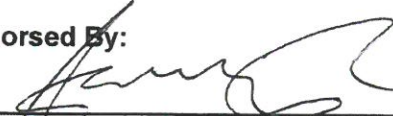# Graduate Certificate in Materials Informatics
North Carolina State University
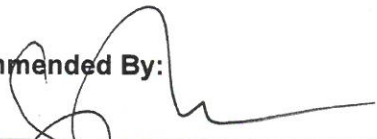
This request has been reviewed and approved by the appropriate campus committees and authorities.

Endorsed By:

_____   4/12/19

Head, Department/Director of Graduate Program (Printed Name and Signature)   Date

Recommended By:

_____   4/12/19

Chair, College Graduate Studies Committee (Printed Name and Signature)   Date

Endorsed By:

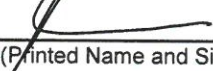_____ Douglas Reeves   4/12/2019

College Dean   (Printed Name and Signature)   Date

Recommended By:

_____   Thomas K. Miller III   5/7/2020
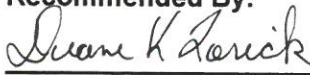
Vice Provost, DELTA (if DE degree)   (Printed Name and Signature)   Date

Approved By:

Peter J. Harries   _____   5/4/2020

Dean of the Graduate School   (Printed Name and Signature)   Date

Recommended By:

_____   Duane K. Larick   5/29/2020

Dean's Council   (Printed Name and Signature)   Date

Approved By:

_____   Warwick Arden   5/29/2020

Executive Vice Chancellor and Provost   (Printed Name and Signature)   Date

Approved By:

_____   6/20/20

Chancellor   (Printed Name and Signature)   Date

(revised August 2015)

NC State University
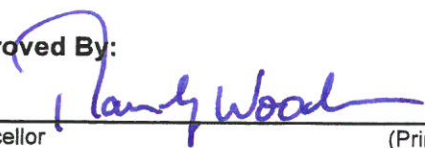## Certificate Proposal Form

Certificate Title: _____Materials Informatics_____

New: ☒

Revision: ☐

Classification of Instructional Programs (CIP) Discipline # (6 digits): _40.1099_

*Please ensure that you select the appropriate CIP code for your certificate program. Please consult this website for more information about CIP codes:

https://nces.ed.gov/ipeds/cipcode/default.aspx?y=55

Certificate Type:

On-Campus: ☐   Distance: ☐   On-Campus & Distance: ☒

Proposed Effective Date: __Aug. 15, 2020_____

Director of the Certificate Program: ___Yaroslava Yingling_____

Program Coordinator (if different from Director):_____

Graduate Services Coordinator: _____

College: _____Engineering_____

Department/Program:__Materials Science and Engineering_____

Catalog Description:

This certificate program is designed for interdisciplinary graduate education at the intersection of materials science, engineering, and data science with the aim of preparing the next generation of materials engineers given the growing demand for data-science skills and knowledge of the artificial intelligence. The skills and knowledge obtained here will serve as foundation for the understanding of materials informatics and high throughput materials discovery that will improve a student's career prospects.

Enrollment:

	On-Campus	Distance
Continuing	Yr. 1-10 Yr. 2- 10 Yr. 3- 1 Yr. 4-0	Yr. 1- 10 Yr. 2- 10 Yr. 3-5__
New	Yr. 1- 10 Yr. 2- 10 Yr. 3-1 Yr. 4-0	Yr. 4-0 Yr.1-10 Yr. 2-10 Yr.3-5 Yr. 4-0

Attachments:

☐   Proposal Document

☐   Statement of other departments likely to be affected and summary of consultation with those departments

☐   Program-level assessment

☐   Campus Routing Form

☐   Signature Page

Graduate Certificate in Materials Informatics

Description
The Materials Science and Engineering (MSE) department proposes to establish a Graduate Certificate Program (GCP) in Materials Informatics (MI). This certificate program is primarily designed for interdisciplinary graduate education at the intersection of materials science, engineering, and data science with the aim of preparing the next generation of materials engineers for growing demand for data-science skills and knowledge of artificial intelligence. The skills and knowledge obtained here will serve as a foundation for the understanding of materials informatics and high throughput materials discovery resulting in improved student career prospects. We anticipate that some students interested in the MI GCP will enroll as distance education students through Engineering Online (EOL). With many on-line MSE and Statistics (ST)/Mathematics(MA) courses to choose from, students can customize their particular certificate programs to focus on specific areas of materials science that interest them.

Learning Outcomes
Upon completion of the MI Graduate Certificate Program, students should be able to:
* Demonstrate an understanding of key materials informatics concepts and components
* Describe and analyze data available from various types of materials characterization methods
* Understand the relationship between materials design and data-driven techniques
* Understand the materials informatics problems and capabilities associated with the design of different types of materials
* Describe available machine learning techniques and materials databases
* Identify a machine-learning algorithm with the desired properties for a given materials problem
* Identify sources of bias and uncertainty in materials data and analysis results
* Apply available tools for structure property prediction of materials

At the time they complete this certificate program, graduates are expected to:

* Be prepared to move into career positions that require a basic comprehension of data science techniques as applied to materials science and engineering problems.
* Be sufficiently satisfied with the overall educational experience of the certificate program to recommend it to others with the same professional goals

Program of Study
The MI GCP will require a total of 12 credit hours, including MSE 723: Materials Informatics (3 credit hours) and three MSE and ST elective courses (9 credit hours) tailored to the needs of the student. The MSE 723 course aims to introduce the emergent field of materials informatics and current approaches that employ informatics and experimental and computational data to accelerate the process of materials optimization, discovery and development. An emphasis will be placed on practical implementation of machine-learning techniques to various materials science problems.

By judicious selection of elective courses, in consultation with the MSE GCP Coordinator, students can customize their GCP to focus on areas of interest to them. A total of four classes are required, including the core course MSE 723:

Required Core Course (* signifies that course is available online):
MSE 723* Materials Informatics

At least one of the following Material Science courses:
MSE 710 Elements of Crystallography and Diffraction
MSE 721* Nanoscale Simulations and
Modeling
MSE 724* Quantitative Materials Characterization Techniques

And at least one of the following Statistics/Mathematics courses:
ST 517 Statistical Methods I (ST grad students are not permitted to use it for
certificate credit) ST 540 Applied Bayesian Analysis
ST 533 Applied Spatial Statistics
MA 540 Uncertainty Quantification for Physical and Biological Models

The fourth course will be taken from outside of the student's degree department. For example, an MSE student's fourth course must be from the ST or MA list (above), whereas a ST or MA student's fourth course must be from the MSE list (above).

Requirements for admission
To be admitted to the Materials Informatics Graduate Certificate Program, a student must have a BS degree in the sciences or engineering from an accredited four-year college or university, and have an overall (or major) GPA of at least 3.0 on a 4-point scale. Potential applicants without the prior background in Materials Science and Engineering are advised to complete MSE 500 prior to applying, although success in that course does not guarantee admission into the certificate program.

An application for acceptance into the MI GCP is required for all new students. Applications will be accepted in the fall and spring semesters, with deadline dates of October 1 and March 1, respectively. Students can begin study in the subsequent fall or spring semester immediately following their acceptance into the program. Students must complete the Graduate School application, found at http://www.ncsu.edu/grad/applygrad.htm. Applications will be reviewed at by the Director of the certificate program.

Registration procedures, registration dates and course availability for each semester can be found on the NC State Registration and Records webpage at http://www.ncsu.edu/registrar/. Additional information regarding the MI GCP can be found on the MSE website (http://www.mse.ncsu.edu) under the Graduate tab. Questions regarding the MI GCP can be directed to the MI GCP Director. Information regarding Engineering Online can be found at engineeringonline.ncsu.edu.

Academic success might have a strong bearing on admission to a degree program but completion of a certificate program in no way guarantees entry into a graduate degree program, which is done through a separate application process.

Academic Performance Requirements

- To receive a Graduate Certificate, a student must maintain a minimum 3.000 grade point average (GPA) on all coursework taken at NC State. All grades on courses taken towards the GCP in courses at the 500-level and above are included in the GPA. Any courses taken at the 400 level and below are not eligible for certificate credit and subsequently do not affect the graduate GPA.
- All courses taken for certificate credit must be completed with a grade of "B" or better.
- All courses taken for certificate credit must be letter-graded. Credit-only courses cannot be used for certificate credit.
- Transfer credit from other institutions is not allowed for the GCP. All coursework must be registered through NC State.
- Up to two courses of post-baccalaureate coursework taken at NC State, if not already used in another graduate program, may be transferred into the GCP. All transfer credit must carry a grade of B or better.
- All GCP requirements must be completed within four (4) calendar years, beginning with the date the student commences courses applicable to the GCP.

Program Administration

The MI GCP will be administered by the Coordinator in the Department of Materials Science and Engineering, in cooperation with the NCSU Engineering Online program for distance-education students.

All required and elective courses for the GCP are courses in MSE, ST, and MA at NC State. The implementation and presentation of the GCP is not expected to require effort outside the normal academic activities of the course instructors. No additional staff or resources will be required.

At the completion of the certificate, students will complete an exit survey for the purpose of evaluating the quality of the certificate program and its impact on students. The exit interviews will be conducted by the program coordinator. The results will be used to inform curricular improvement.

Coordinator for the MI GCP
Yaroslava G. Yingling
Professor
Materials Science and Engineering Department
Campus Box 7907
North Carolina State University
919-515-2624
yara_yingling@ncsu.edu

Enrollment Projection
Initial enrollment will encompass students from SEAS NSF NRT and MSE graduate program. We project an initial annual enrollment of 20 students, but expect that to grow to perhaps 30 students or more within the next 5 years, since it is a very active and throughout after area.

Faculty Participants

All faculty who teach the relevant graduate-level MSE courses will participate in the MSE GCP. In addition, ST and MA faculty who teach relevant courses will also participate. All instructors listed are members of the graduate faculty. Minor changes in the instructors for each course may occur each year to balance teaching loads with other faculty activities.

TABLE 1
Courses for the Graduate Certificate Program in Materials Science and Engineering

REQUIRED COURSE
MSE 723 Materials Informatics
ELECTIVE COURSES
MSE710 Elements of Crystallography and Diffraction MSE721 Nanoscale Simulations and Modeling MSE724 Quantitative Materials Characterization Techniques ST 517 Statistical Methods I ST 540 Applied Bayesian Analysis ST 533 Applied Spatial Statistics MA 540 Uncertainty Quantification for Physical and Biological Models

TABLE 2
Participating faculty in the MSE Graduate Certificate Program

Instructor	Course(s)	Home department
Elizabeth Dickey	MSE 710	Materials Science & Engineering
Yaroslava Yingling	MSE 721 MSE 723	Materials Science & Engineering
Albena Ivanisevic	MSE724	Materials Science & Engineering
Jacob Jones	MSE724	Materials Science & Engineering
Herle M McGowan	ST 517	Department of Statistics
Brian Reich	ST 540 ST 533	Department of Statistics
Ralph Smith	MA 540	Department of Mathematics
Srikanth Patala	MSE723	Materials Science and Engineering

Statement of other departments likely to be affected and summary of consultation with those departments

The departments of Mathematics and Statistics were contacted to solicit the feedback. We received the emails from the following faculty indicating their departmental support:

Dr. Pierre A Gremaud, Professor and Director of Graduate Programs, Department of Mathematics
"I just sent you a short message supporting the creation of the MI GPC.
For whatever it is worth, here are also some thoughts and questions about this proposal that I would not be surprised you will have to answer (I sit on the admin board of the graduate school and have gone through several of these recently).
Overall, this looks like a worthy addition to NC State's portfolio of graduate programs and certificates. It will join a crowded field of new or proposed programs pertaining to "data". The facts that the proposed title (Materials Informatics) avoids both "data" and "analytics" (and ML) is a good thing.
1. Will the certificate be proposed as an on-campus degree, an online degree or both? The fact that EOL is mentioned a couple of times seems to indicate that online delivery is being considered but this should be clearly spelt out in the proposal.
2. The MI GCP will require
-MSE 723 (which is not yet a regular course),
-one of MSE 710, MSE 721 and an online topics course (quantitative materials characterization techniques) listed as MSE 791-602
-one of ST 517, ST 540, ST 533, MA 540,
and a fourth course. The above courses are the only allowed electives, right? If not, what are the conditions under which a course can be considered?
3. The statement "All required and elective courses for the GCP are existing courses in MSE and at NCState, or they are cross-listed with other engineering departments" is kind of funny. Two of the above courses are not yet regular courses (MSE 723 and MSE 791-602).
4. Under "Requirements for admission", it says "... from a regionally accredited four-year college or university". Why regionally?"

Dr. Brian Reich, Associate Professor, Department of Statistics
"Overall I think this looks great. One suggestion is that a machine learning course might be better than ST533 (spatial stats). Our ML courses are still in flux a bit so let me got back to you later with a concrete suggestions."

Dr. Wenbin Lu, Professor and Director of Graduate Programs
"I am okay for the certificate program."
Prof. Ralph Smith, Professor
"I forwarded the proposal to Pierre Gremaud but have not had a chance to get feedback from him. I'll try to catch him this afternoon."

Prof. Alyson Wilson about availability of Math and Stats classes online.

Graduate Certificate in Materials Informatics
Outcomes Assessment Plan

Objectives
1. In this certificate program, students will learn the principles and concepts of materials informatics and high throughput materials discovery
2. The certificate program will provide an educational experience that satisfies the expectations of its graduates.

Objectives and Outcomes
1. By the time they complete this certificate program, graduates should be able to:
   • Describe key materials informatics concepts and components
   • Describe and analyze data available from various types of materials characterization methods
   • Identify the informatics problems and capabilities associated with different types of materials
   • Identify a machine learning algorithm with the desired properties for a given materials problem.
   • Identify sources of bias and uncertainty in materials data and analysis results
2. At the time they complete this certificate program, graduates are expected to:
   • Be satisfied with the usefulness of the certificate program in enabling them to achieve their professional goals
   • Be sufficiently satisfied with the certificate program to recommend it to others with the same professional goals
   • Be satisfied with the appropriateness of the courses in providing the knowledge or training they anticipate needing for their professional goals
   • Be satisfied with the frequency and timeliness of courses offered for the certificate
   • Be satisfied with the quality of teaching in certificate courses
   • Be satisfied with the overall educational experience of the certificate program

Objective 1. In this certificate program, students will learn the principles and concepts of materials informatics and high throughput materials discovery

Outcome	Evidence to be Collected	Source of Evidence	Frequency of Collection
Describe key materials informatics concepts and components	Responses by certificate students to relevant questions on exams from MSE 723	Students	Annually
Describe and analyze data available from various types of materials characterization methods	Responses by certificate students to relevant questions on exams from MSE 723 and elective	Students	Annually
Identify the informatics	Responses by certificate	Students	Annually

problems and capabilities associated with different types of materials			
Identify a machine learning algorithm with the desired properties for a given materials problem	Responses by certificate students to relevant questions on exams from MSE 723 and elective courses	Students	Annually
Identify sources of bias and uncertainty in materials data and analysis results	Responses by certificate students to relevant questions on exams from elective courses	Students	Annually

Objective 2. The certificate program will provide an educational experience that satisfies the expectations of its graduates

Outcome	Evidence to be Collected	Source of Evidence	Frequency of Collection
To be satisfied with the usefulness of the certificate program in enabling them to achieve their professional goals	Exit survey administered by Graduate School	Graduate School	Annually
To be sufficiently satisfied with the certificate program to recommend it to others with the same professional goals	Exit survey administered by Graduate School	Graduate School	Annually
To be satisfied with the appropriateness of the courses in providing the knowledge or training they anticipate needing for their professional goals	Exit survey administered by Graduate School	Graduate School	Annually
To be satisfied with the	Exit survey administered	Graduate School	Annually

frequency and timeliness of courses offered for the certificate	by Graduate School		
To be satisfied with the quality of teaching in certificate courses	Exit survey administered by Graduate School	Graduate School	Annually
To be satisfied with the overall educational experience of the certificate program	Exit survey administered by Graduate School	Graduate School	Annually