or engineering field is eligible for admission to this program. However, the following courses are regarded as minimum pre-requisites to this program.

Chemistry: one year, general
Math: one year calculus, ordinary differential equations, matrix algebra
Computer Science: proficiency in a computer programming language
Physics: one year, calculus based

II. GRADUATE STUDENT ADVISOR

The Nano Science and Engineering PhD program director serves as a temporary faculty advisor to each new graduate student until such a time as the student selects a permanent advisor (Major Professor) to supervise his/her graduate research. The program director will assist all new graduate students with their course registration and provides each student with information pertinent to the Nano SE PhD program.

III. FINANCIAL ASSISTANCE

Financial assistance is available to graduate students through a number of avenues, including graduate fellowships, graduate teaching assistantships (GTA), and graduate research assistantships (GRA). The required applications for all types of financial assistance should be made to the Dean of Graduate Education. Requests may be included in the application package, at the discretion of the applicant.

IV. SELECTION OF RESEARCH TOPIC

Within the first two semesters of graduate studies, all new students not supported by a GRA should make appointments with faculty involved in the NANO SE Ph.D. program to discuss possible research topics. Each student will be matched with a major professor in accordance with his/her interests. The student must file a Program of Study form with the Graduate Education and Sponsored Programs Office within the first two semesters of study. An Advisory Committee, consisting of the major professor and four other faculty, will be formed to guide the student progress. The Advisory Committee is appointed by the Dean of Graduate Education in consultation with the student and the student's major professor. At this time, the major professor becomes the student's advisor on all matters pertaining to guiding the students progress.

V. PROGRAM OF STUDY

The degree of Doctor of Philosophy in Nano Science and Engineering is awarded upon completion of course requirements and demonstration of significant scholarly achievement through independent research. A Ph.D. candidate must demonstrate general competence in the subject matter of his/her chosen field. To this end, the student files and pursues a proposed Program of Study which includes a list of courses that the student intends to take. This Program of Study must be given preliminary approval before the qualifying exam and final approval before the dissertation defense by the student's advisory committee, Nano Science and Engineering Advisory Committee (NANO AC), and the Dean of Graduate Education. The Program of Study must be filed with the Nano Science and Engineering PhD Program director during the first year of residence, and again before the qualifying exam. Below is the summary of the required course of study. Example curricula and schedule of core course offerings can be found in appendix E.

CATEGORY	**CREDITS***
NANO 701 Nano Materials	3
NANO 702 Theory and Applications of Nanomaterials	3
NANO 703 Characterization of Nano Materials	4
NANO 890 Seminar	3
TOTAL NANO Core Credits:	13

Program Major Emphasis: The program major emphasis ensures the student has acquired graduate training at the MS level in a traditional engineering or science discipline, and may be fulfilled in part or in full by a previously earned MS degree. Students entering at the BS level are encouraged to fulfill the requirements for the MS in one of the disciplines for which the MS degree is currently offered at SDSM&T.

General requirements: 27-37
18 core credits, according to program emphasis. Of remaining credits, at least 6 hrs must be outside of students major emphasis.

Major Emphasis-specific requirements:
Chemical Engineering (see requirements for MS in Chem Eng)
Mechanical Engineering (see requirements for MS in Mech Eng)
Electrical Engineering (see requirements for MS in Elec. Eng.)
Metallurgical and Materials Engineering (see requirements for MS in MES)
Physics (see requirements for MS in Physics)
Chemistry (see requirements for MS in MES)

Dissertation Research	30-40
TOTAL REQUIRED FOR PhD	80

*Beyond the BS degree

In approving a proposed Program of Study, the Nano SE PhD Program Director will take into account acceptable graduate-level courses taken at other institutions or other demonstrations of competence in a particular area. The student should summarize this material as directed in Appendix A, and submit this with the Program of Study.

VI. MASTERS DEGREE:

The Nano SE PhD program is designed with the precept that the PhD is the terminal degree for completion of the program. However, under circumstances where a student cannot complete the research and thesis portion of the Nano SE PhD program, but has completed the required coursework, and has obtained a minimum of 40 credit hours, a terminal MS degree may be conferred (see Appendix E for example curricula). No transfer credits which are also counted towards other MS degrees earned at SDSM&T or elsewhere may be applied towards the MS degree in Nano SE.

VII. GPA REQUIREMENTS AND COURSE LOAD

A grade of "B" or better in a course will be accepted as evidence of competence in the subject.

All candidates for the Ph.D. must obtain an average grade of "B" or better in the overall course of study in accordance with the Graduate School requirements. Grades below "C' cannot be credited toward advance degree requirement. A full load for each semester is considered to be nine semester credit hours of course work and/or dissertation. After the advisory committee has been established, a Ph.D. student must register every semester, in accordance with SDSM&T regulations.

Once the student has selected a research topic, he/she will be expected to register for NANO 898 (research) for a number of credit hours agreed to by his/her research advisor. The student will be required to register for a three 1-credit hour graduate seminars, and is expected to attend regularly and participate.

VIII. QUALIFYING EXAMINATIONS

Prior to the end of the fifth semester of study, the student will sit for a qualifying examination consisting of two parts:

(i) A written examination based on the core Nano SE curriculum will be given at the end of the second year of study. This will be a 2 hour written examination, roughly 1/3 of the emphasis will be devoted to each of the 3 required core courses.

(ii) The student will prepare a written research proposal and complete an oral presentation of that proposal in the presence of the Advisory Committee. The topic is to be prepared by the student with the guidance of his/her research advisor. The topic of the proposal will usually be related to the student's anticipated dissertation research; however, the student's research advisor may require the student to prepare a proposal on an unrelated topic.

The written proposal should be no longer than 15 double-spaced, typewritten pages of text, plus nomenclature, references, figures, and appendices. It is recommended that the document be organized in the form shown in Appendix B. This written document must be reviewed by two members of the student's advisory committee before submission to the full committee. The committee members will point out any problems relating to scope and format. However, final approval of the proposal will only come after the subsequent faculty reading and oral exam.

Copies of the final typed proposal must be submitted to the student's advisory committee for faculty reading. At this time, a date will be set for the oral presentation by the student of his/her dissertation research proposal. This presentation should closely reflect the contents of the written proposal and should last no longer than 30 minutes, without interruptions. Background information is to be limited to no more than 20% of the document; the majority of the presentation should be a detailed description of the student's proposed research program. The originality and potential significance of the proposed research should be emphasized. Following the oral presentation, the student will be expected to respond to questions from the attending faculty.

The purpose of the examinations is to test the students knowledge in the program focus areas, teach the student how to write technical research proposals, test the student's understanding of the relevant literature, test the student's imagination and judgment in a research environment, and test the student's ability to present work in clear, concise written and oral English. Clear and substantial portions of both the written and oral presentations must demonstrate the student's original ideas. The proposal must be for the most part a product of the student, not that of the advisor or Committee. The outcome of this examination procedure will be a Pass, a Conditional Pass (usually requiring a re-write and/or re-submittal of the proposal), or a Fail. An examination may be repeated only once and only at the discretion of the student's advisory committee.

Passing the qualifying examination shall be considered equivalent to satisfying both the preliminary and comprehensive examination requirements, as described in the graduate school degree requirements in the SDSM&T catalog.

Failing the Qualifying examination: Students who fail the written portion of the exam may retake the exam in the following year, with the permission of the advisor. Students must schedule the oral portion of the qualifying examination by the end of the 5th semester of study (*e.g*. mid-term of the 3rd year). ***If a student does not complete and pass both parts of the examination by the end of the 5th semester, an evaluation of the student's progress and eligibility for an assistantship will be initiated during the 6th semester***. Contingent on the outcome of this evaluation, a recommendation will be made, with the following outcomes: **a)** a specific timeline for completion of these exams, not to exceed one year, will be submitted by the student and/or the faculty advisor, and approved by the Nano AC and the Nano PhD Program Director, or **b)** the student will be dismissed from the program. After failure to successfully complete these exams on the second attempt, the student will be dismissed from the program.

IX. ADMISSION TO CANDIDACY

Provided the student has passed both portions of the qualifying examination, the student may apply to his/her major professor for admission to candidacy on an official certification form available from the Graduate Education and Sponsored Programs Office. At this time, no less than four months before the scheduled dissertation defense, the student will be considered a PhD candidate.

X. DISSERTATION

Of major importance to the Ph.D. degree are the student's research and the resulting dissertation. The research results are expected to be of publishable quality. The student's research advisor may specifically require publication of one or more peer-reviewed journal articles, equal to or exceeding the Nano PhD program publication requirements. The time necessary to complete the Ph.D. requirements depends largely upon how soon a student initiates research and the degree to which he/she devotes effort to its pursuit. Detailed instructions concerning the dissertation and the time schedule that must be followed during the semester of intended completion of the Ph.D. requirements are given in the Graduate Bulletin.

Information on guidelines for writing and formatting a Doctoral Dissertation are available from the Office of Graduate Education. Student should obtain a free copy of "Instruction for the Preparation of Thesis and Dissertation" from the Graduate Office. All students are expected to follow the guidelines found within the manual. The final version of the dissertation must be submitted by the candidate to each member of his/her advisory committee no later than TWO weeks before the scheduled dissertation defense.

XI. DEFENSE OF DISSERTATION

The student will be required to give an oral presentation (30-45 minutes), open to the public, on the major findings of his/her research. An oral examination will follow the presentation; conducted by the student's major professor with only the student's Advisory Committee in attendance. The student's Advisory Committee will question the student to test the quality and completeness of the research.

XII. PUBLICATION REQUIREMENT

Publication in peer-reviewed journals is a pre-requisite to demonstrating achievement at the level of the PhD. It is suggested that each student would be first author on 3 peer reviewed journal articles prior to obtaining the PhD. A minimum of 2 peer-reviewed journal articles are required, with the student being first author on at least 1 published article prior to graduation. Any exception must be approved by the NAC.

XIII. GRADUATE COMMITTEE

The graduate committee will be formed according to the rules laid out by the Graduate office. One member of the committee must fulfill the requirements of the graduate office to act as the graduate representative, and therefore must not be a Nano program faculty advisor. A list of Nano program faculty will be provided to the graduate office annually by the NAC or on request.

APPENDIX A:

PROGRAM OF STUDY FOR PH.D. STUDENTS
GRADUATE ADVISORY COMMITTEE SIGNATURE PAGE

The original program of study is due to the Office of Graduate Education no later than midterm of the second semester of registration as an advanced degree-seeking candidate.

If the program of study is being revised, a new form must be submitted, complete with all approval signatures.

_____ Original _____ Revision

Student Name and ID #: _____ Today's Date: _____
(Print)

Current Ph.D. Department/Program: _____

Specialization/emphasis (if applicable): _____

Undergraduate degree received: _____

State your dissertation research area, as close to the anticipated topic as possible:
_____
_____

Graduate Advisory Committee:

By signing below I agree that the courses listed represent a specific program leading toward graduation.

Major Professor (Print Name & Dept)	**Signature**	**Date**
Graduate Division Representative (Print Name & Dept)	**Signature**	**Date**
Committee Member (Print Name & Dept)	**Signature**	**Date**
Committee Member (Print Name & Dept)	**Signature**	**Date**
Committee Member (Print Name & Dept)	**Signature**	**Date**
Committee Member (Print Name & Dept)	**Signature**	**Date**
Committee Member (Print Name & Dept)	**Signature**	**Date**
Program Coordinator (Print Name & Dept)	**Signature**	**Date**

I certify that the courses listed represent a specific program leading toward graduation. I understand that the course list can be changed at a later date with the approval of my Graduate Advisory Committee.

Submitted for approval by: _____ _____
Signature of Student **Date**

Dean of Graduate Education: _____ _____
Signature of Dean **Date**

(Note: See graduate education website for most recent approved forms: http://www.sdsmt.edu/Academics/Graduate-Education/Grad-Ed-Forms/.)

Coursework Schedule

International students not exempted from the Graduate English Proficiency Program must include English 390 in the coursework schedule.

Courses transferring from another program at SDSM&T or from another institution must be identified as such with an asterisk (*) in front of the course name. Courses transferring from another institution require attachment of transcript copy evidence. Courses transferring from an institution outside the United States must also include a course description from the transferring university.

Required courses include only those course credits which apply toward degree requirement, including 300-400 level courses approved by petition or on waiver by the Graduate Education and Research Committee. Courses not required and not previously approved on waiver should be listed as Others.

All courses should be listed by semester date, in the order of planned completion. (Sem/Yr example Fall 2003, Spring 2004, etc.) (Under Course Name spell out course title completely.)

		Number of Credit Hours		
Sem/Yr	Course name and number	Required Courses	Research	Others

APPENDIX B:

RECOMMENDED OUTLINE FOR THE WRITTEN PORTION OF THE RESEARCH PROPOSAL

1. Cover page
2. Summary (one page) including:
   - research objectives
   - significance of the proposed research
   - student's original contributions
3. Literature survey (maximum 3 pages), including:
   - the general literature in the field
   - specific literature on the proposed topic
4. Proposed research program (~8 pages, not including figures), including:
   - research objectives
   - expected significance
   - broad design of experiments and/or modeling to be undertaken
   - description of proposed experimental and/or numerical methods
   - relation of the proposed program to the goals of the research cited in the literature survey
5. Extension of the research to future work
6. A clear and concise statement of the student's original contributions
   – schedule for completion of research
7. Nomenclature
8. References
9. Appendices
   A. Copy of the reference most pertinent to the proposed research program
   B. Other relevant materials.

APPENDIX C:

FACULTY AND RESEARCH INTERESTS

Dr. S. Phil Ahrenkiel, Associate Professor of Nanoscience and Nanoengineering, PhD University of Colorado Boulder, high resoltution TEM microscopy and diffraction methods, energy and nano materials.

Dr. Robert B. Anderson, Assistant Professor Nanoscience and Nanoenginering, PhD South Dakota School of Mines and Technology; Photonics, optics, super-resolution imaging, computational methods.

Dr. Dimitrios E. Anagnostou, Associate Professor of Electrical and Computer Engineering, PhD University of New Mexico. Reconfigurable, planar and flexible antennas and RF devices. Synthesis of EM structures using Neural Network techniques. Integration of microwave components with active and passive devices including RF-MEMS. Fractal, compact, ultrawideband (UWB), Log-periodic antennas and antenna arrays for remote sensing and wireless communication applications.

Dr. Hao Fong, Professor of Chemistry, PhD University of Akron, Nano-scaled polymer, ceramic and carbon/graphite fibers and their applications.

Dr. Haiping Hong, Research Scientist IV, PhD Hebrew University, Jerusalem, Carbon based Nano-materials, Nano-composites, Nano-fluids, Nano-grease.

Dr. Jing Liu, Assistant Professor Nanoscience and Nanoengineering, PhD Purdue University; Photonics and non-linear microscopy, imaging, single molecule detection, DNA repair.

Dr. David Salem, Professor of Chemical and Biological Engineering / Materials and Metallurgical Engineering, Director Composites and Polymer Engineering Laboratory; PhD University of Manchester; Polymer Nano-composties and Polymer Physics.

Dr. Steve Smith, Professor of Nano Science and Engineering; PhD University of Michigan, Ann Arbor; Energy and time-resolved nanoscale optical spectroscopy, nanophotonics, electronic and photonic properties of nano- and energy-materials.

Dr. Keith Whites, Steven P. Miller Endowed Chair and Professor of Electrical and Computer Engineering, Ph.D., University of Illinois at Urbana/Champaign. Artificial electromagnetic materials; high impedance surfaces; ultra-wideband antennas and wireless communications; space-based gossamer antennas; solar sails and electromagnetic sailcraft; RF and microwave circuits; computational electromagnetics.

Dr. Haeyeon Yang, Associate Professor of Nano Science and Engineering; PhD Brown University, Providence; Molecular Beam Epitaxy, semiconductor nano-materials, scanning tunneling microscopy.

Dr. Zhengtao Zhu, Associate Professor of Chemistry, PhD SUNY Binghamton, Organic-inorganic nano-composites, Nano imprinting and lithography.

APPENDIX D:

Elective courses:

NANO 401: Introduction to Nanoscience	3
NANO 445/545: Introduction to Nanomaterials	3
NANO 475/575: Advanced Processing/Nanoengineering of Polymeric Materials	2
NANO 504: Nanophotonics	3
NANO 604: Nanophotonic Materials	3
NANO 704: Crystallography and Structure of Nanomaterials	3
NANO 705: Nanoelectronics	3
NANO 708: Nanomaterials for Photovoltaics	3
NANO 709: Scientific Programming and Visualization	3
NANO 711: Introduction to Direct Write Technology	3
NANO 712: Electromagnetic Properties of Heterogeneous Materials	3
NANO 713: Dielectric and Magnetic Properties of Nano-Scale Materials	3
NANO 714: Functional Fillers and Nanoscale Minerals	3
NANO 715: Polymeric Nanomaterials	3
NANO 716: Nanotechnology of Engineering and Construction Materials	3
NANO 717: Nano Chemistry	3
NANO 718: Small Scale Mechatronics	3
NANO 719: Atomic Force Microscopy/Nano-Mechanics	3
NANO 720: Contemporary Condensed Matter Physics	3
NANO 791 INDEPENDENT STUDY	1 to 3
NANO 792 TOPICS	1 to 3
MES 601 Fundamentals of Materials Engineering	4
MES 603 Condensed Matter Physics	4
MES 604 Chemistry of Materials	4
MES 708/708L Adv Instrumental Analysis	3-1
ME/ChE 612 Transport Phenomena – Momentum	3
ME/ChE 613 Transport Phenomena – Heat	3
ChE 614 Transport Phenomena – Mass	3
Phys 721 Adv Electricity and Magnetism	3
Phys 743 Statistical Mechanics	3
Phys 777 Quantum Mechanics I	3
Phys 779 Quantum Mechanics II	3
MES 712 Interfacial Phenomena	3
MES 713 Advanced Solid Mechanics	3
MES 728 Heterogeneous Kinetics	3
MES 737 Solid State Physics I	3
MES 770 Continum Mechanics	3

APPENDIX E: SAMPLE CURRICULUM AND PROJECTED COURSE OFFERINGS

Course Offerings Schedule:

FA 15	SP 16	FA 16	SP 17	FA 17	SP 18	FA 18	SP 19	Fall 19
Nano 702	Nano 504	Nano 703	Nano 705	Nano 702	Nano 604	Nano 504	Nano 604	Nano 702
Nano 703	Nano 701	Nano 604	Nano 890	Nano 703	Nano 709	Nano 703	Nano 704	Nano 703
Nano 717	Nano 890	Nano 715	Nano 709	Nano 717	Nano 890	Nano 715	Nano 890	Nano 717
elective	Nano 704	elective	Nano 504	elective	Nano 701	elective	Nano 709	elective
elective	Nano 709	elective	elective	elective	Nano 708	elective	Nano 704	elective

Example Curricula:

student entering program with MS (research intensive):

										Credits:
	Nano 702 (3)	Nano 701 (3)								
	Nano 703 (4)									11
seminar		Nano 890 (1)		Nano 890 (1)		Nano 890 (1)				3
research	Nano 898 (2)	Nano 898 (5)	Nano 898 (9)	Nano 898 (8)	Nano 898 (9)	Nano 898 (8)				40
transfer										26
	9	9	9	9	9	9				80

student entering program with MS (coursework intensive):

										Credits:
	Nano 702 (3)	Nano 701 (3)	elective (4)	elective (3)	elective (3)					
	Nano 703 (4)									21
seminar		Nano 890 (1)		Nano 890 (1)		Nano 890 (1)				3
research	Nano 898 (2)	Nano 898 (2)	Nano 898 (6)	Nano 898 (5)	Nano 898 (6)	Nano 898 (8)				30
transfer										26
	9	9	9	9	9	9				80

student entering program at the BS level (research intensive) :

										Credits:
	Nano 702 (3)	Nano 701 (3)	elective (4)	elective (4)	elective (3)	elective (3)				
	Nano 703 (4)	elective (3)	elective (3)	elective (3)	elective (3)					37
seminar		Nano 890 (1)		Nano 890 (1)		Nano 890 (1)				3
research	Nano 898 (2)	Nano 898 (2)	Nano 898 (2)	Nano 898 (1)	Nano 898 (3)	Nano 898 (5)	Nano 898 (9)	Nano 898 (9)	Nano 898 (8)	40
transfer										0
	9	9	9	9	9	9	9	9	8	80

Terminal MS:

							Credits:
	Nano 702 (3)	Nano 701 (3)	elective (3)	elective (3)	elective (3)		21
	Nano 703 (4)				elective (2)		
seminar		Nano 890 (1)		Nano 890 (1)			2
research	Nano 898 (2)	Nano 898 (5)	Nano 898 (5)	Nano 898 (5)			17
	9	9	8	9	5		40